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May 5, 2021

British Columbia Utilities Commission
Suite 410, 900 Howe Street
Vancouver, BC
V6Z 2N3

Attention: Mr. Patrick Wruck, Commission Secretary

Dear Mr. Wruck:

Re: FortisBC Energy Inc. (FEI)

Application for a Certificate of Public Convenience and Necessity (CPCN) for Approval of the Advanced Metering Infrastructure (AMI) Project

Pursuant to sections 45 and 46 of the *Utilities Commission Act* (the UCA), FEI applies to the British Columbia Utilities Commission (BCUC) for a CPCN for the AMI Project. The AMI Project is needed to address the present and expected long term challenges with contracting for manual meter reading services, and enhance system resiliency by providing FEI with the ability to strategically manage system load and prevent system pressure collapse during an extended loss of supply.

The AMI solution will be capable of collecting natural gas consumption and other information from all customer meters and will have additional capacity for collection of information on infrastructure and pipeline assets. The AMI system will also allow customers to access their hourly consumption information through a secure and private online customer information portal. The scope of the AMI Project consists of:

1. Replacing existing customer meters with advanced meters and the associated infrastructure to support delivery of hourly metering information from the advanced meters at customer premises, back to FEI; and

2. Installing communicating sensors on FEI's pipeline assets.

FEI also seeks BCUC approval, pursuant to sections 59 to 61 of the UCA, for the creation of four new asset accounts with associated depreciation and net salvage rates, and four deferral accounts to capture the costs of developing the AMI Project and preparing the Application.

Request for Confidential Treatment of Certain Appendices

To support the Application, FEI has filed several appendices, with the following ones being filed confidentially pursuant to Section 18 of the BCUC's Rules of Practice and Procedure regarding confidential documents, as set out in Order G-15-19.

- Appendix E – Risk Analysis
- Appendix G – Financial Schedules

FEI respectfully requests that the BCUC hold the above listed documents confidential, and that such information should remain confidential after the regulatory process for this Application is completed. Below FEI outlines the reasons for keeping the information confidential.

<u>Appendix E</u>

Appendix E are engineering documents and should be kept confidential on the basis that they contain operationally sensitive information pertaining to the Company's assets. In particular, it identifies areas of risk to the Project including detailed information that if disclosed, could impede the security of FEI's information systems and its ability to work safely and reliably operate its gas system assets and could risk the safety of both its workers and the public. These documents also include cost estimates and identify Project risk. They should be kept confidential on the basis that FEI will be going to the market to seek competitive bids for deployment of the Project. If the estimated costs for the work is disclosed, FEI reasonably expects that its negotiating position may be prejudiced. For instance, the bidding parties with knowledge about the estimated costs may use the estimate costs as a reference for their bidding.

<u>Appendix G</u>

Appendix G includes cost estimates, containing capital cost estimates for the Project. They should be kept confidential on the basis that FEI will be going to the market to seek competitive bids for the deployment of the Project. If the estimated costs for the work is disclosed, FEI reasonably expects that its negotiating position may be prejudiced. For instance, the bidding parties with knowledge about the estimated costs may use the estimate costs as a reference for their bidding.

Access to Confidential Information for Interveners

Should parties that choose to register in the review of this Application require access to some or all of the information filed confidentially, FEI has provided a proposed Confidentiality Declaration and Undertaking Form in Appendix K-3, to be executed before confidential information may be released to registered parties under the terms of the undertaking. FEI expects that registered interveners would generally be able to access the confidential information as long as they executed the Undertaking of Confidentiality, subject to the possibility of there being a registered intervener in relation to whom (given their particular characteristics or circumstances) further protections are required. FEI requests that the BCUC provide it with the opportunity to file comments on any objections or concerns that it may have, should any other registered parties seek access to confidential information.

If further information is required, please contact the undersigned.

Sincerely,

FORTISBC ENERGY INC.

Original signed:

Diane Roy

Attachments

cc (email only): Registered Parties to the FEI Annual Review for 2020 and 2021 Delivery Rates

FORTISBC ENERGY INC.

Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure Project

May 5, 2021

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1. APPLICATION

1.1 INTRODUCTION

FortisBC Energy Inc. (FEI or the Company) applies to the British Columbia Utilities Commission (BCUC), pursuant to sections 45 and 46 of the *Utilities Commission Act* (UCA), for a Certificate of Public Convenience and Necessity (CPCN) for the Gas Advanced Metering Infrastructure (AMI) Project (referred to as the AMI Project or the Project) as described in this application (the Application). FEI is also requesting related approvals, pursuant to sections 59-61 of the UCA, of the creation of four new asset accounts with associated depreciation and net salvage rates, and four new deferral accounts.

FEI has determined a need to automate its meter reading process for all FEI customers. FEI's current meter reading practices are highly manual, vulnerable to errors and can be inconvenient for customers; further, the utility industry is overwhelmingly moving towards some form of meter automation, leading to changes in both market conditions and customer expectations. Automation is more accurate and convenient for customers, will alleviate the cost and service risks of manual meter reading and provides a cost-effective, long-term solution. Automation will also provide additional customer benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system.

The Project will replace most existing customer meters with advanced meters, retrofit those meters that are not replaced with AMI communication modules, and install the associated AMI network and infrastructure to support delivery to FEI of hourly gas consumption and other metering information from the advanced meters/modules at customer premises. The Project will also include the installation of communication modules on infrastructure and pipeline assets enabling the remote collection of information related to the integrity of FEI's gas system. Additionally, FEI customers will have the ability to access their hourly consumption information through FEI's secure and private online customer portal, and to be notified of gas flow anomalies for use by FEI and the customer to help identify potential gas leaks, faulty appliances or appliances/equipment mistakenly left on.

FEI submits that the information provided in this Application, which meets the requirements of the BCUC's CPCN Guidelines,[1] demonstrates that the Project is in the public interest.

FEI requests that the Project be approved as set out in the Application. A draft Procedural Order and draft Final Order are included in Appendices K-1 and K-2, respectively.

[1] Appendix A to Order G-20-15.

1.2 EXECUTIVE SUMMARY

1.2.1 FEI Needs to Automate the Meter Reading Process

The Project is needed to automate the meter reading process for FEI customers. This process is presently done manually for by far the majority of FEI customers. Automation refers to the ability to communicate with the meters at customer premises to collect gas consumption readings, alarms, and other diagnostic information.

Meter automation is more accurate and convenient for customers than manual meter reading practices

Nearly all of FEI's over 1,000,000 meters are read manually each month, with only a small number of meters that communicate remotely due to customer requirements. FEI's current meter reading practices are highly manual and vulnerable to errors, and can be inconvenient to customers. The limitations of manual meter reading can be resolved through automation, which results in a lower number of bill estimates, provides greater bill accuracy, and requires minimal access to customer premises. All of these work together to improve the customer experience as compared to manual meter reading.

Automation is becoming the industry standard, thereby changing both market conditions and customer expectations

Utilities serving gas and electric customers across North America, including within Canada and British Columbia itself, have transitioned away from manual meter reading and implemented different forms of meter automation. The technology is available for natural gas, electricity, and water, as well as multi-commodity utilities. As a result, advanced metering technology is now commonplace across North America and is no longer considered new or cutting edge.

In British Columbia, customers in FEI's service territory have access to the type of information that newer metering technology provides through their electricity providers, including BC Hydro and Power Authority (BC Hydro) and FortisBC Inc. (FBC). Maintaining a manual meter reading process will result in FEI lagging behind its peers. This has implications in both customer expectations and market availability of meter reading contractors.

Automation alleviates cost and service risks and provides a cost-effective, long-term solution

The transition to automation addresses cost and service risks presented by manual meter reading, including:

- *Meter reader retention issues and safety risks:* FEI's meter reading process is highly manual, requiring a meter reader to visit each meter installation, read the meter, and then manually enter digits into a hand-held device. The nature of meter reading makes it difficult to retain meter readers, which creates a risk to customer service.

- *Supply and cost of manually read meters:* Due to the industry trend towards automated meter reading, suppliers of both products and services that support manual meter reading have gradually been faced with changing markets. In response to the continued automation of meter reading by utilities, members of the industries that support manually read meters and manual meter reading are shifting their business models.
- *Rising cost and uncertainty of third party manual read providers:* As utilities continue to automate their meter reading processes, the decline in the number of meters requiring manual reading is reducing the economies of scale that customers and service providers enjoyed in the past, and decreasing service providers' ability to generate revenue to cover their fixed costs while offering competitive meter reading rates.

Automation provides customer benefits and operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system

The automation of meter reading is an opportunity to provide transformational change to key components of the utility customer experience, creating a platform for future opportunities for customer experience enhancements and providing operational opportunities that support the safety, resiliency[2] and efficient operation of the gas distribution system.

Automation provides an opportunity to better meet evolving customer expectations. While meter automation resolves the inconvenience of manual meter reading at the customer's property and improves the accuracy of customer bills, reducing any need for the customer to make efforts to resolve concerns with accuracy, it also provides the opportunity to meet current and evolving customer expectations with respect to having access to energy use information.

Finally, depending on the form of automation, there are potential benefits for customers in the long term as well as immediate opportunities in the operation of the gas distribution system. Some of these opportunities and benefits include improved emergency response to gas odours and leaks, better availability of data for operational and project use, and improved integrity[3] management. In particular, Automation provides the opportunity to improve the resiliency of FEI's gas system in the event of a gas supply emergency. Increasing the resiliency of FEI's gas system is a key need that Automation would support in three distinct ways: by allowing near real-time visibility of the load on the system; by providing FEI the ability to strategically disconnect gas remotely in an emergency situation; and by providing the ability to keep pressure in the system to minimize time for customer reconnections.

[2] "Resiliency" is defined as the ability to prevent, withstand, and recover from system failures or unforeseen events as described further in Section 4, Subsection 4.3.2.4.

[3] "Integrity" is defined as the ability of individual system elements to meet their original design specifications, and to fulfil their intended purpose or application as described further in Section 4, Subsection 4.3.2.4.

1.2.2 FEI Evaluated Automation Alternatives and Selected AMI as Providing the Best Overall Value

To address the Project need for automation of the meter reading process, FEI compared the two technologies available in the gas metering industry: partial automation of meter reading using Automated Meter Reading (AMR) technology to enable drive-by meter reading; and full automation of meter reading using AMI technology characterized by a fixed two-way communication network.

A comparison of these alternatives determined that while AMR could partially satisfy some of the drivers of the Project need, only by implementing AMI would customers and the Company realize the full value of meter automation. While AMR would partially meet the need to automate the manual meter reading process, AMI would deliver all of the drivers of the need for Automation. Deploying an AMR solution would ultimately lock the Company and customers into a technology with limited benefits and offer no ability to realize future opportunities to enhance the customer experience or FEI's operations in the same way that AMI technology would enable. Where AMR would provide limited benefits to the Company and customers, an AMI alternative would provide those same benefits, while both providing important additional benefits for customers now and in the future and providing the opportunity to enhance critical areas of the Company's operations. Table 1-1 summarizes the four drivers of the Project need and illustrates the results of the analysis comparing how AMR and AMI would support the different drivers. The table also includes the Baseline scenario, which is defined within this Application as the costs FEI expects to incur if the proposed Project is not approved.[4]

Table 1-1: Overview of Alternatives

Alternatives: Project Need Analysis

EVALUATION	SCORE
FULLY; Project need is fully met	✔
PARTIALLY; Project need is partially met	!
NOT; Project need is not met	✖

	AMI	AMR	BASELINE
Automation is more accurate and convenient for customers than FEI's current meter reading practices, which are highly manual, are vulnerable to errors and can be inconvenient for customers	✔	!	✖
Automation is becoming the industry standard, thereby changing both market conditions and customer expectations	✔	✖	✖
Automation alleviates the cost and service risks of manual reading and provides a long term cost effective alternative	✔	!	✖
Automation provides additional customer benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system	✔	✖	✖

[4] The Baseline scenario is based on FEI's current status quo operations and includes future cost increases to manual meter reading for the reasons set out in Section 3.3.3 and further described in Section 6.2.2.3.

Finally, in comparing the AMI and AMR alternatives, although AMI had a slightly higher overall estimated delivery rate impact over the analysis period (less than half a percent higher), the significant non-financial benefits of AMI resulted in it being FEI's proposed solution.

1.2.3 Project Description, Timeline, Costs and Delivery Rate Impact

Project Description

The Project will replace most existing customer meters with advanced meters, retrofit those meters that are not replaced with AMI communication modules, and install associated AMI network/infrastructure to support delivery of hourly gas consumption and other metering information from the advanced meters/modules at customer premises, back to FEI. Communication modules will also be installed on the gas network and pipeline assets to enable the remote collection of information on FEI's gas system integrity.

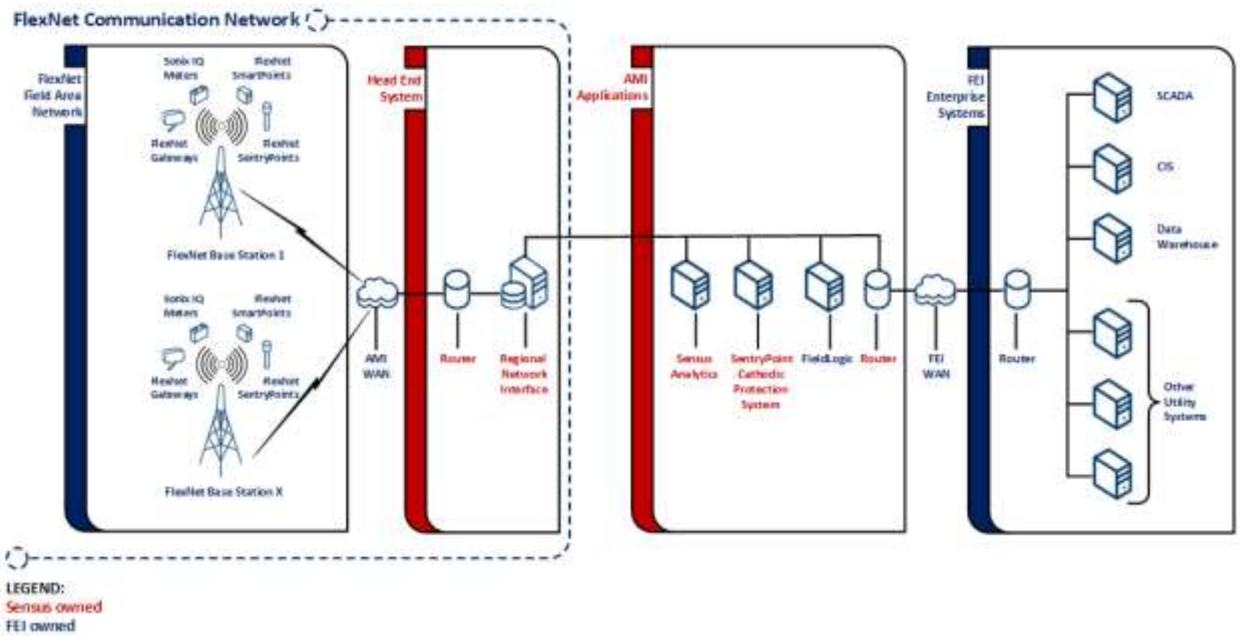
FEI's engineering standard for meter set design includes installation of meter set bypass valves and regulators. As part of FEI's meter exchange sustainment program, meter set bypass valves are installed and regulators are replaced. Given that the Project will require every meter to either be exchanged or upgraded with a communication module, the Project will deploy bypass valves and replace residential and small commercial regulators for all applicable meters.

Upon Project completion, FEI customers will have the ability to access their hourly consumption information through FEI's secure and private online customer portal, and to be notified of gas flow anomalies for use by FEI and the customer to help identify potential gas leaks, faulty appliances or appliances/equipment mistakenly left on.

Following a Request for Proposal (RFP) process, FEI selected Sensus USA Inc. and Sensus Canada Inc. (Sensus) as the AMI Network vendor of choice. FEI has contracted with Sensus to provide its AMI technology solution as a Software as a service (SaaS) model.

Figure 1-1 depicts the logical architecture of the Project including integration of the Sensus AMI technology components with FEI enterprise systems.

Figure 1-1: Project Logical Architecture



Project Timeline

The Project implementation will take four and a half years from BCUC approval. The Project timeline is divided into several implementation phases. Beginning in 2022, FEI will prepare, define, design, build and integrate AMI technology with FEI's billing system to be ready for deployment of AMI technology, advanced meters, regulators, bypass valves and meter/non-meter AMI communication modules in six deployment regions. Beginning in 2024, FEI will augment its enterprise data repository with gas interval consumption, develop enhancements to the customer portal to provide customers with the ability to view their hourly consumption information and enable capabilities to notify customers of gas flow anomalies for use in identifying potential gas leaks, faulty customer appliances and appliances/equipment with unintended gas flow. Final acceptance and Project close out, where FEI determines that all contract deliverables are met and finalized and business processes are stable and supported, will occur in 2026.

Table 1-2 details the broad, preliminary schedule by implementation phase. After receipt of BCUC approval, FEI will issue a Notice to Proceed to Sensus and the to-be selected Deployment Vendor, allowing 90 days to mobilize for implementation.

Table 1-2: Project Schedule

Activity	Date
CPCN Filing	May 2021
Prepare	Q2 2021 – Q3 2022
Define	Q2 2022 – Q2 2023
Design, Build, Integrate and Ready For Deployment	Q2 2022 – Q3 2024
Deploy AMI Technology / Billing System Integration	Q3 2022 – Q3 2023
Deployment Region 1: Lower Mainland South	Q4 2022 – Q2 2025
Deployment Region 2: Lower Mainland North	Q2 2024 – Q4 2026
Deployment Region 3: North Interior	Q2 2023 – Q3 2025
Deployment Region 4: South Interior	Q1 2023 – Q2 2026
Deployment Region 5: Vancouver Island	Q3 2023 – Q3 2026
Deployment Region 6: Kootenays	Q3 2024 – Q4 2026
Deploy Enterprise Data Repository, Customer Portal, Leak Detection	Q1 2024 – Q1 2025
Final Acceptance	Q3 2026
Close Out	Q3 2026 – Q4 2026

Project Costs and Delivery Rate Impact

The AMI Project capital cost is estimated at $638.4 million and the incremental Project capital cost (over the Baseline scenario which is the continuation of manual meter reading) is estimated at $476.0 million. During the Post-deployment phase, FEI estimates reduced capital spending of $355.0 million. FEI also estimates Post-deployment incremental O&M savings of $318.6 million. The Post-deployment phase is the time period from 2027 to 2046 over which the new AMI meters are expected to be in service, based on the estimated useful life of the new AMI meters of 20 years. The majority of the financial benefits of the Project, consisting primarily of reduced meter reading costs, will be realized over this Post-deployment phase.

Overall, the AMI Project is expected to be effectively rate neutral over the 26-year analysis period, with the incremental levelized delivery rate impact estimated to be 0.125 percent using conservative assumptions. There would be an overall rate savings for customers if the future cost of manual meter reading is higher than the Baseline low case cost scenario that has been assumed.

1.2.4 Customer, Public, Stakeholder and Indigenous Communities Consultation

The Project represents one of the more extensive projects FEI has proposed, due to its impact to approximately 1,100,000 residential, commercial and industrial gas customers, and all communities across FEI's service territory. Consultation and engagement began in late 2019, including publicly announcing the Project. The focus of FEI's activities has been to consult and engage with customers, other stakeholders, Indigenous groups specifically, and the broader public about the Project and solicit their feedback to support the development of this Application and the Project itself.

Key consultation and engagement activities to date include:

- Project notification letters to provincial and local governments, and Indigenous communities in FEI's service territory;
- In-person and virtual meetings with municipalities and Indigenous communities, and follow-up phone calls and emails to confirm receipt of notification letters;
- Telephone town halls and virtual information sessions with provincial and local government leaders;
- A customer perception survey and direct customer communications;
- Public information sessions, both in-person and virtual;
- Creation of a dedicated Project webpage, phone line and email address; and
- Ad campaigns, social media communications and media outreach.

FEI has consulted and sought feedback from the public and other stakeholders and has engaged with the potentially impacted Indigenous groups in the area of the Project. FEI will continue to work with all identified stakeholders and Indigenous groups to address issues and concerns throughout the lifecycle of the Project. A detailed analysis of consultation, engagement and communication activities can be found in Section 7 of the Application.

1.2.5 Conclusion

FEI believes the information contained in this Application demonstrates that the Project is in the public interest and should be approved as set out in the Application.

1.3 *SUMMARY OF APPROVALS SOUGHT*

FEI is seeking the necessary approvals to implement the Project as proposed and ensure the appropriate financial treatment of costs for regulatory purposes. The approvals sought are summarized below. The specific form of approvals sought is set out in Appendix K-1.

1.3.1 Certificate of Public Convenience and Necessity

FEI, pursuant to sections 45 and 46 of the UCA, applies to the BCUC for a CPCN for its AMI Project. A detailed description of the Project is contained in Section 5 of the Application. The Project capital cost is estimated to be $638.4 million with an estimated incremental levelized delivery rate impact of 0.125 percent.

1.3.2 New Asset Accounts

FEI, pursuant to sections 59-61 of the UCA, is requesting approval for the creation of four new asset accounts with associated depreciation and net salvage rates as follows:

- 478-10 / AMI Meter Hardware – depreciation rate set to 5 percent, no net salvage
- 474-00 / AMI Meter Installation – depreciation rate set to 5 percent, 1.58 percent net salvage
- 402-06 / AMI Software – depreciation rate set to 10 percent[5]
- 488-30 / AMI Communications and Equipment – depreciation rate set to 6.67 percent, no net salvage

1.3.3 New Deferral Accounts

FEI, pursuant to sections 59-61 of the UCA, is requesting approval of the creation of four new deferral accounts as follows:

- A non rate base **AMI Application and Feasibility** cost deferral account attracting a weighted average cost of capital (WACC) return until it is placed into rate base, to capture development and application costs for this Project. Once transferred to rate base FEI proposes an amortization period of three years.
- A non rate base **AMI Foreign Exchange (FX) Mark to Market Valuation** deferral account to isolate the impact of any foreign exchange hedging used to reduce foreign exchange risk of the Project.
- A rate base **Existing Meter Cost Recovery** deferral account to capture the remaining rate base value of meters to be exchanged as part of this Project with a rolling amortization period of five years.
- A rate base **Previously Retired Meter Cost Recovery** deferral account to capture the remaining rate base value of previously retired meters with an amortization period of ten years.

1.3.4 Confidential Filings Request

Certain sections and appendices of the Application contain operationally and commercially sensitive information, including detailed information that, if disclosed, could impede the security of FEI's information systems and gas system assets. Some of the Confidential Appendices also contain market-sensitive information that should be kept confidential so as not to influence the contractor selection process for the Project. FEI will mark confidential information as such, where applicable.

In accordance with the BCUC's amended Rules of Practice and Procedure established by Order

[5] There is no net salvage for software as there are no associated removal costs.

G-15-19 regarding Confidential Documents, FEI expects that registered interveners would generally be able to access the confidential information as long as they executed an Undertaking of Confidentiality, subject to the possibility of there being a registered intervener in relation to whom (given their particular characteristics or circumstances) further protections are required. A sample of the Undertaking of Confidentiality is included as Appendix K-3.

1.4 *PROPOSED REGULATORY PROCESS*

FEI proposes that the Application be reviewed by way of a written hearing process as further detailed below. A written hearing would provide the most effective means for addressing the matters outlined in the Application. Those include technical and financial details not well suited to oral proceedings, as well as the updating of earlier work that the BCUC undertook in considering past meter automation-related applications in this province.

FEI would require a BCUC decision on the proposed AMI Project within 12 months of the filing date in order to maintain firm contract pricing on the proposed AMI system as has been negotiated with the AMI vendor. With this consideration, the Company proposes the following regulatory timetable for review of the Application:

Table 1-3: Proposed Regulatory Timetable

Action	Date (2021)
Application Filed	Wednesday, May 5
BCUC issues procedural order	Thursday, June 10
FEI to publish Notice	Wednesday, July 7
Registration of Interveners	Wednesday, August 11
BCUC Information Request (IR) No. 1	Wednesday, August 11
Intervener IR No. 1	Wednesday, August 18
FEI Response to BCUC and Intervener IR No. 1	Wednesday, September 15
BCUC and Intervener IR No. 2	Wednesday, October 6
FEI Response to BCUC and Intervener IR No. 2	Wednesday, November 3
Submissions on Further Process	Wednesday, November 17

With regard to participant interest in the regulatory review of the Application, FEI believes that in order to ensure a thorough, comprehensive, and efficient review of the Company's proposed AMI Project, the BCUC must consider potential participants' specific interest in the Application at the time of registration, and ensure that intervener status is limited to those individuals or groups that can adequately demonstrate they will be directly affected by the Application. In the absence of this consideration, it is likely that significant additional costs (related to participants without a direct interest in the Application) will be incurred to complete the regulatory review of the Application, which will ultimately have to be recovered from FEI's customers. The Company submits that the granting of interested party status, rather than intervener status, for participants unable to sufficiently demonstrate a direct interest in the AMI Project is appropriate in order to ensure an efficient and thorough review of the Application.

1.5 *STRUCTURE OF THE APPLICATION*

The Application is structured as follows:

Section 1 provides the Executive Summary of the Application and summary of the approvals sought.

Section 2 provides the Company's financial and technical capacity, contact information for the AMI Project, and legal counsel.

Section 3 describes the need for the AMI Project, including that:

- Automation is more accurate and convenient for customers than FEI's current meter reading practices, which are highly manual, are vulnerable to errors and can be inconvenient for customers;
- The utility industry is overwhelmingly moving towards some form of meter automation, leading to changes in both market conditions and customer expectations;
- Automation alleviates the cost and service risks of manual reading and provides a long term cost effective solution; and
- Automation provides additional customer service benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system.

Section 4 provides a summary of the alternatives considered to the AMI Project, specifically comparing AMI and AMR.

Section 5 provides a detailed description of the AMI Project including Project components and Project scope. The section summarizes lessons learned from FBC's electric AMI project and FEI's natural gas pilot project that will inform the AMI Project. It outlines the procurement process undertaken as part of this Application, the Project schedule, Project risks and other considerations.

Section 6 provides details on the Project cost estimate, the assumptions upon which the financial analysis is based, and the estimated delivery rate impacts. The section also includes the proposed treatment of the existing gas meters that are to be replaced as part of the Project.

Section 7 discusses FEI's Indigenous and public consultation efforts regarding the AMI Project.

Section 8 describes how the Project supports British Columbia's energy objectives and describes the Project's inclusion within FEI's most recent long-term resource plan.

Section 9 concludes that the Project is in the public interest and should be approved.

2. THE APPLICANT

2.1 NAME, ADDRESS AND NATURE OF BUSINESS

FEI is a company incorporated under the laws of the Province of British Columbia and is a wholly-owned subsidiary of FortisBC Holdings Inc., which in turn is a wholly-owned subsidiary of Fortis Inc., a Canadian-based utility holding company. FEI maintains an office and place of business at 16705 Fraser Highway, Surrey, British Columbia, V4N 0E8.

FEI is the largest natural gas distribution utility in British Columbia, providing sales and transportation services to over 1 million residential, commercial, and industrial customers in more than 100 communities throughout British Columbia. FEI's distribution network delivers natural and renewable gases to more than 80 percent of the gas customers in British Columbia.

2.2 FINANCIAL CAPACITY

FEI is regulated by the BCUC and is capable of financing the Project. FEI has credit ratings for senior unsecured debentures from Dominion Bond Rating Service (DBRS) Morningstar and Moody's Investors Service of A and A3, respectively, which support the issuance of debt in the capital markets. Additionally, FEI has access to equity injections, as required, from Fortis Inc. to finance the equity portion of the costs of projects. The liquidity of Fortis Inc.'s common shares in the Toronto Stock Exchange (TSX) and the New York Stock Exchange (NYSE), together with its other share plans, provide an equity platform for FEI and affiliated companies to draw upon to finance their major capital projects.

2.3 TECHNICAL CAPACITY

FEI has the technical capacity to undertake the Project, having extensive experience in testing and, where required, replacing, on average approximately 60,000 meters in accordance with Measurement Canada requirements each year. FEI has over 1 million meters installed across its service territory to measure the volume of gas flowing to a customer's location. FEI operates a Measurement Canada-accredited meter test facility allowing the Company to manage all aspects of FEI's gas meter fleet and of the electric meter fleet of FBC internally, including administering each utility's respective compliance sampling and testing program, completing meter maintenance and leading the annual meter exchange program.

FEI has completed successful Information Systems projects in the past, including the implementation of the Customer Information System (CIS) as part of the 2009 Customer Care Enhancement (CCE) Project. FEI (then, Terasen Gas) successfully implemented the new CIS software, including converting data from legacy systems and integration with other FEI systems.

FEI's affiliated company, FBC, successfully developed and completed its own AMI project. FEI has leveraged FBC's experience with its AMI project as described in Section 5.3.1. In developing significant infrastructure projects, FEI contracts with experienced consultants or relies on internal resources. Further, when required, FEI augments its internal engineering, environmental, project management, and communications and consultation resources with experienced external consultants who provide specialist support.

FEI's selected advanced meter provider and network vendor, Sensus, USA Inc. and Sensus Canada Inc. (Sensus), has over 100 years of experience developing and providing metering solutions for the utility industry; it has provided assistance with over 300 AMI system deployments.

FEI will engage in a request for proposal (RFP) process to identify the appropriate contractor(s) for the deployment of the advanced meters and other Project components. The RFP process will incorporate key considerations such as prior experience, safety, and compliance with FEI's functional requirements.

The key senior positions on the current Project team are outlined in Section 5.6.2. The Executive Sponsor of the Project is the Vice President, Customer Service & Information Systems. The team will be augmented and adjusted as the Project proceeds through the design and deployment phases.

2.4 COMPANY CONTACT

Diane Roy
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Regulatory Affairs - Gas
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2.5 LEGAL COUNSEL

Ludmila B. Herbst, Q.C.
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Fax: 604-661-9349
E-mail: lherbst@farris.com

3. PROJECT NEED

This section demonstrates the need for the Project, which is to automate the meter reading process (referred to throughout the Application as Automation) for FEI customers. In this context, Automation refers to the ability to communicate with the meters at customer premises to collect gas consumption readings, alarms, and other diagnostic information. This Automation will provide a more accurate and more convenient process for customers and provide a stable, cost-effective meter reading solution for the long term. Access to more timely information will also improve safety and system resiliency[6]. Further, Automation will empower customers to make informed energy decisions, enhance their energy conservation efforts, and have more control over their energy costs.

In the following sections, FEI will show that:

- Automation is more accurate and convenient for customers than FEI's current meter reading practices, which are highly manual and are vulnerable to errors, and can be inconvenient for customers;
- Automation is becoming the industry standard, thereby changing both market conditions and customer expectations;
- Automation alleviates the cost and service risks of manual reading and provides a cost-effective, long-term alternative; and
- Automation provides additional customer benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system.

The need for Automation is described in further detail below.

3.1 *METER AUTOMATION IS BOTH MORE ACCURATE AND MORE CONVENIENT FOR CUSTOMERS*

In the following sections, FEI broadly describes the current state of metering and then outlines the limitations and challenges associated with manual meter reading that Automation will resolve. More specifically, that Automation results in a lower number of estimated bills, provides greater bill accuracy, and requires minimal access to customer premises. All of these work together to improve the customer experience as compared to manual meter reading.

3.1.1 The Current State of Metering

This section broadly sets out the current state of FEI's metering. FEI will describe the following:

[6] "Resiliency" is defined as the ability to prevent, withstand, and recover from system failures or unforeseen events as described further in Section 4, subsection 4.3.2.4.1

- The current meter fleet, including the types of meters in use, the number installed, how the present meters work, and why manual meter reading is required in relation to them;
- The meter testing and exchange process, including Measurement Canada requirements and the impact the process has on residential customers;
- The process for collecting data from the present meter fleet including the volume of manual meter reads, the manual meter reading process, and information about the third-party contractor engaged in manual meter reading; and
- How that meter data is used for billing and customer information purposes.

3.1.1.1 FEI's Current Meter Fleet Requires Manual Reading

The following table lists the number of meter types installed across FEI's service territory to measure the volume of gas flowing to a customer's location.[7] Nearly all of FEI's over 1,000,000 meters are read manually each month; approximately 4,400 meters communicate remotely due to customer requirements.

Table 3-1: FEI's Current Meter Fleet

Meter Type	Description	Customer Type	Number Installed
Diaphragm	A meter that measures the amount of gas through the known volume that is displaced for each stroke of the diaphragm. The diaphragm also provides the seal between the measuring chambers of the device. The mechanical nature of the diaphragm meter limits its capabilities to simply measuring the amount of gas consumed over a given period for billing purposes and customer information. Without an additional communication device, this meter type requires manual meter reading.	Residential & Commercial	1,037,652 (small) 25,888 (large)
Ultrasonic	A meter that measures gas flow velocity with sound waves to calculate a volumetric measurement. Industrial ultrasonic meters have been used by FEI in installations that may require remote reading capabilities for safety or meter access reasons. Other ultrasonic meters have been used for applications with	Residential, Commercial & Industrial	4,592 (Residential) 1,724 (Commercial) 3 (Industrial)

[7] Meter counts are derived from FEI's Meter Population Report dated January 6, 2021 and are accurate as of that date.

Meter Type	Description	Customer Type	Number Installed
	space constraints. The majority of FEI's current ultrasonic meters do not contain a communication device and as such require manual meter reading.		
Rotary	A meter where each turn of a lobe moves a specific quantity of gas through the meter. Within the meter, there are two figure "8" shaped lobes and the rotors spin in precise alignment. FEI's current rotary meters typically do not contain a communication device and as such, the majority currently require manual meter reading.	Commercial & Industrial	9,338
Turbine	Gas turbine meters are velocity-sensing devices. The direction of flow through the turbine meter is parallel to the turbine rotor axis and the speed of the rotation of the turbine meter is nominally proportional to the rate of flow. Gas volumes are derived or "inferred" from the rotations of the turbine rotor. FEI's current turbine meters typically do not contain a communication device and as such, the majority currently require manual meter reading.	Commercial & Industrial	331

In the context of this Application, FEI is seeking to automate the reading of all meters within the FEI fleet. To accomplish this, FEI does not propose to replace the entire meter fleet; rather, only the diaphragm (residential and commercial) and residential ultrasonic meters are identified for replacement. Commercial and industrial ultrasonic, rotary and turbine meters can instead be retrofitted with a communication device to allow for Automation. As such, the following three sections are largely focused on the meter related processes for the residential and commercial meters that will be replaced.

3.1.1.2 Meter Testing and Exchanges Significantly Impact Residential and Commercial Customers

Measurement Canada is a federal regulatory agency that establishes the requirements for energy metering devices and installations in Canada. The *Electricity and Gas Inspection Act*

(EGIA) and Regulations set the rules for the sale of natural gas, and define units for energy measurement. The EGIA requires that:

- natural gas meters be approved for use in Canada;
- only approved and verified meters are used to determine the amount of natural gas consumed; and
- the accuracy of electricity and natural gas meters be verified in accordance with the time periods stipulated in the Regulations.

As per section 19 of the EGIA, FEI samples and tests its meter fleet in accordance with Measurement Canada Regulation S-S-06 requirements to ensure that the meters are performing as expected and are providing accurate measurements. Meters are tested in the year prior to their seal expiry.[8] This results in a different number of meters tested each year; the average is over 10,000 per year.[9] Information obtained through the testing process informs the expected lifespan of the meter types. That is, meter testing establishes the replacement schedule for meters that fall within a certain production or refurbishment date range.

The testing process for residential diaphragm meters is different from other meter types and begins with a meter-sampling phase. This phase is required due to the significant number of meters in place. Every year a portion of FEI's more than 1,000,000 residential diaphragm meters is qualified to undergo Measurement Canada compliance sampling test requirements. The sampling process involves identifying meters to test, contacting the customer to arrange a time to remove and replace the meter, taking the meter out of service and installing a new meter in its place.[10] Once the meter is removed from service, it is tested as part of the sample to determine the meter exchange schedule for similar meters and the new meter that was installed during the sampling process remains in service at the customer's location.

In determining the meter exchange schedule, meters are grouped according to when they are due for sampling based on their lifespan. For diaphragm meters, when a sample of the group is tested, the continuation of the use of that group of meters in the field is based on the results of the test. When a meter or group of diaphragm meters has reached the expected lifespan, or when there are not enough diaphragm meters in the group to form a sample, Measurement Canada requires that the meters be exchanged. This results in a different number of meters exchanged each year; the average is approximately 60,000 per year. In 2021, for example, 45,000 meters have been identified as needing to be exchanged based on the sampling and testing of 9,000 meters in 2020.

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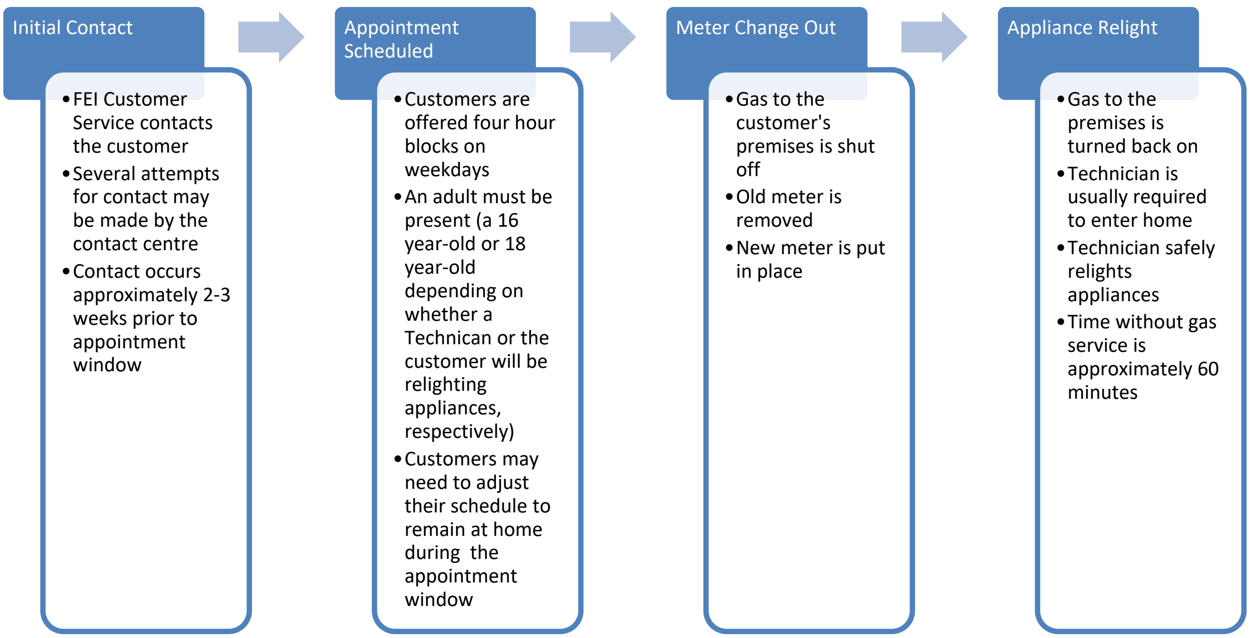
8 The measurement mechanism within the meter is sealed to protect against tampering. The date that the meter is tested and sealed represents the start date for the lifespan of that meter. Measurement Canada regulations govern the lifespan of meters which then sets the expiry date of the meter.

9 Average of 10,700 and calculated for the period 2014-2021, representing the period that the current Measurement Canada compliance sampling plan (S-S-06) has been in place.

10 In accordance with Measurement Canada compliance sampling plan S-S-06.

The meter testing and exchange process impacts approximately 60,000 FEI customers on average per year. Figure 3-1 below details the necessary customer interactions and appointment bookings that are required to support the current meter exchange process.

Figure 3-1: Overview of the Meter Exchange Process from the Perspective of a Customer



Once booked, there is some risk that FEI will need to cancel a given meter exchange appointment in the event of an emergency requiring personnel to attend elsewhere. In case of a cancelation, or the customer[11] not being present at the time the technician is on site, a new appointment window is booked.

Customers may be further impacted if, at the time their meter is exchanged, the technician is unable to relight their appliances and they do not relight their appliances themselves (e.g., if the customer is not home at the time of the exchange). In these situations, the gas is not turned back on; instead, a tag is left at the customer's home, and they must contact FEI to arrange for a relight at a later time.

In the context of this Application, and subject to Measurement Canada regulations, the complete replacement of the meter fleet for residential and most commercial customers to support Automation will mean that the meter testing and exchange process will not thereafter be required for residential and most commercial customers for several years.

3.1.1.3 FEI Requires an Average of Over 1,000,000 Meter Reads Per Month

Meter readers manually collect readings from the vast majority of FEI's over 1,000,000 meters each month. In addition to regular monthly meter readings, off-cycle meter reads are also

[11] Or an adult present at the customer's premises at the time of the scheduled appointment window.

needed for final reads for customers who are moving in or moving out or for special checks to assist with investigating matters such as bill disputes or switched meters.

Table 3-2 below shows the number of regular and off-cycle reads that were completed by the Company's meter reading services contractor (Olameter Inc. (Olameter)) in the 2016-2020 period. As shown below, FEI's meter reading needs have been gradually increasing to the point where FEI now requires over 12,000,000 reads per year, averaging over 1,000,000 manual meter reads per month.

Table 3-2: Manual Meter Reads Completed 2016-2020

Year	Regular Reads	Off-Cycle Reads	Total Manual Meter Reads
2016	12,073,896	85,874	12,159,770
2017	11,265,816	73,297	11,339,113
2018	12,407,474	66,303	12,473,777
2019	12,568,170	61,563	12,629,733
2020	12,820,149	66,922	12,887,071

3.1.1.4 The Current Meter Reading Process Is Highly Manual

The following steps illustrate the highly manual nature of the current meter reading process:

1. Each meter reader begins their workday at one of FEI's muster sites throughout the province. They pick up an electronic hand-held device that contains their meter reading route for the day; they also collect any keys required for access to premises along their route.
2. Each meter reader drives and/or walks to each customer premises within their assigned area and must enter each customer's property to access the meter.
3. If this step is required to access the property where the meter is located, the meter reader will use a key or input an entry code. Keys and codes are provided by customers in advance.
4. Once at the meter, the meter reader views the digits on the meter and manually enters the digits (the reading) into their electronic hand-held device.
5. The meter reader exits the property, securing any gates or doors as required.
6. The meter reader repeats steps two through five for all meters noted on their route.
7. At the end of their shift, the meter reader returns to their assigned muster site and places their hand-held device into a docking station for recharging, downloading of the day's collected data, and uploading of the next day's route information.
8. Data is transferred into the billing system where various system checks and calculations occur before bills are generated.

From a customer's perspective, the meter reading process requires an unfamiliar third party (the meter reader) to access their property on a monthly basis. As noted above, some customers may have to provide spare keys or entry codes to FEI for access to the meter on their property.[12] Managing and maintaining up-to-date keys and access codes are ongoing challenges for FEI's meter reading contractor.

3.1.1.5 Manual Meter Reading Spans the Province and Results in Greenhouse Gas (GHG) Emissions

Currently, there are approximately 150 meter readers reading FEI meters throughout the province on a daily basis. These meter readers are typically based out of more than 30 of FEI's muster sites, which are situated as far north as Fort Nelson, and as far south as Langford. The number of meter readers based out of each muster site is dependent on the number of meters in the area, but can reach up to 15 in various parts of the Lower Mainland. Other meter readers work alone in an area, or with one or two others. In urban areas, meters are more plentiful and are generally located in relative proximity to each other. In more rural areas, there are fewer meters and they are located farther apart.

On average, a meter reader drives 35,000 km per year to perform their work in FEI's service territory. Taking into account the need for 150 meter readers to cover FEI's service territory, this is the equivalent of 1,100 metric tonnes of carbon dioxide equivalent (tCO_2e), or the same as heating approximately 250 homes for a year.

3.1.1.6 FEI Has Outsourced its Meter Reading Service

FEI has outsourced its meter reading for the majority of FEI customers since 1988 and for all customers since 2006. FEI has used its current third-party service contractor, Olameter, since 2013.[13] The current contract term expires December 31, 2022; however, the contract includes the ability to extend services for four additional terms of one year each through to December 31, 2026.

Olameter invoices FEI monthly and FEI pays the same rate per read for all regular meter readings in the province, and a higher per-read rate for any off-cycle reads. Off-cycle reads are reads that require a special visit to a premises outside of the regular meter reading schedule, such as final reads for customers who are moving in or out and reads to assist in investigating billing-related matters.

FEI includes performance standards in its meter reading contracts to support a positive experience for customers. Current standards are defined in Table 3-3 below. The contractor

[12] The terms of the agreement between FEI and Olameter include a number of sections designed to ensure that access to customer premises is protected through keys management. These include: requiring Olameter to maintain keys in a secure, locked manner at a FEI facility using FEI provided key presses when not being used for meter reading; maintaining documented processes for check in/check out of keys on a daily basis; and maintaining documented processes for retrieving lost or stolen keys.

[13] FEI repatriated all aspects of gas customer service delivery in 2012. The third-party provider of metering services remained the same through 2012; FEI contracted with Olameter, a new third-party contractor in 2013.

may be penalized for not meeting required standards and in some instances, may receive an incentive for performing above certain levels.[14] For example, for contract years 2017 and 2018, financial penalties for failing to meet meter reading window distribution and completion targets were paid by Olameter.[15] Olameter paid no penalties for the 2019 contract year.

Table 3-3: Manual Meter Reading Performance Standards

Performance Standard	Definition	Performance Level
Meter Reading Accuracy	The number of correct monthly meter reads divided by the total number of regular reads on a monthly basis.	98%
Meter Reading Completion	The number of actual monthly meter reads obtained within the meter reading window as a percentage of the monthly meter reads requested.	95%
Monthly Reading Window Distribution	The number of monthly meter reads obtained in each workday within the meter reading window. The performance level is to be obtained on the first two workdays in the meter reading window.	80%[16]
Accuracy – Off-Cycle Reads	The number of correct off-cycle reads divided by the total number of off-cycle reads, captured on a monthly basis.	99%
Completion – Off-Cycle Reads	The number of actual off-cycle reads assigned to and completed on or before the required date as a percentage of off-cycle reads requested on a monthly basis.	90%
Resolution – Customer Escalations	All issues raised by customers and brought to the attention of the Contractor to be responded to within two business days and resolved within three business days or in a timeframe agreed to with the customer.	98%

3.1.1.7 Meter Reading Provides Data for Billing Purposes and Customer Information

Meter reading is the first step in FEI's revenue collection process. The metering data that is collected is then converted to gas usage in order to bill the customer for the amount of energy used.

Usage data also offers customers some insight into their energy habits, as they can see their usage relative to the previous month and the previous year. Currently, this is the extent of the

14 Incentives for performance were first introduced in 2020 and incentives have not yet been paid out to Olameter.

15 Annual penalty amounts are reflected as a credit on one of the monthly invoices from Olameter to FEI.

16 The monthly reading window distribution metric has been updated twice. In 2016 the standard was expanded to a three-day window and in 2020 to 80 percent. Prior to 2020, the distribution percentage was 95 percent.

insight this monthly data can offer. Meter reads are captured once per billing cycle, and there is a lag (the duration of which depends on how a customer receives their bill) between when the meter is read and when these customers see the usage on their bill. As a result, the customer has no understanding of gas usage on a daily, weekly, or real time basis and therefore lacks information that would allow for meaningful choices to reduce energy consumption.

With that context for the meters and metering process, the next section describes how Automation addresses the limitations of manual meter reading in more detail.

3.1.2 Automation of the Meter Reading Process Reduces Estimates and Improves Bill Accuracy

The current meter reading process results in estimated bills[17] and inaccuracies that adversely affect quality of service. As described in Section 3.1.1 above, the manual meter reading process requires meter readers to view the digits on the meter and manually enter those digits into a device. This gives rise to two primary causes of inaccurate bills to customers:

1. **Human Error:** Manually transcribing four to five digits for each meter is prone to human error. Although the meter reading devices do provide a reasonability check on the input data to protect against some errors, inaccurate inputs are still possible. When meter reads are input incorrectly, the customer's bill will be inaccurate and they will be charged an incorrect amount for the service they have received. The customer's bill will be affected until an accurate read is obtained in the future. This negatively affects the customer experience.
2. **Need for Estimates:** Where a meter cannot be manually read due to access issues, bad weather, meter reader availability, or other factors, FEI must use estimates of usage instead of an actual meter read. Estimated bills are a forecast based on historical usage and as such, there will be variances from actual use. These variances create challenges for customers as they result in overpayments or underpayments, which are returned to or collected from customers in future bills once actual meter reads have been obtained.

The number of estimates over the last five years that FEI has used for billing purposes, and the reasons for using these estimates, are shown in Table 3-4 and Table 3-5, respectively. The first table provides the number of bills that were estimated in each year and the second table provides the number of estimates per reason as captured by Olameter. The first table captures all manual estimates, the vast majority of which have been identified by reason based on information provided by Olameter in the second table.

[17] The process results in estimated meter reads that are used as the basis for a bill. For ease of reference, this is referred to as an estimated bill.

Table 3-4: Total Estimated FEI Meter Reads 2016-2020

Year	# of Estimates	# of Meter Read Requests	Estimates as % of Total
2016	380,398	12,159,770	3.13%
2017	463,564	12,313,865	3.76%
2018	579,997	12,502,206	4.64%
2019	613,849	12,696,599	4.83%
2020	1,398,982	12,894,341	10.85%

Table 3-5: Olameter Estimated Meter Reads by Reason 2016-2020

Summary by Reason	2016	2017	2018	2019	2020	Total
Dog	14,187	16,775	18,021	34,370	29,732	**127,937**
	4.11%	3.63%	3.15%	5.67%	2.14%	**3.50%**
Customer Prevented Access	51,781	61,003	58,623	56,003	58,804	**334,757**
	15.01%	13.20%	10.23%	9.24%	4.23%	**9.16%**
Supervisory Estimates (Lack of Available Readers)	172,669	252,269	342,275	367,190	692,140	**1,952,945**
	50.06%	54.59%	59.75%	60.57%	49.82%	**53.46%**
Seasonal Conditions/Obscured by Vegetation	39,553	65,789	78,090	68,193	101,429	**383,893**
	11.47%	14.24%	13.63%	11.25%	7.30%	**10.51%**
COVID-19 Exposure Risk					418,793	**418,793**
					30.15%	**11.46%**
Other	66,732	66,244	75,839	80,449	88,328	**434,560**
	19.35%	14.34%	13.24%	13.27%	6.36%	**11.90%**
Total Estimated Meter Reads	**344,922**	**462,080**	**572,848**	**606,205**	**1,389,226**	**3,652,885**

The overall percentage of FEI estimated reads has been trending upward since 2016 and peaked in 2020, representing the number of customers receiving a bill that does not reflect their actual usage for that particular period.

Inaccurate bills, whether due to human error or estimates, often result in customer confusion on their actual energy use, resulting in payment issues, dissatisfaction, and inquiries in the form of calls, emails or chat requests into the contact centre. Although FEI does not separately track meter reading-related contacts by communications channel from customers, it estimates that of monthly meter reading-related inquiries there are approximately 2,800 interactions via telephone, email and chat requests.[18]

[18] Average based on code identifiers from Customer Service Representatives for the years 2018, 2019 and 2020.

Automated billing will reduce billing inaccuracies. This is illustrated in Table 3-6 below which shows the relative percentage of estimated reads for FEI's affiliated electric utility, FBC, which implemented Automation in 2016. When FBC figures are compared to the FEI 2020 figures above, it is also evident that Automation has the ability to minimize impacts of external factors on estimated bills. For example, because the majority of FBC customers no longer have their meter read manually, they have not seen the same number of estimated bills due to the pandemic in 2020 that FEI customers have experienced.

Table 3-6: Total FBC Estimated Meter Reads 2014-2020[19]

Year	# of Estimates	# of Meter Read Requests	Estimates as a % of Total
2014	18,597	836,509	2.2%
2015	35,446	892,135	4.0%
2016	12,035	966,834	1.2%
2017	8,873	998,179	0.9%
2018	9,929	1,063,904	0.9%
2019	8,710	1,071,860	0.8%
2020	13,674	1,150,397	1.2%

With Automation, FEI expects that its estimates would be in a similar range as FBC as a percentage of meter read requests, and fall within the range of one to two percent per year. As such, FEI estimates this would improve the accuracy of approximately 260,000 to 390,000 bills each year, all else being equal, resulting in an improved experience for a large number of customers each year.[20]

Further, depending on the form of Automation, FEI customers may also have enhanced bill accuracy through the ability to get real time reads for move-in and move-outs, daily readings that can be used for more accurate bills when rates, levies or other fees are changed, and potentially shorter timelines for meter-related investigations.

3.1.3 Automation Improves Convenience for Customers

Automation removes the need for meter readers to access customer property on a regular monthly basis and reduces or eliminates any of the dissatisfaction and inconvenience to customers associated with access to their property for meter-reading purposes.

As described above, manual meter reading requires utility employees or contractors to access customer properties on a monthly basis. In some cases, this is not convenient for customers, such as when the property is protected by a locked gate or dog. As of March 2021,

[19] 2016 represents the first full year of automated reads for FBC.

[20] Calculated using the 2016-2019 average percentage of estimates of 4 percent per year (per Table 3-6) and using 2020 number of meter read requests as follows: at 2% = (4% x 12,894,000) – (2% x 12,894,000) = 515,760 – 257,880 = 257,880 and at 1% = (4%x 12,894,000) – (1% x 12,894,000) = 515,760 – 128,940 = 386,820.

approximately 8,000 customers have either a locked gate or a dog identified to be on premises. In these cases, customers are required to provide keys or gate codes and asked to keep their dogs inside for the few days surrounding the planned meter reading date. This is a source of dissatisfaction and inconvenience for customers as well as a source of risk for the meter reader when the required steps are not taken.

As Table 3-5 above indicates, over the last five years, 12.7 percent of estimated meter reads were for reasons relating to dogs, gates and keys, equating to approximately 90,000 estimated reads on an annual basis.[21] Seasonal conditions and landscaping accounted for another 10.5 percent of all meter reads estimated.

The COVID-19 pandemic served to highlight the existing issues associated with manual meter reading, as access to customer property became even more significantly impeded during this time. Beginning in March 2020, FEI's meter reading services contractor estimated any meters that required touch access (e.g., in a meter room with a door, behind a gate, etc.). As shown in Table 3-5 above, an additional 11.5 percent of meter reads were estimated in 2020 for reasons relating to COVID-19. While the rate of estimates attributed to COVID-19 dropped in the latter half of 2020, estimates for this reason continued through March 2021, when Olameter committed to returning to its pre-pandemic meter reading practices. The exact circumstances of the COVID-19 pandemic may not repeat themselves, but they illustrate the limitations of manual meter reading. Other types of natural disasters, such as forest fires and flooding, occur in British Columbia and create access issues, which obstruct manual meter reading and result in increased estimated bills.

Finally, customer complaints associated with manual meter reading activities average over 500 complaints per year as shown in the table below (for the five-year period 2016 through 2020). Each complaint is reviewed and investigated by Olameter with a response back to the customer in accordance with the performance standards set out in the contract. While this table may not be indicative of the overall customer perception or satisfaction with manual meter reading (because it reflects a small proportion of the total number of meter reads completed each year), it does highlight that customers formally raise a consistent level of concern each year with the manual reading process.

Table 3-7: Number of FEI Customer Complaints Received for Manual Meter Reading (2016-2020)

Complaint Category	2016	2017	2018	2019	2020
Meter Readers[22]	441	512	518	576	545
Vehicle[23]	13	16	22	23	17
Total	**454**	**528**	**540**	**599**	**562**

21 If 2020 is excluded due to the impacts of COVID-19, the four-year average is approximately 80,000 due to dogs on premises, gates and keys.

22 These are concerns raised specific to the presence of the meter reader and their actions while at the customer's premises.

23 These are concerns raised by customers specific to the location or presence of the meter reader's vehicle at their premises.

To provide a comparison, the number of complaints to FBC (with AMI in place) related to meter reading activities is provided below and demonstrates the reduction in complaints associated with the transition to an automated approach. For FBC, 2016 was the first full year that meter reading was automated and, while small in overall number, FBC saw a reduction of approximately 75 percent in complaints within the first year. Minimal to zero complaints have been received by FBC in recent years in relation to meter reading activities.

Table 3-8: Number of FBC Customer Complaints Received for Manual Meter Reading (2013-2020)

Complaint Category	Manual Reading		Automation					
	2013	2014	2015	2016	2017	2018	2019	2020
Meter Reading	10	24	22	5	1	3	0	0

As described in the sections above, there are multiple limitations and challenges associated with manual meter reading. These include a higher level of estimated bills that result in bill inaccuracies and customer experience challenges, and regular access to customer premises that can be inconvenient for customers and result in complaints and dissatisfaction for some customers.

While FEI has been managing to the best of its ability through these limitations, Automation would alleviate a significant portion of these concerns through greater bill accuracy and less inconvenience and as a result, provide enhancements to the customer experience as demonstrated by FBC and other utilities that have undergone the transition.[24] In that regard, the limitations of manual meter reading noted above are not unique to FEI and are a component of the overall transition of the utility industry away from manual meter reading towards Automation as further described in the following section.

3.2 AUTOMATION IS BECOMING THE INDUSTRY STANDARD, THEREBY CHANGING BOTH MARKET CONDITIONS AND CUSTOMER EXPECTATIONS

Utilities serving gas and electric customers across North America, including within Canada and British Columbia itself, have transitioned away from manual meter reading and implemented different forms of meter Automation. Over the last 20 years, the advanced metering technology available to utilities has continued to advance while the cost of the technology has declined.[25] The technology is available for natural gas, electricity, and water, as well as multi-commodity utilities. As a result, advanced metering technology is now commonplace across North America and is no longer considered new or cutting edge. Driven by the reduction of cost, coupled with advances and maturity in the technology that allow greater customer and operational benefits,

[24] U.S. Department of Energy Advanced Metering Infrastructure and Customer Systems Results from the Smart Grid Investment Grant Program, September 2016, pp. 21-23 https://www.energy.gov/sites/prod/files/2016/12/f34/AMI%20Summary%20Report_09-26-16.pdf

[25] Util-Assist Report, Appendix A, p. 13.

as well as supporting conservation and customer empowerment efforts, this automated metering trend is expected to continue.

This move away from manual processes and toward technological innovations is not unique to the utilities sector. Customers today are increasingly engaged and seek to be informed; they are looking for information to consider in their choices around energy selection and usage. In British Columbia, customers in FEI's service territory have access to the type of information that newer metering technology provides through their electricity providers, including BC Hydro and FBC, as further described in Section 3.2.3.

Maintaining a manual meter reading process will result in FEI lagging behind its peers. This has implications in both customer expectations and market availability of meter reading contractors. There is value in remaining aligned with common industry standards and technologies because it allows FEI to gain insight and knowledge on best practices that support the experience of customers and the effective and efficient operation of the system as well as meet the evolving expectations of customers.

The following sections outline the current state and details of the trend toward Automation in North America and Canada, generally and more specifically in British Columbia.

3.2.1 The Current State of Meter Automation for Utilities Across North America

FEI commissioned Util-Assist Inc. (Util-Assist)[26] to complete a report detailing the gas utility Automation projects across Canada and the United States, including identifying the form of Automation (i.e., AMI[27] or AMR[28]) (the Util-Assist Report). The Util-Assist Report, included as Appendix A, provides a broad overview of the evolving trends related to the transition to Automation by gas utilities within North America. As well, it notes that Automation, particularly AMI, promotes and meets the demand for tools that support conservation, customer service, and customer empowerment. Further, the Util-Assist Report highlights that there are common established drivers for Automation based on successful approvals and implementations to date, as well as emerging drivers that are now becoming more common in various applications and approvals. These drivers for Automation are summarized in the table below.

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[26] Util-Assist is a leading Canadian consultant for North American utilities to develop cost-effective, achievable strategies on utility systems integration and implementation, conservation initiatives, and other smart grid applications.

[27] Refers to Advanced Metering Infrastructure. Advanced Metering is defined as "a metering system that records customer consumption [and possibly other parameters] hourly or more frequently and that provides for daily or more frequent transmittal of measurements over a communication network to a central collection point. The key concept reflected in this definition is that Advanced Metering involves more than a meter that can measure consumption in frequent intervals. Advanced Metering refers to the full measurement and collection system, and includes customer meters, communication networks, and data management systems. This full measurement and collection system is commonly referred to as Advanced Metering Infrastructure (AMI)." The Util-Assist Report, p.5.

[28] Refers to Automated Meter Reading, or Automated Metering. "This is a system where aggregated kWh usage, and in some cases demand, are retrieved via an automatic means such as a drive-by vehicle or walk-by handheld system". The Util-Assist Report, p.6.

Table 3-9: Summary of Established and Emerging Meter Reading Automation Drivers in North America[29]

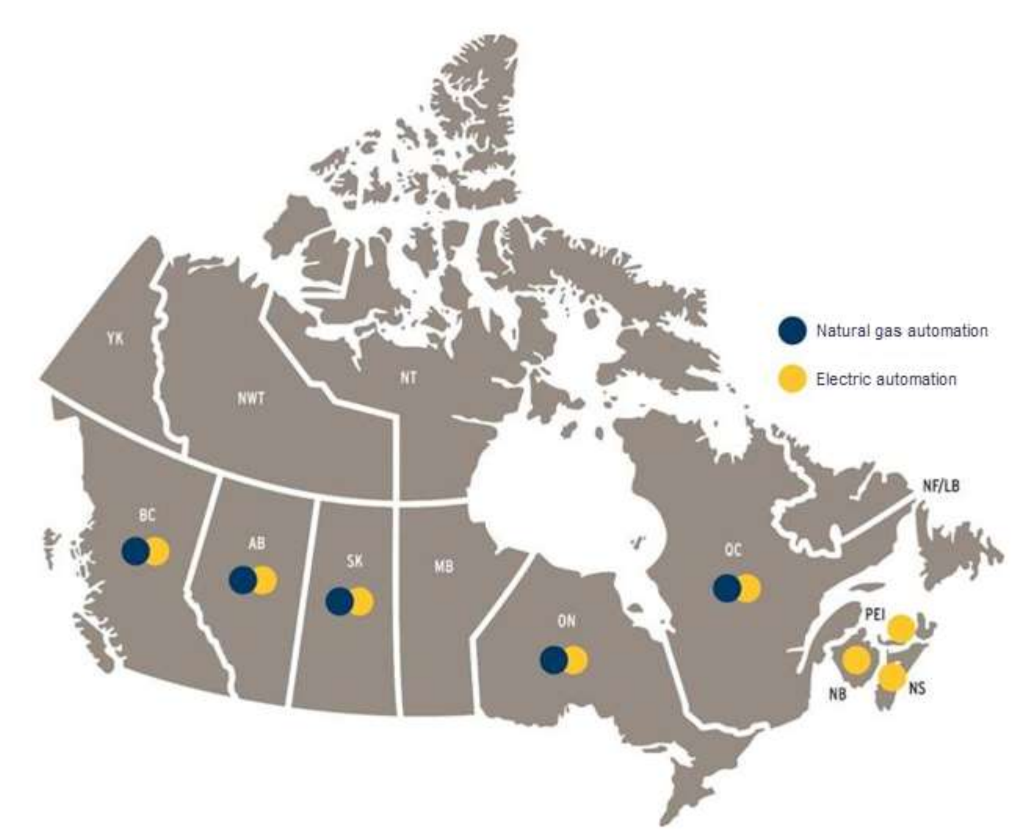
	Established	Emerging
Summary of Drivers for Automation Projects	• Operational efficiencies such as remote reading and shut-off needs, timely and efficient maintenance, revenue protection, and reduced gas lost • Enhanced usage data for bill alerts, pricing, and supply monitoring • Increased customer bill accuracy • Improved customer experience	• Conservation and demand side management enabler • Data analytics opportunities (proactive issue identification) • Leak detection and pipeline monitoring • Emission reduction target enabler and associated societal benefits

3.2.2 The Current State of Meter Reading Automation for Utilities Across Canada

The migration of utilities to Automation has been an important trend that continues across Canada. Figure 3-2 below illustrates where Automation has been approved and/or deployed either partially or entirely across Canada.

[29] The Util-Assist Report, pp. 17-24.

Figure 3-2: Meter Automation across Canada



Regarding electric meter automation, according to the Natural Resources Canada report Smart Grid In Canada 2018 (published in 2019) (the Natural Resources Canada Report) and attached as Appendix B, 82 percent of electric meters in Canada have been classified as AMI as of December 12, 2018. The Natural Resources Canada Report indicates that AMI technology has been completely or partially approved to be deployed by electric utilities in all the provinces of Canada, with the exception of Manitoba, Newfoundland and the three territories.

Regarding gas meter automation, there is a clear trend towards the adoption of automated technology in the gas sector. FEI commissioned the consumer research company, Insights Matter, to conduct an independent third-party survey of other Canadian natural gas utility companies to determine the level of progress towards automated metering for each utility (the CGA Insights Matter Survey). The results of the CGA Insights Matter Survey, provided in Appendix C, indicate that approximately 2,000,000 meters out of an estimated 7,000,000 total gas meters in Canada have already been migrated to some form of Automation. The remaining approximately 5,000,000 meters that are not automated are attributable to FEI and two other utilities – Enbridge and Manitoba Hydro – both of which are cited in the study to be currently investigating the installation of some form of Automation in the near future.

3.2.3 The Current State of Meter Automation for Utilities Within British Columbia

Over the past ten years, the two major electric utilities within British Columbia have both migrated entirely to AMI technology.

In 2011, BC Hydro began implementing an AMI system known as its Smart Metering Initiative across its service territory. BC Hydro was mandated by government to implement AMI technology.[30] The benefits that BC Hydro cited for installing advanced meters included the "modernization of B.C.'s electricity system, improved safety and reliability, reduced electricity theft, and the ability to provide customers with new tools to manage their energy use and ultimately save money."[31] These benefits also largely apply in the case of natural gas and are described further in Section 3.4 below.

BC Hydro was required, pursuant to the *Clean Energy Act* and the Smart Meters and Smart Grid Regulation, to proceed with Automation. By the completion of the Smart Metering Initiative in 2015, BC Hydro had installed almost 2,000,000 smart meters at customer premises.

In FBC's case, an application to the BCUC for a CPCN was required in order to proceed. FBC filed an Application for a CPCN for the Advanced Metering Infrastructure Project (FBC AMI CPCN) on July 26, 2012. On July 23, 2013, the BCUC issued its Decision and Order C-7-13 approving the FBC AMI CPCN subject to the condition that FBC would apply for an opt-out provision. Following the BCUC approval of FBC's Radio-off AMI Meter Option on December 19, 2013, FBC began implementing its AMI system across its service territory and completed deployment in 2016. In approving FBC's application, the BCUC accepted that "the need for the Project is not singular". The Decision further stated that "the Commission Panel has concluded […] that it can consider future needs. These future needs include ongoing and future system modernization to improve efficiency, reducing losses due to theft of electrical energy, enhance customer service, and reduce costs."[32] These factors, along with the benefits identified by BC Hydro above, are consistent with the needs that FEI has taken into account in developing the Application.

Five municipally owned electric utilities in British Columbia are not regulated by the BCUC. Of these, the City of Penticton has been using AMR technology to read its electric meters since 2003. As of the date of this Application, the remaining municipal electric utilities, including the communities of Grand Forks, Nelson, New Westminster and Summerland, have not yet moved away from manual meter reading. As of the filing of this Application, while the City of New Westminster is contemplating an AMI system, they have postponed their request for proposal process.

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[30] See *Clean Energy Act*, S.B.C. 2010, c. 22, s. 17; Smart Meters and Smart Grid Regulation, B.C. Reg. 368/2010.

[31] BC Hydro Smart Meter Press Release from Jan 18, 2011. https://www.bchydro.com/news/press_centre/news_releases/2011/bchydrcomsmart-meters.html.

[32] Order C-7-13, page 41.

The two major distributors of natural gas in British Columbia are FEI and Pacific Northern Gas (N.E.) Ltd. (PNG(NE)).[33] PNG(NE) recently received BCUC approval to transition to AMR. In its application, PNG(NE) set out several non-financial benefits of pursuing Automation, including timely and accurate meter reading, reduced workforce injuries, increased customer satisfaction, environmental benefits from reduced vehicle emissions, and improved revenue protection.[34] Once PNG(NE) has completed the deployment of automation technology, FEI will be the only remaining large regulated utility within British Columbia where meter reading is not automated.

3.3 AUTOMATION ALLEVIATES COST AND SERVICE RISKS AND PROVIDES A COST-EFFECTIVE, LONG-TERM SOLUTION

The transition to Automation addresses cost and service risks presented by manual meter reading, including meter reader retention issues and safety risks, supply and cost of manually read meters as well as rising cost and uncertainty of third party manual meter reading providers, each of which is described further below.

3.3.1 Manual Meter Reading Is a Physically Demanding and Highly Repetitive Job with Inherent Risks

The nature of meter reading makes it difficult to retain meter readers, which creates a risk to customer service. A transition to Automation would remove that risk as well as reduce the other issues described below.

As described in Section 3.1.1.4, FEI's current meter reading process is highly manual, requiring a meter reader to visit each meter installation, read the meter, and then manually enter digits into a hand-held device. The work is highly repetitive, and meter readers are generally paid on a piecework basis. They face multiple hazards in their work, including:

- Aches, strains and other physical injuries;
- Inclement weather;
- Dangerous driving and walking conditions; and
- Threats from animals (domestic and others).

Meter readers must drive and/or walk to each meter that they read, for up to eight hours per day. According to data provided by Olameter, meter readers drive on average 35,000 km annually to complete their work throughout FEI's service territory. The work is physically demanding; job postings for meter readers require incumbents to be physically fit with the ability to walk long distances (15-20 km) on a daily basis in order to fulfill the daily duties of the job. In addition, meter readers are required to be outside for the majority of their workday, encountering

[33] Pacific Northern Gas Ltd. serves a smaller, dispersed number of customers in the west.
[34] PNG(NE) Application for a CPCN to Implement AMR Infrastructure, pp. 11-12

all types of weather and a variety of terrain. They are sometimes threatened or bitten by animals, including customers' dogs.

Although mitigation measures and protocols are in place, these hazards lead to injuries, and impact the meter reader's ability to read the meters on their route. An inability to read meters in turn leads to estimated reads which affect the customer's bill and the customer's experience with FEI.

For reference, Table 3-10 below shows the number of safety-related incidents reported by Olameter in 2020. The number of incidents and days lost for 2020 suggest that for every incident, an average of seven workdays was lost, which is equivalent to one-third of a billing period. Further, and in most of these cases, despite the fact that the incident may ultimately have prevented a meter read and required generation of an estimate, FEI is invoiced for any read of this nature (where the meter reader attempted the read and traveled to the meter location), and that cost factors into customer rates. FEI does not have the data to provide an exact monetary amount based on safety incidents; however, in total, FEI is invoiced an average of $334,000[35] per year for meter reads that are estimated where an attempt to read has been made by Olameter.

Table 3-10: 2020 Safety Statistics for Manual Meter Reading

2020 Safety Incidents	Number of Incidents	Total Number of Days Missed
Animal/Insect Bite/Attack	7	0
Contusion	1	0
Extreme Weather	2	5
Eye Injury	1	1
Puncture/Laceration	2	0
Slip, Trip, Fall	17	288
Sprain, Strain	13	13
Grand Total	**43**	**307**

Due to the nature of the work, meter readers are difficult to retain. Regular recruitment is required in order to maintain sufficient numbers of trained staff. This negatively impacts FEI customers in a number of ways, including:

- Lack of available applicants who are able to do the work results in an increased number of meter readings being estimated (as shown in Table 3-5 above, over half of the amount of total estimated bills are due to meter reader resource challenges);
- New meter readers (or meter readers who are new to a particular route) work less efficiently; they are unfamiliar with the routes and spend more time locating the meter on the premises. This also leads to a greater number of meter readings being estimated until the meter reader is familiar with the route; and

[35] Average annual cost of estimates 2016-2020.

- Customers may see someone they are unfamiliar with on their property in search of their meter, which may cause concern and result in the customer calling FEI for clarification.

The following section details the challenges related to the supply of manually read meters.

3.3.2 Supply of Manually Read Meters Is Decreasing and Costs Will Increase

Due to the industry trend towards Automation, suppliers of both products and services that support manual meter reading have gradually been adapting to the changing market place. In response to the continued automation of meter reading by utilities, members of industries supporting manually read meters and manual meter reading are shifting their business models. This has been most evident in the meter manufacturing industry, as discussed in this section, and with respect to an outsourced manual meter reading provider, discussed in more detail in Section 3.3.3.

Diaphragm meters for residential and small commercial applications in the North American gas utility industry are supplied by only three major vendors and there are indications that manufacturers are preparing for a technological shift. In September 2020, FEI received notice from one of the three vendors, Itron Inc. (Itron), that it was ending the manufacture of all diaphragm meters, effective 2021.[36] Going forward, Itron will focus its efforts towards developing and marketing gas ultrasonic meters to provide AMI capability for residential and small commercial customer segments. Similarly, of the remaining two vendors serving the residential/small commercial gas distribution market within North America, one vendor (Sensus) has already developed an ultrasonic meter and the other vendor (Honeywell-Elster) is in the process of developing an ultrasonic meter.

It is expected that new market participants for diaphragm meters are unlikely to materialize and as such, the absence of Itron as a supplier in the diaphragm meter market place is expected to result in an increase in the unit price and an overall decrease in the supply available. This is because supply will not meet demand in the short term; in the long term, utilities will see reduced competition and higher costs among diaphragm meter manufacturers. The first year that Itron will not be a supplier of diaphragm meters is 2021; the expected increase in unit price will be seen later in 2021 and into the following years.

As corroborated by the CGA Insights Matter Survey[37] and the Util-Assist Report[38], FEI expects that the metering supply industry will continue to transition from the support and production of diaphragm meters and manual meter reading toward adopting and supporting automated metering. FEI expects this transition will increase costs and negatively impact supply over the longer term.

[36] As of 2020, FEI has approximately 78,000 installed Itron diaphragm meters in its service territory.
[37] Appendix C.
[38] Appendix A.

3.3.3 Long-Term Manual Meter Reading Costs Are Uncertain and Expected to Increase

As utilities continue to automate their meter reading processes, the decline in the number of meters requiring manual reading is reducing the economies of scale that customers and service providers enjoyed in the past, and decreasing service providers' ability to generate revenue to cover their fixed costs while offering competitive meter reading rates. The history of manual meter reading in British Columbia provides a clear example of this dynamic. Prior to 2012 and FEI's decision to repatriate its customer service activities, a single contractor manually read meters for both BC Hydro and FEI customers. FEI's decision to move its manual meter reading services from this single contractor was motivated in part by BC Hydro's plans to automate. A rise in manual meter reading costs for FEI customers as a result of BC Hydro's planned Automation was contemplated in FEI's (then Terasen Gas Inc.) Customer Care Enhancement (CCE) Project CPCN filed on June 2, 2009, at pp. 34-35:

> An additional challenge Terasen Gas anticipates in the future will be the restructuring of meter reading services to support a standalone natural gas option. BC Hydro is moving toward a fully functional smart metering solution, expected to be complete by the end of 2012, which at this point does not accommodate support for a parallel gas read through the same infrastructure.
>
> Terasen Gas intends to continue to outsource manual meter reading to continue to take advantage of the cost benefits associated with a joint gas / electric read for as long as that option is available. However, Terasen Gas would expect to bring forward a technology project in the near term once BC Hydro has confirmed its plans to move forward with their smart metering initiative. Meter reading has always been outsourced for the majority of Terasen Gas' service area as a residual benefit to customers following the 1988 sale by BC Hydro of the Lower Mainland gas division. As a result, Terasen Gas has never developed adequate in house technologies to perform this function. The legislative requirement for BC Hydro to move to smart metering will leave Terasen Gas customers at risk for a significant increase in manual meter reading costs in the future. Terasen Gas intends to begin looking at technology solutions to mitigate this risk.

Since 2013, Olameter has covered much of the same service territory as was covered previously by a single contractor reading meters for both FEI and BC Hydro, with, all else equal, the same fixed costs as in the past, but only generating revenue from one utility. This was also the case for the contractor continuing to read BC Hydro's meters, prior to the completion of BC Hydro's Smart Metering Initiative. Since 2015, there is one less meter reading contractor in the province, which restricts competition for these services, and is one factor that FEI believes has led to an increase in FEI's meter reading costs.

While FEI has chosen to continue contracting for meter reading services from Olameter in the short term, FEI believes the viability of contracted meter reading services in the future is uncertain, in terms of both cost and availability. There are few providers available today and fewer anticipated in the future. There is a material risk to customers and the Company that the current practice of outsourcing manual meter reading will not be sustainable in the long term. That is, either the existing provider(s) may move on to other lines of business, similar to the case of the manufacturers of the diaphragm meters, or the costs for this third-party support will continue to grow and approach the cost of providing the service in-house.

Other than Olameter, FEI is not aware of another manual meter reading service provider able to provide meter reading service on the scale required by the Company. As shown in the CGA Insights Matter Survey[39], Enbridge is the only other gas utility in Canada that uses contract meter reading services and does so on a smaller, regional scale with different service providers in different regions. All the other Canadian gas utilities that do manual meter reading use in-house services or services of a subsidiary company. As Enbridge has indicated its intention to develop a business case for Automation going forward, FEI anticipates that the trend towards Automation within the utility industry in Canada will make it unlikely that a viable manual meter reading service provider will materialize. This creates uncertainty in terms of the ability to provide the service to customers. What is certain is that costs will continue to increase without a competitive market and that a competitive market is increasingly unlikely.

In that regard, FEI considers repatriation of the meter reading function in-house as the only manual meter reading solution that could be viable in the long term. In practice, this approach would give FEI direct control of the function and more influence over costs and quality. In-house meter reading would be more costly than the current outsourced model but would bring with it certainty over levels of service and future expenses.

In addition to the meter device, meter reading, and operational cost and service risks noted above, continued reliance on manual meter reading results in limitations on FEI's ability to meet evolving customer expectations for customer service while also placing limitations on conservation and customer empowerment opportunities. This final and important driver of the need for meter Automation is discussed in the following section.

3.4 AUTOMATION PROVIDES CUSTOMER BENEFITS AND OPERATIONAL OPPORTUNITIES THAT SUPPORT THE SAFETY, RESILIENCY AND EFFICIENT OPERATION OF THE GAS DISTRIBUTION SYSTEM

Automation is an opportunity to provide transformational change to key components of the utility customer experience, creating a platform for future opportunities for customer experience enhancements and providing operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system.

[39] Appendix C.

3.4.1 Automation Provides an Opportunity to Better Meet Evolving Customer Expectations

In its 2020-2024 Multi-Year Rate Plan (MRP) Application, FEI reiterated the importance of continued efforts and priority placed on enhancing the customer experience, in both the short and long term.[40] Customers' expectations for service have changed over the last several years and are expected to keep changing based on improvements and access to technology and experiences with other service providers. Namely, FEI customers increasingly value ease of interaction, convenience, and responsiveness and they expect proactive communication from FEI. Further, changes in customer expectations and behaviour, as well as available technologies, require FEI to regularly evaluate the services provided to its customers and consider opportunities to deliver on customer expectations. Finally, with customers comparing their experiences with FEI to their last best customer experience, the limited information they have access to currently as a result of manual meter reading means that FEI is falling short in this aspect of service as compared to other customer service experiences.

As described above, Automation resolves the inconvenience of manual meter reading at the customer's property and improves the accuracy of customer bills, reducing any need for the customer to make efforts to resolve concerns with accuracy; however, it also provides the opportunity to meet current and evolving expectations around details of customers' energy use. Customer feedback has indicated the importance of detailed consumption information is high on the list of customer priorities for their bill from FEI and FBC (FortisBC).[41] Further, in a recent poll of FortisBC's MyVoice panel, approximately 75 percent of respondents rated having comprehensive online information about home energy use as very important.[42] Automation also provides support for achieving energy conservation targets and objectives, ultimately creating potential for customer empowerment. That is, access to detailed energy information better enables customers to make informed energy choices, empowering them to participate in programs and seek options and, as a result, providing the opportunity to participate more fully in their energy choices now and in the future. An example of increased customer empowerment is the capability of a customer to more quickly adapt their behaviour in direct response to their own daily and weekly consumption patterns and see results of changes in their behaviour on their bill much more quickly as a result. Without Automation, customers are unable to see daily gas consumption patterns that provide better insight into their household behaviours that contribute to their energy use.

The following chart provides the number of transactions in the FortisBC customer portal in 2020 specific to views of their energy use, as compared to other common types of inquiries in the customer portal. In total, FBC customers account for approximately 15 percent of the total use of the FortisBC customer portal in 2020; however, the chart below shows that, relative to gas

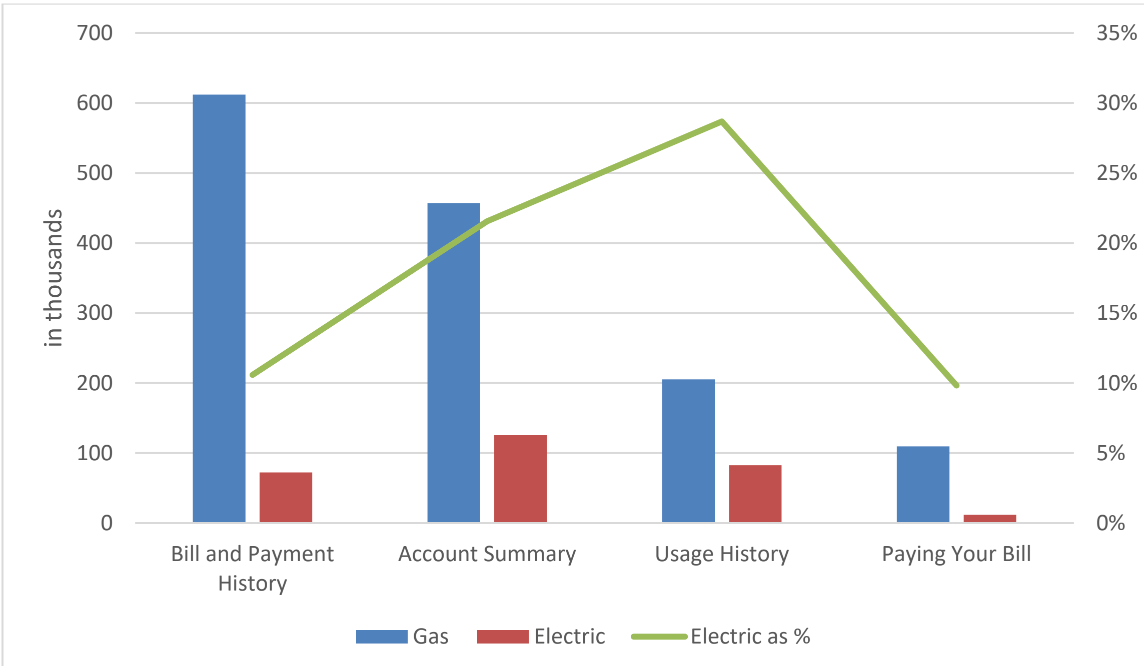
[40] FEI Multi-Year Rate Plan Proceeding, Exhibit B-1, filed March 11, 2019, Section 1.3.

[41] Research conducted by Akendi 2017-2019 on behalf of FortisBC to determine what customers are looking for from their utility bill.

[42] The MyVoice panel represents customers that are willing to participate in surveys and provide their feedback on various subjects from time to time. Results help inform and provide an indication of customer attitudes but are not considered statistically representative.

customers, electric customers account for approximately 30 percent of the page views related to consumption information, suggesting that customers are interested in their detailed energy usage if it is available to them.

Figure 3-3: Common Customer Portal Transactions and FBC Use Relative to Total



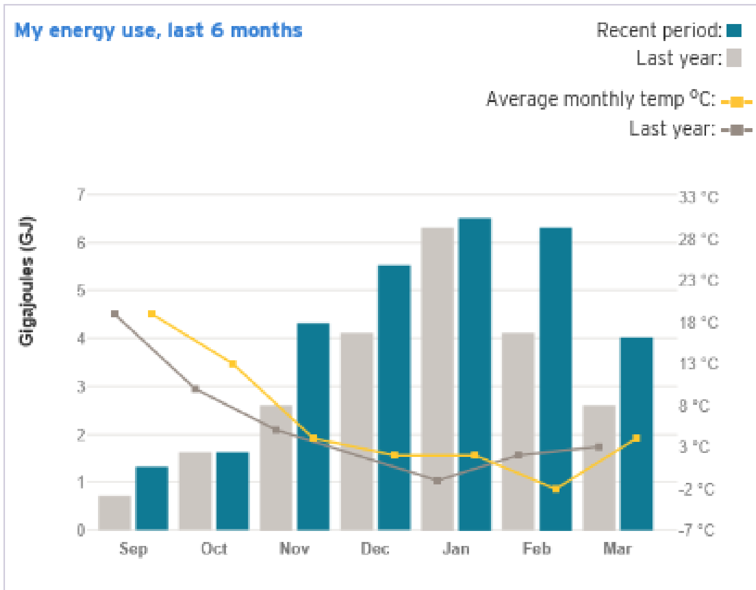
While there may be several factors that influence the differences in behaviour among the gas and electric groups of customers, aside from the type of energy, a key difference is the amount and level of consumption information that is available to these two customer groups. To illustrate and compare the difference in available information, Figure 3-4 below provides the granularity of information currently available to FEI customers through the customer portal while Figure 3-5 provides the granularity of information available to FBC customers through the customer portal (which is similar to the information available to customers of BC Hydro). The images show that FBC customers have access to detailed hourly consumption information while gas customers are limited to a single data point for each month. Due to the increased level of granularity, electric customers may be accessing the portal more frequently than gas customers because the information provides more useful insights into their energy consumption.

Figure 3-4: FEI Energy Use Information Available to Customers Today

Usage history

View and/or download historical monthly consumption data for a specific time frame.

Last 6 months ☑ Show last year as comparison



Bill from date	Bill to date	# of days	Billed GJ	Average temp °C
19/02/2021	19/03/2021	29	4.0	4
21/01/2021	18/02/2021	29	6.3	-2
18/12/2020	20/01/2021	34	6.5	2
19/11/2020	17/12/2020	29	5.5	2
20/10/2020	18/11/2020	30	4.3	4
18/09/2020	19/10/2020	32	1.6	13
19/08/2020	17/09/2020	30	1.3	19

Download consumption history table

○ Text file(.txt) ◉ Spreadsheet (.csv)

Download File

Print

Figure 3-5: FBC Energy Use Information Available to Customers Today

FortisBC Consumption hourly

View and/or download historical monthly consumption data for a specific time frame.

Hourly From Jun 01, 2020 To Jun 01, 2020

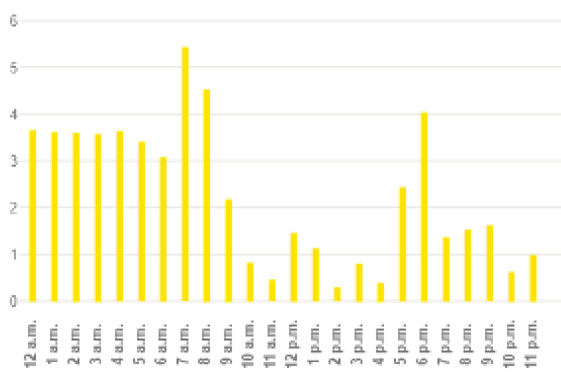
Show last year as comparison Text file(.txt) Spreadsheet (.csv)

Update Chart Download File

My energy use, hourly.

Please note that gaps in data may occur if meter connectivity was not consistent.

Last 12 Months May 2020 - Jul 2020 < Weekly May 15 - Jul 15 < Daily May 31 - Jun 06 < Hourly Jun 01



Data will be updated daily for your review. Learn more about advanced metering.

All times shown are in Pacific Time.

From date	Hour	Billed kWh
01/06/2020	11 p.m.	0.979
01/06/2020	10 p.m.	0.614
01/06/2020	9 p.m.	1.592
01/06/2020	8 p.m.	1.506
01/06/2020	7 p.m.	1.346
01/06/2020	6 p.m.	4.018
01/06/2020	5 p.m.	2.412
01/06/2020	4 p.m.	0.379
01/06/2020	3 p.m.	0.8
01/06/2020	2 p.m.	0.269
01/06/2020	1 p.m.	1.109
01/06/2020	12 p.m.	1.445

In addition to the transaction information above, FEI also collects information through post-interaction surveys that apply to the customer portal. In those surveys, customers have made the following comments regarding consumption within the last year, specifically as to how FEI could improve in relation to what they may receive from other providers, like BC Hydro:

- “It would be nice to know how my consumption would be on a daily basis, the way like, BC Hydro gives”
- “I wish I could see more information, more data like with BC Hydro, I know electricity may be a little different. You can go back and see daily usage as opposed to just usage per month”
- “If we could see the consumption, same as BC Hydros stuff, in the middle of the consumption period...to be able to manage that for that period”
- “I would like to see a few more features added, such as daily use of gas, I don't know how practical that is. But I'd love to have it”
- “Because they can't show daily use of the gas. With BC Hydro, I can find out how much usage I have every day, but with Fortis BC, I can't. I only, it only shows monthly billing after the meters read”
- “The one thing you can't see is, like all it shows is a previous amount and it shows you how much you used last month compared to a year ago, but it doesn't say, where you currently are in a cycle. So, hydro says, right now, we're forecasting you're end month bill to be, based on my usage. So, Fortis gas doesn't to that. So, it's hard to know, how much money it's going to cost at the end of the month.”
- “So, I have an account with both BC hydro and Fortis BC. BC Hydro provides more live consumption history on a day to day basis. Fortis doesn't. I feel as a consumer, I would like to track my day to day usage. So, that I could change my usage patterns accordingly.”
- “Hydro for example, you can look up and see what your usage is on a daily basis. Where as the Fortis website it gives you a monthly update. So some days I use a lot of gas, I would like to know which days those are and why. But I can't tell that.”

As noted above, Automation will provide the necessary data to support customer needs for more detailed energy use information today and the future; however, and depending on the form of Automation, future opportunities for enhancements to other components of customer experience will be possible. These opportunities are expected to include enhanced billing options, and targeted demand side management opportunities.

There are expectations from customers for better information regarding their energy use and Automation is a critical component to meeting this need. In addition, and as further described in Section 8.2, both FEI and the Province have set significant targets for energy conservation in the coming decade.[43] Without Automation, the detailed data to support customer information needs is not available and FEI will find it increasingly challenging to keep up with customer expectations that continue to evolve. Similarly, without Automation customers will find it increasingly challenging to make informed energy choices that support customers, FEI and the Province in meeting long-term energy conservation goals.

3.4.2 Automation Provides Customer Benefits and Operational Opportunities

Depending on the form of Automation, there are benefits for customers in the long term as well as immediate opportunities in the operation of the gas distribution system. In particular, Automation provides the opportunity to improve the resiliency[44] of FEI's gas system in the event of a gas supply emergency. Increasing the resiliency of FEI's gas system is a key need that Automation would support in three distinct ways:

- by allowing near real-time visibility of the load on the system;
- by providing FEI the ability to strategically disconnect gas remotely in an emergency situation; and
- by providing the ability to keep pressure in the system to minimize time for customer reconnections.

These benefits and opportunities are listed in Table 3-11 below, and, in addition to all of the benefits already described in Section 3, are further described and evaluated in Section 4 in the context of the alternatives considered and according to the drivers for the need to automate.

Table 3-11: Potential Additional Benefits and Operational Opportunities of Meter Automation

Customer Benefits	Operational Opportunities
Better consumption data for customer use	Reductions in GHG emissions
The ability to offer enhanced DSM opportunities	A meter technology that is going to be available the next twenty years
The ability to offer enhanced billing options	Increased system resiliency
	Improved system planning abilities
	Better availability of data for operational and project use
	Better theft detection abilities
	Improved emergency response to gas odours and leaks

[43] FEI has set an interim target, 30BY30, to reduce it customer emissions by an amount equivalent to 30 percent by 2030.

[44] "Resiliency" is defined as the ability to prevent, withstand, and recover from system failures or unforeseen events as described further in Section 4, subsection 4.3.2.4.1

Customer Benefits	Operational Opportunities
	Increased distribution system monitoring and alarms
	Improved integrity[45] management of the system
	Leak detection downstream of the meter

For a comprehensive description and summary of all benefits and opportunities of Automation, please refer to Section 4.

3.5 SUMMARY

As described in the sections above, there are four key drivers for the need to transition to Automation for FEI's customers:

- Automation is more accurate and convenient for customers than manual meter reading practices;
- Automation is becoming the industry standard, thereby changing both market conditions and customer expectations;
- Automation alleviates the cost and service risks of manual reading and provides a cost-effective, long-term alternative; and
- Automation provides additional customer benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system.

Together, these drivers provide a compelling need for FEI to move towards Automation now.

Ultimately, Automation provides a more accurate and convenient process for customers while providing a stable, cost-effective meter reading solution for the long term. Access to more timely information will also improve safety and system resiliency. Finally, Automation will empower customers to make informed energy decisions, enhance their energy conservation efforts and have more control over their energy costs.

In the next section of the Application, FEI will outline the automated metering alternatives that were considered, including the benefits expected to be realized with each alternative.

45 "Integrity" is defined as the ability of individual system elements to meet their original design specifications, and to fulfil their intended purpose or application as described further in Section 4, Subsection 4.3.2.4.8.

4. PROJECT ALTERNATIVES

To address the Project need for Automation as described in Section 3, FEI compared the two Automation technologies available in the gas metering industry. Those are:

- Partial Automation of meter reading using AMR technology to enable drive-by meter reading; and
- Full Automation of meter reading using AMI technology characterized by a fixed two-way communication network.

A comparison of these alternatives determined that while AMR could partially satisfy some of the drivers of the Project need, only by implementing AMI would customers and the Company realize the full value of Automation. Based on the financial analysis undertaken as described further in Section 4.4, the many additional benefits offered by AMI could be achieved with a delivery rate impact that is estimated to be less than half a percent higher than AMR. Table 4-1 summarizes the four drivers of the Project need and illustrates the results of the analysis comparing how AMR and AMI would support the different drivers. The table also includes the Baseline scenario, which is defined within this Application as the costs FEI expects to incur if the proposed Project is not approved.[46]

Table 4-1: Overview of Alternatives

Alternatives: Project Need Analysis

EVALUATION	SCORE
FULLY; Project need is fully met	✔
PARTIALLY; Project need is partially met	!
NOT; Project need is not met	✖

	AMI	AMR	BASELINE
Automation is more accurate and convenient for customers than FEI's current meter reading practices, which are highly manual, are vulnerable to errors and can be inconvenient for customers	✔	!	✖
Automation is becoming the industry standard, thereby changing both market conditions and customer expectations	✔	✖	✖
Automation alleviates the cost and service risks of manual reading and provides a long term cost effective alternative	✔	!	✖
Automation provides additional customer benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system	✔	✖	✖

In the remainder of Section 4, FEI presents an analysis to determine how effectively each alternative addresses the drivers for the Project need. Section 4.1 describes the process FEI used to define and evaluate the two alternatives, leading to the determination of a preferred alternative. Sections 4.2 and 4.3 provide separate evaluations of AMR and AMI technologies as

[46] The Baseline scenario is based on FEI's current status quo operations and includes future cost increases to manual meter reading for the reasons set out in Section 3.3.3 and further described in Section 6.2.2.3.

distinct alternatives to address the Project need. Within each section, FEI presents the evaluation of each alternative by:

- Presenting an overview of each technology;
- Addressing the suitability of each technology for meeting the drivers of FEI's Project need as identified in Section 3 and represented in Table 4-1; and
- Providing a financial summary of each alternative.

Finally, in Section 4.4 FEI concludes that, based on the alternatives analysis, the preferred alternative is AMI because it is the only alternative that would fully support all the drivers of the Project need to automate the meter reading process.

4.1 *ALTERNATIVES OVERVIEW*

FEI's alternatives analysis is informed by FEI's knowledge and experience of automated metering technology. Over the past 15 years, FEI has been following both the evolving meter technology market and the types of technology adopted by other North American gas and electric utilities. The Company is familiar with the two categories of technology within the gas residential meter automation market in North America. FEI is also familiar with the vendors that supply different technologies as the Company has been procuring both diaphragm and ultrasonic meters from these vendors for many years. In addition, FBC's experience in procuring and deploying an electric AMI system provided the Company with an understanding of the scope and depth of information necessary to define the best alternatives available for FEI.

FEI's analysis of the alternatives to manual meter reading included determining the capabilities that would benefit customers or, as applicable, the Company. This was done through a process of reviewing the challenges and opportunities facing both FEI's customers and different operating departments within the Company to evaluate how meter Automation would provide relevant benefits. FEI also reached out to other North American utilities that had already deployed different variations of the two available technologies to understand how their customers and organization were able to benefit by deploying Automation. FEI expanded upon this work by commissioning a benchmarking study of recent gas AMI projects completed by other utilities within North America to fully appreciate the business drivers, opportunities and challenges this technology presented (the Util-Assist Report). The Util-Assist Report is included as Appendix A and summarized in Section 3.2.1.

FEI assessed the value proposition offered by both AMR and AMI technologies by conducting a Request for Proposal (RFP) process. The RFP process for the meter automation technologies is described in Section 5.3.3. The RFP responses gave FEI the opportunity to evaluate the capital and ongoing operational costs in addition to validating the capabilities of each technology, giving FEI the opportunity to confirm the ability of each alternative to support the different drivers of the Project need identified in Section 3. Based upon this work, FEI was able to evaluate each technology leading to a determination of the preferred alternative.

4.2 ALTERNATIVE 1 – PARTIAL AUTOMATION – AUTOMATED METER READING (AMR) TECHNOLOGY

This section will assess the suitability of AMR technology as an alternative for meeting the Project need. The section first considers the limitations of partial Automation in addressing the project drivers. A financial summary follows, which describes both the capital and operating costs associated with implementing this alternative and the estimated delivery rate impacts. The section then concludes with the assessment that, despite providing an estimated small reduction to customer rates, the AMR alternative is not an effective solution in the FEI context as it fails to fully meet any of the four drivers of the Project need.

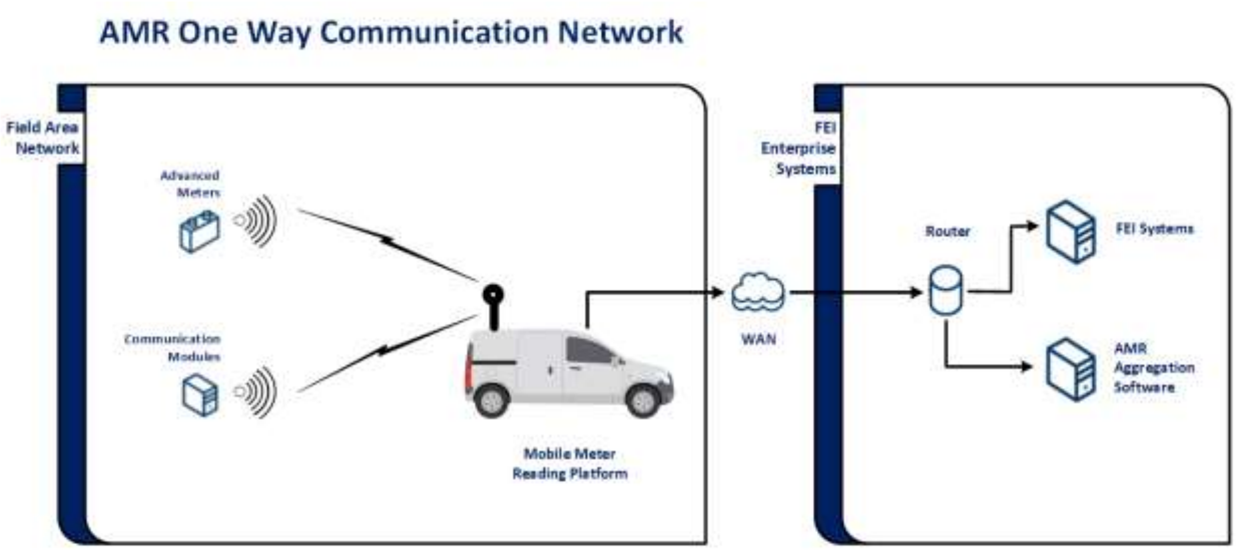
4.2.1 Overview of AMR Alternative

AMR is a system in which customer meter reads are retrieved using an automatic means most commonly by driving by with a vehicle, although it can also entail fly-by with an airplane or in some cases walk-by with a handheld device. AMR is a one-way communication technology, where communication modules retrofitted to the meter are used to transmit readings using radio signals to a vehicular-based mobile meter reading base station. A meter reader drives the vehicle carrying the mobile base station along a predetermined route through a section of the service territory and meter reads are transmitted remotely from the meter communication modules to the base station. The meter reader then returns to a utility facility in order to connect the mobile base station to the utility network where the meter reads are downloaded for use by the billing system.

For the AMR alternative, FEI investigated a drive-by solution in which a single meter read would be collected from each meter once per billing cycle on a monthly basis. Each work day, meter readers would drive through parts of the service territory along routes designed to read every meter each billing cycle. At the end of each day, the vehicular-based mobile meter reading base station would be connected to FEI's network and the customer readings would be transmitted to FEI's billing systems as described above. Finally, this approach to meter reading is assumed to be in place for over 20 years, which is the expected service life of AMR technology based largely upon the capacity of the battery within the communication module attached to each meter.

Figure 4-1 below depicts a typical AMR system, which reflects what was contemplated as the AMR alternative in this Application.

Figure 4-1: AMR System Diagram



The following section evaluates the suitability of the AMR alternative to meet all of the drivers of the Project need.

4.2.2 Suitability of AMR to Meet the Project Need

As described in Section 3, the Project need to automate the meter reading process has been characterized by four distinct drivers:

1. Automation is more accurate and convenient for customers than FEI's current meter reading practices, which are highly manual and are vulnerable to errors and can be inconvenient for customers;
2. Automation is becoming the industry standard, thereby changing both market conditions and customer expectations;
3. Automation alleviates the cost and service risks of manual reading and provides a cost-effective, long-term alternative; and
4. Automation provides additional customer benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system.

The sections below consider the suitability of the AMR alternative for meeting each of these four drivers.

4.2.2.1 *Automation is More Accurate and Convenient for Customers than FEI's Current Manual Meter Reading Practices, which Are Highly Manual, are Vulnerable to Errors and Can Be Inconvenient for Customers*

As discussed earlier, an AMR alternative would provide partial Automation of the manual meter reading function by allowing FEI to collect monthly meter reads via a vehicular-based mobile meter reading base station. AMR would address some of the challenges encountered by manually reading meters as described in Section 3. For instance, AMR would eliminate the need for meter readers to enter customer premises, making the process more convenient and less intrusive for customers. AMR would also reduce the challenges of manual meter reading, such as human error and access issues. AMR would improve billing accuracy, preventing the potential for bills to be generated using incorrect meter reads. In addition, the fact that meter readers would be driving and not walking between meters is expected to provide some enhancement to meter reader safety, which will improve the recruitment and retention of meter readers, leading to a more stable workforce and fewer bill estimates resulting from meter routes not being completed. Finally, AMR would enable an overall reduction in vehicle usage given that the number of meter readers driving throughout the service territory to collect meter reads would decrease. This reduction in vehicle usage is estimated to create a net reduction in GHG emissions of approximately 50 percent compared to current meter reading activities.

However, as AMR is not a fully automated solution, there would continue to be challenges related to bill accuracy and customer inconvenience. Examples of these challenges include:

- Vehicle access issues that impact meter reading would still exist, particularly in relation to inclement weather or natural disasters such as floods or wildfires;
- The requirement for meter readers to collect the reads through extensive operation of a vehicle would result in ongoing risks with respect to driving-related incidents, increasing the potential for incomplete meter reading routes and also still involving long-term challenges with recruitment and retention;
- The inability to complete "on-demand" reads would mean off-cycle manual reads would continue to be required for service disconnections, reconnections, vacant premises, service interruptions or other reasons that necessitate a meter read; and
- The resolution of inquiries raised by customers or FEI would continue to require time and expense as special visits would need to continue outside of the regular meter reading schedule.

Therefore, AMR would only partially meet the driver to improve accuracy and convenience for customers as estimates would continue to impede bill accuracy and delays to address billing inquires or service requests would continue to cause inconvenience for customers.

4.2.2.2 *Automation Is Becoming the Industry Standard, Thereby Changing Both Market Conditions and Customer Expectations*

AMR offers no improvement to the amount, timing or availability of consumption data for customers to use in informing their energy choices, as meter readings would still be obtained and recorded monthly for billing purposes. In addition, FEI would continue to be unable to offer enhanced Demand Side Management (DSM) programs to further support customers with opportunities to support energy conservation and save money. In the long-term, as customers continue to expect access to the detailed information to make fully informed energy use decisions, the AMR alternative would leave FEI to face a growing risk of failing to meet those expectations.

4.2.2.3 *Automation Alleviates the Cost and Service Risks of Manual Reading and Provides a Cost-Effective, Long-Term Alternative*

The implementation of AMR would decrease the cost and service risks associated with FEI's current manual meter reading model by reducing the number of people required to read the meters within FEI's service territory.

However, since meter readers would be required to complete this work, all the risks outlined in Section 3.3 relating to the availability of manual meter reading vendors and price risks in the future as utilities across Canada transition to Automation would still be applicable. The only difference to the current model would be that the risks would be adjusted to reflect the smaller scale associated with the reduction of meter readers required to complete the work. In general, the companies that have migrated to AMR use an in-house model for the drive-by meter reading function. Therefore, the opportunity for FEI to outsource this activity is expected to continue to present challenges with the deployment of AMR technology.

Additionally, the deployment of AMR technology would mean the risk associated with procuring diaphragm meters at a reasonable price would continue to exist as the number of meter manufacturers is decreasing from three to two, as discussed in Section 3.3.2. This risk would be compounded as gas meter manufacturers are expected to continue transitioning toward ultrasonic meters. As such, an investment in AMR may leave FEI facing an escalating risk of being locked into a commitment to a technology for over 20 years that is currently trending toward obsolescence in the long term.

Finally, while AMR technology is scalable by allowing for additional meter modules to be connected to the AMR system, meter manufacturers are investing most of their product development efforts into AMI since AMR has limited ability to accept technical enhancements. Therefore, as new innovations are developed within the gas metering industry, AMR would provide minimal opportunity to realize future benefits for either customers or the Company.

In summary, while AMR would reduce some of the cost and service risks associated with FEI's current manual meter reading model, the Company would still be faced with the challenge of sourcing cost-effective service for driving the meter reading routes. Similarly, FEI would be left with the challenge of sourcing diaphragm meters from a market that contains a decreasing number of diaphragm meter suppliers as suppliers shift toward ultrasonic meters. Finally, the deployment of AMR would prevent customers and the Company from benefiting from innovations that are developed in the future by meter manufacturers.

4.2.2.4 *Automation Provides Additional Customer Benefits as well as Operational Opportunities that Support the Safety, Resiliency and Efficient Operation of the Gas Distribution System*

In addition to the benefits realized by partially automating the meter reading function as described earlier, AMR would provide a small number of operating benefits not available today. AMR would reduce the potential for theft through the use of tamper alarms that are stored in the module. However, these alerts to FEI are not provided in real-time and would only become known to the Company upon collecting the read on its regular monthly reading cycle. AMR would improve safety for the meter readers as they would not be required to be in direct contact with potential hazards that exist along the route or within each customer's premises. However, meter readers will still be exposed to the range of driving-related hazards[47] present within British Columbia's urban and rural areas.

In general, AMR would contribute little in the way of advancing key operating benefits beyond meter reading activity. The key operating benefits that AMR would not be able to provide include:

- Advancing the resiliency of the system, including the ability to monitor load on the system, conduct targeted temporary shutdowns to reduce load, and enable timely restoration of service;
- Improvements to system planning which requires granular gas usage and system pressure data to model customer usage patterns which help to define emerging capacity constraints;
- Improvement to the integrity management system in relation to the monitoring for pipeline corrosion;
- Availability of field data to support operational and project work;
- Detection of smaller leaks and unintended gas flows and timely response to larger leaks;
- Enhanced safety with the ability to shut off gas flow remotely;
- Improved safety for the meter reading function; and
- The ability to offer enhanced billing options for customers.

In summary, AMR would provide a small number of operating benefits compared to existing conditions. However, the lack of important features including the ability to provide detailed and timely information regarding gas usage and operating parameters, and the inability to remotely

[47] As set out in Section 3.3.1

disconnect service, severely limits the overall capacity for FEI to realize key operating benefits or provide additional customer benefits with AMR.

4.2.2.5 Summary of AMR Suitability to Meet the Project Need

Overall, the AMR alternative would only meet a portion of the drivers for the Project need and therefore, the Project need as a whole would remain unmet.

By deploying AMR, the meter reading function would be partially automated resulting in reduced potential for errors and less intrusive meter reading processes. In addition, there would be a reduction in GHG emissions with fewer meter reading vehicles on the road. However, there would continue to be concerns with bill accuracy and time consuming processes for customer inquiries and service requests.

AMR would not provide the information to empower customers with timely access to energy use information for more effective decision-making and FEI would have no opportunity to offer enhanced DSM programs. Similarly, FEI would be unable to offer enhanced billing options to customers.

AMR would allow FEI to reduce the resources required to complete the meter reading function; however, the Company would need to continue to manage through the growing uncertainty within the meter reading industry. In addition, FEI would be locked into a long-term situation in which the Company would continue to face the risk of rising meter costs as competition decreases within the meter market and meter manufacturers transition to ultrasonic meters. Additionally, FEI and customers would have limited ability to benefit from future innovations developed within the meter manufacturing industry.

Finally, AMR would provide only limited operating benefits, offering no opportunity to advance key needs such as enhanced system resiliency, system planning, system integrity and safety.

The following section provides an overview of the financial analysis for the AMR alternative.

4.2.3 AMR Financial Analysis

The AMR financial analysis was performed based on a full cost of service (COS), with the incremental COS being the difference between AMR and Baseline.

The table below provides a summary of the net present value (NPV) of the total capital and operating costs for the AMR alternative in addition to the incremental capital and O&M compared to Baseline over a 26-year[48] analysis period.

[48] Section 6.3.1.1.

Table 4-2: AMR Alternative: NPV of Capital and Operating Costs ($ millions)

Financial Summary	AMR
Capital Costs:	
Meter Capital	$458.9
Project Management	$26.2
Software Capital	$2.2
Network Capital	$0.3
Non-Meter Capital	$5.4
AFUDC	$3.6
Total Capital	**$496.6**
O&M Costs:	
Meter Reading Costs	$102.0
Operations, Contact Centre and Meter Shop O&M	$55.4
New O&M	$7.3
Total O&M (incl. Capitalized Overhead)	**$164.7**
Baseline Capital[1]	$372.8
Baseline O&M[2]	$323.5
AMR Incremental Capital[3]	**$123.8**
AMR Incremental O&M Savings[4]	**($158.8)**

Notes:
[1] Appendix G-1, Page 1, Line 13
[2] Appendix G-2, Page 1, Line 21 less 16 percent for capitalized overheads[49]
[3] AMR Capital, $496.6, Less Baseline Capital $372.8
[4] AMR O&M, $164.7, Less Baseline O&M $323.5

The NPV of the revenue requirement associated with the above capital and O&M Is $1,197.6 million. When compared to the NPV of the Baseline revenue requirement of $1,232.1 million[50], the incremental NPV of the revenue requirement is a decrease of $34.5 million, with an incremental levelized delivery rate decrease of 0.286 percent.

The estimated capital and O&M costs are discussed in the sections below.

4.2.3.1 AMR Capital Costs

The estimated capital costs associated with the AMR alternative are as follows.

49 FEI's current capitalized overhead rate is 16 percent, BCUC order G-319-20.
50 Appendix G-3, schedule 10, line 25.

Meter Capital

Meter capital for the AMR alternative includes estimated costs of retrofitting each existing diaphragm meter with an electronic module. Therefore, the capital cost includes both the visit to each meter as well as the cost of the module to support AMR. The AMR equipment costs are estimated based on the results of the network vendor procurement process, described in Section 5.3.3.1, and are largely made up of the cost of the communication modules that would be attached to FEI's existing residential and commercial diaphragm meters. Deployment costs are estimated based upon RFP responses (Section 5.3.3).

Under the AMR alternative, FEI's existing meter exchange, bypass valve, and regulator replacement programs would continue to be completed as part of FEI's existing sustainment capital program and have been included in capital spending to provide the full costs over the analysis period.

The NPV of meter capital costs under the AMR alternative are estimated to be approximately $458.9 million.

Project Management

Project management for the AMR alternative includes estimated costs associated with internal and external staffing resources to manage the installation of the modules on existing meters, including costs for travel, supplies, facilities and vehicles.

The NPV of Project management costs under the AMR alternative are estimated to be $26.2 million.

Software Capital

Software capital comprises all estimated expenditures to design, install, test and commission the software environments required to operate an AMR system, as well as estimated development costs associated with integrating AMR components with existing FEI systems.

The NPV of Software costs under the AMR alternative is estimated to be $2.2 million.

Network and Non-Meter Capital

Network capital for the AMR alternative includes estimates for the infrastructure required to facilitate programming and downloading data from AMR mobile meter reading devices, including estimated costs such as the Information Systems (IS) hardware to attach the AMR vehicular-based mobile meter reading base stations to the network and transmit customer readings to FEI's billing systems.

Estimates for non-meter capital costs for the AMR alternative are related to the purchase of approximately 30 vehicular-based mobile meter reading base stations that would be used to collect meter reads throughout the service territory. This would include equipment for installation in approximately 25 full-time meter reading vehicles as well as installation in a few existing vehicles for off-cycle reads and spares in case of failure.

The NPV of Network and non-meter capital costs under the AMR alternative is estimated to be $5.7 million.

4.2.3.2 AMR Operating & Maintenance Costs

The O&M costs associated with the AMR alternative are as follows.

Meter Reading

Meter reading would include estimates for labour and vehicle costs associated with reading the AMR meters, which generally involves driving near each premises with a vehicular-based mobile meter reading base station that automatically receives the read. The implementation of this technology would allow for a reduction in meter reading costs by increasing the number of meters read by an individual in a day while eliminating the need for a reader to physically access every individual meter to collect a read. Therefore, fewer meter readers would be required overall.

Meter reading costs under the AMR alternative are estimated to be $102.0 million on an NPV basis.

Operations, Contact Centre and Meter Shop O&M

This category of O&M costs relates to estimates for O&M expenses that would be impacted by deploying an AMR system, such as operations field work, customer contact centre costs, and compliance work in the meter shop. An AMR system would provide some benefits to FEI in these areas, including improved productivity and lower operating costs related to meter reading O&M. The prospect for bill errors resulting from manual entry errors would also be significantly reduced, thereby reducing the amount of time spent in investigating errors and correcting bills. However the current process for collecting off-cycle reads (on/off, re-reads) would only see marginal improvements as off-cycle reads would still require a resource to drive to an area close to the meter to obtain a reading (though a small amount of time would be saved from not having to exit the vehicle, access the customer’s property and manually enter the read into a handheld device).

These O&M costs under the AMR alternative are estimated to be $55.4 million on an NPV basis.

NEW O&M

New O&M includes estimated expenditures related to the labour and software licensing that would be required to support the new AMR systems. The costs associated with maintaining the AMR modules, such as replacing units that do not report and responding to tamper alarms, is also included in new O&M. Additional O&M costs under the AMR alternative are estimated to be $7.3 million on an NPV basis.

4.2.4 Summary of AMR Alternative

The AMR alternative does not fully meet all of the drivers of the Project need. AMR would provide a partially automated meter reading solution to reduce, but not fully address, errors, while providing some improvement to customer convenience. AMR would not empower customers with timely energy usage capabilities or allow for participation in enhanced DSM programs. AMR would only reduce but not eliminate the risks and costs associated with FEI's current manual meter reading model and the Company would be locked into a technology that is trending toward obsolescence over the long-term. Finally, AMR does not allow the Company to advance key operating opportunities or offer customers enhanced billing options.

FEI's financial analysis of an AMR alternative demonstrates that an AMR alternative could be deployed at an estimated $34.4 million decrease in the NPV of the Company's revenue requirement, which amounts to a decrease in customer rates by 0.286 percent on a levelized basis over the 26-year analysis period. While this alternative is forecast to result in a small reduction in rates, it would deliver only a portion of the many potential benefits that can be provided by automating a metering system. For this reason, FEI has concluded that AMR would not provide a cost-effective, long-term solution.

The following section provides an evaluation of the second alternative considered by FEI for addressing its Project need; an AMI alternative.

4.3 *ALTERNATIVE 2 – FULL AUTOMATION – METER READING USING ADVANCED METERING INFRASTRUCTURE*

Similar to Section 4.2, this section will assess the suitability of AMI technology as an alternative for meeting the Project need. The section first considers how effectively the range of capabilities offered by full Automation is able to address the Project drivers. A financial summary follows, which describes both the Project and operating costs associated with implementing this alternative, and estimated delivery rate impacts. The section then concludes by making the determination that in light of the many important benefits provided by the technology, the AMI alternative is a cost-effective approach that would provide the most value to customers and the Company in the long term.

4.3.1 Overview of the AMI Alternative

AMI is a metering system that records customer consumption, meter diagnostic information and other field data on an hourly or more frequent basis and transmits the data multiple times during a 24-hour period over a two-way communication network from the meter to the utility. The communication network also allows the utility to transmit commands and update firmware to customer meters or other end points as required. AMI has historically been deployed using a module that is retrofitted onto a diaphragm meter that does not provide for a remotely operated shut off valve, or more recently, as an ultrasonic (advanced) meter allowing manufacturers to incorporate a remotely operated gas shut off valve. Finally, similar to AMR, the AMI technology is expected to offer a 20-year service life limited largely by the capacity of the battery.

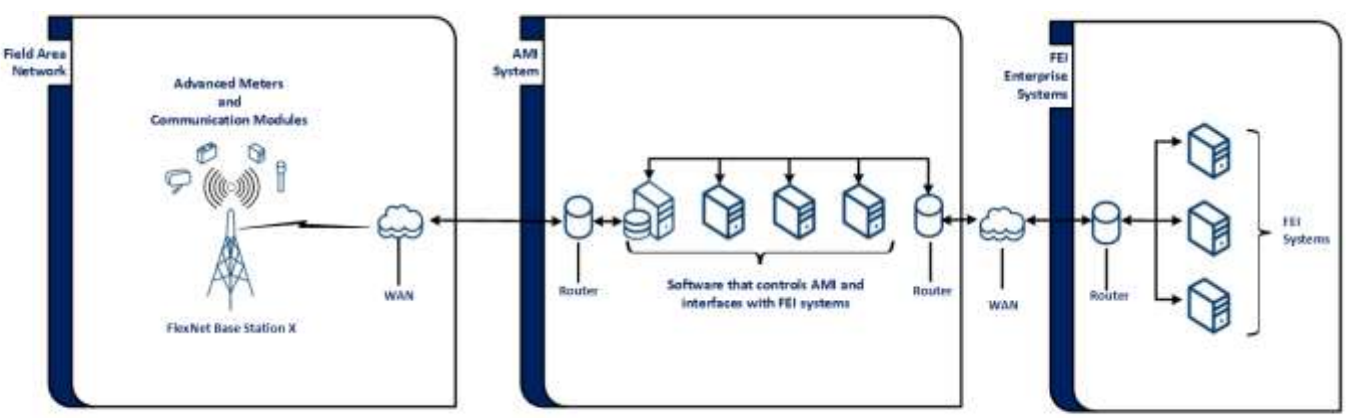
FEI investigated the AMI alternative that replaces existing residential and commercial diaphragm meters with advanced meters and retrofits communication modules within the remaining meters including larger commercial and industrial meters. This approach would allow all meters in the fleet to be connected to the AMI network. FEI chose the advanced meter option for the AMI alternative because the AMI module approach would provide a limited ability to meet the Project need compared to the advanced meter. For instance, the deployment of AMI modules retrofitted onto diaphragm meters would lead to:

- Ongoing inconvenience for customers related to delay in certain services;
- Increasing risk associated with being locked into the related technology for over 20 years while the diaphragm meter market is shrinking and meter manufacturers are transitioning to ultrasonic meters; and
- Reduced opportunity to advance key operational benefits now and in the future.

FEI's AMI alternative would include the installation of two-way network infrastructure to support wireless delivery of data between both the advanced meters and other field devices and FEI's existing enterprise information systems. Each advanced meter includes a shut-off valve to support remote control of the gas flow to each customer meter.

Figure 4-2 below depicts a typical AMI system, as is contemplated for the AMI alternative in this Application.

Figure 4-2: AMI System Diagram



The following section evaluates the suitability of the AMI alternative to meet the Company's need to automate the meter reading process as described in Section 3.

4.3.2 Suitability of AMI to Meet the Project Need

Similar to the review presented for AMR in Section 4.2, the sections below will review the suitability of the AMI alternative for meeting the four drivers of the Project need as listed below:

1. Automation is more accurate and convenient for customers than FEI's current meter reading practices, which are highly manual and are vulnerable to errors and can be inconvenient for customers;
2. Automation is becoming the industry standard, thereby changing both market conditions and customer expectations;
3. Automation alleviates the cost and service risks of manual reading and provides a cost-effective, long-term alternative; and
4. Automation provides additional customer benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system.

The sections below consider the suitability of the AMI alternative for meeting each of these four drivers.

4.3.2.1 Automation is More Accurate and Convenient for Customers than Current Manual Meter Reading Practices, which Are Highly Manual, Are Vulnerable to Errors and Can Be Inconvenient for Customers

An AMI alternative would allow FEI to fully automate the manual meter reading function by enabling the Company to collect hourly meter reads six or more times per day over a fixed communication network. Although a small number of reads would still need be collected manually to accommodate customers that choose to have their advanced meter read manually (estimated to be 2 percent) or for those meters that are located in areas where it is not economically feasible to install a fixed network (estimated to be 1.5 percent), AMI would significantly reduce the need for manual meter reading services.

AMI would fully address, where implemented, the challenges of manual meter reading, such as human error and access issues, as described in Section 3.1.1 and, as a result, enhance FEI's customer service and billing accuracy by increasing the accuracy of collected meter reads and avoiding the need for estimates.

AMI would allow for remote reading of advanced meters, which provides several benefits including:

- Fully mitigating the safety risks which lead to challenges recruiting and retaining meter readers resulting in unread meter reading routes and increased estimates as discussed in Section 3.3.1;
- Reducing customer concerns related to meter readers entering onto their property in order to collect a meter read;
- Enabling FEI to address customer billing inquiries in a timely manner using on demand meter reading;
- Allowing for remotely managing and monitoring service disconnections and reconnections; and

- Allowing for remotely managing vacant premises and service interruptions.

Having fewer site visits results in less disruption for customers, and when combined with timely resolution of inquiries and service requests, would have a positive impact on the customer's experience with FEI.

Finally, AMI would provide environmental benefits by reducing vehicle usage. Overall, vehicle usage would decrease by approximately 90 percent as meter readers driving to collect regular meter reads and off-cycle reads would be replaced with the collection of meter reads through a fixed network. This reduction in vehicle usage is estimated to create a net reduction in GHG emissions by 1,100 tCO2e.

4.3.2.2 Automation Is Becoming the Industry Standard, Thereby Changing Both Market Conditions and Customer Expectations

AMI would provide customers with more frequent and detailed information about their energy consumption. The information could be accessed online through the customer portal or by telephone, chat or email with a customer service representative. In addition, detailed consumption information provided by AMI would enable customers to make more informed decisions about their energy usage and needs.

AMI would be used to further enhance programs within the DSM portfolio, potentially resulting in customer energy savings. Lack of energy use awareness can prevent customers from taking advantage of cost-effective measures or behavioural opportunities to save energy. AMI would help inform customers and FEI about energy usage and patterns. The availability of hourly consumption data to customers and FEI would open up new opportunities for DSM programs, including:

- Near real-time consumption reports to enhance commercial and industrial energy assessments, home energy reports for residential customers, measurement and verification activities and DSM program evaluation;
- Increased customer awareness of energy consumption on an end-use or time-of-day perspective may cause them to use less energy;
- Providing customers with the ability to identify their estimated usage for the billing cycle in advance would enable proactive opportunities to reduce use;
- Providing FEI with data to better characterize customer segments in order to make even more informed decisions when planning for future DSM programs. For instance, this data would help better inform the Residential End Use Study, Commercial End Use Study and Conservation Potential Review; and
- Gas AMI devices may be used to gather real-time data when conducting pilots and demonstrations for new natural gas saving technologies rather than FEI being required to purchase separate data loggers for this purpose.

Providing adequate information in a timely manner combined with offering DSM programs that give customers the ability to make effective energy use decisions in support of energy conservation and saving money, would enable FEI to meet the evolving expectations of customers in the long-term. In addition, AMI will provide better information for use by FEI in its COS Analyses for the purposes of rate design.

4.3.2.3 Automation Alleviates the Cost and Service Risks of Manual Reading and Provides a Cost-Effective, Long-Term Alternative

AMI will allow FEI to address the cost and service risks of the Company's current manual meter reading process over the long-term as described below.

4.3.2.3.1 AMI WOULD REDUCE RELIANCE ON THIRD PARTY METER READING SERVICES

The implementation of AMI would greatly reduce FEI's exposure to cost and service risks associated with FEI's current meter reading model. While a small number of meters would still be read manually, the vast majority of meters would be read remotely without any requirement for field support. FEI is still evaluating how the residual manual meter reading activity would be performed under the AMI alternative. However, the Company expects that if outsourcing this function is no longer viable, the reduced scope would make repatriation of this function significantly less expensive.

4.3.2.3.2 AMI WOULD FUTURE-PROOF THE METERING TECHNOLOGY

AMI would allow FEI to eliminate the risk associated with procuring diaphragm meters at a reasonable price. Furthermore, as the meter manufacturers continue to transition to ultrasonic meters, FEI would not be exposed to the risk of a shrinking meter supply over the long-term.

As gas meter manufacturers continue to focus resources toward development of AMI technology, the risk of technological obsolescence would be fully mitigated with the AMI alternative. Furthermore, as AMI technology is designed with a fully functioning two-way network, FEI's customers and the Company could benefit from future innovations such as potential enhancements to the meter capabilities through remote firmware upgrades, connection of new types of field devices to the network and increased capabilities through data analytics.

AMI technology is scalable for customer growth, and therefore would support the same services and functions for more meters and other field devices in the future. In addition, the network is designed with the capability to carry data for other utilities within FEI's service area, which may create revenue opportunities for FEI and its customers in the future.

4.3.2.4 Automation Provides Additional Customer Benefits as well as Operational Opportunities that Support the Safety, Resiliency and Efficient Operation of the Gas Distribution System

AMI would advance key benefits that would enhance FEI's operations as listed below.

4.3.2.4.1 AMI WOULD ENHANCE FEI'S SYSTEM RESILIENCY

Resiliency refers to the ability to prevent, withstand, and recover from system failures or unforeseen events. Resiliency encompasses concepts such as preparing for, operating through, and recovering from significant disruptions, no matter the cause. A key element that contributes to natural gas system resiliency is load management capabilities. Load management relates to the ability both to accurately assess the actual load across all parts of the gas system, and when necessary, to strategically reduce load on the gas system. Managing load helps to maintain the pressure on the system by restoring the balance of gas supply and demand in the event of a supply emergency. FEI currently has visibility of the overall load on the gas system; however, there is limited visibility regarding where the load is located within the system. Similarly, controlled load shedding is partially within FEI's control today; however, FEI currently has no direct ability to remotely or automatically disconnect or otherwise curtail gas supply to customers. In the event of a sustained loss of gas supply, FEI is currently only able to respond by curtailing load in three ways: (1) by directing interruptible customers to immediately disconnect from the system, (2) by making public appeals for all customers to reduce their gas usage, and (3) by shutting down major sections of the system with a single valve. With FEI's current meter fleet, customers have to be manually disconnected from the system. Currently, the disconnection requires a field visit to each site which impedes FEI's ability to quickly implement load adjustments in emergency situations.

On December 29, 2020, FEI filed an Application with the BCUC for approval of a CPCN for the Tilbury Liquefied Natural Gas Storage Expansion Project (the TLSE Project Application). FEI filed a revised redacted TLSE Project Application on March 25, 2021. The TLSE Project Application sets out in detail the need to enhance the resiliency of FEI's system. In particular, Section 3 of that application explains resiliency, addresses the need for additional resiliency investments, and provides a brief explanation of how the TLSE Project supports supply-side resiliency solutions. The following section expands on the TLSE Project Application's discussion[51] of the AMI Project's role in complementing FEI's system resiliency by providing a demand-side resiliency solution.

An investment in AMI would provide FEI with near real-time information about the total load on the overall system and detailed information about energy usage by individual customers. The Company would also be able to more accurately forecast the load on the system throughout the duration of the emergency to determine whether load shedding is required.

If at any point during a gas supply emergency FEI deems it necessary to reduce load to balance the system, AMI would allow for surgical reduction of load to minimize the disruption of service to customers. AMI would also allow FEI to confirm that interruptible customers have complied with any requests to adjust their gas usage. Finally, the Company would be capable of measuring the impact of appeals to the public to reduce load, minimizing the service interruption to customers.

[51] High-level detail of the AMI Project is provided at Section 3.3.2, pages 31 and 32 of the TLSE Project Application, Exhibit B-1-3.

In the event of an extended gas supply emergency that requires a large section of the system to be shut down, AMI would enable the Company to execute a controlled shutdown. A controlled shutdown would provide FEI with the ability to maintain pressure within the section of the system that has been shut down throughout the duration of the gas supply emergency. However, a controlled shutdown would also allow the Company to define which meters are required to be temporarily interrupted so critical services can continue operating in the section of the system that has been shut down. The ability to maintain a positive pressure within the section of the system that is shut down, would enable FEI to avoid the possibility of a pressure collapse within the pipe. A pressure collapse is an industry term that refers to a situation in which the gas pressure in the system is drawn down to atmospheric pressure, providing the opportunity for air to enter into the system. By keeping the system pressurized, FEI would be able to minimize restoration time for customers by avoiding the need to purge the system of air prior to initiating customer reconnections.

The AMI alternative would also support FEI's response to other major emergencies such as earthquakes, wild fires, flooding, system damage and other hazardous operating conditions. In each situation, the AMI alternative would enable detection of any customer with gas service that is directly impacted by the emergency and support a timely response for customer safety including a temporary disruption of service if necessary through either remote shutoff by FEI or automatic shutoff due to high gas flow detected by the advanced meter.

4.3.2.4.2 AMI WOULD ENHANCE FEI'S SYSTEM PLANNING

The diaphragm meter currently plays a minor role in system planning. The majority of customer consumption data is collected manually on a monthly basis, which limits FEI's understanding of the real-time behavior of gas consumers and the direct response of the gas system to customer demand. FEI does not have the technological means to examine in detail the changes to hourly consumption patterns that occur in various customer rate classes, premise types or industry sectors in response to a variety of factors that currently influence energy use or will influence future energy use. As a result, FEI presently has a limited ability to project future impacts of changes in use and peak demand on various sectors, beyond what it is able to derive from monthly consumption data.

AMI would enhance FEI's understanding of the real-time behavior of gas consumers and the direct response of the gas system. In particular, improved understanding of customer usage patterns can be developed which would be used to support system design, improve utilization of peak resources and quantify capacity benefits of DSM activities on peak demand. As such, FEI would be able to enhance its modeling of the impacts of future growth or changes in demand over time across the system. This would allow FEI to better define the scope and timing of required capacity improvement projects, ensuring the system has sufficient capacity to deliver all hours of the day under peak conditions. These improvements are expected to provide financial and service benefits for both the customer and the Company through more targeted, and therefore more cost-effective, options to maintain sufficient capacity under peak conditions. Supported by AMI data, models of impacts on peak demand can be more fully and confidently utilized, resulting in reduced costs and improved resiliency for customers.

AMI would also provide benefits for the development and commissioning of local renewable natural gas (RNG) production facilities on the FEI distribution network. More granular consumption data would improve FEI's ability to verify locations with adequate sustained local demand to further encourage and attract RNG producers to attach and inject into the distribution network. Finally, AMI meters are also hydrogen compatible, which is an important feature as FEI continues to investigate the use of other renewable gases for the purposes of GHG reductions.

4.3.2.4.3 AMI Would Offer Improved Safety for the Meter Reading Function

AMI would significantly reduce the need to walk or drive in order to complete the meter reading function. As such, the safety issues related to the function would be largely addressed by deploying this alternative.

4.3.2.4.4 AMI Would Offer Additional Safety Benefits Related to Theft Detection

AMI would provide additional safety benefits through the near real-time use of alarms to alert FEI to issues at the meter. AMI technology would allow FEI to detect potential theft through anomalies in gas usage, tamper alarms, and other alerts communicated by the meter in near real-time as further described in Section 5.4.1.3. Awareness of the potential for theft in a timely manner would allow FEI to investigate sites and premises to assess if unauthorized alterations have created unsafe conditions.

4.3.2.4.5 AMI Would Improve Emergency Response to Larger Gas Leaks Downstream of the Meter

The remote shut-off capabilities of AMI would provide FEI with the ability to enhance safety for customers, the public and employees when responding to emergencies such as gas leaks or structure fires. Advanced meters can detect large leaks downstream of the meter and be programmed to automatically shut off the internal valve, eliminating any potential for the development of a hazardous situation. The advanced meter would provide an alarm to FEI indicating the meter's internal valve has closed because of a high flow rate. Customers could be notified about the alert and may be able to safely remain in their homes while they wait for FEI to investigate the alert.

4.3.2.4.6 AMI Would Improve Leak Detection for Smaller Leaks Downstream of the Meter

AMI would also enable FEI to detect smaller leaks and unexpected consumption downstream of the gas meter in the customer's house gas lines and below the flow rate of the AMI automatic shut off threshold. In these situations, hourly, high resolution data consumption from the advanced meters could be used to generate timely exception reports that alert FEI to unexpected flows over a given threshold. FEI would have the ability to contact the customer to determine if the identified constant flow is valid. By taking a proactive approach to these flow anomalies, FEI expects to help customers identify leaks in their house lines or appliances that have unintended gas flow.

4.3.2.4.7 AMI WOULD INCREASE DISTRIBUTION SYSTEM MONITORING AND ALARMS

AMI would provide a variety of sensors including pressure, temperature and level and associated alarms that will allow FEI greater ability to remotely monitor distribution system performance for both operation and project support.

Remote monitoring sensors installed on the AMI network would provide near real-time visibility of pressure changes, temperature changes, and reduced gas odorant tank levels. In addition, much of the monitoring processes for FEI's distribution system are done manually by site visits. AMI would enable improved monitoring of these assets and network data automatically transmitted via sensors would reduce the number of site visits required to collect data and would allow FEI to be more responsive with maintenance and repair activities.

4.3.2.4.8 AMI WOULD ENHANCE FEI'S SYSTEM INTEGRITY MANAGEMENT

The integrity of FEI's gas network is impacted by geological, hydrological, and seismic hazards, as well as corrosion, stress-corrosion cracking and potential third party damage. Due to the significant consequences of gas network failures, FEI conducts a series of systematic and coordinated manual monitoring and maintenance programs to prevent failures and preserve the gas network integrity. These programs include utilization of cathodic protection systems, in-line inspections, above grade surveys, monitoring of water crossings, monitoring of identified natural or third-party caused geological hazards, as well as surveys to locate gas leaks at the meter set and on the underground network of pipes.

AMI would allow FEI to deploy cathodic protection sensors on its gas network for remote monitoring purposes. These remote monitoring sensors would provide near real-time visibility on the performance of the cathodic protection system that helps maintain the integrity of FEI's distribution system gaslines. If this cathodic protection system experiences a failure, this near real-time monitoring capability will allow FEI to quickly investigate the failure, resolve it and then reactivate the affected cathodic protection system, which is a critical component of maintaining FEI's overall system integrity management plan.

4.3.2.4.9 AMI WOULD OFFER ENHANCED BILLING OPTIONS

AMI would provide FEI with the ability to offer enhanced billing options. Advanced meters would enable FEI to provide billing enhancements to customers, such as consolidated billing for multiple customer locations and flexible billing dates. FEI has a number of customers with multiple natural gas accounts that are consolidated to a single bill where the accounts are read on different dates and therefore billing of all accounts is delayed until the last meter read is obtained. AMI would enable FEI to obtain meter readings at different locations simultaneously and bill these accounts immediately.[52]

AMI would also provide FEI with the ability to allow customers to choose a billing date that meets their needs rather than be restricted to the date dictated by the scheduled meter reading

[52] FEI notes that consolidated billing could potentially lead to lower bill printing and payment processing costs depending on the number of customers that are more inclined to consolidate their accounts; however, it is unable to forecast the magnitude of savings in this regard.

route; this option could be of particular importance to help some customers, such as customers on a fixed income, avoid or reduce late payment charges.

4.3.2.5 Summary of AMI Suitability to Meet the Project Need

Deployment of the AMI alternative would allow FEI to meet all the drivers for the Project need.

AMI will fully automate the meter reading function, significantly reducing the potential for errors while being far less intrusive for customers. In addition, there would be a reduction in GHG emissions by reducing the meter reading vehicles on the road. Billing accuracy will also be greatly improved and customer inquiries and service requests would be addressed in a timely manner.

AMI would provide the information to empower customers with timely access to energy use information for more effective decision-making and FEI will have the opportunity to offer customers enhanced DSM programs for a greater opportunity to support conservation and save money.

AMI would allow FEI to fully address growing uncertainty related to the Company's current meter reading model. FEI would also have certainty regarding its costs and supply of meters in the long-term. Additionally, customers and the Company would be able to benefit from any innovations that are developed in the long-term within the metering industry.

Further, AMI would provide the opportunity to advance a range of key operating benefits in areas such as system resiliency, system planning, system integrity and safety. Similarly, FEI would be able to offer enhanced billing options to customers.

The following section provides an overview of the financial analysis for the AMI alternative.

4.3.3 AMI Financial Analysis

The AMI financial analysis was performed based on a full COS Analysis, with the incremental COS being the difference between the total COS for AMI and Baseline.

The table below provides a summary of the NPV of the capital and operating costs for the AMI alternative compared to Baseline, over the 26-year analysis period.

Table 4-3: AMI Alternative: NPV of Capital and Operating Costs ($ millions)

Financial Summary	AMI
Capital Costs:	
Meter Capital	$481.2
Project Management	$35.2
Software Capital	$9.1
Network Capital	$17.1
Non-Meter Capital	$3.6
AFUDC	$12.7

Financial Summary	AMI
Total Capital	**$558.9**
O&M Costs:	
Meter Reading Costs	$78.3
Operations, Contact Centre and Meter Shop O&M	$12.8
New O&M	$97.9
Total O&M (incl. Capitalized Overhead)	**$189.0**
Baseline Capital[1]	$372.8
Baseline O&M[2]	$323.5
AMI Incremental Capital[3]	**$186.1**
AMI Incremental O&M Savings[4]	**($134.5)**

Notes:
[1] Appendix G-1, Page 1, Line 13
[2] Appendix G-2, Page 1, Line 21 less 16 percent for capitalized overheads[53]
[3] AMI Capital, $558.9, Less Baseline Capital $372.8
[4] AMI O&M, $189.0, Less Baseline O&M $323.5

The NPV of the revenue requirement associated with the above capital and O&M Is $1,247.1 million. When compared to the NPV of the Baseline revenue requirement of $1,232.1[54] million, the incremental NPV of the revenue requirement is an increase of $15.0 million, with an incremental levelized delivery rate increase of 0.125 percent.

The estimated capital and O&M costs are discussed in the sections below.

4.3.3.1 AMI Capital Costs

The estimated capital costs associated with the AMI alternative are as follows.

Meter Capital

Meter capital for the AMI alternative includes estimated costs of replacing each existing diaphragm meter with an advanced meter. Therefore, the capital cost includes the visit to replace each meter, the cost of the advanced meter, and a bypass valve and regulator when required.

This would include all material and installation costs for the meters, bypass valves and regulators. Since existing meters would be replaced as part of the AMI alternative, existing programs to replace regulators and install bypass valves would be accelerated and completed at the same time as meter replacement, realizing cost savings mainly as a result of efficiencies gained from the bulk purchase of bypass valves and regulators.

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[53] FEI's current capitalized overhead rate is 16 percent, BCUC order G-319-20.
[54] Appendix G-4, schedule 10, line 25.

Meter capital costs under the AMI alternative are estimated to be $481.2 million on an NPV basis.

Project Management

Project management costs include estimated labour and support costs for both internal and external resources for the system design, project management, process and change management, quality assurance, field supervision and administrative functions of the AMI Project. Project management also includes costs for travel, supplies, facilities and vehicles.

Project management costs under the AMI alternative are estimated to be $35.2 million on an NPV basis.

Software Capital

Software capital costs are comprised of estimates of all required capital expenditures to design, install, test, and commission the software environments needed as part of the AMI alternative, as well as estimated development costs associated with integrating new AMI environments with existing FEI systems.

Software capital costs under the AMI alternative are estimated to be $9.1 million on an NPV basis.

Network and Non-Meter Capital

Network and non-meter capital costs are comprised of estimates of all network licence and setup costs, including network (as defined in Section 5.4.1.1) design and installation.

These costs cover miscellaneous non-meter hardware items, including gateways, transmitters, switches, and cathodic protection devices. These costs would also include handheld/drive-by meter reading devices to outfit vehicles throughout the FEI service territory that would be required to read individual meters that are not within network coverage.

Network and non-meter capital costs under the AMI alternative are estimated to be $20.7 million on an NPV basis.

4.3.3.2 AMI O&M Costs

Additional details supporting the AMI O&M costs are discussed below including the total NPV of the estimated costs for the 26-year analysis period.

Meter Reading

Meter reading costs include estimates for remote reading of meters using the proposed AMI alternative as well as costs to manually read any devices that are not within network coverage.

Meter reading costs under the AMI alternative are estimated to be $78.3 million on an NPV basis.

Operations, Contact Centre and Meter Shop O&M

This category of O&M activity includes estimates of costs associated with meter exchanges, operations, contact centre and meter shop work.

The gas shut-off valve in the advanced meter would enable FEI to realize cost savings related to this category of activity O&M. Remote shut off and turn on of gas flow would allow FEI to respond remotely to many issues occurring in the field, reducing the need to dispatch employees to attend customer premises.

Therefore, these O&M costs under the AMI alternative are estimated to be $44.9 million on an NPV basis.

New O&M

These estimated costs relate to work required to maintain and manage the AMI alternative and its integration with existing FEI systems. This includes SaaS[55] fees, software licensing, support, site leases for base station sites and bandwidth costs to connect field end points to the data centres.

New O&M costs are estimated to be $97.9 million on an NPV basis.

4.3.4 Summary of AMI Alternative

An AMI alternative would fully address all drivers of the Project need. AMI would provide a fully automated meter reading solution greatly reducing errors and increasing customer convenience. AMI would empower customers with timely energy usage capabilities and allow customers to participate in enhanced DSM programs. AMI would greatly reduce the risks and costs associated with FEI's current manual meter reading model while addressing the risk of obsolescence. Finally, AMI would allow FEI to advance key operating opportunities and enable the Company to offer customers the opportunity for enhanced billing options.

FEI's financial analysis of an AMI alternative demonstrates that the AMI Project could be deployed at an estimated $15.0 million increase in the NPV of the Company's revenue requirement, which amounts to an increase in customer rates by 0.125 percent on a levelized basis over the 26-year analysis period. FEI's financial and non-financial analysis of the AMI alternative demonstrates that for a comparative delivery rate impact of less than half a percent, customers and the Company will receive significant incremental benefits.

[55] Software as a Service is a software licensing and delivery model in which software applications are licensed on a subscription basis from a vendor.

4.4 CONCLUSION: THE AMI ALTERNATIVE PROVIDES THE BEST OVERALL VALUE TO CUSTOMERS AND THE COMPANY IN THE LONG-TERM

Table 4-4 below provides a comparison of the AMI alternative against the AMR alternative. Included within the table is the Baseline which reflects FEI's current manual meter reading process described in Section 3.

Table 4-4: Analysis of Alternatives for Meeting the Project Need

Alternatives: Project Need Analysis

EVALUATION	SCORE
FULLY; Project need is fully met	✔
PARTIALLY; Project need is partially met	!
NOT; Project need is not met	✖

	AMI	AMR	BASELINE
1 Automation is more accurate and convenient for customers than FEI's current meter reading practices, which are highly manual, are vulnerable to errors and can be inconvenient for customers	**AMI**	**AMR**	**BASELINE**
A more accurate and reliable meter reading process	✔	!	✖
A meter reading process that is more convenient and less intrusive for customers	✔	✔	✖
Ability to resolve billing concerns and customer requests in a timely manner	✔	✖	✖
Reductions in Greenhouse Gas (GHG) emissions	✔	!	✖
2 Automation is becoming the industry standard, thereby changing both market conditions and customer expectations	**AMI**	**AMR**	**BASELINE**
Better consumption data for customer use	✔	✖	✖
The ability to offer enhanced DSM opportunities	✔	✖	✖
3 Automation alleviates the cost and service risks of manual reading and provides a long term cost effective alternative	**AMI**	**AMR**	**BASELINE**
Reduced reliance on third party meter reading services in a market characterized by increasing uncertainty	✔	!	✖
A meter technology that is going to be available for the next twenty years	✔	✖	✖
4 Automation provides additional customer benefits as well as operational opportunities that support the safety, resiliency and efficient operation of the gas distribution system	**AMI**	**AMR**	**BASELINE**
Increased system resiliency	✔	✖	✖
Improved system planning abilities	✔	✖	✖
Improved safety for the meter reading function	✔	!	✖
Better theft detection abilities	✔	!	✖
Improved emergency response to larger gas leaks downstream of the meter	✔	✖	✖
Improved leak detection for smaller leaks downstream of the meter	✔	✖	✖
Increased distribution system monitoring and alarms	✔	✖	✖
Enhanced integrity management of the system	✔	✖	✖
The ability to offer enhanced billing options	✔	✖	✖

While AMR would partially meet the need to automate the manual meter reading process, AMI would deliver all of the drivers of the need to automate FEI's meter reading process. Deploying an AMR solution would ultimately lock the Company and customers into a technology with limited benefits and offer no ability to realize future opportunities to enhance the customer experience or FEI's operations in the same way that AMI technology would enable. Where AMR would provide limited benefits to the Company and customers, an AMI alternative would provide those same benefits, while providing important additional benefits for customers now and in the future and also while providing the opportunity to address critical areas of the Company's operations.

A financial summary of FEI's alternatives analysis is presented in Table 4-5. Review of the alternative financials determined that:

- AMR has a smaller up front capital investment, lower operating costs and a small estimated rate reduction. However, it is unable to fully meet any of the drivers of the Project need to automate; and
- AMI provides a solution that meets all aspects of the Project need and does so for a comparable investment and with a delivery rate impact that is less than half a percent higher.

Table 4-5: Summary of Alternative Financials

	AMR	AMI
Capital Costs (NPV, $millions)		
Meter Capital	$458.9	$481.2
Project Management	$26.2	$35.2
Software Capital	$2.2	$9.1
Network Capital	$0.3	$17.1
Non-Meter Capital	$5.4	$3.6
AFUDC	$3.6	$12.7
Total Capital	**$496.6**	**$558.9**
O&M Costs (NPV, $millions)		
Meter Reading Costs	$102.0	$78.3
Operations, Contact Centre and Meter Shop O&M	$55.4	$12.8
New O&M	$7.3	$97.9
Total O&M (incl. Capitalized Overhead)	**$164.7**	**$189.0**
Incremental Capital (NPV, $millions)	**$123.8**	**$186.1**
Incremental O&M (NPV, $millions)	**($158.8)**	**($134.5)**
Incremental To Baseline Revenue Requirement (NPV, $millions)	**$(34.5)**	**$15.0**
Incremental Delivery Rate Impact (%)	**-0.286%**	**0.125%**

For all of the reasons summarized above, and given the small difference in delivery rate impact between the two alternatives, FEI proposes the AMI alternative as being the best long-term solution for customers.

Section 5 of this Application will describe FEI's proposed AMI alternative in detail.

5. PROJECT DESCRIPTION

5.1 INTRODUCTION

In this section, FEI describes the Project in detail based on the AMI alternative proposed in Section 4 of the Application.

Specifically, FEI will:

- Provide an overview of the Project scope (Section 5.2);
- Provide a history of the Project development activities that informed FEI's procurement processes and Project implementation planning (Section 5.3);
- Describe the technical components of the Project (Section 5.4);
- Provide an overview of the Project implementation approach and Project schedule (Section 5.5);
- Provide an overview of FEI Project leadership roles and accountabilities for managing the Project (Section 5.6);
- Demonstrate that FEI has identified the key Project risks and is taking a prudent approach to risk management (Section 5.7);
- Describe considerations of the Project (Section 5.8); and
- Show that FEI has been comprehensive in planning for the Project (Section 5.9).

5.2 PROJECT OVERVIEW

The Project team worked with a broad cross-section of representatives throughout FEI, and engaged with consultants and other utilities to define scope and detailed requirements for the proposed AMI alternative.

5.2.1 Project Scope

The proposed AMI alternative will replace most existing customer meters with advanced meters, retrofit those meters that are not replaced with AMI communication modules, and install associated infrastructure to support delivery of hourly gas consumption and other metering information from the advanced meters/modules at customer premises, back to FEI. The Project will also include the installation of communication modules on infrastructure and pipeline assets enabling the remote collection of information on FEI's gas system integrity. Additionally, FEI customers will have the ability to access their hourly consumption information through FEI's secure and private online customer portal, and to be notified of gas flow anomalies for use by FEI and the customer to help identify potential gas leaks, faulty appliances or appliances/equipment mistakenly left on.

Specifically, the Project will deliver the scope described below, collectively referred to in this Application as the AMI Solution:

Installation of:

1. Approximately 1,100,000 residential, commercial, and industrial advanced meters and meter retrofits of communication modules capable of remote gas consumption measurement;
2. Approximately 1,100 communication modules on the gas network to increase operational awareness of the gas system state;
3. The AMI network and infrastructure to communicate with customer meters and other communication modules on the FEI gas network;
4. Approximately 780,000 bypass valve sets, as required, on residential and small commercial meter sets;
5. Residential and small commercial meter set regulators to replace those that will exceed their expected service life prior to the first meter exchange planned for post-AMI Solution deployment;

Capabilities to:

1. Remotely monitor the condition of AMI network infrastructure;
2. Provide alarms for critical status of meters, for residential and small commercial customer meters, such as meter tamper, high temperature, low battery, high consumption, reverse gas flow, meter health and others;
3. Enable remote turn off/on (valve closure/open) of gas service for residential and small commercial meters;
4. Turn off gas supply to large groups of customers quickly in the event of an emergency, for residential and small commercial meters;
5. Detect and deter gas theft;
6. Facilitate automated data collection, including daily consumption register readings and hourly consumption interval readings[56] from approximately 1,100,000 residential, commercial, and industrial customer meters;
7. Enable customer access to hourly consumption information via enhancements to FEI's secure customer portal;
8. Provide notification of gas flow anomalies for use in identifying potential gas leaks, faulty customer appliances and appliances/equipment mistakenly left on, for residential, commercial, and small industrial customers;

[56] A consumption register records all consumption through the meter since manufacturing. A consumption interval designates only consumption recorded during an interval of time (typically hourly).

Provisioning for:

1. Operational process changes and associated change management, training, and communications necessitated by the Project; and
2. Implementation of the Network Vendor's support model for the AMI Solution.

5.3 *PROJECT DEVELOPMENT ACTIVITIES*

FEI reviewed lessons learned from the 2014 FBC AMI project and conducted a Gas AMI pilot project in 2017 to inform requirements for procurement processes and implementation planning for the AMI Solution.

5.3.1 Learnings from FBC Electric AMI

While the Project will benefit from many valuable insights derived from the experiences of the Electric AMI project, this section highlights how the following key lessons learned have been incorporated into planning for the Gas AMI Solution:

1. To identify all processes expected to be impacted by new technology and ensure availability of sufficient resources to map out process changes, a preliminary assessment of the scope of people and process change will be completed prior to regulatory approval and be validated during the Define phase of the Project (Section 5.5.1.2);
2. To ensure impacted business units have a lead role in designing new work processes, people and process change management frameworks will be developed, in collaboration with business units and impacted employees, during the Prepare phase of the Project (Section 5.5.1.1);
3. To ensure communications are frequent, timely, centralized, standardized and easy to understand, FEI initiated early engagement with customers, stakeholders and Indigenous communities in 2019 to inform communication planning for the Project;
4. To avoid increased cost and time pressures resulting from encountering meter sets that presented unanticipated challenges (as experienced during the FBC AMI implementation), from October 2020 through April 2021, FEI conducted a meter set survey for the 1,100,000 gas meter sets. Survey outcomes included updated natural gas meter set profiles and information pertaining to issues with meter access;
5. To ensure processes are understood for handling scenarios that may impede deployment, including but not limited to customer refusals or handling of meters that are physically difficult to change, the Project team began working with business units to develop and document processes while awaiting regulatory approval;
6. To streamline access to required sites, keys, and local FEI field resources, FEI will define processes and designate a communication liaison during deployment; and

7. To deal with escalated project issues and/or provide guidance to Project resources, FEI will ensure sufficient FEI field management resources will be available and on-site as deemed necessary.

5.3.2 Natural Gas Pilot Project

To better understand the challenges of implementing an AMI system in the gas utility context, FEI conducted a pilot project (Pilot) in 2017 through early 2018. The Pilot provided valuable information on network connectivity and data collected from advanced meters and communications modules. Insights gained from the Pilot were used to determine the Project scope and inform implementation planning.

5.3.2.1 Objectives of the Pilot

The objectives of the Pilot were to assess:

1. The ease of installation of the network technology, AMI advanced meters and meter communication modules;
2. The effectiveness and reliability of the network technology;
3. Data collection performance;
4. Operational business process impacts; and
5. Areas of expected benefits.

5.3.2.2 Scope of the Pilot

During the Pilot, AMI meters and communication modules were installed on existing residential services at single and multi-family dwellings and commercial properties in the Fraser Valley. Non-meter communication modules installed included odorant level monitors, pressure and temperature sensors at distribution regulator stations and cathodic protection sensors on pipelines. The network consisted of five Base Stations and 295 advanced meters and communications modules, which transmitted data to a test system connected to a portal viewable by the Pilot team for further analysis.

5.3.2.3 Pilot Outcomes

Upon completion of the Pilot, FEI confirmed Pilot objectives were met based on the following outcomes/key learnings:

- Parallel installation of network and communication modules created challenges as a repeat visit to a communication module was sometimes required to confirm module connectivity to the network;
- Non-meter communication modules installed during the Pilot functioned well in a variety of geographical and temperature conditions;

- FEI field staff, when provided with training, have the expertise to deploy all non-meter communication modules throughout the service territory after the network is functional;
- The current meter exchange methodology of calling customers to book an appointment for a technician site visit, will provide an additional customer communication channel during meter deployment;
- Non-meter communication modules can remotely monitor sites to provide information that previously could only be gathered through a site visit by a field technician;
- Durations for installation of sensors and communication modules at distribution sites were confirmed;
- Hourly (or more frequent) meter readings for residential and commercial customers were successfully transmitted to a test system;
- Change and Leave Off (gas service will be left off when meters are replaced if a customer is not home to facilitate relight) will be necessary to ensure adherence to schedule. Therefore a robust relight process will be required;
- Installation and commissioning of 295 advanced meters and communication modules did not present unanticipated challenges; and
- Detection of gas theft by comparing the amount of gas delivered to the distribution system against measured gas consumption in neighbourhoods was not feasible.

5.3.2.4 Informing Planning for the Gas AMI Solution

Learnings from the Pilot highlighted planning considerations for a full-scale deployment of a network, advanced meters and other communications modules. Planning for the AMI Solution incorporated the following key insights gained from the Pilot:

1. To validate network coverage and reduce repeat site visits by field technicians, network installation will be completed first in each deployment region, enabling a fully operational network prior to the installation of advanced meters, communication modules, bypass valves and regulators;
2. To leverage the expertise of FEI field staff, deployment of non-meter communication modules will be conducted by FEI field technicians;
3. To allocate sufficient time and resources for deployment of meter exchanges and non-meter communication modules, installation durations will be derived from FEI experience as confirmed by the Pilot; and
4. To maintain consistency FEI will follow its current meter exchange methodology for contacting customers to book field technician appointments.

5.3.3 Procurement Processes for the Solution

FEI used Request for Proposal (RFP) processes for the selection of the Project network and infrastructure, installation deployment services, the supply of bypass valves, and the supply of residential and small commercial regulators. While planning for the Project, an iterative approach was undertaken to research, design and define FEI's high-level functional requirements. The requirements were used as the basis for the RFP processes described in the following sections. Proposals were evaluated by a cross-functional team of FEI subject matter experts.

5.3.3.1 Network Vendor RFP

The FEI Natural Gas Network Vendor RFP was released in October 2017 and covered the provision of the following:

1. Meter hardware and functions:
    - Automated Meter Reading Devices (AMRD) to be installed on existing diaphragm meters;
    - New diaphragm meters with AMRDs;
    - New advanced meters with embedded AMI radios;
    - Non-meter sensors;
2. Network hardware and functions:
    - Collectors and routers required to build the network;
    - Meter control system (AMI Head End System (HES)) and services;
    - Labour for network installation;
3. Meter Data Management System (MDMS) and services; and
4. Other services, including but not limited to, training and security requirements.

Table 5-1 describes key technical considerations that informed evaluation of Network Vendor RFP proponents/proposals.

Table 5-1: Network Vendor RFP Technical Considerations

		Description
Core Product	Meters	Availability of next generation solid state meters with remote disconnect
	Communications	Assessment of network solutions offered
	Meter Data Management	Assessment of meter data management platforms offered
	Warranties	Assessment of warranties offered to mitigate FEI risk

		Description
Market Readiness/ Compliance	Hardware	Assessment of next generation products and timing of market availability
	Measurement Canada	Assurance of Measurement Canada meter approval
	Safety Compliance	Assurance of compliance with Underwriters Laboratories Inc. (UL) Canadian safety certification
Future Proofing	Hardware	Assessment of existing/future hardware version, capability and scalability
	Network	Assessment of network interoperability and alignment with industry standards

After evaluation and scoring of each proposal, one vendor's proposed solution was not mature enough for consideration. The top two vendors were invited to provide product demonstrations, after which reference checks were conducted and contract negotiations were initiated.

Sensus USA Inc. and Sensus Canada Inc. (Sensus) were selected as the AMI Network Vendor of choice. Sensus offers mature, proven AMI technology as described in Section 5.4. The Sensus technology best met FEI's network functional requirements, is capable of integrating with existing and future FEI systems to enable delivery of FEI's AMI Solution, and is scalable to accommodate future customer growth.

5.3.3.2 Deployment Vendor RFP

FEI previously released an AMI Deployment Vendor RFP in October 2017; however, the process was not completed due to, among other things, changes in FEI's service requirements and changes in the deployment vendor marketplace. As consequence, FEI will release a new RFP in Q2 2021 that covers the provision of the following services:

1. Installation Services:
    - Installation of new advanced meters;
    - Installation of by-pass valves at most meter sets;
    - Installation of new regulators at some meter sets; and
    - Installation of new AMI communicating modules on large commercial and industrial meters.
2. Other Deployment Services:
    - Installation services workforce management;
    - Logistics and material management, in support of installation services;
    - Recycling of removed meters and regulators;

- Management of customer keys/access;
- Providing operational reporting; and
- Management of customer escalations.

3. Provision of installation personnel with the training, tools and equipment required to complete their work safely and reliably.

When determining the successful Deployment Vendor in Q4 2021, FEI will consider each proponent's profile and experience, work plan, and ability to deliver the scope of services in accordance with the Deployment Vendor RFP.

5.3.3.3 *Other Supporting Contracts*

FEI's engineering standard for meter set design includes installation of meter set bypass valves and regulators. As part of FEI's meter exchange sustainment program, meter set bypass valves are installed and regulators are replaced. Given that the Project will require every meter to either be upgraded with a communication module or be exchanged, full deployment of 780,000 bypass valves is included in scope of the Project.

In May 2020, FEI undertook procurement processes to select preferred suppliers of bypass valves, and residential and small commercial regulators.

Bypass Valve and Regulator Suppliers

Negotiations have commenced with the preferred supplier of bypass valves and the preferred regulator supplier. At the date of this submission, negotiations are ongoing with both preferred suppliers. FEI expects to finalize both contracts in Q2 2021.

5.4 *THE PROJECT ARCHITECTURE AND TECHNICAL COMPONENTS DESCRIBED*

This section provides a high-level overview of how technical components of the Project are logically architected to enable delivery of the Project scope.

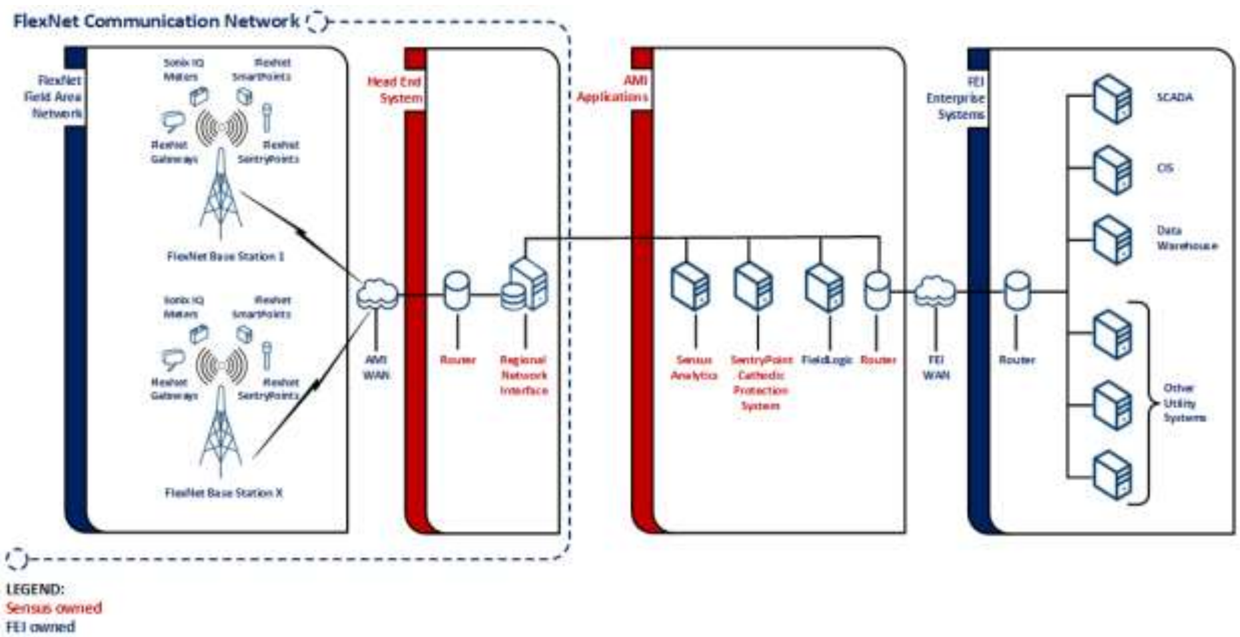
5.4.1 The End-to-End Project Architecture

Figure 5-1 depicts the logical architecture of the Project including integration of the Sensus AMI technology components with FEI enterprise systems. Technology components, and their associated functions, are described as follows:

- Sensus FlexNet Field Area Network (Section 5.4.1.1);
- Sensus Head End System (Section 5.4.1.2);
- Sensus FlexNet Communication Network (Section 5.4.1.3);

- AMI Applications (Section 5.4.1.4); and
- FEI Enterprise Systems (Section 5.4.1.5).

Figure 5-1: Project Logical Architecture



5.4.1.1 Sensus FlexNet Field Area Network

The Sensus FlexNet field area network (FAN) is a long-range radio network that provides scalable and reliable two-way communication infrastructure enabling communication modules (End Points) installed on meters or other field-based devices to transmit data for collection by Sensus FlexNet Base Stations (Base Stations).

Base Stations are long-range radio transceiver data collectors, usually mounted on tower and tall building infrastructure to ensure optimal coverage over large geographic areas. They provide two-way communication to the End Points described below and the Sensus Head End System (described in Section 5.4.1.2).

Information, such as meter consumption and status, will be transmitted to Base Stations at regular intervals by the following, which are collectively referred to as End Points:

1. **Sensus FlexNet Gateways:** standalone communication modules for station and pipeline/gas main sensing applications;
2. **Sensus SonixIQ™ advanced meters**: customer meters that comprise the majority of the Project End Points;
3. **Sensus FlexNet SmartPoint® modules**: communication modules to be mounted on existing gas meters where no installation of an advanced meter is contemplated; and

4. **Sensus FlexNet SentryPoints™**: communication modules to be installed on the gas network for cathodic protection applications (described in Section 5.4.1.4.2).

All End Points:

- Contain an integrated two-way radio frequency (RF) transceiver that is used for two-way wireless communication;
- Are programmed for hourly reads by default, with the exception of FlexNet Gateways which are expected to read data every 15 minutes;
- Transmit read data several times a day;
- Are able to transmit and receive encrypted data;
- Are reconfigurable remotely or locally using handheld devices;
- Transmit consumption with indication, if present, of alarm conditions including indication of a low battery voltage;
- Are capable of remote updates to firmware;
- Immediately transmit priority alarms to the system operator; and
- Read meters on demand.

FlexNet SmartPoint® modules, FlexNet Gateways and FlexNet SentryPoints™ are also referred to in this Application as non-meter sensors.

5.4.1.2 Sensus Head End System

A Head End System (HES) is the back office that controls the advanced metering infrastructure. Sensus' HES application is the Regional Network Interface (RNI)™, a configuration of network software and servers that communicate with Base Stations to continuously gather and process data to store or forward to other AMI applications (Section 5.4.1.4). Through standards-based interfaces, the RNI enables integration with FEI enterprise systems. Standards-based interfaces ensure that applications can share data freely with one another in a way that has been designed and endorsed by a standardization group usually comprised of vendors, experts, users and other stakeholders.

Specifically, the RNI:

- Receives and stores data from the Base Stations;
- Coordinates secure data requests with downstream FEI enterprise systems;
- Permits reporting of performance metrics and events such as priority alarms;

- Provides tools for monitoring, optimizing and managing network performance and overall health; and
- Provides controls and mechanisms for communication with End Points in a secure manner to ensure compliance with FEI customer data privacy obligations.

5.4.1.3 *FlexNet Communication Network*

The FlexNet communication network is the infrastructure that enables secure, dedicated (licensed radio-frequency spectrum) two-way data transmission between the End Points and Base Stations, and the HES.

Through the AMI wide area network (WAN), which will be supplied and managed by FEI, data from the Base Stations is received, aggregated and forwarded to the HES. Using dashboard capabilities that provide an overview of End Points on the network, system operators are able to manage, monitor and assess overall network health and:

- Identify and respond to alarms requiring attention such as meter health and temperature, meter tampering, low battery, etc.;
- Enable remote turn off/on of gas service;
- Turn off gas supply to large groups of customers as necessitated by emergencies; and
- Detect possible gas theft.

5.4.1.4 *AMI Applications*

Other Sensus AMI applications, further described below, are required to enable capabilities of the AMI Solution including meter data management, monitoring of FEI's corrosion mitigation assets, and mobile configuration and troubleshooting of End Points.

5.4.1.4.1 SENSUS ANALYTICS

Sensus Analytics (SA) is Sensus' meter data management software application that stores, validates, and processes high volumes of data sent from End Points. Its data management tools aggregate information from multiple systems to produce bill-ready data for use by FEI enterprise systems.

SA will deliver:

- Billing interfaces;
- Capabilities for data analysis, validation, estimation, and editing;
- Web-based reporting;
- Capabilities for graphical mapping;
- Automated notifications; and

- Capabilities to provide information to FEI staff on desktop, tablet, or smart phone interfaces.

5.4.1.4.2 CATHODIC PROTECTION SOFTWARE

SentryPoint Cathodic Protection is Sensus' software application that monitors FEI's corrosion mitigation assets. It automates the collection of data from communication modules on the gas network and delivers alarms to notify operators of potential problems and failures.

With traditional cathodic protection methods, FEI gains insight into the corrosive condition of assets several times a year. The cathodic protection software provides much more timely information. The software monitors corrosion remotely providing FEI with near-immediate information on the state of the assets through hourly readings and alarms. This technology will enable FEI corrosion specialists to work more efficiently by focusing on asset maintenance rather than data collection.

5.4.1.4.3 FIELDLOGIC™ SOFTWARE

Sensus' FieldLogic™ software, which will be owned and supported by FEI, includes a Windows mobile-based handheld computer and a smart phone app to configure and troubleshoot End Points. Using the hand-held computer or smart phone, FEI will be able to perform on-demand interrogation to control activation, programming and diagnostic settings of End Points.

5.4.1.5 *FEI Enterprise Systems*

5.4.1.5.1 DATA REPOSITORY AND LEAK DETECTION

FEI's data repository system is used for enterprise reporting and data analysis to inform FEI business strategy and decisions. The Project will enhance the data repository to:

- Provide gas interval consumption and metering information; and
- Enable capabilities to notify customers of gas flow anomalies for use in identifying potential gas leaks, faulty customer appliances and appliances/equipment that have been mistakenly left on.

5.4.1.5.2 CUSTOMER PORTAL

The current customer portal provides customers with access to their personal usage information, including current and past gas usage trends, payment and financial interactions and other billing data. The Project will enhance the existing customer portal to provide customers with a greater depth of detail of their hourly, daily or monthly usage with charts and graphs that are not possible to generate with the existing metering system data, including:

- Interval data at the hourly, daily, monthly and seasonal profiles as well as costs; and
- Granular comparisons from past billing periods to the current billing period.

5.4.2 The Project Software as a Service (SaaS) Model and Managed Services

SaaS is a software licensing and delivery model in which software applications are licensed on a subscription basis from a vendor who hosts the software applications and related data using its own server hardware, databases, networking and computing resources.

The AMI industry is in a state of continuous innovation. This is both a benefit and a risk to utilities using this technology to better serve their customers. Innovation can create a risk that environments require an upgrade or that technology gets stranded (before the end of its life cycle) in order to support vendor software or security releases. For complex, integrated computer systems, a SaaS model provides the utility with certainty that the system as a whole will meet contracted service level agreements. Many companies are moving to SaaS for certain applications for this reason.

The following Project applications will be owned, installed, operated and maintained by Sensus as a SaaS model:

- Head End System (Regional Network Interface (RNI)™) - IT hardware and software;
- Sensus Analytics - IT hardware and software; and
- SentryPoint cathodic protection – IT hardware and software.

Although owned by FEI, the FlexNet communication network (End Points, Base Stations, and AMI WAN) will be also be operated and maintained as managed services by Sensus.

Sensus will provide data centre services including, but not limited to, hardware and software patching, updates and upgrades. Additionally, Sensus will provide 24 x 7 x 365 monitoring of the availability and performance of the applications to ensure they are available to FEI.

The Sensus network and data infrastructure was evaluated for security and reliability, and all FEI and customer data will be hosted, stored, and accessed within Canada only. The Project SaaS environment uses a full-scale, replicated system for its backup and disaster recovery environment located in a different geographical area within Canada, with a recovery time objective (RTO) of 48 hours.

5.5 *IMPLEMENTATION APPROACH AND PROJECT SCHEDULE*

This section outlines the preliminary integrated, master Project schedule covering key project activities. Activities to plan and develop the Project, undertake the regulatory process, and prepare for implementation precede the start of planned implementation activities.

The implementation start date will be set after receipt of regulatory approval, with a complete integrated system and operational processes in-service date approximately four and a half years later.

5.5.1 The Project is Divided into Several Phases

Implementation of the Project is divided into the following phases, each with associated activities and milestones as described in the following sections:

1. Prepare (5.5.1.1);
2. Define (5.5.1.2);
3. Design, Build, Integrate and Ready For Deployment (5.5.1.3);
4. Deploy AMI Technology/Billing System Integration (5.5.1.4);
5. Deployment Regions 1 – 6 (5.5.1.5);
6. Deploy Enterprise Data Repository, Customer Portal, Leak Detection (5.5.1.6);
7. Final Acceptance (5.5.1.7); and
8. Close Out (5.5.1.8).

5.5.1.1 Prepare

During the Prepare phase, FEI contract negotiations with the to-be selected meter Deployment Vendor are finalized. The Project is organized and key FEI team members are mobilized. Standards, policies, processes, technologies and management frameworks are prepared to govern and manage the Project implementation. FEI team training is conducted to ready for Project kick-off, following regulatory approval.

5.5.1.2 Define

The full AMI Solution team is mobilized during the Define phase once Sensus and the to-be selected Deployment Vendor on-board their resources. Standards, policies, processes, technologies and management frameworks are communicated to the full implementation team and the Project is formally kicked-off.

Sensus and FEI will complete a number of joint workshops to define technology and integration requirements of the AMI Solution. FEI's preliminary assessment of the scope of people and process change is validated against workshop outcomes. Strategies for change management, training, internal communication and external relations are developed.

The Project deliverables, activities and responsibilities are coordinated to further develop details of the integrated master schedule which will govern the Project milestones and the order of operations for all subsequent phases of the Project implementation.

5.5.1.3 Design, Build, Integrate and Ready For Deployment

Requirements from the Define phase are translated into final designs for the build and testing of all technical components of the AMI Solution including changes to FEI systems required for integration. Operational process changes, necessitated by the implementation, are designed and validated.

Base Station site locations and lease agreements are finalized. The application for the radio-frequency spectrum license required for the FlexNet communication network is completed.

The HES and AMI applications are installed, configured and tested. Installation of network communication devices, non-meter sensors and advanced meters is planned for six deployment regions (outlined in Section 5.5.1.5).

Meter deployments, logistics and procurement activities are planned. Associated management processes and reports are developed.

Plans for FEI people and process change management, training, internal communications and external relations are developed. FEI training material development initiates.

5.5.1.4 Deploy AMI Technology/Billing System Integration

FEI acceptance testing is conducted for End Point qualification and certification, integration with FEI's billing system, and proper network functioning. The HES, AMI applications (Section 5.4.1.4), and associated billing system integration, are deployed. FEI is positioned to receive billing data from advanced meters.

5.5.1.5 Deployment Regions 1 – 6

Network communication devices, non-meter sensors, advanced meters, bypass valves, regulators and associated operational process changes will be deployed in phases in six deployment regions: Lower Mainland South (1), Lower Mainland North (2), North Interior (3), South Interior (4), Vancouver Island (5), and Kootenays (6).

In each deployment region, a deployment vendor warehouse is secured and procurement activities are undertaken to coordinate receipt of all meter and non-meter inventory.

A review session of each deployment region's network design precedes Sensus' installation of the network, which completes first to enable a fully operational network prior to the installation of non-meter sensors, advanced meters, bypass valves and regulators.

To achieve required performance stability, the network is optimized, which may include reconfiguration of Base Stations or antennae, or installation of new Base Stations.

FEI people and process change management, training, internal communications and external relations plans are deployed and monitored.

Each deployment region will meet FEI acceptance criteria to ensure performance standards and functionality of the AMI Solution are met.

Stabilization support of the AMI Solution initiates. FEI people and process changes continue to be monitored.

5.5.1.6 *Deploy Enterprise Data Repository, Customer Portal, Leak Detection*

During this phase, FEI conducts acceptance testing:

- To augment FEI's enterprise data repository used for reporting and data analytics, with gas interval consumption and metering information;
- To provide customers with the capability to access and view their consumption information via the customer portal; and
- To provide the ability to notify customers of gas flow anomalies for use in identifying potential gas leaks, faulty customer appliances and appliances/equipment that have been mistakenly left on.

Plans for FEI people and process change management, training, internal communications and external relations are deployed and monitored. Functionality is deployed for the enterprise data repository, customer portal and leak detection. Operational support is invoked.

5.5.1.7 *Final Acceptance*

In this phase, FEI confirms that:

- Contract obligations of Sensus and the to-be selected Deployment Vendor are met and all work is complete;
- All required inspections, acceptance tests and performance tests have been carried out and passed;
- The AMI Solution meets performance expectations and is in compliance with service level agreements; and
- FEI business processes and systems are stable and supported.

5.5.1.8 *Close Out*

During Close Out, all deliverables are finalized. Documentation is signed off, approved and archived ensuring that all work is completed according to the Project plan and scope. All project management processes are executed, including reconciliation and closure of financial accounts. Final reporting is completed.

5.5.2 Project Schedule

Table 5-2 details the broad, preliminary schedule by implementation phase. After receipt of BCUC approval, FEI will issue a Notice to Proceed to Sensus and the to-be selected Deployment Vendor, allowing 90 days to mobilize for implementation.

An overview of the summary schedule, in a Gantt chart, is provided as Appendix D.

Table 5-2: Project Schedule

Activity	Date
CPCN Filing	May 2021
Prepare	Q2 2021 – Q3 2022
Define	Q2 2022 – Q2 2023
Design, Build, Integrate and Ready For Deployment	Q2 2022 – Q3 2024
Deploy AMI Technology/Billing System Integration	Q3 2022 – Q3 2023
Deployment Region 1: Lower Mainland South	Q4 2022 – Q2 2025
Deployment Region 2: Lower Mainland North	Q2 2024 – Q4 2026
Deployment Region 3: North Interior	Q2 2023 – Q3 2025
Deployment Region 4: South Interior	Q1 2023 – Q2 2026
Deployment Region 5: Vancouver Island	Q3 2023 – Q3 2026
Deployment Region 6: Kootenays	Q3 2024 – Q4 2026
Deploy Enterprise Data Repository, Customer Portal, Leak Detection	Q1 2024 – Q1 2025
Final Acceptance	Q3 2026
Close Out	Q3 2026 – Q4 2026

5.6 NECESSARY PROJECT RESOURCES UNDER CLEAR GOVERNANCE FRAMEWORK

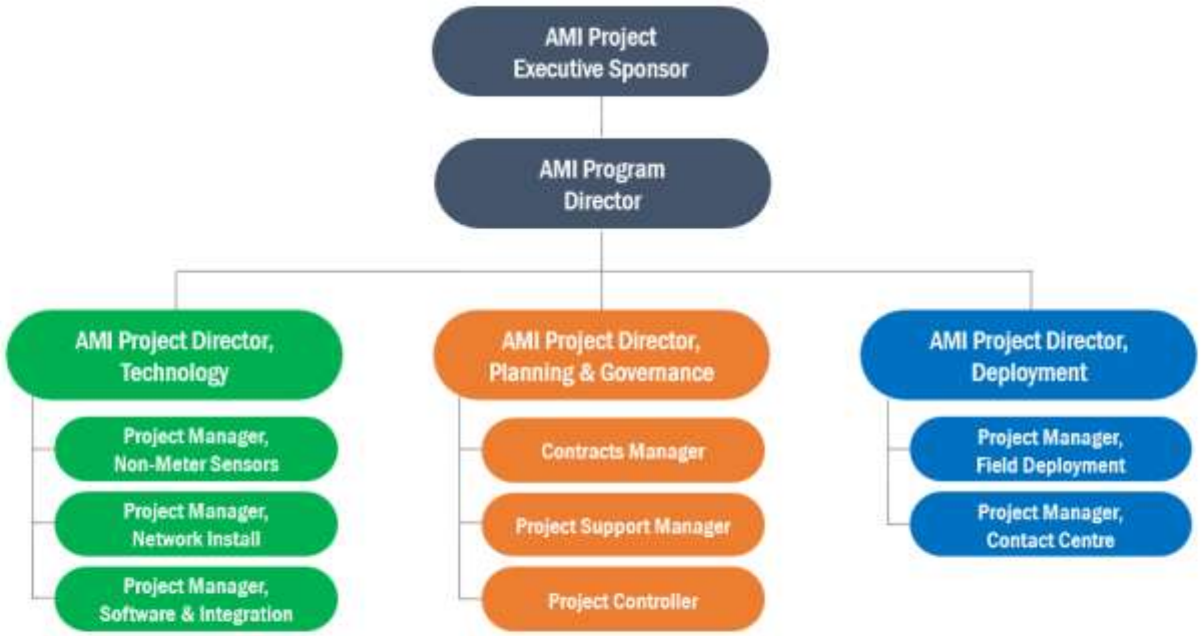
The Project will impact many functional areas within FEI and will change how the Company interacts with customers. To be successful, the entire Company must be prepared for the required changes that will occur to operations, processes and communications. FEI departments, as represented by functional managers and their respective departmental resources, will provide their expertise when required to ensure a successful implementation.

FEI's Project is organized to ensure the Project is resourced with an appropriate mix of internal and external expertise.

5.6.1 Project Leadership Team

The Project, including Sensus and the to-be-selected Deployment Vendor resources, will be governed and managed by FEI's Project leadership team as shown in Figure 5-2. FEI's Project leadership roles are described in Sections 5.6.2 and 5.6.3.

Figure 5-2: Proposed FEI Project Functional Organization Chart



5.6.2 Project Sponsorship

5.6.2.1 AMI Project Executive Sponsor

The *VP, Customer Service & Information Systems* will ensure alignment of the Project with organizational strategy. As FEI champion of the Project, the Executive Sponsor will provide continuity between the Project, the business community, external stakeholders, Indigenous communities, and strategic level decision-making groups.

5.6.2.2 AMI Program Director

The *Director, Energy Measurement & Technology* holds overall accountability for acceptable delivery of the AMI Solution on time, in scope and on budget. The AMI Program Director will ensure that sufficient and appropriate resources are assigned, and provide business context, expertise, support and guidance to the Project delivery team to ensure obstacles are removed and business objectives of the Project are achieved. In this role, the AMI Program Director will also keep abreast of Project activities to ensure adequate and consistent communication between the AMI Project Executive Sponsor, the Project team and representatives from all major aspects of FEI operations.

5.6.3 Project Execution

Execution of the Project will be led by three AMI Project Directors, each with specific areas of accountability as described below in Sections 5.6.3.1, 5.6.3.2 and 5.6.3.3.

5.6.3.1 AMI Project Director, Technology

The *AMI Project Director, Technology* is accountable for delivery of all technology aspects of the Project on time and within budget. This role is active in planning technology scope and schedule; provides guidance and direction to FEI project managers; liaises with Sensus' resources to ensure that FEI requirements and Sensus contractual obligations are met; approves technology related scope changes; signs off on major deliverables; provides approval to proceed to each succeeding phase of the Project, including final acceptance; and resolves and/or escalates issues.

5.6.3.1.1 PROJECT MANAGER, NON-METER SENSORS

The *Project Manager, Non-Meter Sensors* is responsible for developing, in conjunction with Sensus, the detailed non-meter sensor deployment plan and managing execution ensuring adherence to deployment milestones established in the Project master integrated schedule. This role provides oversight and guidance to FEI and Sensus Project team members; manages costs; resolves and/or escalates issues; and manages the hand-off of installed non-meter sensor infrastructure to operational groups.

5.6.3.1.2 PROJECT MANAGER, NETWORK INSTALL

The *Project Manager, Network Install* is responsible for managing, in conjunction with Sensus, the design, planning and scheduling of required communication infrastructure and supporting network devices ensuring alignment with deployment milestones established in the Project master integrated schedule. This role provides oversight and guidance to FEI and Sensus' network device deployment Project team members; manages procurement activities and costs; supervises site lease acquisition activities, resolves and/or escalates issues; ensures the network meets all specifications and committed service levels; and manages the hand-off of installed network infrastructure to operational groups.

5.6.3.1.3 PROJECT MANAGER, SOFTWARE & INTEGRATION

The *Project Manager, Software & Integration* is responsible for overseeing Sensus' design and delivery of the SaaS model including the definition of requirements, design, build, testing and integration of all associated enhancements to FEI's systems including the billing system, enterprise data repository, customer portal, and functionality for leak detection. Per the Project master integrated schedule, this role provides oversight and guidance to FEI and Sensus' software and integration Project team members; manages procurement activities and costs; resolves and/or escalates issues; and manages the deployment, and subsequent hand-off, of installed software to operational groups.

5.6.3.2 *AMI Project Director, Planning & Governance*

The *AMI Project Director, Planning & Governance* is accountable for establishing the methodology for managing the Project and oversees the development of policies, procedures and governance practices required for Project control. This role guides detailed planning of the Project master integrated plan for all scope; signs off on major deliverables; provides approvals to proceed to each succeeding Project phase; resolves and/or escalates issues; and provides guidance and direction to the FEI Planning & Governance team responsible for project reporting, financial management, contracts administration, regulatory and legal interactions, community relations and change management.

5.6.3.2.1 CONTRACTS MANAGER

The *Contracts Manager* is responsible for drafting, evaluating, negotiating and facilitating execution of procurement activities. This role serves as a single point of contact for administration of contracts; manages all contract-related correspondence and documentation; facilitates resolution of, or escalates contract related issues; and communicates contract-related information to all stakeholders. The Contracts Manager also manages all Project documentation in accordance with the governance practices established for Project controls.

5.6.3.2.2 PROJECT SUPPORT MANAGER

The *Project Support Manager* is responsible for facilitation and management of regulatory and legal requirements and interactions; supporting community relations; and working with groups throughout the Company to guide FEI people and process change management. This role provides oversight and guidance to develop strategies/plans, and subsequently manage FEI change including operational process redesign, internal communications, external relations, and training design and delivery.

5.6.3.2.3 PROJECT CONTROLLER

The *Project Controller* is responsible for collaborating with FEI, Sensus and to-be Deployment Vendor Project Managers to develop and maintain the Project's detailed master integrated schedule. This roles manages the Project budget; analyzes progress reported against the master integrated schedule; maintains and manages the Project risk repository and issue log; and prepares financial and performance reports.

5.6.3.3 *AMI Project Director, Deployment*

The *AMI Project Director, Deployment* is accountable for delivery of all meter deployment aspects of the Project on time and within budget. This role is active in planning meter deployment scope and schedule; approves meter related scope changes; signs off on major deliverables; provides approvals to proceed to each succeeding Project phase; resolves and/or escalates deployment issues; provides guidance and direction to FEI project managers; and liaises with the to-be selected Deployment Vendor to ensure contractual obligations are met.

5.6.3.3.1 PROJECT MANAGER, FIELD DEPLOYMENT

The *Project Manager, Field Deployment* is responsible for developing, in conjunction with the to-be selected Deployment Vendor, the advanced meter deployment plan, and managing execution ensuring adherence to deployment milestones established in the Project master integrated schedule. This role provides oversight and guidance to FEI and to-be selected Deployment Vendor installation Project team members; ensures FEI quality, health, safety and environment standards have been met; manages procurement activities and costs; resolves and/or escalates issues; and manages the hand-off of installed meter infrastructure to operational groups.

5.6.3.3.2 PROJECT MANAGER, CONTACT CENTRE

The *Project Manager, Contact Centre* liaises with FEI Customer Service and is responsible for collaborating with the to-be selected Deployment Vendor to inform workflows, processes and training that will ensure interactions with FEI customers provide an experience equal to that provided by FEI Contact Centre staff. This role provides oversight and guidance to the to-be selected Deployment Vendor Project team members; ensures FEI customer service quality standards and to-be Deployment Vendor contractual metrics have been met; and resolves and/or escalates issues.

5.7 RISK ANALYSIS AND CONTINGENCY DETERMINATION

The overall objectives of the risk analysis process were to:

- Identify key risk areas requiring the Project team's attention for planning the Project;
- Perform qualitative analysis to prioritize and rank the risk using a risk matrix, as described in Section 5.7.2;
- Identify those risk items that can have a critical effect on the Project outcome; and
- Articulate critical risk information that was used as an input to the Project's cost and schedule risk quantification and contingency estimation.

5.7.1 Risk Analysis and Management

FEI engaged Yohannes Project Consulting Inc. (YPCI), a company specializing in risk management, to guide FEI's risk analysis. In accordance with FEI's risk management framework, risk drivers were quantitatively and qualitatively identified. The detailed Risk Analysis and Risk Register (the YPCI Risk Report) is included as Confidential Appendix E-1.

5.7.2 Risk Identification

The risk identification and qualitative analysis was completed using the AACE International Recommended Practice: 62R-11 *"Risk Assessment: Identification and Qualitative Analysis"* (Rev. May 11, 2013) (AACE 62R-11) as a guide.

Risks were identified through workshops that leveraged the knowledge of internal FEI employees experienced with large-scale projects, including but not limited to the FBC AMI Project. Additionally, FEI solicited risk knowledge from a consultant familiar with several North American AMI implementation projects and spoke to several utilities who have deployed electric and gas AMI solutions.

The appropriate risk likelihood and consequence (probability and exposure or consequence) scales relevant to the Project are based on the 5 by 5 risk assessment matrix recommended in AACE 62R-11 illustrated in Figure 5-3.

Figure 5-3: Risk Assessment Matrix

		Note: For purpose of selecting impact of an event, utilize most severe outcome of Project Specific and Corporate impact analyzed				
		Very Low	**Low**	**Medium**	**High**	**Very High**
Probability (Likelihood)	**Very High (>50%)**	Moderate	Moderate	Major	Major	Major
	High (5 - 50%)	Minor	Moderate	Major	Major	Major
	Medium (1-5%)	Minor	Moderate	Moderate	Major	Major
	Low (0.1-1.0%)	Minor	Minor	Moderate	Moderate	Moderate
	Very Low <0.1%	Minor	Minor	Minor	Minor	Moderate

5.7.3 Risk Register, Qualitative Assessment and Action Plan

This risk identification process identified a number of risks which are tabulated in the risk register document included in Appendix 3 to the YPCI Risk Report (Confidential Appendix E-1). The risk response actions to deal with the identified risks were also recorded, forming the basis of the qualitative risk analysis. Once the risks were identified, a qualitative analysis was completed to prioritize or rank the risks so that the Project team could focus on risk response actions and mitigation for the high priority risks. Through this qualitative process FEI applied a likelihood category and consequence rating to each risk identified, as shown in the Risk Assessment matrix in Figure 5-3 above. The product of the likelihood and consequence was then used to establish the overall risk score and ranking for each risk.

The risk register is dynamic and risks will be continually identified, tracked and updated throughout the Project.

5.7.4 Quantitative Risk Analysis (QRA) and Contingency Determination

FEI developed the base cost estimate using AACE International Recommended Practice No. 18R-97 as a guide. The cost estimate is based on preliminary designs, known existing quantities, labour rates and estimated customer growth. Detailed low, expected and high estimates were completed for cost categories of Project Management, Software Capital, Network Capital, Non Meter Capital, Meter Capital and AMI Meter Deployment.

The ranged estimate, combined with expert judgment and the expected value method, was used to calculate the total required contingency for the Project following recognized best practices described in AACE RPR-08. While contingency will be managed in aggregate, the contingency calculated for each cost category was used as an input to the financial model to best approximate the expected impact of the contingency spend.

YPCI subsequently completed a quantitative analysis evaluating the impact of the Project's risks to validate contingency estimates prepared by FEI's Project estimating personnel.

As a result, FEI's recommended contingency for the Project is $34.3 million, or 6.2 percent. As the project design advances through detailed design, the contingency will be re-evaluated using a methodology that continues to align with AACE recommended practices.

5.8 *PROJECT CONSIDERATIONS*

The technology associated with AMI has been a topic of public discussion since at least 2011. Concerns have been expressed regarding the electromagnetic radio signals from the meters and collectors, as well as the privacy and security of consumption information recorded and transmitted by the meters. These topics gained considerable attention in the media, particularly in British Columbia, in connection with BC Hydro's and FBC's respective smart meter and AMI implementations. The discussion provided below examines these previously expressed concerns in the context of FEI's proposed AMI Solution.

5.8.1 Radiofrequency Electromagnetic Fields

FEI's proposed AMI Solution is comprised of two-way communicating End Points connected as part of a Radio Frequency (RF) network. There has been discussion with respect to potential effects on human health resulting from exposure to RF electromagnetic fields in the frequency range of 3 kilohertz to 300 Gigahertz. Such concerns were addressed by the BCUC in approving FBC's AMI project. As the Panel summarized on p. ii of its July 2013 decision,[57] in granting a CPCN for FBC's AMI Project, its findings included the following:

- Health Canada's Safety Code 6 takes into account the scientific evidence related to the impact of thermal and non-thermal effects of radio frequency emissions on human health and provides an appropriate degree of precaution in setting the limits for these emissions;
- The radio frequency emissions generated by the Project are significantly below the levels set out in Safety Code 6 established by Health Canada to ensure such emissions are not harmful to human health;
- While there are individuals who feel strongly the low level electromagnetic emissions will have a negative impact on their health, the scientific evidence in this Proceeding does not persuade the Panel that there is a causal link between radio frequency emissions and the symptoms of electromagnetic hypersensitivity.

[57] Decision accompanying BCUC Order C-7-13, page ii.

FEI commissioned an independent study that examined the specific technology proposed for the Project and compared exposure levels from all End Points of the proposed FEI network to the Safety Code 6 exposure limit as well as other commonly used devices (the Exponent RF Technology Report). The Exponent RF Technology Report is provided as Appendix F-1 and concludes that the proposed meters are many orders of magnitude below the safe exposure limits set out by Health Canada. The Exponent RF Technology Report further states that:

> Under typical operation, the Sonix IQ gas meter transmits RF energy a total of approximately 0.34 seconds per day. This very short transmission time also means that the indoor RF exposure from the Sonix IQ gas meter is about 24 million times lower than the SC6 exposure limit, and substantially lower than the RF exposures from common natural and man-made sources.

FEI also commissioned an independent study reviewing the latest scientific research on the potential health effects of EMF, as well as the potential impact of FEI's chosen technology (the Exponent RF Health Report). The Exponent RF Health Report summarizes the comprehensive risk assessments and reviews of RF exposure and health conducted by independent scientists with expertise in relevant scientific disciplines, which have consistently concluded that the scientific evidence in the large number of published scientific studies does not confirm that RF fields at levels below the scientifically-based exposure limits are a cause or contribute to development of any adverse health effects, including cancer, other chronic diseases, or non-specific adverse symptoms that affect well-being. The Exponent RF Health Report is provided as Appendix F-2.

FEI and Sensus have reviewed both Exponent reports and confirm that all statements made with respect to the technology and how FEI intends to implement it, are accurate.

5.8.2 Security

The security of customer information is a high priority to FEI. Given the nature of the AMI Solution, security needs to be considered for several components. These include the meters, network, Base Stations, HES, Sensus applications and FEI enterprise systems. Since many components are installed at residential or business properties and on Company-owned infrastructure, it is critical that the electronic security of the components be comprehensive.

The requirement for security of information within all elements of the AMI Solution is thus a key consideration throughout design, procurement and implementation. FEI's objective is to follow the security specifications set out in the AMI-SEC[58] AMI System Security Requirements. In addition, FEI will ensure that security audits are carried out by a third-party agency during implementation and on an on-going basis thereafter to verify that the AMI Solution implemented continuously meets or exceeds the security standards as set forth in AMI-SEC.

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[58] AMI-SEC is a North American Advanced Metering Infrastructure task force charged with developing security guidelines, recommendations, and best practices for AMI system elements.

The security requirements for the AMI Solution include considerations for, but not limited to, the following:

- Confidentiality, integrity, security and privacy of data at rest or in transit;
- Controls for malicious code detection, spam protection and intrusion detection;
- User authentication and user role controls based on access of least privilege (that is, users can be set up in the system with the least amount of access required to complete their roles);
- Audit controls and logging of user actions and events; and
- Resistant to outside electromagnetic interference.

FEI retained a cybersecurity expert consultant to provide a detailed analysis on mechanisms built into the Sensus AMI technology and in particular to how the Company will be using the technology and integrating it with existing and new systems as part of the Project. This independent analysis concluded that the system provides sufficient levels of security for the purposes of its intended use and made recommendations that will inform definition and design deliverables of the Project.

In summary, the security architecture is designed to secure customer data and minimize risks of security breaches on the infrastructure. The meters, non-meter sensors, network, and HES are monitored to prevent intrusion and malicious attacks against the AMI Solution.

5.8.3 Privacy

FEI respects its customers' privacy and seeks to protect their personal information. The protection of personal information in British Columbia is governed by the provisions of the *Personal Information Protection Act* (PIPA) and the federal *Personal Information Protection and Electronic Documents Act* (PIPEDA), as applicable. FEI's privacy policy is applicable to all of the Fortis companies within British Columbia. The privacy policy applies to all personal information collected, used or disclosed by FEI, some of which will be collected using the advanced metering system.

The following are some important points regarding customer privacy as it applies to the AMI Solution:

- The privacy policy applies to the collection, use and disclosure of personal information through the AMI Solution used by FEI, including advanced meters, metering equipment systems and technology;
- FEI already collects gas consumption information about its customers. The AMI Solution will allow FEI to collect the same data, but more frequently;

- The information collected is sent automatically from the meter through encrypted wireless technology. The information transmitted is de-identified and must be re-identified when received by FEI to determine which customer it is associated with;
- The AMI Solution cannot collect personal information about the source of gas consumption within a premise; it can only collect aggregate gas consumption data for the entire premise at any given time;
- FEI considers the security of consumption information collected via the AMI Solution to be an important and significant priority. The measures enacted to ensure security of information include, but are not limited to, the following:
  - Controls for malicious code detection, spam protection and intrusion detection;
  - User authentication and user role controls;
  - Audit controls and logging of user actions and events;
  - Alarms for outside electromagnetic interference and other tampers;
  - Encryption providing confidentiality for customer data;
  - Use of firewalls; and
  - Secure storage of customer data. The security architecture is designed to secure customer data and mitigate the risk of security breaches.

5.8.4 Customer Refusals and Opt-Out

FEI believes some customers will not want an advanced meter installed on their premises; consequently, it is possible that some customers will seek to refuse the installation of an advanced meter.

FEI plans to work with these customers, seeking to understand any concerns they may have, sharing the benefits of the Project and addressing their concerns to the extent possible. By doing so, FEI hopes to successfully transition these customers to advanced meters. Regardless of FEI's efforts, some customers may continue to refuse the installation of an advanced meter. In these cases, FEI intends to continue productive dialogue with the customer throughout deployment of the Project where possible, making an effort to address concerns so that an advanced meter can be installed. Where a customer is refusing the installation of the advanced meter due to its remote communicating capabilities, the customer will have the option to have an advanced meter installed with the internal communicating radio turned off for a fee. The advanced meter will continue to operate as a meter when deactivated; however, it will no longer communicate with Base Stations. Customers choosing to opt out will be required to pay for their meters to be manually read.

5.8.5 Anticipated Amendments to FEI's General Terms and Conditions and Rate Schedules

FEI anticipates that, should the AMI Solution be approved, certain amendments to FEI's General Terms and Conditions (GT&Cs) and applicable commercial and industrial rate schedules will be required. These tariff changes will be required to reflect the new and updated operating terms, conditions, fees and meter specifications as a result of the Project. FEI believes that it would be most efficient to propose specific tariff changes related to the Project after the BCUC makes a determination on the Project and, if approved, closer to the actual implementation date. This application will also include the processes and fees for customers who choose the Radio-off AMI Meter Option, and the proposed fees will be set to recover the incremental costs of opting out of the AMI Solution. As such, FEI expects to file an application for the necessary tariff changes at least six months prior to the Project's first regional deployment. However, from a broad perspective, the following two tables provide an indication of the potential tariff amendments currently anticipated, which would be included in a future application.

Table 5-3: Summary of Potential Amendments to the FEI GT&Cs

Section	Potential Amendments
Definition: "Advanced (or AMI) Meter"	New definition for advanced meters with activated integrated wireless transmit functions.
Definition: "Radio-off AMI Meter"	New definition for advanced meters with integrated wireless transmit functions that are disabled.
Definition: "Radio-off Customer"	New definition for customers with advanced meters who wish to have the wireless transmit functions disabled.
11.2 (Measurement)	Amendments to reflect specifications of advanced meters.
11.3 (Testing Meters)	Amendments to reflect specifications of advanced meters.
14.4 (False-Site Visit)	New subsection reflecting the terms and conditions for when an FEI representative is refused access to a Premise. This section will also reference the new "False Site Visit Charge" set out in the Standard Charges Schedule.
16.8 (Customer Selected Bill Date)	New subsection reflecting the terms and conditions relating to allowing customers the ability to select their bill due date.
18. (Radio-Off Advanced Meter Option)	New section reflecting the terms and conditions for customers who choose the Radio-off AMI Meter Option. More specifically, the section will outline the process for enrollment for customers who wish to have an advanced meter installed but with the internal communicating radio turned off for a fee. This section will also reference the applicable "Radio-off Option Standard Charges" set out in the Standard Charges Schedule.

Section	Potential Amendments
Standard Fees and Charges Schedule	"Meter Testing Charges" Amendments to reflect specifications of advanced meters. Potential revised rate(s) after internal cost analysis.
Standard Fees and Charges Schedule	"Reactivation Charges" Amendments to reflect specifications of advanced meters. Potential revised rate(s) after internal cost analysis and to reflect manual reactivation.
Standard Fees and Charges Schedule	<u>Proposed New Charges</u> "Radio-off Option Standard Charges" • Pre-Commencement of AMI Solution Deployment Per-Premise Setup Fee • Per-Premise Setup Fee • Per-Read Fee Other Charges • Remote Reconnection of Meter after Disconnection Charge • False Site Visit Charge

Table 5-4: Summary of Potential Amendments to the FEI Rate Schedules[1, 2]

Section	Draft Amendments
8. (Measuring Equipment)	Amendments to reflect specifications of advanced meters.
9. (Measurement)	Amendments to reflect specifications of advanced meters.

<u>Notes</u>:

[1] Applicable FEI Rate Schedules (RS) may include RS 4, 5, 6, 7, 22, 23, 25, 26 and 27.

[2] RS 5 used as an example.

5.9 *CONCLUSION*

The AMI Solution has been developed with the assistance of industry experts and internal resources with the relevant knowledge and experience. In planning for AMI Solution delivery, FEI has drawn on key learnings from a similar project completed by FBC and the Pilot project conducted in the gas utility context.

Further, FEI submits that it has developed a reasonable Project schedule, which will be managed under a clear governance framework, taking into consideration the necessary Project resources. Finally, FEI believes it has identified the key risks and considerations that could impact successful completion of the Project and has taken a prudent approach to risk management.

6. PROJECT COSTS

6.1 INTRODUCTION

This section discusses the costs of the Project, including contingency, and the financial analysis. Within the financial analysis section, FEI provides the assumptions, the accounting treatment, and the estimated incremental delivery rate impact of the Project.

FEI approached the financial analysis for this Project by comparing two full cost scenarios, with the difference between the scenarios being the incremental financial impact of the Project. The first scenario is FEI's Baseline meter program that represents the costs FEI expects to incur if the AMI Project is not approved. The second relates to the proposed AMI Solution. FEI took this analytical approach because of the number of changes to both operating and capital costs that will take place with approval of the Project and the requirement to understand what the operating and capital costs would have been without the Project to determine the impact. The following discussion details the expected cost of the AMI Solution compared to the expected cost of the Baseline scenario, with the difference between the two being the expected incremental cost of the Project.

As discussed in Section 5.5, the Project implementation is scheduled to take four years. In addition to these four years of implementation, FEI will continue to incur development and regulatory proceeding costs up until deployment starts in 2023. For the purpose of this section and analysis, costs have been grouped into three phases:

1. Pre-deployment - the time period from 2021 to 2022. During this phase, costs are being incurred for Project development and for the regulatory proceeding;
2. Deployment – the time period from 2023 to 2026. These are the years in which the majority of the AMI meters will be deployed; and
3. Post-deployment – the time period from 2027 to 2046. This is the time period over which the new AMI meters are expected to be in service, based on the estimated useful life of the new AMI meters of 20 years. The majority of the financial benefits of the Project, consisting primarily of reduced meter reading costs, will be realized over this phase.

Only the costs in the Pre-deployment and Deployment phases are classified as the cost of the Project. The costs and savings in the Post-deployment phase are provided to evaluate the financial impact of the Project over the financial analysis period.

In the following Section 6.2, cost estimates are provided, followed by additional details supporting the estimates. In Section 6.3, the financial analysis discussion uses these cost estimates to calculate the estimated incremental delivery rate impact of the Project.

6.2 PROJECT COSTS

This section provides the expected capital and O&M costs of the AMI Solution, as well as the incremental costs when compared to the Baseline costs. Table 6-1 below summarizes the total estimated capital and O&M costs of the AMI Solution, the current Baseline meter program costs, and the incremental costs. Costs shown are in estimated as-spent dollars and include contingency and allowance for funds used during construction (AFUDC).

Table 6-1: Capital and Operating Cost Summary

Project Costs As-Spent in $Millions		Pre Deployment	Deployment	Subtotal (1+2)	Post Deployment	Total (3+4)	
Line	Item	2021 - 2022 (1)	2023 - 2026 (2)	2021 - 2026 (3)	2027 - 2046 (4)	2021 - 2046 (5)	Reference [1] (6)
	AMI						
1	Capital[2]	48.6	589.8	638.4	119.3	757.7	Schedule 6,Line 46 + Schedule 9,Line 31+Line 39+Line 41+Line 43
2	O&M	34.7	72.8	107.6	234.3	341.9	Schedule 2,Line 13
	BASELINE						
3	Capital	46.8	115.6	162.4	474.3	636.7	Schedule 6,Line 28
4	O&M	35.1	77.2	112.3	548.2	660.5	Schedule 6,Line 12
	INCREMENTAL [3]						
5	Capital	1.8	474.2	476.0	(355.0)	121.0	Schedule 6,Line 39 + Schedule 9,Line 28+Line 36+Line 40
6	O&M	(0.4)	(4.3)	(4.7)	(313.9)	(318.6)	Schedule 2,Line 14

Notes:

[1] *Appendix G-3 contains the AMI financial schedules.*

Appendix G-4 contains the Baseline financial schedules.

Appendix G-5 contains the Incremental financial schedules.

[2] *Includes AMI Application and Development deferral additions and AFUDC.*

[3] *Incremental cost AMI Solution less Baseline.*

As shown in Table 6-1, the AMI Solution capital cost is estimated at $638.4 million[59] compared to the Baseline capital cost of $162.4 million[60] with the incremental capital cost of the Project estimated as $476.0 million[61]. Additionally, there is an estimated incremental O&M reduction over the Pre-deployment and Deployment phases of $4.7 million[62].

During the Post-deployment phase, FEI estimates reduced capital spending of $355.0 million[63]. FEI also estimates Post-deployment incremental O&M savings of $318.6 million[64].

When considering the entire life cycle of the Project, there is an estimated reduction in costs of $197.6 million[65].

[59] Table 6-1, column 3, line 1.
[60] Table 6-1, column 3, line 3.
[61] Table 6-1, column 3, line 5.
[62] Table 6-1, column 3, line 6.
[63] Table 6-1, column 4, line 5.
[64] Table 6-1, column 4, line 6.
[65] Table 6-1, column 5, line 5 + column 5, line 6.

FEI has prepared the cost estimates based on AACE Class 3 specifications in accordance with the BCUC's CPCN Guidelines. Cost estimates are based on a mix of negotiated contract prices, FEI current costs adjusted for inflation, and FEI's estimates of future expected costs.

Further details on the costs set out in Table 6-1 are provided in Section 6.2.1 for capital costs and Section 6.2.2 for O&M costs.

6.2.1 Capital Costs

This section provides information supporting the capital costs introduced in Table 6-1 above. The capital cost is made up of the following categories:

1. Meter Capital which is composed of meter hardware, meter installation, bypass valve hardware and installation, and a contact centre booking charge. This capital is discussed further in Section 6.2.1.1;
2. AMI Project Management discussed in Section 6.2.1.2;
3. AMI Network & Software discussed in Section 6.2.1.3;
4. Non-Meter Capital discussed in Section 6.2.1.4; and
5. Meter Reading Capital, which is only applicable to the Baseline scenario, and is discussed in Section 6.2.1.5.

Table 6-2 below summarizes the detailed AMI Solution, Baseline, and incremental Project capital. As the investment in the Project will result in substantial savings Post-deployment, these estimates have also been included in the table.

Table 6-2: Capital Cost Summary

Line	Project Capital Costs As-Spent in $Millions Item	Pre Deployment 2021 - 2022 (1)	Deployment 2023 - 2026 (2)	Subtotal (1+2) 2021 - 2026 (3)	Post Deployment 2027 - 2046 (4)	Total (3+4) 2021 - 2046 (5)	Reference [1] (6)
1	Meter Capital	28.4	507.9	536.3	111.7	648.0	Schedule 6, Lines 3 through 9
2	AMI Project Management	15.6	38.0	53.7	-	53.7	Schedule 6, Lines 13 through 17 + Schedule 9 Lines 31+39+41
3	AMI Network & Software	3.6	24.4	28.0	6.4	34.4	Schedule 6, Lines 10 through 11
4	Non-Meter Capital	0.1	3.5	3.6	1.2	4.8	Schedule 6, Line 12
5	AFUDC	0.9	15.9	16.8	-	16.8	Schedule 6, Line 36 + Schedule 9 Line 43
6	**AMI Solution**	**48.6**	**589.8**	**638.4**	**119.3**	**757.7**	Sum of Lines 1 through 5
7	Meter Capital	46.6	112.5	159.1	456.0	615.1	Schedule 6, Lines 1 through 5
8	Non-Meter Capital	0.2	3.1	3.3	3.2	6.6	Schedule 6, Lines 6
9	Meter Reading Capital	-	-	-	15.1	15.1	Schedule 6, Lines 7 through 9
10	**Baseline**	**46.8**	**115.6**	**162.4**	**474.3**	**636.7**	Sum of Lines 7 through 9
11	Meter Capital	(18.2)	395.4	377.3	(344.4)	32.9	Line 1 less Line 7
12	AMI Project Management	15.6	38.0	53.7	-	53.7	Line 2
13	AMI Network & Software	3.6	24.4	28.0	6.4	34.4	Line 3
14	Non-Meter Capital	(0.1)	0.4	0.2	(2.0)	(1.8)	Line 4 less Line 8
15	AFUDC	0.9	15.9	16.8	-	16.8	Line 5
16	Meter Reading Capital	-	-	-	(15.1)	(15.1)	Line 9
17	**Project Costs[2]**	**1.8**	**474.2**	**476.0**	**(355.0)**	**121.0**	Sum of Lines 11 through 16 [3]

Notes:

[1] *Appendix G-3 contains the AMI financial schedules*

Appendix G-4 contains the Baseline financial schedules

Appendix G-5 contains the Incremental financial schedules

[2] Incremental cost AMI solution less Baseline

[3] AMI Project Management has been allocated to asset accounts in incremental financial schedules. Detail in lines 11-14 are before Project Management allocation and do not agree to amounts in the incremental financial schedules that are after allocation of project management. The reference for Line 17 that agrees to financial schedules is Schedule 6, Line 39 + Schedule 9, Lines, 28+36+38 +40.

As shown in the table above, the AMI Solution capital cost is estimated at $638.4 million[66] and the incremental Project capital cost is estimated at $476.0 million[67]. The Project is estimated to generate incremental net savings of $355.0 million[68] in capital spending over the Post-deployment phase.

The AMI Solution capital costs include contingency and AFUDC. Section 5.7 discussed project risk and described FEI's approach to determining contingency. FEI has included $34.3 million[69] in contingency through deployment of the Project allocated to meter capital, AMI project management, network & software, and non-meter capital. AFUDC is discussed in Section 6.3.2.1 below.

The sections that follow provide additional details supporting the costs included in each of the capital categories. Confidential Appendix G-1 and G-2 contains the detailed calculations for the capital and O&M costs used in this analysis.

6.2.1.1 Meter Capital

The meter capital cost is the largest portion of Project capital costs. The AMI Solution meter capital cost is estimated at $536.3 million[70] which is $377.3 million[71] higher than what is estimated to be spent in the Baseline estimate of $159.1 million[72]. This incremental cost is offset by an estimated $344.4 million[73] in meter capital savings in the Post-deployment period driven by the decreased volume of meter exchanges.

Meter capital has been forecast on a unit basis for both meter exchanges and new customer additions. Table 6-3 below summarizes the estimated number of meter exchanges and new meter additions expected in both the AMI and Baseline scenarios during the Pre-deployment, Deployment, and Post-deployment phases.

[66] Table 6-2, column 3, line 6.
[67] Table 6-2, column 3, line 17.
[68] Table 6-2, column 4, line 17.
[69] Section 5.7.4 .
[70] Table 6-2, column 3, line 1.
[71] Table 6-2, column 3, line 11.
[72] Table 6-2, column 3, line 7.
[73] Table 6-6, column 4, line 11.

Table 6-3: Meter Unit Summary

Meter Units 000's		Pre Deployment	Deployment	Subtotal (1+2)	Post Deployment	Total (3+4)
Line	**Item**	**2021 - 2022 (1)**	**2023 - 2026 (2)**	**2021 - 2026 (3)**	**2027 - 2046 (4)**	**2021 - 2046 (5)**
1	Meter Exchanges	45.0	1,053.6	1,098.6	106.6	1,205.2
2	New Meters	23.5	42.5	66.0	144.6	210.6
3	**Total AMI Meter Units**	**68.5**	**1,096.1**	**1,164.6**	**251.2**	**1,415.9**
4	Meter Exchanges	90.0	214.0	304.0	894.2	1,198.2
5	New Meters	23.5	42.5	66.0	144.6	210.6
6	**Total Baseline Meter Units**	**113.5**	**256.5**	**370.0**	**1,038.8**	**1,408.8**
7	Meter Exchanges	(45.0)	839.6	794.6	(787.6)	7.0
8	New Meters	-	-	-	-	-
9	**Incremental Units**	**(45.0)**	**839.6**	**794.6**	**(787.6)**	**7.0**

For the AMI Project, FEI expects to complete an estimated 1.1 million[74] meter exchanges in the first two phases of the Project and an estimated 106 thousand[75] exchanges Post-deployment. The number of meter exchanges over the Baseline is an estimated incremental 795 thousand[76] through the Deployment phase, offset by a reduction of 788 thousand[77] meter exchanges in the Post-deployment phase.

FEI notes the Baseline meter exchange units are based on FEI's current meter exchange and sampling program. The Post-deployment phase for Baseline includes the continuation of the Baseline existing meter exchange program, and AMI includes an annual allowance of 0.50 percent of meter failures that would require replacement based on historical failure data provided by the manufacturer.

In Table 6-3, FEI has also shown the estimated new customer addition meters, and used the same volume assumption for both AMI and Baseline resulting in no incremental volume change for new meter additions.

Meter capital consists of meter hardware, meter installation, bypass valve hardware and installation, and the capitalized cost of contact centre meter exchange bookings. Each of these items is discussed separately below.

Meter Hardware

Meter hardware consists of meters, regulators, and large commercial and industrial meter AMI modules. Based on FEI's experience, approximately 50 percent of the time a meter is exchanged, the regulator also needs to be replaced. FEI has included in the cost estimates the assumption that 50 percent of regulators will be replaced in both AMI and Baseline scenarios. FEI's current meters, the new AMI meters, and large meter modules are sourced in US dollars

[74] Table 6-3, column 3, line 1.
[75] Table 6-3, column 4, line 1.
[76] Table 6-3, column 3, line 9.
[77] Table 6-3, column 4, line 9.

and have been included in the cost estimate in CAD dollars.[78] Specific to the AMI Solution, the AMI meters and larger meter modules have been negotiated to have fixed term pricing through Deployment. The cost of the regulators is based on FEI's current cost with the addition of a bulk volume discount and fixed term pricing during Deployment for the AMI Solution scenario.

Meter Installation

Meter installation consists of the costs to install meters, regulators, and large meter modules. As discussed in Section 5.3.3.2, FEI is in the RFP process for an AMI Deployment Vendor. Since a vendor-supplied cost estimate is not available, FEI has estimated meter installation costing assuming internal FEI labour and related costs. Schedules 2.1, 2.2, and 2.3 in confidential Appendix G-1 contain the detailed assumptions for meter installation. Schedule 2.2 contains the detail supporting the incremental cost of installing the AMI meters.

Bypass Valve Hardware and Installation

As described in Section 5.3.3.3, bypass valve installation is part of the standard meter exchange activity. The AMI Project accelerates the meter exchange process and, as a result, also accelerates the timing of the planned installation of bypass valves to the Deployment phase of this Project. Currently, bypass valves are deployed on an estimated 20 percent of FEI's meter fleet. The AMI Project will see full deployment of bypass valves on existing meters sooner than would be achieved in FEI's Baseline meter program. The incremental cost of deploying the bypass valves sooner than would be achieved under the Baseline scenario results in incremental savings in the Post-deployment capital spending. The savings are predominantly driven from avoided inflation on the cost of the bypass valves, fixed pricing through Deployment, and efficiencies in installation achieved through the mass AMI meter deployment.

Contact Centre Bookings Charge

A small unit cost for each meter exchange booked through FEI's customer contact centre is capitalized and added to meter installation. This unit cost has been included in the financial model using current costs escalated by inflation annually.[79] The AMI Solution will result in current meter exchange activity being halted in 2022 leading up to AMI Deployment, and as a result FEI expects a small decrease in the contact centre booking charge in 2022 specific only to the AMI Solution. During the Deployment phase, the increased volume of meter exchanges will drive an increase in this charge; whereas during the Post-deployment phase, there will be an offsetting decrease in this charge associated with a decreased volume of meter exchanges.

6.2.1.2 AMI Project Management

AMI Project management only applies to the AMI Solution and is therefore only an incremental cost in the financial analysis. AMI Project management costs include resources (project team incremental labour), consulting and legal costs, and miscellaneous costs such as travel,

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[78] Based on foreign exchange discussed in Section 6.3.1.4.
[79] Section 6.3.1.2 discusses inflation rate.

supplies, facilities, vehicles, and communications. Included in these categories are those costs incurred during the Pre-feasibility stage (prior to 2020) and the regulatory application and proceeding costs. AMI Project management capital does not include the labour to complete the installation of the network and meters.[80] Table 6-4 below summarizes what is included in AMI Project Management Costs.

Table 6-4: AMI Project Management Cost Summary

Line	Project Management Capital ($millions)	2020	2021	2022	2023	2024	2025	2026	Total	Reference [1]
1	Labour			3.7	7.3	7.5	6.2	4.1	28.9	
2	Network & Software Consulting			0.8	2.2	2.1	1.2	0.4	6.7	
3	Misc. Expenses			1.4	2.3	1.6	1.5	0.8	7.7	
4	**Total Project Management - Capital**	**-**	**-**	**6.0**	**11.8**	**11.2**	**9.0**	**5.3**	**43.2**	Schedule 6, Lines 13 through 17
5										
6	**Project Management Deferral ($millions)**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**	
7	Labour	1.4	2.0						3.3	
8	Consulting and Legal	0.4	2.1	1.6	0.3	0.2	0.2	-	4.9	
9	Misc. Expenses	0.2	0.4						0.6	
10	Pre-Feasibility	1.7	-						1.7	
11	**Total Project Management - Deferral**	**3.6**	**4.5**	**1.6**	**0.3**	**0.2**	**0.2**	**-**	**10.5**	Schedule 9, Line 31+39+41
12										
13	**Total Project Management Capital & Deferral**	**3.6**	**4.5**	**7.6**	**12.1**	**11.5**	**9.2**	**5.3**	**53.7**	Line 4 + Line 11

Notes:

[1] *Appendix G-3 contains the AMI financial schedules.*
Appendix G-4 contains the Baseline financial schedules.

As shown in Table 6-4 above, FEI estimates the total cost of AMI Project management to be $53.7 million[81]. This includes $43.2 million that will be allocated to the Project capital items and $10.5 million that is proposed to be added to the deferral account as described in Section 6.3.2.2. The costs that will remain in capital will be allocated to meter hardware, meter installation, software, and network capital asset accounts. The $6.7 million[82] in network and software consulting has been allocated to network and software asset accounts based on the respective weighting of network and software project capital costs. The $28.9 million[83] of labour and $7.7 million[84] of miscellaneous expense have been allocated to asset accounts based on total project cost weighting[85].

6.2.1.3 AMI Network & Software

AMI network and software costs only apply to the AMI Solution; therefore, they are only an incremental cost in this analysis. AMI network costs are comprised of all setup costs, including Base Station system design and installation. AMI software costs are comprised of all required capital expenditures to design, install, test, and commission the software environments needed

[80] Section 6.2.1.1 meter installation.
[81] Table 6-2, column 3, line 2.
[82] Table 6-4, column 10, line 2.
[83] Table 6-4, column 10, line 1.
[84] Table 6-4, column 10, line 3.
[85] Confidential Appendix G-3, Schedule 6, line 13-17 detail the allocated amounts.

as part of the AMI Solution, as well as development costs associated with integrating new AMI environments with existing FEI systems.

FEI notes a material portion of the software and network costs are sourced in USD[86] and FEI has negotiated fixed USD pricing through Deployment.

6.2.1.4 Non-Meter Capital

Non-meter capital costs cover miscellaneous non-meter hardware items, including gateways, transmitters, switches, cathodic devices, and handheld/drive-by meter reading devices. The Project's investment in the AMI network will enable savings to planned non-meter capital related to cathodic protection sensors, cellular infrastructure, station chart recorders, and portable pressure recorders.

FEI estimates the incremental non-meter capital costs through the Deployment phase as $0.2 million[87] which will be offset by incremental capital savings in the Post-deployment phase of $2.0 million[88].

6.2.1.5 Meter Reading Capital

As discussed in Sections 3.3.3 and 6.2.2.3, FEI has included in the Baseline scenario the future costs associated with bringing manual meter reading in-house. The capital required to bring meter reading in-house includes one-time technology set up costs, vehicle purchase, and mobile computing hardware that will be used by meter readers. Under the Baseline scenario, FEI estimates that in 2027 $5.3 million of capital spending will be required to set up in-house meter reading. Included in this amount are $1.6 million in technology set up cost, $3.5 million in vehicle purchases, and $0.2 million in mobile computing hardware. FEI notes the vehicle and mobile computing hardware will follow a 9-year and 5-year capital refresh rate respectively. The collective amount of meter reading capital included in the analysis for the Baseline Post-deployment phase is $15.1 million[89].

As FEI describes in Sections 6.2.2.3 and 6.3.3.1, a low and high case cost estimate was prepared for the future costs associated with bringing meter reading in house. To be conservative FEI has used the low case cost estimate in the analysis as described above. For comparative purposes, the high case cost estimate for in house meter capital in 2027 is $7.7 million of capital spending including $2.0 million in technology set up cost, $4.6 million in vehicle purchases, and $1.1 million in mobile computing hardware. The high case cost estimate also includes a 9-year and 5-year capital refresh rate for vehicles and mobile computing respectively, resulting in a collective meter reading capital amount of $23.9 million.

[86] Foreign exchange discussed in Section 6.3.1.4.
[87] Table 6-2, column 3, row 14.
[88] Table 6-2, column 4, row 14.
[89] Table 6-2, column 4, line 9.

6.2.2 O&M Costs

With the implementation of the AMI Project, there will be a net O&M savings in all phases, with significant savings in the Post-deployment phase primarily from reduced costs of manual meter reading. This section discusses the incremental O&M expenses FEI expects to incur, and the offsetting savings identified in the following O&M categories:

1. New AMI O&M including incremental labour, AMI software, and AMI network discussed in Section 6.2.2.1;
2. Meter installation O&M discussed in Section 6.2.2.2;
3. Meter reading O&M discussed in Section 6.2.2.3;
4. Operations O&M discussed in Section 6.2.2.4;
5. Customer service O&M discussed in Section 6.2.2.5; and
6. Meter shop O&M discussed in Section 6.2.2.6.

Table 6-5 below summarizes the net O&M savings expected as a result of this Project. FEI notes these amounts are after reducing the gross amounts for capitalized overheads.[90]

Table 6-5: Incremental O&M Savings Summary

Incremental O&M[1] As-Spent in $Millions		Pre Deployment	Deployment	Subtotal (1+2)	Post Deployment	Total (3+4)	Reference[2]
Line	Item	2021 - 2022 (1)	2023 - 2026 (2)	2021 - 2026 (3)	2027 - 2046 (4)	2021 - 2046 (5)	(6)
1	New AMI O&M	0.8	21.5	22.2	152.5	174.7	
2	Meter Installation O&M	(0.9)	(2.4)	(3.4)	(16.9)	(20.3)	
3	Meter Reading O&M	(0.0)	(21.7)	(21.7)	(404.4)	(426.2)	
4	Operations O&M	(0.0)	(0.6)	(0.6)	(25.8)	(26.4)	
5	Customer Service O&M	0.0	0.0	0.1	(12.7)	(12.6)	
6	Meter Shop O&M	(0.2)	(1.0)	(1.3)	(6.5)	(7.8)	
7	**Incremental O&M costs / (savings)**	**(0.4)**	**(4.3)**	**(4.7)**	**(313.9)**	**(318.6)**	Schedule 2, Line 14 & Agrees to Table 6-1 Line 6

Notes:

[1] *O&M costs net of capitalized overheads.*

[2] *Appendix G-5 contains the incremental financial schedules.*

As shown above, FEI estimates incremental savings in total O&M through the Pre-deployment and Deployment phases of $4.7 million[91] and a further $313.9 million[92] in savings through the Post-deployment phase.

The sections below will discuss each O&M item in more detail.

[90] FEI's current capitalized overhead rate is 16 percent, BCUC order G-319-20.
[91] Table 6-5, column 3, line 7.
[92] Table 6-5, column 4, line 7.

6.2.2.1 New AMI O&M

The new O&M that will be incurred as a result of the implementation of AMI includes incremental internal labour, AMI network O&M, and AMI software O&M.

- **Internal labour:** Consists of an incremental 10 full-time equivalent (FTE) employees including a system engineer, and network and software support personnel. The 10 FTEs will be gradually phased-in primarily over the Deployment phase, reaching 10 FTEs in 2026, the final year of Deployment. In that year, the annual incremental staffing cost is estimated to be $1.4 million. This amount has been escalated by inflation[93] each year in the Post-deployment phase.
- **AMI network O&M**: Consists of the managed network services, radio licenses, backhaul bandwidth, lease costs, and network security. In 2026, the year of full Deployment, the annual network O&M is estimated to cost $4.3 million. This amount has been escalated by inflation[94] each year in the Post-deployment phase. FEI notes that $1.5 million of the cost relating to the managed service is sourced in USD and is subject to foreign exchange.[95]
- **AMI software O&M**: Consists of hosting fees, SaaS fees, license cost, and internal software updates. In 2026, the year of full Deployment, the annual software O&M is estimated to cost $1.9 million. This amount has been escalated by inflation[96] each year in the Post-deployment phase. FEI also notes the hosting and SaaS fees are sourced in USD and are subject to foreign exchange.[97]

6.2.2.2 Meter Installation O&M

Currently, FEI allocates 14 percent of the meter exchange installation cost to O&M and this has been included in both the AMI Solution and Baseline scenario. However, for the AMI Solution, the incremental meter exchange activities in the Deployment phase are not allocated to O&M, as these activities are incremental to normal operation. All of the exchanges in the Post-deployment phase are allocated 14 percent to O&M.

FEI estimates $3.4 million[98] in savings related to meter installation O&M through the Deployment phase and an additional $16.9 million[99] in savings Post-deployment. The Deployment phase savings result from the full cost of the incremental meter exchanges being allocated to capital. The Post-deployment savings result from reduced meter exchanges in this phase.

93 Section 6.3.1.2.
94 Section 6.3.1.2.
95 Section 6.3.1.4.
96 Section 6.3.1.2.
97 Section 6.3.1.4.
98 Table 6-5, column 3, line 2.
99 Table 6-5, column 4, line 2.

6.2.2.3 Meter Reading O&M

Meter reading is the largest component of O&M costs impacted by the AMI Project and the area with the largest savings. Meter reading O&M presented here consists of the manual costs of reading meters and the cellular costs for current large commercial and industrial meters.

Table 6-6 below summarizes the estimated incremental meter reading costs / (savings), and the discussion that follows provides additional details for each of the phases of the Project.

Table 6-6: Meter Reading O&M Summary

Meter Reading O&M[1] As-Spent in $Millions		Pre Deployment	Deployment	Subtotal (1+2)	Post Deployment	Total (3+4)
Line	Item	2021 - 2022 (1)	2023 - 2026 (2)	2021 - 2026 (3)	2027 - 2046 (4)	2021 - 2046 (5)
1	Meter Reading	25.4	34.4	59.8	29.1	89.0
2	Large Commercial / Industrial Cellular	1.0	1.4	2.4	1.1	3.5
3	**AMI Meter Reading O&M**	**26.4**	**35.9**	**62.3**	**30.2**	**92.5**
4	Meter Reading	25.4	55.5	80.9	432.5	513.4
5	Large Commercial / Industrial Cellular	1.0	2.1	3.1	2.1	5.2
6	**Baseline Meter Reading O&M**	**26.4**	**57.6**	**84.0**	**434.6**	**518.6**
7	Meter Reading	-	(21.1)	(21.1)	(403.4)	(424.5)
8	Large Commercial / Industrial Cellular	(0.0)	(0.7)	(0.7)	(1.0)	(1.7)
9	**Incremental Meter Reading O&M**	**(0.0)**	**(21.7)**	**(21.7)**	**(404.4)**	**(426.2)**

Notes:

[1] *O&M costs net of capitalized overheads.*

Pre-deployment Phase

FEI expects an immaterial amount of savings in the Pre-deployment phase, limited to the large commercial and industrial meter modules starting to be deployed in 2022, which results in a reduction in current cellular reading costs for those meters that move to the new AMI network.

Deployment Phase

In the Deployment phase, FEI expects $21.7 million[100] in meter reading O&M savings. These savings result from the reduction in volume of non-AMI meters that require manual reads as they are exchanged with an AMI meter that will be read remotely via the proposed network. The savings estimate is based on FEI's current outsourced meter reading cost including inflation[101] less the cost of any AMI meters that may need to be manually read. Based on FBC's experience with electric AMI meters, FEI has included the conservative assumption that 1.5 percent of the AMI meters will have network connectivity issues and will require a manual read. For the purpose of this analysis, FEI has also assumed FEI's operations field crews will

[100] Table 6-6, column 2, line 9.
[101] Section 6.3.1.2.

complete 25 percent of the AMI meter reads and the remaining 75 percent will be completed by an outsourced meter reading provider.

Included in the total savings for the Deployment phase is a reduction in cellular costs for current large and industrial meters being read via cellular network as these costs will be reduced when they migrate over to the new network. FEI notes that for purposes of the financial analysis, FEI has assumed that 50 percent of the larger commercial and industrial meters will remain on the cellular network as these meters send serial data that will not immediately be available to be received by the head end system.

Post-Deployment Phase

In the Post-deployment phase, FEI estimates $404.4 million[102] in savings. These savings are based on avoided in-house manual meter reading costs less the cost of manually reading any AMI meters with network connectivity issues plus the savings of reduced cellular costs for the large commercial and industrial meters.

For the reasons set out in Section 3.3.3, FEI's Baseline scenario assumes manual meter reading would continue to be contracted out to a third party until the end of 2026 when the renewal periods of the existing manual meter reading contract expire, and, for the purposes of the financial analysis, assumes that FEI would convert to an in-house approach thereafter. To provide a good understanding of the potential range in costs for the Baseline scenario, FEI prepared two cost estimates for this in-house approach. Both a high case and a low case were developed, based on 2021 costs and escalated to 2027 dollars with inflation applied at 2 percent. Both cases use the same assumptions regarding the volume of meter readers, and include different costs for capital items including vehicles and tablets used by meter readers, as well as different labour rates depending on union affiliation. FEI has taken a conservative approach to the potential benefits of the AMI Project by including only the low case cost estimate in its financial analysis describing the estimated savings. Using this approach, the average annual O&M for in-house meter reading in the Post-deployment phase is estimated at $21.6 million[103] ($17.0 million for labour comprised of 176 FTEs, and $4.6 million for expenses related to vehicles, phones, clothing, and tablet subscriptions in support of in-house meter reading labour). This results in the $432.5 million[104] total cost of manual meter reading for the entire 20-year Post-deployment phase.

This avoided cost of $432.5 million is offset by estimated incremental costs of $29.1 million[105] to manually read AMI meters with network connectivity issues. As described in the Deployment phase above, FEI has assumed 1.13 percent[106] of AMI meters will need to incur a manual reading charge.

102 Table 6-6, column 4, line 9.
103 Table 6-6, column 4, line 4 / 20: $432.5 million / 20 years = $21.6 million average annual O&M.
104 Table 6-6, column 4, line 4.
105 Table 6-6, column 4, line 1.
106 1.50 percent of meters less 25 percent that will be read by field operation crews = 1.13 percent.

6.2.2.4 Operations O&M

Operations O&M refers to O&M activities completed by FEI's field crews.

FEI's Operations team conducted a review of current activities and identified several activities that would be reduced with the functionality introduced within the AMI Project. Reduced activities include meter trouble calls, meter reads, meter identifications, disconnects, unlocks, cathodic protection data gathering, and odour measurement.

The Operations team also identified incremental O&M that would be introduced because of AMI including increased trouble calls, supporting analytics, and redeployed meter exchange activity.[107]

Table 6-7 below summarizes the reduction in existing Operations O&M and the incremental Operations O&M included in the financial analysis.

Table 6-7: Operations O&M Summary

Operations O&M[1] As-Spent in $Millions		Pre Deployment	Deployment	Subtotal (1+2)	Post Deployment	Total (3+4)	
Line	Item	2021 - 2022 (1)	2023 - 2026 (2)	2021 - 2026 (3)	2027 - 2046 (4)	2021 - 2046 (5)	Reference (6)
1	Existing Operations Activities	(0.0)	(0.6)	(0.6)	(54.0)	(54.6)	
2	New Operations Activities	-	-	-	28.2	28.2	
3	**Incremental Operations O&M costs / (savings)**	**(0.0)**	**(0.6)**	**(0.6)**	**(25.8)**	**(26.4)**	Agrees to Table 6-6 Line 4

Notes:

[1] O&M costs net of capitalized overheads.

As shown in the above table, through the Deployment phase, FEI expects minimal savings, estimated at $0.6 million, mainly enabled by the SentryPoints[108] installed on the gas network that will reduce cathodic protection activities.

The majority of the Operations O&M savings in the Post-deployment phase, estimated in total at $25.8 million, come from a reduction in Operations activities.

6.2.2.5 Customer Service O&M

The AMI Project will enable savings in FEI's customer service function. Customer service identified savings will come from the following reduced activities: billing investigation and exceptions, meter reading coordinator workload, improvements in vacant premises processing, and meter switching identification and validation.

FEI estimates incremental costs in customer service O&M through the Deployment phase of $0.1 million[109] related to AMI process training. Post-deployment savings are estimated at $12.7 million[110].

[107] This is due to the reduction in meter exchange activity that is currently charged to capital, but with AMI could be retained as O&M or could be redeployed to other capital projects. To be conservative, FEI has assumed that the costs would reside in O&M.

[108] Section 5.4.1.1.

6.2.2.6 Meter Shop O&M

Meter shop O&M is directly impacted by the reduction in volume of meter exchanges and specifically, the reduction in the meter sampling recall program. The AMI Project will halt the meter sampling program in the years 2022-2026 and then resume in 2027 but with a significant decrease in volume of meters included in the sample as a result of the entire meter fleet being replaced with a young vintage. FEI estimates incremental savings in meter shop O&M through Deployment of $1.3 million[111] and a further $6.5 million[112] in the Post-deployment phase. All savings result from the reduced volume of meters included in the annual meter sampling program.

6.3 *FINANCIAL ANALYSIS*

The financial analysis completed for the AMI Project uses the capital and O&M costs discussed above and calculates the cost of service for both the AMI Solution and the Baseline meter program. The incremental cost of service for the AMI Solution is the difference between the cost of service of the AMI Project and the Baseline. The financial schedules supporting the cost of service for AMI, Baseline and Incremental cost / (savings) are included in Appendices G-3, G-4, and G-5 respectively.

6.3.1 Assumptions Included in the Analysis

In addition to the cost information provided in the sections above, the financial analysis uses the following assumptions.

6.3.1.1 Analysis Period

The financial analysis period FEI has used is 20 years after deployment of the last AMI meter installed. The 20-year period is equal to the estimated useful life of the new AMI meters. The last AMI meter to be exchanged is in 2026, resulting in 2046 as the final year of the analysis period. Twenty years Post-deployment plus 6 years 2021-2026 for Pre-deployment and deployment result in a 26-year analysis period.

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[109] Table 6-5, column 3, line 5.
[110] Table 6-5, column 4, line 5.
[111] Table 6-5, column 3, line 6.
[112] Table 6-5, column 4, line 6.

6.3.1.2 Inflation

Inflation is estimated to be two percent over the 26-year analysis period. This is comparable to the historical five year average BC CPI from 2016-2020 which is also approximately two percent.[113]

The inflation assumption has been consistently applied to all capital and O&M and to account for annual cost inflation.

6.3.1.3 Discount Rate

The NPV of the revenue requirement has been calculated over a 26-year period using a 5.47 percent nominal discount rate based on FEI's after tax WACC as per FEI's Approved 2021 Revenue Requirement.[114]

6.3.1.4 Foreign Exchange

The foreign exchange rate used in the analysis is 1.33 USD/CAD for any costs denominated in USD. The exchange rate used was the spot rate at October 31, 2020. FEI notes the current spot USD/CAD rate is 1.23[115] at time of filing, but FEI has conservatively used the higher 1.33 rate. FEI has not included any forward assumptions regarding USD/CAD exchange rate and recognizes the potential risk associated with future changes in the exchange rate. Section 6.3.2.3 discusses a proposed mitigation mechanism related to foreign exchange risk.

6.3.1.5 Existing Book Value of Meters and Installation

Included in the financial analysis for both AMI and Baseline scenarios is the opening balance of current plant and accumulated depreciation for existing (non-AMI) meter hardware (asset class 478-10) and meter installation (asset class 474-00 and 474-02) specific to the series 200[116] and 400[117] meters as at January 1, 2021. The opening gross plant balance of existing meter hardware is $163.3 million, less accumulated depreciation of $90.3 million, for a net book value of $73.0 million. The opening gross plant balance of existing meter installation costs is $265.7 million, less accumulated depreciation $87.1 million for a net book value of $178.6 million.

FEI notes the opening balances only include the values of the 200 and 400 series meters, and exclude the plant values associated with commercial and industrial meters, bypass valves, and capitalized overheads as these are not impacted by the Project.

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113 https://www2.gov.bc.ca/gov/content/data/statistics/economy/consumer-price-index.
114 Order G-319-20.
115 April 30, 2021 spot USD/CDN rate.
116 Series 200 meters refer to residential meters.
117 Series 400 meter refer to small commercial meters.

These opening balances have been included in the analysis to capture the ongoing cost of service in the Baseline scenario and to calculate the value for the meters no longer in use in the AMI scenario.

6.3.1.6 *Depreciation and Net Salvage*

Depreciation, net salvage, and capital cost allowance (CCA) rates for the asset classes that are relevant to this analysis are those approved in FEI's 2020-2024 MRP Application.[118] Table 6-8 below summarizes the rates for the existing asset classes, as well as the proposed rates for the AMI asset classes.

Table 6-8: Depreciation and Net Salvage Rates

Rates Used In Analysis	Depreciation	Net Salvage
Baseline Rates (existing approved)		
478-10 / Non AMI Meter Hardware	6.06%	0.00%
474-00 & 474-02 / Meter Installations	5.91%	1.58%
483-20 / GP Computer Software	12.50%	0%
483-10 / GP Computer Hardware	20.00%	0%
484-00 / Vehicles	11.07%	0%
AMI Rates:		
478-12 / AMI Meters	5.00%	0.00%
474-03 / AMI Meter Installation	5.00%	1.58%
402-06 / AMI Software	10.00%	0.00%
488-30 / AMI Communication and Equipment	6.67%	0.00%

FEI proposes the AMI meters and installation costs be added to plant into their own asset class with the depreciation rate set to the manufacturer's useful life estimate for the meters, equalling 5 percent (20 years). The net salvage rate for AMI meters (to recover the costs of removal over the lives of the meters) has been set equal to that of existing meters with the expectation that the costs of removal will be similar.

FEI notes the depreciation rate shown in the table above for existing meter installations of 5.91 percent is the weighted rate of the two existing asset classes for meter installation.[119] FEI also

[118] Order G-165-20.

[119] Consistent with Order G-44-12, starting January 2012, all regulator and meter installation asset additions are recorded in account 474.02 and amortized using the Amortization Accounting approach. This approach is based on the estimated average service life of the assets instead of relying on individual retirement of assets, resulting in an evenly distributed allocation of the asset cost over the total life of the investment. The Amortization Accounting approach is suited for situations where there are numerous units of property and which are difficult to track in sufficient detail. Existing meter installation costs added prior to 2012 continue to be tracked and amortized in account 474.00.

notes the proposed new rates for AMI software and AMI Communication and Equipment[120] have been assumed to be equivalent to the rates FBC uses for similar assets. FEI has used these rates for the purposes of the financial analysis and requests approval of these rates in this Application, but notes that a new depreciation study is expected to be filed before the majority of the assets are in service, and these rates will be reviewed and confirmed at that time.

6.3.2 Accounting Treatment

6.3.2.1 Treatment of Capital Costs

Consistent with FEI's approved CPCN treatment, the capital costs of the Project will be held outside of rate base in capital work in process, attracting AFUDC, until they are placed into service. As construction is completed on the various assets included in the Project, the assets will be commissioned and placed into service. The assets will enter rate base on January 1 of the year following their in-service date by adding the capital cost of the assets into the appropriate plant asset accounts. Depreciation of the assets included in FEI's rate base will begin the year that they enter rate base. The AMI meters exchanged during the Deployment phase of the Project will enter rate base January 1 in the year following the date of the meter installation.

6.3.2.2 AMI Application and Feasibility Cost Deferral

In this Application, FEI seeks approval for the creation of the AMI Application and Feasibility Cost deferral account. The purpose of this account is to capture costs associated with developing the AMI Project and the regulatory proceeding to review the Application. Similar to the capital costs discussed above, the account will be non-rate base and earn an after tax WACC carrying cost until it enters rate base. FEI expects to incur costs of approximately $9.9 million, inclusive of the preliminary project planning, application development and regulatory proceeding costs, as well as costs associated with additional public communications and consultations. Upon approval of the AMI Project FEI will transfer the balance to rate base and proposes to amortize the costs accrued to this account over three years beginning in 2023.

6.3.2.3 AMI Foreign Exchange (FX) Mark to Market Valuation

FEI is also seeking BCUC approval under sections 59-61 of the UCA for a deferral account, entitled the "AMI FX Mark to Market" deferral account, to capture the mark-to-market valuation of any foreign currency risk mitigation contracts (FX Contracts) entered into related to the Project. The deferral account is an important tool to mitigate external income statement volatility that would arise with the use of FX Contracts. This treatment is similar to what the BCUC

[120] The proposed asset class that will hold the AMI network and non-meter capital.

approved for the Mt. Hayes LNG Facility CPCN[121] and the Customer Care Enhancement CPCN[122] and is similar to what FEI has proposed in the TLSE Project Application.[123]

A significant portion of the costs of the Project includes US Dollar (USD) payments giving rise to exchange rate risk. Table 6-9 below summarizes the estimated value of USD exposure through deployment of the Project.

Table 6-9: US Dollar Exposure

US Dollar Exposure ($millions)	2021	2022	2023	2024	2025	2026	Total
Total US Dollar Exposure included in costs	6.9	3.2	50.8	89.9	84.4	44.1	279.2

FEI may mitigate a portion of the risk by locking in foreign exchange rate exposure using FX Contracts to mitigate the risk of fluctuations in the value of USD/CAD currency exchange rate. The extent of currency risk mitigation will be based on FEI's risk assessment of the overall exposure as well as the cost and effectiveness of the FX Contracts.

While using FX Contracts will help mitigate the risk of exchange rate differences, these types of contracts are considered derivative instruments under FASB Accounting Standards Codification 815, Derivatives and Hedging, which would require FEI to record a fair value (mark-to-market) entry at the end of each accounting period. In the absence of an approved deferral account, those mark-to-market adjustments would be included in FEI's earnings for the period.

Due to the potential volatility in FEI's external financial statements arising from the required recognition of mark-to-market valuation of FX Contracts, FEI requests approval of a deferral account to capture these mark-to-market adjustments over the course of the Project. The deferral account will not attract a financing return, as the mark-to-market adjustments are non-cash.

The deferral account treatment of the mark-to-market adjustments related to the foreign exchange rate hedging for the Project will have no impact on customer rates. The use of the requested deferral account will not increase or decrease the expected cost of the Project because the hedging provides more certainty on the exchange rate for the USD denominated cost components and thus mitigates the foreign exchange risk upon settlement, or payment. The FX Contracts will provide increased cost certainty as they lock in the foreign exchange rates for USD denominated cost components obtained by FEI for this Project. At the end of the Project, the amount of the deferral account will be zero, since the deferral account only captures any unrealized gains and losses related to the requirement to mark-to-market the FX Contracts.

The requested deferral account is beneficial to FEI and its customers. It allows FEI to mitigate the impact on its external financial statements arising from undertaking the hedging of the USD denominated payments during the Project execution. By doing so, it facilitates the use of FX

[121] Order G-145-08.
[122] Order G-96-10.
[123] Filed with the BCUC on December 29, 2020. A revised redacted version was filed on March 25, 2021.

Contracts that will provide increased certainty to customers on the exchange rate used for the USD portion project costs.

FEI will report on the use of this deferral account as part of the Project progress reports filed with the BCUC.

6.3.2.4 Accounting Treatment for Retirement of Existing Meters

As part of the AMI Project, existing meters will be replaced with new AMI meters. Therefore, the financial analysis includes the recovery of the remaining rate base value associated with the existing in-service series 200 and 400 meters, and also the rate base value of meters embedded in accumulated depreciation that have been previously retired (due to the group accounting method employed by FEI). Each of these items is discussed separately below.

Recovery of Existing Meters

FEI has considered two options for the recovery period of the remaining rate base value of existing meters to be removed from service as part of the proposed AMI Project. In both cases, the existing meters would be removed from service as they are replaced over the 2023-2026 period, with the remaining net book value for the retired meters transferred to a new rate base deferral account named “Existing Meter Cost Recovery”. The first option would be to amortize the account over a 5-year period, and the second to amortize the account over a 10-year period. The 5-year amortization period is consistent with the BCUC’s decision for the recovery of the remaining costs of FBC’s existing electric meters as determined by Order C-7-13 in FBC’s AMI CPCN Application. The 10-year amortization period is based on the estimated remaining life of the existing meters as determined in the 2017 Depreciation Study approved as part of FEI’s 2020-2024 MRP Application.

FEI is proposing an amortization period of 5 years, and has assumed this treatment in the financial analysis for the Project. The estimated remaining rate base value of FEI’s gas meters to be transferred to the deferral account and amortized over 5 years is approximately $79 million[124].

Recovery of Previously Retired Meters

In addition to the recovery of the remaining rate base value for meters to be retired due to the AMI Project, there is approximately $74 million[125] in remaining rate base value for meters previously retired in the normal course of business but that, due to the group asset accounting employed by FEI, had a remaining net book value at the time of retirement. The remaining net book value for these assets resides in accumulated depreciation.[126] With the existing meters

[124] Table 6-10, Line 9.

[125] Table 6-10, Line 10.

[126] The approved regulatory treatment at the time of retirement is to credit plant in service and debit accumulated depreciation such that the remaining net book value remains in accumulated depreciation and is taken into account in future depreciation studies to recover the costs over a future period. The amounts represent unrecovered depreciation.

being retired due to the AMI Project and to continue recovery of the aforementioned remaining rate base value as approved, FEI proposes to transfer this balance to a new rate base deferral account named the “Previously Retired Meter Cost Recovery” deferral account, with an amortization period of 10 years, which is similar to the estimated average remaining life of the existing meters. This would effectively recover the remaining rate base value over the same time period that would have occurred if there were no AMI Project.

Table 6-10 below provides a continuity view of the existing in service meter hardware and installation asset values including the proposed transfers to recovery deferrals.

Table 6-10: Existing Meter Asset Continuity ($ millions)

Line	Non-AMI Meter Losses	2021	2022	2023	2024	2025	2026	Total	Reference[1]
1	Beg Hardware and Installation[2]	429.0	424.1	426.7	355.6	213.3	71.1		Schedule 7, Line 4 + Line 5
2	Additions	13.9	2.5	-	-	-	-		Schedule 7, Line 23 + Line 24
3	Retirements	(18.7)	-	(71.1)	(142.2)	(142.2)	(71.1)		Schedule 7, Line 41 + Line 42
4	End Hardware and Installation	424.1	426.7	355.6	213.3	71.1	-		Schedule 7, Line 59 + Line 60
5									
6	Accumulated Depreciation, Beginning[3]	(177.4)	(184.3)	(209.6)	(195.9)	(130.2)	(47.4)		Schedule 8, Line 4 + Line 5
7	Depreciation	(25.6)	(25.3)	(25.5)	(21.2)	(12.7)	(4.2)		Schedule 8, Line 23 + Line 24
8	Retirement	18.7	-	71.1	142.2	142.2	71.1		Line 3
9	**Existing Meter Write Off[4]**	**-**	**-**	**(19.6)**	**(30.7)**	**(21.9)**	**(7.2)**	**(79.4)**	Schedule 9, Line 13
10	**Previously Retired Meter Write Off[5]**	**-**	**-**	**(12.3)**	**(24.7)**	**(24.7)**	**(12.3)**	**(74.0)**	Schedule 9, Line 4
11	Accumulated Depreciation, Ending	(184.3)	(209.6)	(195.9)	(130.2)	(47.4)	-		Schedule 8, Line 61 + Line 62
12									
13	NBV, Beginning[6]	251.6	239.9	217.1	159.7	83.1	23.7		Line 1 + Line 6
14	NBV, Ending	239.9	217.1	159.7	83.1	23.7	-		Line 4 + Line 11

Notes:

[1] *Appendix G-3, AMI Financial Schedules.*

[2] *Beginning plant values of 163.3 + 265.7 as reported in Section 6.3.1.5.*

[3] *Beginning plant values of 90.3 + 87.1 as reported in Section 6.3.1.5.*

[4] *Line 9 sums to $79.4.*

[5] *Line 10 sums to $74.0.*

[6] *Beginning plant values of 72.99 + 178.6 as reported in Section 6.3.1.5.*

6.3.3 Estimated Delivery Rate Impact

Using the cost information, assumptions, and regulatory accounting treatment discussed in this section, FEI has calculated a cost of service for both the AMI Project and the Baseline meter program with the difference between them resulting in the incremental impact of the AMI Project. Table 6-11 below summarizes the NPV of the annual revenue requirements over the term of the analysis (26 years) for each of the scenarios and includes the levelized delivery rate impact for each. The variance between the two represents the incremental impact from the AMI Project.

Table 6-11: Levelized Delivery Rate Impact

Levelized Rates	AMI	Baseline	Incremental
NPV Annual Revenue Requirement millions	1,247	1,232	15
Levelized % Increase 2021 Rates	10.348%	10.223%	**0.125%**

The estimated incremental delivery rate impact expected over the 26-year analysis period for the AMI Project is 0.125 percent when compared to 2021 rates. In 2027, the year after full AMI deployment, the cumulative delivery rate impact would be at its highest level of 4.79 percent, resulting in a cumulative annual average bill increase of $21 dollars for a residential customer consuming 90 GJs per year. Each year thereafter, the cumulative delivery rate impact would decrease resulting in an overall average of 0.125 percent per year over the 26-year analysis period. The year 2033, the year after the proposed "Existing Meters Cost Recovery" deferral account has been fully amortized, will be the first year the incremental delivery rate impact will be a decrease.

6.3.3.1 Delivery Rate Impact Sensitivity to Future Meter Reading Savings

FEI notes the incremental delivery rate impact is sensitive to the underlying inputs. Specifically, the rate impact analysis is sensitive to the underlying input used for future meter reading savings. For the reasons set out in Section 3.3.3, and further described in Section 6.2.2.3, FEI has included in the Baseline scenario the cost of bringing manual meter reading in-house starting in 2027. The cost assumptions used in the Baseline scenario are based on FEI's low case cost estimate. FEI has provided Table 6-12 below summarizing the delivery rate impact associated with the variability in the assumption regarding future meter reading savings.

Table 6-12: In-House Meter Reading Scenario Delivery Rate Impact Sensitivity

Line	Meter Reading Costs Scenario	Baseline Impact	AMI Impact	Incremental Impact
1	Continuation of current embedded costs	0.000%	0.325%	0.325%
2	Future in-house meter reading low case	0.200%	0.325%	0.125%
3	Future in-house meter reading high case	0.770%	0.325%	-0.445%

The analysis discussed in this section is based on line 2 and results in the incremental impact of 0.125 percent. If FEI were to use the high case cost estimate for future in-house meter reading, the incremental delivery rate impact would decrease by 0.57 percent to a levelized delivery rate decrease of 0.445 percent. FEI has also provided the delivery rate impact associated with the unlikely scenario of maintaining the current cost of outsourced manual meter reading embedded in FEI's current O&M costs on line 1.

6.3.3.2 Fort Nelson Impact

The analysis for the AMI project has been prepared by including costs and benefits for all of FEI's service areas, including Fort Nelson. When the Project commences, direct costs will be charged to Fort Nelson. Direct charges include meter capital, meter installation, any associated meter write off, and network hardware. Common capital items, such as software and Project management costs will be allocated to Fort Nelson based on the number of meters deployed. O&M items such as the reduced meter reading costs and annual network servicing costs will be allocated to Fort Nelson based on the number of customers. These allocation approaches are consistent with current allocation methods for Fort Nelson. Fort Nelson's cost of the project is estimated at $1.5 million in capital and would require a meter write off of an estimated $0.1 million. The estimated levelized delivery rate increase of the project for Fort Nelson would be 1.41 percent.

6.4 *SUMMARY*

In summary, the AMI Project is expected to incur $638.4 million in capital expenditures through the Deployment phase, which is equal to $476.0 million incremental to what would otherwise be spent under the Baseline scenario (during normal operations of the existing meter program). The $476.0 million of incremental capital is projected to be offset by future savings in capital and O&M expenditures in the Post-deployment phase.

Overall, the AMI Project is expected to be effectively rate neutral over the 26-year analysis period, with the incremental levelized delivery rate impact estimated to be 0.125 percent using conservative assumptions. There would be an overall delivery rate savings for customers if the future cost of manual meter reading is higher than the Baseline low case cost scenario that has been assumed.

Specific approvals sought in light of the discussion in this section include:

- The creation of four new asset accounts with associated depreciation and net salvage rates:
    1. 478-10 / AMI Meter Hardware – depreciation rate set to 5 percent, no net salvage;
    2. 474-00 / AMI Meter Installation – depreciation rate set to 5 percent, 1.58 percent net salvage;
    3. 402-06 / AMI Software – depreciation rate set to 10 percent;[127]
    4. 488-30 / AMI Communications and Equipment – depreciation rate set to 6.67 percent, no net salvage;
- Creation of a non rate base **AMI Application and Feasibility** cost deferral account attracting a WACC return until it is placed into rate base, to capture development and application costs for this Project. Once transferred to rate base FEI proposes an amortization period of 3 years;

[127] There is no net salvage for software as there are no associated removal costs.

- Creation of a non rate base **AMI Foreign Exchange (FX) Mark to Market Valuation** deferral account to isolate the impact of any foreign exchange hedging used to reduce foreign exchange risk of the Project;
- Creation of a rate base **Existing Meter Cost Recovery** deferral account to capture the remaining rate base value of the meters to be exchanged as part of this Project with a rolling amortization period of 5 years; and
- Creation of a rate base **Previously Retired Meter Cost Recovery** deferral account to collect the remaining rate base value of previously retired meters with an amortization period of 10 years.

7. CONSULTATION

7.1 *INTRODUCTION*

Consultation, engagement and communication are integral components of FEI's project development process. To guide effective and meaningful consultation, FEI created a Consultation, Engagement and Communications Plan (Appendix H-1) outlining its objectives, strategies and general approach.

To ensure the effectiveness of its Consultation, Engagement and Communications Plan, FEI considered lessons learned from the implementation of advanced electric meters by FBC between 2013 and 2016. In addition, FEI conducted a Customer Perception Survey of advanced meters, and implemented best practices from other North American utility deployments of advanced meters. Best practices from the COVID-19 pandemic were also considered to ensure FEI engaged and consulted in a safe, effective and timely manner.

The Project spans across FEI's entire service territory, meaning an ongoing and multifaceted approach was required, including letters and emails, information sessions, outreach to media outlets, advertising campaigns, social media and direct customer communications to accomplish consultation objectives. FEI will continue to use its Consultation, Engagement and Communications Plan to guide activities throughout the Project and will update the plan to incorporate feedback as necessary.

In the following sections, FEI will:

- Demonstrate how FEI is undertaking, and will continue to undertake, appropriate consultation regarding the Project with the public, government and industry stakeholders (Section 7.2); and
- Demonstrate how FEI is undertaking, and will continue to undertake, appropriate engagement regarding the Project with Indigenous groups (Section 7.3).

7.2 *FEI IS UNDERTAKING APPROPRIATE CONSULTATION*

Due to its broad nature, reaching nearly 1.1 million customers in 135 communities, FEI developed a comprehensive Consultation, Engagement and Communications Plan to consult with stakeholders and the broader public, outlining key consultation objectives which aim to:

- Ensure balanced and objective information is available, promoted and understood;
- Communicate and engage effectively on the benefits of the new meters, and address concerns or provide explanations when unable to do so; and
- Create opportunities for customers, communities and stakeholders to provide feedback.

Prior to the development of the Consultation, Engagement and Communications Plan, FEI conducted a Customer Perception Survey to understand customers' preferred communication and consultation methods. Further details are discussed in Section 7.2.4. The Customer Perception Survey guided the development of the Consultation, Engagement and Communications Plan and helped to maximize reach and ensure customers and communities across the province were informed of the Project. The Consultation, Engagement and Communications Plan included outreach over a variety of channels including direct stakeholder and general media communications, a news release, digital and print ads, in-person and virtual information sessions, and direct customer communications. A website, phone number and email were set up to provide ongoing consultation opportunities. This consultation work began in late 2019, with FEI announcing the Project, contacting stakeholders, and starting broader community and customer consultation including 12 in-person information sessions to support consultation for the Project.

Since publicly announcing the Project, FEI has consulted with employees, customers, provincial and local governments, stakeholders, and the public. Throughout 2020 and early 2021, FEI's efforts included providing ongoing Project updates, responding to public inquiries over email and phone, exploring joint-use opportunities with municipalities, and hosting and promoting virtual information sessions. As of March 1, 2021, FEI has responded to more than 500 public inquiries via telephone (*Project phone line and FEI customer service*) and email. FEI is committed to continuing consultation and communication throughout the Project.

The following sections provide details of FEI's consultation on the Project, including:

- Community, social and environmental considerations that FEI used to guide its consultation with stakeholders (Section 7.2.1);
- Identification of stakeholders with an interest in the Project with whom FEI has and will continue to consult (Section 7.2.2);
- Communication materials and methods used and employed by FEI to consult with stakeholders regarding the Project (Section 7.2.3);
- Public consultation activities to date, and how FEI incorporated feedback (Section 7.2.4);
- Government consultation activities to date (Section 7.2.5);
- Industry association consultation activities to date, and how FEI incorporated lessons learned and safety features (Section 7.2.6);
- Issues and concerns raised about the Project by customers, residents, businesses and stakeholder groups, and how FEI responded to these issues or concerns to date (Section 7.2.7);
- FEI's commitment to address any existing or anticipated issues or concerns (Section 7.2.8);
- FEI's documentation and evidence of all consultation efforts to date (Section 7.2.9);

- FEI's commitment to future consultation and communications; (Section 7.2.10); and
- Demonstration of FEI's transparent consultation process throughout the Project to support deployment, respond to customer concerns and minimize disruptions (Section 7.2.11).

7.2.1 FEI's Consultation Approach Reflects Community, Social and Environmental Considerations

The Project will take place across FEI's service territory. It will include replacing customers' existing gas meters to new advanced gas meters, and creating the infrastructure needed to support the wireless network throughout FEI's system.

Limited construction of new infrastructure is planned for this Project and as such, FEI anticipates there will be minimal community and social impacts. FEI anticipates environmental benefits as a result of the project, including reductions in GHG emissions. These positive environmental impacts would be achieved through increased operational efficiencies, such as fewer cars on the road required to manually read meters thereby reducing annual GHG emissions by 1,100 tonnes; and by customers' ability to better manage their energy use through AMI technology, which may lead to consumption reductions (Section 3). Notwithstanding that, FEI is committed to ongoing communications and consultation with customers, government, stakeholders and the public throughout the Project.

Furthermore, FEI will look into creating training and job opportunities for local and Indigenous communities as part of Project implementation.

7.2.2 FEI Has Identified Key Stakeholders for Public Consultation

FEI has identified three primary groups potentially impacted by the Project. FEI remains committed to communicating with and seeking feedback from these groups throughout the Project. Communication and consultation methods will be refined as necessary, based on feedback from the groups. These groups are:

1. FEI's residential and commercial natural gas customers;
2. Provincial government bodies, including: the Ministry of Energy, Mines and Low Carbon Innovation (formerly, the Ministry of Energy, Mines and Petroleum Resources), and Members of the Legislative Assembly (MLAs); and
3. Municipal and regional governments, including: the mayors, councils, city managers and/or staff within FEI's gas service territory.

7.2.3 FEI Has Used Appropriate Communications Materials and Methods to Support Consultation

FEI has used a variety of methods to communicate and consult with those identified as potentially being affected by the Project.

On October 3, 2019, FEI publicly announced the Project via a news release, social media posts and webpage. Following this, customers were notified via a bill insert in FEI's November 2019 billing cycle (Appendix H-12). The announcement explained the drivers behind the Project, provided details on public information sessions and ways customers and the public could provide feedback. It also included details on the Project's upcoming regulatory process, helping to support interested parties to get involved. FEI notified provincial, municipal and regional government officials of the Project prior to the public announcement and invited them to participate in virtual information sessions (see Appendix H-2 for recipient list, and Appendices H-3 and H-4 for copies of the notification letters).

In October and November 2019, FEI hosted 12 in-person public information sessions throughout the province as part of consultation with communities throughout its service territory. FEI promoted these information sessions using an advertising campaign, social media posts, a blog post on FortisBC.com, and outreach to media outlets. Further customer communications occurred through 2020, including content on FEI's blog and *Energy Moment* newsletter, social media, website updates and bill inserts.

In February 2021, FEI hosted four virtual information sessions to provide a Project update to customers and stakeholders. To notify customers of the virtual information sessions, FEI used newspaper and social media advertising, its *Energy Moment* newsletter, the Project website, and FEI's online bill payment platform. FEI contacted provincial, municipal, and regional governments directly via email on February 4, 2021, to provide a Project update and invite them to two dedicated virtual information sessions, where they could get a Project update and have their questions answered. Summaries of these virtual information sessions are included in the Consultation Log (Appendix H-2).

7.2.4 FEI Developed Project Specific Tactics to Research, Consult and Communicate with Stakeholders to Date

Customer Research

FEI contracted a third-party firm to complete a Customer Perception Survey for residential and commercial gas customers. The Survey ran from September 3 to 24, 2019, and included 722 respondents. The full results are included in Appendix H-5.

The Customer Perception Survey helped provide insight into customers' current knowledge and understanding of advanced gas meters, as well as their preferred communication and consultation methods throughout the Project.

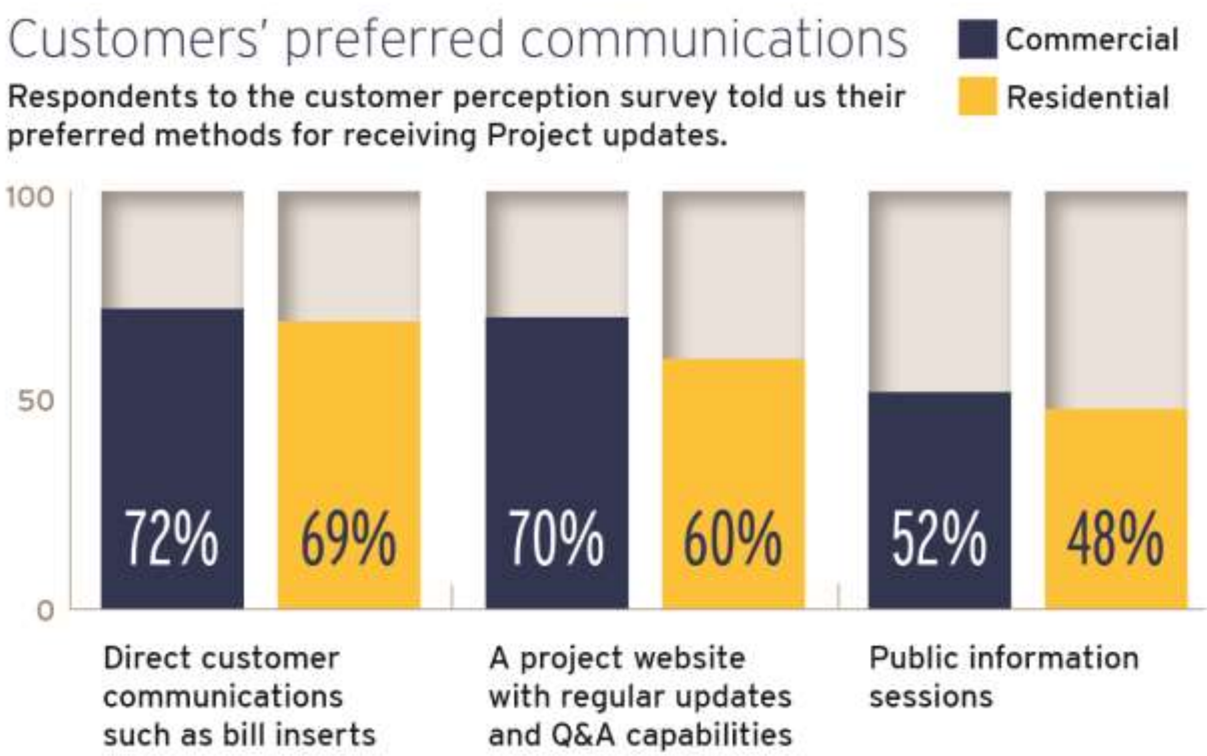
The results of the Customer Perception Survey indicated:

- Customers preferred FEI communicated with them regarding the Project via direct customer communications, a Project webpage and information sessions (Figure 7-1);
- While most customers were aware of advanced gas meter technology, most were only "somewhat familiar"; and

- Customers valued several benefits of the Project including enhanced safety features such as leak detection, reduced GHG emissions, as well as the future capability to access daily consumption data to help them monitor and make informed decisions on their gas use.

This feedback informed communication methods utilized in the Project's Consultation, Engagement and Communications Plan. This included a focus on direct customer communications such as bill inserts and content in the *Energy Moment* newsletter, and maintaining an up-to-date website with a FAQ page. Details on these methods of communication are discussed later in this section.

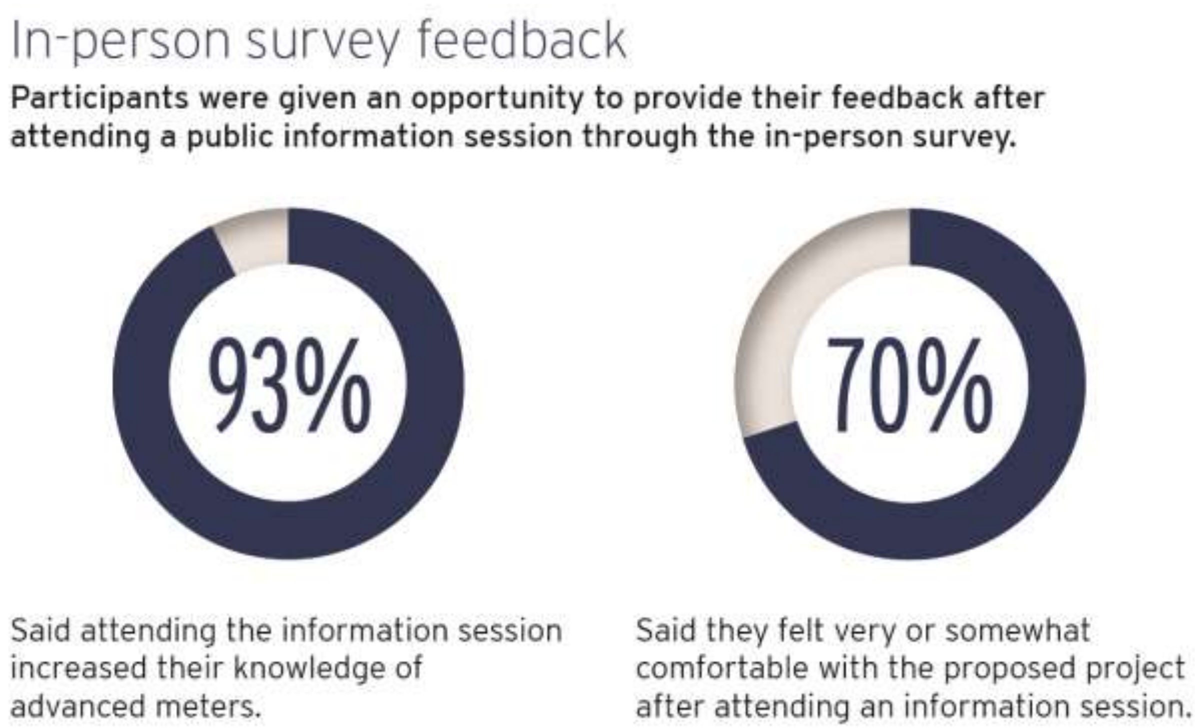
Figure 7-1: Customer Perception Survey Feedback



Separate, and in addition to the Customer Perception Survey, FEI developed an in-person survey to support the 2019 public information sessions. The in-person survey, used exclusively at the public information sessions, sought additional feedback from participants at the conclusion of their interaction with FEI, and provided FEI with general feedback regarding how the information sessions were received. About one-third of attendees elected to complete the in-person survey. The survey inquired about participants' existing understanding of advanced meters, if they felt more knowledgeable about advanced meters having attended a public information session, and their level of comfort with the Project. Those who completed the in-person survey indicated the information session provided valuable insight about the Project

(Figure 7-2). FEI will look to use similar surveys throughout the Project to help guide future communication and consultation. In-person survey questions and results are located in Appendix H-7.

Figure 7-2: 2019 Public Information Session "In-Person Survey"



7.2.5 Consultation and Communication Activities to Date

Customer and Public Communications

FEI used a variety of communication channels to support consultation and raise awareness of the Project, with about two-thirds of respondents to FEI's Customer Perception Survey indicating they preferred to stay updated via direct communications and a website. The communications FEI used included:

- Project announcement, including a news release, website, *Energy Moment* newsletter, bill insert, a notification on FEI's online bill payment platform and social media;
- 2019 public information session promotion, including outreach to media outlets, newspaper and digital advertising, a blog post on FortisBC.com, and social media;
- 2021 virtual information session promotion, including newspaper and social media advertising, *Energy Moment* newsletter and a notification on FEI's online bill payment platform; and

- Ongoing communications and Project updates, including social media, bill inserts and website updates.

Media

In late 2019, FEI's outreach to media outlets helped reach a large number of people across British Columbia to inform them about the Project. This outreach to media outlets encouraged people to learn more by visiting the Project website, attending an information session, or contacting FEI. Between October and December 2019, there were 65 print, online, radio and television stories published about the Project. Print, radio and television coverage reached an estimated audience of 700,000, while online stories were published on websites attracting estimated monthly audiences of approximately 5.4 million people.

From January 1, 2020 to February 28, 2021, four further media stories were published reaching an estimated audience of 42,000 and on websites attracting estimated monthly audiences of approximately 19,000 people.

Social media

FEI's social media accounts provide direct channels to update, inform and talk to customers and the general public. Between October 1, 2019 and February 28, 2021, FEI published 48 posts across Facebook and Twitter to inform its online audience of the project. These posts reached more than 1.12 million British Columbians, and generated 26,670 engagements (including post shares, retweets, comments, likes and link clicks).

Webpage

There were 22,390 unique visitors (defined as distinct individuals) to the Project webpage between October 1, 2019 and February 28, 2021.

Energy Moment

To ensure customers remained updated, FEI included content in its *Energy Moment* newsletter in October 2019, January and March 2020, and February 2021 (Appendix H-20). *Energy Moment* is an FEI-produced newsletter that goes to more than 40,000 subscribers. FEI will continue to provide Project updates via *Energy Moment* as the Project progresses. Similarly, external public communication channels will continue to be used as needed to inform and engage customers and the public as the Project progresses.

The following appendixes have more information:

- Appendix H-6: Project communication metrics;
- Appendix H-8: News media coverage;
- Appendix H-9: 2019 information session campaign wrap report (*note: 2021 information session campaign wrap report was not available at time of filing*);

- Appendix H-10: Announcement news release;
- Appendix H-11: Project website;
- Appendix H-12 and H-21: Bill inserts (November 2019, and March and September 2020);
- Appendix H-13: 2019 media outreach; and
- Appendix H-26: 2021 virtual information session online bill payment platform notification

Paid Advertisements

Paid advertising allows FEI to reach large numbers of customers and the public to raise awareness of the Project and offer opportunities to provide feedback. Advertising campaigns were used to promote the 2019 and 2021 information sessions and drive participation, reaching a total audience of 4.16 million British Columbians.

In 2019, FEI targeted communities across FEI's service territory between October 7 to November 17, including:

- Print ads in 50 newspapers, reaching an estimated audience of more than 1 million;
- Geo-targeted digital ads on websites including Weather Network, Postmedia and Google, reaching an estimated audience of almost 1.5 million; and
- Promoted Twitter content reaching an estimated audience of more than 100,000.

In 2021, advertising ran from February 8 to 24 and targeted FEI's entire service territory. It was predicted to reach an audience of more than one million. FEI expects to be able to confirm the campaign's effectiveness in late April 2021, when it receives a campaign summary report. The campaign included:

- Ads in the *Vancouver Sun* and *Province* newspapers, and in targeted regions of Black Press' newspaper network. This was expected to reach an audience of about 440,000;
- Paid and non-paid social media content on Facebook and Twitter generating more than 1.12 million impressions (audience views), 19,000 engagements (likes, shares, comments, etc.) and over 8,300 people clicking the link to learn more; and
- Social media also generated over 500 comments across Facebook and Twitter, which FEI monitored and responded to as appropriate. Most comments related to network operations, safety features, customer benefits and Project costs.

The following appendixes have more information:

- Appendix H-9: 2019 advertising campaign report;
- Appendixes I-14: Examples of 2019 and 2021 print ads; and

- Appendixes I-15, I-16: Examples of 2019 digital ads and 2021 social media ads.

Bill Inserts

FEI has updated residential and commercial customers by directly contacting them via bill inserts, as the customer perception survey indicated more than two-thirds of customers preferred this method of communication. Bill inserts are sent to customers with their bill, including as part of an email sent to paperless billing customers. They are generally supported by a notification posted on FEI's online bill payment platform, which reaches approximately 455,800 gas customers who have registered with Account Online.

Bill inserts were sent in November 2019 and March 2020 to announce the Project and provided an update regarding a planned meter survey. These inserts are available in Appendix H-12. An additional bill insert was sent in September 2020 to update customers on the meter survey (Appendix H-21).

Public Information Sessions

Information sessions provide an opportunity to directly consult with the public and customers, either face-to-face or virtually to answer questions and address concerns. About half of the respondents to FEI's customer perception survey indicated they preferred information session opportunities as a way to learn more.

FEI hosted 12 information sessions throughout its service territory in late 2019, ensuring that subject matter experts, technical meter experts, and local community relations representatives were available to the public at each session. The information sessions included: examples of what the new meters would look like; display boards with Project information (Appendix H-18); and materials attendees could take home for future reference (Appendix H-19).

FEI held information sessions in communities that were deemed centrally located within its service territory that had appropriate facilities and were accessible by neighbouring communities serviced by FEI. Information session locations and dates included:

- Prince George – October 15, 2019
- Fort Nelson – October 16, 2019
- Kelowna – October 22, 2019
- Vernon – October 23, 2019
- Kamloops – October 24, 2019
- Cranbrook – October 28, 2019
- Castlegar – October 29, 2019
- Oliver – October 30, 2019
- Courtenay – November 4, 2019

- Victoria/Saanich – November 5, 2019
- Lower Mainland (Burnaby) – November 13, 2019
- Fraser Valley (Chilliwack) – November 20, 2019

A total of 66 people attended the 2019 in-person information sessions. Inquiries relating to Project timelines and scope of work, customer benefits, costs and general meter inquires. Some attendees expressed concerns regarding privacy, perceived health impacts and Project costs, as outlined in more detail in Section 7.2.7, while others expressed interest in early adoption opportunities. Overall, the safety benefits proposed by the Project were well received by attendees. A summary of information sessions is included in Appendix H-2.

On February 23 and 24, 2021, FEI held two virtual information sessions to provide customers with the latest Project information ahead of filing. The sessions included a presentation on Project progress since the Project was previously announced, as well as the opportunity for attendees to engage with FEI to have their questions answered and provide feedback. Subject matter experts and community relations representatives were available to answer questions. In total, 71 participants joined the sessions with about 30 questions answered. Questions generally focused on meter and network technology, early adoption opportunities, Project costs, and Project safety benefits. A summary of the questions asked and feedback provided is included in Appendix H-2. The information session presentation is included at Appendix H-25.

FEI will continue to host similar consultation opportunities as the Project progresses.

Project Email and Phone Line

Providing a direct way for customers and the public to contact FEI regarding the Project is an essential part of ongoing consultation. FEI established a Project email and phone line in advance of publicly announcing the Project. These have been included in all promotional activities and materials.

As of March 1, 2021, FEI had received over 230[128] email and phone inquiries into its Project email and phone line. A summary of these inquiries and responses is located in Appendix H-2.

Employee Communications

The key objective of FEI's employee communications was to introduce the Project to employees, many of whom are also FEI customers and who live and work in communities serviced by the company. Various activities supported this objective including:

- Internal video with the Vice President, External Relations and Market Development discussing the need for the Project;
- Dedicated Project page on FEI's intranet and various articles on the Project;

[128] 230 refers to Project email and phone line inquiries specifically, while other figures include inquiries from FEI's contact centre phone lines.

- Leadership communication with the option of participating in a conference call;
- Traveling roadshow on the project with the Vice President, Energy Supply to have a dialogue with employees across the province on the Project;
- Virtual presentations to contact centre employees; and
- Discussion of the Project at the 2019 annual leadership summit.

FEI will continue to engage with employees as the Project progresses.

7.2.6 FEI Has Undertaken Appropriate Provincial, Local and Regional Government Consultation to Date

FEI's Stakeholder and Government Consultation Log (Appendix H-2) provides a summarized log of the meetings, discussions, presentations, and correspondence FEI has completed with provincial, local and regional government stakeholders. FEI consulted with local and regional government through a variety of methods, such as in-person discussions at the Union of BC Municipalities Conference (UBCM), virtual information sessions, and e-mail correspondence.

Provincial, Municipal and Regional Government Information Sessions

MLAs and City/Municipal Managers across FEI's service territory were invited to participate in virtual information sessions, where they could learn more, ask questions and provide feedback. Provincial, municipal and regional government representatives were invited to these opportunities via emailed notification letters. FEI ensured key Project team members were available to answer any questions asked.

- On October 11, 2019: Four MLAs and five municipal partners attended separate virtual information sessions. Questions were general in nature and included discussions about potential Project costs, customer benefits, and FEI's consultation and communication plans for customers and the public; and
- On February 18, 2021: Seven MLAs and 14 municipal partners attended separate virtual information sessions. Questions from the municipal session were technical in nature regarding the proposed network, joint-use opportunities and environmental benefits, while the session with MLAs produced a single question about how FEI intends to manage the data it receives from meters.

The letters sent to MLAs and city/municipal managers are included as Appendices H-3 and H-4 (2019), H-22 and H-23 (2021). For more detail regarding the virtual information sessions, please refer to the Consultation Log (Appendix H-2).

7.2.7 FEI Has Engaged With Industry Associations to Collect Subject Matter Expertise Regarding Best Practices and Safety Features

In addition to the affected parties identified above, FEI has also engaged with BC Hydro and Power Authority (BC Hydro) regarding the Project. BC Hydro has knowledge and expertise regarding its own smart metering upgrade program. FEI met with BC Hydro in early 2020 to discuss its lessons learned and understand its experiences with the smart meter program.

In addition, the Institute for Catastrophic Loss Reduction (ICLR) approached FEI in November 2020 to discuss the Project and learn more about the safety capabilities of the proposed meter. FEI met with members from the ICLR in fall of 2020 to discuss the Project. The ICLR provided a recommendation that FEI investigate the potential to include automatic seismic shut-off devices as a feature of the proposed advanced meter.

7.2.8 FEI Has Responded to Questions and Concerns Raised by Customers and Stakeholder Groups

As of March 1, 2021 FEI had responded to more than 500 public inquiries over telephone (*Project phone line and FEI customer service),* email and at information sessions. A variety of topics were discussed during these interactions, with several central themes emerging regarding issues and concerns around health, privacy and customer rates (see Appendix H-2 for further details on interactions and topics discussed). Notably, a number of these inquiries were supportive of the Project and requested to be early technology adopters, while others inquired about employment opportunities and expressed general support for the Project's expected safety enhancements.

Health

Concerns regarding the new network generally pertained to perceived health effects related to radiofrequencies (RF), and concerns about how the Project could exacerbate perceived pre-existing sensitivity to wireless technology (Section 5.8.1).

FEI's responses generally included discussions regarding:

- Emissions from the proposed technology would fall well below Health Canada's Safety Code 6 standards for RF fields. More details are provided in Section 5.8.1;
- FEI would be proactively offering a radio-off option; and
- That the new meters only send information over the wireless network at intervals and for generally less than a few seconds a day (Section 5.8.1).

Privacy

Privacy concerns centred on whether FEI could use the new technology to tell when customers were using specific appliances and how customer information would be protected.

FEI's responses generally included discussions regarding:

- The new network will be owned and operated by FEI, all data will be retained in Canada, and the new network will meet leading industry security standards (more details in Section 5.8.2);
- The only data advanced meters transmit is a gas reading at a certain point in time along with a code used to identify a meter;
- Customer information such as account balance, consumption data, and name and address will not be transmitted;
- All meter reading information sent wirelessly will be encrypted to North American and international standards; and
- All customer personal information, including but not limited to that involved in this Project, will be protected under the *British Columbia Personal Information Protection Act*.

FEI's privacy policy applies to all personal information collected by FEI (see Section 5.8.3 for detailed information regarding privacy). FEI will continue to address questions and concerns raised about privacy in an open and transparent manner.

Customer Rates

A small number of public inquiries raised concerns regarding the Project's costs and the potential to impact customer rates. FEI responded to explain why it was pursuing the Project, including customer benefits such as the ability to access daily gas usage information and safety features that include remote leak detection and shut-off capabilities. These benefits are detailed further in Section 4 of the Application. It should be noted that during early stages of consultation, the Project cost had not yet been determined.

7.2.9 FEI Will Address or Respond to Outstanding Issues or Concerns

FEI has responded to all concerns raised and sought to address them where possible. FEI's responses generally received either a positive reply or an acknowledgement for the information FEI provided (see Appendix H-2 for a log of interactions). FEI acknowledges that there are some members of the community that remain opposed to the Project due largely to perceived health issues associated with the new meters' RF and the increased use of wireless technology in general. One of the key ways FEI has sought to address RF-related concerns is by communicating that customers can select a radio-off option from the outset of the Project.

FEI will continue to consult with the public as the Project progresses, including continuing to look at ways to address or respond to future concerns raised.

7.2.10 FEI's Documentation and Evidence Supporting Consultation Efforts

All documentation, correspondence and communication materials that supported consultation in connection with the Project are included in Appendixes H-1 to H-26.

7.2.11 Consultation and Communications Plan Going Forward

FEI anticipates interest in the Project will increase as it approaches deployment, and as such, FEI will update its Consultation, Engagement and Communications Plan. To ensure it is effective, FEI's updated plan will incorporate:

- Lessons learned since Project announcement and during consultation completed so far;
- Lessons learned from FBC's deployment of advanced meters;
- Feedback received from early consultation;
- Ongoing dialogue with customers, stakeholders and municipalities; and
- Industry best practices as learned from other utilities that have deployed similar technology.

Due to the scale and geographic reach of the Project, FEI's future consultation and communication activities will be tailored to address the unique needs of the various regions it serves. Broadly speaking these activities are expected to include:

- Direct notifications and virtual information sessions for provincial, local and regional governments;
- Customer communications, including via bill inserts and *Energy Moment;*
- General Project updates communicated via a website, social media, advertising and media outreach;
- Stakeholder and community presentations and meetings;
- Public information sessions; and
- Regular employee updates.

The Project website, email address and phone number will be maintained as an easy-to-access channel for customers and the broader public to provide FEI with feedback. As well, FEI will continue to regularly update all levels of government and other stakeholders.

7.2.12 Overview of Sufficiency of Public Consultation Process to Date

FEI believes that its consultation and communication activities at the time of filing the Application have met the requirements of the Application guidelines.

FEI recognizes the extensive nature of this Project and the additional consultation efforts required to support it. The Project will require almost all natural gas meters to be exchanged, affecting approximately 1.1 million residential, commercial and industrial customers, reaching communities throughout the province and FEI's entire service territory. Based on the scale and scope of the Project, FEI ensured it used the variety of channels available to maximize Project promotion and encourage consultation. These efforts surpassed FEI's standard outreach and consultation for a typical major project and included:

- Two advertising campaigns. One in 2019 targeting almost 50 different communities in British Columbia and one in 2021 targeting FEI's entire service territory, collectively reaching an audience of more than 4.16 million;
- Three bill inserts to inform customers directly;
- 12 in-person information sessions in 2019, held throughout the province to gather feedback and answer questions;
- Two virtual information sessions in 2019, for provincial, municipal and regional governments;
- Four virtual information sessions in 2021, to provide a Project update to customers, the community and provincial, municipal and regional governments;
- A total of 69 news stories on the Project including newspaper, radio, television and online coverage reaching an estimated audience of 740,000 people and featuring on webpages with 5.4 million monthly visitors; and
- Approximately 22,390 unique visitors accessing the Project webpage and more than 500 customers contacted FEI directly via phone or email with questions or comments between October 2019 and March 2021.

This demonstrates FEI's commitment to promoting awareness of the Project and providing ample opportunities for feedback. FEI has responded to all feedback received. FEI is committed to maintaining an open and transparent consultation process throughout the Project to support deployment, respond to customer concerns and minimize disruptions.

7.3 *ENGAGEMENT WITH INDIGENOUS GROUPS*

FEI engages meaningfully with Indigenous groups through transparent, frequent, two-way dialogue. FEI is guided by its 'Statement of Indigenous Principles', developed in 2001, with guidance and input from Indigenous leaders across British Columbia (Appendix I-1). This collaborative approach leads to early identification of issues or concerns, and a shared interest in finding mutually agreeable solutions. Since October 3, 2019, FEI has engaged with Indigenous groups who are potentially affected by the Project. Engagement with Indigenous groups ahead of FEI's Project submission to the BCUC included two notification letters, follow-up phone calls and face-to-face meetings as requested. FEI tracked these discussions, with no outstanding concerns raised at the time of filing.

FEI seeks to build relationships with Indigenous groups across the province and will continue to abide by its core principles throughout the lifecycle of the Project. At the time of filing, there are no known outstanding issues; however, FEI will continue to engage with Indigenous groups throughout the life of the project and will address issues and concerns that may arise.

FEI also recognizes that while the constitutional duty to consult typically rests with Crown agencies, its Indigenous engagement activities as a proponent of the Project will aid the appropriate Crown agency in its responsibilities. As a result, FEI recognizes that its engagement approach should be thorough, timely and meaningful, and potential impacts of the Project on the title, rights and interests of affected Indigenous groups should be documented and considered. Moreover, FEI is committed to working with Crown agencies to identify, avoid and mitigate potential impacts on Indigenous title, rights and interests and where appropriate to discuss and develop options for accommodation.

The following sections provide details of FEI's Indigenous engagement on the Project, including:

- FEI has identified the Indigenous groups that may be impacted by the Project (Section 7.3.1);
- FEI has consulted with potentially affected Indigenous groups in a thorough, timely and meaningful manner (Section 7.3.2);
- FEI has addressed the issues and interests raised by Indigenous groups to date (Section 7.3.3);
- FEI's commitment to address any existing or anticipated issues or concerns (Section 7.3.4);
- Documentation of issues and interests raised by Indigenous groups (Section 7.3.5);
- Engagement, consultation and communication with Indigenous groups to date has been appropriate (Section 7.3.6);
- In accordance with its Statement of Indigenous Principles, FEI is committed to continued engagement with Indigenous groups throughout the Project (Section 7.3.7); and
- Overview of sufficiency of FEI's engagement process to date (Section 7.3.8).

7.3.1 Indigenous Groups Potentially Affected

The list of potentially affected Indigenous groups is presented below (Table 7-1). Due to the nature of the Project, the potential impacts for Indigenous groups are anticipated to be minimal.

FEI is committed to continued engagement with Indigenous communities that have customers on Crown reserve lands, as these groups have been identified as those potentially affected by the scope of the Project.

Table 7-1: Indigenous Groups Engaged

Indigenous Communities		
Adams Lake Indian Band	Musqueam Indian Band	Squiala First Nation
Aitchelitz Band	Neskonlith Indian Band	Stz'uminus First Nation
Chawathil First Nation	Okanagan Indian Band	Sumas First Nation
Cheam First Nation	Osoyoos Indian Band	T'Sou-ke First Nation
Coldwater Indian Band	Penticton Indian Band	Tk'emlúps te Secwépemc
Cowichan Tribes	Prophet River First Nation	Tsartlip First Nation
Esquimalt Nation	Seabird Island Indian Band	Tsawout First Nation
Fort Nelson First Nation	Semiahmoo First Nation	Tsawwassen First Nation
Halalt First Nation	Shíshálh First Nation	Tseshaht First Nation
Hupacasath First Nation	Shxwhá:y Village	Tseycum First Nation
Katzie First Nation	Skeetchestn Indian Band	Tsleil-Waututh First Nation
K'ómoks First Nation	Skowkale First Nation	Tzeachten First Nation
Kwaw Apilt First Nation	Skwah First Nation	Union Bar Indian Band
Lheidli T'enneh First Nation	Snuneymuxw First Nation	Wei Wai Kum Nation
Lhtako Dene First Nation	Songhees First Nation	Westbank First Nation
Little Shuswap Lake Indian Band	Soowahlie Indian Band	Williams Lake Indian Band
Lower Nicola Indian Band	Splatsin First Nation	Yakweakwioose Indian Band
Matsqui First Nation	Squamish Nation	ʔaq'qm (St. Mary's Indian Band)

7.3.2 FEI's Engagement with Indigenous Groups to Date

In line with FEI's outreach activities to all customers, Indigenous engagement activities commenced on October 3, 2019, with the mail-out of electronic and hard copy letters (see Appendix I-2 for engagement details and Appendix I-3 for a copy of the letter). This was followed by targeted outreach discussions, phone calls and follow-up emails to all 54 Indigenous communities listed above.

On February 9, 2021, a letter was emailed to Indigenous groups, providing a Project update and inviting them to participate in FEI's public virtual information sessions on February 23 and 24, 2021 (see Appendix I-2 for engagement details and Appendix I-4 for a copy of the letter).

FEI has also conducted public communications and engagement activities across its service territory to support the Project (Section 7.2), which would have reached Indigenous groups and customers. This included using a variety of methods (for example bill inserts, media outreach, a webpage and advertising) to communicate and engage with those potentially affected by the Project, as detailed in Section 7.2.4. These activities support FEI's ongoing and direct engagement with Indigenous communities.

7.3.3 FEI Has Responded to Issues and Concerns Raised by Indigenous Groups

Through the course of FEI's initial engagement, Indigenous groups raised minimal issues or concerns. Following the first notification from October 3, 2019, two communities contacted FEI requesting in-person meetings.

Okanagan Indian Band

This band requested additional information about the Project on October 16, 2019. An in-person meeting was held on November 7, 2019, in Vernon (presentation included as Appendix I-5). Questions were related to Application timelines, number of customers potentially affected on-reserve, location of network infrastructure, plans on working with other service providers, potential employment opportunities and privacy impacts. FEI followed up with additional details on November 29, 2019 and indicated that it would continue to engage with Okanagan Indian Band and provide further updates as they became available.

Coldwater Indian Band

A telephone meeting with Chief and Council was held on May 13, 2020. Questions from Chief and Council focused on issues related to safety (fires, carbon monoxide, and electromagnetic fields) and access, and were addressed by FEI during the call. Coldwater Indian Band also indicated a preference for working through a community appointed liaison during deployment and FEI was able to confirm that this can be arranged if the Project proceeds. Both parties agreed that further engagement would be beneficial closer to deployment and FEI agreed to remain in touch.

In addition, three Indigenous groups reached out to FEI for more information following the distribution of the letter on February 9, 2021. Skeetchestn Indian Band and Squiala First Nation requested registration information to the public information sessions, while Stz'uminus First Nation inquired about the number of FEI gas customers that reside in their community.

7.3.4 FEI Will Address or Respond to Outstanding Issues or Concerns Raised by Indigenous Groups

At the time of filing, there are no outstanding issues or concerns that have been raised by Indigenous communities. FEI will continue to engage with affected Indigenous groups as the Project progresses.

7.3.5 Documentation and Evidence Supporting Consultation Effort

A summary of interactions to date with Indigenous groups is found in Appendix I-1.

7.3.6 FEI's Indigenous Engagement Process to Date Has Been Appropriate

On October 3, 2019, FEI notified the 54 potentially affected Indigenous groups of the Application's filing date with the BCUC (originally anticipated for early 2020) and provided details on how they can become involved in the regulatory process (Appendix I-3). On February 9, 2021, FEI provided an update to the expected regulatory filing date, which had moved to spring 2021. (Appendix I-4).

FEI will reach out to all potentially impacted Indigenous groups again after filing to inform them of the Application's submission and, in greater detail, how they can get involved.

7.3.7 FEI is Committed to Future Engagement and Communications with Indigenous Groups

In accordance with its Statement of Indigenous Principles, FEI remains committed to engaging with Indigenous communities in an ongoing, transparent and meaningful manner. In addition to activities outlined above in Section 7.2.10 that will reach gas customers within Indigenous communities, future engagement activities will include letters, email, phone calls, and virtual meetings or community information sessions if requested.

Furthermore, FEI will look into creating training and job opportunities for local and Indigenous groups as part of Project implementation. Opportunities will be explored as the Project progresses.

Future engagement activities will be guided by FEI's Consultation, Engagement and Communications Plan to address issues or concerns raised throughout the life of the Project.

7.3.8 Overview of Sufficiency of Engagement Process to Date

Indigenous communities that are potentially affected were identified and appropriately engaged through multiple rounds of engagement. At the time of filing, there are no outstanding issues or concerns that have been raised by Indigenous communities. FEI will continue to inform and engage with Indigenous communities as the Project progresses. If concerns are raised, FEI is committed to responding and addressing them in a respectful, timely, and transparent manner.

FEI believes it has undertaken an appropriate level of engagement with Indigenous groups at this current stage of the Project and is committed to continuing engagement throughout the life of the Project.

7.4 *SUMMARY OF CONSULTATION*

FEI has consulted and sought feedback from public and all stakeholders and has engaged with the potentially impacted Indigenous groups in the area of the Project. FEI's consultation and engagement has been sufficient to date, and FEI will continue to work with all identified stakeholders and Indigenous groups to address issues and concerns throughout the lifecycle of the Project.

8. PROVINCIAL GOVERNMENT ENERGY OBJECTIVES

8.1 INTRODUCTION

Section 46 (3.1) of the UCA states that in considering whether to issue a CPCN, the BCUC must consider:

(a) the applicable of British Columbia's energy objectives,

(b) the most recent long-term resource plan filed by the public utility under section 44.1, if any, and

(c) the extent to which the application for the certificate is consistent with the applicable requirements under sections 6 and 19 of the *Clean Energy Act* (CEA).

Sections 6 and 19 of the CEA, as referred to in (c) above, do not apply to FEI.[129] In this section, FEI will:

- Describe how the Project is consistent with British Columbia's energy objectives as well as BC's Smart Meters and Smart Grid Regulation and CleanBC Plan (Section 8.2); and
- Describe how the Project is consistent with FEI's most recent long-term resource plan (Section 8.3).

8.2 BRITISH COLUMBIA'S ENERGY OBJECTIVES

The Project is consistent with British Columbia's energy objectives, which are defined in section 2 of the Clean Energy Act (CEA). The CEA contains a set of sixteen specific energy objectives for the province of BC It provides a guide to help the province meet its self-sufficiency goals and to reduce GHG emissions. The CEA includes several social and economic goals for the province, including a greater focus on encouraging economic development, creating and retaining jobs, and encouraging economic development for First Nations and rural communities through the development of clean and renewable power.

The CEA further promotes energy efficiency objectives as a consideration in evaluating the activities, programs and rate-setting undertaken by utilities within British Columbia. The CEA defines British Columbia's energy objectives, which include:

(b) to take demand-side measures and to conserve energy

[129] The BCUC has held that "[s]ections 6 and 9 of the *CEA* apply to electric utilities only and accordingly are not relevant to this Application": Terasen Utilities (Terasen Gas Inc., Terasen Gas (Whistler) Inc. and Terasen Gas (Vancouver Island) Inc.) 2010 Long Term Resource Plan – Decision (February 1, 2011), p. 16; FortisBC Energy Inc. 2017 Long Term Gas Resource Plan – Decision and Order G-39-19 (February 25, 2019), p. 3.

(d) to use and foster the development in British Columbia of innovative technologies that support energy conservation and efficiency and the use of clean or renewable resources

(g) to reduce B.C. greenhouse gas emissions

(k) to encourage economic development and the creation and retention of jobs.

These energy objectives provided in the CEA placed focus on demand-side management measures and advanced metering. The Project implements AMI technology and provides a foundation to support and enable natural gas conservation and efficiency primarily through the provision of improved natural gas consumption information for customers. Improved consumption data will support natural gas conservation by providing consumers with actionable insight on their consumption further enabling the implementation of demand side measures to reduce consumption. Finally, reducing customer consumption of natural gas will contribute to lowering GHG emissions in BC and is consistent with climate action plans which are described in greater detail below.

The Project will also support the energy objective stated in section 2(k) of the CEA "to encourage economic development and the creation and retention of jobs". The Project will support this objective by creating jobs and contributing to the local economy. The Project will create jobs in BC through FEI's contractors, and result in the procurement of goods and services from locally-owned and operated vendors and subcontractors. FEI also anticipates an increase in the use of local services, such as dining, accommodations and other services, during deployment, which will benefit the economy.

The provincial government explicitly stated its support for advanced metering solutions, mandating BC Hydro to install advanced meters by the end of 2012 and establish a program to install and put into operation a smart grid by the end of 2015 as provided in the CEA and the Smart Meters and Smart Grid Regulation (2010). The provincial government also demonstrated its support for advanced metering for utilities other than BC Hydro. Section 17 (6) of the CEA provides:

(6) If a public utility, other than the authority, makes an application under the Utilities Commission Act in relation to smart meters, other advanced meters or a smart grid, the commission, in considering the application, must consider the government's goal of having smart meters, other advanced meters and a smart grid in use with respect to customers other than those of the authority.

FEI submits that the implementation of AMI supports British Columbia's energy objectives as cited above and meets the government's goal of having advanced meters and a smart grid (as defined in the CEA and in the related regulation) in use for FEI customers.

8.2.1 Smart Meters and Smart Grid Regulation

The provincial government has given effect to the 2007 BC Energy Plan in several enactments, including the Smart Meters and Smart Grid Regulation (2010). The Smart Meters and Smart Grid Regulation (2010) details the prescribed requirements of "Smart Grid" and "Smart Meter". FEI has examined the regulation, and although the regulation is clearly "electricity utility" focused, there is much that applies to natural gas as well. FEI has determined that its proposed Project is aligned with many of that regulation's requirements. A summary table of the regulation requirements, adapted for a natural gas utility focus, is provided below.

Table 8-1: Summary of Smart Meter and Smart Grid Requirements

Category	Requirements of Smart Grid Regulation	FEI's Proposed AMI Solution
Meter	Measures commodity supplied to an eligible premises	✓
	Transmits and receives information in digital form	✓
	Enables remote disconnect for residential premises	✓
	Records and timestamps measurements of natural gas consumption	✓
	Records intervals at a frequency of at least 60 minutes	✓
	Can be configured remotely or onsite	✓
Installation	An advanced meter will be installed for each eligible premises	✓
	Secure hardware and software systems will be installed to: • Monitor, control and configure advanced meters and communications infrastructure • Store, validate, analyze and use the data measured by and received from advanced meters • Provide secure internet access for data about a customer's natural gas consumption, measured by the advanced meter • Integrate with the utility's other systems	✓
	Communications infrastructure includes a telecommunications network that is capable of delivering two-way, digital and secure communications	✓
	Communications infrastructure must integrate to the utility's systems	✓
Smart Grid	Enable two-way, digital, and secure communication among system devices, automation-enabled devices and the systems and equipment used by the utility for monitoring and controlling its natural gas system	✓
	Integrate the operation of the smart grid with the utility's other operations	✓

8.2.2 The CleanBC Plan

In December 2018, the provincial government released its CleanBC Plan, which aims to reduce climate pollution, while strengthening BC's economy. Through its consultation with the provincial government regarding the CleanBC Plan, FEI and FBC (together FortisBC) developed its climate plan, the Clean Growth Pathway to 2050 (Clean Growth Pathway), which outlines FortisBC's vision for aligning with the BC government's goal to transition to a low carbon and renewable energy economy and address climate change solutions in a global context. Under the Clean Growth Pathway, FortisBC has set an interim target, 30BY30[130], to reduce its customers' emissions by an amount equivalent to 30 percent by 2030. FortisBC's 30BY30 target and the Clean Growth Pathway are based on four key pillars:

- **Renewable Gases** – increasing the amount of renewable gases (such as renewable natural gas hydrogen and syngas) delivered to customers which displaces conventional natural gas, lowering emissions and contributing towards BC's transition to a lower carbon future.
- **Energy Efficiency and Conservation –** investing in energy efficiency and conservation to help customer reduce their consumption, save on energy costs, and lower their emissions.
- **Zero and Low Carbon Transportation** – investing in electric vehicle charging infrastructure to support the transition of light duty vehicles to electricity and investing in our Natural Gas for Transportation (NGT) program to help heavy duty vehicles transition from higher emitting fuels like diesel.
- **LNG for Marine Fuelling and Global Markets** – providing liquefied natural gas (LNG) to the marine shipping industry and to customers around the world to help lower emissions in transportation, industry and energy generation by displacing higher emitting fuels like coal, bunker oil and diesel.

The Project is aligned with the CleanBC Plan and FortisBC's Clean Growth Pathway as follows:

- the proposed advanced meters are compatible with certain renewable gases, such as hydrogen and biomethane;
- the proposed advanced meters provide detailed data which can enhance energy efficiency programs and help customers to better manage their gas consumption; and
- the proposed advanced meters substantially eliminate manual meter reading thereby avoiding GHG emissions associated with meter reading vehicles as described in Section 4.3.2.1.

8.3 *LONG TERM GAS RESOURCE PLAN*

FEI's most recent Long Term Gas Resource Plan (LTGRP) was filed on December 14, 2017 (2017 LTGRP) and was accepted by the BCUC on February 25, 2019 by Decision and Order G-39-19. The 2017 LTGRP cites advanced metering solutions in a number of instances as important for gaining better data on customer usage that would allow the utility to better plan its

[130] The 30BY30 target is an absolute target to avoid 3.9 million tonnes of carbon dioxide equivalent (CO_2e) emissions by the year 2030.

system to meet changing customer needs and end-use trends. Some of the potential benefits of advanced monitoring of demand close to the end use were directly addressed in the Action Plan[131] and public hearing on FEI's LTGRP.

In Section 2 of the 2017 LTGRP, FEI describes the importance of innovative and integrated customer solutions for positioning natural gas services competitively within BC's energy marketplace for the benefit of all customers. Advanced metering is cited as a potential solution that FEI is exploring.

In addition, FEI responded to a number of information requests (IRs) on AMI technologies related to carbon emissions, demand side management and demand forecasting. In responses to IRs, FEI referred to its investigation of AMI for load aggregation, efficiency, and detection of fugitive emissions.[132]

In Section 6.2.1.3 of the 2017 LTGRP, FEI describes how its exploratory peak analysis work remains theoretical because it is not supported by direct measurement of FEI's customer end-use trends. The current monthly meter reading data is insufficient to reliably understand what use trends are occurring that could impact peak demand. Advanced metering is noted as a possible solution to provide improved data for analysing end use trends and analysing peak demand trends. The data provided by AMI will help FEI to determine the impacts its Conservation & Energy Management (C&EM) measures on peak demand.[133] Advanced metering, as proposed for the Project, represents the primary technology that would enable this improved understanding of the impact of changing end-use trends on both total annual and temperature sensitive customer demand.

Further discussion of the key opportunities enabled by AMI technology for use in long term resource planning is provided in Section 4.3.2.4.2.

8.4 *CONCLUSION*

In summary, the Project is consistent with British Columbia's energy objectives and FEI's most recent long-term gas resource plan. The Project is also aligned with the provincial government's CleanBC Plan and will positively contribute towards emissions reductions in BC. These factors support the approval of the Project.

[131] The 2017 LTGRP included an Action Plan (section 9) that identifies the activities that FEI intends to take during the first four years of the 20-year planning horizon.

[132] 2017 LTGRP, BCSEA IR 1.1.1.

[133] 2017 LTGRP, BCUC IR 1.29.1, BCUC IR 1. 29.3.2, BCUC IR 2.64.1.

9. CONCLUSION

The AMI Project is in the public interest. The Project will allow FEI to automate the meter reading process, which will provide a more accurate and convenient process for FEI customers, and a more stable and cost-effective meter reading solution for the long term. FEI's current meter reading practices are highly manual, are vulnerable to errors and can be inconvenient to customers. The Project will reduce FEI's reliance on third-party meter reading services where there is increasing uncertainty in the market regarding price and availability of services, and will ensure FEI has a meter technology in place that will be available for the long term.

FEI recognizes that the Project represents a large investment in FEI's system resulting in a slight increase in customer rates; however, the benefits of the full AMI Solution are significant. AMI will allow FEI to advance key operating benefits, including increasing system resiliency, improving system planning abilities, providing better data for operational and project use, and improving emergency response and detection of leaks downstream of the meter. AMI will also empower FEI customers with better consumption data to support decision making and conservation efforts. In addition, AMI will provide FEI with the ability to offer enhanced billing and DSM options.

FEI has appropriately planned and defined the Project and will continue to work with customers and stakeholders, including Indigenous communities, to address issues and concerns as part of the Project deployment, as well as the public more generally.

The Company requests that the BCUC approve the Project and grant the other approvals sought as set out in the Application.

Appendix A

UTIL-ASSIST REPORT – AN OVERVIEW OF NORTH AMERICAN GAS AMI

May 12, 2020

An Overview of North American Natural Gas AMI and AMR Projects

Table of Contents

Section 1: Introduction

1.1 About the Author

This report has been created by Util-Assist Inc., a leading consultant for North American utilities. Established in 2005, the firm was created to assist utilities by operating in the middle ground between vendors and customers in the electric, water and gas utility industry. Util-Assist consultants work with the utility sector to develop cost-effective, achievable strategies on utility systems integration and implementation, conservation initiatives, and other smart grid applications.

Over the years, Util-Assist has supported over 70 AMI implementations (representing over four million meters), helping many of the utilities develop solid business cases to justify moving to advanced metering infrastructure (AMI) for electric, water, and gas services. Util-Assist also gained considerable experience guiding utility clients to meet regulatory requirements in jurisdictions throughout Canada, and Util-Assist consultants have testified on behalf of several utilities at regulatory hearings as an expert witness.

Util-Assist was contracted by FEI to help with initial project planning and request for proposal (RFP) development for gas AMI provision and deployment services, and to consult on FEI's development of business case and regulatory filing material. In support of this latter initiative, FEI asked Util-Assist to provide this in-depth research report exploring the state of gas AMI in the North American landscape.

1.2 About this Report

This report was commissioned by FortisBC Energy Inc. (FEI), in the context of its interest in deploying new metering and infrastructure technology to enhance its natural gas distribution operations. The report details natural gas advanced metering infrastructure (AMI) and automated meter reading (AMR) projects across Canada and the U.S. (where possible with a focus on Canadian utilities and AMI projects) with the goal of presenting data and insights to support FEI's AMI strategy, business case, and regulatory application.

The focus of the analysis portion of this report is to explore the available and emerging technologies in the North American gas industry, identify what has proven successful in other utility projects, and detail what might factor into FEI's business case and regulatory filing in support of its chosen technology and approach. Because FEI's costs and benefits were not finalized at the time of writing, specific or direct comparisons of these aspects are not included.

1.3 About Gas AMI

1.3.1 AMI Versus AMR

While there are many different configurations and capabilities available within any given advanced metering infrastructure (AMI) or automated meter reading (AMR) system, this report uses these terms as they are defined by the Federal Energy Regulatory Commission (FERC). These definitions are as follows:

Advanced Metering: Advanced metering is a metering system that records customer consumption [and possibly other parameters] hourly or more frequently and that provides for daily or more frequent transmittal of measurements over a communication network to a central collection point. The key concept reflected in this definition is that advanced metering involves more than a meter than can measure consumption in frequent intervals. Advanced metering refers to the full measurement and collection system, and includes customer meters, communication networks, and data management systems. This full measurement and collection system is commonly referred to as advanced metering infrastructure (AMI).[1]

Automated Metering: Automated metering refers to a system where aggregated kWh usage, and in some cases demand, is retrieved via an automatic means such as a drive-by vehicle or walk-by handheld system.[2]

Generally, AMI is capable of two-way communication where the meters transmit detailed (daily, hourly, etc.) meter reads and other information over a wireless network back to utility systems, and the system can also send data or commands out to meters or modules (e.g., updates, status check requests/pings, etc.) AMR is an older, one-way technology, where the meters (or communication modules on the meters) transmit readings (typically monthly) via radio signal, which are typically collected by reading personnel with receiving equipment on foot, or in a vehicle (including airplanes, known as aerial meter reading). However, it is also possible to have a one-way AMR system communicate over a fixed network, without the need for reading personnel.

1.3.2 Gas AMI Background

As this report will explore, gas AMI (meaning gas meters communicating over a fixed two-way network) is still not widespread in the United States or Canada. Gas metering has traditionally lagged behind electric metering and has not been a primary target for technological advancements like AMI, in part because of cost and technical challenges, and in part because government subsidies and mandates have traditionally only incentivized electric AMI. An enabling technology for AMI use cases is solid-state meters, which are more precise and longer lasting than mechanical meters, and can include built-in computing and communications capabilities. Advanced electric meters were being considered for widespread deployment in Canada in the early 2000s; in Ontario, the Minister of Energy tasked the Ontario Energy Board with developing a smart meter implementation plan in July of 2004, with the goal of having smart meters installed for all Ontario customers by December 31, 2010.[3]

Gas meters, by comparison, faced greater cost and engineering challenges switching from their traditional mechanical diaphragm design to a solid-state design, which measures gas ultrasonically by using pulses of sound to measure flow of fluid through the meter. These meters offer several advantages over traditional meters but initially cost three or four times as much as traditional mechanical meters. While not a new technology (ultrasonic meters began to be adopted for industrial applications in the 1970s and 1980s), advances in electronics were needed before ultrasonic meters became a viable option for widespread and residential use. These advances came in the following decades, and the technology and worldwide market saturation matured along with them. Manufacturers first introduced residential ultrasonic gas meters for overseas markets, and the technology is now well established in Europe and parts of Asia; ultrasonic meters were first deployed in the UK in 1991, and major Japanese gas companies including Tokyo Gas, Osaka Gas, and Toho Gas began deploying them in the early 2000s.[4] While residential ultrasonic meters are already in their second and third generations overseas, vendors have been slower to introduce North American models, and most advanced gas meter deployments in North America to date have been module-based projects where mechanical gas meters are retrofit with AMI modules for use on electric AMI networks. However, with standalone and ultrasonic gas AMI solutions from major meter manufacturers now at a mature state, AMI vendors have been adapting and certifying their products for use in North America, and these offerings are now ready for widespread residential use in the North American market.

While combined networks and AMI or AMR module retrofit projects are still popular, cost-efficient options, the past decade has seen a number of advancements in gas AMI technology, which are creating new opportunities and incentives for widespread and standalone gas AMI projects. As manufacturing and battery technology continually improve, gas meter costs have come down while their features and operational life have increased. For example, the Sonix 600 meter as available in 2004 from the meter and AMI vendor Sensus had a 10-year battery warranty, with an advertised typical battery life of 13 years under normal conditions[5], while the newest Sensus Sonix IQ residential smart gas meter has an advertised 20-year battery life, with available warranty, according to the Sensus press release from October 2019.[6]

The images below show a comparison of the two gas meter forms: a traditional mechanical meter versus a current ultrasonic meter. The meters are shown to approximate scale, both meters are for residential use and are currently available on the market from Sensus (note that sizes are approximate and can vary based on exact meter configuration).[7]

	Sensus R-275 Mechanical Meter	Sensus Sonix IQ Solid-State Ultrasonic Meter
Height	240mm (13.4”)	200mm (8”)
Width	257mm (10.1”)	253mm (10”)
Depth	215.9mm (8.5”)	114mm (4.4”)
Weight	6.35kg (14 lbs.)	2.86kg (6.3 lbs.)

Besides being easier to ship, store, install, configure, and maintain, current-generation AMI meters also have numerous sensor, communication and computing capabilities built into them, which allows the meters to send data and alarms to the utility over the AMI network. Utilities can use this information, like alarms or more detailed meter data, to dispatch personnel to investigate or send remote meter shut-off commands, as some gas AMI meters have shut off valves built into them. Current generation gas AMI meters also have standard integrated sensors and alarms to monitor issues like flow, temperature, tampering, or theft.

Meter manufacturers are also starting to maximize their meters’ increasing onboard computing capabilities. Meters are now able to transmit multiple data streams; for example, meters have the capacity and ability to be configured to carry electric, water, and gas data simultaneously. The newest generation of meters are also being designed to act as edge-computing devices to deliver high-resolution data to improve safety and operations.[8] Edge computing is an emerging trend that allows computations and decisions to be made in the meter (or other devices at the “edge” of the network) as util-assist | Solutions. Simplified.

opposed to having all decisions and calculations made in the central utility systems like the head end system (HES) or meter data management system (MDM). Examples of this include meters that can make the decision to shut themselves off under certain conditions, or having the meters process or refine raw data before sending them back to the utility, potentially saving communication time and bandwidth on the network. Other edge devices include AMI-compatible sensors that enable telemetry capabilities and the collection of cathodic protection, pressure, and temperature readings. Vendors are also offering distributed intelligence devices in support of smart city initiatives, where infrastructure and energy consumption in urban areas can be automated with calculations and operations being performed by the field devices. A popular option is smart street lighting, where connected streetlights can both be used as network communication devices and also automatically adjust their light output, for example dimming to save energy when not needed, or brightening to increase safety and visibility in specific areas.

Despite the advancements and cost decreases that have taken place in the gas AMI market over the past decade, the technology is not yet widespread among North America gas utilities.[9] However, while cost and benefit barriers can still exist for deploying gas AMI meters and networks, particularly for utilities who have already deployed AMR and won't see large manual meter reading reductions, AMI is becoming the new standard for large-scale gas meter upgrades as existing assets reach their end of life. AMI is being recognized as a key technology that can promote and meet demands for conservation, customer service, and customer empowerment, and as additional opportunities and use cases for financial, safety, and operational benefits all continue to increase, gas AMI will begin to dominate the marketplace. This paper will explore these factors and opportunities in the context of the North American market and FEI's potential gas AMI deployment.

Section 2: Analysis

This analysis section summarizes the trends and information found in examining reference gas project details, with the goal of providing context, useful benchmarking comparisons, and support for FEI's project planning and business case. It will also address regulatory considerations and trends in the North American gas industry, and explore some of the emerging opportunities that are making gas AMI a more attractive investment for both current and future needs of utilities, customers, and society at large.

2.1 Select Gas AMI and AMR Projects

One-way AMR for natural gas reading has been in use for decades, and has been implemented by approximately 90 percent of gas utilities across the United States[10]. Two-way AMI for natural gas metering, while less common among the approximately 1,400 natural gas utilities and distribution companies across North America[11], is becoming the standard for meter upgrade projects, as utilities look to upgrade from manual reading or replace aging AMR systems nearing their end of life.

Below is a chart summarizing a selection of the larger gas AMI and more recent AMR projects in Canada and the United States. The included utilities were chosen as representational of their geographical areas, with consideration also of their technologies, focusing on gas AMI projects where possible. This is not an exhaustive list of all AMI and AMR projects, but is meant to be representational of more recent and larger-scale projects (above 100,000 endpoints), and shows the growing distribution and prevalence of AMI technology for gas utilities.

Utility	Project Type	Quantities	Timeframe and Notes
AltaGas (Alberta)	Aerial Gas AMR	80,000 gas AMR modules	2015 to 2016
ATCO Gas (Alberta)	Aerial Gas AMR	1.1 million gas AMR modules	Deployment from 2010 through 2014. Switched to aerial meter reading in July 2018.
City of Medicine Hat Utilities (Alberta)	Electric, water, and gas AMI	31,717 electric AMI meters 26,736 water AMI modules 23,378 gas AMI modules	Deployment from 2012 through 2015. The first project in Canada to include electric, water and gas measurement, monitoring, and control over a single AMI network.
Energir (Quebec)	Gas AMR	225,000 gas AMR modules	
SaskEnergy and SaskPower (Saskatchewan)	Electric and gas AMI	500,000 electric AMI meters 370,000 gas AMI modules	Deployment 2014 through 2018. Electric meter deployment halted in 2014. Mass gas module installations completed in 2017.

Utility	Project Type	Quantities	Timeframe and Notes
Alliant Energy (Wisconsin, Iowa, Minnesota)	Multi-state electric and gas AMI	1 million electric AMI meters 400,000 gas AMI modules	2007 start; deployment ongoing
Ameren Illinois	Electric and gas AMR, now transitioning to AMI	678,000 electric AMR meters 476,000 gas AMR modules	Aiming for 62% electric AMI coverage by 2022
Atmos Energy (Louisiana, Texas, Mississippi, Tennessee, Kentucky, Kansas, Colorado)	Multi-state, gas-only AMI module deployment	Serves approximately 3 million customers; all being transitioned to gas AMI modules over time	Deployment began in 2007 with 75,000 meter pilot, and is ongoing through service territory. One of the largest all-natural-gas distributors in the United States.
Baltimore Gas and Electric (BG&E – Maryland)	Electric and gas AMI	1.36 million electric AMI meters 730,000 gas AMI modules	Deployment 2009 through 2011
Con Edison (New York)	Electric and gas AMI	3.6 million electric AMI meters 1.3 million gas AMI modules	Planning and network 2015-2016 Implementation 2017-2022
Dominion Energy (Utah, Wyoming, Idaho)[12]	Gas AMR	650,000 gas AMR modules	2016 project start
TECO Peoples Gas (Florida)	Gas AMR	400,000 gas AMR modules	
San Diego Gas and Electric Company (California)	Electric and gas AMI	1.4 million electric AMI meters 900,000 gas AMI modules	Deployment from 2008 through 2010
SoCalGas (Southern California)	Gas AMI	6 million gas AMI modules (2.4 million new meters with AMI modules, and 3.6 AMI module retrofits)	Deployment 2013 through 2017. The largest gas-only AMI project in North America.

Utility	Project Type	Quantities	Timeframe and Notes
Liberty Utilities (Iowa, New England, Illinois, Missouri, Georgia, New Hampshire, California)	Multi-state, multi-utility AMI deployment for electric, water, and gas	266,000 electric AMI meters 173,000 water customers (meter type TBD) 336,000 gas customers (meter type TBD)	2019 start Deployment TBD
City of Long Beach (California)	Gas AMI	156,000 gas AMI modules	Deployment 2014-2017. Added 90,000 water endpoints to the network after gas deployment.
New Mexico Gas Company	Gas AMR	345,000 gas AMR modules	
Niagara Mohawk Power Corporation/ National Grid – Not Yet Approved (New York)[13]	Electric and gas AMI	1,690,000 electric AMI meters 640,000 gas AMI modules	(Proposed) 2020 project start with 4 year deployment starting in 2022. Under consideration with the New York State Public Service Commission as of December 2019.
Nicor Gas (Illinois)	Gas AMI	Approximately 2.2 million gas AMI modules	2019-2020 deployment
NorthWestern Energy (Montana, South Dakota, Nebraska)	Multi-state electric and gas AMI	65,000 electric AMI meters 48,000 gas AMI modules in South Dakota 44,000 gas AMI modules in Nebraska	2018-2019 deployment
NV Energy (Nevada)	Electric and gas AMI	1.2 million electric AMI meters 170,000 gas AMI modules	2009-2013 deployment
Pacific Gas and Electric Company (PG&E – California)	Electric and gas AMI	5.4 million electric AMI meters 4.4 million gas AMI modules	Deployment 2007 through 2011. The largest AMI deployment in North America

Utility	Project Type	Quantities	Timeframe and Notes
Puget Sound Energy (Washington State)	Electric and gas AMI	1.1 million electric AMI meters 800,000 gas AMI modules	Deployment 2018-2023

2.1.1 Select Projects Map

Below is a map of the selected gas AMI and AMR projects included in the preceding summary chart.

2.2 Benchmarking of Current Landscape

While establishing a standard benchmark for gas AMI or AMI projects in general is complicated by many factors, including utility and regulatory priorities, opportunities and challenges inherent in each utility's operations and service territory, and regulation at the regional and/or federal level, this report aims to identify general trends and commonalities between recent gas automation projects, including both AMR and AMI-based deployments. This includes examining project costs and benefits in relation to project size and type, identifying typical project cost areas and proportions, and comparing benefit areas for gas projects. This section also includes an overview of gas AMI benefits, including those that would be unique, or are only beginning to emerge as opportunities for projects incorporating the latest solid-state meters or sensor types.

2.2.1 Reference Project Selection and Data

Reference Projects

The scope of this report and reference project selection are centered around information and references that are most relevant or of most interest to FEI's project and goals. As such, this report focuses on American and Canadian projects only. Additional projects are referenced to help establish overall trends and benchmarking for the North American natural gas utility landscape.

Limitations

The research presented in this report is limited to what was either available to the public at the time of writing, or non-confidential information available to Util-Assist as a result of its consulting practice and expertise. Certain projects, including City of Medicine Hat Utilities and SaskEnergy, were not subject to utility board approval, and so the information available on these projects is limited to what was presented to boards of directors or requested by and provided to applicable councils. Other projects referenced in this report had only limited information available in public filings, or else had figures attached that were still subject to change, and so these projects are only referenced to the extent that their data was available or finalized. For example, Niagara Mohawk Power Corporation, a large-scale electric and gas AMI project being planned in the state of New York, was not used as a detailed reference project for this report because as of the time of writing, the figures and statements contained in its application are still subject to revision following the latest review and challenges by interveners and the New York State Public Service Commission.

2.2.2 Project Costs and Benefits Analysis

The depth of benchmarking for gas-only AMI projects in North America is limited, because these projects are still uncommon in Canada and the United States. In general, gas-only deployments or the gas meter portions of mixed projects will have higher meter and installation costs than electric counterparts, although gas hardware costs have begun to drop in recent years. For utilities considering the installation of solid-state gas AMI meters, benchmarking is limited further, because although ultrasonic meter technology has already matured by several generations in overseas markets, meter models for residential use in North America have only recently been released by major manufacturers. Solid-state gas AMI meters will have higher costs, but also offer greater capabilities and a wider range of possible benefits for utilities and customers, compared to traditional meters with attached AMI modules.

Given these limitations, the chart below provides an overview of gas and mixed-utility AMI/AMR project costs, with the intention of providing an overview of how project types and their dollar values compare. Note that in the chart below, all dollar amounts are in Canadian Dollars, and USD figures have been converted to CAD at the average annual Bank of Canada exchange rate for the year the figures were calculated or filed.

Utility and Project Type	Total Cost (CAD Non-NPV)	Total Project Cost per Meter (CAD)	Comments
ATCO Gas Canadian Gas AMR 1.04 million AMR meters	$121 million (with 20% contingency: $9.7 million for first two years of deployment[14])	$116	Large operational savings realized, with low endpoint cost due to AMR. Route optimization added operational savings beyond just switch to automated reading. Large service territory now served by aerial AMR.
SoCalGas U.S. Gas AMI 2.4 million meters with AMI modules 3.6 million AMI module retrofits	$1,135 million ($963 million capital and $199 million O&M, with 6.5% contingency of $73.3 million)	$192	Business case was based on an extended term, and benefited from broad government support for environmental and conservation initiatives. The cost-effectiveness of the project relies upon the materialization of forecasted conservation benefits.
Nicor Gas U.S. Gas AMI 2.2 million AMI modules	$337 million	$153	A large AMI module project with a slim benefits margin – a positive business case was only reached by comparing against a base case that included switching from bi-monthly to monthly reads. Any cost overages will jeopardize the project's cost effectiveness. [15]
San Diego Gas and Electric U.S. Gas+Electric AMI 1.4 million electric AMI meters 900,000 million gas AMI module retrofits	$700 million	$326	The business case was allowed to include "newly quantifiable benefits," which were benefits not previously quantified or quantifiable in past projects reviewed by the CPUC. These benefits were given a value range of $34 million to $46 million CAD, which made up a significant portion of the net benefits.
Con Edison U.S. Gas+Electric AMI 3.6 million electric AMI meters 1.3 million gas AMI module retrofits	$3,086 million ($1,642 million capital and $1,444 O&M)	$633	Extremely high total cost per meter, due to above average installation costs and ongoing IT operations costs. However, the business case included commensurate benefits (largely electric), which yielded a very high total project value.

Utility and Project Type	Total Cost (CAD Non-NPV)	Total Project Cost per Meter (CAD)	Comments
City of Medicine Hat Canadian Gas+ Water+Electric AMI 81,800 AMI endpoints (23,000 gas modules)	$19.2 million (projected, with gas portion of $5.2 million) $21.9 million (actual)	$242 (projected) $267 (actual)	Lower than expected benefits, higher than expected costs, and small meter population yielded low financial benefits.

2.2.3 Benefit Areas Analysis

This section analyzes the proportional make-up of gas project financial benefits. Only gas-related benefits and projects are included in this section, but because the projects vary in their technology types, division and definitions of benefits, and available details, they are not compared against each other, but are presented to give a benchmark of how different gas project business cases have been formulated.

2.2.3.1 SoCalGas Benefits Breakdown

SoCalGas' AMI business case had operational benefits equal to $853 million USD, or 84.5% of project costs. The business case was only made cost effective by identifying and claiming financial conservation benefits, in particular, demand side conservation benefits and CO2 reduction benefits totalling $576 million USD over 25 years. While not unique in allowing these benefits to be quantified, the state of California's government and regulatory alignment with environmental and conservation priorities allowed the business case to become cost-effective. The total benefits amounts claimed in the business case were $1.434 billion USD in operational benefits and $576 million USD in demand side conservation benefits, as shown below.

Benefit Type	% of Total Benefits
Meter Reading	53%
Customer Services Field	19%
Customer Billing Services	5%
Other O&M	5%
Sub-Total O&M Benefits	**81.2%**
Working Cash	4%
Metering	10%
Other Capital	5%
Sub-Total Capital	**18.6%**

Benefit Type	% of Total Benefits
Theft	0.2%
TOTAL OPERATIONAL BENEFITS	**100%**
Demand Side Conservation Benefits of $576 million USD	**+40%** (Conservation benefits equal 29% of total combined operational+conservation benefits)

2.2.3.2 Nicor Gas Benefits

The Illinois-based Nicor Gas project, while a good example of a recently-approved standalone gas AMI project (deployment ongoing 2019-2020), had its business case and benefit-cost-analysis classified as confidential, and detailed figures are not available to the public in its filings. For this reason, Nicor Gas has been used to benchmark certain high-level figures where possible, but it has not been included as a detailed reference project. Only high-level breakdowns of Nicor's benefit areas are available in public documents, which are shown below:[16]

Benefit Type	% of Total Benefits
Reduced Meter Reading	75%
Meter Operations Savings	13%
Other benefits	12%

Nicor Gas formulated its benefits based on meter reading savings compared to a base case or status quo that involved a switch monthly manual reading (although they were on manual bi-monthly reading at the time of their filing). Nicor was able to argue that because their AMI system would provide monthly reads, that the benefits should be calculated against costs to perform manual monthly reads. The business case also included remote disconnect benefits (and is one of the few gas business cases that attempted to do so). However, while these financial benefits were claimed, they would require separate valve hardware to realize, and the costs for this hardware and its installation were not included in their benefit-cost analysis.

2.2.3.3 City of Medicine Hat Gas Benefits Breakdown

A breakdown of the City of Medicine Hat's gas benefits is shown below. The City of Medicine Hat was a combined electric, water, and gas project, and so its business case benefits are difficult to benchmark against. The project had certain cost and benefit efficiencies compared to gas-only projects, and some of its benefits may be attributed to the other utility types or divided among the different business units.

Benefit Type	% of Total Benefits
Reduced Meter Reading	38%

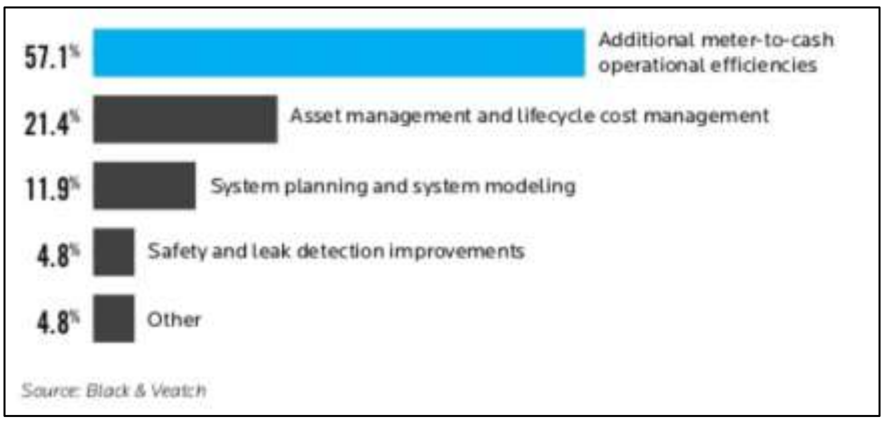
Benefit Type	% of Total Benefits
Reduced Repair Visits and Service Orders	5%
Reduced Distribution Network Losses and Theft	14%
Avoided Meter Replacement Costs	43%

2.2.3.4 ATCO Gas Benefits Breakdown

As an AMR project, ATCO Gas's proposed financial benefits were composed entirely of O&M savings from reduced meter reading and associated costs. Other benefits like improved billing accuracy and improved employee safety were included as non-financial benefits. ATCO Gas's realized O&M savings were reported in a 2019 document. Savings exceeded forecasts by 8%, or $3.5 million, but these figures also include savings achieved by route optimization and other contributing factors, and could not be entirely attributed to the AMR project.

2.2.4 Gas AMI Benefits Descriptions

While hardware costs for solid-state meters may be higher than for traditional meters and modules, they also offer a wider range of benefits, some of which have not been claimed in previous gas AMI business cases, or else they are only beginning to be considered in addition to the benefits traditionally captured by simple automated reading. A 2016 survey of 85 natural gas utilities from around the world, conducted by Black & Veatch, found that 35% of respondents had already upgraded to AMI, and another 24% were considering upgrading from AMR to AMI.[17] The utilities were also asked what their primary reason for upgrading or considering the upgrade to AMI was, and the majority (57.1%) cited meter-to-cash operational efficiencies as their primary reason. The full results are shown below.[18]



The results of the survey above are in line with what is typically presented in gas business cases: operational efficiencies like reduced manual reading are the largest benefit category, with asset management, system planning, and safety and leak detection benefits included in lesser quantities. However, the Black & Veatch report concludes that, although "AMR alone already solves many low-hanging, high-cost meter-to-cash challenges […] utilities should look at AMI not simply as another way to further improve the meter-to-cash process but to obtain real-time insights and analysis on the entire distribution network […] and improve visibility, reliability and cost structures by seeing more opportunity in data analytics as well as corrosion and leak detection."[19]

This section provides an overview of the key benefits of gas AMI, some of which are only available or become far more practical or are greatly improved with modern solid-state meters and a robust gas AMI communication network.

Remote Meter Reading

Remote meter reading is the primary financial benefit provided by gas AMR and AMI, as meters can be read with greater frequency and with greater accuracy compared to manual reading by field personnel. Automated reading reduces labour and vehicle requirements, which in turn allows utilities to reduce safety incidents and emissions.

Enhanced Gas Usage Data

AMI meters and reading provide more frequent and granular gas usage data, which benefits both customers and utilities. This data opens the door to further benefits like customer bill alerts, dynamic pricing and supply monitoring for market need, and more advanced analytics capabilities in development in the marketplace, like leak identification and even appliance fault detection. The enhanced data made available by AMI is the foundation for the primary benefits and initiatives available with the technology.

Remote Shut-Off

Remote shut off of meters for safety or other reasons is possible via radio-controlled valves, or else by AMI meters with integrated shut-off valves. This is a relatively new capability in the North American gas market, and processes for remote disconnection or reconnection of service needs to consider things like relighting appliances and safety checks. However, remote shut-off capabilities offer a wide range of benefits like reducing field labour, increasing safety for customers and utility personnel, and gives utilities options for improving response and safety in emergency situations. The ability to shut off individual meters or groups of meters affected by an emergency provides safety benefits for utility customers and the general public, while also giving utilities greater control and efficiencies, because they can manage outages and shut-offs down to the endpoint level, rather than at a distribution level only. At-risk meters can be shut off in response to an emergency situation, or they can be shut off proactively if an emergency or hazardous conditions are anticipated.

Increased Meter Reading Accuracy

AMI meters and verification capabilities can greatly reduce the number of estimated or incorrect meter reads, leading to customer service benefits, and reduced strain on customer service personnel. Solid-state gas meters can also read more precisely than mechanical counter parts, and are less prone to mechanical issues or failures.

Reduced Gas Losses (Theft or Leaks)

AMI offers several methods for reducing gas losses resulting from leaks or theft. AMI meters and/or sensors can detect tampering, leaks or pressure changes at endpoints or along the pipeline system, and offer data to help identify areas where gas is being lost or unaccounted for.

Avoided Pipeline Corrosion

AMI can be used to collect data from sensors as part of cathodic protection monitoring systems, which help identify pipelines at risk of corrosion. Readings from these sensors have traditionally been collected manually, and are typically only collected on a quarterly or even yearly basis. AMI allows readings to be collected with greater frequency or on-demand, allowing utilities to perform more efficient and timely maintenance, with lower monitoring costs.

2.3 Emerging Opportunities and Trends in Use of Gas AMI

Traditionally, gas AMI benefits and use cases have been limited to a small subset of the benefits that utilities pursue with electric AMI, primarily reduced manual meter reading and more accurate or more frequent readings. Some of this limitation is because many utilities elected or were restricted to deploying gas AMI modules on mechanical meters, because solid-state gas AMI meters were either not available or were cost-prohibitive at their early introduction. The use of gas modules can reduce capital costs but limits capabilities compared to current-generation solid-state gas AMI meters.

However, capabilities emerging on the gas AMI market, including integrated remote gas shut-off and a variety of sensors, are making way for gas AMI adoption in the mass market. The addition of pipeline and environmental sensors, to monitor and alert for leaks, corrosion, pressure and temperature events, flooding, and earthquakes or shifting ground can also add numerous safety and maintenance benefits for the entire distribution system, from the stations and pipelines down to the meter on the customer's home. These and other emerging benefits offered by gas AMI are detailed below.

2.3.1 Demand Side Management and Non-Pipes Alternatives

Gas AMI can enable a more efficient distribution system with reduced losses and conservation potential, and can offer expanding use cases and opportunities for the future. Regulatory bodies in both Canada and the United States have begun exploring and encouraging demand side management (DSM) initiatives for natural gas, including plans for demand response (DR) programs to reduce gas demand in peak periods. These initiatives align with both environmental and conservations goals, as well as with the pursuit of strategies or resources to accommodate growth while deferring or avoiding costly gas infrastructure investments. These strategies and resources are referred to as non-pipeline alternatives. In this context, gas AMI and the conservation programs it can enable are being explored as opportunities to meet growing gas demand in the short-term without necessitating new gas infrastructure that would be at risk of becoming stranded assets that will not be needed in the future, imposing substantial costs to gas utilities and their customers.[20]

In Ontario, the Minister of Energy directed the Ontario Energy Board to procure a study of natural gas efficiency in the province, with the following objectives:[21]

- To inform natural gas Demand Side Management (DSM) program design and delivery at the midterm review of the 2015-2020 DSM Framework
- To provide guidance to utilities for DSM program design and delivery beyond 2020
- To support the assessment of the role that DSM may serve in future distribution infrastructure planning processes at the regional and local levels

In the U.S., SoCalGas launched the first residential gas DR pilot, in the winter of 2016-2017, which involved notifying customers of event days where conservation would be most beneficial. Among enrolled customers, this resulted in a 3.7% average reduction in demand on three of seven event days.[22]

Con Edison in New York is also offering and developing a gas DR program, and began by running a gas DR pilot for the winter of 2018-2019. Their program, called Smart Usage Rewards for Reducing Gas Demand, uses a structure similar to electric DR programs in operational parameters, marketing, enrollment, event notifications, incentive payments, and tie-in with a smart thermostat program for residential participants.[23] Con Edison is continuing its gas DR program based on lessons learned from its pilot, as part of its overall Smart Solution for Natural Gas Customers Program.

2.3.2 Conservation through Gas AMI

AMI has become an important technology for enabling conservation, because the detailed usage information it provides to customers allows them to reduce consumption and alter usage behaviours. While this effect is well documented with electric conservation programs, it has not been heavily studied or proven with natural gas customers, partly because gas

AMI is not deployed in many jurisdictions. This has made gas conservation programs difficult to plan, and has made conservation benefits for gas AMI, whether financial or non-financial, difficult to quantify or justify.

However, the SoCalGas' AMI regulatory application, subsequent deployment, and conservation campaign results provides some insight on how gas conservation benefits can be framed and how they are viable and can be realized. The utility included forecasted financial conservation benefits in its business case, and were also obligated to report their conservation pilot programs and results to the CPUC. Below is a summary of the SoCalGas gas conservation program forecast, and its achieved results.

SoCalGas estimated that customers will reduce gas usage based on information they receive about their current and past gas usage. The SoCalGas calculations resulted in a total estimated conservation of just under 1% for residential customer usage, totalling $148 million USD in savings, which were claimed as a benefit in the SoCalGas business case.[24]

From 2013 to 2017, SoCalGas ran four advanced meter conservation campaigns, with the goal of achieving its 1% reduction target. As described in its August 2017 Semi-Annual Report[25], the SoCalGas campaigns used the following methods and approaches to inform customers of their gas usage and test their effectiveness at encouraging savings:

- **Bill Tracker Alerts (to 440,000 enrolled customers)**: weekly text or email messages sent to enrolled customers, detailing usage information for the week
- **Seasonal Energy Updates (60,000 customers)**: targeted messaging and savings tips to customers identified through advanced meter-enabled analytics as those with gas usage habits most sensitive to colder weather
- **Paper Home Energy Reports (to 32,000 customers)**: monthly reports detailing customer usage comparison to similar homes, natural gas usage breakdown, and personalized savings tips
- **SoCalGas Usage Reports (to 14,000 customers)**: reports developed in-house testing the effectiveness of a SoCalGas-developed peer comparison algorithm as well as utility analytics and personalized messaging capabilities

SoCalGas reported that "the new and continued successful treatments produced average gas savings of 1.6 percent during the 2016-2017 fall/winter period," and summarizes these findings in the table below.[26]

Percent Reduction in Fall/Winter 2016-2017 Gas Usage for Residential Conservation Treatments

Treatment	Percentage Reduction
11 New Treatments	**1.74%**
9 2015-2016 Treatments	1.42%
1 2014-2015 Treatment	1.31%
Overall % Reduction	**1.60%**

The SoCalGas conservation results are a useful benchmark in proving that AMI can enable reduction of natural gas usage just as it does electricity usage, and that conservation benefits are viable for gas-only AMI business cases—whether they are quantified as financial savings or framed as non-quantifiable environmental benefits.

2.3.3 Data Analytics for Increased Customer Safety and Service

Many gas customers, including those at FEI, have indicated in focus groups and surveys that having analytics information for increased safety, reducing usage, and appliance fault detection is a desirable benefit of AMI. Utility data analytics is an emerging capability enabled by the detailed consumption data provided by AMI; analytics solutions use algorithms to analyze meter data and identify abnormal consumption patterns, which can help flag a variety of issues including leaks, appliances that are left on, or appliances that are faulty or malfunctioning. Utilities then have the ability to notify customers of issues, or proactively address issues through field visits before they become hazardous or more severe.

SoCalGas successfully applied analytics capabilities on its gas AMI network and in the first two years after full AMI deployment, the utility used consumption analytics awareness to identify 8,335 situations that warranted field visits for investigation. The types and the quantities of these situations are shown in the table below:[27]

Gas consumption data analytics results through December 31, 2017

Findings from completed field visits (project to date)	Number of field visits	Percent
Total field visits generated by consumption analytics awareness	**8,335**	
Gas services closed by SoCalGas field technician due to excessive registration, awaiting resolution. Resolution takes place at the time of the follow-up field visit to reinstate gas service.	3,447	41.36%
Gas leak found by SoCalGas field technician	2,193	26.31%
Gas or hot water leaks corrected by the customer as a result of SoCalGas field visit	1,084	13.01%
Hot water leaks where the hot water heater was in continuous demand	995	11.94%
Abnormal gas usage resulting from an appliance in use for an extended period of time (e.g., appliances unintentionally left on).	616	7.39%

SoCalGas has been able to identify, investigate, and respond to potential safety situations, as well as reduce emissions at customer premises to both save energy and improve air quality. In cases where gas was used to heat water, the utility was also able to identify water leaks and faulty water heaters. While still in its early stages, analytics capabilities and use cases will only continue to develop, and will offer utilities further benefits and a valuable means of improving safety, reliability, and the quality of service provided to the end customer.

2.3.4 AMI Sensors for Leak Detection and Pipeline Monitoring

In addition to enabling customers to reduce their consumption, deploying a gas AMI network can offer tremendous potential for utilities to reduce lost and unaccounted for gas in their distribution systems. AMI-integrated sensors can provide utilities with valuable operational information and alerts for unsafe or abnormal conditions. These sensors can enable or enhance a variety of cost-saving and safety capabilities, including more accurate monitoring of gas flow through the network, leak detection, pressure and temperature monitoring, methane detection, and integrity and corrosion monitoring, including cathodic protection programs.

Although pipeline monitoring standards vary depending on regulations and utility policy, most pipeline survey or in-field data collection only takes place once per year, or less frequently – for example, United States federal regulation only requires pipelines in business districts to be surveyed for leaks annually, while other pipelines only need to be surveyed every 3 to 5 years.[28] Using a gas AMI network to collect sensor readings can allow utilities to gather data more frequently, and take timely action to address issues before they become more serious, more dangerous, or more costly to mitigate.

AMI-enabled sensors not only communicate data and alarms more frequently, but they are also far more cost-effective than traditional monitoring methods. The City of Medicine Hat Gas Operations Superintendent stated that before AMI, the utility used a SCADA system for pressure monitoring, and that the cost to deploy equipment for a single monitoring point was about $5,000, where as an AMI smart gateway to monitor pressure costs about $400.[29] CMH deployed the Sensus FlexNet network, over which smart gateway communication points can send information from a variety of sensors back to the utility.

There is a large opportunity to reduce leaks and improve natural gas system monitoring in North America, as distribution leaks are a substantial problem for gas utilities and distribution companies with aging infrastructure, particularly leak-prone cast iron or unprotected steel pipes. In 2011 alone, gas distribution companies in the United States reported leaking 69 billion cubic feet (1.9 trillion litres) of natural gas into the atmosphere.[30] A 2019 study from the University of Regina found that the province of Saskatchewan has leaked or spilled approximately 1 billion litres of natural gas per year from 2000 to 2018—and this figure only includes leaks and spills that have been detected and documented.[31]

For residential safety and detection, utilities have begun implementing and testing AMI-enabled natural gas detectors (NGDs), which are devices that can detect dangerous levels of methane near service points of entry, and send alarms to utility operators. Con Edison in New York began a pilot installation of 9,000 NGDs for residential locations in 2018, which included an outreach plan to let customers know they were receiving a detector, and meetings with local fire departments to inform them of the program. As of April, 2019, Con Edison reported that approximately 3,700 sensors had been installed, that feedback on the program has been positive, and that several gas leaks have been addressed proactively before any negative events occurred.[32]

Implementing gas AMI and sensors on the distribution system can yield a variety of benefits for both utilities and their customers. Increased system monitoring for maintenance and safety, improved safety and response time for issues, and an overall more efficient distribution system provides safety and operational benefits for utilities, and creates the potential to limit customer rate increases by reducing lost and unaccounted for gas. Utilities that are able to prevent or prioritize leak repairs and maintenance activities will benefit from a safer, more efficient distribution network. This in turn offers both cost saving and environmental benefits to utilities and their customers, such as the ability to defer or avoid infrastructure investments on systems that are near capacity, and the ability to reduce the amount of natural gas lost to the atmosphere—the primary component of which is methane, a potent greenhouse gas.

2.3.5 Remote Disconnect Gas Meters

Remote disconnection and reconnection of meters is a valuable safety and operational feature of AMI, as it allows quicker, safer, and less labour-intensive handling of disconnections and reconnections for scenarios including customer move-ins and outs, cases of non-payment, work on the distribution system, and safety issues. This is a functionality that has been standard in electric AMI meters for some time, but the more complicated physical process of shutting off gas flow has traditionally required that a separate radio-controlled shut-off valve unit be installed on the gas line, which adds hardware and installation costs on top of meter replacement or retrofit. However, newer solid-state gas meters can have remote shut off valves integrated into the meters themselves, which saves space and avoids the need to purchase and install extra hardware.

Because of the related cost and technology barriers, remote shut off capabilities for gas have not been widely deployed in the past. Of the projects researched and referenced for this report, remote shut-off capabilities for gas only appear to have been considered in two cases: City of Medicine Hat Utilities, and Niagara Mohawk Power Corporation (doing business as National Grid, in New York, which applied to install an AMI network for 1.7 million electric meters and 640,000 AMI gas modules).

CMH received pricing for optional Sensus Remote Gas Shutoff (RGS) units, but there is no indication that the utility evaluated the costs or benefits of these units, and remote shut-off was not considered in the gas portion of its business case. In its 2018 AMI application, National Grid listed remote gas shut-off capabilities and methane detection as future, non-quantified benefit opportunities for AMI integration. These capabilities and related devices are described in National Grid's application as follows:

> **Gas Remote Service Valve**: The AMI solution is expected to integrate with gas remote service shutoff valves that are in the vendor development phase, allowing [National Grid] to remotely disconnect the customer's service for safety reasons, such as residential methane detection alarms, gas leaks, storm hardening, and customer natural gas calls. This capability enables improved management of storm restoration with a specific focus on the affected customers and regions, leading to efficient service restoration and improved customer satisfaction while ensuring the safety and reliability of the system.
>
> **Residential Methane Detectors**: Residential methane detectors ("RMD") equipped with communication devices, also known as smart residential methane devices, are currently in research and development for AMI deployment. In the event the smart RMD senses methane at a customer location, it would be able to send a notification to the [National Grid] through a fixed communication network, expediting National Grid's response even if a customer has not called to report the issue.[33]

Note that National Grid has proposed the future installation of separate shut-off valve and methane detection units, and the costs and benefits of purchasing and deploying these units was not calculated or included in the business case.

Remote disconnect capabilities for gas meters offer utilities similar cost and emission reduction benefits that are provided by electric remote shut-off meters, but can also provide further safety and disaster management benefits when combined with other sensors. For example, flood or seismic activity sensors—which can come built into meters or be separate units deployed in strategic locations—can trigger automatic meter shut-offs or issue alarms to the utility which can then perform remote shut-offs for affected meters. This can improve utility responses to storm or earthquake scenarios and help focus efforts on affected customers and regions (as opposed to disrupting whole gas service districts), which results in more efficient restoration, improved customer satisfaction, and increased safety and reliability.[34]

Remote disconnect meters also provide similar benefits for system work and maintenance activities. Utilities can plan and initiate disconnections and reconnections of targeted meters to allow work on the gas distribution system for maintenance, construction, or disaster response. Furthermore, any meters that experience issues during or after maintenance or restoration activities can be monitored and disconnected if needed, or else be configured to shut off automatically if an issue arises.

As gas meter technology advances, the barriers to achieving remote disconnect benefits—like the added cost and complexity of installing separate sensor and shut off hardware—are being eliminated. Newer gas AMI meters with integrated valves and sensors allow remote disconnect, automatic shut-off and enhanced safety-monitoring measures to be deployed uniformly across a whole meter population in a cost-effective manner.

2.3.6 Societal Benefits

Gas and electric utilities have begun to include financial societal benefits in business cases, as public and governmental pressure to reduce emissions and conserve energy grows across all sectors. For example, National Grid's business case includes a quantified benefit category labelled "Societal Benefits (CO2 Emissions Reductions)". While the formulas for calculating these benefits were not disclosed, the Societal Benefits are described as benefits derived "from reduced greenhouse gas emissions due to AMI-enabled energy conservation and reduced vehicle trips to read meters, connect and disconnect service, and investigate service anomalies." National Grid forecast these benefits to have a value of $62 million USD on a 20-year NPV basis, or approximately 8% of the project's total benefits. Quantifying other societal benefits, from capabilities like leak reduction, enhanced safety measures, and remote shut-off capabilities, can provide substantial value to gas AMI business cases.

If not quantified in terms of dollars, societal benefits can still form an important non-financial benefit for gas AMI business cases and their projects in general. In its AMI filing, SoCalGas included CO2 reduction estimates derived from customers using AMI-provided data to lower their gas usage, as well as from the reduction of driving needed for manual meter reading. SoCalGas estimated that the implementation of its gas AMI system would eliminate over 6 million vehicle miles annually and reduce greenhouse gas emissions by over 3000 tons of CO2 per year.[35] These air quality and climate benefits were included as non-financial societal benefits, which are an important element factoring into how the project will be perceived in climate and/or conservation-focused jurisdictions.

2.4 Regulatory Decisions and Support

Even in jurisdictions where AMI is understood to be an enabling or foundational technology, the costs of these systems is usually the quickest and largest point of contention. However, while regulators often focus on the financial bottom line, the essential question they are asking is, "what is in it for the customer?" The answer to this could be financial benefits that can help prevent rate increases, or granting customers direct benefits like increased safety, or usage information and opportunities to save money or manage consumption. It is up to the utility to show that clear financial savings can be realized, or, if qualitative benefits to customers are being proposed, the utility must show that customers actually want or will use these benefits. Customers, and regulators who are considering their interests, are generally receptive to investments by utilities, but if the investment—like AMI—is not being evaluated strictly on financial value, then it must be an investment in something customers are specifically looking for in order for the investment to be in the public interest.

Within this context, neutral business cases can be supported with additional context and priorities beyond the financial. Customer experience is becoming more critical across all industries, and safety, conservation, and resilience for natural gas will be large contributing factors as the technology enabling these capabilities becomes standard in the market. Below are details of regulatory considerations and comments provided on gas AMI projects.

2.4.1 SoCalGas Decision

SoCalGas's project is a useful reference point in that it is the largest gas-only AMI project in North America. It received approval from the California Public Utilities Commission (CPUC) in April 2010, and SoCalGas was authorized to recover deployment costs up to $1.0507 billion USD.[36] In approving the SoCalGas project, the CPUC reached the following conclusions:[37]

- The technology choices proposed by SoCalGas, including the stand-alone communications equipment, the choice of battery technology, and the information technology solutions are reasonable, appropriate, and technically feasible.
- Development and implementation of a cost-effective gas-only AMI system is consistent with state energy policy objectives.
- Commission precedence dictates in concept the inclusion of terminal value in AMI cost effectiveness showings.
- The proposed $26.3 million USD benefit for terminal value of AMI equipment included in the SoCalGas business case is appropriately calculated, and therefore shall be included in the business case analysis.
- The proposed $757.5 million USD benefit for elimination of the meter reading workforce after the implementation of an AMI system is reasonably forecast in the SoCalGas AMI business case, and therefore shall be included in the business case analysis.
- The proposed $148 million USD gas conservation benefit included in the SoCalGas business case is reasonably forecast in the SoCalGas AMI business case, and therefore shall be included in the business case analysis.
- SoCalGas' proposed 10% contingency fund is not consistent with what has been deemed reasonable in past AMI cases.
- The SoCalGas AMI proposal is cost effective.
- The cost-effectiveness of SoCalGas' AMI proposal relies upon the materialization of forecast conservation benefits.
- If the forecast conservation benefits of this project do not materialize, ratepayers may face undue burden.
- The degree of conservation response depends in part on supporting efforts and outreach on the part of SoCalGas to ensure customers are aware of and engaged in conservation opportunities.

The SoCalGas application was approved, with authorized funding of $1.05 billion USD, with the following modifications:[38]

- Allowed contingency was lowered from 10% to 7%
- The fund for workforce retention and retraining was raised by $1 million USD, to better protect the employment interests of the meter reading workforce, with funds to be used for extending severance, vocational training, and other transitional opportunities

The CPUC's acceptance of gas conservation benefits was critical in making the project cost-effective. The CPUC accepted some uncertainty in the estimation of gas conservation enabled by AMI, as SoCalGas would represent the state's first gas-only AMI deployment. The Commission ultimately accepted SoCalGas's conservation and participation figures, and stated, "it is important to recognize that AMI can serve to support broad and ambitious goals articulated by this Commission [including] The California Long Term Energy Efficiency Strategic Plan, [which] sets targets for deep energy reduction and envisages a 'rapid evolution in both technology and customer behavior to make energy efficiency a "way of life" among Californians by 2020.'" The CPUC concludes by writing that "in order to achieve a 40% reduction in energy use, or Zero Net Energy Homes, as envisioned by [The California Long Term Energy Efficiency Strategic] Plan and policy goals, a whole suite of initiatives will have to be employed [and] in this context, [the CPUC] review here is as much strategic as it is technical."[39]

2.4.2 Nicor Gas

The Illinois Commerce Commission approved the Nicor Gas AMI plan and rate filing in 2018, and concluded that, "The record demonstrates that many customer and operational benefits will be achieved by installing AMI across Nicor Gas' service territories. Furthermore, AMI will enhance safety [and] the record is clear that customers realize significant benefits, such as the use of [energy usage reports], which allow customers more decision-making capability with their gas usage. As Nicor Gas has shown its customers will receive positive benefits and safety will be improved, the Commission supports this effort."[40]

Supporting testimony offered by Nicor Gas during its application offers insight into the industry's overall direction as well as the factors that the Commerce Commission considered in approving the Nicor Gas AMI project. The statements below are quotes from this testimony.

> "As the cost of AMI solutions has decreased, the functionality has increased, and the technology has matured to the point where a number of U.S. gas utilities have begun adopting AMI as the state of the art technology for not just meter reading, but also for operations data improvement.
>
> **Combination Electric and Gas ("E&G") Utilities.** Many combination E&G utilities have rapidly adopted Gas AMI as part of their overall adoption of AMI for both parts of the utility business. Much of this activity was driven by the electric AMI opportunities and, in many cases, prompted by Department of Energy ("DOE") Smart Grid Investment Grants begun in 2009 to promote electric Smart Grid adoption. While this adoption of Gas AMI is leveraging combination opportunities, it has resulted in the advancement and validation of AMI as a viable gas operations technology and has provided insights into the opportunities for advanced gas metering and other sensor data to enhance gas operations.
>
> **Gas-Only Adoption of AMI.** While many straight gas utilities have made initial investments in AMR technology to reduce the operational costs of meter reading, there are some notable examples of larger gas AMI deployments in California and other states. These large scale deployments have provided sample business cases and technology validations for the viability of gas-only AMI implementations.
>
> **AMR to AMI Transition.** Many gas only utilities have invested in AMR technologies focused solely on automating the meter reading function. These technologies were well-proven and provided a simple business case based on the expected cost savings in meter reading activities. As the differential cost of AMI endpoints has now converged with AMR endpoints, these utilities are now examining the potential migration path from AMR to AMI. This migration scenario is often prompted by the need to replace AMR modules as they reach functional obsolescence or "end of life" battery capacity." [41]

2.4.3 San Diego Gas and Electric

The California Public Utilities Commission approved the San Diego Gas and Electric Company's advanced metering infrastructure project in 2007, and wrote in its decision to approve the project that the project was "part of [the CPUC's] effort to transform California's investor-owned utility distribution network into an intelligent, integrated network enabled by modern information and control system technologies," and that "the deployment will improve customer service by providing customer premises endpoint information, assist in gas leak and electric systems outage detection, transform the meter reading process and provide near real-time usage information to customers."[42]

SDG&E identified and quantified a number of benefits previously considered non-quantifiable (which became classified as newly-quantified benefits). The CPUC agreed to include these newly-quantified benefits to the extent that reasonable quantifications could be made, and ultimately allowed a total of $32 million to $43 million USD in additional benefits from newly quantified sources. These benefits included:

Improved Public Safety benefits ($5 million USD benefit)

SDG&E attributes these benefits to increased security and tolerance to attacks/natural disasters, detecting customer's electrical back-feed into SDG&E's electrical system from unmapped photovoltaic or distributed generation sources, and quicker detection of gas leaks.

Environmental ($11 million USD benefit)

SDG&E claims the conservation effect of information feedback can provide an additional $8 million in carbon dioxide (CO_2) reductions, and AMI DR can provide $46 million USD of reduced nitrous oxides (NO_x) and sulphur oxides (SO_x) emissions during critical peak periods and from use of distributed generation.

Enabling Technologies Advancements/Deployments ($13-24 million USD benefit)

SDG&E calculated this benefit coming from AMI's role as enabling means to increase DR.

2.4.4 Con Edison

The New York State Public Service Commission approved the Con Edison AMI Business Plan in March of 2016, and as of the time of writing, the Con Edison deployment is currently underway. In its approval order, the Commission summarizes the drivers supporting AMI as meeting energy demands, system resiliency necessitated by climate trends, and more informed and empowered customers. The Commission stated the following in its decision:

> "The energy demands of the modern economy, and the need for system resiliency caused by climate trends, create an increasing need for utilities to have granular situational awareness of their distribution systems. At the same time, customers require increased ability to manage their energy consumption and energy bills. Advanced Metering Infrastructure (AMI) is a technology that addresses both of these goals.
>
> Consolidated Edison Company of New York, Inc. (Con Edison or the Company) has filed with the Commission an AMI Business Plan. AMI will contribute to the modernization of the Company's electric system and gas distribution system, creating substantial operating savings and efficiencies as well as increased visibility and control of its system.
>
> Equally important, the deployment of AMI will transform the relationship between Con Edison and its customers. The enhanced information enabled by AMI will assist in managing outages and service connections, and will empower customers to manage their bills by participating in demand response and other opportunities presented by a modernized system."[43]

2.5 Technology and System Setup

In examining the technologies and network models chosen by the utilities in this report, it is clear that no single vendor or network model can be considered superior to all other across the market; the best-fit solution for a given utility will depend on many factors including utility requirements and desired use-cases, as well as service territory and geography.

While the ownership models for the networks used by the utilities referenced in this report were not publicly disclosed, the basic technical architecture for gas AMI networks can support both vendor-managed or utility-operated models, and the market has matured to so that technology options are available to support and adapt to utility needs over the lifecycle of the project, typically meaning a twenty-year timeframe. Following an open and competitive procurement for the AMI network, meters, and related systems ensures that utilities can select from all options and ensures that all their individual requirements can be met, for the most competitive cost.

Gas solid-state meters and standalone network technology has reached the point of readiness for North-American mass-market adoption, and its current state compares to where electric solid-state metering was ten or fifteen years ago. The metering technology and its hardware and software capabilities have matured, all while costs have come down. In marketing materials and proposals to utilities, two of the market leaders in metering and network technology, Itron and Sensus, have articulated solid-state metering plans as being foundational to technology roadmaps.

The North American mass-market strategies for both meter and network vendors, and for third-party hardware and software developers, centre on the benefits and capabilities that are available with new AMI network technology and advanced solid-state metering applications. A well-implemented AMI network will be robust enough to serve multiple entities or commodities, carrying data from gas, water, and electric meters, and interoperability standards ensure that other devices like sensors or smart streetlights can communicate via the network also. This offers utilities opportunities to reduce or share costs by licensing the use of their networks and/or back-office systems to other distribution companies or municipalities within their service territories. SoCalGas has been pursuing options to use its gas AMI network for multi-commodity and multi-purpose applications. The utility launched a pilot in 2018 that is allowing the use of its network by two water utilities, San Gabriel Valley Water Company and California American Water, as well as a water analytics company, with the goal of exploring opportunities to “provide significant operational and conservation benefits to water agencies and their customers within SoCalGas’ service territory”.[44]

Section 3: Reference Project Details

3.1 City of Medicine Hat Utilities

The City of Medicine Hat (CMH) in Alberta provides electric, gas, and water utility service to its approximately 63,000 residents. The City is exempt from retail competition because of its ability to produce enough electricity to meet its own usage requirements. Electricity generation, distribution, and retail are all performed by the City of Medicine Hat.[45]

3.1.1 Project Overview

CMH went to market in 2011 with requests for proposals (RFPs) for advanced metering infrastructure (AMI) a meter data management system (MDM), and meter installation services. Util-Assist Incorporated (Util-Assist) was contracted as a consultant to help CMH with the procurement process, AMI project management, and with financial and strategic planning.

CMH's AMI deployment included a total replacement or retrofit of approximately 82,000 meters, consisting of electric meter replacements and a mix of replacements and retrofits of the water and gas meter population. CMH's total meter upgrade quantities are shown in the table below.[46]

Service Type	Total Meters
Electric	31,717
Water	26,736
Gas	23,378
Total	**81,831**

3.1.2 Technologies and System Setup

After a competitive RFP and evaluation process, CMH selected Sensus as its network vendor, who was contracted to provide the Sensus FlexNet AMI network system with two-way communication to Sensus iCon electric and iPERL water meters, as well as Sensus SmartPoint gas transceivers, which would come installed on new gas meters or else be retrofit onto existing gas meters in the field. CMH's project was the first in Canada to involve the implementation of electric, water and gas measurement, monitoring, and control over a single network. The FlexNet system's benefits included point-to-multipoint topology, which requires less equipment than a mesh-based network to implement, and the ability to interface with the city's fiber optic network for backhaul.[47]

Sensus proposed its FlexNet M2 modules for CMH's gas endpoints, which offered the following functionality[48]:

- Tamper and broken pipe detection and alarms
- Top-of-the-hour reads for gas
- 2-Watt transceivers, with two-way communication to the network without requiring an electric meter backbone or a local network of additional collectors

3.1.3 Implementation Timelines

CMH's project timeline as anticipated in 2011[49] is shown below:

Milestone	Dates
Task 1 (Procurements)	March 2011 to January 2012
Task 2 (Deploy Communication Network and MDM System)	March 2012 to August 2012
Task 3 (Test Meter Data with Billing System)	May 2012 to August 2012
Task 4 (Full Deployment of Electric, Gas and Water Meters)	Original target of January 2013 revised to December 2015 in later planning

In CMH's April 7, 2016 Steering Committee presentation[50], CMH reported on its installation progress and indicated that it had completed 98.5% of its planned installations, as shown in the screenshot below. The 1.5% incomplete installations were mostly because of customer refusals and access issues. There were also three-hundred and forty industrial gas meter exchanges that could not be completed on time because the Sensus 900GM module faced delays in receiving Measurement Canada approval. The presentation also reported how gas installations saw the fewest customers avoiding or outright refusing their meter exchanges, as shown in the screenshot below.

Avoidance & Refusals:

Remaining Electric Meters	
Refusals	71
Avoidance	28
Total Meters:	99

Remaining Gas Meters	
Refusals	32
Avoidance	14
MC Delays	340
Total Meters:	386

Remaining Water Meters	
Refusals	96
Avoidance	421
Field Design	213
Total Meters:	730

3.1.4 Implementation Costs

CMH's original anticipated project costs, as proposed to the CMH City Council in 2010, were as follows[51]:

- Capital cost: $18.6 Million.
  - Electric Utility $6.6M, Gas Utility $5.2M, Water Utility $6.8M

Following positive results from the five-hundred meter pilot project in 2012, the City's AMI program was officially approved by the City Council, which published in its annual report that the project would be a $19.2 million project with an 8.5 year payback period.[52] As a shared-utility project, CMH was able to split shared costs (e.g., network costs, systems, or resources supporting all three utility services) among the three utility divisions.

3.1.4.1 Projected Total Project Costs and Costs per Meter

The total project capital cost for the CMH project was estimated at approximately $19 million (non-NPV). A summary of the gas portion of the CMH business case is shown below.

Gas Portion of Project	
Item	**Amount**
Total Costs	**$14.3 million**
Total Benefits	**$16.8 million**
Benefits to Cost Ratio	1.171
Payback Period	13.41 years
Total Capital Cost	**$7.4 million**

The meter inventory and costs per meter assumed in the business case are shown in the table below.

Service Type	Total Meters	Capital Cost	Total Project Cost per Meter
Electric	30,613	$5.2 million	$168
Water	22,434	$6.6 million	$294
Gas	26,106	$7.4 million	$283
Total	**79,153**	**$19.2 million**	**$242**

3.1.4.2 Actual Project Cost

In October 2018, the City Council requested a report on final project costs and benefits, and CMH utilities reported that the final costs exceeded capital estimates by approximately $3 million, and that the AMI project ended up costing $21.9 million.[53] Using the updated meter counts and revised total project cost at project close, the actual cost per meter across all three utility services for the project was $267.63. CMH's wrap-up report detailed the extra project costs as including higher than expected capital costs, a longer installation timeframe that anticipated, and unexpected repair costs required at customer homes to fix aging electric meter connectors.

3.1.5 Benefits

3.1.5.1 Proposed Benefits

When presenting its AMI project to council, CMH proposed the following benefits:[54]

- **Reduce meter reading costs** (reduced revenue requirements and lower rate increases.)
- **Improve "read to bill" time** (reduction in the time between when the meter is read to when the customer is billed. Improves cash flow.)
- **Elimination of estimated monthly readings** (solves accounting issues with voided consumptions and environmental charges.)
- **More accurate meter reading** (reduced calls on meter re-reads by both Gas Technicians and Meter Readers.)
- **Meters will be read actual consumption based on monthly rate changes** (reduces bills being prorated, which

can be lost or excess revenue. Reduces/eliminates the need for bill credits due to excess collection.)

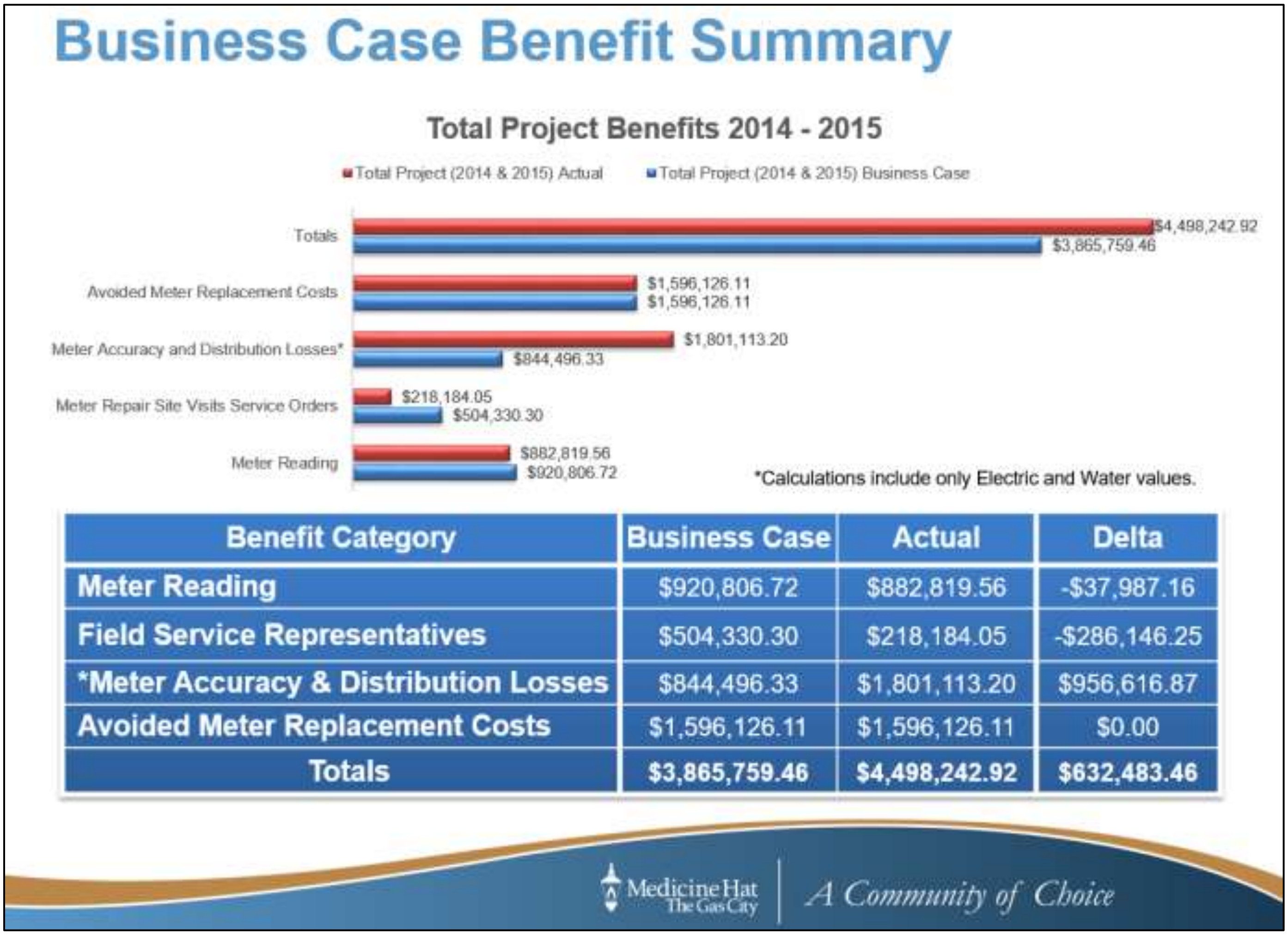
- **Early detection of meter problems such as over or under consumptions** (reduction in revenue loss and unexpected charges for customers.)

CMH proposed the following gas financial benefits:

Benefit	Benefit Amount	Benefit NPV
Reduced Meter Reading	$6.5 million	$3.0 million
Reduced Repair Visits and Service Orders	$0.8 million	$0.35 million
Reduced Distribution Network Losses and Theft	$2.3 million	$1.1 million
Avoided Meter Replacement Costs	$7.3 million	$3.7 million
Totals	**$16.8 million**	**$8.1 million**

3.1.5.2 Realized Benefits

In 2015 and 2016, CMH utilities worked to perform a business case reconciliation to examine benefits realized in the first two years of the project, and how they compared to the projected benefits in the business case. These findings were then presented to the City Council. The slide below shows a summary of projected versus actual benefits for 2014 and 2015 combined.[55]



Benefit Category	Business Case	Actual	Delta
Meter Reading	$920,806.72	$882,819.56	-$37,987.16
Field Service Representatives	$504,330.30	$218,184.05	-$286,146.25
*Meter Accuracy & Distribution Losses	$844,496.33	$1,801,113.20	$956,616.87
Avoided Meter Replacement Costs	$1,596,126.11	$1,596,126.11	$0.00
Totals	**$3,865,759.46**	**$4,498,242.92**	**$632,483.46**

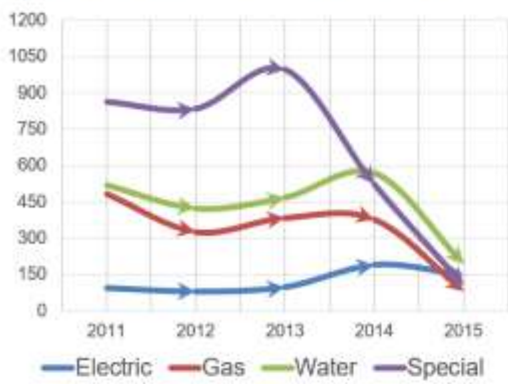
Overall the project was yielding positive results; based on best financial and benefit savings estimates available at the time, CMH was seeing higher than expected benefits due primarily to electric and water loss reductions. Because CMH's gas loss data was not trusted, no gas distribution loss reduction benefits were included in their benefits assessment.[56]

Meter reading and site visit benefits were lower than expected during the project's first and second years (2014-2015). CMH's meter deployment was slower to start and slower to reach full saturation than expected, meaning meter readers had to be retained longer then expected. CMH was also not able to reduce its field visits by its forecasted amounts, however, it should be noted that this is because of higher than expected electric and water meter failures in 2015, while gas meters saw a lower than expected failure rate, and thus provided a benefit surplus. The table below shows CMH's 2015 failure rates and the effect on the budgeted benefits.[57]

	Electric	Water	Gas
Expected Failures	115	84	457
Budget for Repair	$15,081.02	$24,110.31	$76,066.94
Forecast Failure Rate	0.75%	0.75%	3.5%
Budget Per Meter	$131.37	$286.59	$166.50
Actual Meter Failures	184	259	107
Forecast Minus Failures	-69	-175	350
Benefits/Savings Compared to Forecast	**-$9,090.91**	**-$50,117.14**	**$58,251.30**

CMH also saw dramatic reductions in gas, water, and special read-related customer service truck rolls as AMI meters and modules were deployed. The screenshot below shows CMH's truck roll reductions.[58]

Customer Service Truck Rolls



Year	Truck Rolls			
	Elect.	Gas	Water	Special Reads
2011	95	483	519	865
2012	80	326	423	835
2013	99	384	468	996
2014	190	378	568	521
2015	149	80	193	105

- Gas, Water and Special Reads (Questionable Read or Customer Complaint) investigations reduced by 83%, 62% and 87% respectively.
- Electric meter investigations increased due to 2014/2015 hot socket alarms. This is a safety concern and the Utility is being proactive.

Note that electric-related truck rolls increased due to hot socket alarms, which resulted from aging electric connections in customer homes. Costs to address this issue, including costs to repair customer premises, were one cause of cost overruns on the project. While emission and vehicle maintenance savings from truck roll reductions were not captured as a financial benefit in the business case, CMH did estimate total kilometre reductions, which was referenced as a safety and environmental benefit. The table below shows the CMH's estimated trip and kilometre reductions through 2015.[59]

Truck Roll Reductions	Totals
Service Calls (15km average per)	1,281
Move Outs (15km average per)	6,965
Disconnections (15km average per)	735
Meter Reader (12-20km average per)	4,920
Total Trips Reduced	**13,901**
Total Kilometer Reduction	**203,595**

According to CMH's October 2018 recap report provided to City Council, final cost savings on reduced meter readers equal approximately $1 million per year,[60] which tracks closely with the business case's anticipated meter reading reduction benefits. The Medicine Hat News article reporting on the 2018 recap states that total project benefits only equal $1.2 million per year, but this figure only includes meter reading benefits, and limited meter replacement avoidance and reduced service call benefits. The assumptions and exclusions factoring into this benefit total are not clear, so it is not possible to analyze total realized benefits versus the business case.

3.2 SaskEnergy

SaskEnergy is a Saskatchewan Crown corporation that delivers natural gas to 93% of the communities in the province. The company owns 70,000 kilometres of distribution pipelines, 15,000 kilometres of transmission pipelines, and serves over 397,000 customers. Its service territory covers nearly all of the Province of Saskatchewan, some 600,000 square kilometers.[61]

3.2.1 Project Overview

SaskEnergy and SaskPower collaborated for a planned deployment of gas and electric AMI in the province of Saskatchewan. SaskEnergy's portion of the implementation was to install approximately 370,000 gas modules on existing gas meters, while SaskPower was going to install 500,000 AMI-capable electric meters.[62]

Apart from what was disclosed in news releases and referenced in the SaskEnergy and SaskPower annual reports, little information on the project business case details is available to the public. Business case and project details were not widely reported or filed publicly, as Saskatchewan does not have a public utilities commission or board[63] but instead has a rate review panel that advises the government of Saskatchewan on rate applications. Benefit realization details and follow-up reporting on the project are also lacking, as the electric AMI project was halted in 2014. As of 2019, SaskPower's residential AMI meter deployment was still on hold, and SaskPower has stated that "residential smart meters for homes are not planned until SaskPower identifies a meter that meets [its] new, more rigorous safety specification for Saskatchewan."[64]

3.2.2 Technologies and System Setup

The Sensus FlexNet network was installed and planned as the basis for multiple applications, beginning with meter reading and billing for electric smart meters and a two-way radio module upgrade to existing natural gas meters. The Sensus FlexNet system was chosen to provide two-way communications reaching all points in the utility's service area, with all data protected and secured in local SaskPower data centres.[65] The battery-powered electronic modules installed on gas meters allow SaskEnergy to bill monthly actuals instead of estimates. The chosen modules were set to communicate up to six times daily and have an expected battery life of twenty years.[66]

The planned AMI network was to "communicate across a network consisting of approximately 400 tower sites across the province. These are primarily existing SaskTel tower locations where AMI equipment is then installed." [67] Sensus was responsible for managing and installing the FlexNet communication network.[68]

3.2.3 Implementation Timelines

SaskEnergy's initial proposed deployment timeline and zone designations, shown below, were released in its October 2013 news release.[69]

Zone 1	Regina	October 2013-March 2015
Zone 2	Saskatoon	January 2014-March 2015
Zone 3	Yorkton	June 2014-July 2014
Zone 4	Melfort	June 2014-July 2014
Zone 5	Swift Current	August 2014-September 2014
Zone 6	Kindersley	August 2014-September 2014
Zone 7	North Battleford	October 2014-November 2014
Zone 8	Meadow Lake	October 2014-November 2014
Zone 9	La Ronge and far north	December 2014-January 2015
Zone 10	Estevan	December 2014-January 2015

Based on the successful outcome of the various field and system tests completed in 2012, SaskEnergy and SaskPower chose to undertake a full-scale installation of approximately 350,000 gas modules and 500,000 advanced electric meters in mid-2013. The project's implementation progress year to year, summarized below, was reported in SaskEnergy's annual reports.[70]

- **2013:** Project start
- **2014-2015:** At the end of 2014, more than 150,000 AMI modules had been installed and were being utilized in Regina and Saskatoon.
- **2015-2016:** More than 125,000 AMI gas modules were installed throughout the province in 2015, bringing the total to nearly 279,000 modules (73% of SaskEnergy distribution meters). As of March 31, 2016, more than 11,000 additional modules were installed.
- **2016-2017:** Installed 49,879 AMI gas modules throughout the province, bringing the total to nearly 341,000 or 87% of SaskEnergy distribution meters.
- **2017-2018:** Nearly 32,000 AMI meters were installed, bringing the total to 373,000 AMI customers or approximately 94% of total distribution customers.
- **2018-2019:** 97.7% of provincial meters were equipped with Advanced Metering Infrastructure modules

3.2.4 Implementation Costs

The original SaskPower AMI program was approved by the SaskPower Board of Directors in August 2010, with an estimated cost of $190 million.[71] The SaskEnergy portion of the AMI project was projected to cost approximately $39.6 million or about $105 per natural gas meter retrofit.[72] Information on the final cost of the SaskEnergy implementation, and how costs were affected by the cessation of the electric portion of the project was not publicly available.

3.2.5 Benefits

At the time of approval, SaskPower's AMI benefits were given a conservative estimate of $470 million over twenty years, with the project paying for itself in just over eleven years.[73] The SaskEnergy portion of the project was expected to pay for itself in seven to ten years, and included the following financial benefits:

- Significantly reduced costs for manual meter reading services
- Reassigning labour historically dedicated to turning off or on services
- Avoided meter replacement costs
- Deferred and avoided meter accuracy audit/program costs
- Reduced meter repair costs
- Reducing losses in revenues due to meter failure and/or energy theft

SaskEnergy's proposed non-financial benefits included:

- Actual billing instead of estimates – actual usage would more accurately reflect the energy used by customers on a regular basis
- Reducing SaskEnergy's carbon footprint; for example, by eliminating the need to dispatch service technicians for meter reads
- Enabling Saskatchewan to pace with other regions in North America that have modernized their systems (B.C., Alberta and Ontario)
- Resolving billing questions more efficiently
- Customers seeing cost savings related to energy efficiency initiatives sooner

No information on realized benefits was available.

3.3 ATCO Gas

Part of the ATCO Group of Companies, ATCO Gas delivers natural gas service to more than 1.1 million customers in nearly three-hundred communities in the province of Alberta. ATCO Gas is headquartered in Edmonton, Alberta, with sixty-nine offices across the province, and provides service to municipal, residential, business and industrial customers.[74]

3.3.1 Project Overview

The ATCO project was initiated in 2011 to replace manual meter reading with automated meter reading (AMR) via communication modules. Once its two-year deployment was complete, the ATCO project, comprising approximately 1.1 million gas communication modules, made it the largest gas automation project in Canada.[75] In the summer of 2018, ATCO switched from ground collection to aerial (plane) automated meter reading, making it the largest aerial reading project in North America.[76]

3.3.2 Technologies and System Setup

Itron, Inc. was chosen via RFP as the ATCO project's hardware and network vendor. Itron provided ATCO with a gas AMR system to operate independently of the province's electric AMI networks, which included of approximately 1.1 million gas communication modules, mobile and handheld collectors and associated software.[77].

3.3.3 Implementation Timelines

In ATCO Gas's 2011 General Rate Application, ATCO Gas proposed to install AMR modules on all 1,044,000 residential and low-use customer premises over a five-year period, starting in 2010 and then progressing into mass installations beginning in 2011, as shown in the table below.[78]

	2010	2011	2012	2013	2014	Total
Module Installations	10,000	134,000	348,000	333,000	219,000	1,044,000

The actual implementation went quicker than anticipated and took place over just two years, with mass installations starting in 2011 and finishing in 2013.[79]

3.3.4 Implementation Costs

ATCO's forecasted expenditures are shown in the table below, from ATCO's rate filing.[80] (Note ATCO uses the term "Low Use" to mean customers with low gas use, i.e., residential and small commercial customers.)

	ATCO Gas (Total) - Low Use AMR Project - By Year					
	2010	2011	2012	2013	2014	Total
Units	10,000	134,000	348,000	333,000	219,000	1,044,000
Forecast ($ millions)	3.7	17.2	37.4	35.2	27.5	121.0

The proposed costs assume a cost per meter of $115.90. The Alberta Utilities Commission did not object to the low-use AMR proposal, and approved it with the following provisions:[81]

1. **Timing of reading reduction benefits:** A discrepancy between reduction in staff and the module installation schedule needed to be corrected

2. **Contingency:** ATCO included a 20% cost contingency, which the commission felt should be reduced
3. **Opportunity for daily reads:** The commission wanted assurance that collecting daily reads would not require additional costs or site visits to realize
4. **Radio frequency off or opt-out program:** The commission wanted the introduction of a program to allow radio signals turned off

3.3.5 Benefits

ATCO Gas cited the following as the primary non-financial benefits granted by a switch to AMR:

- Improved billing accuracy and customer convenience
- Improved employee safety by reducing risks of falls and slips in the winter when going house-to-house

Once deployed, aerial reading reduced the distance employees drive by over 600,000 km per year, and eliminated the associated travel safety risks.[82]

By implementing AMR, ATCO's forecast that it would be able to eliminate or redeploy 200 FTE meter reading personnel, each with a fully loaded cost of $76,175, and did not expect to incur severance costs. However, representatives for Calgary cited concerns in their filing review that there was not reasonable assurance that meter readers would assume open positions and that this had implications for the business case's assumed operating and maintenance (O&M) figures.[83]

ATCO Gas's realized O&M savings were reported in a 2019 document, as shown in the table below.[84]

	Forecast in 2011-2012 GTA		Actual		
Year	AMR Meters Implemented[1]	O&M Savings ($000)	AMR Meters Implemented[1]	O&M Savings ($000)	Unit Meter Reading Cost
2010	10,000		6,246		$1.59
2011	134,000	520	225,175	1,835	$1.53
2012	348,000	4,490	690,388	7,349	$0.97
2013	333,000	7,810	192,697	12,782	$0.40
2014	219,000	13,700	26,937	13,886	$0.29
2015		19,670	25,296	13,884	$0.28
2016			15,315		$0.22
2017			17,211		$0.21

[1] Includes growth and retrofits

Total O&M savings equaled $49,736,000, approximately $3.5 million higher than the forecast of $46,190,000. It should be noted these figures also include savings achieved by route optimization, and as noted by the Utilities Commission, it is "difficult, if not impossible, to isolate the impact of earnings resulting from changes directly related to the AMR project from other contributing factors."[85] However, the dramatic reductions in unit meter reading costs show savings being realized alongside AMR installations, and the aerial meter reading capabilities implemented in 2018 were reported to reduced operating costs by over $300,000 annually and significantly reduced vehicle and equipment maintenance costs.[86]

3.4 SoCalGas (Southern California Gas Company)

The Southern California Gas Company is the primary provider of natural gas to Southern California. It supports six million meters and serves over 20 million consumers within 20,000 square miles including 12 counties, 230 cities and 270 communities.

SoCalGas is the largest natural gas distribution utility in the United States, providing natural gas service to 21.7 million customers in Central and Southern California. Its service territory spans 22,000 square miles from Fresno to the Mexican border, reaching more than 550 communities and serving 5.9 million meters through 101,000 miles of pipeline. More than 90 percent of Southern California single-family home residents use natural gas for home heat and hot water. In addition, natural gas plays a key role in providing electricity to Californians—about 60 percent of electric power generated in the state comes from gas-fired power plants.[87]

3.4.1 Project Overview

Southern California Gas Company (SoCalGas) deployed gas AMI for six million meters in its service territory over the 2009-2015 timeframe, consisting of 2.4 million new meters with pre-installed AMI modules and 3.6 million modules to be retrofit to existing meters in the field. SoCalGas was California's first large-scale deployment of gas-only AMI. It gave the regulator four reasons to adopt its gas AMI system:

- First, the proposal is consistent with and supportive of the State's Energy Action Plan's endorsement of energy conservation. SoCalGas' AMI system will provide individual customers with access to energy usage information to manage their energy bills by changing their energy consumption behavior as it relates to real time energy usage and costs.
- Second, the proposal provides substantial operational efficiencies that will benefit SoCalGas customers. These operational benefits offset approximately 84.5% of the cost of the AMI system. Together with the reasonable demand-side conservation benefits, the proposal is cost-effective for SoCalGas customers.
- Third, the proposal provides significant environmental benefits. Upon full implementation, AMI will eliminate annually over 6.3 million vehicle miles from California's roads and highways and remove 3000 tons of greenhouse gas CO2 emissions from California's air.
- And finally, the proposal offers the potential for a communications network capable of being used by water agencies and companies to promote water conservation and better water management.[88]

3.4.2 Technologies and System Setup

SoCalGas selected Aclara RF Systems, Agile Sourcing Partners, Inc., and Capgemini America, Inc. to manufacture and deliver the technology and to provide support for the development and integration of the various information systems necessary to implement the project.[89] The total number of Aclara Data Collector Units (DCUs) installed as part of the network was 4,535.[90] Two-hundred and seventy-five SoCalGas employees were installing modules as of 2013. When fully staffed, 326 personnel were to be involved in module installation.[91]

3.4.3 Implementation Timelines

The AMI project was approved by the California Public Utility Commission (CPUC) in April 2010, and the project's five-year deployment proceeded according to the timeline below: [92]

- October 29, 2012 First module installed
- December 31, 2013 1,127,389 modules installed
- December 2014 2,877,639 modules installed
- December 2015 4,572,006 modules installed
- December 2016 5,796,873 modules installed
- December 2017 5,926,881 modules installed (final)

SoCalGas' plan contemplated that the network DCUs would be constructed prior to the installation of the modules so that the modules would be effective in delivering benefits to customers. SoCalGas began installing its network infrastructure in June 2012 and its modules in October 2012.[93]

3.4.4 Implementation Costs

Estimated:

The estimated deployment cost for the SoCalGas AMI was approximately $1.09 billion USD of which $903 million USD was capital expenses and $187 million USD was operating and maintenance expenses.[94] The final budget as approved by the CPUC was $1.05 billion USD, which was also supplemented by re-directing $13.5 million USD of previously approved General Rate Case funding for a Remote Automated Meter Reading (RAMR) project. SoCalGas halted the implementation of its RAMR project (a drive-by meter reading system) when its AMI application was submitted, and in the AMI application requested that this funding be re-directed to the AMI project, which the CPUC approved. This brought the total budget for the SoCalGas Advanced Meter project to $1.06 billion USD, which included a contingency fund of $68.7 million USD.[95]

Actual:

SoCalGas reported its advanced meter project spending in its 2018 semi annual report, as shown in the table below:[96]

Financial Results (in $Thousands)
Recorded 2010 through December 2017

	2010	2011	2012	2013	2014	2015	2016	2017	Project to Date
Project Management Office	2,719	6,477	6,634	4,945	4,027	3,415	3,006	2,854	**34,077**
Meters, Modules & Installation	120	3,718	28,410	115,516	183,117	170,078	58,829	7,833	**567,620**
Network	877	3,743	14,429	23,805	18,796	15,306	14,572	13,461	**104,989**
Information Technology	6,011	16,873	21,931	16,015	10,469	11,109	6,248	5,775	**94,430**
Customer Outreach	324	1,026	2,088	5,502	5,190	4,786	3,999	2,143	**25,057**
Employee Awareness	65	3,078	3,732	2,088	1,046	1,087	752	383	**12,231**
Support Organizations[12]	-	-	707	3,500	4,517	4,684	11,512	2,145	**27,065**
Overheads & AFUDC[13]	2,222	9,471	21,291	32,577	38,311	32,268	29,433	14,257	**179,830**
Total	**12,338**	**44,386**	**99,223**	**203,947**	**265,472**	**242,732**	**128,350**	**48,851**	**1,045,300**

In its report, SoCalGas states that “although the project has fully allocated the authorized contingency SoCalGas believes the project will be delivered within the approved budget.”[97] If the project is successfully delivered within budget, its total project cost per meter will be approximately $178 USD.

3.4.5 Benefits

The 2008 SoCalGas business case projected the following project costs and benefits, shown in direct value terms for 2008.[98]

Summary of Operational Costs and Benefits
"Stand Alone" SoCalGas AMI
In 2008 Direct Dollars ($Millions)

Costs	Total	Deployment 2009 - 2015	Post Deployment 2016 - 2034
O&M	$261.0	$90.7	$170.3
Capital	$704.1	$542.7	$161.4
Total Costs	$965.2	$633.4	$331.7
Benefits			
O&M	$1,164.7	$118.1	$1,046.6
Capital	$266.8	$41.4	$225.4
Theft	$2.4	$0.3	$2.1
Total Benefits	$1,433.9	$159.7	$1,274.1
Net Benefits	$468.7	($473.7)	$942.4

Note that the total project terms is twenty-five years, which SoCalGas based on a five-year deployment period, plus a “twenty-year useful life of the AMI system [which] was determined based upon the responses to a Request for Proposal issued to AMI technology vendors during 2008.”[99] The problem with this timeline, as the CPUC regulators pointed out, is that even under ideal circumstances, only the meters and modules installed in 2015 could be expected to last through 2034, and so the benefits are likely overestimated.

A summary of the proposed operational benefits are shown below, including the percentages of expected benefits per operational category.

Summary of Operational Benefits
2009 – 2034
In 2008 Direct Dollars ($Millions)

Functional Area	Operational Benefits	Percent of Total
Meter Reading	$757.6	53%
Customer Services Field	$270.5	19%
Customer Billing Services	$65.8	5%
Other O&M	$70.8	5%
Sub-Total O&M	$1,164.7	81.2%
Working Cash	$50.6	4%
Metering	$141.2	10%
Other Capital*	$75.0	5%
Sub-Total Capital	$266.8	18.6%
Theft	$2.4	0.2%
Total Benefits	$1,433.9	100%

* Other Capital includes $19.9 million in Meter Reading benefits

The meter reading reductions realized by SoCalGas following their deployment are shown in the table below. By June 2017, only 97% of meter reading personnel who were employed in 2010 were reduced. Of this, 22.33% had left the company, while 75.15% had transitioned within the company.[100]

Table 10
Status of Meter Reading Personnel Employed in April 2010

Meter Reading Personnel	Work Force in April 2010	Remain in Meter Reading June 30, 2017	Left Company	Transition Within Company
Full-time	166	2	24	749
Part-time	818	17	192	
Management	46	7	14	25
Total	1,030	26	230	774
Percent of Work Force	100%	2.52%	22.33%	75.15%

In addition to the forecasted operational benefits, SoCalGas also believes customers will utilize the information provided by the AMI system to lower their gas usage. Along with the reduced cost of operations, should residential customers reduce natural gas consumption by 1% installation of the network will more than pay for itself.[101] In addition, deployment of SoCalGas gas AMI system will eliminate over 6.3 million vehicle miles each year as manual meter reading is eliminated, thus reducing greenhouse gas emissions by over 3000 tons of CO2 per year upon completion of the full deployment. These climate impacts are considered non-financial societal benefits in addition to the customer savings that will be realized, which are a powerful project driver for climate and conservation-focused jurisdictions like California. SoCalGas' conservation potential estimates are shown in the table below.[102]

Table 2: Estimates of conservation potential from daily online feedback to SoCalGas customers

Feedback type	% of customers participating	Savings potential (%)	Initial total conservation estimate (% of participants with 'smarted' meters)	Conservation estimate in Y5, assuming 1% participation growth rate per year
Web-based	6.5	5	0.325	0.525
Display-based	6.5	10	0.65	1.05
Total conservation effect			**0.975**	**1.575**

In its follow-up reporting to the CPUC, SoCalGas provided the following summary of its conservation treatment group results:

> "Four out of eleven treatments tested during the 2013-2014 heating season campaign generated average savings of about 1.3 percent. Four out of seven residential treatments tested during the 2014-2015 heating season campaign generated average savings of about one percent. Fourteen out of fourteen residential treatments tested during the 2015-2016 campaign generated average savings of over 1.4 percent."[103]

Regarding the above results, SoCalGas reports that "the new and continued successful treatments produced average gas savings of 1.6 percent during the 2016-2017 fall/winter period," and summarizes these findings in the table below.[104]

Percent Reduction in Fall/Winter 2016-2017 Gas Usage for Residential Conservation Treatments

Treatment	Percentage Reduction
11 New Treatments	**1.74%**
9 2015-2016 Treatments	1.42%
1 2014-2015 Treatment	1.31%
Overall % Reduction	**1.60%**

SoCalGas has also realized service delivery enhancement benefits using AMI-enabled data analytics. In its AMI approval, the CPUC recognized AMI as a "system-wide technology platform with the ability to expand operating benefits as new applications emerge," and SoCalGas has implemented data analytics as one of these new applications. The utility's Advanced Meter team analyzes data for unusual consumption patterns to identify potential safety situations, gas or hot water leaks, and malfunctioning appliances, which reduces waste, emissions, and the financial burden on customers from loss or higher usage.[105] From the time of full implementation through December, 2017, SoCalGas was able to identify 8,335 situations that resulted in the generation of exploratory service orders to investigate issues at customer premises. The types of situations SoCalGas identified and investigated were:

- Excessive gas registration
- Gas and hot water leaks
- Water heater issues where hot water was in continuous demand
- Abnormal appliance use, e.g., appliance unintentionally left on

SoCalGas has realize benefits including more rapid detection and resolution of gas and hot water leaks, enhanced safety, energy and financial savings, reduced greenhouse gas emissions, and conservation of scarce water supplies, and expects additional service and safety benefits to accrue for its operations and its customers.[106]

3.5 Con Edison

Founded in 1823 as the New York Gas Light company, Con Edison's electric, gas, and steam service provides energy for the 10 million people who live in New York City and Westchester County.

3.5.1 Project Overview

Con Edison's AMI project will involve the deployment of nearly five million endpoints between 2017 and 2022, including:

- 3.5 million electric AMI meters
- 1.2 million gas modules, retrofitted to existing mechanical meters
- Replacing 180,000 old gas meters with new mechanical meters and AMI modules[107]

The New York State Public Service Commission approved the Con Edison AMI Business Plan in March of 2016, and as of the time of writing, the Con Edison deployment is currently underway. In its approval order, the Commission summarizes the drivers supporting AMI as meeting energy demands, system resiliency necessitated by climate trends, and more informed and empowered customers. The Commission stated the following in its decision:

> "The energy demands of the modern economy, and the need for system resiliency caused by climate trends, create an increasing need for utilities to have granular situational awareness of their distribution systems. At the same time, customers require increased ability to manage their energy consumption and energy bills. Advanced Metering Infrastructure (AMI) is a technology that addresses both of these goals.
>
> Consolidated Edison Company of New York, Inc. (Con Edison or the Company) has filed with the Commission an AMI Business Plan. AMI will contribute to the modernization of the Company's electric system and gas distribution system, creating substantial operating savings and efficiencies as well as increased visibility and control of its system.
>
> Equally important, the deployment of AMI will transform the relationship between Con Edison and its customers. The enhanced information enabled by AMI will assist in managing outages and service connections, and will

empower customers to manage their bills by participating in demand response and other opportunities presented by a modernized system."[108]

In its 2015 AMI Business Plan, Con Edison cites the three primary drivers below as reasons to deploy AMI technology:[109]

- **Reforming the Energy Vision (REV):** In line with the New York Public Service Commission's REV strategy, AMI can empower both electric and gas customers with interval meter data to evaluate their energy consumption and make informed energy decisions.
- **Digital Customer Experience (DCX):** AMI can support Con Edison's DCX initiative, which seeks to leverage state of the art digital technologies to enhance customer engagement, experience, and communication.
- **AMI Technology Maturity and Market Competition:** Building on the success of other large global AMI projects, Con Edison will be able to deploy a cutting-edge AMI technology platform, do so at a very competitive price, and realize maximal benefits while limiting risk through the use of advanced technology and lessons from other utilities who have deployed AMI.

3.5.2 Technologies and System Setup

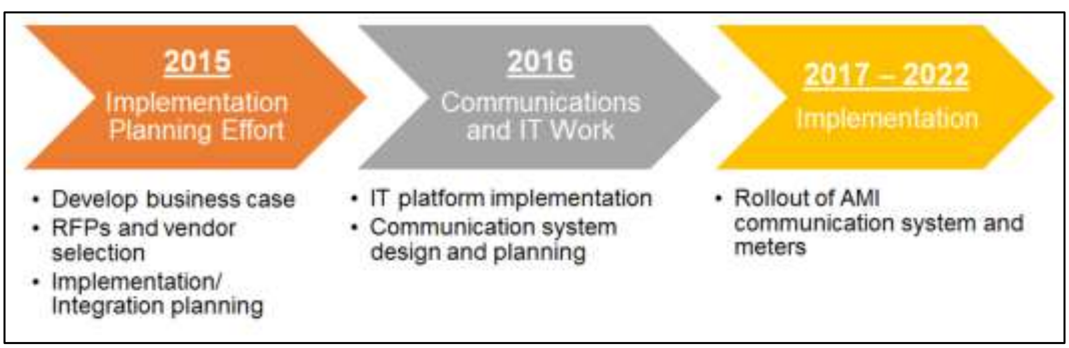
- Meter Vendor: Aclara[110]
- MDM software: Siemens EnergyIP
- Software implementer: OMNETRIC Group (Siemens/Accenture JV)[111]
- AMI Vendor and Installer: Smart Grid Solutions
- AMI Technology: SGS' ProFieldMETER

The business plan proposes the following specifications for the 1.2 million gas customers:[112]

- **Network System Coverage:** 100%
- **System Performance – Interval Reads:** 99.50%
- **Gas Meter Register Reads:** Hourly gas interval reads
- **Gas Customer Data Presentment:** Data to be displayed on portal next day

3.5.3 Implementation Timelines

Con Edison's AMI implementation schedule is defined in its business plan, and comprises the three major phases shown below:[113]



Communications system deployment began in January 2017 and has proceeded on schedule; as of the end of March

2019, Con Edison has installed approximately 6,070 network communication devices.[114] In June 2017, Con Edison put several AMI back office systems in service and began the deployment of AMI meters. Billing functionality for the AMI meters went live on August 15, 2017, and an upgrade of the AMI system to enable the deployment of methane sensors was completed in September, 2018. At the time of its last AMI Metrics report in April 2019, Con Edison has installed nearly 1.12 million meters across its service territory.[115]

3.5.4 Implementation Costs

The Con Edison project used a 20-year evaluation period, with a six-year project life and five-year meter deployment scenario. The Con Edison project was estimated to cost $1.074 billion USD in new capital and incur $552 million USD in operational costs to run the system (2015 present-value basis). The anticipated total project cost per meter is $495 USD.

Con Edison's 2015 AMI Business Plan outlines the anticipated implementation costs (in USD), which are shown below. [116]

Cost Category	Description	Capital Investment 20 Years	Ongoing O&M 20 Years	Total Expenditure 20 Years
AMI Meters	Physical AMI Meter (and supporting labor) to be installed at each premise/location	$747 million	N/A–Accounted for in Ongoing Operations	$747 million
AMI Communications	AMI Network Infrastructure to support communications from the AMI meters to "head end"	$103 million	$332 million	$434 million
IT Platform and Ongoing IT Operations	IT platform/systems to enable and support AMI system	$285 million	$618 million	$904 million
Project Management and Ongoing Operations	Management of project during deployment/ implementation and on-going AMI Operations	$149 million	$180 million	$329 million
	TOTALS	**$1.284 billion**	**$1.130 billion**	**$2.414 billion**

The more detailed cost areas listed in the business case are shown below, but further breakdown of how costs were allocated between these detailed cost areas was not provided in the filing:[117]

- Meters, including hardware, shipping, handling, insurance, freight, testing, and warranty support
- Initial core deployment meter installation work, including minor repair work, and call center appointment scheduling
- Ongoing meter replacement work
- RF Communications planning and design and implementation
- RF communications hardware requirements

- Miscellaneous equipment for RF Communication hardware mounting requirements
- Lease costs for some number of third party sites to mount RF equipment
- AMI Data Center Setup, Software acquisition, and ongoing software maintenance
- AMI Systems Operations
- AMI System Software On-Going Maintenance
- AMI RF communication System field Maintenance
- AMI RF communication “backhaul” WAN communication services
- IT MDMS Implementation Costs
- IT “middleware” applications and systems implementation costs
- IT systems integration work
- IT hardware environment to support MDM and middleware
- IT operations staff for ongoing MDM and Middleware systems
- Information systems costs to support new business practices associated with theft, tamper and other forms of unaccounted energy losses
- AMI Operations
- Web-based energy information services
- Project Management Office (PMO)
- Customer engagement
- External communications

3.5.5 Benefits

The project’s anticipated gas benefits are shown below. Note that electric-only benefits such as conservation voltage detection have been excluded from this list.

Financial benefits

- Reduction in meter reading
- Reduction in Field Services (e.g. turn-ons & turn-offs)
- Reduced call center labor
- Gas and electric meter capital replacement avoided costs
- System retirement and discontinued AMR installation program
- Revenue protection
- Meter accuracy / irregular meter condition (IMC)
- Bad debt
- Inactive meter/unoccupied premises
- No more estimated bills

Non-financial benefits

- Risk Reduction Benefits – The communications network will enable the remote control of meter service switches that allow the Company’s Control Center operators to respond more effectively to system emergencies.
- Future Benefits – The AMI network will provide the capability to integrate new sensor functions to improve

operational awareness of system conditions. The AMI system will also support the development of future billing programs and market interactions

- Conservation support
- The Natural Gas Detector (NGD) is a safety device that will provide continuous monitoring of the environment for methane (the primary component in natural gas) near the gas service point of entry to detect concentrations above a threshold of 10% LEL (Lower Explosive Limit) or 0.5% gas-in-air, which will result in an alarm. Con Edison has worked with a methane sensor manufacturer and the Company's AMI system vendor to develop a battery-powered sensor that can be integrated with the AMI communications network. Con Edison began the installation of the NGDs on October 22, 2018, and the pilot installation of 9,000 sensors will span from 4Q 2018 through 3Q 2019. As of the end of March 2019, roughly 3,700 of the estimated 9,000 sensors have been installed. This new technology is helping the Company to improve both public safety and customer experience. The devices have detected gas leaks proactively that were addressed before an event occurred. Overall feedback on this program has been positive.[118]

Total NPV

Con Edison's BCA yielded a total project 20-year net present value of $1.08 billion USD, calculated using the values shown in the chart below (figures in millions of USD).[119]

Business Case Component	Costs & Benefits (20 Year NPV)
A. Costs (20 Year NPV)	
O&M Expense for AMI System	$552
New Capital Investment for AMI System	$1,074
Sub-Total	***$1,626***
B. AMI Benefits (20 Year NPV)	
AMI Cost Reduction Benefits	$1,280
Customer and Company Benefits	$1,426
Sub-Total	***$2,706***
C. Total (20 Year Net NPV)	
Benefits Less Costs	***$1,080***
Discounted Payback Period*	***10***

*NPV and Payback calculated based on discount rate of 6.1% (Con Edison's WACC)

3.6 San Diego Gas and Electric Company

San Diego Gas & Electric provides energy service to 3.5 million consumers through 1.4 million electric meters and more than 850,000 natural gas meters in San Diego and southern Orange counties. In 2008, SDG&E launched an initiative to modernize its electricity and natural gas infrastructure.

3.6.1 Project Overview

SDG&E installed 1.4 million new smart electric meters and approximately 900,000 new smart gas meters. In the course of its regulatory filing, SDG&E successfully petitioned to have its AMI Business Case figures, including both detailed cost and benefit figures, filed under seal and redacted from public documents. SDG&E stated that protection of the figures and calculations was necessary to ensure that potential bidders for project elements would not be aware of the utility's internal evaluations and cost expectations for technologies or services. For this reason, specific cost and benefit figures were not available for reference in this report.

3.6.2 Technologies and System Setup

SDG&E selected Itron for the smart grid and natural gas system modernization project. The collected advanced meter data is managed by the Itron Enterprise Edition (IEE) MDM and is integrated to other utility systems and data analysis applications. SDG&E was particularly interested in delivering data to its CIS system to streamline billing.

At the outset of this project, more than 270,000 of SDG&E's gas meters were more than forty years old. A benefit of Itron's broad form fit was that many meters could be retrofitted to accommodate the gas module. SDG&E was able to perform their system upgrade while only changing out 35,000 meters, saving costs as well as deployment time. In addition, visiting each meter site to install the gas module gave the company the opportunity to perform other maintenance activities throughout its service territory.[120]

3.6.3 Implementation Timelines

SDG&E's deployment was scheduled to begin in mid-2008. From 2008 through 2010, SDG&E was to install approximately 1.4 million new, AMI-enabled, solid state electric meters and 900,000 AMI enabled gas modules.

3.6.4 Implementation Costs

Anticipated total project costs as outlined in the CPUC project filing were $572 million USD, through 2011.[121] After undergoing a Settlement Agreement process as part of its regulatory proceedings, the SDG&E proposal, business case, and legal requirements were analyzed and modified by multiple parties. This led to modifications to both the SDG&E project's costs and benefits, and ultimately a cost-effective business case on a 17-year term. The Settlement Agreement determined a total project cost of $652 million USD.

Specific cost allocations and figures were redacted from public filings, but the following cost areas were identified in SDG&E's Business Case supplemental reporting:[122]

Start-up and Design Costs

- Communications system
- Information Technology and Application
- Management and other Costs

Installation / Operations and Maintenance Costs

- Meter System and Installation
- Communication System
- Information Technology and Application
- Customer Services
- Management and Other Costs
- Gas Service Impacts

3.6.5 Benefits

SDG&E's business case benefits were split into three categories: Systems Operations Benefits, Customer Service Benefits, and Management and Other Benefits. Overall, a CPUC review of SDG&E's business case found that the AMI application was not cost effective once it had corrected some of SDG&E's assumptions (specifically regarding the benefits to be obtained from demand response, which SDG&E had relied upon heavily to make its case). The CPUC analysis determined that benefits would fall short of costs by approximately $38.5 to $49.5 million USD, and that the proposal as filed would not be approved.

However, in its Settlement Agreement, SDG&E was able to move to a positive benefits case by adding functionality to the proposed system, including a Home Area Network communication system and remote disconnect/reconnect functionality for electric meters, as well as by exploring an extended warranty on AMI equipment.[123]

The total financial benefits following the Settlement Agreement were estimated to range from $692 million to $703 million USD, yielding total net project benefits of between $40 and $59 million USD.[124] While specific benefit calculations and tables were kept confidential from the public, the following benefits and figures were disclosed:

Financial Benefits

- In its application, SDG&E claimed it would see $69.4 million USD in benefits associated with reduced energy theft (both electric and gas), improved meter accuracy, and reduced billing exceptions.
- SDG&E's customer service field staff would be reduced by approximately 25%.
- SDG&E claimed that electric meter accuracy benefits would amount to $53 million USD.
- The reduction of re-bills and estimated reads eliminated the need for regular visits to customer sites by meter readers, reducing costs associated with rolling a truck such as fuel costs and CO_2 emissions.
- SDG&E is now able to more proactively schedule maintenance activities, reducing the need for overtime and unplanned vehicle trips.

Projected Non-Financial Benefits

- Since far fewer employees will visit customer premises, typical meter reading injuries and vehicle accidents and usage will be reduced [125]
- Improved billing accuracy[126]

Citations

[1] Federal Energy Regulatory Commission. (August 2006. Revised 2008) *Assessment of Demand Response & Advanced Metering.* https://www.ferc.gov/legal/staff-reports/demand-response.pdf

[2] Power Grid International. (October 1, 2008) *AMR vs AMI.* https://www.power-grid.com/2008/10/01/amr-vs-ami/#gref

[3] Ontario Energy Board. (January 26, 2005) *Smart Meter Implementation Plan – Report of the Board to the Minister.* https://www.oeb.ca/documents/communications/pressreleases/2005/press_release_sm_implementationplan_260105.pdf

[4] Huang, Liji. (2012) *City Natural Gas Metering. http://www.ourenergypolicy.org/wp-content/uploads/2012/11/InTech-City_natural_gas_metering.pdf*

[5] Sensus, Inc. (2004) *Sensus Metering Systems Sonix Ultrasonic Gas Meter*
http://www.measurementcontrols.in/sensusdocs/SX_600.pdf

[6] Sensus Inc. (October 29, 2019) *New Sensus Sonix IQ Gas Meter Goes Beyond Measuring with Smart Sensing*. https://sensus.com/news-events/news-releases/new-sensus-sonix-iq-gas-meter-goes-beyond-measuring-with-smart-sensing/

[7] Sensus Product documents, available at: https://sensus.webdamdb.com/bp/#/

[8] Itron, Inc. (January 8, 2019) *Itron Recognized for Internet of Things Innovation with 2019 IoT Breakthrough Award.* https://wwwprodcd.itron.com/na/newsroom/press-releases/2019/01/07/itron-recognized-for-internet-of-things-innovation-with-2019-iot-breakthrough-award-press-release

[9] Webb, Romany. (July 2018) *Deploying Advanced Metering Infrastructure on the Natural Gas System: Regulatory Challenges and Opportunities*. http://columbiaclimatelaw.com/files/2018/07/Webb-2018-07-AMI-and-Natural-Gas.pdf

[10] New Mexico Gas Company. *Automated Meter Readings.* https://www.nmgco.com/en/automated_meter_readings

[11] See note 9 (Webb report). Page 4.

[12] Itron Inc. (March 22, 2016) *Itron Secures Contract with Questar Gas to Upgrade Metering Infrastructure.* https://www.itron.com/na/company/newsroom/2016/07/12/itron-secures-contract-with-questar-gas-to-upgrade-metering-infrastructure

[13] Niagara Mohawk Power Corporation. (November 15, 2018) *Report of Niagara Mohawk Power Corporation d/b/a National Grid on the Proposed Implementation of Advanced Metering Infrastructure* http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B5A9009BC-356F-4B0F-B3C7-F255EA8AA5A8%7D

[14] Alberta Utilities Commission. (July 20, 2012) *AUC Decision 2012-191 – ATCO Gas 2011-2012 General Rate Application Phase I Compliance Filing.* Page 16. http://www.auc.ab.ca/regulatory_documents/ProceedingDocuments/2012/2012-191.pdf

[15] State of Illinois Commerce Commission. *Northern Illinois Gas Company d/b/a Nicor Gas Company – Proposed General Rate Increase in Gas Rates and Revisions to Other Terms and Conditions of Service 17-0124 – ORDER.* (January 31, 2018). Page 12. https://www.icc.illinois.gov/downloads/public/edocket/464441.pdf

[16] Northern Illinois Gas Company d/b/a Nicor Gas Company. (July 24, 2017) *Revised Rebuttal Testimony of JEFFREY T. BUXTON Executive Consultant, Black & Veatch Management Consulting, LLC On behalf of Northern Illinois Gas Company d/b/a Nicor Gas Company.* Pages 11-12. *https://www.icc.illinois.gov/downloads/public/edocket/450811.pdf*

[17] Black & Veatch. (2016) *2016 Strategic Directions: Natural Gas Industry Report.* Page 24. https://www.slideshare.net/PramodSingh54/2016-strategic-direction-report-natural-gas

[18] See previous note: Black & Veatch 2016 Strategic Directions Natural Gas Industry Report. Page 24.

[19] See previous note: Black & Veatch 2016 Strategic Directions Natural Gas Industry Report. Page 25.

[20] See note 9 (Webb report). Page 12.

[21] ICF International. (June 30, 2016) *Natural Gas Conservation Potential Study.* https://www.oeb.ca/oeb/_Documents/EB-2015-0117/ICF_Report_Gas_Conservation_Potential_Study.pdf

[22] The Brattle Group. (June 2018) *Demand Response for Natural Gas Distribution – Opportunities and Challenges*. http://files.brattle.com/files/13929_demand_response_for_natural_gas_distribution.pdf

[23] Consolidated Edison Company of New York, Inc. (July 1, 2019). *Gas Demand Response Report on Pilot Performance – 2018/19.* http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B168BE55E-62A7-456E-B874-5D53BB5F74DF%7D

[24] CPUC. Summary of Decision on Application Of Southern California Gas Company For Approval Of Advanced Metering Infrastructure. Section 9.1.3.1. http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/116294-01.htm#P82_2102

[25] SoCalGas Advanced Meter Semi-Annual Report, February 2018. Pages 22-23. https://www.socalgas.com/regulatory/documents/a-08-09-023/SoCalGas_Advanced_Meter_Semi_Annual_Report_FEB2018.pdf

[26] SoCalGas Advanced Meter Semi-Annual Report, February 2018. Page 24. https://www.socalgas.com/regulatory/documents/a-08-09-023/SoCalGas_Advanced_Meter_Semi_Annual_Report_FEB2018.pdf

[27] SoCalGas Advanced Meter Semi-Annual Report, February 2018. Page 12. https://www.socalgas.com/regulatory/documents/a-08-09-023/SoCalGas_Advanced_Meter_Semi_Annual_Report_FEB2018.pdf

[28] See note 9 (Webb report). Page 10.

[29] Sensus, Inc. Sensus Smart Gas ebook available at: https://sensus.webdamdb.com/bp/#/

[30] House Natural Resources Committee Democratic Staff (August 1, 2013). *Natural Gas Pipeline Leaks Cost Consumers Billions.* https://www.markey.senate.gov/documents/markey_lost_gas_report.pdf

[31] Allen, Bonnie, CBC News (November 15, 2019). *Oil and gas leaks among 15,000 spills on new map of Saskatchewan.* https://www.cbc.ca/news/canada/saskatchewan/oil-gas-leaks-spills-map-saskatchewan-1.5360963

[32] Con Edison (April 30, 2019). *AMI Metrics Report.* Available at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BB18CF247-8C6D-489F-BF94-CE32CE103C86%7D

[33] State of New York Public Service Commission (November 15 2018). *Report of Niagara Mohawk Power Corporation d/b/a National Grid on the Proposed Implementation of Advanced Metering Infrastructure*. Available at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={39BF47E1-4C3C-4C8D-B90F-0626984E28B8}

[34] See above note (National Grid AMI Proposal). Page 60.

[35] SoCalGas Application Errata Testimony for Sarah Darby, Oxford University: https://socalgas.com/regulatory/documents/a-08-09-023/Testimony/errata/Chapter%2005%20Conservation%20Impacts-S_Darby_Errata.pdf

[36] CPUC. (April 8, 2010) *Decision on Application of Southern California Gas Company for Approval of Advanced Metering Infrastructure*. Section 1 – Summary. http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/116294-01.htm#P82_2102

[37] CPUC. (April 8, 2010) *Comments on Proposed Decision.* http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/116294-11.htm

[38] CPUC. Summary of Decision on Application Of Southern California Gas Company For Approval Of Advanced Metering Infrastructure. http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/116294-01.htm#P82_2102

[39] CPUC. (April 8, 2010) *Comments on Proposed Decision.* http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/116294-11.htm

[40] State of Illinois Commerce Commission. *Northern Illinois Gas Company d/b/a Nicor Gas Company – Proposed General Rate Increase in Gas Rates and Revisions to Other Terms and Conditions of Service 17-0124 – ORDER.* (January 31, 2018). Pages 17-18. https://www.icc.illinois.gov/downloads/public/edocket/464441.pdf

[41] Northern Illinois Gas Company d/b/a Nicor Gas Company. (July 24, 2017) *Revised Rebuttal Testimony of JEFFREY T. BUXTON Executive Consultant, Black & Veatch Management Consulting, LLC On behalf of Northern Illinois Gas Company d/b/a Nicor Gas Company.* Pages 4-6. https://www.icc.illinois.gov/downloads/public/edocket/450811.pdf

[42] CPUC. (April 12, 2007) *Opinion Approving Settlement On San Diego Gas & Electric Company's Advanced Metering Infrastructure Project*. https://www.sdge.com/sites/default/files/D0704043-SmartMeter4-12-07_Final_0.pdf

[43] State of New York Public Service Commission (March 17, 2016). *Order Approving Advanced Metering Infrastructure Business Plan Subject To Conditions.* Pages 1-2. *http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={8C26CF58-5669-4A16-85BC-7D4AE21BFF8D}*

[44] Southern California Gas Company. (February 28, 2018) *Advanced Meter Semiannual Report. https://www.socalgas.com/regulatory/documents/a-08-09-023/SoCalGas_Advanced_Meter_Semi_Annual_Report_FEB2018.pdf*

City of Medicine Hat

[45] https://www.medicinehat.ca/government/departments/finance/customer-service/utility-billing

[46] AMI Steering Committee Presentation, *AMI Steering Committee April 7,2016.pdf*

[47] https://sensus.com/news-events/news-releases/city-of-medicine-hat-alberta-chooses-sensus-technology-for-electric-water-and-gas-utility-automation/

[48] Sensus Proposal _*Medicine Hat_Executive Summary_FINAL.doc*

[49] AMI Project Status Report August 26 2011 https://maportal.gov.ab.ca/EXT/MeNet/Lists/Practices/Attachments/568/Attachment%203%20AMI%20Project%20Status%20Report%20August%2026%202011.pdf

[50] AMI Steering Committee Presentation: *AMI Steering Committee April 7 2016.ppt* slide 5

[51] Smart Metering Business Case Summary: *Smart Metering Presentation Council.ppt*

[52] 2012 City of Medicine Hat Annual Report, page 16: https://www.medicinehat.ca/Home/ShowDocument?id=5379

[53] Gallant, Colin. (October 10, 2018) *Smart meters not as lucrative.* https://medicinehatnews.com/news/local-news/2018/10/10/smart-meters-not-as-lucrative/

[54] AMI Steering Committee Presentation: *AMI Steering Committee April 7 2016.ppt*

55 AMI Steering Committee Presentation: *AMI Steering Committee April 7 2016.ppt* slide 12

56 CMH Committee Meeting Presentation: *CMH – 2015 Business Case Info Slides (Nov 27)* slide 11

57 AMI Steering Committee Presentation: *AMI Steering Committee April 7 2016.ppt* slide 18

58 CMH Committee Meeting Presentation: *CMH – 2015 Business Case Info Slides (Nov 27)* slide 14

59 CMH Committee Meeting Presentation: *CMH – 2015 Business Case Info Slides (Nov 27)* slide 16

60 See earlier note: Medicine Hat News Report.

SaskEnergy

61 SaskEnergy 2018-2019 Annual Report: https://www.saskenergy.com/about_saskenergy/annual_report/documents/2018-19/SaskEnergy%202018-19%20Annual%20Report-web.pdf

62 SaskPower and SaskEnergy (October 17, 2013). *Media Release: Next generation power and gas meter provincial installations begin following successful 16-month testing period.* https://www.saskenergy.com/about_saskenergy/news/news_releases/2013/MR_AMI%20prov%20rollout%20FINAL.pdf

63 Government of Canada – Office of Consumer Affairs (Modified April 9, 2019). *Provincial and territorial utility commissions and boards.* https://ic.gc.ca/eic/site/oca-bc.nsf/eng/ca03012.html

64 SaskPower News Release. (July 18, 2019) *SaskPower Continues Non-Residential Smart Meter Program.* https://www.saskpower.com/about-us/media-information/news-releases/SaskPower-continues-non-residential-smart-meter-program

65 Sensus, Inc. (January 27, 2014). *Sensus Deploys FlexNet AMI Solution for SaskPower and SaskEnergy*: https://sensus.com/news-events/news-releases/sensus-deploys-flexnet-ami-solution-for-saskpower-and-saskenergy/

66 SaskEnergy FAQ. *Advanced Metering Infrastructure (AMI) Frequently Asked Questions.* https://www.saskenergy.com/residential/FAQ_AMI.pdf

67 Crown Investments Corporation Smart Meter Review Terms of Reference, August 15, 2014: *CIC-SaskPower Smart Meter Review Terms of Reference*, page 2. https://www.saskatchewan.ca/~/media/news%20release%20backgrounders/2014/oct/5%20terms%20of%20reference%20%20smart%20meters.pdf

68 Sensus news release: https://sensus.com/news-events/news-releases/sensus-deploys-flexnet-ami-solution-for-saskpower-and-saskenergy/

69 See earlier note: October, 2013 news release.

70 SaskEnergy Annual Report Archive: https://www.saskenergy.com/about_saskenergy/annual_report/Archive/default.asp

71 See earlier note: October, 2013 news release.

72 See earlier note: October, 2013 news release.

73 See earlier note: October, 2013 news release.

ATCO Gas

[74] ATCO Gas Linkedin Profile: https://ca.linkedin.com/company/atco-gas

[75] Itron Inc. News Release (August 1, 2013) *Itron Completes Installation of Canada's Largest Meter Automation Project at ATCO Gas.* https://www.itron.com/lam/company/newsroom/2013/08/01/itron-completes-installation-of-canada-s-largest-meter-automation-project-at-atco-gas

[76] ATCO Gas. *2018 Sustainability Report*: https://www.atco.com/content/dam/web/about-us/investors/2018-sustainability-report.pdf

[77] See earlier note: Itron 2013 news release.

[78] Alberta Utilities Commission Decision 2011-450 (December 5, 2011) *ATCO Gas 2011-201 General Rate Application Phase I.* Page 42. http://www.auc.ab.ca/regulatory_documents/ProceedingDocuments/2011/2011-450.pdf

[79] Alberta Utilities Commission Decision 23604-D01-2019 (February 27, 2019). *AUC-Initiated Review Under the Reopener Provision of the 2013-2017 Performance-Based Regulation Plan for the ATCO Utilities*. Page 15. http://www.auc.ab.ca/regulatory_documents/ProceedingDocuments/2019/23604-D01-2019.pdf

[80] See earlier note: AUC Decision, December, 2011.

[81] See earlier note: AUC Decision, December, 2011.

[82] See earlier note: ATCO Gas 2018 Sustainability Report. Page 17.

[83] See earlier note: AUC Decision, December, 2011. Page 43.

[84] See earlier note: AUC Decision, February, 2019. Page 15.

[85] See earlier note: AUC Decision, February, 2019. Page 15.

[86] See earlier note: ATCO Gas 2018 Sustainability Report. Page 17.

SoCalGas

[87] Southern California Gas Co. (June 29, 2017). *SoCalGas Joins Nest to Announce Results of Winter Seasonal Savings Energy Efficiency Program*. https://www.prnewswire.com/news-releases/socalgas-joins-nest-to-announce-results-of-winter-seasonal-savings-energy-efficiency-program-300482114.html

[88] SoCalGas Advanced Metering Infrastructure Testimony to CPUC in support of Gas AMI Application – Executive Summary: https://www.socalgas.com/regulatory/documents/a-08-09-023/Application/Executive%20Summary.PDF

[89] SoCalGas Advanced Meter Semi-Annual Report, August 2013: https://www.socalgas.com/regulatory/documents/a-08-09-023/SoCalGas-Advanced-Meter-Semi-Annual-Report-83013.pdf

[90] SoCalGas Advanced Meter Semi-Annual Report, February 2018: https://www.socalgas.com/regulatory/documents/a-08-09-023/SoCalGas_Advanced_Meter_Semi_Annual_Report_FEB2018.pdf

[91] See Note 89: SoCalGas August 2013 Semi-Annual Report. Page 12.

[92] SoCalGas Advanced Meter Semi-Annual Reports, available at: https://www.socalgas.com/regulatory/A0809023.shtml

[93] See Note 89: SoCalGas August 2013 Semi-Annual Report. Page 9.

[94] See note 88: SoCalGas AMI Application – Executive Summary

[95] SoCalGas Advanced Meter Semi-Annual Report, February 2018: https://www.socalgas.com/regulatory/documents/a-08-09-023/SoCalGas_Advanced_Meter_Semi_Annual_Report_FEB2018.pdf

[96] See above note: SoCalGas February 2018 Semi-Annual Report. Page 12.

[97] See above note: SoCalGas February 2018 Semi-Annual Report. Page 12.

[98] SoCalGas. September 29, 2008. *Southern California Gas Company Advanced Metering Infrastructure – Chapter III – SoCalGas AMI Deployment Plan Costs And Operational Benefits.* https://www.socalgas.com/regulatory/documents/a-08-09-023/Testimony/Chapter%2003.PDF

[99] See above: 2008 SoCalGas AMI Deployment Plan. Page III-4.

[100] SoCalGas Advanced Meter Semi-Annual Report, February 2018: https://www.socalgas.com/regulatory/documents/a-08-09-023/SoCalGas_Advanced_Meter_Semi_Annual_Report_FEB2018.pdf

[101] See above note: SoCalGas AMI Deployment Plan.

[102] SoCalGas Application Errata Testimony for Sarah Darby, Oxford University: https://socalgas.com/regulatory/documents/a-08-09-023/Testimony/errata/Chapter%2005%20Conservation%20Impacts-S_Darby_Errata.pdf

[103] See earlier note (SoCalGas 2018 Semiannual Report). Page 23.

[104] See above note (SoCalGas 2018 Semiannual Report). Page 24.

[105] See above note (SoCalGas 2018 Semiannual Report). Page 12.

[106] See above note (SoCalGas 2018 Semiannual Report). Page 12.

Con Edison

[107] State of New York Public Service Commission (March 17, 2016). *Order Approving Advanced Metering Infrastructure Business Plan Subject To Conditions.* Page 6. *http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={8C26CF58-5669-4A16-85BC-7D4AE21BFF8D*

[108] See above note: March 2016 NYPSC Order Approving AMI Business Plan. Pages 1-2.

[109] Consolidated Edison Company of New York, Inc. (November 16, 2015). *Advanced Metering Infrastructure Business Plan.* https://www.coned.com/-/media/files/coned/documents/accountandbilling/about-your-bill-rates/09-ami-panel-exhibits-ami-001-ami-005.pdf

[110] T&D World news article (May 12, 2016). *ConEd Orders Aclara Smart Meters for AMI Project*. https://www.tdworld.com/ami/coned-orders-aclara-smart-meters-ami-project

[111] Power Grid International news article (November 2, 2017). *New York utilities team with Omnetric on AMI rollout*. https://www.power-grid.com/2017/11/02/new-york-utilities-team-with-omnetric-on-ami-rollout/#gref

[112] See note 108: Con Edison AMI Business Plan. Page 66.

[113] See note 108: Con Edison AMI Business Plan. Page 4.

[114] Con Edison (April 30, 2019). *AMI Metrics Report.* http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BB18CF247-8C6D-489F-BF94-CE32CE103C86%7D

[115] See note 113: April 2019 AMI Metrics Report. Page 3.

[116] See note 108: Con Edison AMI Business Plan, 2015.

[117] See note 108: Con Edison AMI Business Plan, 2015. Pages 53-54.

[118] See note 113: April 2019 AMI Metrics Report. Page 4.

[119] See note 107: Con Edison AMI Business Plan, 2015. Page 56.

San Diego Gas and Electric Company

[120] Itron Case Study: https://www.itron.com/-/media/feature/products/documents/case-study/itron-technology-enhances-meter-reading--customer-service-across-gas-service-territory.pdf

[121] CPUC. (April 12, 2007) *Opinion Approving Settlement On San Diego Gas & Electric Company's Advanced Metering Infrastructure Project*. https://www.sdge.com/sites/default/files/D0704043-SmartMeter4-12-07_Final_0.pdf

[122] SDG&E. (December 31, 2004) *Advanced Metering Infrastructure (AMI) Business Case Supplemental Filing (filed January 12, 2005)*. https://www.smartgrid.gov/document/advanced_metering_infrastructure_ami_business_case_supplemental_filing

[123] See above note: CPUC Opinion Approving Settlement on SDG&E AMI Project.

[124] See above note: CPUC Opinion Approving Settlement on SDG&E AMI Project. Page 93.

[125] Itron Case Study: https://www.itron.com/-/media/feature/products/documents/case-study/itron-technology-enhances-meter-reading--customer-service-across-gas-service-territory.pdf

[126] See above note: CPUC Opinion Approving Settlement on SDG&E AMI Project.

Appendix B

NATURAL RESOURCES CANADA – SMART GRID IN CANADA REPORT

Natural Resources Canada | Ressources naturelles Canada

SMART GRID IN CANADA

2018

Canada

Authors: Anjali Wadhera, Josef Ayoub and Marylène Roy

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Qulliq Energy Corporation

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About This Report

This report provides an update on smart grid activities in Canada since the last report published in 2014. Key research, development, demonstration and deployment activities related to smart grid are highlighted as of December 2018. The report is intended to be a useful reference for Canadian and international smart grid practitioners, stakeholders and policymakers.

This report is published by Natural Resources Canada's CanmetENERGY research centre in Varennes, which manages the Canada Smart Grid Action Network (CSGAN) shown in Figure 1. CSGAN members discuss regional activities, share research topics of interest, collect smart grid metrics in Canada, present international knowledge and experience sharing opportunities, track standard development, and explore smart grid outlooks. CSGAN members' updates have contributed significantly to producing this report.

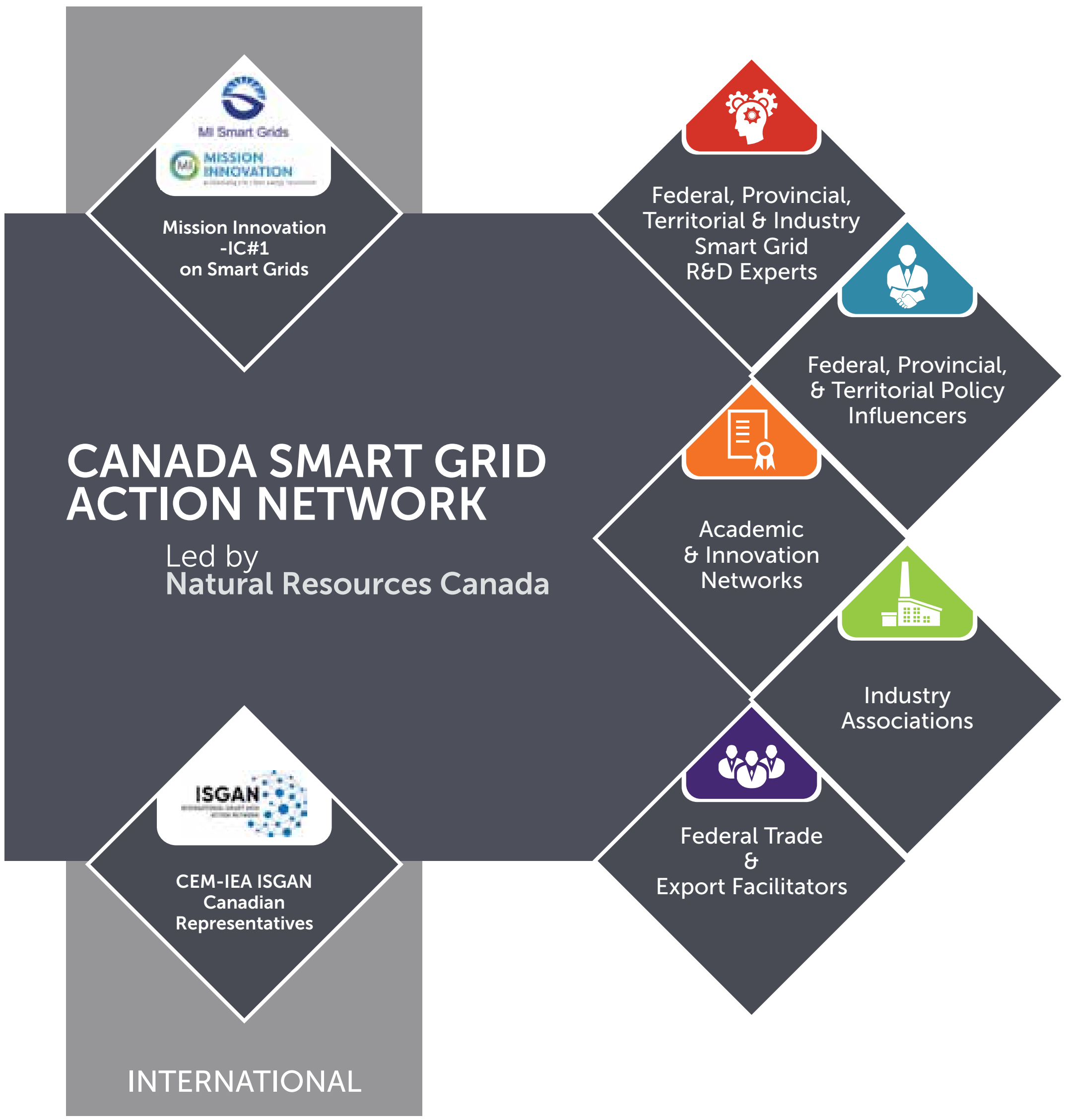

Figure 1: Canada Smart Grid Action Network (CSGAN) members

About CanmetENERGY

Natural Resources Canada's CanmetENERGY is Canada's leading research and technology organization in the field of clean energy. Nearly 175 scientists, engineers and support staff at the CanmetENERGY facility in Varennes, Quebec design and implement clean energy solutions, and expand on research areas that help produce and use energy in ways that are more efficient and sustainable.

CanmetENERGY has been addressing technical, institutional and regulatory barriers for smart grid technologies for over a decade such as limitations to integrating renewable energy on the grid, demand flexibility, smart inverter controls and smart grid related standards. CanmetENERGY also established CSGAN to connect key Canadian smart grid stakeholders and to leverage opportunities under the International Smart Grid Action Network and Mission Innovation—Innovation Challenge #1 on Smart Grids. CSGAN brings together members from provincial and territorial energy ministries, federal departments, academia, innovation networks, and industry associations to exchange their knowledge and experience about smart grid activities.

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Abbreviations

AC	Alternating Current
AEC	Advanced Energy Centre
AESO	Alberta Electric System Operator
AMI	Advanced Metering Infrastructure
BC	British Columbia
BCUC	British Columbia Utilities Commission
BEV	Battery Electric Vehicle
C&I	Commercial and Industrial
CEA	Canadian Electricity Association
CEATI	Centre for Energy Advancement through Technological Innovation
CEM	Clean Energy Ministerial
CEV	Clean Energy Vehicle
CMD	Connect My Data
COP	Conference of the Parties
CSA	Canadian Standards Association
CSGAN	Canada Smart Grid Action Network
DC	Direct Current
DER	Distributed Energy Resource
DERM	Distributed Energy Resource Management
DG	Distributed Generation
DMD	Download My Data
DR	Demand Response
DSO	Distribution System Operator
EDA	Electricity Distributors Association
EDC	Export Development Canada
EV	Electric Vehicle
FIT	Feed-in Tariff
GHG	Greenhouse Gas
GI2	Green Infrastructure Phase 2
HVDC	High Voltage Direct Current
IC	Innovation Challenge
ICE	Innovative Clean Energy
ICT	Information and Communication Technology
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IESO	Independent Electricity System Operator of Ontario
IoT	Internet of Things
ISED	Innovation, Science and Economic Development
ISGAN	International Smart Grid Action Network
IT	Information Technology
LEV	Light Emission Vehicle

LRP	Large Renewable Procurement
MI	Mission Innovation
MI-IC1	Mission Innovation – Innovation Challenge #1
microFIT	Micro Feed-in Tariff
NARIS	North American Renewable Integration Study
NBP	New Brunswick Power
NESTNet	Natural Sciences and Engineering Research Council Energy Storage Technology Network
NRCan	Natural Resources Canada
NSERC	Natural Sciences and Engineering Research Council
OEB	Ontario Energy Board
PCF	Pan-Canadian Framework
PF	Power Factor
PHEV	Plug-in Electric Vehicle
PV	Photovoltaics
QEC	Qulliq Energy Corporation
R&D	Research and Development
RD&D	Research, Development and Demonstration
RDD&D	Research, Development, Demonstration and Deployment
RE	Renewable Energy
RECSI	Regional Electricity Cooperation and Strategic Infrastructure Initiative
REP	Renewable Electricity Program
RES	Renewable Energy System
RPP	Regulated Price Plan
SCADA	Supervisory Control and Data Acquisition
SDTC	Sustainable Development Technology Canada
SGIN	Smart Grid Innovation Network
SIRFN	Smart Grid International Research Facility
TCP	Technology Collaboration Program
TEQ	Transition Énergétique Québec
ToU	Time-of-use
TRL	Technology Readiness Level
TSO	Transmission System Operator
UL	Underwriters Laboratories
V2B	Vehicle-to-Building
V2G	Vehicle-to-Grid
V2X	Vehicle-to-Everything
VPP	Virtual Power Plant
VV	Volt-var
ZEV	Zero Emission Vehicle

GENERAL FRAMEWORK

General Framework

The impacts of climate change are becoming more evident not only in Canada but around the world. The Intergovernmental Panel on Climate Change report finalized in October 2018 states that human activities have accelerated global warming, which poses significant risks to human health, security and biodiversity.

Canada has been proactive in addressing global warming by participaring in initiatives like the *Paris Agreement* at the twenty-first Conference of the Parties (COP21) in 2015. This international call for action committed countries to reducing greenhouse gas (GHG) emissions to diminish effects of global warming. The *Paris Agreement* commits countries to reduce (GHG) emissions by 30% below 2005 levels by 2030, and to strengthen efforts in limiting the global average temperature rise to below 2 °C as compared to preindustrial measurements. Following this agreement, the Government of Canada, collaborated with provincial and territorial governments to develop the *Pan-Canadian Framework on Clean Growth and Climate Change* (PCF) in 2017. The PCF identifies the electricity sector as a key sector in Canada's transition to a low-carbon economy as the Government of Canada works with provinces and territories to:

- Invest in non-emitting and renewable energy (RE) sources for access to clean electricity;
- Increase connectivity in transmission lines between provinces and territories to share clean electricity;
- Modernize the power system through demonstration and deployment of smart grid technologies to better integrate RE and energy storage while expanding RE capacity; and
- Reduce reliance on diesel by engaging Indigenous Peoples and northern and remote communities to improve quality of life.

Canada has one of the cleanest electricity systems in the world with 80% of electricity produced by non-emitting sources. However in pursuit of a low-carbon economy, the electricity sector will have to increase grid capacity while replacing emitting generation sources with clean geration like RE. Additional grid capacity will be required for the electrification of sectors like transportation, industrial processes and buildings looking to leverage a clean electricity system to reduce their respective emissions. Furthermore, large centralized generation plants are no longer the only source of supply for the power grid as decentralized RE systems (RES) are also being deployed. The variability of RE sources like solar photovoltaics (PV) and wind requires new technologies which includes grid flexibility options, to ensure grid reliability and resiliency in the transition to a cleaner modernized grid.

By applying technologies pioneered in the digital information and telecommunication sectors, smart grid can connect electricity generation facilities and customers through real-time communication. New approaches involving digitalization will be necessary to effectively operate a modernized grid with bidirectional power flow, advanced protection and control capabilities, and tools that benefit customers. From generation, transmission and distribution, to behind the meter, digital monitoring and controls can provide added value like demand response (DR) programs where customers gain incentives for adjusting their consumption based on grid needs. This technology is key to enable RESs to reduce GHG emissions in the electricity sector, and establish a smarter grid.

SMART GRID DRIVERS AND TECHNOLOGY

Smart Grid Drivers and Technology

The traditional grid is evolving as new technology is adopted to upgrade infrastructure, reduce operation costs, emit less GHG and meet increased demands. To accommodate this new grid technology, research, development, demonstration and deployment (RDD&D) efforts are necessary to ensure grid reliability. Cleaner generation sources like wind or solar are variable by nature and new grid technology must be seamlessly integrated to maintain customer grid service. More distributed generation (DG), variable renewable energy (RE), and other distributed energy resources (DERs) with information communication technology (ICT) are coming online as the resources required to build a smart grid.

Variable RE deployment in Canada is rapidly growing. The total installed wind capacity has surpassed 12.7 GW in 2018 [1], where approximately 1 GW of this capacity is interconnected to the distribution system (assuming that 20 MW projects and less are distribution connected) [2]; and solar PV has surpassed 2.6 GW [3] grid-connected capacity, out of which almost 2.3 GW is distribution connected largely as a result of solar PV installations in Ontario [4].

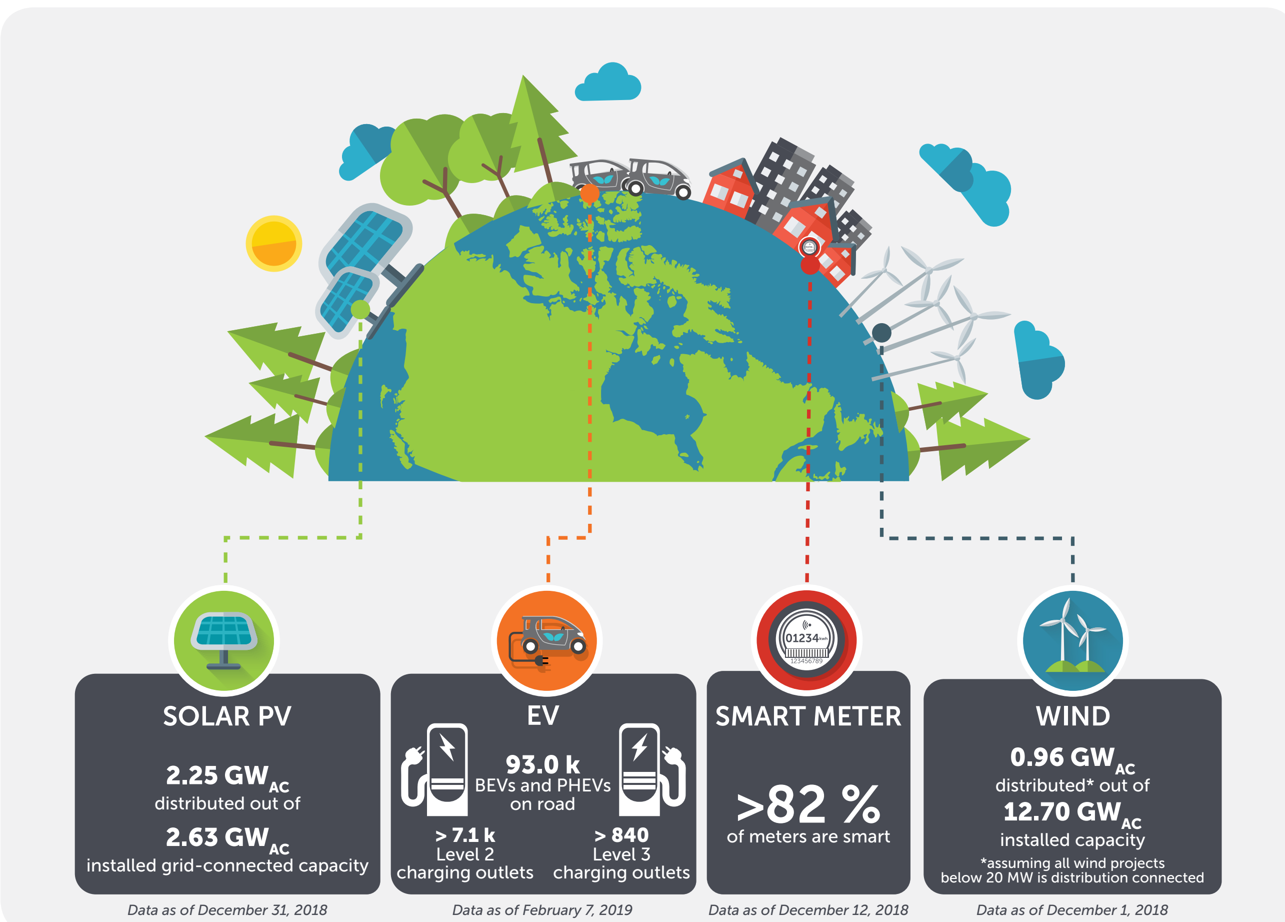


Figure 2: Select smart grid deployment metrics for Canada in 2018

DERs are a way to effectively use RE generation and support grid services like peak-shaving, voltage control and congestion management. In addition to traditional energy storage technologies like pumped hydro plants and batteries, DERs are also comprised of DG and controllable loads. Controllable loads include systems managing space heating loads (e.g. HVAC, smart thermostats) or water heating loads (e.g. electric water heaters), have the potential to provide the grid with added flexibility. The flexibility potential in residential space and water is estimated to be 39 GW/85 GWh in Canada, and is only a fraction of the controllable load potential across various sectors [5]. Additional controllable load potential exists in other sectors like industrial processes, commercial buildings and electrified transportation.

Electric vehicles (EVs) are seen as a potential mobile grid resource with controllable load characteristics. With access to a clean grid, EVs can be the transportation sector's means of reducing GHG emissions.

More Canadians have been purchasing EVs in the last few years [6] with over 87,000 Battery and Plug-in Hybrid EVs (BEV and PHEV respectively) that require fuel from the power grid. There are more than 850 Level-3 public EV chargers and over 5,800 Level-2 public EV chargers [7] which can draw a maximum of 150 kW [8] and 19.2 kW per charger respectively [9].

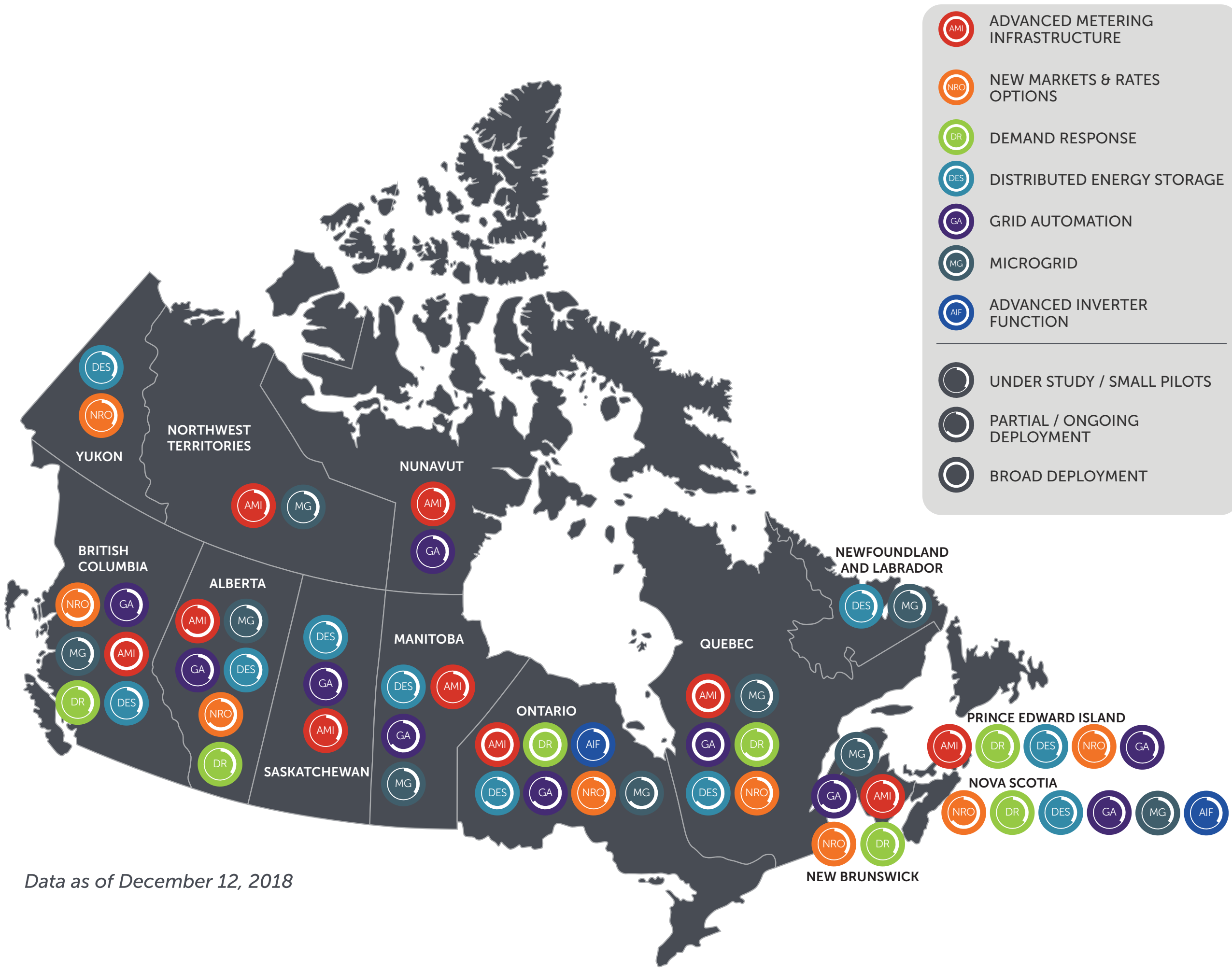


Figure 3: Deployment levels of different smart grid applications across Canada

Given that over 82% of meters in Canada are classified as smart meters, there is an opportunity for utilities to more actively interact with customers to better assess and manage potential load flexibility on the grid. Smart meters can be used as a gateway for information exchange with the customer to support customer tools and utility operations, such as establishing incentives to support their grid operation strategies.

Figure 3 shows the levels of various smart grid applications deployed across Canada. The level of deployment of each application is indicated by the inner circle: a 1/3 circle indicates under study or small pilots, a 2/3 circle indicates partial or ongoing deployments and a full circle indicates broad deployment. Provinces and territories are assessed based on publicly available information and input from provincial and territorial government representatives on CSGAN. Note that for Ontario, a deregulated market and time-of-use (ToU) rate structure has been deployed for many years hence the infographic is tracking new pilots testing different price structures. For definitions on the seven highlighted smart grid applications, see Appendix: Smart Grid Applications operations, such as establishing incentives to support their grid operation strategies.

PUBLIC SECTOR ACTIVITIES

Public Sector Activities

The public sector supports RD&D to better understand technical and non-technical barriers for broader smart grid deployments. Transitioning from technical demonstrations to market pilots allows for real-world experiences to address concerns like commercialization, system operation, and scalability. The public sector is also supporting deployment of mature technologies to catalyze the transition to a cleaner low-carbon economy.

Figure 4 summarizes public investments announced in smart grid RDD&D projects across Canada. Each icon indicates the type of smart grid activities at least one project in the province or territory received funding. Canada has invested $261 million public dollars to fund $758 million in total project value since 2003 over 135 projects. Funding for academic networks and projects are not included, nor are the significant contributions made through the Smart Grid Fund under the Ministry of Ontario Energy, Northern Development and Mines. The vast majority of funding, about $231 million of the total publicly investments are from federal funds, whereas $30 million was invested through provincial or territorial funds.

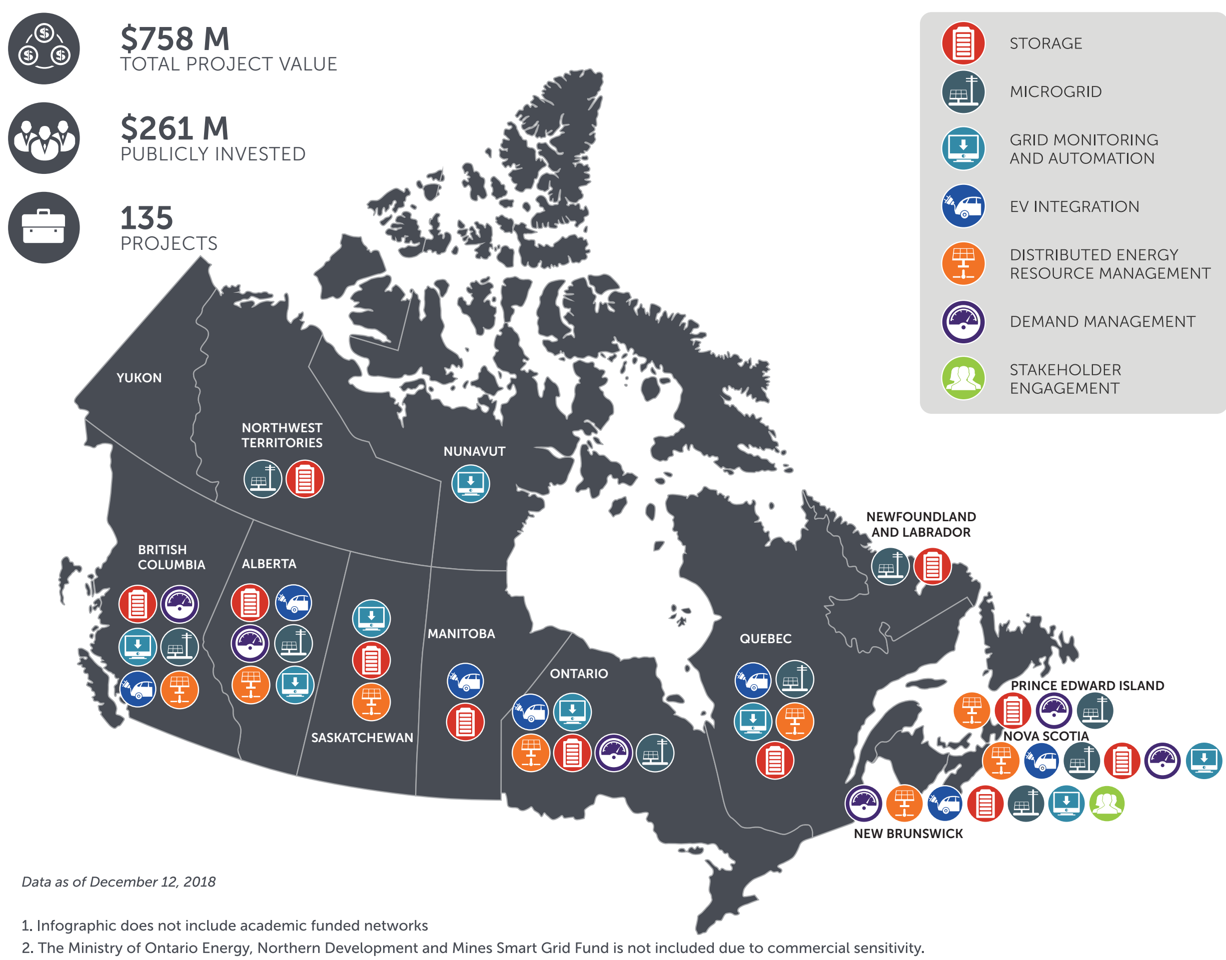


Figure 4: Public investments in smart grid RDD&D since 2003

As shown in Figure 5, a significant amount of funding has been invested related to distributed energy resource management (DERM), storage and EV integration. Stakeholder engagement received most of its total project value from public funding followed by demand management, grid monitoring and automation, and storage. Projects related to EV integration has increased almost entirely due to a federal funding envelope dedicated to EV infrastructure deployment, with Canadian companies and utilities leading these projects. Canadian companies also dominate as the lead proponent on storage projects, whereas utilities are dominating projects related to DERM and grid monitoring and automation given utility investments in grid assets. The largest investments have been made in DERM closely followed by projects related to storage. The different types of lead proponents being funded for various smart grid projects are described in Figure 6. Canadian companies are the lead proponents on the majority of publicly funded demonstration and deployment projects, closely followed by utilities. Note, utilities are classified as any organization responsible for generating, transmitting or distributing power or energy.

The smart grid is supported by various public programs as a catalyst to work towards climate change solutions. Federal, provincial and territorial governments collaborate to expand the smart grid knowledge base and support innovation by policy and diverse funding programs.

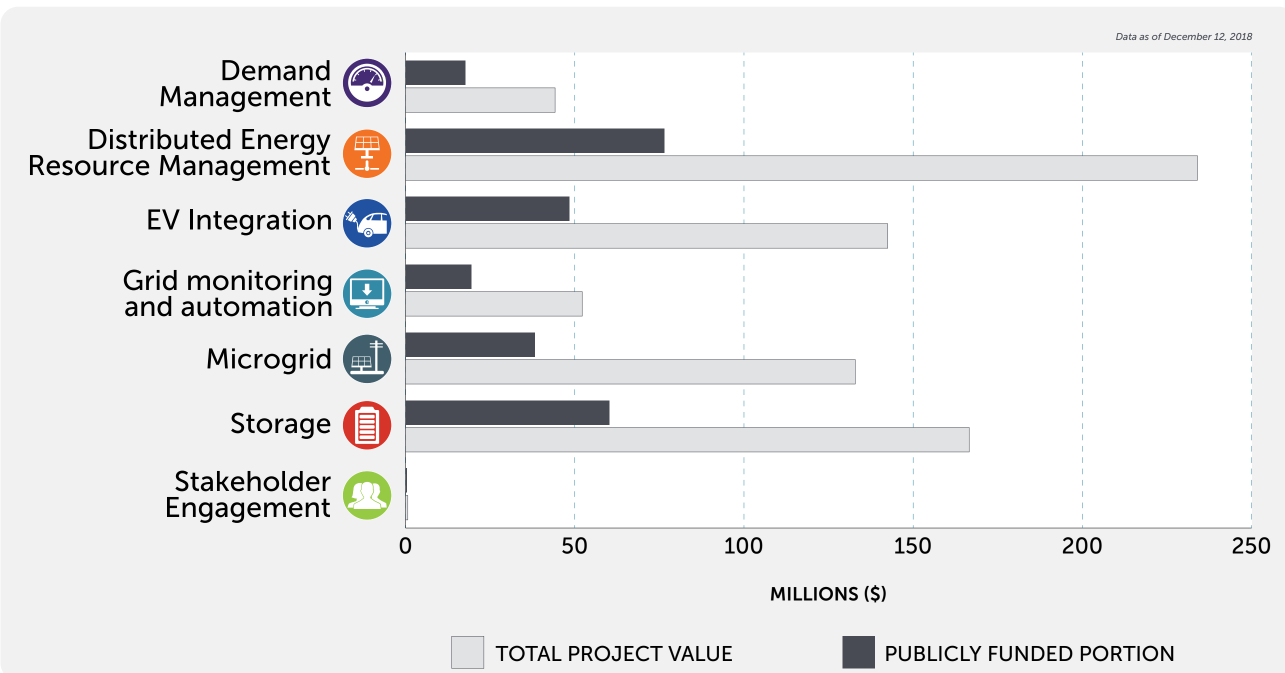
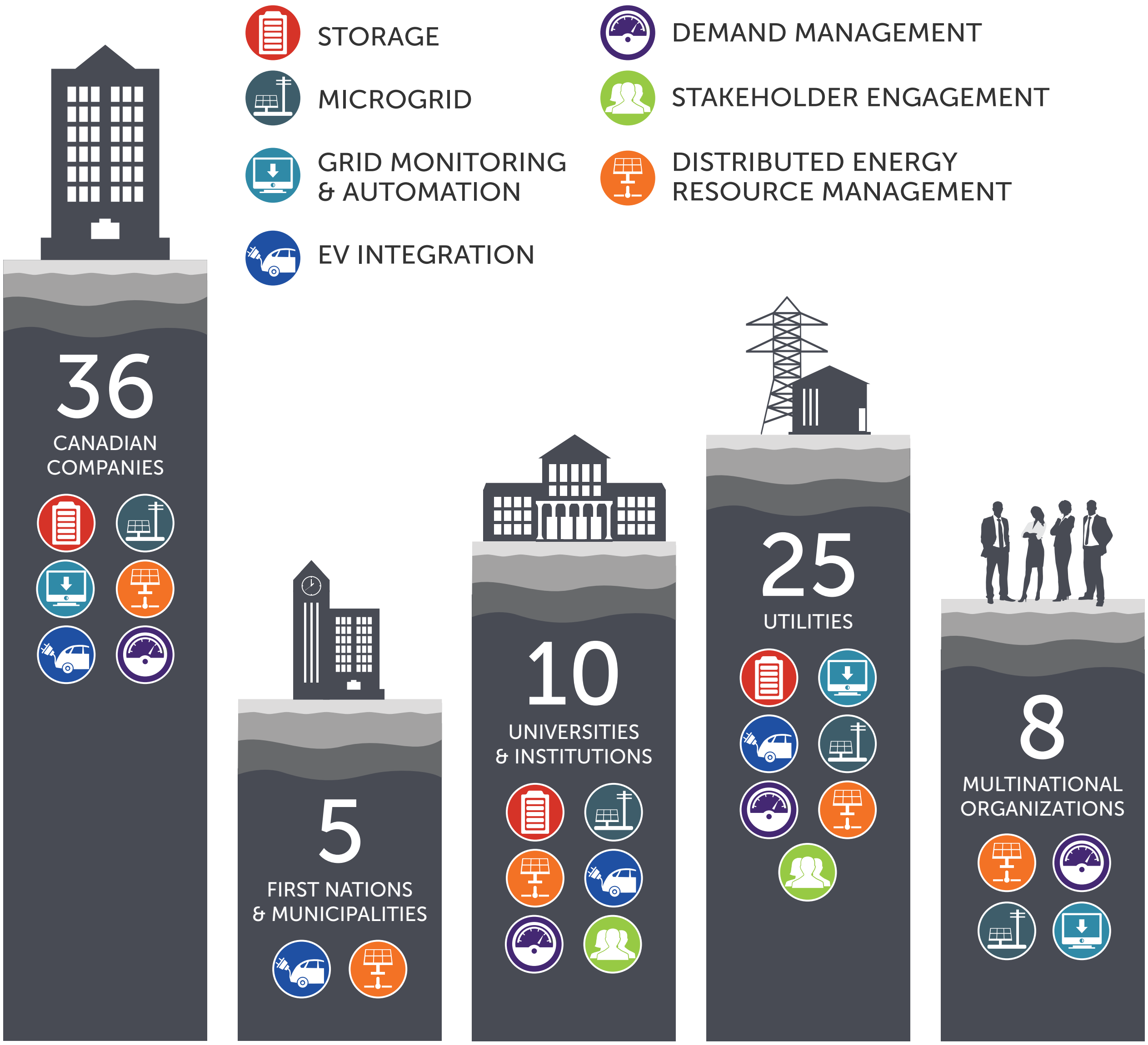


Figure 5: Publicly funded projects funding compared to total project value



Data as of December 12, 2018

1. Infographic does not include academic funded networks.
2. The Ministry of Ontario Energy, Northern Development and Mines Smart Grid Fund is not included due to commercial sensitivity.

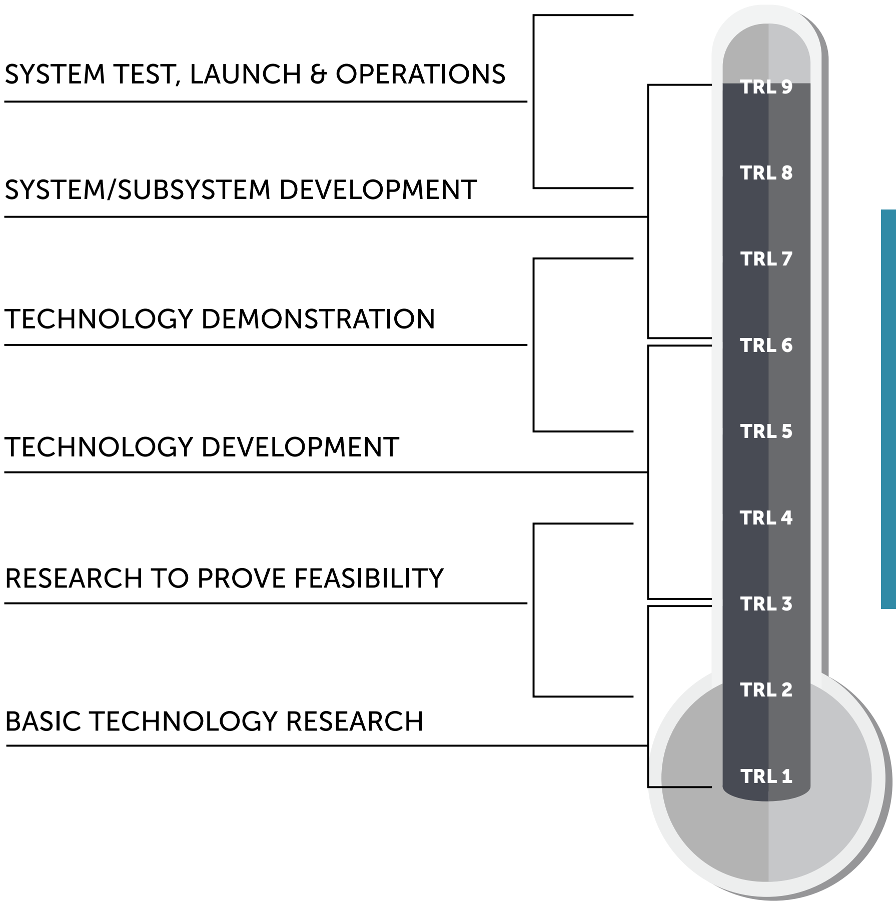
Figure 6: Lead proponents for publicly funded smart grid demonstration and deployment projects

Federal Leadership

In Budget 2017, the federal government announced more than $2.3 billion to support clean technology, Canadian firms and exports. Several programs were created that relate to smart grid directly or indirectly as a result of this announcement.

Federal Funding Programs

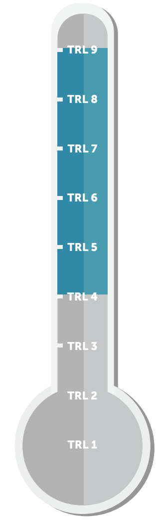
Figure 7 is a summary of recent and ongoing federal funding programs that are related to smart grid technology RDD&D in Canada, at least in part. Funding streams are open to government organizations and legal entities incorporated or registered in Canada unless otherwise indicated; internal funding indicates programs only open to government departments whereas external funding is available only to non-federal government entities. This summary does not include funding support from the Natural Sciences and Engineering Research Council (NSERC), an agency supporting academic innovative research, including smart grid related topics. Some federal programs limit the type of projects funded according to technology readiness level (TRL), as explained in Figure 7. If a program uses TRL as a metric to determine which projects are funded, this will be included in the program summary.



TRL is an indicator for technology maturity. This indicator is used by certain funds to target specific development stages. This report covers all TRL levels, since smart grid activities span all TRLs.

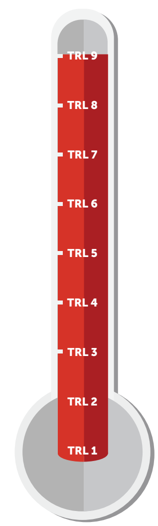
Figure 7: Technology readiness level scale

FUND		DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
FUND	ENERGY INNOVATION PROGRAM	NRCAN	ONGOING	$52.9/YEAR	CONTINUOUS INTAKE



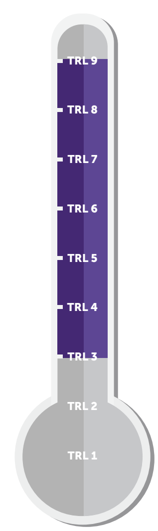
The *Energy Innovation Program* accelerates clean energy technology research and development (R&D) related to investigating renewable, smart grid and storage systems; decreasing diesel usage by industrial operators in northern and remote communities; reducing methane and volatile organic compound emissions; lowering GHG emissions in the building sector; advancing carbon capture, use and storage; and improving industrial efficiency. This program provides internal government and external funding.

FUND		DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
FUND	PROGRAM OF ENERGY RESEARCH AND DEVELOPMENT	NRCAN	ONGOING	$35/YEAR	CONTINUOUS INTAKE



The *Program of Energy Research and Development* funds internal energy R&D projects focused on building a sustainable energy future for Canada's economy and environment. This fund only supports federal departments and agencies, or outside organizations working directly with a federal department or agency.

FUND		DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
FUND	CLEAN GROWTH PROGRAM	NRCAN	2017-2021	$155	CLOSED

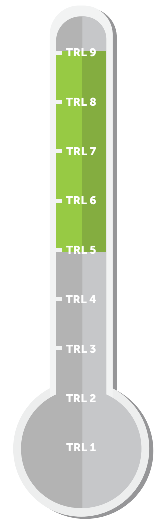


The *Clean Growth Program* supports clean technology RD&D projects in energy, mining and forestry to help Canada meet its climate change goals and create clean jobs.

FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
GREEN INFRASTRUCTURE PHASE II	NRCAN	N/A	$812	N/A

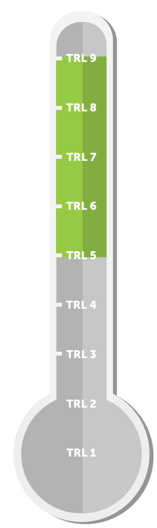
The *Green Infrastructure Phase II* (GI2) fund accelerates the deployment and market entry of next-generation clean energy infrastructure through various programs. GI2 consists of multiple programs that focus on dedicated infrastructure streams as described below. This fund is for external funding only.

FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
SMART GRIDS	NRCAN	2018-2022	$100	CLOSED



The *Smart Grid Program* under the GI2 supports the demonstration and deployment of smart grid technologies from utility-led projects to reduce GHG emissions, better utilize existing electricity assets, and foster innovation and clean jobs.

FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
ELECTRIC VEHICLE INFRASTRUCTURE DEMONSTRATIONS	NRCAN	2018-2022	$30	CLOSED



The *EV Infrastructure Demonstrations Program* under GI2 supports the demonstration of next-generation and innovative EV charging infrastructure projects.

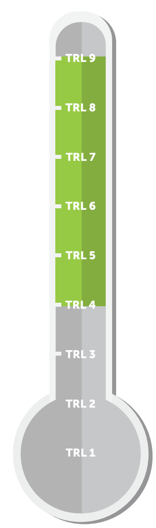
FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
ELECTRIC VEHICLE AND ALTERNATIVE FUEL INFRASTRUCTURE DEPLOYMENT INITIATIVE - PHASE 2	NRCAN	2018-2022	$80	CLOSED

The *EV and Alternative Fuel Infrastructure Deployment Initiative Program* under GI2 supports the deployment of EV Fast Chargers (Level-3) as well as Natural Gas and Hydrogen Fueling Stations.

FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
EMERGING RENEWABLE POWER	NRCAN	2018-2023	$200	CLOSED

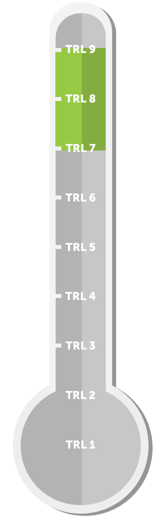
The *Emerging Renewable Power Program* under GI2 supports the deployment of offshore wind, instream tidal, geothermal, concentrated PV, and other emerging RE technologies.

FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
ENERGY EFFICIENT BUILDINGS RD&D	NRCAN	2018-2026	$182	CLOSED



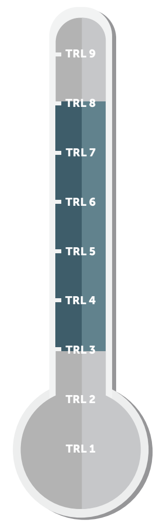
The *Energy Efficient Buildings RD&D Program* under GI2 supports the development and implementation of building codes for existing buildings and new net-zero energy-ready building initiatives.

FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
CLEAN ENERGY FOR RURAL AND REMOTE COMMUNITIES	NRCAN	2018-2024	$220	VARIABLE



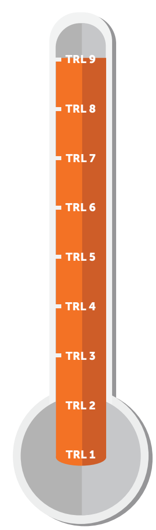
The *Clean Energy for Rural and Remote Communities Program* under GI2 aims to reduce reliance on diesel fuel in Canada's rural and remote communities and industrial sites by supporting a transition to more sustainable energy solutions.

FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
SD TECH FUND	Sustainable Development Technology Canada (SDTC)	ONGOING	$400	CONTINUOUS INTAKE



The *SD Tech Fund* supports Canadian companies with the potential to become world leaders in their efforts to develop and demonstrate new environmental technologies related to climate change, clean air, clean water and clean soil.

FUND	DEPT.	YEAR	AMOUNT (millions)	FUND STATUS
STRATEGIC INNOVATION FUND	Innovation, Science and Economic Development (ISED)	2017-2022	$1,260	VARIABLE



The *Strategic Innovation Fund* supports various types of innovation projects through four different streams across all of Canada's industrial and technology sectors.

Clean Growth Hub

The Clean Growth Hub is a federal government resource supporting companies and projects, coordinating programs and tracking results in the cleantech sector. This team of experts helps firms of all sizes and stages of development to better understand government programs and services.

Export Development Canada

Export Development Canada (EDC) helps Canadian cleantech companies expand to global markets by providing financing, risk protection, and market knowledge. EDC's global clients value Canada's experiences leveraging smart grid technologies including smart meter deployment, robust grids, and off-grid and grid-tied microgrids. EDC is committed to supporting commercialization and trade of Canadian solutions that enable clean energy, resource efficiency and clean water.

Generation Energy

In 2017, the Government of Canada launched *Generation Energy,* a nationwide open and inclusive dialogue lasting 6 months, to exchange ideas on what a low-carbon energy future would look like for the next generation of Canadians. This initiative convened more than 380,000 Canadians including subject experts, Indigenous and community leaders. A report was released in June 2018 outlining the energy future Canadians envisioned. Despite diverse stakeholders, there was consensus on access to affordable, reliable and clean energy. The report's findings included four complimentary pathways to transition to the depicted future: energy efficiency, clean power, renewable fuels and cleaner oil and gas.

Between 2012 and 2017, EDC worked with 190 cleantech companies to facilitate $5 billion in export sales.

Regional Electricity Cooperation and Strategic Infrastructure

As part of Green Infrastructure Phase I, Budget 2016 allocated $2.5 million for Natural Resources Canada to advance regional electricity cooperation. The *Regional Electricity Cooperation and Strategic Infrastructure Initiative* (RECSI) funded studies and dialogues to identify critical electricity infrastructure projects with the potential to achieve significant GHG reductions.

Two regional dialogues and studies were conducted in Western and Atlantic Canada—Western Canada; included Alberta, British Columbia, Manitoba, Northwest Territories and Saskatchewan; Atlantic Canada's included New Brunswick, Newfoundland and Labrador, Nova Scotia and Prince Edward Island. While recognizing that electricity infrastructure and market structures are different across provinces and territories, both studies came to the same conclusion that coordinated regional investment can provide a more affordable and cleaner energy mix for Canadians.

Provincial and Territorial Initiatives

Given that the provinces and territories each manage their respective electricity systems, each's approach to smart grid differs according to its assets and needs; economic development considerations and energy and environmental policy drivers. Smart grid activities by provincial and territorial governments are highlighted in this section.

Alberta

Alberta's *Climate Leadership Plan* adds 5,000 MW of RE to replace fossil fuels to meet the 30% RE generation by 2030 target [10]. The Alberta Electric System Operator (AESO) has been tasked with managing a competitive and transparent process for RE project bids under the Renewable Electricity Program. The first round set a record for the lowest renewable electricity pricing in Canada, with a weighted average price of ₵3.7/kWh. 600 MW was procured in the first round at the end of 2017 and is planned to be operational by the end of 2019. The projects selected in Round 1 are summarized in Table 1.

The second and third rounds of the *Renewable Electricity Program* (REP) were running concurrently with successful proponents announced in December 2018 as listed in Table 2 and Table 3 respectively. The second round of the REP displayed the Government of Alberta's commitment to encourage greater participation by Indigenous communities in the electricity sector and the development of renewable electricity by requiring a minimum 25% Indigenous equity ownership. The AESO was also tasked with designing and implementing the transition to a capacity market by 2021 [11]. Various stakeholder engagement activities are being carried out until 2019 when the first procurement begins in an effort to foster a market structure that will encourage innovation and present economic opportunities for a modernized grid [12].

The Alberta Smart Grid Consortium was established in July 2017 to accelerate smart grid demonstration and deployment initiatives in Alberta with key collaborators: Alberta Innovates; Alberta Energy; Alberta Distribution Facility Owners, consisting of ATCO, ENMAX, EPCOR, FortisAlberta, Alberta Federation of Rural Electrification Associations, and EQUS; and the cities of Lethbridge, Medicine Hat and Red Deer.

Table 1: AESO RE Procurement Round 1 Results [13].

PROPONENT	RE SOURCE	CAPACITY (MW)
EDP Renewables Canada Ltd.	Wind	248
Enel Green Power Canada, Inc.	Wind	115
Enel Green Power Canada, Inc.	Wind	30
Capital Power Corporation	Wind	202

Table 2: AESO RE Procurement Round 2 Results [14].

PROPONENT	RE SOURCE	CAPACITY (MW)
Sawridge First Nation	Wind	48
Blood-Kainai First Nation	Wind	202
Paul First Nation	Wind	113

Table 3: AESO RE Procurement Round 3 Results [14].

PROPONENT	RE SOURCE	CAPACITY (MW)
Transalta Corp.	Wind	207
Potentia Renewables Inc.	Wind	71
Potentia Renewables Inc.	Wind	122

British Columbia

The Ministry of Energy, Mines and Petroleum Resources released its *2018/19–2020/21 Service Plan* in February 2018 outlining goals, objectives, strategies and performance measures for British Columbia (BC) [15]. BC's goals include a clean, reliable and affordable energy portfolio that meets current and future needs. BC has dedicated programs to meet energy efficiency and conservation goals through BC Hydro's PowerSmart and FortisBC's rebates and programs. Additionally, its *Innovative Clean Energy (ICE) Fund* is funded through a levy on certain energy sales and is designed to support the province's clean energy and economic priorities.

Since 2008, the ICE Fund has committed more than $100M to support pre-commercial clean energy technology projects, clean EV, R&D, and energy efficiency programs.

BC is committed to reducing GHG emissions in the transportation sector. The *BC Renewable & Low Carbon Fuel Requirements Regulation* requires the average carbon intensity of transportation fuels to be reduced 10% by 2020 relative to 2010 measurements [16]. The Clean Energy Vehicle (CEV) Program launched in 2011 has provided $82 million in funding to promote the uptake of zero emission vehicles (ZEVs) [17]; this has resulted in BC having one of the highest per capita adoptions of ZEVs and one of the largest charging and hydrogen fueling networks in Canada. Further, in 2018 the BC Utility Commission (BCUC) launched an inquiry exploring the regulatory issues, cost burden and safety concerns impacting stakeholders regarding EV charging stations levying a usage fee [18].

Manitoba

Manitoba released its *Climate and Green Plan* in 2017, a strategic framework to address approaches to sustainable development in a comprehensive way [19]. With over 99% of electricity generated from clean, renewable sources, the framework on clean energy under the climate pillar puts an emphasis on:

- demand-side management through Efficiency Manitoba, an agency with the mandate to reduce energy consumption and save money on electricity bills;
- Investigation into a clean heating program given the large heating loads;
- Electrification of public transit;
- Community Energy Plans, a tool for municipalities to help their communities achieve deeper efficiency improvements across all sectors;
- Replacing diesel generation in off-grid communities;
- Energy-efficient home and buildings;
- Supporting investments in cleantech; and
- Low Carbon Government, that consider exploring electric vehicle charging infrastructure at government-owned buildings and increasing zero-emission vehicles in the government fleet.

The Energy Opportunities Office created a $30 million Manitoba Energy Jobs Fund to develop innovative local energy companies and appeal to international companies to establish operations in the province [20].

Manitoba Hydro has a *Grid Modernization Program* with projects focused on:

- Increasing network visibility and access to system data with the necessary communication infrastructure along lines and at substations;
- Building a resilient system by installing smart devices to improve distribution infrastructure utilization, and support customer and utility innovation;
- Developing business intelligence and related systems to leverage big data for improved financial and operational decisions, in addition to further interactions with customers during outages; and
- Designing and implementing a distribution control centre to enable a modernized grid.

New Brunswick

The Government of New Brunswick released the New Brunswick *Climate Change Action Plan* in 2016 with commitments to reduce GHG emissions [21]. The plan expands on energy efficiency and clean energy programs, investing in new technologies and making the government carbon-neutral by 2030.

New Brunswick Power (NBP) submitted a plan in 2017 to deploy smart meters for all residential and commercial customers which was subsequently rejected by the regulator in summer 2018 due to its view that it lacked a positive business case [22]. Given that advanced metering is essential to achieving the goals of the Energy Smart program, NB Power intends to resubmit its application to deploy smart meters with a more nuanced and complete business case which shows a positive return for rate payers.

Energy Smart NB evolved from a project where NBP engaged Siemens Canada to modernize New Brunswick's energy infrastructure for capital and fuel cost savings in addition to lowering GHG emissions. Energy Smart NB has a goal of saving New Brunswick approximately 600 MW and 2 TWh by 2038 using their three pronged approach:

- Smart grid investments in digitization of the power system;
- Smart habits including energy efficiency and DR programs; and
- Smart products to improve the lives of customers.

Newfoundland and Labrador

Newfoundland and Labrador is developing a new *Climate Change Action Plan* and a *RE plan* focused on further positioning the province as an energy hub and creating RE employment opportunities [23]. Newfoundland and Labrador is also working towards diverse distributed energy distribution, prioritizing communities isolated from the primary power grid [24]. In addition to energy efficiency and reduced electricity bills, Newfoundland and Labrador Hydro and Newfoundland Power have offered a net metering program since July 2017 in an effort to support a clean environment [25]. The net metering program allows RE projects up to a maximum of 100 kW and sized smaller than a customer's load to be connected to the grid. This program is accepting up to 5 MW of generation across the province.

Nova Scotia

Nova Scotia released its *Electricity Plan 2015–2040* summarizing public and stakeholder consultations on the transformation of the power grid for short and long-term plans [26]. The report highlights the following 4 themes:

- Stable electricity prices;
- Importance of innovation, as demonstrated by the Department of Energy and Mines has demonstrated by collaborating with Innovacorp, an early-stage venture capital organization, to create the Smart Energy Innovation program to award $700 k as part of the province's *Electricity Plan*;
- Accountability from the vertically integrated regulated utility Nova Scotia Power; and
- Competitive market like the renewables to retail market created where independent RE producers are able to sell to retail customers [27].

Nova Scotia Power has received approval from the Nova Scotia Utility and Review Board for a $133 million smart meter roll out in June 2018 with deployments starting in early 2019 and expected to be completed by late 2020 [28].

Smart grid solutions are explored through several pilots in the province related to storage and microgrids to ensure a goal of 40% RE generation by 2020 is achieved. Additional pilot programs being developed include the *SolarHomes* program and the *Solar Electricity for Community Buildings Pilot Program* to encourage solar in Nova Scotia Communities [29].

Northwest Territories

The Northwest Territories released its *2030 Energy Strategy* to outline a long-term approach for secure, affordable and sustainable energy [30]. Extensive public consultations with communities, businesses, Indigenous governments and other stakeholders identified the need to address climate change, energy affordability and develop the energy potential in Northwest Territories. The *2030 Energy Strategy* highlights 6 strategic objectives which will be re-evaluated every 5 years:

- Find solutions through community engagement, participation and empowerment;
- Reduce GHG emissions from electricity generation in diesel-powered communities by an average of 25%;
- Reduce GHG emissions from road vehicles by 10% per capita;
- Increase the share of RE used for space heating to 40%;
- Increase residential, commercial and government building energy efficiency by 15%; and
- Develop energy potential, address industrial emissions, and strive to meet national climate change objectives.

The *2018–2021 Action Plan* details all the actions and initiatives planned in the short-term to achieve each strategic objective [31]. Annual reports will be released publicly to track progress in achieving the outlined objectives.

Nunavut

Nunavut's only electrical power provider, Qulliq Energy Corporation (QEC), uses imported fossil fuel to meet demand. QEC launched a net metering program in April 2018 to allow customers to install up to 10 kW of generating capacity with any surplus sent back to the grid for bill credits. Solar panels supplied RE to the Iqaluit Grid for the first time in March 2016 as part of a pilot project; this demonstration project with a capacity of 2.86 kW seems promising from a performance point of view [32].

A feasibility study was completed in 2016 by QEC to assess the wind potential in 25 different communities. The report concluded that certain communities have potential for wind power generation that could displace or reduce fossil fuel requirements for power generation [33].

QEC also installed Advance Metering Infrastructure (AMI) in Iqaluit and replaced all conventional customer meters with smart meters. Through implementing AMI, QEC has the capability to pull consumption data for automated billing. QEC is looking for more opportunities to roll out AMI in other communities.

Ontario

Ontario released *A Made-in-Ontario Environment Plan* in 2018 to ensure a healthy environment and economy for future generations [34]. The guiding principles of this plan are centred on clear rules and strong enforcement, trust and transparency, as well as resilient communities and local solutions. One of the calls of action to address climate change is to increase access to clean and affordable energy through efforts like:

- Connecting Indigenous communities in Northern Ontario to clean electricity;

- Increasing the renewable content requirements in gasoline through the Greener Gasoline regulation;

- Encouraging community-based systems like district energy where appropriate, and heat pumps for space and water heating;

- Requiring a voluntary renewable natural gas option for customers;

- Investigating tax policies that could make it cost effective for homeowners to invest in energy efficiency measures;

- Integrating smart grid technologies and DERs; and

- Accelerating adoption of low-carbon vehicles by removing regulatory barriers.

Ontario and its partners have invested approximately \$200 million through the *Smart Grid Fund* into 45 grid modernization projects to develop innovative solutions empowering the customers and further increasing the reliability of the system. Projects were funded in various categories including proactive customers, data analytics, EV integration, energy storage, grid automation, microgrids and building local capacity.

The wholesale competitive electricity market structure in Ontario is largely unchanged since it opened in 2002 [35]. The Independent Electricity System Operator (IESO) has undertaken the *Market Renewal* project in 2016 to restructure the electricity market to meet future system needs while reducing cost. Four initiatives are supported through this project to efficiently meet Ontario's current and future needs:

- Single Schedule Market: align market price with dispatch schedules to ensure economic benefits align with grid benefits and simplify dispatching necessary resources to maintain grid stability [36].

- Enhanced Real-Time Unit Commitment: optimize generator commitments based on larger time duration rather than on a per hour basis and account for all implicated resource costs to make a commitment decision [37].

- Day-Ahead Market: enable certainty for market participants committing dispatchable resources in terms of price and production commitments, real-time operation conditions, and cost-effective decisions for the overall system [38].

- Incremental Capacity Auction: gain access to increments of capacity in a competitive market that will ensure system reliability at low-cost with the added benefit of having the ability to adjust for dynamic supply and demand conditions [39].

The IESO historically procured new supply, including energy storage and other clean energy generation, to meet Ontario's energy needs through various programs. The *Feed-in Tariff (FIT) Program* (for projects 10 kW to 500 kW inclusively) and the *microFIT Program* (for projects less than 10 kW) allowed Ontario to grow RE capacity with the majority of contracts awarded to solar PV projects. Before the final *FIT* 5 call, the *Large Renewable Procurement (LRP) Program* was launched to procure RE projects greater than 500 kW in a competitive bidding process. The *LRP1* process ended in April 2016 resulting in 16 contracts being awarded for 454.9 MWAC RE capacity [40]. Table 4 summarizes the contracts awarded for *FIT* programs 1–5, *microFIT* and *LRP*. The *FIT*, *microFIT* and *LRP* programs have all been completed; the final *FIT* application period was in 2016, *microFIT* reached its procurement target by the end of 2017, and the second round of *LRP* (*LRP2*) was suspended during the Request for Qualifications stage in 2016.

Energy storage capabilities were evaluated through the *Grid Energy Storage Procurement*

Phase 1 contracts with approximately 34 MW procured, and *Phase 2* awarded 10-year contracts in November 2015 for an additional 16.8 MW of energy storage [41]. The facilities under the *Grid Energy Storage Procurement Phase 1* in service as of November 2018 are summarized in Table 5, and contracts awarded under Phase 2 are summarized in Table 6.

Table 4: Summary of IESO RE Project Contracts by Program Stream as of September 2018 [42].

			SOLAR PV		WIND	
PROGRAM	NUMBER OF FIT CONTRACTS	TOTAL CAPACITY CONTRACTED [MW]	NUMBER OF CONTRACTS	TOTAL RATED POWER [MW]	NUMBER OF CONTRACTS	TOTAL RATED POWER [MW]
FIT 1 to FIT 5	4070	4792	3906	1797	55	2831
microFIT	29,669	257	29,665	257	4	0.02
LRP	16	455	7	140	5	300

Table 5: IESO Energy Storage Procurement Phase 1 Facilities in service as of November 2018 [43].

ANCILLARY SERVICE PROVIDER	TECHNOLOGY	POWER CAPACITY (MW)	ANCILLARY SERVICE TYPE
Guelph Energy Storage Lp	Flywheel	5	Regulation Service
Sault Ste Marie Energy Storage Lp	Battery—Solid	7	Reactive Support and Voltage Control
Hydrogenics Corporation	Hydrogen (Power-to-Gas)	2.5	Regulation Service
Powin Energy Ontario Storage Ii Lp	Battery—Solid	2	Reactive Support and Voltage Control
Powin Energy Ontario Storage Ii Lp	Battery—Solid	2.4	Reactive Support and Voltage Control
Powin Energy Ontario Storage Ii Lp	Battery—Solid	2	Reactive Support and Voltage Control
Powin Energy Ontario Storage Ii Lp	Battery—Solid	2.4	Reactive Support and Voltage Control
Hecate Energy Ontario Storage Vii Lp	Battery—Solid	2	Reactive Support and Voltage Control

Table 6: IESO Energy Storage Procurement Phase 2 Contracts as of January 2019 [43].

PROPONENT	TECHNOLOGY	CAPACITY (MW)
Ameresco Canada Inc.	Battery—Solid	2.0
Ameresco Canada Inc.	Battery—Solid	2.0
SunEdison Canada Origination LP	Battery—Flow	2.0
SunEdison Canada Origination LP	Battery—Flow	1.0
SunEdison Canada Origination LP	Battery—Flow	2.0
NextEra Canada Development & Acquisitions, Inc.	Battery—Solid	2.0
NextEra Canada Development & Acquisitions, Inc.	Battery—Solid	2.0
NRStor Inc.	Compressed Air	1.75
Baseload Power Corp.	Battery—Flow	2.0

The Ontario Energy Board (OEB) established the R*egulated Price Plan* (RPP) in 2005 to provide low-volume electricity customers stable predictable electricity prices [44]. Today, almost all RPP-eligible customers have smart meters and over 96% pay under the ToU electricity rate structure [45]. In 2015, the OEB released their *RPP Roadmap* which lays out a plan for a comprehensive review of the *RPP*, including working with electricity utilities across the province to pilot different ToU rate structures. The pilots are targeting approximately 18,000 customers to test the impact of both price and non-price mechanisms on customer behaviour, including additional tools for customers to better understand and manage their electricity consumption. These pilots will help inform future OEB decisions on offering customers a choice between different electricity rate structures with a view to improve system efficiency [46].

The Electricity Distributors Association (EDA) is the voice of Ontario's local electricity distribution companies—the municipally and privately owned utilities that deliver safe, reliable power to more than five million homes, businesses and institutions across the province. *The Power to Connect* series of EDA policy papers outlines a bold vision for the transformation of Ontario's electricity grid. The papers identify challenges and provide high-level solutions to ensure a resilient, reliable electricity system that meets evolving customer demands now and well into the future.

Prince Edward Island

The Government of Prince Edward Island released its *Energy Strategy 2016/2017* with stakeholder and public input. The *Energy Strategy* assesses the province's current energy usage and streamlines a vision for the future highlighting three guiding principles [47]:

- Lowering greenhouse gases;
- Implementing cost effective actions and decisions; and
- Increasing local economic development.

A grid modernization study was completed by Power Advisory LLC to find methods that would reduce system peak, shift energy consumption with cost savings or emission reductions, increase distributed generation and further increase wind integration. This document will be used to guide Government policies on electricity rate structures and related infrastructure which can enable the future smart grid.

The first *Demand Side Management Plan* was filed with the Island Regulatory and Appeals Commission in June 2018 [48]. PEI Energy Corporation in partnership with efficiency PEI put forth a plan that addresses efficiency and conservation as a preliminary stage before using advanced metering infrastructure for programs like DR.

Quebec

Quebec released its *Energy Plan 2030* in 2016 with a particular focus on economic and environmental benefits for all customers [49]. One of the plan's targets is to increase RE generation by 25%.

The key policy directions highlighted are:

- Ensure integrated governance of the energy transition;
- Promote transition to a low-carbon economy;
- Offer a renewed, diversified energy supply to customers; and
- Define a new approach to fossil energies.

Transition Énergétique Québec (TEQ) was created as an initiative outlined by the Energy Policy 2030 for a public corporation to ensure a smooth transition to meet energy targets set by the Government of Quebec. Plans are created every 5 years with input from partners to ensure measures are in place to meet government targets. The first plan, *2018–2023 Master Plan,* was released as a short-term plan for energy transition, innovation and efficiency to meet 2030 targets.

TEQ and SDTC collaborated on the TechnoClimat Program to support energy innovation and GHG emission reduction for technology in pre-commercial phases in Quebec.

Hydro-Québec submitted a request to regulators to gradually introduce dynamic pricing options on a voluntary basis for summer 2019 [50]. Increased pricing during morning and evening peak hours would provide an incentive for customers to reduce or shift consumption to off-peak hours when the system is less constrained.

Quebec plans to create a DC fast charging network where revenue generated will be used to further expand the network which is seen as a critical element to facilitate the rapid EV uptake [51]. Workplaces are also incentivized through the charging station at work program (i.e. *Roulez vert-volet branché au travail*) that provides funds to procure and install EV charging infrastructure at Level-1 and/or Level-2 [52].

As of January 2018, Quebec became the first province in Canada to adopt a ZEV standard [53]. Credits are accumulated by each automaker dependent on the number of ZEVs and Light Emission Vehicle (LEVs) sold or leased, and their respective range in electric mode. A percentage is calculated based on the number of credits and the total number of new cars sold or leased in the province.

Manufacturers are required to sell or lease an increasing percentage of ZEV and LEV motor vehicles in the Quebec market per year. Bonus credits will also be given for sales and leases from 2014 until 2017 to give automakers some flexibility to meet future targets.

Saskatchewan

SaskPower, the principal electric utility in Saskatchewan, is expanding their commercial and industrial (C&I) AMI through the second phase of the smart meter pilot project [54]. The second phase adds 7500 smart meters, resulting in about 15% of C&I customers in Saskatchewan with smart meters by the end of 2018, and further C&I deployment proposed for upcoming years. Deployed smart meters will support better customer insights into their consumption, eliminate billing estimates, as well as extend operational visibility into the grid.

SaskPower is preparing for a 2019 launch of their outage management system and distribution supervisory control and data acquisition (SCADA) system, which are part of their integrated advanced distribution management system. SaskPower has been deploying intelligent switching and metering at substations, with the objective of integrating 200 substations and all C&I meters into the advance distribution management system by 2020.

SaskPower has announced a new *Power Generation Partner Program* which supports the development of new small renewable ranging from 100 kW to 1 MW and new carbon neutral non-RE projects throughout Saskatchewan. An existing net metering program also allows for up to 100 kW installations to offset customer consumption. The first of two 10 MW utility-scale solar projects is expected to be in service as early as 2019 with a total commitment of 60 MW of solar power by 2021 [55].

In early 2016, Manitoba Hydro and SaskPower signed a 20-year 100 MW power sales agreement which could lead to annual reductions of approximately 0.2 to 0.4 Mtonnes of carbon dioxide displaced from Saskatchewan's electricity emissions [56].

Yukon

Yukon is developing an integrated strategy on climate change, energy and economy through various stakeholder collaborations and engagements [57]. Current policies in place include the *Independent Power Production Policy Implementation* supporting the uptake of RE generation. The Micro-generation Program also enables RESs to be connected to the grid and provides customers with incentives to diversify Yukon's energy supply. The *Innovative Renewable Energy Initiative* is a $1.5 million fund to support commercial-scale electrical or heat generation from RE sources like wind, solar PV and run-of-river hydro.

RESEARCH AND INNOVATION NETWORKS

Research and Innovation Networks

Research and innovation networks are exploring emerging ideas and trends. Smart grid activities backed by research and innovation networks are highlighted in this section.

Advanced Energy Centre at MaRS Discovery District

The Advanced Energy Centre (AEC) was founded in 2014 as a public-private partnership with founders from MaRS Discovery District, Ontario Ministry of Energy, and Siemens Canada. While supporting the adoption of innovative energy technologies in Canada and sharing expertise in international markets, the AEC offers a range of programming related to:

- building energy efficiency,
- utility transformation,
- community energy,
- energy data access, and
- going global services.

The AEC leverages their strong partnerships to facilitate necessary consultations contributing to the evolution of the energy industry. In March 2018, *The Future of Energy: Taking the Digital Leap* workshop gathered a diverse audience and presented a 2030 scenario where various digital technologies were integrated into society. Topics related to human behaviour, big data, AI and blockchain implementation in the energy sector were described by industry leaders and then further explored through collaborative discussions.

The Energy Innovation Snapshot was created by AEC as a platform to highlight Canadian commercially demonstrated projects and innovative companies. The intent of this online platform is to help discover and connect Canada's energy innovators.

Of 220 cleantech companies supported by MaRS Discovery District, 27 are related to smart grid.

NSERC Energy Storage Technology Network

NSERC supports and promotes post secondary research projects for the benefit of Canadians. Through various programs, NSERC has invested over $6.1 million since 2015 towards smart grid-related topics [58]. A significant part of this investment went to support the NSERC Energy Storage Technology Network (NESTNet).

Led by the Centre for Urban Energy at Ryerson University, NESTNet consists of 27 Canadian researchers from 15 universities working alongside partners and collaborators from 26 technology companies, utilities and government agencies. Since 2015, NESTNet has been developing, testing, demonstrating and commercializing next-generation energy storage technologies, products, processes and services.

NESTNet will receive a total of $5.2 million in NSERC funding and $3.5 million from partner organizations over its five-year term.

NESTNet projects are divided into four themes:

- Energy storage technologies, which focuses on batteries, flywheels, compressed air energy storage, thermal storage and hybrid energy storage models.
- Power electronics converters, which includes modular converters, digital controllers, SCADA systems, and power electronics for repurposed EV batteries.
- Power systems integration, which enables seamless integration of energy storage into power systems by developing tools, solutions and reliability benchmarks.
- Economics and policy, which investigates the techno-economic challenges of integrating of energy storage into power systems, including from policy, regulation and social acceptance issues.

Smart Grid Innovation Network

The Smart Grid Innovation Network (SGIN) is a partnership between NBP, the University of New Brunswick and Siemens Canada to enable the successful deployment of smart grid initiatives in New Brunswick and to drive and support a smart grid ecosystem for innovation, technology advancement and R&D. SGIN helps prepare products and solutions at various maturity levels for market. To date, 39 companies have received help and mentorship through the network.

INDUSTRY SUPPORT

Industry Support

Industry associations are key for gathering private companies to mutually benefit from lessons learned, future-proofing, market entry and success, and technology development required to profit from smart grid uptake. Smart grid activities backed by some key industry leaders are highlighted in this section.

Canadian Electricity Association

The Canadian Electricity Association (CEA) represents members that generate, transmit, and distribute electrical energy to customers across Canada. CEA works with its members to ensure an affordable and reliable electricity grid to all Canadians.

To address Canada's energy transition to clean renewable electricity, CEA supports development in integrated clean energy solutions including smart grid solutions. Improvements to existing technology while encouraging new innovation is critical to achieving grid modernization.

CEA has been advocating five key recommendations to continue this vision:

- Design and implement a national energy strategy;
- Implement the financial and policy instruments that enable further carbon reduction;
- Incentivize the electrification of vehicles, industry and commercial buildings;
- Build, support and invest in a deeply embedded culture of innovation; and
- Enhance Canadian businesses competitiveness in the face of increasing nationalistic policies.
- Centre for Energy Advancement through Technological Innovation

According to CEA experts, approximately 20% of the $350 billion required for electricity infrastructure investments between 2011 and 2030 will be invested in smart grid technologies [59].

Centre for Energy Advancement through Technological Innovation

The Centre for Energy Advancement through Technological Innovation (CEATI) gathers utility companies, government agencies, and technical experts across the world to collaborate on power system programs related to generation, transmission, distribution, and utilization. Within each of its 22 distinct Interest Groups, CEATI facilitates knowledge exchange through various programmatic activities, most notably technical projects, in-person meetings, workshops and conferences, including the annual *Smart Grid Conference*. CEATI's Smart Grid portfolio comprises 7 Interest Groups that cover different components of a smart grid:

- Distribution automation, and network components and architecture;
- Emerging technologies and DER integration;
- Distribution planning, reliability and asset lifecycle management;
- Power quality and advanced technologies;
- Protection and control technologies and solutions;
- Cyber and physical security related to people, property, and processes; and
- Demand-side energy management programs and technologies.

SmartGrid Canada

SmartGrid Canada is an industry association dedicated to advancing smart grid for the benefit of Canadians. The association brings together electric utilities along with other smart grid stakeholders to discuss lessons learned, shared experiences, and current trends on grid modernization technology and utility transformation.

Annual conferences are hosted to bring together industry leaders to discuss the business implications of integrating energy storage, distributed energy resources, electric vehicles and other modernization initiatives into the grid. As the smart grid has matured, the conference has broadened to discuss topics of utility-city collaboration and the cyber security implications of a more connected grid.

SmartGrid Canada has conducted broad research on Canadians' attitude towards smart grid since 2012. Two thousand Canadians were surveyed about their opinion of their electric utility provider, thoughts on different pricing structures, intentions about solar energy and electric vehicles investments, and incentives necessary to leverage their behind-the-meter resources for grid flexibility. The survey provides a useful reference for monitoring the evolution of customer perceptions of the smart grid in Canada.

INTERNATIONAL COLLABORATIONS

International Collaborations

Canada is well positioned through various international engagements to exchange technical and policy insights related to RE integration efforts leveraging smart grid technologies. As the host of the 10th Clean Energy Ministerial (CEM) meeting in May 2019, ministers and high-level government delegates will be welcomed from over 25 countries to advance towards a clean energy future. Canada will be taking the time during this event to highlight the leadership of women, Indigenous peoples and youth efforts.

IEA International Smart Grid Action Network TCP

ISGAN is the common name for the International Energy Agency (IEA) Technology Collaboration Programme (TCP), a cooperative program on smart grids. ISGAN is an international strategic platform for the development and exchange of knowledge and expertise to support high-level government attention and action for the accelerated development and deployment of smarter, cleaner, flexible and resilient power grids around the world. It provides a valuable channel for communication of experience, lessons learned and visions on key aspects of smart grid policy, technology and investment.

Currently, 25 executive committee members report on progress and projects to the CEM, in addition to satisfying all IEA Implementing Agreement reporting requirements. As a founding member, Canada continues to actively participate in the network's activities. The work within ISGAN is organized into eight standing working annexes which consist of national experts from participating Contracting Parties, and Canada is an active member on Annex 2, 4, 5 and 6.

- Annex 1 on *Inventory* is completed and gathered information on various smart grid activities of member countries to better delineate and transition the work program of ISGAN.
- Annex 2 on *Case Studies* has currently two priority work streams: an assessment of current case studies on smart grid deployments and in-depth peer-to-peer knowledge sharing through workshops held in conjunction with Annex 4.
- Annex 3 on *Cost-Benefits* analyzes the benefits and costs of smart grid technologies, practices and systems in order to inform policymakers at global, regional, national and sub-national levels.
- Annex 4 on *Policy Insights* collects data, identifies key issues, distills important themes and provides insightful analysis for use by policymakers; and, consolidates and disseminates efforts of other ISGAN Annexes at times beyond ISGAN when appropriate, in support of greater reach and impact.
- Annex 5 on *Testing Labs*, also known as the Smart Grid International Research Facility (SIRFN), gives participating countries access to research facilities to test technology and share the data from these tests among SIRFN participants in pursuit of accelerating the development of smart grid technologies and systems and enabling policies.

- Annex 6 on *Power Systems* contributes to the development of smarter and stronger transmission and distribution systems, by undertaking efforts to improve understanding of smart grid technologies, accelerate their development and deployment, and promote adoption of related enabling regulatory and government policies.

- Annex 7 on *Transitions* investigates institutional changes associated with smart grid deployment. The aim is to support policymakers by focusing on non-technical aspects such as the direction, efficacy and efficiency of the energy system transition.

- Annex 8 on *ISGAN Academy* offers the ISGAN community, particularly high-level engineers and decision makers, a means of continuous professional development in the field of smart grid through a set of e-learning modules and webinars ranging on power system fundamentals to more specialized courses on breakthrough smart grid solutions.

Research laboratories from SIRFN are working to create a common testing platform to quickly and accurately assess the communications and electrical performance of DER devices for different grid codes.

Recent Canadian contributions to ISGAN include deliverables for Annex 5 and Annex 6. Under Annex 5, the paper on *International Development of a Distributed Energy Resource Test Platform for Electrical and Interoperability Certification* was presented at the *World Conference on Photovoltaic Energy Conversion* in June 2018. This paper describes the common certification platform to evaluate DER for interoperability and grid-support functionality using open-source test logic and automated test procedures. To demonstrate the use of the platform, the same testing logic from Underwriters Laboratories (UL) 1741 Supplement A were used at multiple laboratories to generate test results for specified power factor (PF) and volt-var (VV) functions. The paper presents the results from the combined efforts of 11 international labs that demonstrated the portability of the scripts and platform to function in multiple laboratory environments. Thus, the findings of this paper prove DERs are capable to support grid services in a test environment before being deployed and integrated to the power grid. Under Annex 6, Canada contributed to the paper on *Flexibility Needs in the Future Power System* discussed the flexibility potential in residential loads within a Canadian context. The paper explains how advanced load management techniques can leverage smart flexible residential loads as an inexpensive means to provide grid services, support the integration of RE and meet future load growth.

Mission Innovation—Innovation Challenge #1

Launched in 2015 on the margins of the United Nations Climate Conference in Paris (COP21), MI is a global partnership of 23 countries and the European Union aimed at doubling government investment in clean energy R&D over five years, while encouraging greater levels of private sector investment in transformative clean energy technologies. These additional efforts aim to dramatically accelerate the availability of the advanced technologies that will define a future global energy mix that is clean, affordable, and reliable.

MI member countries identified eight Innovation Challenges (ICs) designed to accelerate the global transition to low-carbon economies; MI-IC1 is on smart grid. Co-led by Italy, India and China, Canada along with 16 other participating countries in addition to the European Union are facilitating the uptake of cost effective RE by advancing the development and demonstration of smart grid technologies [60].

Four main sub-challenges have been identified by participating countries: regional grid innovation, distribution grid innovation, micro grid innovation, and cross innovation. From these sub-challenges, six relevant RD&D topics have been selected and constitute the basis for the future work. Canada is co-leading Task 4, and participating in Task 1, Task 3 and Task 5. Results from these tasks will help build a shared understanding of R&D gaps and opportunities in smart grid fields internationally.

- Task 1: Improve storage integration at all-time scales (in operation for system services but also when performing planning studies as an additional degree of freedom) as a source of flexibility.
- Task 2: Use of DR for system services with well-defined interactions between with the market players and the network operators (and TSO-DSO exchange of information).
- Task 3: Develop regional electricity highways with both AC and DC technologies (e.g. long transmission systems, HVDC).
- Task 4: Identify and support improvements of suitable flexibility options (RES generation, flexible thermal power generation, load, network, storage, integration with other energy networks) to ensure adequacy and security.
- Task 5: Study and demonstrate new grid architectures both at transmission and distribution level as a source of flexibility.
- Task 6: Novel/advanced power electronics technology for improving efficiency and controllability of smart grids.

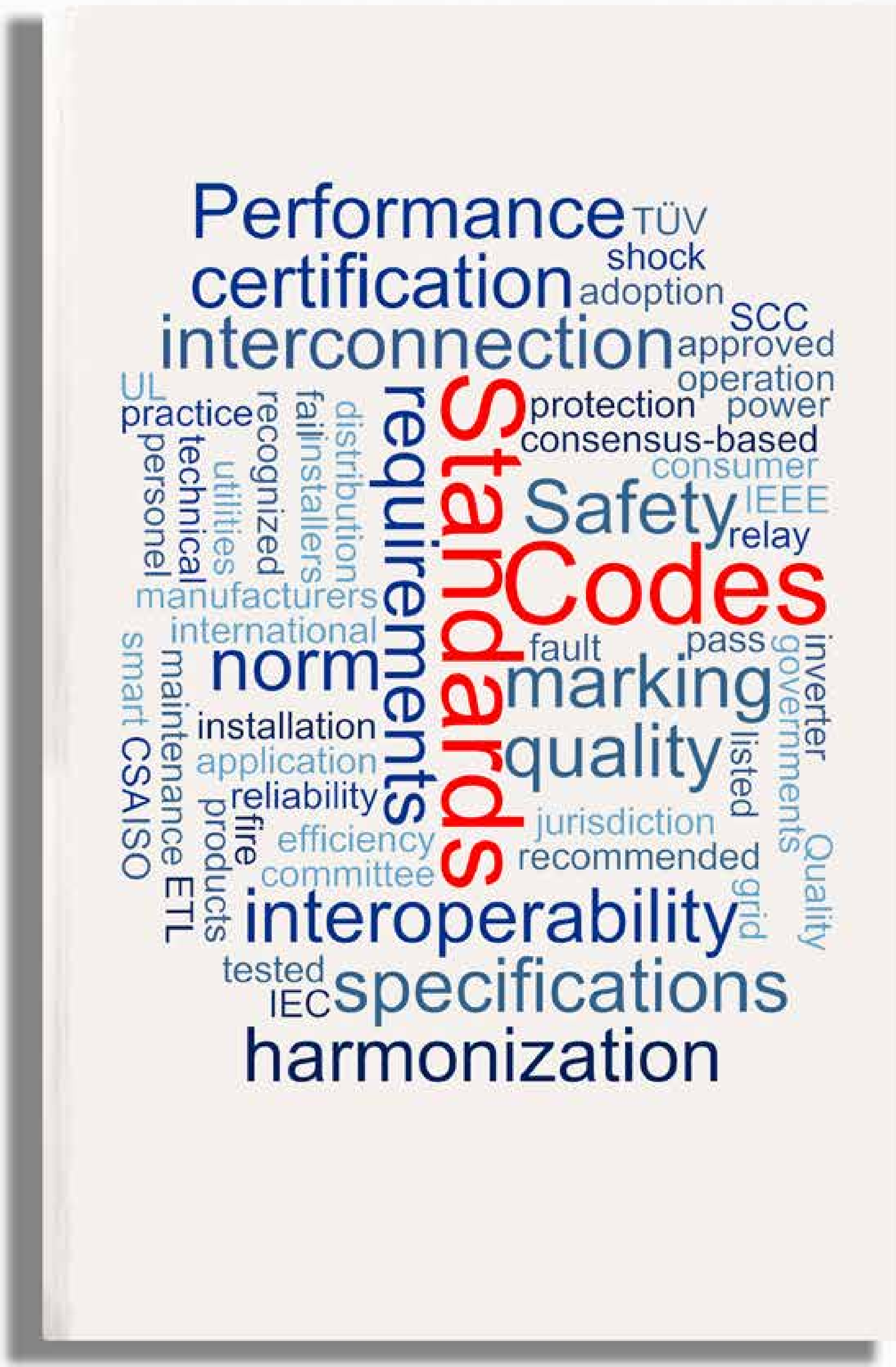
Since the MI-IC1 launch in 2016, four deep-dive workshops have taken place on different key aspects of the Challenge to discuss its ongoing strategy and shared achievements. Fourteen members contributed to the first publication of the *Smart Grids Innovation Challenge Country Report 2017* as an initial effort for annual updates about smart grid-related activities for each country.

North American Renewable Integration Study

Launched in 2016, the *North American Renewable Integration Study (NARIS)* is a collaborative effort between Natural Resources Canada, the Secretaría de Energía and the U.S. Department of Energy. It aims to inform decision makers about the opportunities of adding more RE on the North American power grid. Final results are expected for 2019. *NARIS* is expected to develop state-of-the-art methods, scenarios, and datasets that will help with investigating coordinated grid planning and operations, cross-border transmission, grid flexibility, and other strategies and technologies to enable high penetration of renewables.

Power Forward Challenge

The *Power Forward Challenge* seeks to increase collaboration between innovators from Canada and the United Kingdom to develop end-to-end solutions integrating DERs. Led by NRCan as an Impact Canada Initiative and the Department for Business, Energy and Industrial Strategy, the initiative aims to demonstrate how to integrate disruptive, modular, scalable and interoperable energy resources in a smart grid that adds value for customers and/or service providers. The challenge was launched in fall 2018 with semi-finalists to be announced in mid 2019 and the final award winning team to be announced in March 2021.



STANDARDS DEVELOPMENT

Standards Development

Standards are bringing together proven technical specifications tests, and procedures to ensure safety and performance of products and systems. Some smart grid-related standards are highlighted in this section.

Advanced Inverter Functions and Interconnection Standard

With the rapid uptake of inverter-interfaced storage and RESs, inverters can not only contribute to a balanced grid, but also provide ancillary services like grid protection in response to system disturbances and voltage and frequency support. These capabilities are outlined in the Canadian Standards Association (CSA) C22.3 No. 9 on *Interconnection of Distributed Resources and Electricity Supply Systems* which was updated and released for public comments in fall 2018. This revision also considered alignment with the Institute of Electrical and Electronics Engineers (IEEE) 1547 on *Interconnection and Interoperability of DERs with Associated Electric Power Systems Interfaces* for utility interconnections and advanced inverter functions. The adoption of the standard would allow a smart grid to maximize capabilities from grid resources that are uniformly integrated, in order for utilities to maintain a safe and reliable system.

London Hydro is the first utility to be tested and Certified CMD-compliant by UL Verification Services under the Green Button CMD Certification Program [61].

Green Button

Green Button is a data standard owned by the North American Energy Standards Board formally named the *Energy Services Provider Interface* standard, that includes a common format for energy data, *Download My Data (DMD)*, and a sharing protocol for that data, *Connect My Data (CMD)*. Ontario electricity utilities were early adopters of Green Button—London Hydro being one of the first to adopt the standard in 2012.

Since then, several Ontario electricity utilities, representing about 60% of the province's electricity customers, have implemented *DMD* for their residential and small business customers. These customers can download their energy usage data from their utility's website. London Hydro's Green Button platform was leveraged in a shared services business model with Festival Hydro and Whitby Hydro to deploy *CMD* for their customers. These customers can choose to share their energy usage data with other entities or software tools, which can further analyze their energy use, identify energy efficiency opportunities, and better manage their energy bills. Green Button also presents a new market opportunity for app developers and solution providers to innovate useful customer tools using the standardized energy data format.

OUTLOOK

Outlook

Smart grid is evolving from being an R&D concept to demonstration pilots to deployed commercial solutions. Support from various stakeholders has pushed smart grid deployment forward. Canada continues to be a world leader in supporting clean generation developing solutions and partaking in knowledge sharing activities to accelerate into a future smart grid.

The uptake of smart grid technology enables grid modernization and improvement of current grid operation. Further research and solution demonstrations are necessary to better understand how to use these technologies to build a smarter grid of the future like that shown in Figure 8 where all energy resources are sharing data and communicating. Improved monitoring, control and automation helps to achieve objectives like reduced GHG emissions from various energy resources; improved asset management, safety, resiliency, reliability, customer options, and cost savings.

There has been a drive for campuses, communities and cities to work towards socially responsible goals like net-zero energy or “smart” targets. In 2017, the Government of Canada stated that all federal government operations will be powered by 100% clean electricity by 2025 [62]. Furthermore, 10 Canadian cities have already indicated similar commitments to 100% RE in some part of their future plan, whether it’s for municipal operations or for the entire city [63]. To meet these targets, effective resource management will be key.

In the process of modernizing the power grid, there will be a diverse mix of assets. Utilities have invested heavily to build a reliable, predominantly unidirectional power system. However a bidirectional system is required to effectively integrate a significant amount of DER. In order to maintain the level of service in such circumstances, interconnected DERs will need to be managed as a virtual power plant (VPP) by collectively coordinating resources or, for added resilience against blackouts, a self-sustaining microgrid with seamless transition from grid-connected to islanded mode. Both the VPP and microgrid require visibility and control of connected resources to effectively manage the power between DERs and non-flexible loads. Resources like smart inverters, EVs, and flexible loads can be a means to support this and also provide grid ancillary services. Technology can be used to tap into the potential of existing resources on the grid and/or create tools that will be able to maximize their potential in a cost-effective manner.

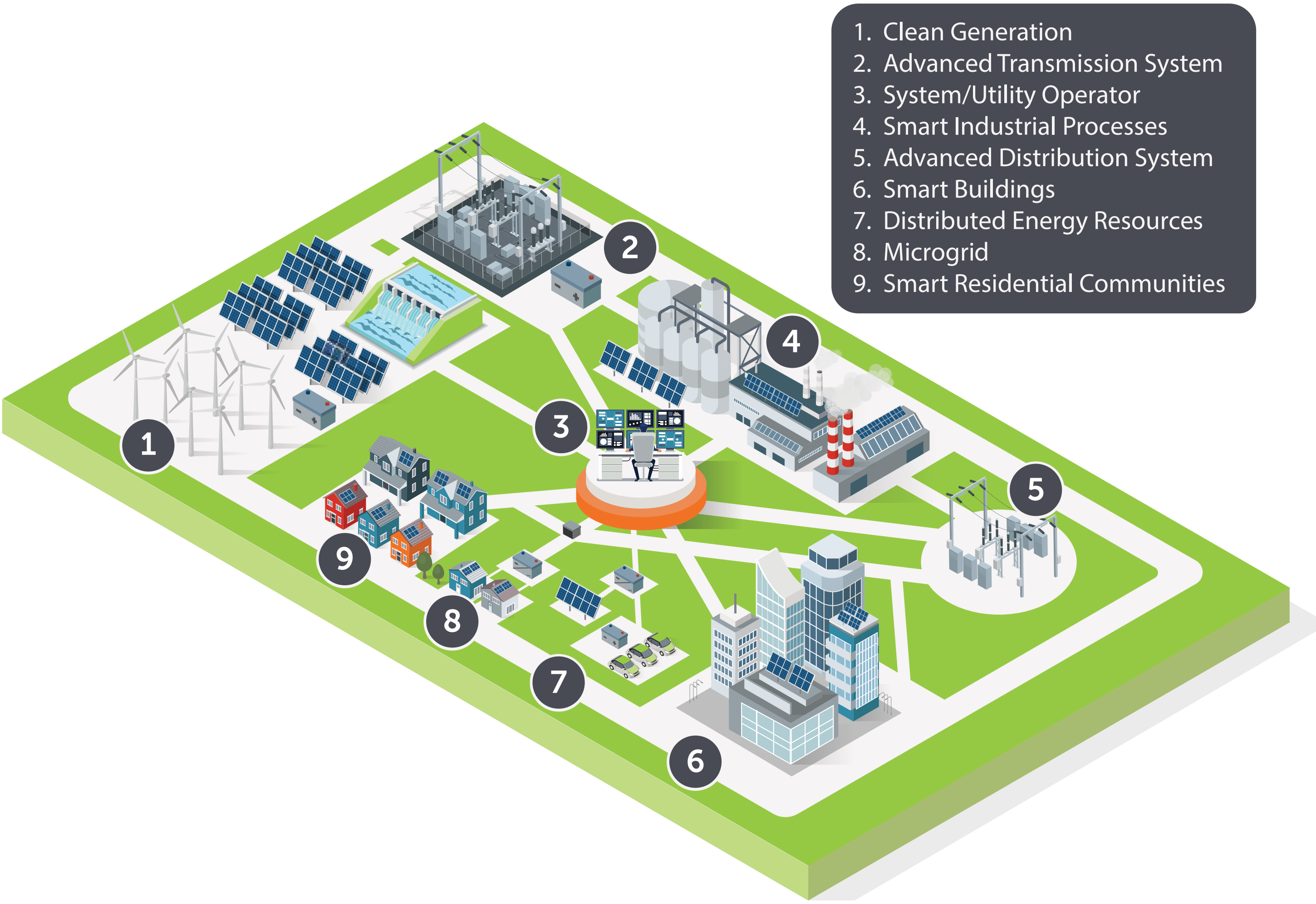


Figure 8: Smart grid of the future

The electrification of various sectors presents challenges and opportunities for the power grid. The impact of the electrification of transport is being studied since EVs using Level-3 and even Level-2 chargers can create huge demand draws if multiple EVs are charging on the same feeder; this can cause great strain on grid assets as feeders can suddenly become overloaded without warning if proper planning precautions are not considered. Tools need to be in place to properly integrate EVs and optimize the potential they offer. Concepts pertaining to vehicle-to-building (V2B), vehicle-to-grid (V2G), and vehicle-to-everything (V2X) are being explored to compliment business operations of the respective building, grid or any other entity where the EV is being integrated.

Beyond EVs and the transportation sector, electrification of other sectors also serves as an opportunity for the smart grid. Resources with flexibility can use technology to become better connected to the grid. Smart buildings and industrial processes can leverage potential in existing equipment to further support system or utility operators, or leverage 3rd party aggregator expertise to gain incentives.

Data is key to better understand how resources can be better managed. Cleaning datasets to improve on current tools, or create new tools with added value for the utility and customers alike can help utilities optimize the use of their assets and modernize their customer relations at the same time. With concepts like big data and data mining being explored across various sectors, the energy sector can also leverage these concepts in grid modernization efforts. Utilities in particular have massive datasets from outage management systems, distribution automation systems, SCADA, asset management, and billing systems that can benefit from an integrated platform where various data is used to improve operations, planning and/or customer relations. Advanced transmission and distribution system infrastructure can collect data relevant for an integrated platform which can include functions like automated DR event negotiations with customers' flexible loads; this serves a cost-effective solution for utilities since flexible load investments have already been made by customers.

With the deployment across Canada of smart meters, there is potential to provide customers with better tools to effectively manage their consumption while providing utilities with a platform to interact with customers. Smart meters can also be a key technology to effectively deploy demand management tactics like ToU or other dynamic rate structures. Net metering also serves as a way for customers to leverage the smart meter deployment to become prosumers consuming and generating their own power. This evolving customer-utility relationship will require further tools with the support of regulations to tap into a mutually beneficial scenario.

Standards can play a key role to ensure interoperability between various grid resources and how they are integrated into a smart grid. If manufacturers of like products are compliant with standards, integrating a variety of resources into systems will be far less complex, and a smart grid will be able to effortlessly communicate with an assortment of resources. ITC is the fundamental communication infrastructure the telecommunication industry has deployed.

Leveraging Internet of Things (IoT) technology over ICT infrastructure allows resources energy resources to communicate and meet their respective objectives. The standardized nature of IoT technology allows for easier integration of additional energy resources coming online, and also to communicate with other smart grids as the networks continue to expand. As smart grids start to communicate and/or connect to other smart grids, having conformity between the grids will allow for straightforward integration. Adequate information technology (IT) services are required to establish and maintain this vast network.

With the proper communication channels in place to gain access to relevant data, intelligence strategies can be used to optimize system operation and planning. Techniques including model predictive control and deep learning can be used to optimize grid operation, planning and maintenance while considering various parameters dependent on the environment, economy, resource health, or human factors. These techniques can also be useful for security measures—cyber and physical alike. Cybersecurity in particular, must include both intentional and non-intentional threats where vulnerabilities are exposed regarding confidentiality, integrity, availability and accountability of digital information. Collaborating with other sectors on cybersecurity can be explored to ensure the smart grid is well equipped to be protected from cyberthreats. The severity of these attacks becomes increasingly critical when transactive energy models are considered.

Transactive energy models like blockchain, a peer-to-peer distributed ledger solution, are becoming increasingly popular as a means to take control of decisions made by utilities, like using more DG to reduce GHG emissions or reduce energy costs. Customers are looking for increasingly interactive and digital solutions that presents more options in service. To deploy these solutions, various aspects need to be carefully considered from managing customer profiles to exchanging data to security concerns to implementing economic framework. These types of solutions challenge the current model of monopolistic electric utility company operations to one that provides customers with more control of their electric service.

Customers are driving the change adopting low cost commercial solutions and becoming prosumers. From DG to EVs, prosumers are investing in various DERs to offset high energy costs or play a part in adopting solutions supporting less GHG emissions. Utilities can leverage prosumer investment in DERs with flexibility potential by creating customer tools and providing customer incentives to leverage these behind-the-meter resources. With more DG and RES installed as a means to reduce GHG emissions, the added grid flexibility will ensure grid operators are able to maintain or improve grid services. Continuous efforts will be necessary to gain knowledge and insights from demonstration projects to better deploy smart grid technology to build a modernized and clean power grid.

Bibliography

[1] Canadian Wind Energy Association, "Installed Capacity," December 2018. [Online]. Available: https://canwea.ca/wind-energy/installed-capacity/. [Accessed December 2018].

[2] Natural Resources Canada, *Internal Wind Tracking*, 2018.

[3] International Energy Agency, "Photovoltaic Power Systems Annual Report," 2018.

[4] Independent Electricity System Operator of Ontario, "A Progress Report on Contract Electricity Supply Q4," 2018.

[5] S. Wong, "CanmetENERGY Research Brief: Summary Report on Canadian Residential Demand Response and Ancillary Service Market Opportunities," Natural Resources Canada, 2015.

[6] Electric Mobility Canada, "Electric Vehicle Sale in Canada in 2018," [Online]. Available: https://emc-mec.ca/new/electric-vehicle-sales-in-canada-in-2018/. [Accessed January 2019].

[7] Natural Resources Canada, "Electric Charging and Alternative Fuelling Stations Locator," [Online]. Available: https://www.nrcan.gc.ca/energy/transportation/personal/20487#/analyze?fuel=ELEC&ev_levels=all. [Accessed February 2019].

[8] H. Ribberink, L. Wilkens, R. Abdullah, M. McGrath and M. Wojdan, "Impact of Clusters of DC Fast Charging Stations on the Electricity Distribution Grid in Ottawa, Canada," in *EVS30 Symposium*, Stuttgart, Germany, 2017.

[9] Hydro Québec, "Electric Vehicle Charging Stations Technical Installation Guide," 2015.

[10] Government of Alberta, "Renewable Electricity Program," [Online]. Available: https://www.alberta.ca/renewable-electricity-program.aspx. [Accessed October 2018].

[11] Alberta Electric System Operator, "Guide to understanding Alberta's electricity market," [Online]. Available: https://www.aeso.ca/aeso/training/guide-to-understanding-albertas-electricity-market/. [Accessed October 2018].

[12] Alberta Electric System Operator, "Capacity market transition," [Online]. Available: https://www.aeso.ca/market/capacity-market-transition/. [Accessed October 2018].

[13] Alberta Electric System Operator, "REP results," [Online]. Available: https://www.aeso.ca/market/renewable-electricity-program/rep-results/. [Accessed October 2018].

[14] Alberta Electric System Operator, "REP news and updates," December 2018. [Online]. Available: https://www.aeso.ca/market/renewable-electricity-program/rep-news-and-updates/. [Accessed April 2019].

[15] Government of British Columbia, "2018/19–2020/21 Service Plan," 2018.

[16] Government of British Columbia, “Renewable & Low Carbon Fuel Requirements Regulation,” [Online]. Available: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels. [Accessed October 2018].

[17] “Clean Energy Vehicles for British Columbia,” [Online]. Available: https://www.cevforbc.ca/. [Accessed October 2018].

[18] British Columbia Utilities Commission, “An Inquiry into the Regulation of Electric Vehicle Charging Service ~ Procedural Order,” [Online]. Available: https://www.ordersdecisions.bcuc.com/bcuc/orders/en/item/305242/index.do. [Accessed October 2018].

[19] Government of Manitoba, “Manitoba’s Made-in-Manitoba,” [Online]. Available: https://www.gov.mb.ca/climateandgreenplan/index.html. [Accessed October 2018].

[20] Government of Manitoba, “Energy Opportunities Office,” [Online]. Available: https://www.gov.mb.ca/sd/environment_and_biodiversity/energy/opportunities.html. [Accessed October 2018].

[21] Government of New Brunswick, “Transitioning to a Low-Carbon Economy,” [Accessed October 2018].

[22] New Brunswick Energy and Utilities Board, [Online]. Available: http://www.nbeub.ca/uploads/2018%20 07%2020%20-%20Decision%20-%20Matter%20375.pdf. [Accessed October 2018].

[23] Government of Newfoundland and Labrador, “The Way Forward III: Building for Our Future”.

[24] Government of Newfoundland and Labrador, January 2019. [Online]. Available: https://gov.nl.ca/wp-content/uploads/Mandate_MinisterCoady.pdf. [Accessed January 2019].

[25] Government of Newfoundland and Labrador, “Minister Coady Supports Public Utilities Board’s Approval of Net Metering Program,” May 2017. [Online]. Available: https://www.releases.gov.nl.ca/releases/2017/nr/0519n09.aspx. [Accessed October 2018].

[26] Government of Nova Scotia, “Our Electricity Future: Nova Scotia’s Electricity Plan,” 2014.

[27] Nova Scotia Power Corporation, “RENEWABLE TO RETAIL,” [Online]. Available: https://www.nspower.ca/oasis/renewable-to-retail [Accessed October 2018].

[28] Nova Scotia Power Corporation, “Nova Scotia Power Set to Roll Out Smart Meters Following UARB Approval,” June 2018. [Online]. Available: https://www.nspower.ca/smartmeters [Accessed October 2018].

[29] Government of Nova Scotia, “Innovation,” [Online]. Available: https://energy.novascotia.ca/electricity/innovation. [Accessed October 2018].

[30] Government of Northwest Territories, “2030 Energy Strategy,” 2018.

[31] Government of Northwest Territories, “Energy Action Plan 2018–2021,” 2018.

[32] Qulliq Energy Corporation, “Solar,” [Online]. Available: https://www.qec.nu.ca/node/167. [Accessed October 2018].

[33] Qulliq Energy Corporation, “Wind,” [Online]. Available: https://www.qec.nu.ca/node/168. [Accessed October 2018].

[34] Government of Ontario, “A Made-in-Ontario Environment Plan,” November 2018. [Online]. Available: https://www.ontario.ca/page/made-in-ontario-environment-plan. [Accessed January 2019].

[35] Independent Electricity System Operator of Ontario, “Electricity Market Today,” [Online]. Available: http://www.ieso.ca/en/learn/ontario-power-system/electricity-market-today. [Accessed September 2018].

[36] Independent Electricity System Operator of Ontario, “Market Renewal—Single Schedule Market,” [Online]. Available: http://www.ieso.ca/en/sector-participants/market-renewal/market-renewal-single-schedule-market. [Accessed September 2018].

[37] Independent Electricity System Operator of Ontario, “Market Renewal—Enhanced Real-Time Unit Commitment,” [Online]. Available: http://www.ieso.ca/en/sector-participants/market-renewal/market-renewal-enhanced-real-time-unit-commitment. [Accessed September 2018].

[38] Independent Electricity System Operator of Ontario, “Market Renewal—Day-Ahead Market,” [Online]. Available: http://www.ieso.ca/en/sector-participants/market-renewal/market-renewal-day-ahead-market. [Accessed September 2018].

[39] Independent Electricity System Operator of Ontario, “Market Renewal—Incremental Capacity Auction,” [Online]. Available: http://www.ieso.ca/en/sector-participants/market-renewal/market-renewal-incremental-capacity-auction. [Accessed September 2018].

[40] Independent Electricity System Operator of Ontario, “Large Renewable Procurement,” [Online]. Available: http://www.ieso.ca/en/Sector-Participants/Energy-Procurement-Programs-and-Contracts/Large-Renewable-Procurement. [Accessed September 2018].

[41] Independent Electricity System Operator of Ontario, “Energy Storage Procurement at the IESO,” [Online]. Available: http://www.ieso.ca/Sector-Participants/Energy-Procurement-Programs-and-Contracts/Energy-Storage. [Accessed September 2018].

[42] Independent Electricity System Operator of Ontario, “A Progress Report on Contracted Electricity Supply: Second Quarter,” 2018.

[43] Independent Electricity System Operator of Ontario, “Energy Storage Procurement at the IESO,” January 2019. [Online]. Available: http://www.ieso.ca/Sector-Participants/Energy-Procurement-Programs-and-Contracts/Energy-Storage. [Accessed January 2019].

[44] Ontario Energy Board, “Regulated Price Plan (RPP),” [Online]. Available: https://www.oeb.ca/industry/policy-initiatives-and-consultations/regulated-price-plan-rpp. [Accessed 2018 October].

[45] Ontario Energy Board, “Regulated Price Plan Roadmap,” 2015.

[46] Ontario Energy Board, “Electricity Pricing Pilots Test More Choice for Residential Consumers,” August 2017. [Online]. Available: https://www.oeb.ca/newsroom/2017/electricity-pricing-pilots-test-more-choice-residential-consumers. [Accessed October 2018].

[47] Government of Prince Edward Island, “An Energy Strategy for Prince Edward Island,” March 2017. [Online]. Available: http://www.peiec.ca/the-strategy.html. [Accessed October 2018].

[48] Prince Edward Island Regulatory and Appeals Commission, “Docket UE20942 Order UE16-04R,” July 2016. [Online]. Available: http://www.irac.pe.ca/document.aspx?file=orders/electric/2016/ue16-04r.htm. [Accessed October 2018].

[49] Government of Québec, “Energy Policy,” [Online]. Available: https://mern.gouv.qc.ca/energie/politique-energetique/. [Accessed October 2018].

[50] Hydro-Québec, “Hydro-Québec rate increase below inflation for fourth consecutive year,” July 2018. [Online]. Available: http://news.hydroquebec.com/en/press-releases/1394/hydro-quebec-rate-increase-below-inflation-for-fourth-consecutive-year/. [Accessed October 2018].

[51] Clean Technica, “Québec Plans To Roll Out EV Fast Charging Network & Re-Invest Revenue,” May 2018. [Online]. Available: https://cleantechnica.com/2018/05/21/quebec-plan-to-roll-out-ev-fast-charging-network-re-invest-revenue/. [Accessed October 2018].

[52] Government of Québec, “Refund for a Terminal at Work,” [Online]. Available: http://vehiculeselectriques.gouv.qc.ca/entreprises/remboursement.asp. [Accessed October 2018].

[53] Government of Québec, “Québec Leads the Way with its ZEV Standard”.

[54] SaskPower, “Pilot 2: SaskPower Expands Non-Residential Smart Meter Pilot,” June 2018. [Online]. Available: https://www.saskpower.com/about-us/media-information/news-releases/pilot-2-saskpower-expands-non-residential-smart-meter-pilot. [Accessed October 2018].

[55] SaskPower, “Second 10 MW Solar Project,” [Online]. Available: https://www.saskpower.com/Our-Power-Future/Infrastructure-Projects/. [Accessed October 2018].

[56] SaskPower, “SaskPower to Buy More Renewable Electricity From Manitoba Hydro,” October 2018. [Online]. Available: https://www.saskpower.com/about-us/media-information/news-releases/saskpower-to-buy-more-renewable-electricity-from-manitoba-hydro. [Accessed November 2018].

[57] Government of Yukon, “Yukon Renewable Energy and Energy Efficiency Update January 2016—June 2018”.

[58] NSERC Energy Storage Technology Network, “About,” [Online]. Available: https://www.ryerson.ca/nestnet/about/. [Accessed September 2018].

[59] Canadian Electricity Association, “Building Canada’s Clean Growth Future,” [Online]. Available: https://electricity.ca/lead/powering-canadas-economy/.

[60] Mission Innovation, “Innovation Challenge 1 Smart Grids,” [Online]. Available: https://www.mi-ic1smartgrids.net/.

[61] London Hydro, “London Hydro 1st Utility to Receive Green Button CMD Certification,” September 2018. [Online]. Available: https://www.londonhydro.com/site/binaries/content/assets/lhcontent/news/mediarelease_onhydro1sttoreceivegbcertificationfinal.pdf. [Accessed November 2018].

[62] Government of Canada, “Greening Government Strategy,” January 2018. [Online]. Available: https://www.canada.ca/en/treasury-board-secretariat/services/innovation/greening-government/strategy.html. [Accessed December 2018].

[63] Renewable Cities, “100% Renewable Energy and Canadian Cities,” [Online]. Available: https://www.renewablecities.ca/articles/100-per-cent-renewable-energy-and-canadian-cities. [Accessed December 2018].

Resources Library

General Framework

Pan-Canadian Framework on Clean Growth and Climate: https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework.html

Conference of the Parties:
http://www.cop21paris.org/

Canada's Paris Agreement Commitment:
https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/progress-towards-canada-greenhouse-gas-emissions-reduction-target.html

Public Sector Activities

NRCan Energy RD&D Investments:
https://www.nrcan.gc.ca/energy/funding/21146

Energy Innovation Program:
https://www.nrcan.gc.ca/energyinnovation

Program of Energy R&D:
https://www.nrcan.gc.ca/energy/funding/perd/4993

Clean Growth Program:
https://www.nrcan.gc.ca/cleangrowth/20254

Green Infrastructure Program:
https://www.nrcan.gc.ca/cleangrowth/19780

Smart Grid Program:
https://www.nrcan.gc.ca/energy/science/programs-funding/19793

EV Infrastructure Demonstration Program:
https://www.nrcan.gc.ca/energy/science/programs-funding/20467

EV and Alternative Fuel Infrastructure Deployment Initiative:
https://www.nrcan.gc.ca/energy/alternative-fuels/fuel-facts/ecoenergy/18352

Emerging Renewable Power Program:
https://www.nrcan.gc.ca/energy/funding/20502

Energy Efficient Buildings RD&D Program:
https://www.nrcan.gc.ca/energy/science/programs-funding/19787

Clean Energy for Rural and Remote Communities Program:
https://www.nrcan.gc.ca/energy/science/programs-funding/20542

SD Tech Fund:
https://www.sdtc.ca/en/apply/funds/

Strategic Innovation Fund:
https://www.ic.gc.ca/eic/site/125.nsf/eng/home

Clean Growth Hub:
https://www.nrcan.gc.ca/cleangrowth/20254

Export Development Canada:
https://www.edc.ca/

Generation Energy:
https://www.nrcan.gc.ca/20093

RECSI Atlantic Region Study:
https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/clean/RECSI_AR-SPM_eng.pdf

RECSI Western Region Study:
https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/clean/RECSI_WR-SPM_eng.pdf

Alberta's Climate Leadership Plan:
https://www.alberta.ca/climate-change.aspx

AESO Renewable Electricity Program:
https://www.aeso.ca/market/renewable-electricity-program/

BC Service Plan :
https://www2.gov.bc.ca/gov/content/governments/organizational-structure/ministries-organizations/ministries/energy-mines-and-petroleum-resources/service-plan

Renewable & Low Carbon Fuel Requirements Regulation:
https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels

Manitoba Climate and Green Plan:
https://www.gov.mb.ca/climateandgreenplan/index.html

New Brunswick Climate Change Action Plan:
https://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Climate-Climatiques/TransitioningToALowCarbonEconomy.pdf

Newfoundland and Labrador Climate Change Action Plan:
https://www.exec.gov.nl.ca/exec/occ/action_plans.html

Nova Scotia Electricity Plan:
https://energy.novascotia.ca/sites/default/files/files/FINAL%20Our%20Electricity%20Future(1).pdf

Northwest Territories 2030 Energy Strategy:
https://www.inf.gov.nt.ca/sites/inf/files/resources/gnwt_inf_7272_energy_strategy_web-eng.pdf

Nunavut Net Metering Program:
https://www.qec.nu.ca/customer-care/net-metering-program

Ontario Made-in-Ontario Environment Plan:
https://www.ontario.ca/page/made-in-ontario-environment-plan

Ontario Smart Grid Fund:
https://www.ontario.ca/document/projects-funded-smart-grid-fund

IESO Market Renewal:
http://www.ieso.ca/en/Market-Renewal

OEB RPP Roadmap:
https://www.oeb.ca/oeb/_Documents/EB-2004-0205/RPP_Roadmap_Report_of_the_Board_20151116.pdf

EDA Power to Connect Series:
https://secure2.mearie.ca/imis15/EDA/EDA_Priorities/EDA_Policy%20Papers/EDA/EDA_Priorities/EDA_Policy_Papers/EDA_PolicyPapers.aspx?hkey=95212a80-e0d3-450c-9eba-8af62605833a

Prince Edward Island Energy Strategy:
http://www.peiec.ca/the-strategy.html

Quebec Energy Plan 2030:
https://mern.gouv.qc.ca/wp-content/uploads/2016/04/Politique-energetique-2030.pdf

Transition Énergétique Québec 2018-2023 Master Plan:
http://www.transitionenergetique.gouv.qc.ca/fileadmin/medias/pdf/plan-directeur/TEQ_PlanDirecteur_web.pdf

ZEV Standard:
http://www.environnement.gouv.qc.ca/changementsclimatiques/vze/index-en.htm

TechnoClimat Program:
https://transitionenergetique.gouv.qc.ca/en/innovation/program/technoclimat/

SaskPower Power Generation Partner Program:
https://www.saskpower.com/-/media/SaskPower/Our-Power-Future/Powering-2030/Sell-your-Power/Infosheet-Power-Generation-Partner-Program-Guidelines.ashx?la=en&hash=F61AA8E60ED3662ABB4B0E131D06F0B24DE9A6CA

Yukon Independent Power Production Policy Implementation:
https://yukon.ca/sites/yukon.ca/files/emr/emr-yukon-independent-power-production-policy.pdf

Yukon Micro-generation Program:
https://yukon.ca/en/micro-generation-program

Research and Innovation Networks

AEC Energy Innovation Snapshot:
http://energyinnovationsnapshot.ca/

NESTNet Outputs:
https://www.ryerson.ca/nestnet/outputs/

SGIN:
http://www.sgin.ca/

Industry Support

CEA :
https://electricity.ca/

CEATI:
https://www.ceati.com/en/

SmartGrid Canada:
http://www.sgcanada.org

International Collaborations

ISGAN Publications:
http://www.iea-isgan.org/publications/

ISGAN Annex 5 International Development of a Distributed Energy Resource Test Platform for Electrical and interoperability

Certification Paper:
https://www.researchgate.net/publication/325976510_International_Development_of_a_Distributed_Energy_Resource_Test_Platform_for_Electrical_and_Interoperability_Certification

ISGAN Annex 6 Flexibility Needs in the Future Power System:
http://www.iea-isgan.org/flexibility-in-future-power-systems/

MI Publications:
http://mission-innovation.net/resources/publications/

MI-IC1 2017 Country Report:
https://smartgrids.no/wp-content/uploads/sites/4/2018/04/MI_IC1_Country_Report_2017.pdf

NARIS:
https://www.nrel.gov/analysis/naris.html

Power Forward Challenge:
https://impact.canada.ca/en/challenges/power-forward

Standards Development

CSA C22.3 No. 9:
https://www.scc.ca/en/standardsdb/standards/25004

IEEE 1547:
https://standards.ieee.org/standard/1547-2018.html

Green Button:
http://www.greenbuttondata.org/

Appendix: Smart Grid Applications

APPLICATION	DESCRIPTION
Advanced Inverter Function (AIF)	Inverter-based generation systems can use advanced functions to effectively respond to maintain (and if used effectively improve) grid operation. AIF capabilities include voltage and frequency support as well as grid protection to respond to disturbances (e.g. voltage and frequency ride through, PF and active power adjustments). The use of these functions directly tackles some variability and DG challenges.
Advanced Metering Infrastructure (AMI)	Smart meters or AMI includes the meter and associated communication communications network. Automatic remote meter reading and interval metering enables new methods of electricity data collection and network planning. Depending on the utility's system integration, AMI could be used to support other systems like outage management, new rate options or billing, DR, and various interactive customer tools.
Demand Response (DR)	DR involves controllable loads shifting their consumption to off-peak hours to relieve the grid during peak hours. In general, DR can be implemented in one of three ways: through a direct load control (instructional signal) sent by the utility, through the SO or controlled by a third party aggregator to a customer; or through an indirect control (price signal) sent to a customer.
Distributed Energy Storage (DES)	Electric storage technologies support grid services such as frequency regulation and peak shaving to further support grid reliability. Any DES supporting microgrids are included. However backup power systems are not included in this category unless the storage technology also provides grid services when it is not providing backup power during an outage, nor does it include large storage connected to the bulk system such as large pumped hydro.
Grid Automation	GA refers to a distribution network that is able to monitor, measure, protect and control using communication to automatically react to service interruptions. This includes fault location, isolation and service restoration (FLISR), or fault detection, isolation and restoration (FDIR), technologies applied to increase the capacity of the distribution grid to reroute power to ensure system reliability. A fully automated grid requires little to no intervention from a grid operator. This category does not differentiate advanced intelligence techniques which can leverage real-time feeder sensing information and control systems (e.g. outage management systems and advanced distribution management systems).
Microgrid (MG)	A MG is a segment of the grid able to control DERs like DG and storage to sustain loads whether connected, or disconnected from the bulk grid to form an isolated network (i.e. islanding mode). This category does not include northern or remote communities.
New Markets & Rate Options (NRO)	NRO looks at how electricity (power and energy) is exchanged. This changes the nature of how the grid operates, and introduces additional players in a smart grid if markets are established. New rates can serve different customer energy needs and help to increase the value proposition of electricity services to customers. Rate options include price signals sent to customers to manage better system peaks, or DR. The most recent developments are tracked so if a province has deployed markets or rate options but new pilots are underway, the new pilots will take precedence.

Appendix C

CGA INSIGHTS MATTER SURVEY

INSIGHTS MATTER

FORTIS BC

FORTISBC METERING INTERVIEW RESULTS & REPORT

COMPLETED: OCTOBER 13, 2020 BY INSIGHTS MATTER

SURVEY BACKGROUND:

FortisBC has been conducting manual meter readings using the same third-party vendor since 2013 and is currently preparing an application for a Certificate of Public Necessity and Convenience (CPCN) to the British Columbia Utilities Commission. The intent of the application is to switch their metering to Advanced Meter Infrastructure (AMI). In order to support the CPCN application, FortisBC wanted to gain an understanding of the use of manual versus advanced gas meter reading practices at other Canadian utilities.

FortisBC wanted an independent third party to obtain this information and selected Insights Matter as their research partner. Insights Matter administered in-depth interviews with industry peers at other Canadian natural gas utilities. A list of 10 industry contacts was provided by FortisBC to Insights Matter, and ten in-depth interviews were completed with the gas providers listed below. Interviews were approximately 25-40 minutes in length and were conducted between July 22 and October 6, 2020.

This report, and the data and commentary provided in it, relates specifically to gas metering.

SURVEY SAMPLE:

Ten interviews were successfully completed via telephone, as detailed below.

RESPONDENT NUMBER	RESPONDENT NAME	COMPANY NAME	INTERVIEW DATE	CONTACT EMAIL	CONTACT PHONE
1	ROB CURELY	ATCO	JULY 22	Rob.Curley@atco.com	780 818 2489
2	TOM HAMILTON	CITY OF MEDICINE HAT	JULY 22	TOMHAM@medicinehat.ca	403 529 8332
3	RICK PAWLUK	MANITOBA HYDRO	JULY 22	ripawluk@hydro.mb.ca	204 227 0706
4	LEANNE STETTNER	SASK ENERGY	JULY 24	lstettner@saskenergy.com	306 539 2566
5	RICARDO PACHECO	ENBRIDGE	JULY 31	Ricardo.Pacheco@enbridge.com	647 537 4169
6	ANDRÉANE PÉLOQUIN	ENERGIR	SEPT 4	andreane.peloquin@energir.com	438 837 0432
7	SCOTT BOUDREAU	HERITAGE GAS	SEPT 18	sboudrea@heritagegas.com	902 229 7087
8	ED KEEF	ALBERTA FEDERATION OF GAS COOPS	OCT 1	ekeef@fedgas.com	780 913 5296
9	DOMINIC FEENAN	PACIFIC NORTHERN GAS	OCT 2	dfeenan@png.ca	250 641 0160
10	MICHAEL DYGDALA	ALTA GAS UTILITIES	OCT 6	MDygdala@agutl.com	780 903 9763

SURVEY OBJECTIVES & RESULTS SNAPSHOT:

The survey objectives were mandated as follows:

1. What is the approach to gas meter reading that Canadian utilities are taking (manual, AMR, AMI)?
2. What proportion of gas meters is being read manually versus AMR/AMI?
3. Which vendors are currently providing gas meter reading services?
4. What plans and intentions do Canadian utilities have when it comes to gas meter reading in the future?

RESPONDENT	TOTAL GAS METERS (REPORTED BY UTILITY)	MANUAL	AUTOMATIC METER READING (AMR)	ADVANCED METER INFRASTRUCTURE (AMI)	OTHER (SCADA)	% OF UTILITY TOTAL GAS METERS USING AMI/AMR/ OTHER	% OF UTILITY TOTAL GAS METERS USING MANUAL	METHOD USED FOR COLLECTING MANUAL READS
ATCO	1,200,000	300	1,199,700	0	0	99.98	0.03	IN-HOUSE
CITY OF MH	90,000	0	0	90,000	0	100.00	0.00	N/A
MB HYDRO	310,100	310,000	0		100	0.03	99.97	SUBSIDIARY (MHUS)
SASK	399,000	2,793	0	396,207	0	99.30	0.70	SUBSIDIARY (SASK POWER)
ENBRIDGE	3,700,000	3,570,000	130,000	0	0	3.51	96.49	VENDORS: UMS, MET, G-TEL
ENERGIR	229,464	675	228,789	0	0	99.71	0.29	IN-HOUSE
HERITAGE	8,000	0	8,000	0	0	100.00	0.00	N/A
AB FED	110,000	30,000	80,000	0	0	72.73	27.27	IN-HOUSE & CUSTOMER
PNG	41,200	40,000	1,200	0	0	2.91	97.09	IN-HOUSE
ALTA GAS	85,000	100	84,900	0	0	99.88	0.12	IN-HOUSE
TOTAL	6,172,764	3,953,868	1,732,589	486,207	100			
% TOTAL METERS	**100.00**	**64.05**	**28.07**	**7.88**	**0.0**	**35.95**	**64.05**	

KEY FINDINGS:

Objective 1: What is the approach to gas meter reading that Canadian utilities are taking (manual, AMR, AMI)?

As the table above indicates, nine of ten utilities interviewed currently utilize Automatic Meter Reading (AMR) or Advanced Meter Infrastructure (AMI) technology for gas metering. Six of these nine utilities use Automatic Meter Reading (AMR) or Advanced Meter Infrastructure (AMI) for 99%+ of their meter reads, while Enbridge and PNG use Automatic Meter Reading (AMR) for a small proportion of their meter reads (3.5% and 2.91%, respectively). However, PNG has received confirmation from the BCUC that they can rollout AMR throughout their NE business, which covers approximately 20,000 meters in addition to the 1,200 meters already converted to AMR.

ATCO has a small number of meters (300) that they read manually because it is not possible to upgrade these. Alta Gas has approximately thirty meters that have not been converted to AMR due to customer refusal related to perceived concerns about the potential health risks associated with radio waves. Further, Alta Gas conducts quarterly periodic manual meter readings for less than 200 meters in the event of failure to capture AMR readings via fly-by. Sask Power will upgrade their remaining meters over the next year or so. Energir has indicated they will upgrade their remaining 675 manual meters to Automatic Meter Reading (AMR) but were unable to comment as to when at this time. Heritage Gas will be fully Automatic Meter Reading (AMR) once they convert approximately 400-500 large rotary meters to AMR by mid-October 2020. Until then, they are being read manually and in-house.

To date, Enbridge has only installed 130,000 Automatic Meter Reading (AMR) meters to service small pockets of residential and commercial/industrial customers. Manitoba Power has approximately 100 meters that are automated via SCADA, which is not classified as Automatic Meter Reading (AMR) or Advanced Meter Infrastructure (AMI). Both Enbridge and Manitoba Power, who largely depend on manual meter reading by an affiliate/subsidiary or third-party vendor, have confirmed that early internal discussions are underway related to building a business case for an Advanced Meter Infrastructure (AMI) conversion.

"We're further behind FortisBC, but today was our first kick-off meeting about venturing down the AMI option. Currently, all of our meters are manually read. In time, we will be sending out an RFP to AMI suppliers." Manitoba Hydro

"We're definitely trying to have more remote access to meter readings. In terms of technology, we're looking at creating a business case for AMI." Enbridge

Objective 2: What proportion of meters are being read manually versus AMR/AMI?

As a function of total meters (6,172,764) reported by the ten utilities interviewed, 64.05% are read manually, but this is heavily weighted by Enbridge due to the sheer number of meters they have (3,700,000). Over 96% of Enbridge's meters are read by third-party vendors. Excluding Enbridge, only 15.5% of total meters are read manually across the remaining seven utilities (383,863 out of 2,472,764).

Eight percent (7.88%) of total meters have been upgraded to Advanced Meter Infrastructure (AMI) technology while twenty-eight percent (28.07%) to Automatic Meter Reading (AMR). Again, the penetration of Automatic Meter Reading (AMR) among total meters reported is due to ATCO, which implemented Automatic Meter Reading (AMR) on most of their 1.3 million meters nearly a decade ago. Energir converted nearly 100% of their meters to Automatic Meter Reading (AMR) in 1993. Heritage Gas has converted almost all of their 8,000 meters to Automatic Meter Reading (AMR) within the last three years, as has Alta Gas, who converted 99.88% of their 85,000 meters in the same timeframe. PNG trialled 1,200 AMR meters and have recently been granted approval to convert a further 20,000 meters in their NE division over the next year or so.

ATCO has expressed complete satisfaction with its Automatic Meter Reading (AMR) technology and has no plans at this time to upgrade to Advanced Meter Infrastructure (AMI). Heritage Gas indicated that it is likely they will consider converting their 8,000 meters to Advanced Meter Infrastructure (AMI) at some point in the future, but it is not a top priority for them right now.

We will potentially convert to AMI, but this is not in our current business plan for the next year or two. We likely will, but it's not a top priority right now because we're so small. The ERTs on each meter that we have are first-generation, so they won't work for AMI. We invested a couple of million dollars in AMR in the last three years, so we can't just put a bunch of towers up and start converting to AMI. Heritage Gas

Objective 3: Which vendors are currently providing meter reading services?

Of the two utilities that predominately read meters manually, Manitoba Hydro captures manual reads via their subsidiary, Manitoba Hydro Utility Services (MHUS), as does Sask Energy utilizing their affiliate, Sask Power. Enbridge has been using Utility Meter Services (UMS) and MET Utilities Management and recently started using G-Tel in August 2020 for reads in SE, SW and Northern Ontario. MET does the majority of these meter reads (2.4 million). Participants voiced no awareness or recall of other vendors in their market area. Further, perceptions of quality changes or price increases due to decreasing third party vendors were unknown by all interview participants. Enbridge suggested that the number of vendors available has likely decreased due to an increasing move toward Automatic Meter Reading (AMR) and Advanced Meter Infrastructure (AMI). This was not based on direct experience but rather was an assumption.

Objective 4: What plans and intentions do Canadian utilities have when it comes to meter reading in the future?

In terms of the future of manual meter reading, all utilities interviewed had either moved to Automatic Meter Reading (AMR)/Advanced Meter Infrastructure (AMI) technology or signalled plans to do so within the next five to seven years. Where there is a decision not to pursue an Advanced Meter Infrastructure (AMI) solution now, it may well amount to a temporary pause. Participant comments suggest they believe that Automatic Meter Reading (AMR)/Advanced Meter Infrastructure (AMI) solutions will eventually have near-universal penetration in the Canadian utility space.

Among those utilities who primarily conduct readings manually, only Enbridge reported using third-party vendors. The other seven utilities who conduct some manual meter readings (ATCO, Energir, Manitoba Hydro, Sask Power, Alberta Federation of Cooperatives PNG, and Alta Gas) stated their manual readings are conducted either in-house or by a subsidiary. The stated reasons for keeping manual readings in-house are cost-effectiveness, technical expertise (in identifying issues with the meters/meter site and ability to conduct routine maintenance repairs), and control/flexibility over human resources. Due to the predominant use of in-house readers, participants were unable to provide clear insights regarding whom the key players are in the manual meter reading space or how the industry has changed over the past five years or the impact these changes have or may have on utilities.

Nearly all participants voiced a strong preference for Advanced Meter Infrastructure (AMI) due to the ancillary value it affords both to the utility and customer. The most notable advantages to customers are that Advanced Meter Infrastructure (AMI) provides ready access to their consumption data online, the ability to receive timely and accurate move-in/move out reads, and increased safety and property protection for things like remote shut off during an emergency (flood, fire, etc.). The benefits to utilities mentioned include remote access, accurate and timely reads, elimination of estimating, ability to troubleshoot immediately, remote disconnect in case of emergency, improved safety/less liability associated with reading vendors or in-house staff and the ability to monitor cathodic protection and pressure.

"Improved safety and reduced liability of someone going on a property and getting injured allows for immediate troubleshooting as we can pull up the meter remotely and disconnect the electrical or gas supply instantly in the case of an emergency. Rids all estimating as prior to AMI, we would read one month and estimate the next, but now our meters are read every four hours, which makes move-in and move-out billing so much easier." City of Medicine Hat

"Safety is paramount and the need to increase the frequency of reads at remote locations. Our northern metering is done once a year, and we have to fly in to do them. So, accessibility is a problem for us. " Manitoba Hydro

"From our perspective and up until recently, the business case for AMI was not there because it was entirely viewed as remote access technology. Flash forward two years, we are looking at ensuring the integrity of the entire system and how can we make it more robust. Remote reading was not there in terms of the cost-benefit analysis. We see it now as a more viable case, a holistic approach that goes beyond meter reading to monitoring specific things. Optimizing the customer experience is important too. If customers are given the ability to access their consumption online, that would be considered a plus." Enbridge

INTERVIEW DETAILS:

SECTION 1: OPENING

Q1. For starters, what sorts of things is your company thinking about when it comes to meter reading or metering services in general? Are there specific things you're thinking about, discussing or planning?

RESPONDENT	COMMENTS
ATCO	Nothing really at this time. We moved to AMR technology many years ago, and initially, we did drive by readings. Within the last five years, we switched to aerial meter reading, which uses the same AMR technology we had originally installed. Not really looking at anything else at this point.
CITY OF MH	We have already moved 100% to an AMI platform using the Sensus FlexNet system.
MB HYDRO	We're further behind FortisBC, but today was our first kick-off meeting about venturing down the AMI option. Currently, all of our meters are manually read. In time, we will be sending out an RFP to AMI suppliers.
SASK	Not that I'm aware of. Previously Sask Power used to provide our manual meter reading services. In 2010, we started talking to them about going to AMI and decided to partner with them in order to build our business case.
ENBRIDGE	Absolutely. We're definitely trying to have more remote access to meter readings. In terms of technology, we're looking at creating a business case for AMI.
ENERGIR	The focus of our discussions is on meeting meter accuracy, which will lead to better billing for clients and cost savings for us and improved client satisfaction with their billing. Advanced reading options will allow us to better manage our gas networks and purchase depending on end-user needs.
HERITAGE	Not really. We rolled out AMR technology three years ago.
AB FED	We monitor eighty (80) local utilities that are in smaller towns, cooperatives and rural areas. Each has its own customer base. Our utilities used to rely on the customer to read their own meters and send these readings to the utility. In total, there are 110,000 customers throughout the province. Now, a lot of the utilities use the ITRON AMR reading system.
PNG	Two years ago, we trialled AMR among 1,200 customers. Last week, we received confirmation from the BCUC that we can rollout AMR throughout our NE business, which covers approximately 20,000 meters. PNG operates in 4 distinct areas, and beyond converting our NE business to AMR, we don't have immediate plans to convert our remaining meters. We will decide if it makes sense to do so in PNG West because we don't have a justifiable business case at this point.

ALTA GAS	At the moment, not really. We've had some preliminary conversations about converting to ultrasonic meter reading, but they are not approved in Canada yet. My understanding is that they should be as of the end of this year or early next. Covid has thrown a monkey wrench into us considering anything new. Once ultrasonic meters are approved, we would conduct a trial. By this, I mean, we would hook them up to the line heaters at our stations, so if they fail in the cold, for instance, there would be no service interruption to the customer. We currently use AMR.

Q2. Do you expect to see changes in the general area of meter reading for utilities? What sorts of changes?

RESPONDENT	YES	NO	NOT SURE	REFUSE	SORTS OF CHANGES
ATCO	X				There's always changes as our business is all technology-based today, and what the future looks like, I'm not sure.
CITY OF MH	X				I would think all companies will go AMI eventually.
MB HYDRO	X				Covid has put a spotlight on the risks associated with manual meter reading and the fact that we have no choice but to send people into various property types to capture the readings. This is not possible going forward. Another example of this is the fact that Manitoba has a big hog industry, and right now, hogs are diseased, and we don't know enough about transmission to humans or vice versa.
SASK	X				Companies will move toward AMI.
ENBRIDGE	X				The way the industry is moving, the idea would be to move away from manual reading, which is inexpensive, and toward remote reading. We're looking at it right now. We purchased Spectra Systems (parent company of Union Gas out of Houston) in March 2019, which included Union Gas Ontario. We integrated as one utility but with two different systems of meter reading, which is why we are presently discussing how to harmonize these systems. We mostly contract out our manual meter readings, and my understanding is that Union Gas contracts out some but not all manual meter readings. In the GTA, we would normally contract out meter reading. Enbridge is now one of the largest gas distribution companies in North America.
ENERGIR	X				We always expect changes with technology, improvements to client satisfaction, and reduced risk. The meter measurement field is quite steady. We expect changes to the development of technology, but the fundamentals don't change too much.
HERITAGE	X				The most general change for us right now is that all of our customers are broken up into different reading cycles, which was necessary to manage the need for readers to go door-to-door. Now that we have rolled out AMR and conduct our readings via drive-by, we are looking to have one or two cycles so we can capture all readings within 1-2 days per month.
AB FED	X				A move toward AMR.
PNG	X				A lot of utilities are moving toward AMR or AMI, but we don't have the justification for AMI.
ALTA GAS		X			The new ultrasonic meters have built-in ERTS, so they are not attached ERTS. I think the built-in is part of the meter itself.
TOTAL	**9**	**1**	**0**	**0**	

a) What is driving these changes?

RESPONDENT	KEY DRIVERS OF CHANGE
ATCO	Technological innovations.
CITY OF MH	(We anticipate) Improved safety and reduced liability of someone going on a property and getting injured. Allows for immediate troubleshooting as we can pull up the meter remotely and disconnect the electrical or gas supply instantly in the case of an emergency. Rids all estimating as prior to AMI, we would read one month and estimate the next, but now our meters are read every four hours, which makes move-in and move-out billing so much easier.
MB HYDRO	Safety is paramount and the need to increase the frequency of reads at remote locations. Our northern metering is done once a year, and we have to fly in to do them. So, accessibility is a problem for us.
SASK	Not sure.
ENBRIDGE	From our perspective and up until recently, the business case for AMI was not there because it was entirely viewed as remote access technology. Flash forward two years, we are looking at ensuring the integrity of the entire system and how can we make it more robust. Remote reading was not there in terms of the cost-benefit analysis. We see it now as a more viable case, a holistic approach that goes beyond meter reading to monitoring specific things. Optimizing the customer experience is important too. If customers are given the ability to access their consumption online, that would be considered a plus.
ENERGIR	Driven by both customer demand, cost savings, improving our relationships with clients, new options for clients to follow their consumption trends.
HERITAGE	These changes are really coming from myself. Most of our readers' time is used loading and downloading data files. It's not efficient in terms of time. We are quite small, have 8000 customers.
AB FED	In rural areas, there are concerns about having persons enter properties to manually read meters as this could lead to cross-pollination (transferring something from one field to the other). AMR is more convenient as the customer doesn't always provide their monthly or annual reading on time. With AMR, the utilities can collect accurate readings on the same day of every month and at the same time of day (8 am).
PNG	Reducing risk to our employees as they have to enter people's properties that have dogs and other hidden hazards. It costs us money to send people out to conduct manual meter readings. AMR will allow us to collect more accurate readings as some of our meters we can't access, but with the radio present, we'll be able to drive by and ping it.
ALTA GAS	I think it's the natural progression of metering.

SECTION 2: CURRENT MANUAL METER READING PRACTICES

Q3. Does your organization currently do any manual gas meter reading? **[IF YES]** Q3a.
How many meters do you read manually?
Q3b. What percentage of your total meters do you think this represents?

RESPONDENT NUMBER	YES	NO	TOTAL METERS	NUMBER READ MANUALLY	% OF TOTAL READ MANUALLY	COMMENTS
ATCO	X		1,200,000	300	.0003	Yes, we do, but it's very minimal. We have to report specific statistics to the AUC, and we're currently blowing our stats out of the water. We have to read manually (twice per year) in the case of customer refusal. The customers whom we read manually for are uncomfortable with what we do with the data fear being spied on or that advanced meter readings will interfere with their medical devices.
CITY OF MH		X	90,000	0	0.0	100% AMI

MB HYDRO	X		310,100	310,000	99.9	We read approximately 310,000/100% (of our) gas meters manually. We have 100 meters that are automated for our large, high volume customers. Plus, we read another 600,000 electric meters manually.
SASK	X		399,000	2,793	0.007	Of our 399,000 endpoints, 99.3% (396,207) are now AMI leaving 2,793 endpoints that are manually read, but these will be upgraded to AMI over the next year. Of the 2,793, approximately 1000 are residential clients, and the remaining 1,793 are high-consumption, large commercial or industrial customers. Our goal is to be 100% AMI by the end of 2021. We did pilot AMR in one community using drive-by meter reading, but that community is in the process of being converted to AMI.
ENBRIDGE	X		3,700,000	3,570,000	97.0	In total, we have about 3,700,000 meters, and out of these, 1-3% (37,000 – 130,000) are remotely read, and the rest (97-99%) are all manual. The remotely read meters are both industrial (high consumption, high volume) and residential customers.
ENERGIR	X		229,464	675	.003	In 1993, we changed 99.98% of our meters to AMR, leaving us with only 675 (.003%) of 229,464 meters that are still manually read. We have a program in place to upgrade these remaining meters to AMR. The reason they are still manual is because they are hard to get to, or replacement is difficult.
HERITAGE		X	8,000	0	0.0	Yes, but this will end as of mid-October. We're in the last stages of converting our large rotary meters to AMR.
AB FED	X		110,000	30,000	27.0	Not really. They read through the AMR system now for the most part. NOTE: AB FED responded "not really" to this question but does in fact read 30,000 meters manually.
PNG	X		41,200	40,000	97.0	We have approximately 41,200 meters, of which 40,000 are read manually (97.08) and 1,200 (2.92%) are converted to AMR.
ALTA GAS	X		85,000	100	0.12	Yes. We conduct our AMR readings via fly-by every month. But if we can't get a read via fly by, we go out and conduct a manual read on the 3rd month.
TOTAL	**8**	**2**	**6,172,764**	**3,953,868**	**64.05%**	

b) How many of your meters are automated? [COLLECT NUMBER AND PERCENT]

RESPONDENT NUMBER	TOTAL METERS	NUMBER OF AUTOMATED METERS	% OF TOTAL AUTOMATED	COMMENTS
ATCO	1,200,000	1,199,700	99.9	*We read approximately 1.2 million meters, of which less than .5% are read manually if that. We're talking about a few hundred customers across Alberta that we still manually read for.*
CITY OF MH	90,000	90,000	100.0	
MB HYDRO	310,000	100	0.10	*We have 100 meters that are automated for our large, high volume customers.*

SASK	399,000	396,207	99.3	
ENBRIDGE	3,700.000	130,000	3.0	
ENERGIR	229,464	228,789	99.7	
HERITAGE	8,000	8,000	100.0	
AB FED	110,000	80,000	72.7	30,000 (27%) of the 110,000 meters are still read manually.
PNG	41,200	1,200	3.0	
ALTA GAS	85,000	84,900	99.88	We have a total of 85,000 meters, and 98-99% of our meters are converted to AMR and the reads conducted via fly-by. In a month, we would conduct less than 200 reads manually should we not be able to capture the read via fly-by. We have approximately 30 customers who refused AMR due to perceived concerns about the health risks associated with the radio waves.
TOTAL	**6,172,764**	**2,218,896**	**35.95%**	

c) Are your manual readings performed in-house or by a third-party vendor?
   a. How many meters are read in-house as opposed to by a third party? [COLLECT NUMBER AND PERCENT]
   b. Which third-party company do you use for your meter reading?
   c. How long have you been using them?

RESPONDENT NUMBER	IN-HOUSE	CUSTOMER	VENDOR	AFFILIATE	N/A	NUMBER/% OF METERS READ IN-HOUSE	NUMBER/% OF METERS READ BY VENDOR/AFFILIATE	VENDOR/AFFILIATE CURRENTLY USED	FOR HOW LONG
ATCO	X					300/100%	0/0%	None	n/a
CITY OF MH					X	0/0%	0/0%	None	n/a
MB HYDRO				X		0/0%	100/100%	MHUS	LATE 90'S
SASK				X		0/0%	2,793/100%	SASK POWER	OVER 20 YRS
ENBRIDGE			X			0/0%	3,570,000/100%	UMS & MET	10-12 YRS
ENERGIR	X					675/100%	0/0%	None	n/a
HERITAGE					X	0/0%	0/0%	None	n/a
AB FED	X	X				NOT SURE	0/0%	None	n/a
PNG	X					40,000/100%	0/0%	None	n/a
ALTA GAS	X					100/100%	0/0%	None	n/a
TOTAL	**5**	**1**	**1**	**2**	**2**				

Q4. I'm curious about what you think the benefits or advantages are to an [IN HOUSE/OUTSOURCED/COMBINED] approach to meter reading. What can you tell me?

RESPONDENT NUMBER	IN-HOUSE	VENDOR/AFFILIATE
ATCO	From my perspective, the people I've employed to do the manual readings have been in the business a long time and are really experienced. They have been involved in the evolution of reader technology. Experience is important.	
CITY OF MH	There were some advantages to in-house manual readers because they had eyes on a property, so (they) were able to identify irregularities such theft, safety concerns, DIY hookups, and leaks. They took pride in their work.	
MB HYDRO		Not sure, I don't see any advantages. It would be nice if we moved it in-house.
SASK		Refuse
ENBRIDGE		The main benefit of outsourcing is the considerable cost savings to us by not having to employ in-house readers as employees come with loading costs equal to 30-35% on top of their salary. We can get a meter read for less than $2 per meter, and the contractors assure that they are effective and efficient in doing their work.
ENERGIR	I wouldn't know the answer, but I would say keeping it in-house and using our own employees is more cost-effective than outsourcing.	
HERITAGE	As I mentioned, we are small, so our in-house readers are also qualified to make some routine maintenance repairs to the site (remove intrusive trees or shrubs) and meters (paint them or attach brackets, etc.). They are unable to make repairs to the meters in the field as they are sealed units. We ship our meters to FortisBC for repair and resealing. For our rotary meters, they can go into the EVCs and change the batteries and perform routine maintenance tasks. My assumption is that outsourced manual meter readers are not technicians or qualified to make onsite maintenance repairs. We're small, so manual meter reading is not a full-time role; we combine it with technical support.	
AB FED	These utilities don't have a lot of manpower, and so the manual readings are typically conducted either every six months or annually. Otherwise, they rely on customer reads. The time required to manually read is huge, given how large the properties are. In high-density areas, a company can manually collect 20 reads per day. In rural areas, they may be able to conduct one. It takes two or three days to have all of their staff go out and conduct manual reads.	
PNG	Conducting our manual reads in-house allows us to have control and flexibility over our resources. For PNG West, we don't have dedicated meter readers. They are also technicians, so (they) can hang the meters, detect odour leaks, etc. For PNG NE, we had dedicated meter readers.	

ALTA GAS	For us, the advantages of AMR are time and no interaction with the customer. A lot of our customers are rural, so they don't like people on their property, and there are no obvious hazards like dogs. We conduct so few manual reads in a month, and in the event that we were unsuccessful in collecting a read via fly-by. The work would be so inconsistent for a contractor as we don't know how many will need to be read each month. Currently, we dispatch a field technician to collect a manual reading. They can assess and confirm the reading on the ERT with a handheld computer. If it comes back as the same number, the pilot may have been slightly off course. If the ERT is failing, we can fix the programming but not the meter. We have to send faulty meters out for repair.	

Q5. [IF VENDOR] Are there lots of choices in the market today when it comes to vendors who provide meter reading services? a) Which ones are you aware of?

d) So approximately how many are there?

e) Are these companies generally local? Provincial? National?

RESPONDENT NUMBER	YES	N/A	NOT SURE	REFUSE	VENDORS AWARE OF	NUMBER OF VENDORS	LOCAL, PROVINCIAL, OR NATIONAL
ATCO		X			N/A	N/A	N/A
CITY OF MH		X			N/A	N/A	N/A
MB HYDRO			X		NONE	NOT SURE	NOT SURE
SASK	X				NONE	NOT SURE	NOT SURE
ENBRIDGE	X				NONE	NOT SURE	NOT SURE
ENERGIR			X		N/A	N/A	N/A
HERITAGE		X			N/A	N/A	N/A
AB FED			X		NONE	N/A	N/A
PNG	X				N/A	N/A	N/A
ALTA GAS		X			N/A	N/A	N/A
TOTAL	**3**	**4**	**3**				

Q6. Thinking back to when your company selected their metering reading partner or vendor. Who else did you consider? [COLLECT NAMES]

RESPONDENT	N/A	NOT SURE	REFUSE	OTHER VENDORS CONSIDERED/COMMENT
ATCO	X			We piloted using contractors in the past up in Ft. McMurray, and they caused us more headaches than they worth, so we don't use vendors anymore. I can't remember who we contracted for this pilot.
CITY OF MH	X			
MB HYDRO		X		
SASK	X			

ENBRIDGE		X		Not sure. I can tell you that this is handled by our contracts department, and they likely follow the standard RFP process.
ENERGIR	X			We've always performed our manual readings in-house, so I don't know about vendors out there. For our AMR readings, we were looking at two vendors (ITRON & AMERICAN METER), and both are meter and reading providers. The AMR meters were installed by us. We went with ITRON because we felt that they were the best fit for our needs. Their quality has always been there, and their pricing has been great. We always get great service from that vendor in terms of answering our questions. We've stuck with this one vendor. We have meters exclusively in the province of Quebec (Montreal, Quebec City, and Northern Quebec).
HERITAGE	X			
AB FED	X			
PNG	X			
ALTA GAS	X			
TOTAL	**8**	**2**	**0**	

Q7. In your opinion, has the number of vendors you have to choose from changed over the past five years?

RESPONDENT NUMBER	YES	NO	NOT SURE	N/A	REFUSE	COMMENTS
ATCO				X		
CITY OF MH				X		
MB HYDRO		X				
SASK				X		
ENBRIDGE	X					Yes. I think what's causing the change is the growth of AMI and consumer demand for access to data.
ENERGIR				X		
HERITAGE				X		
AB FED				X		
PNG				X		
ALTA GAS				X		
TOTAL	**1**	**1**	**0**	**8**		

a) What about the quality – any changes there?

RESPONDENT NUMBER	YES	NO	NOT SURE	N/A	REFUSE	COMMENTS
ATCO				X		
CITY OF MH				X		
MB HYDRO		X				We've had issues in the past, but we've made it a priority to train our readers to manage these issues and to identify issues onsite that they see, so it's gotten better in recent years.

SASK				X		
ENBRIDGE			X			
ENERGIR				X		
HERITAGE				X		
AB FED				X		
PNG				X		
ALTA GAS				X		
TOTAL	**0**	**1**	**1**	**8**	**0**	

b) And what about costs? Have costs for procuring meter reading services changed over the past five years?

RESPONDENT NUMBER	YES	NO	NOT SURE	N/A	REFUSE	COMMENTS
ATCO				X		
CITY OF MH				X		
MB HYDRO		X				
SASK				X		
ENBRIDGE		X				
ENERGIR				X		
HERITAGE				X		
AB FED				X		
PNG				X		
ALTA GAS				X		
TOTAL	**0**	**2**	**0**	**8**	**0**	

c) [IF COSTS ARE INCREASING] What's driving that increase in costs?

RESPONDENT	DRIVERS OF COST INCREASES
ATCO	N/A
CITY OF MH	N/A
MB HYDRO	N/A
SASK	N/A
ENBRIDGE	Inflation drives cost fluctuations, but that is to be expected.
ENERGIR	N/A

HERITAGE	N/A
AB FED	N/A
PNG	N/A
ALTA GAS	N/A

d) [IF COSTS ARE INCREASING] How is your company planning to deal with these rising costs?

RESPONDENT	PLANS TO DEAL WITH RISING COSTS
ATCO	N/A
CITY OF MH	N/A
MB HYDRO	N/A
SASK	It was so inexpensive for us to manually meter read that we couldn't make the business case to upgrade to AMI based on gas meters alone, so we had to partner with Sask Power to present our case.
ENBRIDGE	Nothing.
ENERGIR	N/A
HERITAGE	N/A
AB FED	N/A
PNG	N/A
ALTA GAS	N/A

e) [IF COSTS ARE INCREASING] Do you think these increases are going to have an impact on the industry?

RESPONDENT	IMPACT ON INDUSTRY
ATCO	N/A
CITY OF MH	N/A
MB HYDRO	N/A
SASK	N/A
ENBRIDGE	N/A
ENERGIR	N/A
HERITAGE	N/A
AB FED	N/A
PNG	N/A
ALTA GAS	N/A

SECTION 3: CURRENT ADVANCED METER READING PRACTICES

Now I'd like to talk with you briefly about your advanced meter reading practices.

Q8. Does your organization currently utilize AMI and/or AMR technology for gas metering?
a) What can you tell me about it? [When did you start, how many ERTs/Endpoints?]

RESPONDENT NUMBER	YES AMR	NUMBER AMR ENDPOINTS	YES AMI	NUMBER AMI ENDPOINTS	NO	START YEAR
ATCO	X	1,199,700		0		2011
CITY OF MH		0	X	90,000		2012
MB HYDRO		0		0	X	N/A
SASK		0	X	396,207		2013
ENBRIDGE	X	130,000		0		NS
ENERGIR	X	228,789		0		1993
HERITAGE	X	8,000		0		2017
AB FED	X	80,000		0		2011
PNG	X	1,200		0		2018
ALTA GAS	X	84,900		0		2015
TOTAL	**7**	**1,732,589**	**2**	**486,207**	**1**	

RESPONDENT	COMMENTS ON AMR/AMI HISTORY
ATCO	We installed AMR technology in 2011. Until 2015, we conducted drive-by readings but switched to aerial in 2015. We use a vendor called Clear Grid to conduct our aerial readings. Aerial is much more efficient in terms of cost savings for sure and safety, which is a big advantage for us as injuries happen daily with drive-by or manual reads. With drive-by, you have to employ quite a few people who drive vehicles that need to be maintained and insured. A plane picks up more readers in a day. When aerial was first made known to us, there was just one vendor in Alberta, so we didn't jump on it. They were expensive, so we didn't move ahead. As (the) technology evolved, another aerial reading company, Clear Grid, approached us and offered better pricing and a better product. They've been great. We haven't been approached or sought out any new vendor. It's an expensive contract, so we only sign short-term contracts.
CITY OF MH	We executed a six-month pilot of AMI in 2012 that was successful, so we began full deployment in 2013 and finished in 2015. The Sensus FlexNet system is a "single-tier" system, meaning readings are transmitted directly from the meter endpoint to one or more Tower Gateway Base Stations (TGBs), which are usually miles apart from each other. We have 7 TGBs that cover our area, so a city fibre ring that collects all the data from the endpoints every four hours, which is integrated with our billing system. So, we don't require third-party vendors for anything. We started in 2012 and are now 100% AMI across 90,000 endpoints.
MB HYDRO	For the 100 or so large consumption clients, we don't use AMR or AMI technology but a SCADA System. The system we use is basically a network that allows us to monitor our high-volume customer's consumption and pressure. If there are any issues, it sets off an alarm alerting us that we need to send someone out to inspect.
SASK	We started looking at AMI in 2013 and were fully deployed by 2018 (396,207 AMI endpoints upgraded). We continue to pick away at upgrading the remaining 2,793 endpoints.
ENBRIDGE	Yes, 1-3% of our 3,700,000 meters are read via AMR. We have small pockets of residential customers (130,000/3.7m) who have AMR technology installed plus a small percentage of commercial/industrial customers. We are not using AMI yet.
ENERGIR	In 1993, we changed 99.98% of our meters to AMR, leaving us with only 675 (.003%) of 229,464 meters that are still manually read. We have a program in place to upgrade these remaining meters to AMR. The reason they are still manual is because they are hard to get to or replacement is difficult.

HERITAGE	In 2017, we initially converted 7000 meters to AMR and, since then, have added a further 500-600 customers. The remaining 400500 large rotary meters will be converted by mid-October.
AB FED	In 2011, we started to convert to AMR. Currently, 80,000/110,000 endpoints are AMR.
PNG	Over the past two years, we have converted 1,200 meters to AMR, with a further 20,000 approved to be converted over the next 6-9 months (mid-2021)
ALTA GAS	We implemented AMR in 2015 and through 2016. 84,900/85,000 99.88% are read via AMR. We have about 30 customers who declined AMR. A lot of it is to do with the radio waves as a health risk.

Q9. What sorts of things is your company thinking about specifically when it comes to automated meter reading? Are there specific things you're thinking about, discussing or planning?

RESPONDENT	AUTOMATED METER READING PLANS
ATCO	Nothing on the radar, but we're always looking to improve. In our case, there is not a whole lot of room for improvement, so we're just monitoring at the moment. So long as we're picking up reads every other month and not missing the same meters, then we're satisfied. We have a 99.6% success rate. We are obligated to report to the AUC (Alberta Utilities Commission) two primary statistics; 3-month estimate reads and the monthly read percentage overall.
CITY OF MH	The Sensus FlexNet system is capable of doing a lot of things, so when something new comes along, they can upgrade our software without having to replace our smart readers. We could have worked with the City of Medicine Hat to move to smart street lighting where they could be controlled remotely, but we didn't do that. Remote disconnect is really important in the case of an emergency, meaning if a house was on fire or there was a gas leak. This offers safety as well, given you don't have to send in people into a dangerous situation to manually shut off utilities. This would have been really useful during the floods, for example. AMI allows you to understand the highs and lows of pressure monitoring using a simple battery-operated device placed in remote areas. It also allows us to monitor pipe conditions (corrosion).
MB HYDRO	We are looking to implement full AMI.
SASK	N/A
ENBRIDGE	One of the items we're looking at is what approach makes sense. What metering technologies are out there and approved for use in Canada. The actual technology, what other ancillary functions/data can they deliver in addition to the readings. This would include cathodic and pressure monitoring, automatic shut-offs, etc. How will switching to AMI work alongside currently used standard practices within Enbridge? There are many departments involved in evaluating the various AMI technologies and providers, including engineering, regulatory measurement, business development and, operations are all involved in the decision-making process. What makes sense in terms of a rollout strategy? Do you start with a small pilot project and then go bigger? One of the things we discussed was whether it makes sense to upgrade meters to AMI only as they come due for recertification. But that will take forever and will be at least 25-30 years process. We would consider leveraging Measurement Canada's ability to offer special dispensation on the certification requirements. Each meter has to be reverified after a certain number of years in
	the field (residential = ten years) and often needs to be replaced at that point. What Measurement Canada did for the electricity sector was offer special dispensation provided the meters were well maintained and verified as still accurate, they can be used beyond their recommended replacement date. The benefit to this is that if an area has 100 customers and 10 meters are coming due for replacement, I have to send a tech out there to replace those 10 meters with AMI readers. The next year, I may only have 1 meter coming due. So, it could take years to replace all 100 meters on this basis. If I am able to replace all 100 meters in one trip, it would probably take 3-5 techs over a one-week period to get the job done. This would allow for a homogeneous network of meters calling in so this would make the most sense to me to do it this way. Tackle one area at a time over a five-year period.
ENERGIR	Nearly 100% AMR
HERITAGE	We will potentially convert to AMI, but this is not in our current business plan for the next year or two. We likely will, but it's not a top priority right now because we're so small. The ERTs on each meter that we have are first-generation, so they won't work for AMI. We invested a couple of million dollars in AMR in the last three years, so we can't just put a bunch of towers up and start converting to AMI.
AB FED	We're hoping to convert the remaining 30,000 to AMR. Another 600 will be converted this year. All will be converted to AMR if the utility agrees to convert. We're the umbrella organization that oversees the utilities. We control the installing of the AMR devices, and so when the utility is planning their install, we review every piece of paper they fill out. There's a lot of paperwork involved. We conduct spot audits to ensure they have been done properly.
PNG	AMI demands extra infrastructure and is cost-prohibitive for us given our geographic challenges.

ALTA GAS	The 30 customers who declined AMR are unlikely to convert unless they move, and the new customer agrees to it. If a customer is an AMR refuser, we send someone out on the 3rd month, and there is a charge for this. We've discussed ultrasonic meters, but we would have to do our own in-house/pilot testing first, but it has some interesting features. When we start doing lock-offs for nonpayment, we won't have to send someone onto the property to do this. We would be able to do it from the plane. We can lock- off service in the summer (May until about now), but we choose not to do so in during the winter.

[IF NOT EMPLOYING AMI/AMR] Do you plan on doing this? When? What is the advantage?

RESPONDENT	YES	NO	NOT SURE	N/A	WHEN	ADVANTAGES/COMMENTS
ATCO				X	N/A	No plans to upgrade to AMI
CITY OF MH				X	N/A	Already upgraded to full AMI
MB HYDRO	X				2025	This will allow us to overcome our issues with remote locations. 80% of our population is in the southern half of Manitoba so those in the North are pretty remote, which is why we only conduct readings once a year.
SASK				X		Accurate meter reading, lots of errors with manual meter reading, reduced truck rolls for tenancy changes, etc. I do believe we did see reduced call volume to the customer service area.
ENBRIDGE	X				NOT SURE	Not sure. A smooth integration with Union Gas is a priority for us right now.
ENERGIR	X				NOT SURE	The timeframe for conversion of the remaining 675 to AMR is hard to say. It depends on if the meter has been part of our meter exchange program.
HERITAGE			X		NOT SURE	Not sure for AMI, but eventually (will implement AMI).
AB FED				X		The utilities we oversee are not big enough to move from AMR to AMI. The readings aren't sent to us. There are not that many of our 80 utilities who would have 8,000 customers, for example. AMR meets their needs.
PNG				X	N/A	AMI demands extra infrastructure and is cost-prohibitive for us, given our geographic challenges.
ALTA GAS			X		NOT SURE	We will not be looking at ultrasonic meters until they are approved. We are a smaller utility, so any changes will be taken in small steps. We won't make massive changes right away.
TOTAL	**3**	**0**	**2**	**5**		

SECTION 3: CLOSING

Q10. [IF NECESSARY] Imagine it's five years from now. What will your meter reading look like from the standpoint of a) automated versus manual, and; b) from the standpoint of in-house manual reading versus outsourced?

RESPONDENT NUMBER	FUTURE OF METER READING
ATCO	Given the success that we're having today, all is meeting expectation. I don't see in five years anything changing for us. There may be new opportunities that come along, but we will only act on it if it's a good decision both financially and in terms of customer impact.
CITY OF MH	We will not be going back to any manual reading as we love the hourly reads. If a meter stops or speeds up due to malfunction, we're on it right away and can establish the cause of the problem. We had one case where a customer killed himself by blowing up his house by turning the gas up. We were able to prove that he turned up the gas and that it was not, in any way, a malfunction. Our system is run by the City, the supplier of the product can do all of the data analysis, but we do that all in-house. We are looking at doing more analytics in-house, but that may change in the future. We have tied our system to the GIS so they can run models and analytics, which has been helpful.
MB HYDRO	Fully AMI, so no need for in-house or outsourced metering.

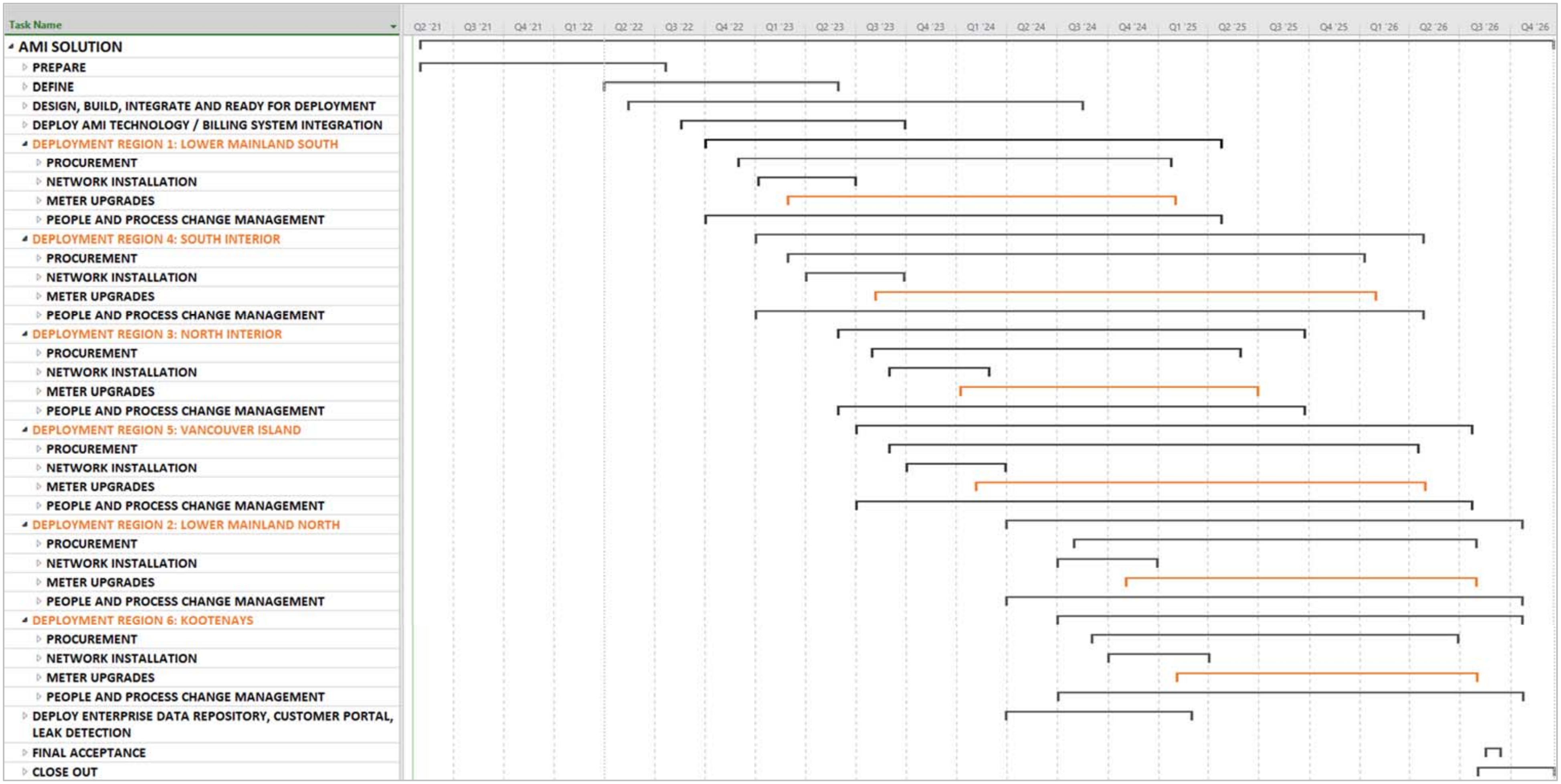
SASK	AMI allows us to do a lot of things like monitoring cathodic protection and pressure. We had a large pipeline rupture, and we used AMI data to show us where the gas wasn't flowing anymore. We were able to identify customers (those who winter elsewhere, Snowbirds) that were unaware of an interruption to service, so no heat, which was an advantage as we were able to stop any unnecessary damage to those properties.
ENBRIDGE	Realistically, within the next 7 years. Along the lines of some of the stuff, Enbridge needs to work out as the two companies (Enbridge and Union Gas) are on two different rates.
ENERGIR	We will be 100% switched to AMR. We may make a move to AMI in the years to come. We're still looking at the technology and benefits. The benefits of AMI would be cost savings, less drive-by, reduce our OPEX costs, improve client satisfaction, and security for the network (allow us to identify faulty equipment and over-pressured valves). Further, with AMI we would be able to have the data hourly so more accurate billing and less dispute with clients and a better understanding of the problematic meters. Urgent shut-off is a benefit as well as the safety of employees during urgent issues.
HERITAGE	Realistically, in five years, we will not have converted to AMI but will have it on our wish list. By then, our AMR cycles will be condensed to two days per month. The ERTs we're starting to buy now are good for 20 years. We use ITRON. All of their ERTs coming out now through ITRON are AMR/AMI compatible I believe.
AB FED	I see all meters converted to AMR, but some of these utilities charge $50/read, so they make money from in-house manual reads. By converting to AMR, they will lose that revenue but will likely gain in terms of more accurate reads and a reduction of imbalances. What I mean by imbalances is when the customer reads, some read right away and send the read in while others might send their reading in 10 days later or the day before the bill is due. AMR allows for readings to be conducted every month.
PNG	At this point, I would say we have 50/50 chance of being fully AMR in five years.
ALTA GAS	I expect we'll have some ultrasonic meters, but for the most part, we will remain status quo with our AMR technology.

Q11. Is there anything else you can tell me about the changes and challenges that are happening in the meter reading industry?

RESPONDENT NUMBER	COMMENTS
ATCO	I go to meetings and conferences all the time, and I know there is new technology coming out, but it's very similar to what we're using now. Not aware of anything particularly groundbreaking.
CITY OF MH	We're trying to understand the changes and challenges that are happening in the meter reading industry constantly. Even now, with Covid, we have 2000 homes with meters in their houses and reading remotely is great because we don't have to place employees at risk by entering homes. There is great justification for the cost of AMI as the rewards are many. We don't have to roll a truck out every time a meter hasn't been read in months. The safety of the meter readers is so important. Injuries happen every day. This was a big point for us. The system we went with is radio, so it can be updated in the future without having to pull any assets.
MB HYDRO	N/A
SASK	One of the big things we've noticed is a desire on the part of customers to have access to real-time data in order to gain efficiency. There are some limitations to the granularity we can provide but adding a customer portal to our website where customers could go into their account and look at their readings whenever they want is worth considering. Third parties are approaching us for our data, including GreenWave and NetZero home builders.
ENBRIDGE	I think AMI needs to go beyond meter reading to really leverage the full potential of automatic shut-offs and the customer experience, for example. AMI will allow Enbridge to control the overall picture of what our system looks like and how it's performing. We don't have everything interconnected at the moment.
ENERGIR	N/A
HERITAGE	We used ITRON to do the AMR installs for us, but one thing to keep in mind for deployment is that we experienced issues with accessing the meters. Locating the meters was a challenge as we have so many different lists and areas. The people we hired were coming out of the US, so they didn't know where or how to find some of our meters. We discovered that some of the meters were missed thus didn't have ERTs on them, which meant we didn't capture a read for them. Our billing system flags us, so we had to go back out and convert the 'hard to find' meters.
AB FED	We monitor the gas supply coming off pipelines from 600 stations to the utilities. If a station goes into alarm, we alert the utility that there is a problem such as low pressure, which could lead to a shortage of supply to their customers. They can check it themselves or send someone out to resolve the problem to prevent losing customers. Some of these stations are 3 hours away.
PNG	No, I don't think I have anything more to add.
ALTA GAS	For us, AMR has been successful. It has delivered cost savings to our company.

Appendix D

PROJECT IMPLEMENTATION SCHEDULE


Task Name
Q2 '21
Q3 '21
Q4 '21
Q1 '22
Q2 '22
Q3 '22
Q4 '22
Q1 '23
Q2 '23
Q3 '23
Q4 '23
Q1 '24
Q2 '24
Q3 '24
Q4 '24
Q1 '25
Q2 '25
Q3 '25
Q4 '25
Q1 '26
Q2 '26
Q3 '26
Q4 '26
AMI SOLUTION
PREPARE
DEFINE
DESIGN, BUILD, INTEGRATE AND READY FOR DEPLOYMENT
DEPLOY AMI TECHNOLOGY / BILLING SYSTEM INTEGRATION
DEPLOYMENT REGION 1: LOWER MAINLAND SOUTH
PROCUREMENT
NETWORK INSTALLATION
METER UPGRADES
PEOPLE AND PROCESS CHANGE MANAGEMENT
DEPLOYMENT REGION 4: SOUTH INTERIOR
PROCUREMENT
NETWORK INSTALLATION
METER UPGRADES
PEOPLE AND PROCESS CHANGE MANAGEMENT
DEPLOYMENT REGION 3: NORTH INTERIOR
PROCUREMENT
NETWORK INSTALLATION
METER UPGRADES
PEOPLE AND PROCESS CHANGE MANAGEMENT
DEPLOYMENT REGION 5: VANCOUVER ISLAND
PROCUREMENT
NETWORK INSTALLATION
METER UPGRADES
PEOPLE AND PROCESS CHANGE MANAGEMENT
DEPLOYMENT REGION 2: LOWER MAINLAND NORTH
PROCUREMENT
NETWORK INSTALLATION
METER UPGRADES
PEOPLE AND PROCESS CHANGE MANAGEMENT
DEPLOYMENT REGION 6: KOOTENAYS
PROCUREMENT
NETWORK INSTALLATION
METER UPGRADES
PEOPLE AND PROCESS CHANGE MANAGEMENT
DEPLOY ENTERPRISE DATA REPOSITORY, CUSTOMER PORTAL, LEAK DETECTION
FINAL ACCEPTANCE
CLOSE OUT

Appendix E

RISK ANALYSIS

FILED CONFIDENTIALLY

Appendix E-1

YPCI RISK ANALYSIS AND RISK REGISTER

FILED CONFIDENTIALLY

Appendix E-2

YPCI RISK MANAGEMENT PLAN

FILED CONFIDENTIALLY

Appendix E-3

YPCI CONTINGENCY ESTIMATE

FILED CONFIDENTIALLY

Appendix F

EXPONENT REPORTS

Appendix F-1

EXPONENT RF TECHNOLOGY REPORT

Electrical Engineering & Computer Science Practice

Radiofrequency Fields in the Environment and from Advanced Metering Infrastructure

Radiofrequency Fields in the Environment and from Advanced Metering Infrastructure

Prepared for

British Columbia Utilities Commission

At the Request of

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Prepared by

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Bowie, MD 20715

May 3, 2021

1509451.000 - 1728

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Acronyms and Abbreviations

AM	Amplitude modulated
CDMA	Code-division multiple access
EIRP	Equivalent isotopically radiated power
FM	Frequency modulated
FSK	Frequency-shift-keying
Gateway	Sensus FlexNet Gateway
GSM	Global system for mobile communications
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEEE	Institute of Electrical and Electronics Engineers
ISED	Innovation, Science and Economic Development Canada
MHz	Megahertz
MoM	Middle-of-minute
ms	Millisecond
mW/cm^2	Milliwatts per square centimeter
RF	Radiofrequency
SAR	Specific absorption rate
SC6	Safety Code 6
SentryPoints	Sensus FlexNet SentryPoints™
SmartPoints	Sensus FlexNet SmartPoint® modules
Sonix IQ gas meter	Sensus Sonix IQ™ advanced meter
W	Watts
W/cm^2	Watts per square centimeter
W/kg	Watts per kilogram
W/m^2	Watts per square meter

Limitations

At the request of FortisBC Energy Inc. (FEI), Exponent prepared this summary report on the types of common environmental exposures to radiofrequency electromagnetic fields and exposure to FEI advanced metering infrastructure. The findings presented herein are made to a reasonable degree of scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

Executive Summary

Similar to other utility companies (both electric and gas) throughout Canada and the United States, FortisBC Energy Inc (FEI) is in the process of modernizing their infrastructure with the proposed upgrade of natural gas meters as part of the Advanced Gas Meters project. Similar to the existing meters, these new meters will record gas consumption over time and will have the added ability to communicate that usage information through a dedicated wireless network. The gas meters will be battery-powered and in addition to communicating gas consumption information, will also allow FEI to remotely detect and respond to gas leaks, including a remote shutoff capability in the event of an emergency.

FEI has selected the Sensus USA Inc. Sensus Sonix IQ™ advanced meter (hereafter, Sonix IQ gas meter) as the equipment to upgrade the gas metering system. The Sonix IQ gas meter will be a component of the FlexNet communication network that operates on a dedicated licensed portion (approximately 900 Megahertz) of the radio spectrum, a different type of operation than the FEI electric meter network, which operates in a license-free mesh network.

The purpose of this report is to describe the radiofrequency (RF) signal technology used by the FlexNet network. The Sonix IQ gas meter is the component of the network proposed to be most widely deployed, so the analysis focuses on the Sonix IQ gas meter, but the report also provides information about RF exposure levels from other components of the FlexNet network and how the exposures from these components compare to RF limits from Health Canada Safety Code 6 (SC6). In addition, this report provides context by describing some other RF sources encountered in daily life from both natural and man-made sources and compares the relative strength of these natural and man-made sources to those of the network components.

In typical operation, the Sonix IQ gas meter transmits RF energy for a total of approximately 0.34 seconds per day. This very low transmission time also means that the exposures in general are also low, especially the indoor RF exposure from the Sonix IQ gas meter, which is about 24 million times below the SC6 exposure limit, and substantially less than RF exposures from common natural and man-made sources.

1. Basic Physics of Electromagnetics

There are many natural and man-made sources of electromagnetic fields. Although not widely recognized, naturally occurring visible light is one of the most common electromagnetic fields to which we are exposed every day. Man-made electromagnetic fields include extremely low frequency sources such as the fields from power transmission and distribution lines, as well as higher frequency sources that are associated with transmission of radio and television broadcast signals and various wireless personal communication devices.

The primary defining characteristic of electromagnetic fields is their frequency. The frequency of an electromagnetic field is determined by the number of times it oscillates (i.e., changes direction) each second, and frequency is what governs how these fields interact with humans.[1]

Electromagnetic Waves

Electromagnetic waves are intuitively difficult to understand since most are invisible to the human eye and cannot be heard, tasted, touched, or smelled. Water waves, on the other hand, are quite familiar and can be used through analogy to illustrate some of the relevant properties of electromagnetic waves. For instance, when one drops a rock in a pond, the rock creates a water wave, which expands outward from the source. The wave propagating on the surface of the pond does not actually carry water molecules with it, rather the wave spreads to adjacent water molecules (propagates) when adjacent water molecules move up-and-down. The wave with the highest amplitude (i.e., height above the pond's surface) is at the source, and as it spreads outward, the height of the waves gets successively smaller. Figure 1, taken with a high-speed camera, illustrates how the up and down motion of the wave is highest at the source and diminishes as it expands outward.

[1] Both electromagnetic fields and electromagnetic waves are used concurrently in this report depending on which is more intuitive and more readily understandable, but in all instances, their meaning is the same.

Figure 1. Illustration of the concept of wave energy movement from a source.

Electromagnetic waves are made up of individual electric fields and magnetic fields and, similar to water waves, as electromagnetic waves propagate away from the source, the amplitude (i.e., the strength of the constituent electric and magnetic fields) decreases.

The Electromagnetic Spectrum

Although often assumed to include only radiofrequency (RF) fields, the electromagnetic spectrum in fact includes all forms of electromagnetic fields. As shown in Figure 2, electromagnetic fields are broadly classified as either *non-ionizing radiation* or *ionizing radiation*.[2] *Non-ionizing radiation* in the radio portion of the electromagnetic spectrum includes RF broadcast signals from amplitude-modulated (AM) and frequency-modulated (FM) radio stations and from television broadcasts, while light from the sun or from a flashlight are common examples of electromagnetic fields in the visible portion of the electromagnetic spectrum. These non-ionizing fields are described in the left side of Figure 1, shaded in light blue. The microwave (sometimes included in the definition of RF) and infrared portions of the electromagnetic spectrum fall between the radio and visible portions of the electromagnetic spectrum. All these non-ionizing fields are too weak to break the bonds within atoms or

[2] The term radiation simply means "energy propagated through space." It is used to describe energy emitted from any particular source such as heat from a campfire, light from a flashlight, acoustic energy from a stereo system, or the broadcast signal from an FM radio antenna (http://er.jsc.nasa.gov/seh/e.html#electromagnetic radiation and http://er.jsc.nasa.gov/seh/r.html#radiation).

molecules. In contrast, *ionizing radiation* such as from X-rays or gamma rays (described in the right side of Figure 1, shaded in purple) is strong enough to break molecular or atomic bonds.[3]

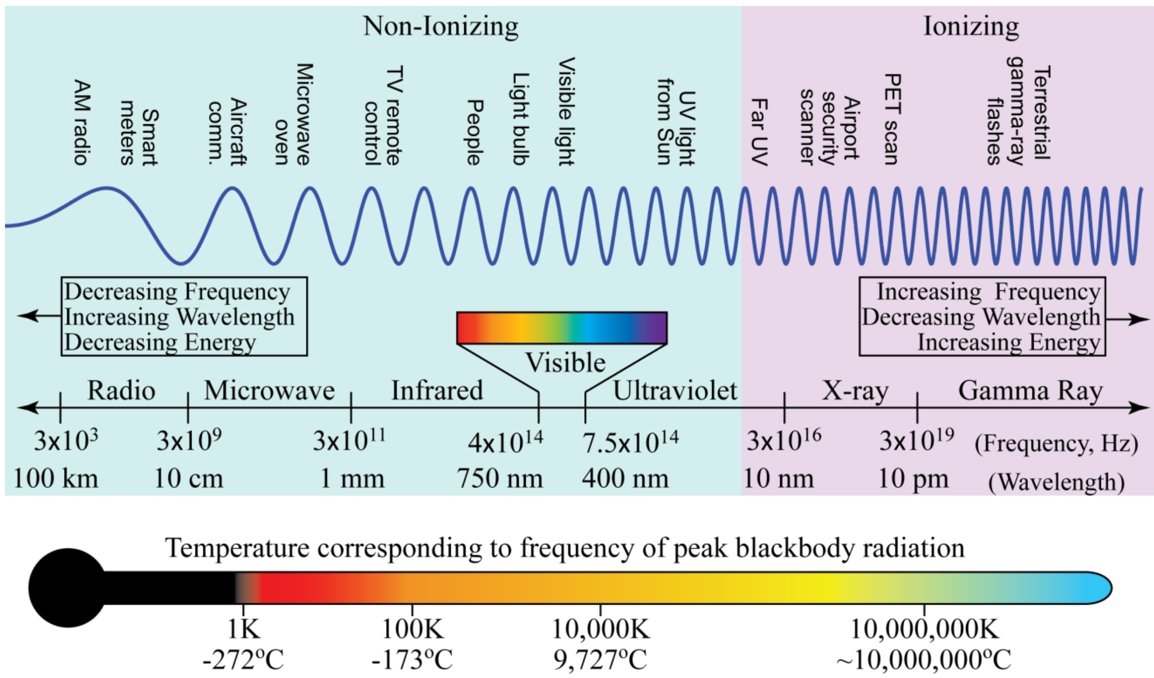

Figure 2. The electromagnetic spectrum and the relationship between frequency, wavelength, energy, and temperature.

Common Sources of Electromagnetic Fields

Technologies such as broadcast transmissions, radar, cell phones, and Wi-Fi are some of the most common man-made sources of electromagnetic fields, but in fact natural sources of RF are far more common and include lightning, the earth itself, and even other organisms, including humans.

The concept that the earth and humans, as well as virtually all objects, are sources of electromagnetic fields warrants additional attention. Extremely hot objects such as the sun produce electromagnetic fields primarily in the visible and ultraviolet portions of the spectrum,

3 http://www.who.int/ionizing_radiation/about/what_is_ir/en/

while colder objects such as the earth produce fields primarily in the infrared portion of the spectrum. This phenomenon is called thermal radiation or heat radiation, while scientists refer to it as blackbody radiation.

Blackbody Radiation

Any object (i.e., blackbody) that has a temperature above absolute zero[4] gives off electromagnetic energy; the temperature of the object determines the frequency at which most of the electromagnetic energy is produced. Hotter objects emit both more energy and energy at higher frequencies than colder objects.

Blackbody radiation from man-made sources

An electric stove provides a good example to illustrate how electromagnetic energy emitted by a blackbody changes at colder and hotter temperatures. When the stove burner is first turned on, it begins to heat up and produces stronger electromagnetic fields in the infrared portion of the spectrum than in the visual portion. This means that the burner still appears the same (black) but the electromagnetic energy can be felt by placing a hand nearby and feeling the infrared heat. As the burner gets hotter, it begins to glow reddish-orange, which is electromagnetic energy in the lower part of the visible spectrum. Household burners cannot heat beyond this point; however, if the temperature did increase further it would begin to glow a yellowish-white color (in the higher portion of the visible spectrum). At still hotter temperatures, such as from a welder's torch, the light would become bluish (the highest part of the visible spectrum), and at even higher temperatures, the light from the welder's torch would be in the ultraviolet range.[5] The same description applies to a gas-stove burner but the transition to blue light is more rapid.

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[4] Absolute zero is the temperature at which the motion of molecules theoretically stops, which is 0 on the Kelvin scale and equivalent to about -273 degrees Celsius or about -460 degrees Fahrenheit.

[5] The emission of this intense heat and ultraviolet light are among the reasons that welders wear protective glasses when performing their work.

Blackbody radiation from natural sources

As noted above, any object that has a temperature above absolute zero radiates electromagnetic energy and it does so at all frequencies (although very small amounts at very low or very high frequencies). Since humans and the earth both have a temperature of ~300 Kelvin, most of their emitted energy is in the infrared portion of the electromagnetic spectrum (i.e., it can be seen with the use of infrared imaging devices), but a very small portion of that energy is also emitted in the radio and microwave portions of the electromagnetic spectrum. Humans and the earth are therefore sources of RF energy (albeit very small sources).

Radiofrequency Communications

RF fields are an integral part of modern technology, particularly wireless communications; they are used in emergency beacon services, air traffic control systems, cell phones, and advanced metering infrastructure, to name a few. RF fields are also widely used in scientific research and many more industrial, commercial, medical, and personal applications. In addition to frequency discussed above, **power, duty cycle, modulation, frequency, reflection, and attenuation** are concepts common to most RF communication systems including the Sensus Sonix IQ™ advanced meter (hereafter, Sonix IQ gas meter) and associated FlexNet End Points supplied to FEI for their proposed gas network by Sensus USA Inc. (Sensus). These concepts are therefore discussed in greater detail below.

Power

The importance of power transmitted by devices is obvious; higher output power leads to higher RF signal levels and thus higher potential RF exposure. The other factors are discussed in greater detail below.

Duty Cycle

An important way man-made sources differ from one another is how often and in what patterns they transmit. Some sources transmit all the time at relatively constant power levels (e.g., FM radio and television broadcasts), while others transmit all the time but vary as to how much power is transmitted (e.g., Wi-Fi routers, AM radio). Intermittent operation is used by technology that only transmits based on data transfer needs and user demand. For example, advanced meters transmit only when they need to transfer data; cell phones transmit based both on user demand and when they interact with the mobile network; and microwave ovens only produce RF fields when they are used.[6]

RF exposure to a particular source based on transmission patterns can be simplified into the source's "duty cycle." Duty cycle is determined as a percentage of time the source transmits information. For example, sources that transmit continuously, whether at constant or varying power, have a duty cycle of 100%. The duty cycle of a device that utilizes an intermittent transmission pattern can be reported as either an operational duty cycle or an average duty cycle.

Since AM/FM radio and TV transmitters transmit continuously, they have a 100% duty cycle. The duty cycle of a Code Division Multiple Access (CDMA) cell phone, however, will vary based on how often the owner of the phone uses it—a 6-minute CDMA cell phone call in a 30-minute period has as an *operational* duty cycle of 20%, while a 1.5-minute call in a 30-minute period has an *operational* duty cycle of 5%.[7] Global System for Mobile (GSM) is another communication protocol commonly used by cell phones in Canada. Rather than transmitting continuously, a GSM phone transmits only 1/8th of the time (but generally at 8 times the power of a CDMA transmission). The duty cycle of the *RF transmission signal* from a GSM phone call is therefore 12.5%. For 6-minute GSM phone call in a 30-minute period, the total duty cycle is the product of the *operational* duty cycle and the duty cycle of the transmission: 20% × 12.5% = 2.5%. The FlexNet End Points send very short transmissions (typically about 55 milliseconds) at regular pre-programmed intervals of once every 4 hours. As discussed in more detail in Section 3, the typical duty cycle is 0.00039% (about 0.34 seconds per day).[8]

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[6] Some cell phones may also change transmission power output based upon circumstances, while all the FlexNet End Points always transmit with the same power output.

[7] When a call is made on a CDMA cell phone, it transmits continuously. This calculated *operational* duty cycle example should not be confused with the *actual* duty cycle of the emission of a CDMA cell phone.

[8] This information was provided by Sensus.

Modulation and Carrier Frequency

Radio broadcasting provides an easily understood example of the concepts of modulation and carrier frequency. The call number of the radio station, such as 88.1 FM or 690 AM in Vancouver, is actually a designation of the carrier frequency (i.e., the carrier signal). The frequency is modulated (i.e., changed) in order to send information on the carrier signal. In AM radio, the frequency of the signal is constant and the amplitude (i.e., strength) of the signal varies (as shown in Figure 3a).[9] This variation in strength is a code that the receiver (i.e., the radio in your car or home) decrypts to receive the information. In FM radio broadcasting, the strength of the signal is constant and the frequency of the signal varies (as shown in Figure 3b).[10] In this case, the variation in frequency is the code for information transfer.

In digital transmission, frequency-shift-keying (FSK) is a modulation scheme where, similar to FM, the frequency of the signal varies, but the variation is only between discrete frequencies (as shown in Figure 3c).[11] The amplitude of the signal in an FSK-modulated system (such as used by FlexNet End Points) does not depend on the transmitted information since only the frequency of the signal varies. This is important in an RF exposure assessment because it means the output power of an advanced meter does not change (it is either on or off) when transmitting.[12]

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[9] http://www.its.bldrdoc.gov/fs-1037/dir-002/_0277.htm

[10] http://www.its.bldrdoc.gov/fs-1037/dir-016/_2377.htm

[11] http://www.its.bldrdoc.gov/fs-1037/dir-016/_2347.htm

[12] This is in contrast to many cell phones in which the power output of the phone may vary from one call to another and even within the same call.

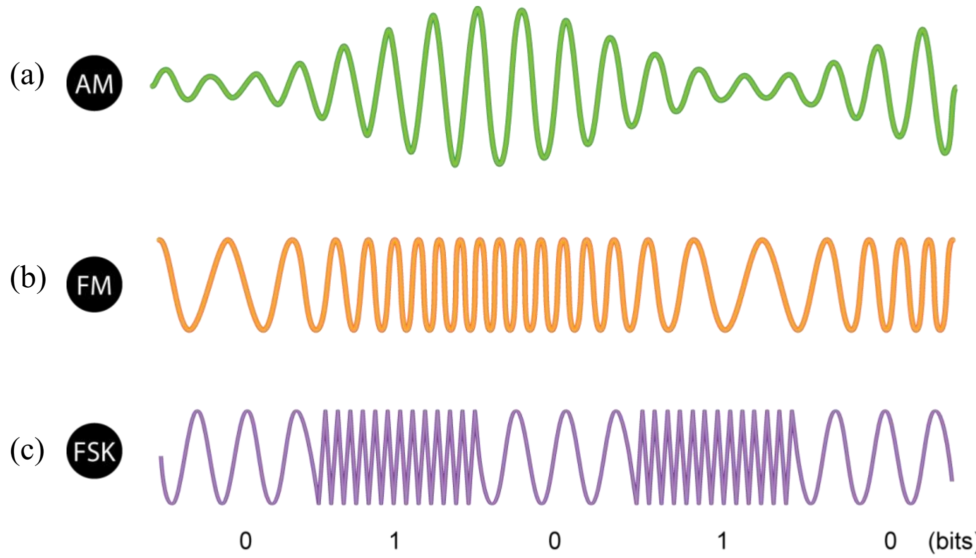

Figure 3. Examples of theoretical AM, FM, and FSK-modulated signals.

Reflection and Attenuation

When an electromagnetic wave reaches a boundary (such as the ground or a wall), part of the energy from the wave will reflect from that boundary and some will be transmitted through (attenuated to a lower level). The amount of energy reflected and the amount that passes through depends both on the frequency of the electromagnetic wave and on the material properties of the boundary.

The building materials of an individual's home therefore can have a significant effect on a person's RF exposure from external sources. For example, at the frequency of FlexNet communications or cell phones, a 20-centimeter-thick concrete wall allows less than 1% of incident RF energy through; a 9-centimeter-thick brick wall allows about 45% of the energy through; and a 1.9-centimeter-thick plywood wall allows over 80% of the energy through (NIST, 1997).[13]

[13] At lower frequencies, such as those used in television or radio broadcasting, the fraction of energy that passes through these materials is substantially higher.

Distance from the Source

While a boundary will cause some of the energy in an electromagnetic wave to reflect and attenuate, the signal strength also diminishes with distance from the source, even if the wave does not pass through any material that causes it to lose energy. This attenuation is due simply to the expansion of the wave, similar to the motion of a water wave described above. When the electromagnetic wave is transmitted, a finite amount of energy is released at the source. As the wave expands, this same amount of energy is spread out over a larger and larger area so that the amount of energy in any particular location decreases as the wave gets farther from the source. The power density of the RF field decreases with the square of the distance from the source according to the inverse-square law.[14] So, an individual located 10 meters away from a source will be exposed to 100 times less RF energy than an individual located 1 meter away from the same source.

[14] A discussion of the inverse square law specific to the FlexNet End Points is provided in Section 3.

2. Health Canada Safety Code 6

History of Safety Code 6

Health Canada is the Canadian federal agency responsible for setting limits on human exposure to RF energy. The health risk assessment of RF exposures performed by the agency and its limits are summarized in Safety Code 6 (SC6). The purpose of SC6, originally published by Health Canada in 1991, is to *"establish safety limits for human exposure to radiofrequency (RF) fields in the frequency range from 3 kHz [Kilohertz] to 300 GHz [Gigahertz]"* (p. I) to protect workers and the general public[15] from RF fields. Innovation, Science and Economic Development Canada (ISED), formerly Industry Canada, published standards for certifying equipment that meets SC6 limits and methods for demonstrating compliance (ISED, 2015a, 2015b, 2015c, 2016).

Since its initial publication, Health Canada periodically updates SC6 as new scientific literature becomes available; these updates published in 1999, 2009, and 2015 include a number of revisions with new versions, and each time give consideration to reviews of scientific research prepared for Health Canada by panels of scientists convened by the Royal Society of Canada (RSC, 1999, 2001, 2007, 2009, 2013). As stated in SC6 (2015):

> *The exposure limits specified in Safety Code 6 have been established based upon a thorough evaluation of the scientific literature related to the thermal and non-thermal health effects of RF fields. . . . The exposure limits in Safety Code 6 are based upon the lowest exposure level at which any scientifically established adverse health effect occurs. Safety margins have been incorporated into the exposure limits to ensure that even worst-case exposures*

[15] The standard discussed in this report is designed to protect the general public including "*[i]ndividuals of all ages, body sizes and varying health status, some of whom may qualify for the conditions defined for the controlled environment in certain situations*" (p. 13). SC6 also applies separate guidelines for persons in controlled environments (e.g., certain workplaces, not discussed herein) where RF fields have been characterized, persons are aware of high strength RF effects, and they can apply mitigation strategies to avoid potential exceedance of exposure limits.

> *remain far below the threshold for harm. The scientific approach used to establish the exposure limits in Safety Code 6 is comparable to that employed by other science-based international standards bodies. … At present, there is no scientific basis for the occurrence of acute, chronic and/or cumulative adverse health risks from RF field exposure at levels below the limits outlined in Safety Code 6. The hypotheses of other proposed adverse health effects occurring at levels below the exposure limits outlined in Safety Code 6 suffer from a lack of evidence of causality, biological plausibility and reproducibility and do not provide a credible foundation for making science-based recommendations for limiting human exposures to low-intensity RF fields (pp. 1–2).*

RF Exposure Limits

The limits for human exposure to RF are specified as Basic Restrictions by SC6. The Basic Restriction is measured in terms of the specific absorption rate (SAR), which is the rate of RF-energy absorption by bodily tissues. Estimating or measuring the SAR from a particular source is quite complex and is not easily accomplished outside a controlled laboratory environment. Therefore, to simplify the safety assessment, SC6 developed Reference Levels in units of power density (e.g., watts per square meter [W/m^2]) that are easy to compute and measure for a comparison to safety limits.[16] SC6 also notes that "*safety factors have been incorporated into the exposure limits*" to ensure that demonstrated health effects are avoided and that "*[t]he protection factors … are a factor of 10 (controlled) and 50 (uncontrolled)*" (RSC, 2014).[17]

Other organizations such as the Institute of Electrical and Electronics Engineers (IEEE) and the European-based International Commission on Non-Ionizing Radiation Protection (ICNIRP)

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16 SC6 also notes that "*[w]hile compliance with the basic restrictions is required, non-compliance with the reference levels does not necessarily mean that the basic restrictions are not respected. In such cases, additional measurements or calculations may be required to assess compliance*."

17 As noted above, Health Canada provided SC6 revisions in 2009 and 2015. The basic restrictions (i.e., SAR limits) in both standards are the same, only the reference levels in the 2015 edition have been changed to provide a more conservative level at which comparison with Basic Restrictions is required.

similarly developed exposure limits for electromagnetic fields based on lengthy and comprehensive assessments of the scientific literature. The SC6 limits for the general public at frequencies of FlexNet transmissions (approximately 900 Megahertz [MHz]) are summarized in Table 1, along with the current IEEE and ICNIRP standards. To determine compliance of either SAR or power density limits with SC6 limits, the source exposure must be averaged over a 6-minute period.

Table 1. Exposure reference values and limits specified by SC6, IEEE, and ICNIRP at 900 MHz

Agency	Reference Level Power Density (W/m^2)	Reference Level Power Density (mW/cm^2)	Basic Restriction SAR Limit (W/kg)
Health Canada SC6 (2015)	2.7	0.27	0.08 (whole body) 1.6 partial body, (over any 1 gram of tissue) 4 (over any 10 grams of tissue in the limbs)
ICNIRP (2020)	4.5	0.45	0.08 (\whole body) 2 (partial body, over any 10 grams of tissue) 4 (over any 10 grams of tissue in the limbs)
IEEE, C95.1 (2019)	4.5	0.45	0.08 (whole body) 2 (partial body, over any 10 grams of tissue) 4 (over any 10 grams of tissue in the limbs)

mW/cm^2 = milliwatts per square centimeter; W/m^2 = watts per square centimeter; W/kg = watts per kilogram; and 1 mW/cm^2 = 10 W/m^2.

3. FlexNet Network and Sonix IQ Gas Meter

Information about all aspects of the design and operation of the FlexNet network were provided to Exponent by Sensus including transmission schedule, duration, modulation and protocol, as well as meter antenna pattern, number of endpoints, and base stations, etc.

The FlexNet communication network operates on a dedicated licensed radio spectrum, which differs from some other network architectures, such as the FEI electric meter network, that operate using a mesh network. Among other benefits, the use of a dedicated licensed portion of the radio spectrum limits external interference sources and limits how often data need to be communicated from individual meters. Each individual meter or module (collectively referred to as End Points) communicates directly with a base station (i.e., it does not relay messages from one device to another) and messages from the meter or module to the base station or vice versa are sent using very brief transmissions.

There are two versions of the FlexNet communication protocol, both of which use short messages of approximately 55 milliseconds and each End Point communicates on a fixed schedule, most typically every 4 hours. The Sonix IQ gas meter communicates using FlexNet version 2 protocol—a spread-FSK type modulation—while all other End Points (discussed in greater detail below) communicate using the FlexNet version 1 protocol—an FSK modulation. An overview of the FlexNet architecture is shown in Figure 4, which indicates that the residential gas meters are installed at the residence, while the other elements of the network are generally located very far from residences.

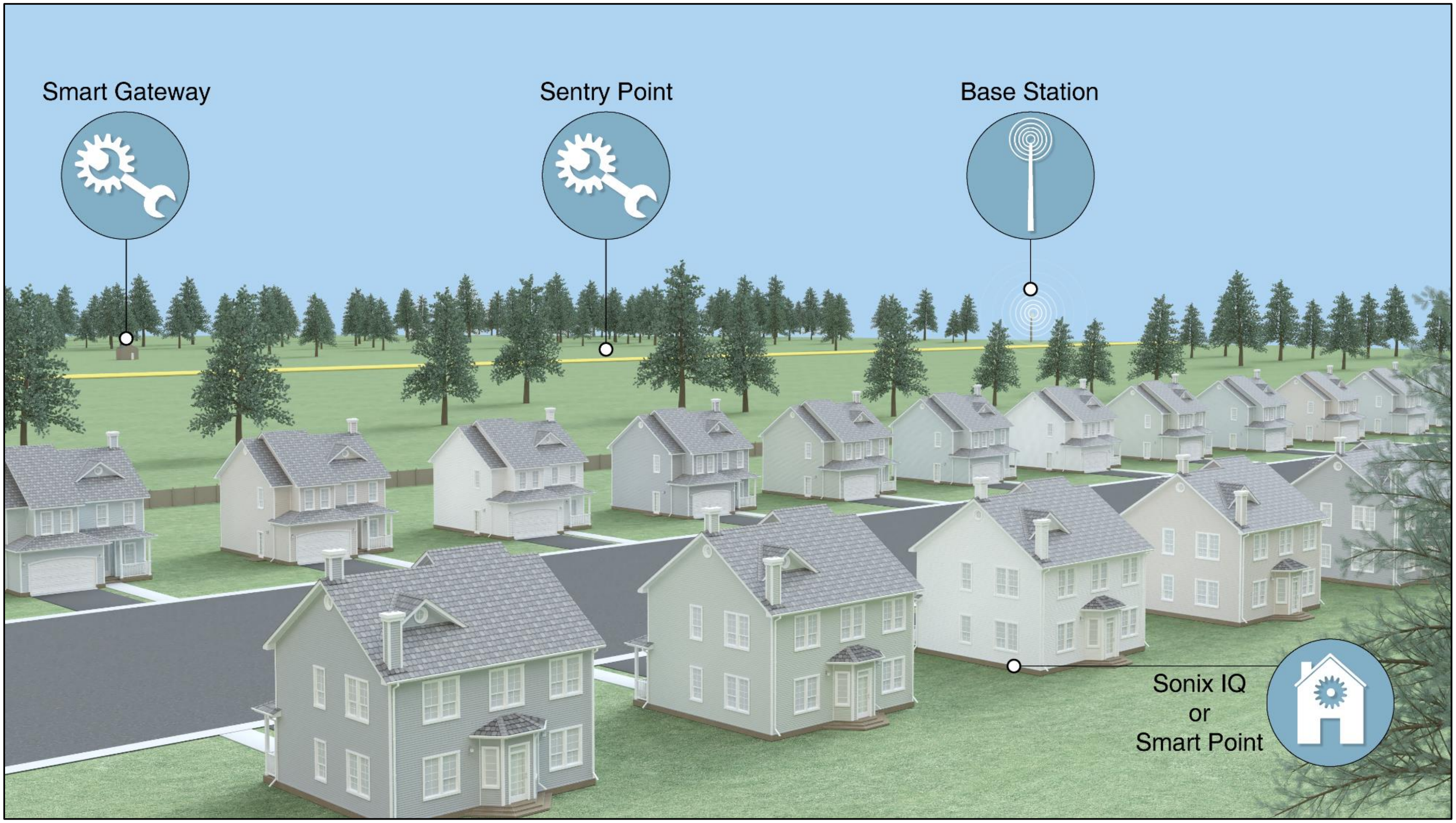

Figure 4. Illustrative overview of the Sensus FlexNet communication network.

End Points

As discussed above, FEI proposes to use several different types of End Points throughout the FEI gas service territory; these End Points will be connected together through the Sensus FlexNet network. There are four primary devices to be deployed:

- Sonix IQ gas meters;
- Sensus FlexNet SentryPoints™ (hereafter SentryPoints);
- Sensus FlexNet Gateways (hereafter Gateways); and
- Sensus FlexNet SmartPoint® modules (hereafter SmartPoints).

Sonix IQ gas meters are proposed to constitute more than 90% of the approximately 1 million End Points anticipated to be deployed. The focus of the assessment is therefore on the Sonix IQ gas meters, but information regarding the other End Points is provided as well. The following list provides a brief introduction to each End Point, and each is also discussed in greater detail below.

- Sonix IQ gas meters are the residential gas meters that will comprise the vast majority of the total FlexNet End Points. These units communicate customer usage data once every 4 hours.
- SentryPoints (cathodic protection units) will be installed far from residences and businesses on gas pipelines to collect and record data to monitor cathodic protection systems on the pipelines. SentryPoints communicate data once every 6 hours.
- Gateways are stand-alone, battery-powered radio transceivers that will be attached to a variety of sensors and equipment (also generally far from residences and businesses) to allow them to remotely connect with the FlexNet network. These devices typically communicate data once per hour, but can be programmed to transmit as often as once per minute.
- SmartPoints will be mounted directly on existing gas meters in cases where the existing meter will not be replaced with a Sonix IQ gas meter. SmartPoints communicate customer usage data once every 4 hours.

Sonix IQ Gas Meter

The Sonix IQ gas meter is a residential gas meter that operates using ultrasonic sound to measure gas flow and has an integrated communication system, an enclosed battery, and an automatic shutoff option. These meters generally will be mounted outside residences or other buildings and will run on the FlexNet version 2 protocol. Similar to the other End Points, the Sonix IQ gas meter will communicate bi-directionally, directly with a base station, on a pre-defined schedule.

Since the FlexNet network uses a licensed band with limited bandwidth, it is important that not all meters transmit at the same time. If all meters transmitted simultaneously, messages could interfere with one another and get lost in the noise. Therefore, each Sonix IQ gas meter is configured to transmit every 4 hours on a pseudo-random schedule of ±20% of the transmission period, which results in a constantly shifting but regular transmission schedule. Using the 4-hour transmission period, for example, if a transmission occurs at 4 AM, the next transmission will occur during a window 48 minutes before to 48 minutes after 8 AM (i.e., 7:12 AM to 8:48 AM), and so on.

It is estimated that in addition to the transmission sent every 4 hours for data reading, approximately three extra status messages will be sent in a given week. The duty cycle of the Sonix IQ gas meter is therefore highly regular and controlled. The maximum duty cycle will occur during the initial installation of the Sonix IQ gas meter at which time it will connect with the base station and establish itself as part of the network. During this process, the meter will send seven different messages, each three times, and these transmissions will occur spaced every 2 minutes. This results in a maximum of 21 messages sent over the course of 42 minutes. This only occurs once when the meters initially connect to the network.

SentryPoints

FEI monitors the operation of safety systems, called cathodic protection, installed to protect gas pipelines from corrosion using SentryPoints. The purpose of these units is to measure and collect data at points of installation to provide that data to central monitoring locations that can evaluate the data and check on the operation of the protective voltage cathodic protection system. SentryPoints represent only a small fraction of the total End Point units. Additionally, unlike Sonix IQ gas meters, these units are not installed at residences.

As discussed above, the SentryPoints will communicate using the FlexNet version 1 protocol. Since cathodic protection needs to be addressed over year-long timescales, data are not required as often, so SentryPoints will communicate with the base station at 6-hour intervals (i.e., four messages each day). The version 1 protocol also uses very brief transmissions occurring on a pseudo-random schedule of ±20% of the transmission period. For example, if transmission occurs at 12:00 AM, the next transmission would occur during a window 72 minutes before to 72 minutes after 6 AM (i.e., 4:48 AM to 7:12 AM), and so on.

Gateways

Gateways are battery-powered communication devices that will be attached to sensors or other units in the field and serve as a hub to connect those sensors (for instance in locations without a power source) to the FlexNet network so that the data provided are available without sending personnel to read the instruments. Gateways are capable of transmitting and forwarding alarms to utility systems or individuals. Approximately 10,000 Gateways are proposed to be installed throughout the system (generally away from residences or buildings), so represent only a small fraction of the total units.

Because the Gateways can be connected to a variety of different sensors, they can also be configured to read and transmit that data at a variable rate. The most common read/transmission rate is expected to read data every 15 minutes and transmit data every hour, but they can be configured to read data every 12 seconds and to transmit every minute.[18] Similar to SentryPoints, Gateways will operate using the FlexNet version 1 protocol with very brief transmissions sent on a schedule based upon ±20% of the chosen transmission period, similar to that described above for the SentryPoint.

SmartPoints

SmartPoints are communication devices that can be mounted directly on existing gas meters in cases where the existing meter will not be replaced with a Sonix IQ gas meter. SmartPoints generally will be located outside residences or other buildings and will operate on the FlexNet version 1 protocol, but will otherwise operate almost identically to the Sonix IQ gas meters with an hourly read schedule and a 4-hour transmission schedule. Approximately 24,000 existing gas meters are expected to need a SmartPoint rather than being replaced with a Sonix IQ gas meter.

Base Station

While approximately 1 million End Points will be installed, the amount of data and total transmission time from the End Points is low enough that only approximately 170 base stations are required to collect the transmitted data. Each base station will be custom engineered for the area in which it is installed (e.g., urban, suburban, rural). They are designed to be mounted high above the ground (typically 20 meters high or more) on poles, towers, buildings, and other structures, similar to existing cell tower installations. The majority of base stations will transmit

[18] Since these are battery-powered units, the limiting factor in transmission schedule is battery lifetime. A unit that transmits once per hour will have a lifetime between 8.7 and 12.25 years (depending on how many sensors are connected). A unit that transmits once per minute will have a lifetime of between 2 to 3 months.

equally in all directions (isotropic antennas), although some will transmit only in specific directions (directional antennas), and each is designed to communicate with up to approximately 60,000 End Points.

While the End Points transmit very infrequently, as described in more detail below, the base stations will typically send four messages per minute with a minimum of one message per minute for synchronization of devices.[19] While the base stations transmit much more frequently than the various End Points, there are very few of them and they are all located tens of meters above ground. Base stations operate at similar power levels as many cell phone transmitters, but there will be only 170 in the entire FEI network area compared to approximately 68,000 cell phone transmitters at more than 6,900 locations throughout British Columbia (see Appendix A, Figure A-1).[20] The relatively short transmission times and limited number mean that base stations will contribute little to overall RF exposures.

RF Characteristics of End Points

End Point Transmission Parameters

Information about the power and gain of the End Point antennas is available from regulatory filings. RF certification documents are available online with each end point assigned a unique identifier code as summarized in Table 2. The effective radiated power of these devices is the product of the power applied to the antenna and the gain of the antenna. All End Points have an equivalent isotopically radiated power (EIRP) of 2 Watts (W) or less.

[19] There is a separate dedicated radio channel used for critical data like alarms, which would be used infrequently.

[20] Source: Government of Canada Spectrum Management System Data (http://sms-sgs.ic.gc.ca/eic/site/sms-sgs-prod.nsf/eng/h_00010.html); SCADACore Canadian Cell Tower Map (https://www.scadacore.com/tools/rf-path/cell-tower-map-canada/). Accessed April 27, 2021.

Table 2. RF certification summary of FlexNet End Points

FlexNet Device	ISED Identification No.	Federal Communications Commission Identification No.	Power (W)	× Gain =	EIRP (W)
Sonix IQ Gas Meter	2220A-SONIXIQV2	SDBSONIXIQV2	0.982	1.995	2.0
SentryPoint	2220A-BHRM100	SDBBHRM100	0.813	1.585	1.3
SmartPoint	220A-GFL3	SDBGFL3	0.776	1.585	1.2
Gateway	2220A-SGW100	SDBSGW100	0.893	1.585	1.4

End Point Duty Cycle

In the FlexNet network, each End Point transmits a fixed amount of data during each transmission on a highly regular transmission schedule. This in turn means that the duty cycle of each End Point is well defined and controlled. The typical duty cycle and total transmission time per day for all endpoints is summarized in Table 3. During typical operation, the Sonix IQ gas meters transmit only for about 0.34 seconds per day total, with similarly short total transmission times for the other End Points. The total transmission time remains very short, even under the maximum expected duty cycle when an End Point goes through startup and connection to the network (see Appendix B, Table B-1).

Table 3. Transmission time and duty cycle of FlexNet End Points under typical operation

End Point	Seconds per day	Duty Cycle (δ)
Sonix IQ Gas Meter	0.34	0.00039%
SentryPoint	0.23	0.00026%
SmartPoint	0.36	0.00042%
Gateway	1.40	0.0016%

Example RF Exposure from End Points

Using the information in Table 2 and Table 3, it is possible to calculate the RF exposure from the various End Points at any particular distance based upon the formula:

$$S = 2.56 \frac{PG}{4\pi R^2} \delta\, TF \qquad \text{(Equation 1)}$$

where S is the power density of a signal at a distance R from the transmitter, with an input power P, an antenna gain G, and a duty cycle of δ. A transmission coefficient, T, can be used to account for any applicable attenuation or reflection from boundary materials, and the factor F can be used to account for the preferential transmission of a signal forward away from the device rather than backward.[21] Finally, the factor of 2.56 is used to include the potential reflection of the signal from the ground that may increase the exposure above that calculated using the standard inverse square law.[22] In order to calculate the RF exposure from the various End Points, it is therefore necessary to know the power and gain of the antenna as well as the duty cycle (other factors, such as distance R and transmission coefficient T, depend on a particular exposure scenario).

Using this approach, the RF signal from a Sonix IQ gas meter at several distances both indoors and outside a building for a typical duty cycle was calculated for a variety of exposure scenarios (see Appendix B, Table B-2). As an example, the indoor exposure was calculated at a distance of 1 meter behind the Sonix IQ gas meter using a typical duty cycle of 0.00039%. This calculation accounts for the preferential transmission in the forward direction so that the amount of energy directed toward the residence is approximately one-tenth that transmitted away from the residence. The calculation also accounts for attenuation of the signal when passing through the walls of the structure (assumed in this example to be plywood and drywall, which absorbs

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[21] Sensus measurements demonstrate that the power transmitted in the backward direction (e.g., indoors) is approximately 1/10th of the power transmitted in the forward direction.

[22] This factor of 2.56 is sometimes applied to far-away sources such as television or radio broadcast signals (ISED, 2015c) and is not generally applicable to the signal from the end points. It is included here, however, to conservatively overestimate the RF exposure from the various FlexNet end points.

about 26% of the signal).[23] Similar estimates also were calculated for the other End Points for outdoor exposure at a distance of 1 meter in front of the unit at a typical duty cycle. The calculated power density (*S* in the second to last column in Table B-2) is calculated using Equation 1 above and then converted to a percent of the SC6 limit using the appropriate value (i.e., as listed in Table 1).

These calculations show that for the typical duty cycle (one transmission every 4 hours) at a distance of 0.25 meters immediately in front of the Sonix IQ gas meter, the RF exposure would be approximately 13,000 times below the SC6 limit. At the maximum duty cycle (during the one-time meter startup and network connection), at a distance of 0.25 meters immediately in front of the Sonix IQ gas meter, the RF exposure would be approximately 1,000 times below the SC6 limit.

At a distance of 1 meter behind the Sonix IQ gas meter (indoors) and a typical duty cycle (one transmission every 4 hours) the exposure would be approximately 24 million times below the SC6 limit. At distances greater than 1 meter, where persons would be expected to spend more time, exposures are far lower. Results for the SmartPoints are similar, but lower than the Sonix IQ gas meter, and exposures from the more distant SentryPoints and Gateways (e.g., outdoors and 10 meters away) range from approximately 60 to 400 million times below the SC6 limit.

[23] Both indoor and outdoor calculations also include a conservative ground reflection factor of 2.56 (ISED, 2015c).

4. Sources of Radiofrequency Fields

There are numerous natural and man-made sources of RF fields. As discussed in the Introduction, some of the natural sources of RF fields are produced by blackbody radiation from warm objects such as the earth and humans; the representative RF exposure values for these natural sources are summarized in Table 4. Common man-made devices include those used for communications and many other purposes. Communication devices used in the home, such as cell phones, Wi-Fi, and Bluetooth devices produce relatively weak fields; however, they are often used in very close proximity to the individual and may therefore result in higher exposures than remote (but more powerful) sources such as radio or television broadcast signals. Other devices . like microwave ovens and radar guns, use RF fields for non-communication purposes such as heating food or measuring speed and distances.

The frequency and representative RF exposure values for some common man-made RF sources are also shown below Table 4. Table 4 provides an estimate for the specific exposure conditions listed, but it is important to recognize that there are wide variations in each of these estimates based on different exposure scenarios. It is also important to note that a majority of sources listed in Table 4 operate continuously or at the very least operate for substantially longer time periods than the few seconds per day the Sonix IQ gas meters will transmit. While Table 4 provides a list of some of the common sources, it is only a very small subset of all RF sources. Figure A-2 in Appendix A shows the many hundreds of RF communication bands, as defined by ISED, used in modern society, all of which have the potential to contribute to electromagnetic field exposure.

Table 4. Frequency and representative RF exposure values for common man-made RF sources[24]

Source	Frequency (MHz)	Reported Value (% of SC6 Limit)*	Exposure Conditions
Blackbody radiation from the earth	0.003 – 3,000	0.009	Typical
Blackbody radiation from humans	0.003 – 3,000	0.018	Typical
Cell Phone	800 – 1,900	5 – 12†	Personal Call
Cordless Phone / Handheld Unit	1,880 – 1,900	0.5 – 3.8	Handheld Unit
Wi-Fi	2,400 – 2,484	0.00007 – 0.75	Typical
Bluetooth	2,400 – 2,484	0.002 – 0.31	At 0.25 – 3 meters
Microwave Oven	2,450	0.01 – 2.4	At 1 meter

* RF exposure is presented as a percentage of the SC6 limit to keep these exposure values both consistent and accurate. The SC6 limit is defined as the applicable SAR limit, wave power density limit, or square of the field magnitude limit, all for uncontrolled environments. Both whole body exposure and spatial peak SAR for the head are used where appropriate.

† An average value based upon Abdulla and Badra (2010) is approximately 7.6% (*see* e.g., Figure 5).[25]

[24] RF exposure can be heavily dependent upon situation, so exposure conditions are provided for each exposure value. For reference, see Mantiply et al. (1997); Foster (2007); Valberg et al. (2007); HPA, (2008); ICNIRP,(2009); Viel et al. (2009); and Abdulla and Badra (2010).

[25] The Abdulla and Badra (2010) study covers phone calls that typically result in higher exposure than texting or data services because these modes of operation generally have lower power output, lower operational duty cycle, and the device is used at greater distance from the head and trunk than phone calls.

5. RF Exposure Comparisons

Evaluating RF Exposure

Sections 3 and 4 discuss the typical RF power and transmission characteristics of various network End Points and various common natural and man-made sources, respectively. These data can be used to describe the power density from the various sources, but the *exposure* of a person involves not just how much energy is absorbed by a person, but also how long or how often that absorption occurs. Although a full RF exposure assessment requires the evaluation of the total RF exposure of a person to all RF sources in his or her environment, such an analysis generally needs to be done on an individual basis, or somehow limited to assess the potential contributions of particular sources. Examples below show the relative strength of various potential exposures but do not constitute full exposure assessments.

Example Exposure Scenarios

The discussion in Section 3 provided example RF calculations for the FlexNet End Points and Section 4 detailed other common natural and manmade sources of RF fields. Comparison of these results shows that End Points in the FlexNet network are both very low power and also operate very infrequently. As a result, the RF exposure from these devices will be extremely low. To illustrate this further, Figure 5 shows a graphic comparison of exposure from a Sonix IQ gas meter to exposures from other common RF sources. The exposure of each source relative to the SC6 limits (sorted from smallest to largest) is shown beneath a graphic of each source, as well as the factor describing how much larger that exposure is than the exposure from a typical Sonix IQ gas meter. This figure demonstrates that not only does the RF exposure from a Sonix IQ gas meter inside a residence represent a tiny fraction of the SC6 allowable limit, but that the exposure from other sources both inside and outside a residence are many times greater than that from the Sonix IQ gas meter.

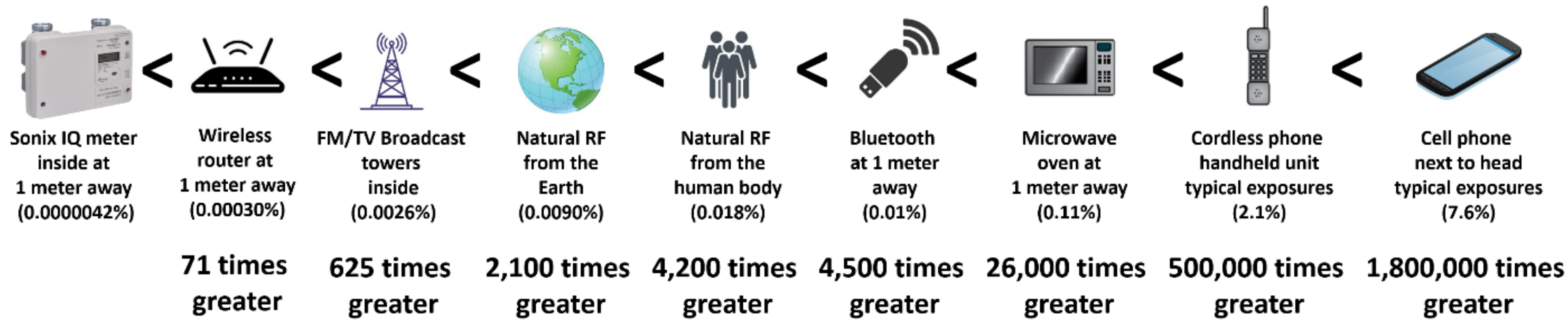

Figure 5. RF exposure of a Sonix IQ gas meter relative to other RF sources.

The RF exposure as a percentage of SC6 limits is shown beneath each graphic in parentheses and a comparison of how much greater each exposure is than that from a Sonix IQ gas meter is shown below that in bold font.

The comparison of exposures shown in Figure 5 represents a simple comparison of some of the relevant potential exposures. A more detailed description is shown below in Figure 6 in which RF exposures are plotted as a percentage of the SC6 limit in a bar graph. In order to show the very small exposure sources on the same scale as the larger exposure sources, the results are presented on a logarithmic scale where each vertical tick in the axis represents an increase by a factor of 10. The graphic is divided into two sections. The portion labeled *RF Exposures in General Environments* shows the general background of RF energy encountered in rural, suburban, and urban environments, and is included to provide context of typical background levels reported in peer-reviewed literature (Joseph et al., 2012). The portion labeled *Typical RF Sources* compares the RF exposure from each of the items shown in Figure 5. In Figure 6, scenarios for the Sonix IQ gas meter are shown for potential exposure outdoors, as well as potential exposure outdoors from the other FlexNet network components. A black line shows the example cell phone exposure is 1.8 million times higher than typical indoor exposure from a Sonix IQ gas meter. Full details of the RF exposure calculations for the End Points are provided in Appendix B, Table B-2.

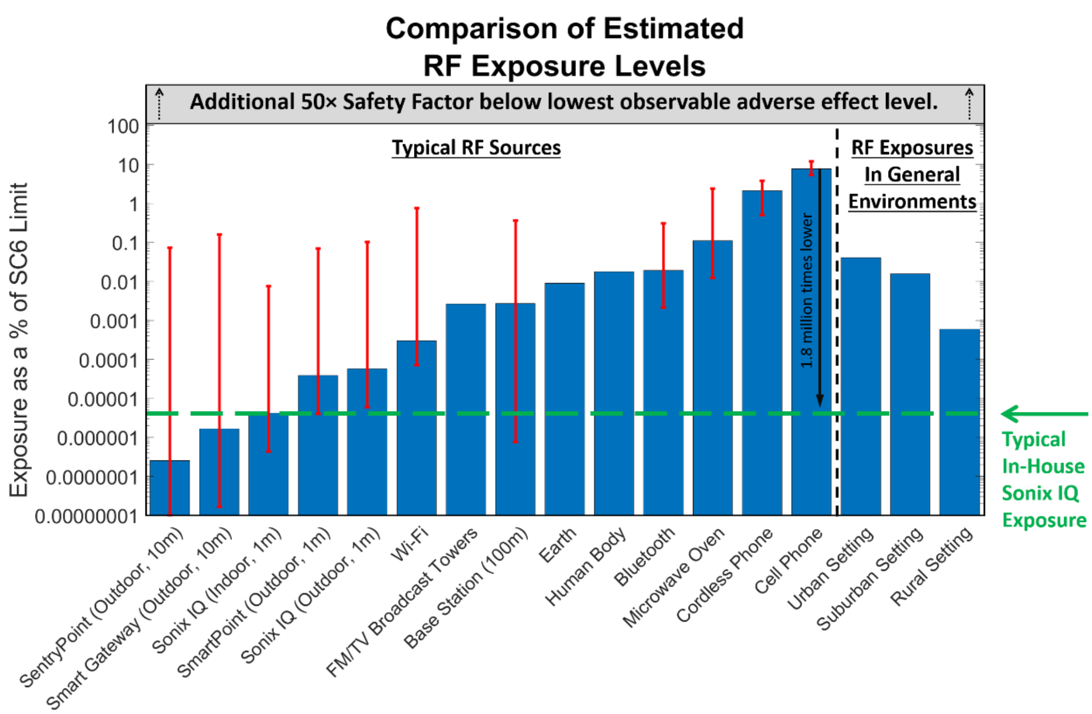

Figure 6. Comparison of RF exposure from End Points to other sources under typical use. The red lines show variability of some man-made sources. Exposures in general environments are from Joseph et al. (2012). Other data sources are from those listed for Table 4.

A red line is shown overlaid on the bar for most man-made sources in Figure 6 to provide an indication of the potential variability in the exposures for these sources. As an example, the exposure from the Sonix IQ gas meter (both indoors and outdoors) is detailed in Appendix B, Figure B-2. The "Indoor, 1m" exposure (third bar from the left in Figure 6) is calculated inside the building at a distance of 1 meter behind the gas meter using a typical duty cycle of 0.00039%. In addition, this calculation accounts for the Sonix IQ gas meter preferentially transmitting in the forward direction so that the amount of energy directed toward the residence is approximately one-tenth of that transmitted away from the house. The calculation also accounts for attenuation of the signal when passing through the plywood and drywall from the walls of the example residence (only about 74% of the signal passes through the combination of plywood and drywall).[26] Similar variability estimates are also provided for other man-made sources based on the peer-reviewed references detailed in Table 4.

Additional Discussion

The RF exposure from the communication of Sonix IQ gas meters is extremely small due to the low power output and very infrequent transmissions. The transmissions are so infrequent and so short that for the approximately 0.34 seconds of transmission per day (*see* Table 3) of the Sonix IQ gas meters, it will take more than 2 years and 5 months (~890 days) until the gas meter transmits for the same amount of time as a 5-minute call on a cell phone.

Another way to put into context the very low total exposure level is to compare the RF power density indoors from a typical Sonix IQ gas meter (i.e., 0.00000011 W/m^2)[27] to a well-known source. The CBC television broadcasting station in Vancouver (call sign CBUT-DT) operates at a frequency of about 600 MHz and a transmitter power of 88.5 kilowatts.[28] Using the same approach as described in Equation 1 above, it is possible to calculate the distance at which the average RF power density from the CBUT-DT broadcast station is the same (indoors) as the

[26] Both indoor and outdoor calculations also include a conservative ground reflection factor of 2.56, as noted in ISED (2015c).

[27] *See* Appendix B, Table B-2.

[28] https://www.fcc.gov/media/television/tv-query. Accessed April 27, 2021.

indoor exposure from the gas meter; a distance as far as approximately 340 kilometers.[29] In other words, residents of British Columbia from Vancouver nearly to Castlegar are currently exposed to a greater power density from the Vancouver CBUT-DT television broadcast station than they would be 1 meter away from a Sonix IQ gas meter installed outside their home.

[29] The CBUT-DT television broadcast station does not transmit the same power in all directions. The maximum transmission power occurs in a direction due east of the station. https://www.fcc.gov/media/television/tv-query. Accessed April 27, 2021.

6. Conclusions

This report describes the basic physics of RF fields in general and outlines characteristics of RF fields important for understanding human exposure to these fields. It also includes a detailed description of the potential exposure to the various End Points of the FlexNet communication network with a focus on the Sonix IQ gas meter, which will constitute approximately 90% of all installed End Points. The report also describes a variety of natural and man-made RF sources and provides a comparison of the potential RF exposure levels from these sources in relation to the Sonix IQ gas meters, as well as to the SC6 limit.

Under typical operation, the Sonix IQ gas meter transmits RF energy a total of approximately 0.34 seconds per day. This very short transmission time also means that the indoor RF exposure from the Sonix IQ gas meter is about 24 million times lower than the SC6 exposure limit, and substantially lower than the RF exposures from common natural and man-made sources. The typical exposure from other End Points are still lower, and hence all End Points of the proposed FEI network will result in exposure levels millions of times lower than the SC6 exposure limit.

7. References

Abdulla H and Badra RE. Head exposure to cellular telephones: A system-level study. 2010 IEEE Latin-American Conference on Communications 15-17 September 2010.

Foster KR. Radiofrequency exposure from wireless LANs utilizing Wi-Fi technology. Health Phys 92:280-289, 2007.

Health Canada. Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz. June 22, 2015. https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/pdf/consult/_2014/safety_code_6-code_securite_6/final-finale-eng.pdf. Accessed April 27, 2021.

Health Protection Agency (HPA). Cordless Telephones: Digital Enhanced Cordless Telecommunications (DECT) and Other Cordless Phones. http://webarchive.nationalarchives.gov.uk/20140714084352/http:/www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1195733767519. Accessed April 27, 2021.

Innovation, Science and Economic Development Canada (ISED). RSS-102 — Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands). Spectrum Management and Telecommunications Radio Standards Specification. RSS-102, Issue 5, March 2015a. https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01904.html. Accessed April 27, 2021.

Innovation, Science and Economic Development Canada (ISED). GL-01 — Guidelines for the Measurement of Radio Frequency Fields at Frequencies From 3 kHz to 300 GHz. Issue 3, March, 19, 2015b. https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01451.html. Accessed April 27, 2021.

Innovation, Science and Economic Development Canada (ISED). TN-261 — Safety Code 6 (SC6) Radio Frequency Exposure Compliance Evaluation Template (Uncontrolled Environment Exposure Limits). Issue 3, March, 2015c. https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf09976.html. Accessed April 27, 2021.

Innovation, Science and Economic Development Canada (ISED). SPR-002 — Supplementary Procedure for Assessing Compliance with RSS-102 Nerve Stimulation Exposure Limits. [3 kHz -10 MHz]. SPR-002, Issue 1, September 1, 2016. http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11198.html. Accessed April 27, 2021.

Institute of Electrical and Electronics Engineers (IEEE), IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 0 kHz to 300 GHz. New York, NY: IEEE, 2019.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Exposure to High Frequency Electromagnetic Fields, Biological Effects and Health Consequences (100 kHz-300 GHz). Oberschleißheim, Germany: ICNIRP, 2009.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz). Health Phys 118:483-524, 2020.

Joseph W, Verloock L, Goeminne F, Vermeeren G, Martens L. Assessment of RF exposures from emerging wireless communication technologies in different environments. Health Phys 102:161-172, 2012.

Mantiply ED, Pohl KR, Poppell SW, Murphy JA. Summary of measured radiofrequency electric and magnetic fields (10 kHz to 30 GHz) in the general and work environment. Bioelectromagnetics 18:563-577, 1997.

National Institute of Standards and Technology (NIST). NIST Construction Automation Program, Report No. 3. Electromagnetic Signal Attenuation in Construction Materials (NISTIR 6055). Gaithersburg, Maryland: US Department of Commerce, 1997.

Royal Society of Canada (RSC). A Review of the Potential Health Risks of Radiofrequency Fields from Wireless Telecommunication Devices, Expert Panel Report. Ottawa, Ontario: Royal Society of Canada, 1999. https://rsc-src.ca/sites/default/files/RFreport-en.pdf. Accessed April 27, 2021.

Royal Society of Canada (RSC). Update 1 to 1999 Report. Krewski D, Byus CV, Glickman BW, Lotz WG, Mandeville R, McBride ML, Prato FS, Weaver DF. Recent advances in research on radiofrequency fields and health. J Toxicol Environ Health B Crit Rev. 4:145-59, 2001.

Royal Society of Canada (RSC). Update 2 to 1999 Report. Krewski D, Glickman BW, Habash RW, Habbick B, Lotz WG, Mandeville R, Prato FS, Salem T, Weaver DF. Recent advances in research on radiofrequency fields and health: 2001-2003. J Toxicol Environ Health B Crit Rev. 10:287-318, 2007.

Royal Society of Canada (RSC). Update 3 to 1999 Report. Habash RW, Elwood JM, Krewski D, Lotz WG, McNamee JP, Prato FS. Recent advances in research on radiofrequency fields and health: 2004-2007. J Toxicol Environ Health B Crit Rev. 12:250-88, 2009.

Royal Society of Canada Expert Panel. Report on A Review of Safety Code 6 (2013): Health Canada's Safety Limits for Exposure to Radiofrequency Fields. Ottawa, Ontario: Royal Society of Canada, 2014. https://rsc-src.ca/sites/default/files/SC6_Report_Formatted_1.pdf. Accessed April 27, 2021.

Valberg PA, van Deventer TE, Repacholi MH. Workgroup report: base stations and wireless networks-radiofrequency (RF) exposures and health consequences. Environ Health Perspect 115:416-424, 2007.

Viel JF, Cardis E, Moissonnier M, de Seze R, Hours M. Radiofrequency exposure in the French general population: band, time, location and activity variability. Environ Int 35:1150-1154, 2009.

Appendix A

Number of Cell Phone Base Stations and Radiofrequency Usage Spectrum Chart (ISED)

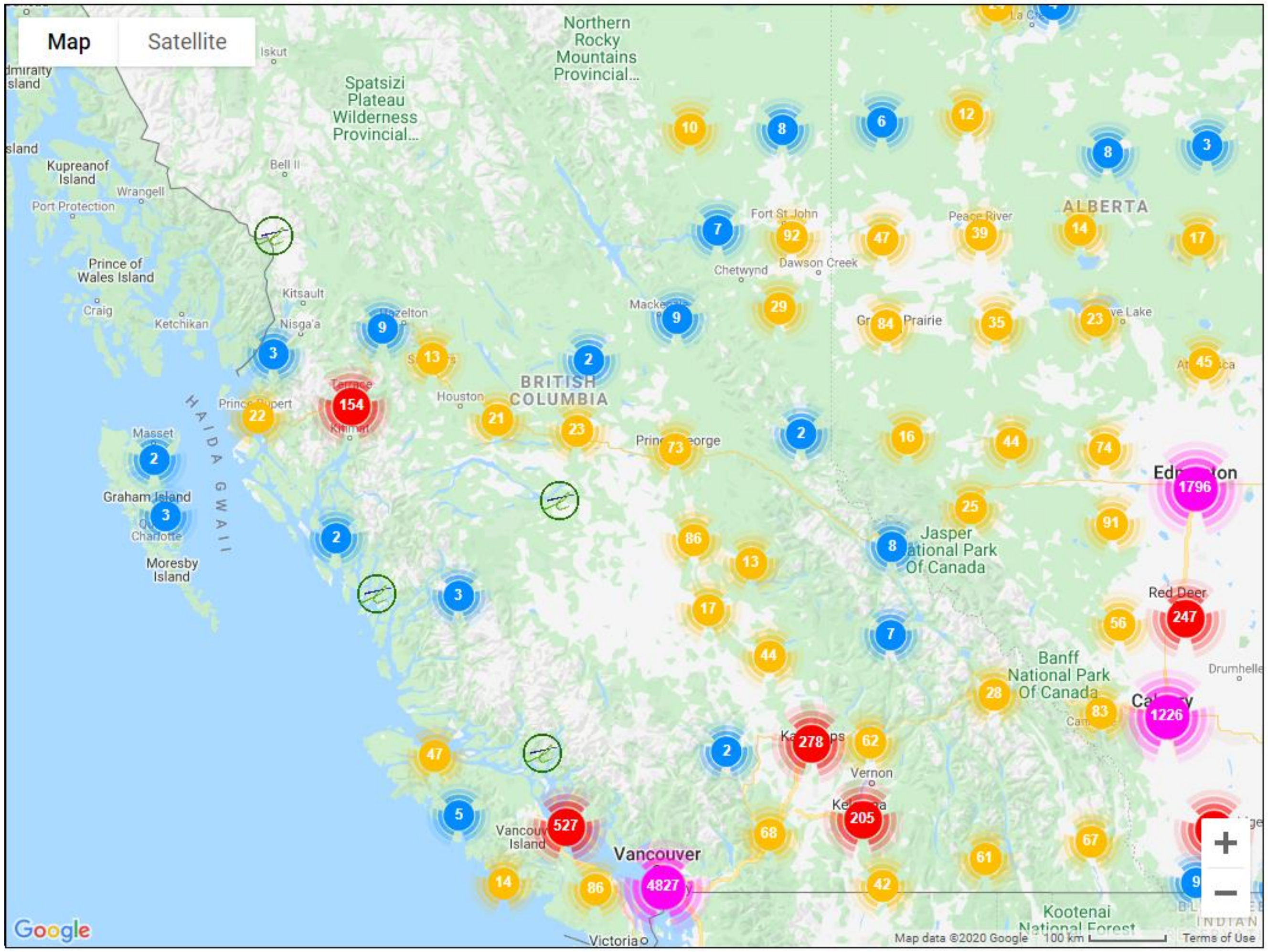

Figure A-1. Locations of cell towers in British Columbia.

Source: Government of Canada Spectrum Management System Data (http://sms-sgs.ic.gc.ca/eic/site/sms-sgs-prod.nsf/eng/h_00010.html); SCADACore Canadian Cell Tower Map (https://www.scadacore.com/tools/rf-path/cell-tower-map-canada/). Circles indicate the number of cell towers in the specified geographic region. Accessed April 27, 2021.

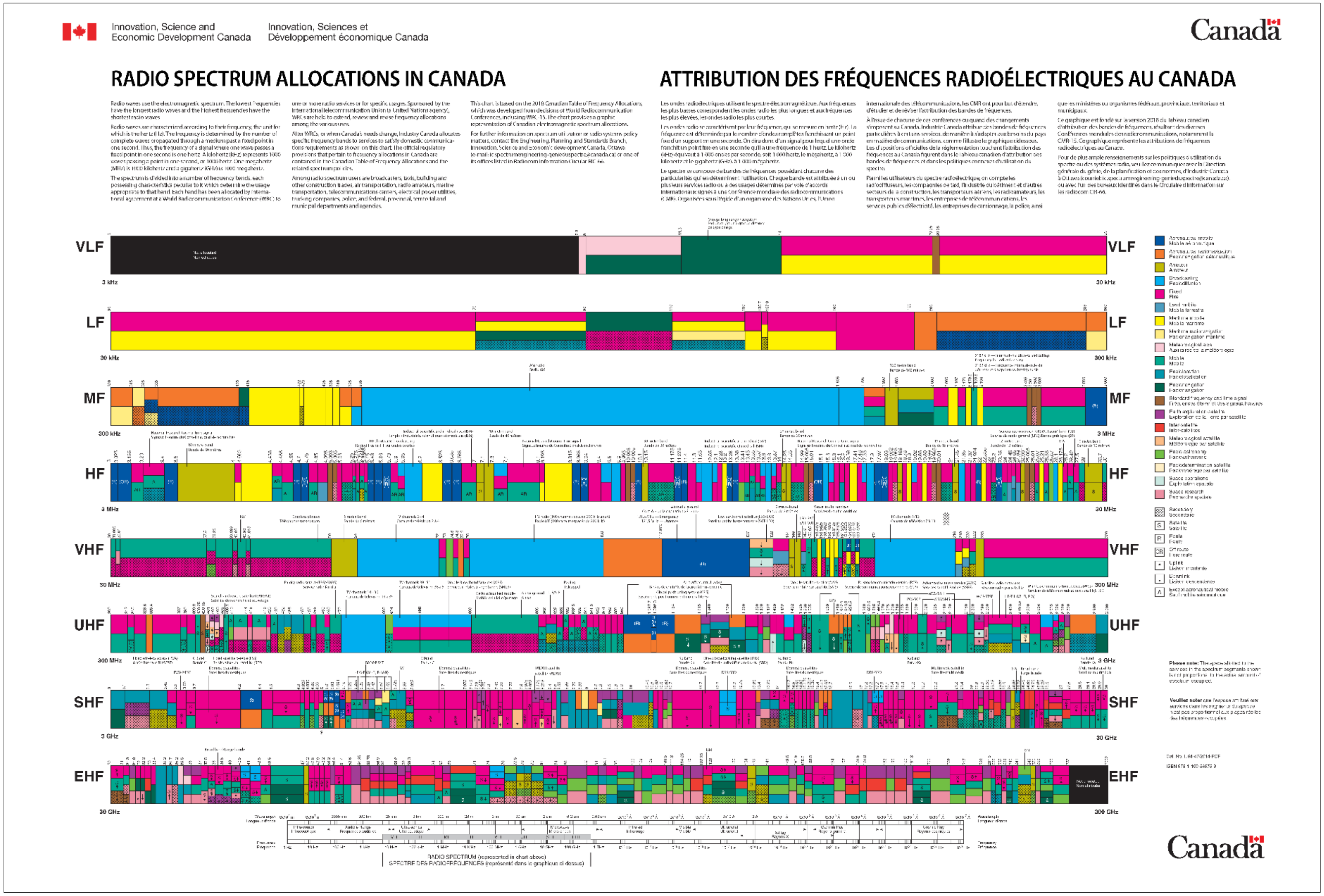

Figure A-2. Radio Spectrum Allocations in Canada.

Source: ISED. https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/2018_Canadian_Radio_Spectrum_Chart.PDF. Accessed April 27, 2021.

Appendix B

Example Exposure Calculations for FlexNet End Points

As discussed above, the Sonix IQ gas meter sends one message that lasts 52.48 milliseconds every 4 hours, while the message length of the remaining End Points (SentryPoint, SmartPoint, and Smart Gateway) is a similarly short at 56.7 milliseconds (though each transmits on a different schedule). The message length, duty cycle, and total transmission times per day are summarized in Table B-1.

Table B-1. Duty cycle of FlexNet End Points*

		Typical Operation†		Short-Term Maximum§	
End Point	Message Length (millisecond)	Duty Cycle (δ)	Seconds Per Day	Duty Cycle (δ)	Seconds Per Day
Sonix IQ Gas Meter	52.48	0.00039%	0.34	0.044%	1.4
SentryPoint	56.7	0.00026%	0.23	0.047%	1.4
SmartPoint	56.7	0.00042%	0.36	0.047%	1.4
Gateway	56.7	0.0016%	1.4	0.095%**	81.6**

* Information was provided by Sensus.

† Under typical operation, Sonix IQ gas meters send one message every 4 hours, as well as about three additional status update messages per week.

§ Sonix IQ gas meters, SentryPoints, and SmartPoints operate at this duty cycle only during the initial installation and connection to the FlexNet network. The initial connection lasts a total of less than 1 hour.

** Gateways can be programmed to read and report data at a variety of intervals. The shortest interval is one transmission per minute. A Smart Gateway could be operated in this manner for the lifetime of the battery (estimated to be approximately 2 to 3 months).

During the short time that one of the FlexNet End Points (Sonix IQ gas meter, SentryPoint, SmartPoint, or Gateway) is transmitting, the power of that transmission is constant and so the potential exposure level (excluding the effect of any external environmental factor such as walls or distance) is determined by the duty cycle of each End Point. The typical and maximum duty cycles of the various End Points are detailed Table B-1. Using these duty cycle numbers, it is possible to calculate exposure levels from an example End Point based upon the duty cycle (at a particular distance).[30]

The formula for calculating the exposure is provided and described at the end of Section 3 in the body of the report and selected results using this formula are provided in Table B-2.

[30] A Sonix IQ gas meter transmits about one-tenth as much power in the backward direction as in the forward direction. (The measurement information was provided by Sensus).

Table B-2. Example calculations of RF exposure from FlexNet End Points

Scenario (Location, Distance in meters [m] or kilometers [km])	Power (*P*) (W)	Gain (*G*)	Ground Reflection Factor	Forward/Back Transmission Factor (*F*)	Transmission through Wall Material (T)	Distance from Source (R)	Duty Cycle (δ)	Power Density (*S*) (mW/cm^2)	% of SC6 Limit
Sonix IQ Gas Meter (Indoors, 3 m)	0.98	2.00	2.56	0.1	0.736	3 meters	0.00036%	0.0000000012	0.00000043%
Sonix IQ Gas Meter (Indoors, 1 m)	0.98	2.00	2.56	0.1	0. 736	1 meter	0.00039%	0.000000011	0.0000042%
Sonix IQ Gas Meter (Indoors, 25 cm)	0.98	2.00	2.56	0.1	0. 736	0.25 meters	0.044%	0.000021	0.0075%
Sonix IQ Gas Meter (Outdoors, 3 m)	0.98	2.00	2.56	1	--	3 meters	0.00036%	0.000000016	0.0000059%
Sonix IQ Gas Meter (Outdoors, 1 m)	0.98	2.00	2.56	1	--	1 meter	0.00039%	0.00000016	0.000057%
Sonix IQ Gas Meter (Outdoors, 25 cm)	0.98	2.00	2.56	1	--	0.25 meters	0.044%	0.00028	0.10%
SmartPoint (Indoors, 3 m)	0.78	1.58	2.56	0.1	0.736	3 meters	0.00039%	0.00000000081	0.00000029%
SmartPoint (Indoors, 1 m)	0.78	1.58	2.56	0.1	0. 736	1 meter	0.00042%	0.0000000078	0.0000028%
SmartPoint (Indoors, 25 cm)	0.78	1.58	2.56	0.1	0. 736	0.25 meters	0.047%	0.000014	0.0051%
SmartPoint (Outdoors, 3 m)	0.78	1.58	2.56	1	--	3 meters	0.00039%	0.000000011	0.0000040%
SmartPoint (Outdoors, 1 m)	0.78	1.58	2.56	1	--	1 meter	0.00042%	0.00000011	0.000039%
SmartPoint (Outdoors, 25 cm)	0.78	1.58	2.56	1	--	0.25 meters	0.047%	0.00019	0.069%

Scenario (Location, Distance in meters [m] or kilometers [km])	Power (*P*) (W)	Gain (*G*)	Ground Reflection Factor	Forward/Back Transmission Factor (*F*)	Transmission through Wall Material (T)	Distance from Source (R)	Duty Cycle (δ)	Power Density (*S*) (mW/cm^2)	% of SC6 Limit
SentryPoint (Outdoors, 50 m)	0.81	1.58	2.56	1	--	50 meters	0.00026%	0.000000000028	0.000000010%
SentryPoint (Outdoors, 10 m)	0.81	1.58	2.56	1	--	10 meters	0.00026%	0.00000000069	0.00000025%
SentryPoint (Outdoors, 25 cm)	0.81	1.58	2.56	1	--	0.25 meters	0.047%	0.00020	0.072%
Smart Gateway (Outdoors, 50 m)	0.893	1.58	2.56	1	--	50 meters	0.00039%	0.000000000045	0.000000017%
Smart Gateway (Outdoors, 10 m)	0.893	1.58	2.56	1	--	10 meters	0.0016%	0.0000000045	0.0000017%
Smart Gateway (Outdoors, 25 cm)	0.893	1.58	2.56	1	--	0.25 meters	0.095%	0.00044	0.16%
Base Station (Outdoors, 3 km)	40.36	16.41	2.56	1	--	3,000 meters*	0.14%	0.0000000021	0.00000076%
Base Station (Outdoors, 100 m)	40.36	16.41	2.56	1	--	100 meters*	0.56%	0.0000073	0.0027%
Base Station (Outdoors, 0 m)	40.36	16.41	2.56	1	--	0 meters*	1.67%	0.0010	0.36%

* Value indicates the horizontal distance from the base station, but includes an antenna height above ground of 15 meters, representative of the minimum expected antenna height above ground.

Appendix C

Curriculum Vitae of Benjamin Cotts, Ph.D.

Appendix F-2

EXPONENT RF HEALTH REPORT

Exponent®

Health Sciences Practice

Status of Research on Exposure to Radiofrequency Fields and Health in Relation to Advanced Metering Infrastructure

Exponent®

Status of Research on Exposure to Radiofrequency Fields and Health in Relation to Advanced Metering Infrastructure

Prepared for

British Columbia Utilities Commission

At the Request of

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May 3, 2021

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Contents

Limitations

At the request of FortisBC Energy Inc. (FEI), Exponent prepared this summary report on the status of research related to radiofrequency exposure and health. The findings presented herein are made to a reasonable degree of scientific certainty. Exponent reserves the right to supplement this report and to expand or modify opinions based on review of additional material as it becomes available, through any additional work, or review of additional work performed by others.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

Acronyms and Abbreviations

°C	degrees Celsius
8-OHdG	8-hydroxy-2-deoxyguanosine
AGNIR	Advisory Group on Non-Ionising Radiation Protection
AM	amplitude modulated
BCCDC	British Columbia Centre for Disease Control
BLM	bleomycin
CDMA	code-division multiple access
DECT	digital enhanced cordless telecommunications
DNA	deoxyribonucleic acid
EMF	electric and magnetic fields
EHS	electromagnetic hypersensitivity
ENU	ethylnitrosourea
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FEI	FortisBC Energy Inc.
FM	frequency modulated
g	gram
GBM	glioblastoma multiforme
GGT	glutathione S-transferase
GHz	gigahertz
GSM	global system for mobile communications
GSR	galvanic skin response
HCN	Health Council of the Netherlands
hsp70	heat shock protein
Hz	hertz
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEI-EMF	idiopathic environmental intolerance attributed to electromagnetic fields
ISED	Innovation, Science, and Economic Development Canada
kHz	kilohertz

LAN	local area network
MDA	malondialdehyde
MHz	megahertz
MN	micronuclei
mW/cm^2	milliwatts per square centimeter
NRC	National Research Council
NSPS	non-specific physical symptoms
NTP	National Toxicology Program
OECD	Organization for Economic Cooperation and Development
OR	odds ratio
RCT	randomized control (or clinical) trial
RF	radiofrequency
RR	risk ratio
RSC	Royal Society of Canada
SAR	specific absorption rate
SC6	Safety Code 6
SCENIHR	Scientific Committee on Emerging and Newly Identified Health Risks
SCHEER	Scientific Committee on Health, Environmental, and Emerging Risks
SCSA	Sperm Chromatin Structure Assay
SmartPoint	Sensus FlexNet SmartPoint® modules
Sonix IQ gas meter	Sensus Sonix IQ™ advanced meters
SSB	single-strand break
SSM	Swedish Radiation Safety Authority
TEM	transverse electromagnetic
TUNEL	terminal deoxynucleotidyl transferase dUTP nick end labeling
TETRA	two-way terrestrial trunked radios
UMTS	Universal Mobile Telecommunications System
WHO	World Health Organization
W/kg	watts per kilogram
W/m^2	watts per square meter

Executive Summary

At the request of FortisBC Energy Inc., Exponent prepared this summary report on the status of research related to exposure to radiofrequency (RF) fields and health. This report follows upon Exponent's report *Exposure to Radiofrequency Fields in the Environment and from Advanced Metering Infrastructure* (hereafter RF Exposure Report [Exponent, 2021]), which provides considerable background information and descriptions of the physics of RF energy, RF field exposures from typical sources, and RF field exposure from the advanced metering infrastructure of the FlexNet Metering system, as well as evaluation of required compliance with Health Canada's Safety Code 6 (SC6) that governs public exposure to RF fields. Readers may wish to review the RF Exposure Report before reviewing this report to become familiar with terminology, technology issues, and RF signals used to support communications between the Sensus Sonix IQ™ advanced meters (hereafter Sonix IQ gas meter) and the proposed FlexNet network.

RF energy, also known as radio waves or fields, refers to a range of frequencies in the electromagnetic spectrum that is typically defined as between 3,000 Hertz (Hz) and 300 billion Hz. RF energy includes frequencies used to operate various devices and technologies, including amplitude-modulated and frequency-modulated broadcast radio, television broadcasts, mobile phones, cordless phones, garage door openers, baby monitors, wireless computer networks, security systems, radar, and microwave ovens, among others. It also includes the RF signal technology used by the Sonix IQ gas meters and other components of the FlexNet network, which operate on a dedicated licensed portion of the radio spectrum of approximately 900 Megahertz. A thorough analysis of RF field exposure from the Sonix IQ gas meters and FlexNet network, described in the RF Exposure Report (Exponent, 2021), shows that calculated exposures will be far less than from many other sources of RF fields and that indoor exposure to RF fields from the Sonix IQ gas meters is about 24 million times below the SC6 exposure limit.

Research on RF fields and health has examined whether exposure to RF fields can cause short- or long-term health effects in humans. In recent years, research has focused primarily on RF fields from mobile phones, in part because of the now ubiquitous use of mobile phones in our daily lives and also because of the close proximity of mobile phones to the human body.

Researchers have applied a variety of study designs and techniques to investigate potential effects on many aspects of physiology and diseases, including cancer in children and adults and symptoms of electromagnetic hypersensitivity. This report summarizes the study designs and approaches used by scientists in determining whether or how an exposure can affect human health and describes the generally-accepted scientific method (i.e., a weight-of-evidence review) used to arrive at valid scientific conclusions on potential health effects of environmental exposures.

Because of the amount and complexity of the scientific research in this area, comprehensive evaluations of the available scientific evidence have been regularly and repeatedly performed for health and scientific agencies by panels comprised of independent scientists with expertise in relevant scientific disciplines. In the past decade, several organizations have conducted reviews that evaluated studies on exposure to RF fields and health, including the European Union's Scientific Committee on Emerging and Newly Identified Health Risks, the Swedish Radiation Safety Authority, the Health Council of the Netherlands, the Health Protection Agency of the United Kingdom, the International Agency for Research on Cancer, and Health Canada (AGNIR, 2012; HCN, 2013, 2014, 2016; IARC, 2013; RSC, 2014; SCENIHR, 2015; SSM, 2016, 2018, 2019, 2020). This report summarizes the comprehensive risk assessments and reviews of exposure to RF fields and health conducted by these organizations, which have consistently concluded that the scientific evidence in the large number of published scientific studies does not confirm that RF fields at levels below the scientifically-based exposure limits are a cause or contribute to development of any adverse health effects, including cancer, other chronic diseases, or non-specific adverse symptoms that affect well-being.

This report further provides a summary of relevant epidemiologic and experimental studies published after the most recent comprehensive review was completed (i.e., SCENIHR, 2015). These recent studies did not provide sufficient evidence to alter the overall conclusions of the reviewing health and scientific organizations—that the research does not confirm that RF fields are a cause of cancer or any other disease at the levels we encounter in our everyday environment. Regarding health effects from mobile phone use, the World Health Organization website states "*[a] large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects* *have been established as being caused by mobile phone use.*"[1] It should be emphasized that exposure to RF fields at a distance of 1 meter from any of the FlexNet meters is more than 3,000-fold lower than the levels at which biological and health effects have been evaluated in this report to assess potential public health and safety of exposure to RF fields.

The regulatory standard in Canada to ensure public safety is the responsibility of Innovation, Science and Economic Development Canada, formerly Industry Canada, which implements the human exposure limits developed by Health Canada in SC6 (Health Canada, 2015). Health Canada's SC6, and the standards developed by other organizations, set exposure limits far below the level at which even minor effects of the known adverse health effects (elevated body temperature, tissues heating) caused by exposure to high levels of RF fields might occur.

Note that this Executive Summary provides only an outline of the material discussed in this report. Exponent's technical evaluations, analyses, conclusions, and recommendations are included in the main body of this report, which at all times is the controlling document.

[1] https://www.who.int/news-room/fact-sheets/detail/electromagnetic-fields-and-public-health-mobile-phones Accessed April 2021.

1. Introduction

The Sensus Sonix IQ^{TM} advanced meters (hereafter Sonix IQ gas meter) proposed by FortisBC Energy Inc. (FEI) communicate customers' gas usage by wireless radiofrequency (RF) signals. Before reviewing research on RF exposure and health, it is important to understand the basics of RF energy and the strength of RF signals that are associated with the operation of the Sonix IQ gas meter and other components of the FlexNet communication network that FEI proposes to implement in its service territory.

As indicated in the Executive Summary, background information and explanations about RF energy, RF exposures from typical sources, RF exposures from the advanced metering infrastructure components of the FlexNet system, and required compliance with Health Canada's Safety Code 6 (SC6) that governs public exposure to RF fields, are provided in the Exponent report, "*Exposure to Radiofrequency Fields in the Environment and from Advanced Metering Infrastructure*" (Exponent, 2021).

RF energy, also known as radio waves or fields, refers to a range of frequencies in the electromagnetic spectrum. The electromagnetic spectrum includes fields in a continuum of frequencies measured in cycles per second (referred to as Hertz [Hz]) and a corresponding range of wavelengths and energies. The electromagnetic spectrum ranges from waves with low frequencies, low energies, and long wavelengths (e.g., power-frequency electric and magnetic fields [EMF]), to waves with high frequencies, high energies, and short wavelengths (e.g., visible light, X-rays, gamma-rays). The RF range is at the lower end of the spectrum, lower than infrared rays, visible light, and ultraviolet light.[2] It is typically defined as between 3,000 Hz (3×10^3; i.e., 3 kilohertz [kHz]) and 300 billion Hz (3×10^{11}; i.e., 300 gigahertz [GHz]). RF energy includes frequencies used to operate various devices and technologies, including amplitude-modulated (AM) and frequency-modulated (FM) broadcast radio, television broadcasts, mobile phones, cordless phones, garage door openers, baby monitors, wireless computer networks, security systems, radar, and microwave ovens. The RF fields from these

[2] While in some disciplines, RF and electric and magnetic fields (i.e., EMF) are used synonymously, the common usage of EMF in epidemiologic and biological studies primarily refers to the electric fields and magnetic fields associated with the generation of electricity from power lines and all electric devices at 60 cycles per second (60 Hz).

devices are designed and regulated to be far below permitted exposure limits and so prevent the possibility of over exposure that might cause tissue heating.

RF signals have been used for familiar items like radio broadcasts for more than one hundred years, and even before that, for wireless telegraphy since the late 1890s. More recently, technological advancements have used very weak RF signals to operate cordless phones, baby monitors, wireless networks, and mobile phones. While research on exposure to RF energy has been conducted since the World War II era to support development of health-based exposure limits and standards, the recent proliferation of this technology has sparked additional research on RF fields, particularly in regard to mobile phones. Research on RF fields and health has increased in part because mobile phones are in widespread use, are used regularly, and are held next to the human body. In 2017, there were over 31 million mobile phones in use in Canada alone[3] and about 5 billion throughout the world.

Although the main focus of this research has been on mobile phones, the widespread introduction of other devices that transmit RF signals, such as wireless utility meters, also has raised questions by some members of the public and scientists about potential RF exposure at levels below that known to be harmful to human health. The main questions that have arisen in regard to RF fields are about cancer risk from long-term exposures and non-specific symptoms affecting overall quality of life from short-term exposures. These areas are the focus of the overview of research in this report.

The European Union's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) published a comprehensive review of the potential health effects of RF energy, static fields, and extremely-low-frequency fields in 2015. Regarding RF fields, the Committee concluded that exposure to RF fields did not cause increased risks of cancer or other adverse effects on health. The purpose of this report is to assess the weight of evidence added since this review to evaluate whether new research would change this conclusion. This report begins with a discussion of factors that affect exposure to RF fields from wireless communication devices, including the Sonix IQ gas meters and associated infrastructure (Section 2). Section 3 provides a description of the methods scientists use to compile and evaluate research on potential effects

[3] https://crtc.gc.ca/eng/publications/reports/policymonitoring/2018/cmr3d.htm Accessed April 2021.

of an exposure on human health and the use of this research by agencies like SCENIHR. Section 4 discusses the nature of the health effects from high exposures to RF energy and the basis for the standards that have been set, and describes the relevant standards applied to ensure the safe use of any device that uses RF energy. Section 5 discusses the reviews that have been conducted by scientific and health organizations. Section 6 summarizes recent research on RF fields, with a focus on studies of cancer and electromagnetic hypersensitivity, and the potential impact of this new research on the conclusions of recent comprehensive reviews, consistent with methods of a health risk assessment described in Section 3.

2. Exposure Characteristics of RF Wireless Communication Devices and FlexNet Meters

RF fields share common characteristics as to their propagation through the air and their interactions with objects as radio waves. The interaction of these fields with objects, however, is largely determined by the characteristics of the object including its size, shape, and composition. In particular, an object's conductivity and permittivity vary according to the frequency of the RF wave. For humans and other organisms, this variation in conductivity and permittivity therefore determines the amount and depth of energy absorption from a particular RF wave.

While the frequency of the RF field, together with the size, shape, and electrical characteristics of the human body, determine the extent of absorbed energy, the intensity of the RF field is strongly influenced by the distance from the source. Close proximity to a weak source such as a mobile phone or other hand-held or worn device provides higher exposure to RF fields than from more powerful sources such as radio or television broadcast stations that are kilometers away. Very large reductions in signal strength occur even at locations a short distance away from an RF source because the signal diminishes with the square of the distance. As described in SC6, limits on the intensity of RF exposure in close proximity to the body are expressed by specific absorption rates (SAR) in units of watts per kilogram (W/kg). Related limits on the strength of RF signals are calculated or measured in units of power density—watts per square meter (W/m^2) or milliwatts per square centimeter (mW/cm^2).

While distance from the RF source is a key component determining the strength of a wireless signal, the duration of time over which one is exposed to RF fields is another important contributor to exposure. Considering exposure as the product of signal strength times the duration exposed is important in the assessment of potential biological and health effects of exposure. Many devices use wireless signals to communicate information, but there are large differences between various RF devices as to the length of time they are designed to transmit. Some sources like AM/FM broadcast stations, global positioning system signals from satellites, and cellular towers transmit continuously. Other sources like mobile phones, cordless phones, home or office Wi-Fi, and baby monitors may be used for long periods. Still other sources are turned on and transmit for only very short periods, including garage door openers, wireless printers, and citizen band radios. The wireless signals from the Sonix IQ gas meters and similar Sensus FlexNet SmartPoint® modules (hereafter SmartPoint) attachments to existing advanced gas meters are at the lowest end of this latter category (*see* Exponent, 2021, Figure 5) because the elements of the system transmit infrequently and then only for a fraction of a second.

As described in the RF Exposure Report, the method FEI has proposed for collecting information from customers about their gas usage involves the transmission of usage by a customer's Sonix IQ gas meter by sending an RF signal with a fixed duration of approximately 55 milliseconds at 4-hour intervals (Exponent, 2021).

The calculated exposures at 1 meter in front of the Sonix IQ gas meters and SmartPoints are very small, just 0.000057% and 0.000039%, respectively, of the SC6 reference value for whole-body exposure to RF fields in uncontrolled environments occupied by the general public. The RF fields from other less common components of the FlexNet system—Sensus FlexNet SentryPoints™ and Sensus FlexNet Gateways—at greater representative distances are still lower (Exponent, 2021).

The very low signal strength and ultrashort transmission times of the proposed Sonix IQ gas meters and other components of the FlexNet system are important to keep in mind as we review and evaluate human exposures to RF fields in the current epidemiologic research where most exposures were from mobile phones and hand-held communicators that are held close to the body. Exposures from mobile phones, which are the RF source most commonly emulated in experimental studies of animals, produce far greater exposures, almost two million times greater than Sonix IQ gas meters, but still are within SC6 regulatory limits (Exponent, 2021, Figure 5). The exposures applied in many of the animal experiments reviewed here in Appendix 1, however, were even higher, up to 125 times above the SC6 basic restriction on SAR for whole-body human exposure of the general public. Most of these latter studies applied exposures that also exceeded 4 W/kg, an adverse effect threshold above which unacceptable heating of the whole body may occur. The remainder of the animal studies reviewed applied RF fields at lower SAR exposures, but only six studies examined exposures that were below the SC6 whole-body exposure limit of 0.08 W/kg and none were as low as the SAR value for a person standing 1 meter from a Sonix IQ gas meter (0.000000046 W/kg).[4]

Overall, the exposure to RF fields at 1 meter from the Sonix IQ gas meters or SmartPoints (indoors) is estimated to be on the order of 1.8 million-fold less than the exposure to RF fields from a mobile phone (~at 0.1 W/kg) in the epidemiologic studies reviewed, and more than 42,000-fold lower than the lowest SAR level (0.00014 W/kg) of any *in vivo* animal study of deoxyribonucleic acid (DNA) and chromosomes reviewed here in Appendix 1. These calculated exposures from Sonix IQ gas meters also can be compared to the regulatory limits in SC6. Indoor exposure from Sonix IQ gas meters is about 24 million times below the SC6 exposure limit.

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4 The exposure a distance of 1 meter in front of the Sonix IQ advanced gas meter is 0.000057% of the SC6 reference level (Exponent, 2021, Table B-2). The SC6 whole body SAR limit is 0.08 W/kg (Exponent, 2021, Table 1), so the SAR level is equivalent to 0.000057% × 0.08 W/kg = 0.000000046 W/kg.

3. Evaluating Scientific Research

Health risk assessment approach

A health risk assessment is the scientific method used by scientists worldwide for determining whether or how an exposure in the environment, such as chemicals in the air, water, or food, or devices such as mobile phones or advanced meters, can affect human health. Health risk assessments include four general steps: hazard identification, dose response assessment, exposure assessment, and specific risk characterization.

In the first step, *hazard identification*, scientists identify and review all of the relevant scientific research studies of effects in humans and laboratory animals to determine the types of health problems that might result from exposure. The next step, *dose-response assessment*, is an evaluation of the data from the hazard identification to determine what intensity and duration of exposure causes adverse effects that were identified. The dose-response assessment is the basis for developing exposure limits and regulatory standards. Next, the *exposure assessment,* evaluates the amount and nature of human exposure from the agent being studied. The final step, *specific risk characterization,* compares the dose-response pattern to the amount of the specific exposure being investigated to determine a level of risk for the exposed population. For some exposures, limits already have been developed from the data as a regulatory standard. In such cases, as for exposure to RF signals from advanced meters, the final step is to compare the specific exposure to the relevant standard.

Hazard identification

In a hazard identification, scientists search out and review all of the relevant scientific research studies to determine the types of health problems that an exposure could cause, regardless of the exposure. This process considers epidemiologic studies of humans in their natural environment, experimental laboratory studies of humans or laboratory animals (*in vivo*), and laboratory studies of cells and tissues (*in vitro*) that may provide evidence for a mechanism—the way in which the exposure interacts with biological tissue. These three types of studies provide different but complementary information to determine how an exposure affects biological organisms.

Dose-response assessment

The second step in the risk assessment process is to determine how responses to the exposure relate to the level of exposure. Almost anything in our environment can produce adverse effects if the exposure is high enough, including water and some vitamins, so the goal is to find the level below which adverse effects do not occur.

In a dose-response assessment, scientists evaluate the scientific research to estimate the amount of exposure (dose) that is likely to result in a particular health effect in humans. This is important because many things that might impact human health only do so after a certain amount of exposure has occurred. A simple summary of the dose-response principle is that for chemicals or physical agents that could affect biological function, more is worse. For this reason, laboratory experiments strive to expose animals at the highest level tolerated, to ensure that potential adverse effects are not missed. Then, exposures at lower levels are used to identify exposure levels that do not produce adverse effects. Studies that demonstrate increased effects with higher doses show a dose-response pattern, which, if consistent across valid studies, can support inferences of causality.

The concept that effects of exposure are closely tied to the intensity of exposure is a familiar part of our daily life. We know, for example, that sunlight can burn unprotected skin, but blocking sunlight by the application of sunscreen lowers an individual's exposure to sunlight, thus reduces the risk of sunburn. Another example is that a 6% solution of sodium hypochlorite, commonly known as bleach, carries a warning label that this substance is hazardous, dangerous, and corrosive. But, a similar, highly-diluted solution is used to disinfect many municipal drinking water supplies; in this case, the concentration of sodium hypochlorite is extremely low, and the dose is far too low to produce a toxic effect.

Exposure assessment

The third step of the process is to determine the way in which people could be exposed in a specific situation, including the amount and duration of exposure. This is important because an individual's exposure is one of the major factors for determining the potential for an impact on health.

Specific health risk characterization

The information developed in the hazard identification, dose-response assessment, and exposure assessment is used to reach a conclusion and characterize the specific health risk, if one exists.

Types of studies considered in a health risk assessment

Research studies can be broadly classified into two groups: 1) epidemiologic studies of people and 2) experimental studies of humans, animals (*in vivo*), and cells and tissues (*in vitro*) conducted in laboratory settings. Taken together, epidemiologic, *in vivo*, and *in vitro* studies provide a more complete picture of a possible disease etiology than any one study type alone, given the unique strengths and weaknesses of each study design. In valid risk assessments of exposure to RF and health, epidemiologic studies are considered alongside experimental studies of laboratory animals, while studies of isolated cells and tissues are generally acknowledged as being supplementary.

Epidemiologic studies

One aspect of epidemiologic research provides descriptive statistics on the population, such as birth rates and mortality rates, to help characterize health and disease in the population. These data are collected by public health agencies such as Health Canada to show trends over time or differences among places. Examples include data that show changes in heart disease deaths over time, variations in infant mortality rates among cities, or cancer occurrence in Canada overall and comparisons among provinces. These data are often evaluated to monitor progress in treating cancer or to evaluate the effects of changes in the rate of cigarette smoking on rates of lung cancer or heart disease over time.

Epidemiologists also study people in their natural environment in relation to individual exposure. These studies are often described as observational rather than experimental, although observational studies can include elements of experimental studies; for example, studies of exposure to RF fields can include interventions, such as turning sources of RF fields on or off at various times during the study. Each of the main types of observational epidemiologic study design—cohort, case-control, cross-sectional, and ecological—have been used to obtain information on exposure to RF fields and health.

In a cohort study, a group of people is observed over a long period to determine whether diseases develop in relation to exposures at various levels. This type of epidemiologic study typically provides the most relevant and reliable information, but cohort studies can be cost-prohibitive and time-consuming because they require following a large number of people over a long period, particularly for conditions that develop over years. Many cohort studies are undertaken in occupational environments because of the large populations, relatively high exposures, and the availability of records on individual workers.

To obtain information more readily, epidemiologists frequently use case-control studies. This type of study compares the exposure of people who have been diagnosed with a particular disease (i.e., cases) to a similar group of people who do not have the disease (i.e., controls). The objective is to assess whether the cases had higher or more frequent exposures than the controls, or *vice versa*. One main challenge of a case-control study is to enroll a control group that is, to the greatest extent possible, similar to the underlying population at risk, from which the cases arose. If this condition is met and a difference is found in the exposure level between the two groups, the investigators can have some confidence that the difference is not being caused by some other factor. Another challenge of case-control studies is that they are retrospective (i.e., the study starts after onset of disease so *past* history of exposure must be evaluated).

Cross-sectional studies examine exposure and health outcomes in the study population simultaneously. These studies generally are used to assess the prevalence (or presence) of the exposure and outcome at a single point in time or a short period (this is sometimes described as providing a "*snapshot*" of disease occurrence within the population). In contrast to cohort studies, cross-sectional studies do not follow the study population over time to observe whether disease develops differently in exposed and unexposed populations. Because exposure and outcome are determined at the same time, a main limitation of cross-sectional studies is that no information is available on whether the exposure preceded the outcome; therefore, this study design cannot be relied upon for causal inference.

In ecological studies, researchers examine the exposure and outcome at the population or community level, often by aggregating individual-level data for a specific geographic region or population. For example, researchers may examine RF field exposures and cancer cases within a specific city or region. These studies are useful when data at an individual level are limited or when there is an interest in examining population-level effects of exposure on an outcome. Because data are examined on a large scale and cannot account for individual-level differences or risk factors, ecological study results are only applicable at the population level and cannot provide conclusions about any one individual's level of risk. Ecological studies are therefore subject to a type of error known as an "*ecological fallacy*," in which the relationship between exposure and outcome observed at the population level are assumed (sometimes incorrectly) to be true for individuals.

In addition to the observational study designs discussed above, researchers also use an experimental epidemiologic study design known as a randomized control (or clinical) trial (RCT). In an RCT, researchers randomly assign the study participants to either an experimental group (i.e., the group that receives the exposure or treatment under study) or a control group, which does not receive the exposure or treatment. Randomizing participants to the two groups reduces the potential for errors (bias) in the study and allows researchers to better isolate the true effect of the exposure or treatment. Because of this, RCTs are generally considered the "*gold standard*" of epidemiologic study designs and provide the strongest evidence for or against a causal association between an exposure and outcome. However, RCTs are not frequently performed to assess the relationship between community exposures and health outcomes, as they are lengthy and expensive to carry out.

The results of epidemiologic studies are expressed as statistical associations—either summarized as an odds ratio (OR) in case-control studies or a risk ratio (RR) in cohort studies. These ratios are a quantitative measure of how an exposure and disease vary together. The strength of an association addresses the question, does this disease occur more often in people with the exposure of concern compared to people who are unexposed? A positive association (i.e., an OR or RR greater than 1.0) indicates that the answer may be yes, but numbers close to 1.0 indicate a weaker link, and higher numbers indicate a stronger link. A positive association may also be interpreted as a measure of the potential increased risk of developing disease in people who are exposed compared to the risk of developing disease in people who are not exposed. While this information from an epidemiologic study may provide an indication of the factors involved in health and disease, it is not used as the sole basis for drawing inferences about cause-and-effect relationships. Neither a statistical association nor a correlation between any two events is a direct indication of cause and effect, and a positive statistical association or a reported increased risk of disease by itself does not represent a conclusion regarding causation. An observed association may in fact be due to the effects of one or more other factors, including random chance or systematic errors within the study. Because each epidemiologic study is only a sample of the population, and no single study is perfect, the results from any one study cannot be used to establish a causal relationship between exposure and disease. Instead, epidemiologic support for causality is usually based on high-quality studies that report consistent results across many different populations and study designs and are supported by experimental data collected from *in vivo* and *in vitro* studies.

Scientific guidance for assessing the overall epidemiologic evidence for causality was formally proposed by Sir Austin Bradford Hill (Hill, 1965). Hill put forth nine criteria for use in an evaluation of causality for associations observed in epidemiologic studies. These criteria included strength of association, consistency, specificity, temporality, biological gradient, plausibility, coherence, experiment, and analogy. Hill cautioned that while none of these criteria are *sine qua non* (i.e., absolutely necessary) of causality, the more the epidemiologic evidence meets these guidelines, the more convincing the evidence is for a potential causal interpretation. The use of these guidelines is recommended after chance has been ruled out with reasonable certainty as a potential explanation for the observed epidemiologic association.

The validity of a study depends upon the quality of the data, which depends upon the methods used to collect and analyze the information from which the results were calculated. To evaluate the results of any type of study, whether an epidemiologic study or laboratory research, it is crucial to assess the way the study was designed and conducted, the number of participants, the accuracy of the exposure assessment, and the statistical methods of analysis. This is particularly necessary in epidemiologic studies to determine whether an association is a result of systematic error (bias) in the selection of participants, misclassification of exposures, secondary effects by other variables such as the presence of other exposures or pre-existing conditions (confounding), or random variation (chance). Even if a statistical association from a single study is deemed valid, further scrutiny is warranted to determine if the statistical association indicates a cause-and-effect relationship.

In epidemiologic research, the results of studies with a smaller number of participants may be difficult to distinguish from normal, random variation. This is also the case for sub-group analyses where few participants are estimated to have high exposure levels. Meta-analysis is an analytic technique that combines the published results from a group of studies into one summary result. A pooled analysis, on the other hand, combines the raw, individual-level data from the original studies and analyzes the data from the studies together. These methods are valuable tools for qualitatively synthesizing the results of a large group of studies because they increase the number of individuals in the analysis, which allows for a more robust and stable estimate of association. The disadvantage of meta- and pooled analyses is that they can convey a false sense of consistency across studies if *only* the combined estimate of effect is considered (Rothman and Greenland, 1998). These analyses typically combine data from studies with different study populations, methods for measuring and defining exposure, and disease definitions. This is particularly true for analyses that combine data from case-control studies, which often use very different methods for the selection of cases and controls and exposure assessment. Therefore, in addition to the synthesis or combining of data, meta- and pooled analyses should be used to understand what factors cause the results of the studies to vary (e.g., publication date, study design, possibility of selection bias), and how these heterogeneous factors affect the associations calculated from the data of all the studies combined (Rothman and Greenland, 1998).

When interpreting the results of epidemiologic studies, epidemiologists and other scientists focus predominantly on the main results of the study (i.e., on analyses that were conducted using the entire study population, or the majority of the study population). In addition to the main analyses, researchers may also conduct sub-analyses of the data, in which subsets, or groups, of the study population are analyzed separately based on one or more shared characteristics (e.g., tumor sub-type, length of exposure duration, gender, age, etc.). The goal of sub-group analyses is to examine if and how the relationship between the exposure and outcome of interest varies across different subsets of the population, and sub-group analyses can sometimes lead to additional research questions that should be explored in future studies. However, sub-group analyses are generally considered secondary to the main analyses and should always be interpreted with caution (Fletcher, 2007; Wang et al., 2007). These analyses are not always planned before the data were collected and instead may represent *post hoc* attempts by researchers to identify any statistically significant associations in the data when none were observed in the main analyses (therefore increasing the chances of their study being published). In addition, sub-group analyses typically include fewer study participants per group compared to the main analyses; this is an issue because small sample sizes decrease the likelihood that a statistically significant finding reflects the true association between exposure and outcome and increase the likelihood that it is due to error or chance.

Experimental studies

A wide variety of approaches are available for assessing the possible adverse effects associated with exposures in experimental studies. The two general types of experimental studies are *in vivo* studies of the effects of planned exposures (i.e., studies of human volunteers, which are usually short-term, and of whole animals, which are usually longer-term), and *in vitro* studies (i.e., studies of isolated cells and tissues). Compared to epidemiologic and *in vivo* studies, *in vitro* studies generally provide less value to human health risk assessments because responses of cells and tissues outside the body may not reflect the response of those same cells if maintained in an intact living system; thus, their relevance cannot be assumed (IARC, 1992). In addition, the results of *in vitro* studies cannot be interpreted in terms of potential human health risks unless they are performed in a well-studied and validated test system. For these reasons, agencies such as the International Agency for Research on Cancer (IARC) treat data from *in vitro* studies as supplementary to data obtained from epidemiologic and *in vivo* studies, and *in vitro* data are not used directly to assess risks to human health. Therefore, this report considers recent human and animal studies of exposure to RF fields but does not review *in vitro* research. Only human and animal studies of RF exposure were considered because they provide more direct information on human health than *in vitro* studies.[5]

[5] *For example,* SCENIHR (2012), which states, *"[i]n vivo results are considered to have more relevance than in vitro results in the overall assessment of a genotoxic hazard*"(p. 26). SCENIHR (2012) also states, "*In vitro studies contribute to acute toxicity testing and can provide information relevant regarding carcinogenesis and other physiological or pathological processes but cannot replace in vivo conditions or long term exposure conditions*" (pp. 27-28).

Furthermore, the reviews conducted by health and scientific agencies have not provided any indication that *in vitro* studies have influenced their conclusions.[6]

Specific methods are used to reduce subjectivity and avoid systematic error (i.e., bias), in scientific experiments (NRC, 1997). These include the random assignment of subjects to control or comparison groups, the unbiased collection of information (e.g., researchers are not aware of the exposure, also termed "*blind*" to the exposure); control of the environmental and procedural variables during the experiment and after so if a difference between exposed and control groups is observed, it can be unambiguously linked to the intended exposure—not extraneous factors; and the need for replication of results in different studies, at various different laboratories, and across species, all of which strengthen the evidence. In addition, each study should contain enough participants or animals to overcome random variation. These factors serve as guidance for weighing the evidence from studies to reach a decision about cause and effect. The more firmly these criteria are met by the studies, the more convincing the evidence.

Some human and animal studies aim to identify biological processes that may be associated with disease states or injury by measuring so called biomarkers. Abnormal levels of biomarkers may be associated with health problems even though they only may be an indirect indicator. An example might be a low blood count, which can be caused by many factors, and so, by itself, is not diagnostic of any specific disease or condition. Despite such limitations, biomarker studies are often done because of the ease of obtaining samples and low cost of analyses compared to more invasive or more specific biochemical analyses.

Studies in which laboratory animals receive high exposures in a controlled environment provide an important basis for evaluating the safety of environmental, chemical, and drug exposures. These approaches are used widely by health agencies to assess risks to humans from medicines, chemicals, and physical agents, because studies in laboratory animals such as rats and mice have

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[6] *See* for example, IARC (2013), which states, *"[o]verall, the Working Group concluded that there was weak evidence that RF radiation is genotoxic, and no evidence for the mutagenicity of RF radiation*" (p. 415). Overall, the SCENIHR Working Group concluded that "*In most of the [in vitro] studies, no effects of exposure at non-thermal levels were reported, although in some cases DNA strand breaks and mitotic spindle disturbances were observed*" (SCENIHR, 2015, p. 153).

been found to be reasonable indictors of adverse effects in humans (Health Canada, 1994; WHO, 1994; IARC, 2013 preamble; USEPA, 2002, 2005).

From a public health perspective, long-term (chronic) studies in which animals undergo exposure over most of their lifetime, or during their entire pregnancy, are of high importance in assessing potential risks of cancer and other adverse effects. In these long-term studies, researchers examine a large number of anatomical sites to assess changes and adverse effects in body organs, cells, and tissues.

These data are used in the hazard identification step of the risk assessment process to determine whether an environmental exposure at any level or circumstance can produce cancer or damage organs and tissues. Health Canada mandates that experimental lifetime *in vivo* studies or *in vivo* studies of exposures to animals during critically sensitive periods be conducted to assess potential toxicity to humans (Health Canada, 1994). Furthermore, the position of the United States Environmental Protection Agency (EPA) is that, "*…the absence of tumors in well-conducted, long-term animal studies in at least two species provides reasonable assurance that an agent may not be a carcinogenic concern for humans*" (USEPA, 2005, pp. 2-22).

Weight-of-evidence reviews

The risk assessment process includes evaluating the methods used in conducting each individual study included in the hazard identification, analyzing the results, and weighing the evidence, giving more weight to studies of better, more reliable designs (i.e., a weight-of-evidence review). This process is designed to ensure that all relevant studies are considered regardless of their conclusions or support for any particular hypothesis. During the weight-of-evidence review, scientists look for replication of results by different researchers or other laboratories to form conclusions about causality, because no single study is capable of assessing causality independently. Two steps necessarily precede a weight-of-evidence evaluation: a systematic review to identify the relevant literature and an evaluation of each relevant study to determine its strengths and weaknesses.

Several agencies have described weight-of-evidence evaluation and health risk assessment approaches, including the IARC, which routinely evaluates substances such as drugs, chemicals, and physical agents for their ability to cause cancer; the World Health Organization (WHO) International Programme for Chemical Safety; the EPA, which sets guidance for public exposures in the United States; the European Commission's Scientific Committee on Health, Environmental, and Emerging Risks (SCHEER);[7] and the United States National Toxicology Program (NTP) (USEPA, 1993, 1996; WHO, 1994; SCENIHR, 2012; NTP, 2019; SCHEER, 2018).

In their 2018 report, *Memorandum of weight of evidence and uncertainties Revision 2018,* SCHEER defined a weight-of-evidence evaluation as *"[a] process of weighted integration of lines of evidence to determine the relative support for hypotheses or answers to a question"*(SCHEER, 2018, p. 9). As part of the weight-of-evidence approach, SCHEER identifies, collects, and selects possible sources of scientific evidence (primarily in the form of peer-reviewed publications) related to the risk assessment question under study and then evaluates each line of evidence on its validity, reliability, and relevance. The results from all relevant individual lines of evidence are then gathered into an overall assessment and any remaining uncertainties are addressed. SCHEER notes that in drawing conclusions from the available evidence, it is important to consider all the information together, and states that,

> *… it is not recommended to simply add together weighting from individual lines of evidence… The severity of the effect/outcome and the likelihood of its occurrence in individuals or in the population at large is another factor to take into account at the integration level. One of the crucial points is the identification of the critical effect both in animal and human studies… The key issues in the evaluation of human evidence are to assess whether the results demonstrate a true causal effect, to identify the affected population and to determine to what extent the adverse effects of the exposure might be avoidable* (SCHEER, 2018, p. 30).

[7] On July 8, 2015, SCENIHR was renamed SCHEER. The organization's review of RF research was published under the name SCENIHR, while the revised weight-of-evidence guidelines document was published under SCHEER, which is reflected in the citations used throughout this report.

4. Exposure Limits and Regulatory Standards

When a health risk assessment process indicates that there might be a potential health hazard from higher exposures to a substance or physical agent, a government agency or technical organization is likely to promulgate a standard. A health standard is developed from the hazard identification and dose response assessment of the risk assessment process described above. A health agency or scientific organization typically evaluates three types of studies (epidemiologic, *in vivo*, and *in vitro*) during the risk assessment. Most organizations identify experts in the many relevant disciplines that perform research on the topic of interest to evaluate the research.

Known adverse health effects can be caused by high exposures to RF fields. The effect that occurs first, given sufficient exposure, is a rise in body or tissue temperature. This is the basis of the applicable public exposure limit. Small changes in whole body temperature are actually not an adverse effect if they represent a change similar to daily changes to which our bodies routinely adapt. National and international health and regulatory agencies have set exposure limits to ensure that the warming of tissues is restricted. The goal of the standard is to limit such warming of tissues, since even modest warming of the body can be distracting and should be limited in a working environment. At higher levels of exposure, more serious adverse effects could occur, including effects similar to hyperthermia and local cell damage. Therefore, the exposure limits in the RF standards are set well below the level at which even minor effects from tissue heating might occur (FCC, 1997; Health Canada, 2015; IEEE, 2019; ICNIRP, 2020a).

Health Canada's Safety Code 6

Similar to the way that agencies have established exposure limits for RF fields in the United States and Europe, the scientists that developed Health Canada's SC6 (*Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz*) used the risk assessment approach to evaluate all research related to exposure to RF fields and health (Health Canada, 2015).

The objective of any standard, whether it regulates drinking water, air quality, or food safety, is to keep exposure below the lowest level at which any established potentially adverse effect is known to occur. The approach scientists use to develop health-based standards is to set the exposure many times below the level at which research suggests that an effect could occur. This conservative approach helps to compensate for unrecognized limitations in the research and exposure assessment, and to afford additional protection to all members of the population. SC6, as well as standards in many other countries, recognize a SAR value of 4 W/kg as the lowest exposure to RF fields known to produce an adverse effect (whole body heating and sequelae thereto). The number used to lower the exposure limit below the lowest known adverse effect level is referred to as a safety factor. For controlled environments, as in occupational settings, where exposures have been measured or calculated and persons are informed, SC6 applies a safety factor of 10 to set a basic restriction limit on exposure. For uncontrolled environments where the general public might encounter RF fields, SC6 applies a safety factor of 50 to an adverse effect SAR level of 4 W/kg to set the basic restriction limit at 0.08 W/kg.

As with most environmental exposures, few studies of RF exposure include children and other sensitive persons. Several methods are used to develop protection for these populations. One approach is to incorporate information about the mechanism by which the agent affects the human body and ascertain whether children or the elderly would react differently because of biological characteristics. Another is to conduct experimental studies of animals at varying stages of development to determine potential sensitivities of the young and the old. Finally, scientists recommend exposure limits that are comfortably *below* levels known to produce effects. This incorporates the basic scientific concept of dose response, which refers to the principle that the probability of an effect occurring, or the severity of an effect, increases with the dose, or amount of exposure.

Basis for the SC6 standard for radiofrequency exposure

RF standards are called safety standards because they address issues of human health and safety, and they prescribe exposure limits for a level in the environment presumed harmless. An exposure limit is the amount of exposure to RF fields at a specified frequency or a range of frequencies that should not be exceeded in order to protect human health with an adequate margin of safety.[8] In Canada, RF safety standards are codified in SC6. The purpose of SC6, originally published by Health Canada in 1991, is to "*establish safety limits for human exposure to radiofrequency (RF) fields in the frequency range from 3 kHz to 300 GHz*" (p. I) to protect workers and the public from RF fields and microwave radiation. SC6 applies to "*all individuals working at, or visiting, federally regulated sites*" and has been adopted by Innovation, Science and Economic Development Canada (ISED) as:

> *… the scientific basis for equipment certification and RF field exposure compliance specifications outlined in Industry Canada's regulatory documents (1–3), that govern the use of wireless devices in Canada, such as cell phones, cell towers (base stations) and broadcast antennas. Safety Code 6 does not apply to the deliberate exposure for treatment of patients by, or under the direction of, medical practitioners* (Health Canada, 2015, p. I).

Since its initial publication, SC6 has been periodically updated as new scientific literature becomes available and has undergone a number of revisions with new versions published in 1999, 2009, and 2015, each time with input from the Royal Society of Canada (RSC). During the revision process prior to finalizing SC6, Health Canada also considered input from the public and scientists for the 9 months before the release of the revised SC6 in 2015.

The scientific basis for SC6 was described as:

> *The exposure limits specified in Safety Code 6 have been established based upon a thorough evaluation of the scientific literature related to the thermal and non-thermal health effects of RF fields … Health Canada scientists consider all peer-reviewed scientific studies, on an ongoing basis, and employ a weight-of-evidence approach when evaluating the possible health risks of exposure to RF fields. This approach takes into account the quantity of studies on a particular endpoint (whether adverse or no effect), but more importantly, the quality of those studies. Poorly conducted studies (e.g. those with*

8 Standards are also used for specifications for manufacturing products to ensure safe construction, or conformity or compatibility among different companies that make the same item, but in this report we are referring to safety standards.

> *incomplete dosimetry or inadequate control samples) receive relatively little weight, while properly conducted studies (e.g. all controls included, appropriate statistics, complete dosimetry) receive more weight. The exposure limits in Safety Code 6 are based upon the lowest exposure level at which any scientifically established adverse health effect occurs. Safety margins have been incorporated into the exposure limits to ensure that even worst-case exposures remain far below the threshold for harm. The scientific approach used to establish the exposure limits in Safety Code 6 is comparable to that employed by other science-based international standards bodies* (Health Canada, 2015, p. 1).

The limits established in SC6 are based upon limiting short-term biological responses to RF fields and do not contain any restriction for long-term or cumulative exposure, noting that:

> *At present, there is no scientific basis for the occurrence of acute, chronic and/or cumulative adverse health risks from RF field exposure at levels below the limits outlined in Safety Code 6. The hypotheses of other proposed adverse health effects occurring at levels below the exposure limits outlined in Safety Code 6 suffer from a lack of evidence of causality, biological plausibility and reproducibility and do not provide a credible foundation for making science-based recommendations for limiting human exposures to low-intensity RF fields* (Health Canada, 2015, p. 2).[9]

Health Canada's mandate regarding human exposure to RF fields from wireless equipment is to carry out research into possible health effects, monitor the scientific literature related to such effects, and develop exposure guidelines for federal activities. These exposure limits are based on the risk assessment process, those established scientific and technical methods for reviewing biological and health research. These exposure guidelines are adopted by ISED, the federal

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[9] It should be noted that SC6 states *"[w]hile the biological basis for the basic restrictions specified in this safety code has not changed since the previous version (2009), the reference levels have been updated to either account for dosimetric refinements in recent years ... or where feasible, to harmonize with those of ICNIRP [International Commission on Non-ionizing Radiation Protection"*(Health Canada, 2015, p. 4).

agency responsible for regulating wireless communications equipment (e.g., mobile phones, cell tower sites, smart meters, Wi-Fi) and exposure of the public to RF fields in Canada.

To assist persons to understand SC6, additional information is available in other documents published by Health Canada including *Understanding Safety Code 6*, an overview of the salient points discussed in SC6, including a high-level summary of the purpose of SC6, an overview of its structure, and summaries of the scientific review process and comparison to international standards; a *Fact Sheet – What is Safety Code 6?* provides a brief overview of SC6 and includes a section entitled *Busting Myths on Safety Code 6*, and a *Technical Guide for Interpretation and Compliance Assessment of Health Canada's Radiofrequency Exposure Guidelines Document*.

The implementation, management, and evaluation of RF field exposures compliant with SC6 at the national level is described by ISED for persons in the far field in uncontrolled environments. ISED's *Radio Standards Specification 102, Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)* sets out the requirements and measurement techniques used to evaluate RF exposure compliance of radiocommunication apparatus designed to be used within the vicinity of the human body in conjunction with *TN-261 — Safety Code 6 (SC6) Radio Frequency Exposure Compliance Evaluation Template (Uncontrolled Environment Exposure Limits)*.

5. Agency Reviews of Radiofrequency Fields and Health

Scientific research on exposure to RF fields and health is reviewed regularly by independent scientific and governmental organizations worldwide. These organizations assemble expert panels to conduct weight-of-evidence reviews. The members of these expert panels have the knowledge and mandate to review relevant research and provide scientifically-grounded public health recommendations.

Within the last decade, several prominent regulatory, scientific, and health organizations have systematically reviewed the research on exposure to RF fields and health. These organizations include the IARC, the International Commission on Non-Ionizing Radiation Protection (ICNIRP), the Health Council of the Netherlands (HCN), the Advisory Group on Non-Ionising Radiation Protection (AGNIR), SCENIHR, the Swedish Radiation Safety Authority (SSM), the United States Food and Drug Administration (FDA), and RSC (AGNIR, 2012; HCN, 2013, 2014, 2016; IARC, 2013; WHO, 2014, RSC, 2014; SCENIHR, 2015; SSM, 2016, 2018, 2019, 2020; ICNIRP, 2020a; FDA, 2020). These organizations have all independently reached the same conclusion regarding exposure to RF fields and human health—that exposure below the current scientifically-based exposure limits (e.g., the ICNIRP guidelines) has not consistently or convincingly been established as causing any type of cancer, other chronic diseases, or non-specific symptoms that adversely affect well-being in humans.

Some studies have reported effects from exposure to RF fields occurring below the level that raises body temperature, often called *non-thermal* effects. These studies have been reviewed by these scientific and regulatory agencies, which have concluded that the observed biological effects attributed to non-thermal levels were not consistent or reproducible, are not supported by any plausible biological explanation as to how they could occur, and in some studies the biological effects reported are not known to be linked to adverse effects on health (SCENIHR, 2009, 2015; AGNIR, 2012; RSC, 2014; HCN, 2016; SSM, 2016, 2018, 2019, 2020; IEEE, 2019; ICNIRP, 2020a).

In addition to the agencies listed above, a number of additional provincial and national agencies with responsibilities for public health routinely provide guidance and communicate health information to the public regarding exposure to electromagnetic fields at varying frequencies. These organizations include the British Columbia Centre for Disease Control (BCCDC), the French Agency for Food, Environment and Occupational Health and Safety, and the Australian Radiation Protection and Nuclear Safety Agency. In this report, information and guidance provided by the BCCDC is summarized in the relevant sections.

Advisory Group on Non-Ionising Radiation

The independent AGNIR published a systematic review of the scientific literature in 2012 for the Health Protection Agency of Great Britain (now part of the National Institute for Health Protection), the United Kingdom's primary government authority on public health. AGNIR reviewed research related to RF field exposure and health published through 2010 and part of 2011 to update its previous reports on electromagnetic fields published since the agency was formed in 1999 (AGNIR, 2012).

Overall, the Advisory Group concluded, *"although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guidance levels causes health effects in adults or children"* (AGNIR, 2012, p. 4). They further stated, *"[t]here are still limitations to the published research that preclude a definitive judgement, but the evidence considered overall has not demonstrated any adverse health effects of RF field exposure below international accepted guideline levels"* (AGNIR, 2012, p. 4). Specific conclusions related to the health outcomes (e.g., cancer, symptoms of well-being) and types of studies (e.g., epidemiologic studies, experimental studies) reviewed are summarized in the relevant sub-sections of Section 6.

British Columbia Centre for Disease Control

The BCCDC has a long history of providing health information to the public about electromagnetic fields at various frequencies. Regarding RF fields, the BCCDC published a *Radiofrequency Toolkit for Environmental Health Practitioners* in 2013 to assist public health officers to assess and communicate the potential risk to health of the many devices and applications that emit RF waves (BCCDC, 2013). The Toolkit included assessments of RF exposure sources; the results of biological studies of cells and animals; human studies of therapeutic uses of RF fields in medicine; occupational studies; and mobile phone studies of cancer, reproduction, cognitive effects, and non-specific symptoms affecting well-being.

The BCCDC also published its *2016 Review: Radiofrequency and Health* in which it described and compared RF field exposures from common devices, discussed research on potential health effects from RF field exposure, and discussed ways in which members of the public, if they choose, can reduce personal exposure to RF fields, with priority given to personal mobile phone use, and cordless (digital enhanced cordless telecommunications [DECT]) handsets (BCCDC, 2016).

International Agency for Research on Cancer

As an agency of the WHO, IARC routinely assembles international working groups of experts to critically and systematically review and evaluate human, animal, mechanistic, and exposure-related evidence on the carcinogenicity of various human exposures as the first step (hazard identification) in a carcinogen risk assessment (IARC, 2013). These evaluations are published as IARC Monographs. Monograph 102 reviewed non-ionizing RF energy (IARC, 2013).

IARC uses specific terms to describe the strength of the evidence in support of causality between specific agents and cancer in humans or experimental animals: *sufficient evidence of carcinogenicity, limited evidence of carcinogenicity,* and *inadequate evidence of carcinogenicity.*[10] After reviewing the literature on RF fields, IARC concluded that there was "*limited evidence of carcinogenicity"* in humans as a result of positive associations observed

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[10] In their 2013 monograph on RF energy, IARC used the following definitions for each term: ***Sufficient evidence of carcinogenicity*** is assigned to a body of epidemiologic research if *"a causal relationship has been established … That is, a positive relationship has been observed between the exposure and cancer in studies in which chance, bias, and confounding could be ruled out with reasonable confidence"* (IARC, 2013). ***Limited evidence of carcinogenicity*** describes a body of epidemiologic research where the findings are inconsistent or there are outstanding questions about study design or other methodological issues that preclude making a conclusion, i.e., that a causal relationship *"is considered … to be credible, but chance, bias, or confounding could not be ruled out with reasonable confidence"* (IARC, 2013). ***Inadequate evidence of carcinogenicity*** describes a body of epidemiologic research where it is unclear whether the data are supportive or unsupportive of causation because there is a lack of data or there are major quantitative or qualitative issues, i.e., *"[t]he available studies are of insufficient quality, consistency or statistical power … or no data on cancer in humans is available"* (IARC, 2013). In 2019, IARC released revised, but virtually identical, definitions of these terms. *Limited evidence of carcinogenicity,* for example, continues to describe a body of epidemiologic research in which *"[a] causal interpretation of the positive association observed in the body of evidence on exposure to the agent and cancer is credible, but chance, bias, or confounding could not be ruled out with reasonable confidence"* (IARC, 2019).

between RF field exposure from wireless phones and glioma and acoustic neuroma[11] in some epidemiologic studies. This conclusion was based almost entirely on studies of RF fields from mobile phone communications—including a series of case-control studies from Sweden (Hardell et al., 1999, 2000, 2001, 2002a, 2002b, 2003, 2006a, 2006b, 2009, 2010, 2011) and the multi-national INTERPHONE study (INTERPHONE Study Group, 2010, 2011)—and was based particularly on studies of RF fields from mobile phones. IARC also rated experimental studies of animals for carcinogenicity of RF field exposure as providing *"limited evidence of carcinogenicity."*

Based on these assessments, IARC classified RF fields overall as "*possibly carcinogenic to humans*" (group 2B), which denotes exposures for which there is limited evidence of carcinogenicity in epidemiologic studies and less than sufficient evidence of carcinogenicity in studies of experimental animals. The other IARC classifications are group 1 ("*carcinogenic to humans*"), group 2A ("*probably carcinogenic to humans*"), and group 3 ("*not classifiable as to its carcinogenicity to humans*").[12] These categories are intentionally meant to err on the side of caution. Since 1971, the IARC has evaluated more than 1,000 agents; currently, 80% of the agents evaluated are classified in group 2B or group 3 (IARC, 2021). Moreover, the IARC statement was based on the review of studies involving exposure to RF fields from mobile phones, which is much greater than RF exposure from advanced meters. The IARC report, however, did not comment on the level of exposure.

Royal Society of Canada

Health Canada is the department of the Canadian government responsible for the nation's public health, including setting limits on exposure. As part of its mission to improve the health of Canadians, Health Canada monitors the scientific research on electromagnetic fields, sets limits on RF field exposure, and commissioned a RSC expert panel to review the current Canadian

11 An acoustic neuroma is also referred to as a *vestibular schwannoma*, which is considered to be a more medically accurate term (Carlson and Link, 2021). For the purposes of this report, we relied the terminology used in the original source material.

12 As of 2019, IARC no longer uses a Group 4 (*"probably not carcinogenic to humans"*) classification. The one agent previously assigned to Group 4 (caprolactam) was re-classified to Group 3.

exposure limits and assess whether the limits were *"consistent with the scientific literature in setting limits that would protect the public from adverse health risks"* (RSC, 2014, p. 2).

Based on their review of the available scientific literature, the expert panel stated that they agreed with the conclusion of previously conducted evaluations by health and scientific organizations that exposure to RF fields is "*possibly carcinogenic*" (i.e., IARC's group 2B). Regarding studies published following the previous reviews they evaluated, the panel concluded *"[n]one of the newer studies materially affect the conclusions of the authoritative reviews. However, a weight-of-evidence evaluation shows that the current evidence for a causal association between cancer and exposure to RF energy is weak"* (RSC, 2014, p. 82). The panel noted that it *"was unable to identify any established adverse health effects occurring at levels below the [current Canadian exposure guidelines]"* (RSC, 2014, p. 18). Specific conclusions related to the health outcomes (e.g., cancer, non-specific symptoms affecting well-being) and types of studies (e.g., epidemiologic studies, experimental studies) reviewed are summarized in the relevant sub-sections of Section 6 below.

World Health Organization

In 1996, the WHO established the International EMF Project *"to assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz."*[13]

The WHO is currently undertaking a comprehensive and critical review of relevant scientific literature to assess potential effects of RF field exposure in the 100 kHz to 300 GHz range. A preliminary draft review of RF research on health was released in 2014 for consultation and comment by experts on RF fields. The review focused on all studied health outcomes of relevance to human health, including cancer, neurodegenerative diseases, fertility, reproduction and childhood development conditions, and effects on the immune, neuroendocrine, and cardiovascular systems.

Regarding health effects from mobile phone use, the WHO website currently states *"[a] large number of studies have been performed over the last two decades to assess whether mobile*

[13] https://www.who.int/peh-emf/project/EMF_Project/en/ Accessed April 2021.

phones pose a potential health risk. To date, no adverse health effects have been established as being caused by mobile phone use."[14]

Scientific Committee on Emerging and Newly Identified Health Risks

The most recent weight-of-evidence review of RF fields and health was released in 2015 by SCENIHR. The Committee consists of independent scientific experts assembled to provide advice on public health and risk assessments to the Department of Health and Consumer Protection of the European Commission. The Committee addresses questions related to emerging or newly identified health and environmental risks and on broad, complex, or multidisciplinary issues requiring a comprehensive assessment of risks to consumer safety or public health. The 2015 report on the potential health effects of exposure to electromagnetic fields serves as an update to their previous review from 2009 (SCENIHR, 2009). In performing its assessment of the literature, the Committee followed the scientific guidelines it had developed for the assessment of the quality of the evidence of human health risks (SCENIHR, 2012). Specific conclusions of this Committee related to the health outcomes (e.g., cancer, non-specific symptoms affecting well-being) and types of studies (e.g., epidemiologic studies, experimental studies) reviewed are summarized in the relevant sub-sections of Section 6 below.

Health Council of the Netherlands

The HCN is an independent scientific advisory body designed to *"advise ... on the current level of knowledge with respect to public health issues and health (services) research"* (HCN, 2016, p. 8). The Electromagnetic Fields Committee of the HCN conducted systematic reviews of the epidemiologic data (HCN, 2013) and experimental animal data (HCN, 2014) on the relationship between RF field exposure and cancer, with the epidemiologic data focusing specifically on the association between mobile phones and tumors of the head. The findings from the two reports were integrated into a third report presenting the Council's overall conclusions after jointly considering both epidemiologic and experimental data (HCN, 2016). Overall, HCN concluded

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[14] https://www.who.int/en/news-room/fact-sheets/detail/electromagnetic-fields-and-public-health-mobile-phones Accessed April 2021.

that it *"considers it unlikely that exposure to radiofrequency fields, which is associated with the use of mobile telephones, causes cancer"* (HCN, 2016, pp. 16-17). Specific conclusions related to epidemiologic and experimental studies of cancer are summarized in the relevant sub-sections of Section 6 below.

International Commission on Non-Ionizing Radiation Protection

ICNIRP is an independent, non-governmental scientific organization recognized by the WHO that sets internationally recognized, science-based guidelines on limits of exposure to non-ionizing radiation; provides science-based guidance and recommendations on protection from exposure to non-ionizing radiation; and establishes principles of non-ionizing radiation protection for the formulation of international and national radiation protection programs (ICNIRP, 2009).

In 2020, ICNIRP published the results of their comprehensive review of RF research that they conducted to update their 1998 exposure limits (ICNIRP, 1998, 2020a). The main objective of the report, *Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz)* was to *"establish guidelines for limiting exposure to EMFs that will provide a high level of protection for all people against substantiated adverse health effects from exposures to both short- and long-term, continuous and discontinuous radiofrequency EMFs"* (ICNIRP, 2020a, p. 483). To set their guidelines, ICNIRP reviewed the scientific evidence for health effects of RF exposure, including reviews conducted by other health and scientific organizations (e.g., WHO, SCENIHR, SSM) and the published literature. Based on their review, ICNIRP concluded:

> *The only substantiated adverse health effects caused by exposure to radiofrequency EMFs are nerve stimulation, changes in the permeability of cell membranes, and effects due to temperature elevation. There is no evidence of adverse health effects at exposure levels below the restriction levels in the ICNIRP (1998) guidelines and no evidence of an interaction mechanism that would predict that adverse health effects could occur due to radiofrequency EMF exposure below those restriction levels* (ICNIRP, 2020a, p. 523).

Swedish Radiation Safety Authority

The SSM's Scientific Council on Electromagnetic Fields monitors current research on potential health risks in relation to exposure to electromagnetic fields and provides advice on assessing possible health risks (SSM, 2020). In a series of annual scientific reviews, the Scientific Council assesses relevant new data and puts these in the context of available information and present knowledge; the result is a gradually developing health risk assessment of exposure to electromagnetic fields.

The Scientific Council's most recent review on electromagnetic fields was published in 2020 and covered studies published from April 2018 up to and including December 2019. The report covered static, low-frequency, intermediate, and RF fields, and reviewed epidemiologic, human, and biological studies. The Scientific Council's overall conclusion was that *"[n]o new established causal relationships between [electromagnetic fields] exposure and health risks have been identified"* (p. 3) and that the results of the research reviewed *"give no reason to change any reference levels or recommendations in the field"* (p. 4). Specific conclusions related to the health outcomes (e.g., cancer, non-specific symptoms affecting well-being) and types of studies (e.g., epidemiologic studies, experimental studies) reviewed are summarized in the relevant sub-sections of Section 6 below.

U.S. Food and Drug Administration

The FDA, as part of their mission to protect and promote public health, *"monitors new scientific evidence that might impact our understanding of the safety profile of medical devices and radiation-emitting electronic products"* (FDA, 2020, p. 4). In 2020, the FDA released a technical report that summarized the agency's comprehensive review of the available scientific literature related to RF field exposure and human health published between January 2008 and August 2019. The agency's review focused on assessing *"any possible causal relationship between [RF] exposure and the formation of tumors"* (FDA, 2020, p. 4).

Overall, the agency concluded that *"[b]ased on the studies that are described in detail in this report, there is insufficient evidence to support a causal association between [radiofrequency radiation] exposure and tumorigenesis. There is a lack of clear dose response relationship, a* *lack of consistent findings or specificity, and a lack of biological mechanistic plausibility"* (FDA, 2020, p. 6). Specific conclusions related to epidemiologic and experimental studies of cancer are summarized in the relevant sub-sections of Section 6 below.

6. Recent Research on Radiofrequency Fields

This section provides a summary of primary, peer-reviewed epidemiologic and experimental research (i.e., published articles that present the authors' original research and findings) published after the most recent comprehensive review—SCENIHR (2015)—was completed through March 2021.[15] The purpose of this update is to assess the impact of these recent studies on the conclusions about adverse effects of relatively low levels of RF energy on such outcomes as cancer and non-specific symptoms, in comparison to the conclusions expressed by the recent weight-of-evidence comprehensive reviews. It focuses on recent epidemiologic and *in vivo* studies of higher quality, regardless of direction of the results, and in general, notes the limitations of weaker studies, such as studies that are too small in size (i.e., too few people or laboratory animals), have not provided adequate controls, or use proxies or less reliable measures of individual exposure assessment. Studies that were identified in the scientific literature as being potentially relevant to the topics under review, but upon examination were of the poorest scientific quality and were not summarized, are listed at the end of the References in Section 8.

The studies summarized in this section examine both near-field exposures (i.e., those close to the body, such as mobile phones and other handsets) and far-field exposures (i.e., from sources located farther from the body such as radio and television transmitters, base stations, and wireless local area network [LAN] access points).[16] Exposures from advanced meters under typical use are in the far field (e.g., ISED, 2015).

[15] SCENIHR (2015) reviewed studies published between 2009 and June 2014, so some studies were included in this report that were published in 2014 after SCENIHR's cut-off date.

[16] Near field and far field are not defined solely by physical distance, but by the physical dimensions of the antenna and distance relative to the wavelength and the signal transmission. The distance to far field is typically close to the size of the wavelength.

Epidemiologic studies of cancer

Summary of prior reviews

Below are statements taken directly from the prior agency reviews discussed in Section 5 that capture the conclusions of national and international health, scientific, and government agencies regarding epidemiologic studies of RF field exposure and cancer.

Advisory Group on Non-Ionising Radiation

> Regarding cancer, AGNIR concluded, "*[t]he overall results of epidemiological studies to date do not demonstrate that the use of mobile phones causes brain tumours or any other type of malignancy, nor do they suggest causation is likely*" (AGNIR, 2012, p. 323). The agency also noted that there is "*very limited information on risks of childhood tumors*" (AGNIR, 2012, p. 323).

British Columbia Centre for Disease Control

> Regarding epidemiologic studies of cancer, the Toolkit published by the BCCDC noted that *"[m]ost of the original studies cited in the reviews did not find an increased risk of head and neck tumours associated with long-term use of [mobile] phones. Because of study design issues and positive findings that have not been replicated by other researchers, doubts remain about whether exposure to RF increases the risk of brain and other cancers of the head and neck"* (BCCDC, 2013, p. 4).

> In 2016 the Centre also published its *2016 Review: Radiofrequency and Health*, in which it described and compared RF field exposures from common devices, discussed research on potential health effects from RF field exposure, and ways in which members of the public, if they choose, can reduce their personal exposure, with priority given to personal mobile phone use, and cordless DECT handsets (BCCDC, 2016).

> *A major concern about the possible effects of exposure to RF is the development of cancer. Some epidemiologic studies have shown an association between long-term and frequent use of cell phones and specific types of brain tumours, especially ipsilateral tumours (located on the same side of the head as the phone*

> *was used) .... However, despite some positive findings, there has been a lack of consistency in epidemiological studies and meta-analyses as to whether long term and intensive cell phone use is a risk factor for the occurrence of brain tumours….The 'possibly carcinogenic to humans' designation by IARC was based solely on cell phone exposure and not from RF fields from other sources. Studies of cancers, other than brain tumours, and their association with cell phone use have mostly been negative.* (p. 9)
>
> *… the syndrome of electrohypersensitivity (EHS) has been attributed to exposures from wireless (cell) phone base stations and other RF-emitting devices. People having EHS suffer from symptoms affecting multiple body systems … In such [experimental] studies, subjects who suffer from EHS and healthy controls are assigned at random to either a 'treatment' group receiving a known exposure to RF signals (from cell phone base station antennae for example) or to a sham exposure group (non-exposure condition). A systematic review of the health effects of exposure to RF from mobile phone base stations concluded that most of the randomized laboratory studies had not detected associations between exposure and the appearance of acute symptoms during or shortly after exposure* (p. 12).

International Agency for Research on Cancer

As discussed in Section 4, the IARC expert working group classified RF fields as *"possibly carcinogenic to humans"* (group 2B). This conclusion was based on *"limited evidence of carcinogenicity"* for glioma and acoustic neuroma among mobile phone users, as reported in some epidemiologic studies, as well as "*limited evidence of carcinogenicity*" in experimental animals.

Royal Society of Canada

With respect to epidemiologic studies, the expert panel concluded:

> *[t]he epidemiological evidence is largely limited to a weak association of prolonged mobile phone use with increased incidence of glioma and acoustic*

> *neuroma. The epidemiological associations are not strong and the various studies are inconsistent with each other* (RSC, 2014, p. 82).

Scientific Committee on Emerging and Newly Identified Health Risks

With respect to epidemiologic studies of cancer, SCENIHR concluded:

> *[o]verall, the epidemiological studies on mobile phone RF EMF exposure do not show an increased risk of brain tumours. Furthermore, they do not indicate an increased risk for other cancers of the head and neck region. Some studies raised questions regarding an increased risk of glioma and acoustic neuroma in heavy users of mobile phones. The results of cohort and incidence time trend studies do not support an increased risk for glioma while the possibility of an association with acoustic neuroma remains open. Epidemiological studies do not indicate increased risk for other malignant diseases, including childhood cancer* (SCENIHR, 2015, p. 5).

SCENIHR further concluded:

> *[t]he totality of evidence of epidemiological studies weighs against cancer risks from base stations and broadcast antennas. In particular, large [epidemiologic] studies modelling RF exposure and investigating the risks of childhood cancers have not shown any association* (SCENIHR, 2015, p. 84).

Health Council of the Netherlands

Overall, HCN concluded that it *"considers it unlikely that exposure to radiofrequency fields, which is associated with the use of mobile telephones, causes cancer"* (HCN, 2016, pp. 16-17). The Electromagnetic Fields Committee of the HCN that prepared the review stated, *"data from several epidemiological studies provide some indications for an association between long-term and/or intensive use of a mobile phone and an increased incidence of tumours in the brain and head and neck region,"* but noted, *"the evidence is weak and inconsistent,"* and that incidence data of the relevant cancers *"do not provide any support for such association"* (HCN, 2016, p. 53). The Committee further noted that while it is *"possible that the exposure to RF EMF resulting from the use of mobile phones plays a role in an association,"* the Committee *"considers it unlikely that such exposure actually induces tumours"* (HCN, 2016, p. 53). The Committee distinguished its conclusions from IARC's findings that a causal interpretation of the relationship between RF field exposure and some cancers is credible, demonstrated by IARC's classification of "*limited evidence*" of carcinogenicity of RF radiation; the Committee stated that it "*considers a causal interpretation unlikely and feels that the combination of bias, confounding and chance might be an explanation for the observations*" (HCN, 2016, p. 53). The Committee acknowledged that the available epidemiologic data suffer from limitations in how the exposure assessments were conducted and noted that, with respect to mobile phone use, "*[t]here is still very limited information on really long-term effects in humans*" (HCN, 2016, p. 17).

International Commission on Non-Ionizing Radiation Protection

Based on their review of the literature, ICNIRP concluded:

> *[t]aken together, the epidemiological studies do not provide evidence of a carcinogenic effect of radiofrequency EMF exposure at levels encountered in the general population. In summary, no effects of radiofrequency EMFs on the induction or development of cancer have been substantiated* (ICNIRP, 2020a, p. 523).

Swedish Radiation Safety Authority

Regarding cancer from mobile phone use, the 2018 SSM report concluded, "*[t]he results were not entirely consistent but mainly point towards a lack of association*" (SSM, 2018, p. 9). The Council's conclusions in the 2019 and 2020 reports remained consistent with this assessment. The 2019 report concluded that studies on brain tumors "*do not give support to any causal relationship with radio wave exposure from mobile phone use*" and the 2020 report concluded, "*[o]verall, the age standardized incidence of brain tumours does not give support to any causal relationship with radio wave exposure from mobile phone use. If there is an impact, it appears to be so weak that it cannot be* *detected in incidence trend studies*" (SSM, 2019, p. 3; SSM, 2020, p. 3). The 2020 report further concluded, "*[t]he results of the research review give no reason to change any reference levels or recommendations in the field*" (SSM, 2020, p. 4).

U.S. Food and Drug Administration

The FDA review concluded that the epidemiologic data reviewed *"continue to support the FDA's findings that there is no quantifiable causal link between [radiofrequency radiation] exposure and tumor formation"* (FDA, 2020, p. 87). The report also concluded:

> *… existing epidemiologic evidence is insufficient to suggest that use of cell phones can be considered as an independent etiological factor capable of influencing the incidence of intracranial and some other tumors in the general population. Existing epidemiological evidence indicates that if any risk does exist, it is extremely low compared to both the natural incidence of the disease and known controllable risk factors. As further research is conducted, we will continue to monitor the available information* (FDA, 2020, p. 87).

Studies of personal, partial-body exposure from mobile phones and hand-held radios

Epidemiologic studies on cancer and RF energy have been conducted since the 1970s on a variety of environmental and occupational sources; however, as the number of mobile phones in use has increased over time, research has focused primarily on users of mobile phones and on mobile phone base stations. Mobile phones transmit and receive RF signals and are tested before marketing to verify that they operate in compliance with national RF standards, which limit energy absorption for partial body exposure to the head and neck area where the phone is held.

Near-field exposure from a mobile phone is nevertheless higher that other environmental sources, even if a hands-free device is used, because of the close proximity of a mobile phone to the human body when the phone is on, even if not transmitting during a phone call. In particular, for brain tissues, the mobile phone used at the ear remains the main source of exposure from commercial devices. Given the dose-response nature of effects on human health, mobile phone exposures represent the highest source of exposure for people in the general population, and therefore, the greatest potential for detecting an adverse response to RF field exposure. Exposures higher than field levels produced by mobile phones are possible in studies of laboratory animals, as described in the sub-section on laboratory studies below. It is important to note that most epidemiologic studies published to date cover the use of mobile phones before the use of texting, data services, and headphones became widespread circa 2011. Phone calls remain more important from an exposure perspective because calls typically result in higher exposure than texting or data services since these modes of operation generally have lower power output, potentially a lower duty cycle, and use the device at greater distance from the head and trunk than phone calls.

Additional epidemiologic studies of mobile phone use and hand-held, two-way personal radios and cancer have been published since the release of the 2015 SCENIHR report. Research on this topic still continues not because epidemiologic and experimental studies have found a problem with RF fields from mobile phones, but because the size of the population using mobile phones is so large, perhaps greater than 5 billion, research will continue to test hypotheses to make sure that even the smallest risk has not been overlooked.

The recent epidemiologic studies of mobile phones and cancer since the SCENIHR report are summarized below, and are grouped by study design (e.g., case-control/cohort studies, cancer incidence rate studies, survival studies, and meta-analyses).

Case-control and cohort studies

Recent studies of mobile phone use and cancer risk include several case-control studies. As discussed in Section 3, case-control studies assess whether cases (those diagnosed with a particular disease) had higher or more frequent exposure compared to the control population (a similar group of people, but without the disease). Case-control studies are well-suited for the analysis of diseases that are rare or have a long-latency period between exposure and disease development (such as many cancers); however, they have several limitations, including the potential for selection and recall bias. For example, the value of using interview or questionnaire responses to assess mobile phone use is constrained by the ability of the participants to accurately remember and report past exposures and behaviors. In addition, one cohort study was conducted during this time period and is included in this section.

The following case-control and cohort studies have been published since the release of the 2015 SCENIHR report:

- **Moon et al. (2014)** investigated the relationship between vestibular schwannomas and mobile phone use in South Korea using two analyses. First, the authors conducted a case-control study, which included 199 cases, diagnosed between 1991 and 2010, and 238 controls, matched for age, gender, and general health conditions. Exposure was assessed using a telephone-administered questionnaire, which included questions on mobile phone use history, average call duration, and use of hands-free devices, among others. No associations were observed between vestibular schwannomas and duration (in years), time (in minutes per day), or cumulative hours of mobile phone use; the authors noted that the control group had, on average, slightly longer and more frequent mobile phone use compared to the cases. Second, the authors conducted a case-case analysis, in which only the case population was examined to assess potential differences in tumor growth or characteristics. Differences in average tumor volume were observed between regular and non-regular phone users and between heavy and light phone users. No significant differences were observed between long-term and short-term users. Based on this analysis, the authors concluded that *"there is a possibility that mobile phone use may affect existing tumors growth"* (p. 586). Limitations of the study include the exclusion of factors in the analyses that may confound the observed relationship between tumor size and mobile phone use, including the participants' age, and the use of self-reported questionnaire data on mobile phone use, the weaknesses of which are discussed above.

- **Shrestha et al. (2015)** conducted a case-control study to investigate the relationship between mobile phone use and pituitary tumor risk in Finland. The study included 80 cases, diagnosed between 2000 and 2002, who ranged in age from 20 to 69, and 240 controls, matched by age, sex, region of residence, and date of interview. Exposure was ascertained through an interview that captured participants' history of mobile phone use.

The authors reported that participants diagnosed with pituitary tumors were less likely to be regular mobile phone users compared to the controls (suggesting a lower risk of tumor development among regular versus never/non-regular phone users), although the association was not statistically significant. No associations between other aspects of mobile phone use and tumors were observed, including total duration of use and cumulative hours of use. The authors concluded that their study found *"no excess risk associated with self-reported short- or medium-term use of mobile phones,"* which they noted *"is consistent with most of the published studies"* (p. 1159). The authors cited the small number of participants who had used mobile phones for longer than 10 years (two cases, nine controls) as a cause for uncertainty regarding the risk associated with longer-term use. The small size of the overall population is a limitation of this study, as is the use of self-reported data on mobile phone use. The observed reduced risk associated with regular use of mobile phones indicates a potential for methodological or study design issues.

- **Carlberg and Hardell (2015) and Hardell and Carlberg (2015)** are two pooled analyses[17] that investigated the use of mobile and cordless phones and either meningioma (Carlberg and Hardell, 2015) or glioma (Hardell and Carlberg, 2015). Both studies pooled data from Swedish case-control studies previously published by the same authors (Hardell et al., 2006a, 2006b; Carlberg et al., 2013; Hardell et al., 2013). In Carlberg and Hardell (2015), no overall association was observed between meningioma risk and use of mobile or cordless phones, while increases were observed for some sub-group analyses. In Hardell and Carlberg (2015), statistically significant overall associations were observed between both mobile phone and cordless phone use and glioma. Neither publication, however, included data from any other published studies, and therefore do not represent a summary of the available studies in this area; thus, their value as pooled analyses is limited.
- **Yoon et al. (2015)** investigated the association between mobile phone use and glioma development in a case-control study in South Korea. The study included 285 cases,

[17] As noted previously, in a pooled analysis, the raw, individual-level data from the original studies is combined and analyzed together.

diagnosed between 2002 and 2007, who ranged in age from 15 to 69, and 285 controls. Mobile phone use was assessed using a self-administered questionnaire; information was obtained from family or friends, when necessary, if the study participants were too ill or had died. No statistically significant associations were observed between glioma risk and any of the exposure variables assessed (e.g., use of mobile phone [yes versus no], type of phone used, lifetime years of use before diagnosis, cumulative hours of use) in analyses adjusted for other potential risk factors, including age, hair dye use, and alcohol consumption. In a sub-analysis of ipsilateral users,[18] statistically non-significant associations were observed between some of the exposure variables and risk of glioma; however, a dose-response relationship generally was not observed. The authors concluded that their results *"do not support the hypothesis that the use of mobile phone increases the risk of glioma"* (p. 1). In addition to the previously discussed limitations of case-control studies, significant differences were reported between cases and controls in this study for several factors, including that the information from questionnaires from cases was obtained more often from family or friends (proxy respondents) than controls. The larger proportion of cases using a proxy respondent compared to controls created a greater potential for exposure misclassification within the case population.

- **Gao et al. (2019)** examined the association between use of hand-held, two-way terrestrial trunked radios (TETRA) that operate in the 380 to 400 Megahertz (MHz) frequency range and risk of cancer among police officers and staff in Great Britain. The study included 48,518 participants of the Airwave Health Monitoring Study, an occupational cohort study. Exposure was defined as the average monthly personal radio call duration during the year prior to study enrollment (median value=30.5 minutes). No association was observed between personal radio use and either risk of all cancers or risk of head and neck cancers. The doubling of monthly call duration among users was not associated with risk of all cancer and was associated with a weak statistically non-significant increase of head and neck cancers. Similar results were observed when all analyses were restricted to police officers only. The authors reported *"no evidence of*

[18] *Ipsilateral users* refer to subjects who predominantly use their mobile phone on the same side of the head as the tumor location; alternatively, *contralateral users* are subjects who predominantly use their mobile phone on the opposite side of the head as the tumor location.

association of personal radio use with cancer risk" (p. 1). Limitations of the study include the small number of cancers, particularly of the head and neck (45 total), and the lack of consideration of post-enrollment exposure, as participants' habits may change over time.

- **Vila et al. (2018)** examined the relationship between occupational RF fields and intermediate frequency exposure and brain tumors within the INTEROCC multinational case-control study. The study included 2,054 glioma cases and 1,924 meningioma cases, diagnosed between 2000 and 2004, and 5,601 controls. Participants' lifetime occupational history information was collected using a questionnaire. Average exposure levels were then assigned for each RF source reported by the participants (involving work with or nearby radars, transmitters, telecommunication antennas, equipment for medical diagnosis and treatment, among others) using a source-exposure matrix approach developed by the authors in which exposure values were assigned based on existing measurement data (*see* Vila et al., 2017); exposures from different-frequency RF sources were combined by weighing the calculated square ratios of RF electric fields and magnetic fields by the corresponding ICNIRP reference levels. Cumulative exposure levels were then calculated by incorporating frequency and duration of exposure. The authors found that approximately 10% of the study participants were occupationally exposed to RF fields. No statistically significant associations were observed between RF magnetic fields or electric fields and glioma or meningioma, regardless of the exposure time window investigated (1 to 4 years versus 5 to 9 years). The authors concluded that their findings "*do not support a positive association between occupational exposure to high-frequency EMF and either glioma or meningioma risk*" (p. 362). Limitations of the study include the small number of exposed and highly-exposed participants (i.e., >90th percentile of exposures), who comprised ~10% and <1% of the total population, respectively, and the absence of information on the specific frequency ranges of the equipment used. In addition, although the source-exposure matrix represents an improved exposure assessment approach, in that exposures can be assigned on an individual level, it is still preferable to collect personal exposure measurement data.

- **Luo et al. (2019)** conducted a case-control study to investigate the association between mobile phone use and thyroid cancer in Connecticut. The study included 462 cancer cases, diagnosed between 2010 and 2011, who ranged in age from 21 to 84, and 498 controls, matched by age. Mobile phone use was assessed through a questionnaire, completed during an in-person interview; questions inquired about frequency and duration of mobile phone use, and use of hands-free devices. No association was observed between mobile phone use (yes versus no) and risk of thyroid cancer. In sub-analyses, statistically non-significant associations were reported between thyroid microcarcinoma (tumor size ≤ 10 millimeters) and long-term (>15 years) and frequent use (>2 hours per day) of mobile phones; however, these associations did not follow a linear dose-response trend and were not observed for larger tumor sizes. The authors concluded that their study *"found no significant association between cell phone use and thyroid cancer"* (p. 2).

- **Luo et al. (2020)** conducted a follow-up of the same study population as in Luo et al. (2019), which examined whether genetic differences in the study participants impacted the relationship between mobile phone use and development of thyroid cancer. The authors reported statistically significant associations between mobile phone use and thyroid cancer for some genetic variations; however, the biological significance of these findings is not clear.

Summary of case-control and cohort studies

Case-control and cohort studies on mobile phone or two-way radio use published since the release of the 2015 SCENIHR report have not provided clear evidence to alter the conclusions of previous reviews by scientific and health agencies. The studies summarized in this section investigated the relationship between exposures to RF fields in both the general public and in the workplace and several cancer types, including glioma (Hardell and Carlberg, 2015; Vila et al., 2018; Yoon et al., 2015), meningioma (Carlberg and Hardell, 2015; Vila et al., 2018), thyroid cancer (Luo et al., 2019), pituitary tumors (Shrestha et al., 2015), and vestibular schwannomas (Moon et al., 2014), as well as general cancers of the head and neck region (Gao et al., 2019). None of the studies reporting original data identified statistically significant associations in the main analysis. Further, no consistent associations were observed in sub-analyses performed across the studies, including those examining mobile phone use and tumor size, tumor volume, exposure duration, or exposure frequency. The only study to report an overall statistically significant association with exposure to RF fields from mobile phone use was the Hardell and Carlberg (2015) pooled study of glioma. The results of these recent studies are therefore consistent with the SSM's 2018 report, which concluded that findings from studies of mobile phone use and cancer "*were not entirely consistent but mainly point towards a lack of association*" (SSM, 2018, p. 9).

Cancer incidence rates over time

Since mobile phone use has become widespread and research has expanded to provide increased information, epidemiologists have examined time trends in rates of brain cancer and other tumors of the exposure areas in populations in which there is widespread use of mobile phones. If associations between mobile phone use and brain cancer exist (as suggested in previous publications by INTERPHONE 2010, 2011; Hardell et al., 2006a, 2006b; Hardell et al., 2011) and were to be causal, then given the near universal use of mobile phones in the population, we might expect to see some increase in annual rates of brain cancer, particularly 10 or more years after mobile use became widespread. The period of 10 years or more would allow for the development of tumors, and if the relationship were causal, would show increases in brain cancer rates as more people had a longer period of exposure through mobile phone use.

While examining time trends in cancer rates can be informative, this approach does have some limitations. Trends are generally examined on a large scale (i.e., regional or national level) and thus cannot account for individual-level data on confounding factors and conclusions about a given individual's level of risk cannot be estimated. This is related to the previously described concept of an "*ecological fallacy*," in which inferences about the nature of individuals (or risks) are inappropriately deduced from information gathered on the larger group to which those individuals belong. Because of these limitations, examination of cancer incidence trends over time alone is insufficient to assess whether a causal relationship exists between an exposure and disease.

Since the release of the 2015 SCENIHR report, a number of studies have reviewed national trends of brain cancer and some other cancers as the use of mobile phones has become almost universal since 1982. Despite dramatic increased prevalence and use of mobile phones in all countries, none of these studies show an increase in the incidence in brain tumors that was attributed to mobile phone use.

In Sweden, the national cancer registry reports no increase in brain cancer, but one group of investigators claim that a subgroup of cases of unknown origin is underreported (Hardell and Carlberg, 2015, 2017). This same group reported inconsistent increases in incidence of thyroid tumors, that is, increases in women but not men (Carlberg et al., 2016, 2020). Another analysis of the incidence of brain cancer in Sweden reports that the overall incidence has been stable from 1982 to 2012, with small increases and decreases within some subgroups (Nilsson et al., 2019). Other investigators in New Zealand (Kim et al., 2015), Australia (Chapman et al., 2016; Karipidis et al., 2018), Japan (Sato et al., 2016, 2017), and Israel (Keinan-Boker et al., 2018) analyzed brain tumor incidence, but reported no change in incidence of brain tumors that appeared to be linked to increased mobile phone use. Philips et al. (2018a, 2018b) reported a rise in malignant brain cancer in the United Kingdom and cited possible causes as an improvement in diagnostic techniques, chance, and exposure to diagnostic computed tomography scans of the head. SSM (2019) in its review of Phillips et al. (2018a, 2018b), noted that the trend for malignant brain cancer did not match the more exponential increase in mobile phone use over the period studied. de Vocht (2019) specifically assessed whether temporal trends in malignant brain tumor incidence were associated with mobile phone use in England. No trend in incidence was traced to mobile phone use or the incidence of acoustic neuroma, meningioma, or benign neoplasms. In the United States and Finland the rates of malignant brain tumors were not reported to have changed during the period since mobile phone use became widespread (Li et al., 2018; Natukka et al., 2019). Davis et al. (2020) report that rates of malignant cancer in Canada and the United States are similar and the differences from rates in the United Kingdom *"is most likely due to factors related to improved data collection practices in surveillance systems … [and] the attribution of any environmental factor as an explanation for past incidence rate patterns is premature."* (pp. 302-303).

Survival Studies

The development of tumors is known to be advanced by exposure to certain chemicals described as tumor promoters. Two studies reviewed the survival of glioma patients in relation to their mobile phone use pattern prior to diagnosis. One study of poor quality suggested a possible difference in outcome in some user groups; the other higher quality international study reported that regular mobile phone use had no effect on survival and other analyses showed statistically significant improvements in survival.

- **Carlberg and Hardell (2014)** analyzed the survival data of Swedish glioma patients included in their previous case-control studies (Hardell et al., 2006b, 2010, 2011, 2013) to assess whether mobile phone use had an impact on survival. The analysis included a total of 1,678 patients enrolled over the study periods of 1997 to 2003 and 2007 to 2009. Exposure was assessed at the time of enrollment using a mailed questionnaire on the use of mobile and cordless desktop phones. A large fraction of the cases originally enrolled, however, were excluded because they were deceased when the analysis of survival was started. Decreased survival was observed between users of mobile phones for more than 20 years and both glioma and astrocytoma grade IV cancers; similar results were observed for long-time users of all phone types combined and for long-time cordless phone use with astrocytoma grade IV only. Statistically significant associations were not observed for these cancers with hours of cumulative phone use, and a decreased risk (i.e., improved survival) was observed for low-grade astrocytoma and mobile phone use. The authors noted that data on wireless phone use after tumor diagnosis were not available, which is a significant limitation of this study.

- **Olsson et al. (2019)** examined whether mobile phone use prior to diagnosis was associated with survival among glioma patients. The study included 806 cases previously enrolled in the INTERPHONE study diagnosed between 2000 and 2002 and ranging in age from 20 to 69 at diagnosis (*see* Lahkola et al., 2007). Mobile phone use was assessed through a computer-assisted personal interview questionnaire. No indication of reduced survival was observed for patients reporting regular use of mobile phones compared to non-users or non-regular users; all observed statistically significant associations were negative, suggesting better survival for mobile phone users. Results were similar across cancer types (glioblastoma, and high- and low-grade gliomas). The authors reported associations between survival and other covariates, including age at diagnosis, tumor grade and location, and treatment.

Recent epidemiologic, cancer incidence, and survival studies of mobile phone use and cancer have not provided reliable evidence to alter the conclusions of the reviews conducted by scientific and health organizations. The overall findings from the studies summarized above are consistent with the conclusions of the 2015 SCENIHR report that *"[o]verall, the epidemiological studies on mobile phone RF EMF exposure do not show an increased risk of brain tumours … Some studies raised questions regarding an increased risk of glioma and acoustic neuroma in heavy users of mobile phones. The results of cohort and incidence time trend studies do not support an increased risk for glioma while the possibility of an association with acoustic neuroma remains open"* (SCENIHR, 2015, p. 5).

Meta-analyses of mobile phone use

In recent years, several meta-analyses have been conducted that examined the relationship between mobile phone use by individuals and brain cancer. As described in Section 3, meta-analyses, in which the results of multiple studies are aggregated into a larger virtual study, are a valuable analytical tool that increases the number of individuals in the analysis, allowing for a more robust and stable estimate of association. These analyses, however, typically combine data from studies with different study populations, exposure assessment methods, and disease definitions, so they can convey a false sense of consistency across studies if *only* the combined estimate of effect is considered. Rather, the factors that contribute to any heterogeneity between the studies should also be examined. Any differences between studies, including the populations studied, quality of the studies, measures of exposure and responses, modifying or confounding factors, and likelihood of publication of no-effect studies, can undermine confidence in a meta-analysis. In addition, meta-analyses are subject to the limitations of the study designs used in the primary analyses; the value of the meta-analyses results will be contingent on the quality of the underlying studies.

The following meta-analyses have been published since the release of the 2015 SCENIHR report.

- **Lagorio and Röösli (2014)** conducted a meta-analysis of 29 studies, all published by 2012, that examined intracranial tumors and mobile phone use. The studies were classified into five groups, based on geographical region or study population. For all groups, negative associations were observed between meningioma and regular use of mobile phone, and statistically non-significant marginal associations were observed with long-term mobile phone use (≥ 10 years). Larger, but statistically non-significant, positive associations were observed between long-term phone use and both glioma and acoustic neuroma. The authors reported high heterogeneity between studies and noted that the primary differences appeared to be methodological (e.g., study design, case definition, exposure assessment approach). The authors noted that *"[s]ummary risk estimates based on heterogeneous findings should not be over-interpreted"* and that "*[o]verall, the results of our study detract from the hypothesis that mobile phone use affects the occurrence of intracranial tumors*" (pp. 79, 88).

- **Wang and Guo (2016)** conducted a meta-analysis of 11 epidemiologic studies, published between 2001 and 2008, to evaluate the association between mobile phone use and glioma risk. The analysis included 5,460 cases and 12,603 controls. No overall association was observed between mobile phone use and glioma risk. In a sub-analysis, a statistically significant association was observed between mobile phone use of more than 5 years and glioma risk. The authors, however, noted significant heterogeneity between studies for both the main and sub-analyses and described the observed association with longer-term phone use as "*weak*" (p. 3).

- **Bortkiewsicz et al. (2017)** conducted a meta-analysis of 24 case-control studies that investigated the association between mobile phone use and brain cancer. The analysis included 26,846 cases and 50,013 controls. No associations were reported between overall mobile phone use and any tumor types, including intracranial tumors, brain cancer, glioma, meningioma, and acoustic neuroma. In sub-analyses, statistically-significant associations were observed between intracranial tumor (all types) and both long-term mobile phone use (> 10 years) and ipsilateral mobile phone use. For nearly all analyses, the authors observed heterogeneity between studies.

- **de Siqueira et al. (2017)** conducted a meta-analysis of three case-control studies of mobile phone use and parotid gland tumor development. The analysis included 768 cases and 4,319 controls. A statistically-significant association was observed between mobile phone use and presence of salivary gland tumors. A significant limitation of this analysis is the small number of studies included, which prevented exploration of sensitivity or sub-group analyses. In addition, as noted by the authors, the studies in the meta-analysis included both benign and malignant tumors and did not make a distinction between them, even though the clinical behavior and genetic profiles of the tumors differ. Because of the limitations, the authors warned that their findings "*need to be read and interpreted with caution*" (p. 2).

- **Prasad et al. (2017)** conducted a meta-analysis on case-control studies published between 1966 and 2016 to investigate whether differences in study quality and funding source explained the variation in results across studies. In total, 22 studies were identified; however, 8 of the studies were part of the same large project (the INTERPHONE study) and thus were not included in the meta-analysis. In an analysis of the remaining 14 studies, no overall association was observed between brain tumor development and mobile phone use; a statistically significant association was observed in a sub-analysis of 7 of the 14 studies that included data on long-term (>10 years) mobile phone use. The authors also examined the results of each of the 14 individual studies and reported that statistically significant associations were more likely to be observed in studies of higher quality. This conclusion is not well-supported by the data however, as studies of higher quality did not consistently report statistically significant associations (only two of the six studies of higher quality reported significant associations) and three of the six studies reported no association at all. The authors also reported that government-funded studies generally received a higher study quality score compared to industry- or mixed-funded studies.

- **Yang et al. (2017)** performed a meta-analysis of 11 studies investigating the potential association between mobile phone use and glioma of the brain. The analysis included 6,028 cases and 11,488 controls. The authors looked at three factors: mobile phone duration (short-term versus long-term), partial laterality (preferred head side use location), and tumor grade. No association was observed between overall mobile phone use and glioma risk. In sub-analyses, statistically significant associations were observed between glioma and long-term (≥10 years) phone use and long-term ipsilateral use. A statistically significant association was also observed between long-term use and low-grade gliomas; no associations were observed for all other combinations of use duration and head side/tumor grade. The authors concluded that their results suggest that long-term mobile phone use may be associated with an increased risk of glioma but noted that "*current evidence is of poor quality and limited quantity*" and that "*substantial*" heterogeneity was observed between studies (pp. 2, 6).

- **Wang et al. (2018)** conducted a meta-analysis of 10 epidemiologic studies to examine the relationship between wireless phone use and risk of adult glioma. No association was observed between adult gliomas and ever use of wireless phones or in subgroup analyses of tumor location or head side use. A statistically significant association was observed with long-term users (≥10 years). High heterogeneity was observed between studies and the authors noted "*inconsistencies among the studies*" (p. e634). The authors concluded that ever use of wireless phones "*was not significantly associated with risk of adult glioma, but there could be increased risk in long-term users*" (p. e629).

- **Röösli et al. (2019)** performed a meta-analysis of 45 epidemiologic studies investigating the relationship between mobile phone use and tumors of the brain, head, and neck. No statistically significant overall associations were observed between ever users or long-term users (>10 years) of mobile phones and glioma, meningioma, acoustic neuroma, pituitary tumors, or salivary tumors. The results were consistent across several sensitivity analyses conducted to determine the potential impact of any one study on the overall associations. The authors reported "*considerable*" heterogeneity across studies of glioma and acoustic neuroma and noted differences in the strength of the associations by research group (p. 231).

- **Chen et al. (2020)** conducted a meta-analysis of eight epidemiologic studies published up to June 2018 to investigate the relationship between users of wireless phones and meningioma in adults. A negative association was observed between adult meningioma and both ever users of wireless phones and short-term (<5 years) users. No association was observed between adult meningioma risk and mid-term (5 to 10 years) or long-term

(>10 years) users or with ipsilateral or contralateral use. The authors reported no heterogeneity across the studies that would affect this analysis.

- **Choi et al**. **(2020)** performed a meta-analysis of 46 case-control studies published up to July 2018 to examine whether cellular phone use was associated with tumor development. The majority of the studies (75%) examined brain tumor outcomes; other tumors investigated included tumors of the head and neck and hematologic malignancies. No association was reported between regular cellphone use and tumor development, compared to never or rarely having used a cellular phone. In subgroup analyses, a statistically significant association was reported between cellular phone use and tumor development in studies of high methodological quality, as adjudged by the authors using two published quality assessment tools, and in studies that used blinding at interviews to ascertain exposure (e.g., researchers were not aware of whether participants were cases or controls when interviewing them); an association was also observed between cellular phone use with cumulative call time of greater than 1,000 hours and tumor development. The authors also reported differences in the associations with tumors in subgroup analyses by research group.

- **Shih et al. (2021a)** conducted a meta-analysis of eight epidemiologic studies published up to May 2020 to investigate the association between exposure to RF fields and breast cancer. The authors reported a statistically signification overall association between RF field exposure and breast cancer development; subgroup analyses also reported a significant association among participants age 50 or older. A statistically signification association was observed between the use of mobile phones and breast cancer development; however, the analysis was based on only two studies. No association was reported for occupational exposure to RF fields. A significant limitation of this analysis is the authors' selection of several inappropriate studies for use in the meta-analysis. Two of the eight studies focused on 50-Hz magnetic-field exposure, which is not relevant to RF exposure, and one study focused on male breast cancer, while all the others investigated female breast cancer risk. As a result of this severe limitation, the journal issued a retraction notice in March 2021 "*on account of the number of uncertainties*" with the authors' methodology and study selection (Shih et al., 2021b)

Summary of meta-analyses

Meta-analyses of cancer and mobile phone use published since the release of the 2015 SCENIHR report have not provided clear evidence to alter the conclusions of previous reviews by scientific and health agencies. No overall associations were reported between mobile phone use and several types of brain cancer, including glioma (Wang and Guo, 2016; Bortkiewsicz et al., 2017; Yang et al., 2017; Wang et al., 2018), meningioma (Lagorio and Röösli, 2014; Bortkiewsicz et al., 2017), and acoustic neuroma (Bortkiewsicz et al., 2017). Chen et al. (2020) reported an overall negative association with meningioma. In sub-analyses performed in some of the studies, statistically significant associations were reported between long-term (≥5 or 10 years) mobile phone use and brain cancer. As noted previously, sub-group analyses should be interpreted with extra caution, as the typically smaller sample sizes may decrease the likelihood that a statistically significant finding reflects the true association between exposure and outcome rather than due to error or chance. In their 2016 report, the HCN states "*[s]ome epidemiological studies provide indications for an association between long-term or intensive use of a mobile telephone and an increased risk of tumours in the brain or head and neck region. However, the studies are not consistent and of varying quality... The final conclusion is, that overall the evidence for an association is weak*" (pp. 33-34). The HCN went on to conclude the following:

> *[t]he Committee feels that it is not possible to state that there is a proven association between long-term and frequent use of a mobile telephone and an increase in the risk of tumours in the brain and head and neck region in humans. Based on the strength of the evidence it can only be concluded that such an association cannot be excluded. The Committee considers it unlikely that exposure to radiofrequency fields, which is associated with the use of mobile telephones, causes cancer* (pp. 16-17).

Exposure from distant radiofrequency sources

Epidemiologic studies also examined RF sources other than mobile phones, including mobile phone base stations, AM and FM radio transmitters, television broadcast transmitters, and Wi-Fi. These sources are typically weaker contributors to individual exposure compared to mobile phone use. Radar, AM/FM radio transmitters, and television broadcast transmitters are far more powerful than mobile phone base stations, but like all types of electromagnetic fields, the strength of the RF signal diminishes rapidly with distance from the source. The proposed FEI network base stations are similar to mobile phone base stations in that they also are low-exposure sources in communities due to generally being located high above ground. Occupational studies focus on occupations with the potential for higher exposure to RF energy, like radar operators and workers at a mobile phone manufacturing facility.

These environmental exposure sources pose difficulties for individual exposure in epidemiological studies because people generally do not spend all their time in one location (i.e., at home), so a valid measurement of average exposure is difficult to determine.

The following epidemiologic studies on exposures from sources other than personal mobile phone use have been published since the release of the 2015 SCENIHR report.

- **Dabouis et al. (2016)** conducted a cohort study on occupational radar exposure in the French Navy. The study included 39,850 military personnel who served on Navy ships during the period from 1975 to 1995; exclusion criteria included female military personnel, personnel of the flotilla, and those who had spent fewer than 200 days on board. Exposure was assessed by electric-field measurements taken in locations where radar exposure levels were expected to be high based on numerical calculations; the mean and peak values were used to represent temporal measurements. The study population was divided into two groups: the "*radar group*" of employees whose occupations took place above the main deck, and the "*control group*" of employees whose occupations were situated under the main deck and who were considered unexposed. Compared to the unexposed group, the all-cause and cancer mortality rates among the radar group were not significantly different, irrespective of time; no effect of age on risk of cancer death was observed. A statistically significant lower mortality rate from respiratory system disease was observed for the radar group compared to the unexposed group. The authors concluded that the results *"did not suggest an increased health risk for military personnel exposed to higher levels of EMF, in particular microwaves emitted by radars and HF [high frequency] communication emitters"* (p. 8). Limitations of the study include the significant portion of missing causes of death (43%);

a lack of smoking data, which is a potential confounding factor; and the use of broad exposure groups that do not account for variability in exposure across or within jobs and tasks. As noted in the study, the use of personal dosimeters would greatly improve the exposure assessment approach.

- **Satta et al. (2018)** conducted a case-control study to examine the relationship between environmental RF field exposure and risk of lymphoma in Italy. The study included 322 cases, diagnosed between 1998 and 2004 and ranging in age from 25 to 74 years, and 444 controls. Exposure was assessed using several methods. First, the study participants responded to a questionnaire on the self-reported perceived distance of the participants' three longest-held residences from fixed radio-television transmitters and mobile phone base stations. Second, the authors obtained spatial data on the location of mobile phone base stations in relation to the participants' geocoded addresses and estimated the RF intensity for all addresses within a 500-meter radius (spatial coordinates for transmitters were not available). Third, the authors collected RF measurements at the door of the longest-held addresses within a 250-meter radius of the base stations. Statistically significant associations were observed between self-reported residential distances within 50 meters to fixed radio-television transmitters and lymphoma, both overall and by one of three sub-types. No associations were observed between mobile phone base stations and self-reported distance, geocoded distance, or estimated RF intensity levels. RF measurement levels were similar between cases and controls. The authors concluded that their results *"do not support the hypothesis of an association between environmental exposure to RF-EMF emissions from mobile phone base stations and risk of developing lymphomas"* (p. 6). The small sample sizes, particularly in subtype analyses and in the highest exposure category, is a limitation of the study. In addition, the exposure assessment approaches used in the study have associated weaknesses. The self-reported distance data are subject to bias; in fact, cases were demonstrated to overestimate their residential distance from mobile phone base stations more often compared to the control population. Geocoding of residential distances can be greatly impacted by potential confounding variables; in this study, the authors adjusted only for vehicle traffic intensity and education. Finally, the RF spot measurements taken at the residences do not necessarily reflect past exposures or changes in exposure over time.

- **González-Rubio et al. (2017)** conducted an ecological study analyzing the relationship between environmental exposure to RF fields and incidence of lymphomas and brain tumors inside the city of Albacete, Spain, in 2015. The authors divided the geographical areas of the city into 110 micro-environments; exposure to 14 frequency bands of RF fields (ranging from 88 MHz to 6 GHz) were then measured within each area using a personal monitoring device transported around in a bicycle. Within each micro-environment, the average RF field exposure levels and the incidence of various cancers (meningioma, glioma, lymphoma, all brain tumors, and total tumors) were then assessed. The authors concluded that the cancer cases *"have a random spatial distribution"* inside the city and that RF field exposure *"shows little correlation with the incidence of the studied tumors"* (pp. 834, 842). They also noted that *"[n]one of the administrative regions exceeded the legal limit established for the urban zone"* (p. 839). This study has several limitations. The measurements collected around the city do not accurately represent the residents' individual exposure levels inside their homes and other buildings; a small number of cancer cases were included (95 total cases identified); residents may have migrated in and out of the city during the study period; and with any ecological study, it is not possible to assess the potential correlation between the exposure and disease of interest.

Regarding distant RF sources, SCENIHR in 2015 reported that:

> *The totality of evidence of epidemiological studies weighs against cancer risks from base stations and broadcast antennas. In particular, large case-control studies modelling RF exposure and investigating the risks of childhood cancers have not shown any association* (2015, p. 84).

A similar conclusion applies to the studies of radar, mobile base stations, and other fixed transmitters evaluated above that did not report associations of these environmental sources with cancer. The BCCDC confirms that the exposures from such sources are quite low:

> *In British Columbia, a series of power density measurements were conducted in 2004 by a BCCDC team at 20 different sites across the province using a dedicated RF survey unit mounted on a vehicle. The power density readings collected in the survey showed that the base stations were largely compliant with Safety Code 6 (SC6) guidelines with exposures 3000 to 1,000,000 times lower than SC6 limits for uncontrolled (public non-workplace) environments* (BCCDC, 2016, p. 5).

Summary of epidemiologic studies of cancer

In recent years, research has focused predominantly on exposure from mobile phones due to the close proximity of the phone to the human body when in use and the increasing number of mobile phones in use worldwide. Recent epidemiologic studies of RF field exposure from mobile phones provide little new evidence in support of an association between exposure and cancer development. As noted previously, these studies have not provided reliable evidence to alter the conclusion of the 2015 SCENIHR report, which states,

> *Overall, the epidemiological studies on mobile phone RF EMF exposure do not show an increased risk of brain tumours. Furthermore, they do not indicate an increased risk for other cancers of the head and neck region. Some studies raised questions regarding an increased risk of glioma and acoustic neuroma in heavy users of mobile phones. The results of cohort and incidence time trend studies do not support an increased risk for glioma while the possibility of an association with acoustic neuroma remains open. Epidemiological studies do not indicate increased risk for other malignant diseases, including childhood cancer"* (SCENIHR, 2015, p. 5).

When evaluated against established scientific criteria for assessing causality (i.e., the Bradford-Hill criteria), the reviewed studies did not provide consistent evidence in support of a causal relationship between RF field exposure and any of the examined cancer outcomes, including brain tumors. Most of the recently-published case-control studies related to exposure from mobile phones reported no statistically significant positive associations between mobile phone use and cancer. Similarly, statistically significant associations were not reported in the main analyses of meta-analyses of mobile phone use and several types of brain cancer. As noted in the National Research Council's (NRC) *Reference Manual on Scientific Evidence*, *"[a]lthough lower [associations] can reflect causality, the epidemiologist will scrutinize such associations more closely because there is a greater chance that they are the result of uncontrolled confounding or biases"* (NRC, 2011, p. 602). Further, the reviewed studies demonstrated an absence of a consistent dose-response relationship (i.e., greater exposure leads to an increased likelihood of disease occurrence) between mobile phone use and cancer development. For most human health assessments, the presence of a dose-response relationship is considered *"strong ... evidence that the relationship between an agent and disease is causal"* (NRC, 2011, p. 603). An additional criterion for evidence of causality is the existence of a plausible biological mechanism that is consistent with existing biological and medical knowledge; as noted by the NRC, "*[w]hen biological plausibility exists, it lends credence to an inference of causality*" (NRC, 2011, p. 604). The lack of biological plausibility between mobile phone use and cancer will be discussed in the following section on *in vivo* studies relevant to cancer. As noted in Section 3, while none of the criteria alone are absolutely necessary to establish causality, the more the epidemiologic evidence meets these guidelines, the more convincing the evidence is for a potential causal interpretation. Indeed, the reverse also holds true—the less the epidemiologic evidence meets these guidelines, the less convincing the evidence for a causal relationship.

Several recent studies examining exposure from far-field RF sources also have been conducted. While considerably fewer studies have been published on these sources compared to studies of mobile phone use (which is consistent with mobile phones being considered the predominant source of exposure for most of the population), none of the recently published studies concluded that exposure from distant sources of RF fields is associated with cancer. This includes a cohort study on occupational exposure of military personnel to radar, which reported no significant differences in all-cause or cancer mortality rates between the exposed and unexposed workers, and a case-control study of environmental RF field exposure, which reported no associations between lymphoma and exposure from mobile phone base stations using multiple exposure metrics (e.g., self-reported distance, estimated intensity levels). The findings of these studies are consistent with the SCENIHR's conclusion that "*[t]he totality of evidence of epidemiological studies weighs against cancer risks from base stations and broadcast antennas.*

In particular, large [epidemiologic] studies modelling RF exposure and investigating the risks of childhood cancers have not shown any association" (SCENIHR, 2015, p. 84).

In addition, studies examining cancer incidence rates over time did not observe correlations between cancer rates and trends in mobile phone use over the same period. This is consistent with the trends observed in Canada, and in British Columbia specifically. The Canadian Cancer Society's 2019 *Canadian Cancer Statistics* publication reported an annual average decrease of 0.6% in the overall brain and central nervous system cancer incidence rate for the period of 1984 to 2015; a larger decrease (2.9%) was observed when focusing on recent years only (2011 to 2015).[19] During this same period, beginning in the early 2000s, the use of mobile phones in Canada grew significantly; in 2017, there were over 31 million mobile phone subscribers, a 3.1% increase from the previous year.[20] Further, the 2016 report by the BCCDC states that from 1990 to 2009, the age-adjusted brain cancer incidence rates in British Columbia were "*fairly flat*" among females and "*slightly decreasing*" among males (BCCDC, 2016, p. 9). Research investigating associations between estimates of exposure to distant RF sources and cancer also reported no consistent positive associations and provided no evidence for a causal relationship between RF exposure and cancer. It is important to note that RF exposures from the FEI base stations and mobile phone antennas would be far lower than exposure from mobile phones and hand-held communicators that are held close to the body during use.

In summary, the results of recent epidemiologic studies do not change the classification of the epidemiologic data as *limited*, as determined by IARC, and are consistent with the conclusions of recent agency reviews (e.g., SCENIHR, 2015; SSM, 2018, 2019, 2020) that the evidence does not confirm that RF fields below scientifically-based exposure guidelines cause or contribute to the development of cancer.

In vivo studies relevant to cancer

Human health risk assessments are not based exclusively on epidemiologic studies; experimental studies in animals and humans (i.e., *in vivo*) also play a key role (Health Canada, 2000; WHO, 2010; USEPA, 2002, 2005). *In vivo* experimental studies are particularly

19 cancer.ca/Canadian-Cancer-Statistics-2019-EN Accessed April 2021.
20 https://crtc.gc.ca/eng/publications/reports/policymonitoring/2018/cmr3d.htm Accessed April 2021.

important to assess the potential role of magnetic fields in carcinogenic processes (IARC, 1992, 2002). Research on animals has burgeoned over the past few decades as researchers have sought to determine if the results of *in vivo* studies provide some biological plausibility for statistical associations reported in some epidemiologic studies between RF field exposure from mobile phones and cancer of the head and neck.

There are two types of *in vivo* studies. The first type, often described as cancer bioassay studies, focuses on the identification of an adverse effect (i.e., the existence of a hazard) by exposing animals to the highest tolerated doses of RF energy over most of their lifetime. The second type focuses on biological measures that serve as potential indicators of carcinogenic processes, which most often focus on changes that might be revealed during short-term exposures. Since genetic mutations to chromosomes and DNA are known to play a role in the development of cancers in humans and animals, research on the potential genotoxic effects of magnetic fields has been of interest for decades.

Since the most recent comprehensive assessment of RF health research was conducted by SCENIHR in 2015, more recent *in vivo* studies that evaluated the incidence of cancer in exposed and control animals and studies of genetic biomarkers in humans and animals were included in this review.

This update first summarizes the conclusions of the SCENIHR review and prior assessments, and then summarizes the results of recent studies of long-term RF exposure of animals on the development of tumors. Then multiple observational, cross-sectional studies of the distribution of measures of chromosomal or DNA damage in human subjects are reviewed, followed by an assessment of experimental studies in which DNA and chromosome damage markers were measured in animals exposed to RF field or sham-exposure control conditions.

Summary of prior reviews

Below are quotes taken directly from prior reviews that capture the conclusions of national and international health, scientific and government agencies regarding experimental studies of RF field exposure and cancer. In aggregate, these reviews concluded that evidence from experimental studies does not support an effect of RF field exposure on carcinogenic processes.

Advisory Group on Non-Ionising Radiation

Regarding experimental studies, AGNIR concluded that *"[r]ecent animal studies have produced no consistent evidence that RF fields cause or increase the risk of cancer"* and that the studies *"have produced no compelling evidence that RF fields are genotoxic or cause robust carcinogenic effects with exposures below guideline values"* (AGNIR, 2012, p. 172).

British Columbia Centre for Disease Control

Long-term bioassays, designed to determine whether RF exposure either alone or in conjunction with known mutagens can initiate or promote development of cancer in animals, have been uniformly negative. Studies of RF fields and toxicological effects such as DNA damage, micronucleus formation, apoptosis, reactive oxygen species, and gene expression changes have been inconsistent and the results have been contradictory. Positive studies have proven difficult to replicate. There is no consistent evidence that exposure to RF produces biological effects in animal central nervous systems. Recent investigations have been unable to confirm that RF exposure alters blood-brain barrier permeability; however, other aspects of brain physiology are less well studied. Behavioural investigations of the role of RF exposure on animal learning and cognitive function are mixed. Immune function studies have been mostly negative, although most of the studies to date have been conducted in adult animals. Effects of RF exposure on endocrine function, particularly on melatonin levels, have been negative, as have been studies on reproductive function in female animals. Overall, the research studies to date have not provided convincing evidence that RF-field exposure produces adverse biological effects in animals (BCCDC, 2013, p. 2).[21]

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[21] BCCDC did not review animal studies in their 2016 report.

International Agency for Research on Cancer

A review of experimental studies of RF field exposures in rats and mice between 1982 and 2011 was reported by the IARC in 2013. The conclusion was that, in aggregate, the studies provided "*limited evidence in experimental animals for the carcinogenicity of radiofrequency radiation*" (IARC, 2013).

Royal Society of Canada

As in earlier studies, the post-2009 studies contain a mix of reports indicating possible genotoxic and epigenetic activity and others showing no evidence of either. There is a wide mix of endpoints (many of which are indirect) and exposure conditions (e.g., different frequencies, modulation schemes, power, exposure duration). There are also methodological weaknesses in many studies (e.g., lack of dosimetry, lack of sham-exposed controls, non-standard assays) ... (RSC, 2014, p. 80).

Animal studies of RF energy and cancer have provided no consistent evidence that exposure to RF energy below SC6 (2013) limits causes or promotes cancer (RSC, 2014, p. 82).

Scientific Committee on Emerging and Newly Identified Health Risks

An updated review of these and some newer studies and analyses prompted SCENIHR (2015) to conclude "*[o]verall, because a considerable number of well-performed studies using a wide variety of animal models have been mostly negative in outcome, the animal studies are considered to provide strong evidence for the absence of an effect [i.e., carcinogenic or other adverse effect]*" (SCENIHR, 2015, p. 86).

Health Council of the Netherlands

… the Committee … conclude[d] that, on the basis of the results of the animal studies presented in this systematic review, it is highly unlikely that long-term continuous or repeated exposure to RF EMF may have initiating or promoting effects on the development of cancer (HCN, 2014, p. 20).

Overall, the studies discussed in this report show that no effects of long-term exposure to RF EMF on the development or growth of tumours in general, or on specific types of tumours, have been demonstrated in rodents. The findings of the few studies that did indicate effects have either not been observed in repetition studies, or might be explained by thermal effects. It is also possible that they were chance findings. This can also only be the conclusion for the few observed protective effects of RF exposure (HCN, 2014, p. 50).

International Commission on Non-Ionizing Radiation Protection

A few animal studies on the effect of radiofrequency EMF exposure on carcinogenesis have reported positive effects, but, in general, these studies either have shortcomings in methodology or dosimetry, or the results have not been verified in independent studies. Indeed, the great majority of studies have reported a lack of carcinogenic effects in a variety of animal models (ICNIRP, 2020a, p. 522).

U.S. Food and Drug Administration

The in vivo studies conducted between January 1, 2008 and August 1, 2018 and [reviewed by the FDA] have contributed to our collective understanding of the potential effects of [radiofrequency radiation] on mammals. Overall, based on certain limitations, these studies have not produced any clear evidence that [radiofrequency] exposure has any tumorigenic effect. In some cases, the authors of these studies suggested the need for more research based on the reported results. Other authors stated that [radiofrequency] exposure does not result in tumor-initiating or -promoting effects (FDA, 2020, p. 33).

… due to the critical limitations of in vivo studies in assessing the effects of [radiofrequency radiation] exposure to humans (e.g., whole-body [radiofrequency] exposure), we cannot draw conclusions about the impact of such exposure to humans based on these in vivo animal studies. The results

> *from such studies should not be applied to human cell phone usage as further research is needed* (FDA, 2020, p. 34).

Human biomarker studies

Human biomarker studies are mini-epidemiology studies in which biological measurements are made on small groups of persons to determine if they differ on some particular measurement that plausibly may be related to the topic of interest. In the studies reviewed here, such measurements were made of DNA and chromosomes extracted from human cells. If not repaired, damage to DNA might result in a mutation that under specific conditions might develop into cancer, which explains the potential relevance of these studies to cancer processes.

The DNA of every cell of the human body is damaged 10,000 times per day by ongoing cellular processes; in rats and mice this rate is 5 to 10 times higher (Ames et al., 1993). In most cases, multiple other cell processes work to effectively repair this damage, or if severe, remove the damaged cell by programmed cell death. If not repaired properly, a mutation may result that, dependent upon other conditions, could lead to cancer. Hence, in the evaluation of biological processes that might lead to cancer, scientists have used a variety of tests to quantify levels of damage to DNA and chromosomes that contain DNA.

Since the SCENIHR review, 12 cross-sectional studies of human subjects have been published on the cellular characteristics and circumstances of populations that differ in terms of their estimated or suspected exposures to mobile phone antennas. As a matter of logic and epidemiological science, because the studies cannot determine whether a measured or reported biological or health outcome occurred before, during, or after RF field exposure (NRC, 2011, pp. 560-561), these studies, like other cross-sectional epidemiologic studies of other exposures or RF fields, cannot establish a cause-and-effect relationship. Although cross-sectional studies cannot establish causation, such studies are initiated to test preliminary hypotheses and can be performed at reasonably low cost.

The focus of these biomarker studies was to determine if one-time samples of human cells analyzed for single strand breaks (SSB) in DNA (as detected by the alkaline comet assay)[22] or the presence of micronuclei (MN) chromosome fragments in blood cells differed between groups of apparently similar persons who varied with respect to their estimated RF field exposure. It is important to understand that even though these test methods are referred to as genetic tests, their ability to detect past events is quite limited. These tests are only capable of detecting effects on cells that may have occurred within about 6 hours before collection of the samples for comet assay analysis or 3 days before the collection of samples for MN analysis (Singh et al., 1988; OECD, 2015).

- **Daroit et al. (2015)** reported a cross-sectional analysis of a convenience sample of 20 men and 40 women between the ages of 19 and 33 years recruited from the School of Dentistry in Alegre, Brazil for their use of mobile phones and other demographic data and obtained samples of oral mucosal epithelial cells by scraping the lower lip, border of the tongue, and floor of the mouth. Potential subjects who reported themselves as smokers, having more than two drinks per week, or who displayed oral lesions upon examination were excluded. The cells from each site were spread on slides (1 slide per site) and 1,000 cells on each slide were examined for cytopathological abnormalities after staining for the DNA of cells (Feulgen reaction). The samples were examined under the microscope by one observer who was blinded and who had a reported inter-rater reliability correlation compared with a more experienced investigator characterized by an interclass correlation coefficient > 0.75. As the sites from the lip and tongue are likely to incur damage from sunlight or other non-specific damage, these data are not reviewed here. The samples obtained from the floor of the mouth are more similar to the cheek samples analyzed in other comparable studies and so those measurements are described below. The primary result was that the mean number of MN in cells from the floor of the mouth was not statistically higher in persons using mobile phones more than 60 minutes per week compared to persons using mobile phones less than 60 minutes

[22] The DNA from single cells are applied to an agarose gel, and when a voltage is applied to the gel, single-strands are distinguished from double-stranded DNA as they migrate away from the undamaged DNA, forming a structure that resembles that of a comet. The double-strand DNA is contained in the head of the comet while the single-strand DNA and fragments (SSBs) are contained in the tail of the comet. The percentage of DNA in the tail is considered to be proportional to the percentage of SSBs that occurred in a particular cell.

each week. When the MN from all sites were analyzed together, the mean MN levels were marginally higher in the group with self-reported mobile phone use more than 60 hours per week (p=0.048), largely because of the inclusion of increased MN observed in samples from the lower lip. The authors reported no significant statistical association between the years of cell phone use and mean value of MN at any of the three oral sites; however, the statistical test used compared median values, not mean values. It also should be noted that the statistical analysis erroneously assumed that the measurements at the three sites were independent of one another, although they cannot be independent because the three samples were obtained from the same person. In addition, it was not demonstrated that the distributions of the MN values were sufficiently similar to conclude that the medians were different or that some other difference had been detected.

- **Gandhi et al. (2015)** carried out a cross-sectional study that describes the results of measurements of DNA damage in persons in the city of Amnistar, India, living in the vicinity of a specific mobile telephone base station (sample group, n=63),[23] and those living in a less densely populated area, presumably in a zone outside the city without a mobile phone tower (control group, n=28), in the period from 2007 to 2009. Finger-prick blood samples were collected and later analyzed for fragmentation of DNA strands in white blood cells as measured by the alkaline comet assay. This assay is used to evaluate transient damage to DNA that may have occurred in the few hours prior to sample collection that had not yet been repaired.

  The authors reported a 4.5-fold increase in the mean tail migration length and a 2.5-fold increase in a calculated "*damage index*" (which was dependent in part on measured migration length between those in the sample and control groups). The DNA damage measurements in the sample group did not vary appreciably with differences in the duration of mobile phone use, the duration of daily calls, or estimates of RF fields in SAR ranges. And, contrary to the authors' interpretation of the study, the percent of cells with tails, damage index, and mean migration length of damaged DNA for mobile

[23] The study noted that 90 base station antennas on towers were operating in the city at the time.

phone users was similar to the values for subjects who did not use mobile phones. Moreover, there was no consistent relationship between distance from the base station across the three measures of DNA damage. The limitations of this study are substantial: the investigators did not describe how particular base stations were selected, did not identify the frequency of the RF signals, did not state how subjects were recruited, and did not provide information about the purpose of the study. Additionally, no information was provided as to the procedures for the handling and analysis of the DNA specimens (blinding) to prevent bias during processing and analysis from knowledge as to the source of the samples. Only 100 cells per sample were analyzed for SSBs, while the Organisation for Economic Co-operation and Development (OECD) calls for 150 cells per sample to be analyzed (OECD, 2015).

- **Banerjee et al. (2016)** canvassed 300 patients from the outpatient department of the Kothiwal Dental College in Moradabad, India, to collect samples of cells from their mouth and analyze them for the presence of MN, which are small extra-nuclear bodies containing chromosomal fragments that may form when chromosomal damage has occurred. Associations between MN frequency and mobile phone use, as reported on a questionnaire, were evaluated. The buccal cells from the mouth were stained with a DNA-specific dye and scored by a single person for the presence of MN. Differences between high- and low-use mobile phone owners, type of mobile phone, and use of wired ear buds were reported. First, the authors claimed that the data showed increases in MN counts with long-term use of mobile phones; however, other possible explanations for the results such as selection bias, geographical variations, subjects that differed with respect to diet, health history, and other factors were not considered. Second, only 1,000 cells per subject were analyzed for MN, but OECD requirements call for 4,000 cells per sample to be analyzed (OECD, 2015). Third, the samples were scored by a single person and the study did not state whether this individual was blinded as to the data submitted on the questionnaires.

- **Shaikh et al. (2016)** conducted a similar cross-sectional study as Banerjee et al. (2016). These investigators in Ahmedabad, India, collected information on mobile phone use and health conditions from an unidentified population and divided 120 male subjects into age-matched, high-use and low-use groups based on estimates of the number of calls made on mobile phones per day and years of use reported by subjects. Cells for analysis were collected by swabbing the inner cheek with a toothbrush and examined by light microscopy for cell types, including MN. The high-use group also reported use of chewing tobacco, smoking, pan masala (a chew made of betel nuts that sometimes includes spices and tobacco), and alcohol use. The differences between MN counts in high-use and low-use groups were very large, just slightly higher than reported for persons "*addicted*" to the chemical exposures listed above. A secondary analysis suggested that the MN counts were greater in persons reporting typical mobile phone use of 3 to 5 hours per day, and somewhat greater counts for persons using mobile phones for 5 to 7, and 7 to 9 hours per day, as compared to persons using mobile phones <1 hour per day. This study did not report any precautions to prevent bias in the analysis and only 1,000 cells per subject were analyzed for MN; OECD requirements call for 4,000 cells per sample to be analyzed (OECD, 2015).

- **Gulati et al. (2016)** conducted another cross-sectional study in the city of Kurukshetra, India, comparing 116 subjects recruited by unknown means living far from a mobile tower (>800 meters) to 106 subjects living near a mobile phone base station (50 to 400 meters). The subjects completed a questionnaire on their demographic characteristics and provided blood samples for analysis of single-strand DNA breaks using the comet assay; inner cheek swabs were also collected for the MN analysis. Most surprisingly, while the authors investigated an association between RF field exposure and proximity to a mobile phone tower, they did not collect information about use of mobile phones, a closer source of RF field exposure. The subjects also were evaluated for polymorphisms in glutathione S-transferase (GGT), a detoxifying enzyme. No significant differences between the near and far subjects were reported for demographic variables, but differences in self-reported conditions, including blood pressure, depression, memory status, insomnia, and hair loss were seen.

  Measurements of RF power density focused on 1.8 GHz and were reported at varying distances, but the number of measurements, the basis for choosing measurement locations, and any methods to exclude interference from RF signals from personal mobile phones were not included. The authors reported that the measurements of comet tail moments were 25-fold higher and MN levels were 3-fold higher in the near group than in the far group and appeared to track with distance and power density. In the near group, persons with residence time ≥ 9 years had higher MN frequencies than those in the far group and were outside the range of normal values (Bonassi et al., 2011). Only 50 cells from each sample were analyzed for SSBs, whereas OECD requirements call for 150 cells per sample (OECD, 2015). The subgroup analyses indicated that SSBs and MN were only elevated in women and for subjects over the age of 45. While the reported differences may seem large, the most surprising result is that the data failed to show large differences between groups of persons with exposures known to affect DNA damage and MN, including smoking, alcohol use, and tobacco chewing in either the near or far group. In fact, the oral buccal MN frequency of tobacco chewers was lower in both groups than that of non-tobacco chewers. These deficiencies preclude giving any weight to this study. Other limitations included how distances to the mobile phone antenna were determined, the potential overlap in RF exposure with that from other mobile phone antennas or other types of antennas, whether any notable industrial activities existed in either area, or how subjects were recruited. The study reported that the analysis of MN specimens, but not that of the DNA, was double-blind. The study did not report the numbers of subjects whose samples were analyzed in each group.

- **Radwan et al. (2016)** described the demographic, lifestyle, and stress factors of 286 men between age 22 and 45 who attended an infertility clinic in Lodz, Poland. One of the factors investigated was the use of a cell phone. Sperm DNA fragmentation was measured using the flow cytometric Sperm Chromatin Structure Assay (SCSA), which detects the susceptibility of the DNA to denaturation by acid (due to the chromatin structure being fragmented) by the degree of DNA staining with acridine orange. The advantages of this method over other methods is the larger number of sperm screened, the objectivity of the test, and that the method is one that has "*demonstrated clear clinically useful cut-off levels for calculating male fertility potential*" (Bungum, 2012, p. 3; Wright et al., 2014). Statistically significant correlations between subjectively rated work stress and over the age of 40 with high levels of DNA fragmentation were reported. No statistically significant correlations between years of cell phone use and low, medium, or high levels of DNA chromatin fragmentation were reported, although the percentage of immature sperms was significantly higher in obese patients and cell phone users. Comparable data on men who did not have cell phones or who were not referred to the infertility clinic were not included in this study.

- **Zothansiama et al. (2017)** conducted a cross-sectional study of persons living near or far from six mobile phone base stations operating at 900 MHz or 1,800 MHz in Aizawl, India, the same city studied by Gulati et al. (2015), but in a later time period (2015 to 2016).[24] The investigators obtained blood samples from residents of Aizawl and measured levels of MN in lymphocytes following stimulation by phytohemagglutinin (a mitogen that promotes cell division) for 72 hours *in vitro*; they also measured biochemical markers of anti-oxidant enzymatic activity and lipid peroxidation. The results were summarized for persons grouped by age, mobile phone use, duration (years), daily use (hours), distance from mobile base stations and measured power density, gender, smoking/alcohol consumption, and diet.

  The frequency of MN was lower in the control group (>300 meters from the mobile base station) than the exposed group (<80 meters from the mobile base station). The MN levels of women were lower than for men. While the percent of mobile phone users, duration of use, and daily mobile phone hours of use did not differ between the exposed and control groups, the MN levels measured in these subgroups were significantly higher in the exposed group than the control group. The authors attribute a 21% difference in mean MN levels in cheek cells between residents living near and far from the mobile base stations to low levels of RF exposure from the mobile base stations. The data also show, however, that the differences in mean MN between users and non-users of mobile phones in both groups were <4% even though RF field exposure to the cheeks of mobile phone users would be far greater than from a distant mobile phone base station. Because of the close proximity of cell phones to the body, especially during use, the exposure to

[24] It is curious that Zothansiama et al. (2017) does not mention the prior study by Gulati et al. (2015) that was conducted in the same city.

an RF field is much greater from a person's mobile phone than from a distant mobile phone base station.

While the authors did obtain some data relevant to other possible explanations including selection bias, geographical variations, diet, smoking, and alcohol use, the analyses performed did not adequately explore the relative contributions of such factors versus mobile phone use to MN and other measures. Only 1,000 cells per subject were analyzed for MN, but OECD requirements call for 4,000 cells per sample to be analyzed (OECD, 2015). The authors did not state how subjects were selected, or whether the analyzes of MN and other data were performed without *a priori* knowledge of the group from which the samples were obtained. Altogether, the results suggest that there are differences in the measures obtained from persons in two different parts of the city, but the data are insufficient to determine the basis for those differences.

- **de Oliveira et al (2017a, 2017b)** used convenience sampling via questionnaire to enroll 86 volunteers, age 18 to 30, in this cross-sectional study. The questionnaire asked about age, sex, place of birth, environmental and dietary exposures and habits, and the use of mobile phones (years of use, minutes per day, preferred side of the face, and headset use). Buccal samples from each side of the mouth were collected and 2,000 cells per subject were evaluated for MN by a single unblinded observer using the Feulgen technique with a DNA-specific stain. About 85% of the subjects reported the right side of the head as the preferred phone placement location during use. No statistically significant differences in the number of MN present were reported between males and females, among three different age groups, or according to other variables identified in the questionnaire including tobacco use, years of phone use, hours of daily exposure, or preferred side of the face for mobile phone use. Subjects reporting occupational exposure to genotoxic substances other than tobacco, however, did have significantly higher levels of MN compared to those who did not ($p=0.000015$). Two of the genotoxic exposures identified were xylene and formaldehyde. Some additional analyses of MN distributions by age and occupational exposure were included in a shorter, summary publication (de Oliveira et al., 2017b).

An independent systemic review of studies of mobile phone use and MN in cells of the mouth and a meta-analysis of the de Oliveira et al. (2017a) study and a prior study (Ros-Lior et al., 2012) did not find statistically significant differences in the frequency of MN in cells obtained from both sides of the mouth, which led to the conclusion that "*mobile phone use is not associated with the occurrence of genotoxic effects in the oral epithelium*" (dos Santos et al., 2020, p. 73).

- **Akdag et al. (2018)**[25] identified volunteers for this cross-sectional study from a survey, but no information was provided as to how the volunteers were recruited. Study participants included those who did not report owning a mobile phone and those who did. For persons using smart phones, the head peak SARs ranged between 0.45 and 0.97 W/kg. Other information was gathered from the subjects by self-report about exposure to chemicals, radiation, smoking, drugs, temperature, as well as age, but only data on age of the groups was described in the paper. Male volunteers between 30 and 60 years were allocated to four groups: control (no mobile phone), use for 0 to 30 minutes per day; 30 to 60 minutes per day; and over 60 minutes per day. Each group included 14 volunteers with the median age of approximately 40 years. Cells attached to the roots of hair were removed from within the ear most often closest to the mobile phone during use. Hair cell DNA was extracted for analysis by the alkaline comet assay. Seven parameters were used to describe the results; many of these were interdependent. Only 100 cells per sample were analyzed for SSBs. The OECD calls for 150 cells per sample to be analyzed (OECD, 2015). While not completely consistent across groups, statistical differences between the control group participants and those who reported using mobile phones more than 60 minutes per day were reported for measures of DNA damage. However, when the differences were compared according to duration of use, duration-dependent changes were not always evident. The study participants were not randomly selected and the investigators who analyzed the data were not blinded as to the group from which the samples were obtained. The investigators also failed to collect samples from both ears so as to test the hypothesis that each ear might differ based upon RF field

[25] This paper was excluded by SSM (2020) for review because it did not include a sham-control, which is a serious limitation for an experimental study but less severe for a cross-sectional epidemiologic study. Therefore it was excluded for this review.

exposure, nor could the investigators determine the contribution of a multitude of other factors that may account for differences between persons and groups. For these reasons, and because of the cross-sectional design of the study, no conclusions can be drawn about the contribution of RF field exposure to the reported results.

- **Vanishree et al. (2018)** researchers at the Navodaya Dental College and Hospital in Raichur, India, selected patients from the Outpatient Department for this cross-sectional study. They assigned 30 men and 30 women into a "*low mobile phone user*" group and the same number of subjects per sex into a "*high mobile phone use*r" group; these assignments were based on the number of years of use and number of hours per day of use. Study subjects were limited to those age 20 to 28 and to those without oral lesions or unspecified "*deleterious habits*." The study did not provide a description as to how information about the demographics or history of subjects was obtained. Cells were scraped from the inside of the right and left cheek for analysis. Counts of MN were reported in 1,000 cells per subject. The average MN count of high mobile phone users was slightly, but significantly, greater than the count in the low-user group but a non-DNA-specific stain was used to identify cell nuclei. Within the high-user group, greater MN counts were generally seen in those mobile phones using code-division multiple access (CDMA) rather than global system for mobile communications (GSM) phones and in non-headphone users compared to headphone users; counts were also higher from the cheek on the side of the head most frequently near the mobile phone. Only 1,000 cells per subject were analyzed for MN; OECD requirements call for 4,000 cells per sample to be analyzed (OECD, 2015). No assessment of confounding exposures or medical history was included, which is significant because all the subjects were patients of the Outpatient Clinic. The analyses were not reported to be blinded as to the history of the patients or the results. In addition, as a cross-sectional study, there can be no assurance that the use of mobile phones preceded the development of MN.

- **Senturk et al. (2019)** reported a cross-sectional study to determine if intense RF energy with a frequency of 2.2 MHz applied to ablate enlarged nasal sinuses during surgery was capable of increasing blood levels of indicators of antioxidant or oxidant activity, or both, including damage to DNA as measured by the alkaline comet assay. Blood samples were obtained from 27 patients on the day prior to surgery and on post-surgical days 1 and 15. Total oxidant levels increased from the day before surgery to post-surgical day 15. Total antioxidants increased above pre-surgery levels on day 1 and 15 post-surgery. The levels of DNA strand breaks in circulating lymphocytes were slightly but not significantly increased on day 1 after surgery; no difference was seen on post-surgery day 15, but the extent of DNA damage was associated with higher total oxidant status on day 15. The physicians provided no information about the patients, their use of medications, including antibiotics (some of which act by damaging DNA, e.g., González et al. [2002]), or blood levels of other parameters that might indicate the leakage of thermally-damaged tissue into the venous circulation.

- **Khalil et al. (2020)** recruited 100 male and female students from Yarmouk University in Jordan who were between age 18 and 30 to provide demographic information and details regarding their mobile phone use in a detailed questionnaire as part of a cross-sectional study. Subjects who reported smoking, drug therapy, illness, use of dietary supplements, mouthwash, and other activities were excluded. The published SAR levels of the volunteers' mobile phones ranged from 0.244 to 1.552 W/kg, but the frequency of the RF signals was not provided. Samples of mucosal cells from both the right and left sides of the mouth were analyzed for damage to DNA using the comet assay and measurements of apoptosis-induced nuclear damage by the terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL) assay. One hundred randomly chosen cells from each sample were analyzed for each. Data from male and female participants were pooled for analysis as no significant differences between the sexes were seen with regard to mobile phone use, age, or ear dominance.

  The primary finding was that the percent of cells with DNA strand breaks or cells showing apoptotic damage from the left or right cheek was no different among those who used mobile phones <30 minutes, 30 to 60 minutes, or over 60 minutes, or for those who used mobile phones <5 years, 5 to 10 years, or >10 years (p-values >0.05). This result is complementary to the authors' previous report that 15- and 30-minute phone calls with an 1,800 MHz mobile phone had no significant effect on levels of 8-hydroxy-2-deoxyguanosine (8-OHdG) or markers of oxidative stress (Khalil et al., 2014).

A subgroup analysis of the seven different measures of DNA damage quantified using the comet assay found that almost all measures from both left and right cheeks were significantly associated with the minutes per day of mobile phone use. In contrast, none of these measures were significantly associated with years of mobile phone use in cells collected from the right cheek and only two measures (comet length and tail length) were associated with years of phone use in cells from the left check. Drawing firm conclusions from subgroup analyses that are contrary to the primary study finding is particularly problematic. Analyses of more rigorous randomized medical trials have concluded that "*[a]uthors often claim subgroup effects in their trial report. However, the credibility of subgroup effects, even when claims are strong, is usually low. Users of the information should treat claims that fail to meet most criteria with skepticism*" (Sun et al., 2012, p. 1).

The participants in Khalil et al. (2020) were reported to have been "*randomly stratified into three groups based on the frequency and intensity of phone use*." A more accurate description is that the participants were allocated to categories of daily exposure duration and years of phone use by the investigators. The authors stated that the analyses were conducted on coded samples; however, only 100 cells per sample were analyzed for DNA strand breaks, while the OECD calls for at least 150 cells per sample to be analyzed (OECD, 2015). One interpretation of these data is that self-reported low, medium, and heavy users of mobile phones have different behaviors or risk factors that affect not only the occurrence of DNA damage but its appearance (as identified by the seven inter-related measurements of individual cell comets). Another possibility is that the pattern of sub-group analyses does not fully reflect the data collected from the 100 participants because data were reported for only 83 left cheeks and 85 right cheeks, which appears contrary to the authors' claim that "*[n]obody dropped out of the study.*" The claim that "*all confounding factors that could cause cytogenetic toxicity were excluded (tobacco, alcohol, recent medication, systemic factor, etc*." is simply naïve. Excluding volunteers who admitted to such uses and history does not guarantee that persons who did not admit to these confounding exposures, did not have such exposures. Further, the study does not appear to address possible occupational exposures or other exposures that may have been associated with the participants' education.

Summary of human biomarker studies

The conclusions of IARC (2013) on human genetic studies was that "*that there was weak evidence that RF radiation is genotoxic, and no evidence for the mutagenicity of RF radiation*." (p. 415). A review of seven studies (one cohort and six cross-sectional studies) published between 2009 and 2018 looked for associations between proximity to mobile phones or base stations and markers of genotoxicity in small convenience samples (Revanth et al., 2020). The review concluded that "*the majority of the studies found that the effects of mobile phone radiation ... having the potential to cause some buccal cell abnormalities*" (p. 280). That conclusion was based on just four of the seven studies and was too limited to be informative.

The papers rated highest for quality by the Revanth et al. (2020) study did not report genotoxic effects of mobile phone use. Despite the importance that Revanth et al. (2020) placed on the importance of using staining cells with DNA-specific stains to avoid mistakenly interpreting cells as having MN (false positives), they did not note that the seven studies reviewed provided evidence to support that concern. Studies that reported more MN in persons classified as having higher exposures to RF fields used non-specific stains (three of four studies) whereas none of the three studies that used stains specific to DNA reported increases in MN among persons with higher RF exposures. In short, the ratings of the papers were based on unclear and superficial criteria which as applied by the reviewers were inconsistent and do not support their conclusion. The four studies that were reviewed by Revanth et al. (2020) that were published after 2014 were reviewed above (Gandhi et al., 2015; Banerjee et al., 2016; de Oliveira et al., 2017; Vanishree et al., 2018).

The studies reviewed here, published after 2014, included five biomarker studies that assessed damage to DNA by the comet assay, six that assessed damage to DNA by the MN assay, including one that used the comet assay and the MN assay and one that used the 8-OHdG assay. One study used the SCSA assay. The reported differences between the levels of these markers and estimates of RF exposure in nine studies were based solely on self-reported mobile phone use. Three other studies described exposure based upon distance from mobile phone base stations, which also included mobile phone use (two studies) and measurements of RF power density at residences (two studies).

All these methods for categorizing subjects by estimated exposure were crude and likely subject to considerable bias. Furthermore, only 3 of the 12 studies reviewed reported that the analyses of the data were performed in a fully blinded fashion. While all studies attempted to some extent to minimize confounding by other exposures, these measures applied were not consistent across studies and appeared not to have been successful. None of the laboratories that performed the sample analyses appeared to have demonstrated expertise, nor the historical database necessary to carry out these complex tests, and none of the data reported in these studies met the criteria required to confirm a clear positive response (OECD, 2015). Also, these cross-sectional studies provided little opportunity to explore dose-response relationships except for three studies that used distance as a surrogate for exposure, which is correlated with measured exposures. All these limitations, in combination with the cross-sectional design of the studies, means that the results of these studies cannot be interpreted as showing a causal relationship between effects of exposure to RF fields on surrogate biomarkers and cancer development.[26]

Cancer assessment of animals after chronic radiofrequency exposure

U.S. National Toxicology Program

In 2000, the NTP began designing and planning a study of rats and mice to be exposed to RF fields simulating those of mobile phones, with signal modulations characteristic of 2G mobile phones (i.e., GSM) and 3G mobile phones (i.e., CDMA). The results were summarized in draft technical reports published for review in March 2018, with separate reports for rats (NTP, 2018a) and mice (NTP, 2018b).

Pilot studies of exposures for 5 days provided strong evidence confirming that exposure of rats to RF fields at 900 MHz and mice to RF fields at 1,900 MHz increased subcutaneous body temperature above 1 degree Celsius (°C) in both rats and mice at exposure levels above SAR

[26] This is consistent with a consensus comment that *"the use of biomarkers for early effects depends on the existence of knowledge about the significance of the event as a predictor of subsequent risk of cancer for humans. In the absence of this knowledge, it is still uncertain whether measurements, in humans, of some biological event known to presage cancer in an experimental system can be taken to add to the evidence from experimental systems alone"* (IARC, 1992, p. 30).

levels of 4 W/kg and 6 W/kg, respectively. In a second 28-day study, groups of pregnant female rats and groups of adult male and non-pregnant female rats and mice were exposed to GSM or CDMA RF fields. The subcutaneous body temperatures of pregnant female rats were significantly increased at exposure to CDMA RF fields at 6 W/kg, and exposure of male mice to GSM RF fields at 5 W/kg and higher significantly increased body temperature.

The main NTP experiments involved exposure of rats and mice to RF fields for 2 years, almost their entire expected lifetime. In the rat study, the subjects were exposed to GSM or CDMA RF fields (1.5 W/kg, 3 W/kg, or 6 W/kg) beginning prior to birth to the end of life. As in the shorter-term studies, significant reductions in body weight gains of pregnant female rats as well as their male and female pups were dose-related with exposure to GSM RF fields. Significantly increased survival over the 2-year period of male rats exposed to GSM RF fields was reported at all SAR levels in a dose-related fashion; the survival of male rats exposed to CDMA RF fields at 1.5 W/kg and 3 W/kg was also increased. Similarly, survival of female rats increased with exposure to CDMA RF fields at 6 W/kg.

The examination of multiple organs in rats at the end of the study showed a trend of increasing malignant schwannomas of the heart with GSM and CDMA SAR levels in male rats, but the incidence was only elevated above historical controls at 6 W/kg in males exposed to CDMA RF fields. An increase in the incidence of brain glial tumors was not reported at any exposure levels in male rats exposed to either GSM or CDMA RF fields, but a weak trend was noted with exposure to CDMA RF fields. In female rats, the NTP labeled this evidence as "*equivocal*," despite no reported statistically significant increases in the incidence of schwannomas in the heart or tumors in the brain, or a dose-response trend with RF field exposure.

Mice were similarly exposed to GSM or CDMA RF fields (2.5 W/kg, 5 W/kg, or 10 W/kg) for part of their lifetime; these exposures began in adulthood. The survival of male mice exposed to GSM RF fields at 5 W/kg and CDMA RF fields at 2.5 W/kg was higher than that of unexposed control mice. Unlike rats, no increase in the incidence of tumors of the heart or brain was reported in any RF-exposed group of mice. Examination at the end of the study showed a higher incidence of malignant lymphoma in female mice exposed to GSM RF fields at 2.5 W/kg and 5 W/kg and to CDMA RF fields at 2.5 W/kg; however, these incidences were not considered increased at the highest exposure levels (10 W/kg), leading researchers to classify these findings as equivocal. Changes in the incidence of liver cancer were reported for male mice (a decrease in carcinomas at 2.5 W/kg and an increase of hepatoblastoma at 5 W/kg). All tumor rates in mice were within the range of historical rates of control reported in other NTP studies.

Overall, the results of the NTP studies indicate that RF field exposure to levels that cause heating of the body[27] can have acute adverse effects, and that lifelong exposure at slightly lower levels also may increase survival with increasing SAR exposure. With regard to cancer, increased incidence of malignant tumors in the hearts of GSM- and CDMA-exposed males above those reported in unexposed controls and historical controls provide, as the report states, "*clear evidence of carcinogenic activity*" as a positive finding for male rats. For female rats the evidence was rated "*equivocal.*" The report states that data evaluated for both male and female mice only provided "*equivocal evidence of carcinogenicity*" with GSM and CDMA RF field exposure. The level of evidence rated "*equivocal,*" was categorized as "*uncertain findings*."

Although the statistical testing for some measures such as body weight was adjusted for multiple comparisons, these data deserve additional scrutiny because other measures like tumor incidence were not. Given the thousands of pair-wise and trend comparisons made in these reports between exposed and control rats and mice, one must assume that a substantial fraction of the statistically significant differences reported could have been false positive findings (i.e., occurred by chance alone). Further, the SAR level that is considered the threshold above which adverse effects of whole-body exposure to RF fields may be expected is 4 W/kg in rats, non-human primates, and humans (D'Andrea, 1999). This has led federal agencies in Canada, the United States, and Europe to set the standard for whole-body exposure of the general public to be 50-fold lower, at 0.08 W/kg (FCC, 1997; Health Canada, 2015; ICNIRP, 2020a). Most effects reported in the NTP study occurred at levels of RF fields above the accepted threshold

[27] Tissue heating is a well-established effect of RF exposure at sufficiently high levels. Scientifically-established RF exposure limits, however, are set well below levels at which adverse heating of the tissue or body may occur. Thus, the study findings of the NTP study are, in general, not informative with respect to potential effects of low-level RF field exposure from everyday sources, including smart meters.

for thermal effects, which is a strong indication that chronic thermal input is a likely mechanism for effects related to RF exposure.

Following review by an outside *ad hoc* peer-review panel conducted in March 2018, the NTP released its final reports in November 2018 (NTP, 2018c, 2018d). In the final reports, even though the actual study results remained unchanged, some of the conclusions drawn based on these data were revised or upgraded. For example, the final report indicates *"clear evidence"* that exposure to RF fields with GSM and CDMA modulation was associated with development of schwannoma in the hearts of male rats, and *"some evidence"* for tumors in the brain (GSM and CDMA) and adrenal glands of male rats (GSM). The evidence for GSM- and CDMA-modulated carcinogenic effects was rated *"equivocal"* in female rats. Even though the maximum exposures of mice to RF fields were 67% higher than for rats, the evidence for any effects altogether was weaker for mice. In its assessment of the NTP study, ICNIRP (2019, 2020b) expressed concerns about the absence of a blind review of the pathology, and the interpretation of statistical significance given the thousands of statistical comparisons made. The substantially lower survival of the male control rats (28%) compared to all GSM RF-exposed males (50% to 68%) and CDMA RF-exposed males (48% to 62%) in the two highest exposure groups, suggests the "*strong possibility that the decrease in survival resulted in underrepresentation of late-developing tumors in the controls that importantly affected the statistical results*" (p. 530).

An important analysis and review of data in the NTP study was recently published by five scientists at the Federal Office for Radiation Protection in Germany (Kuhne et al., 2020). They show that the temperature increases in heavier male rats imposed by the higher RF field exposure in the NTP study were much greater than it appeared ("*likely exceeded 1.4 °C for more than 300 days*") leading to stress on the heart that would explain cardiomyopathy and malignant tumors of the nerve sheaths in the heart (schwannomas).

Ramazzini Institute

A recent study conducted at the Ramazzini Institute in Italy exposed rats to 1,800 MHz GSM RF fields for 19 hours per day from gestational day 12 (in utero) until the end of life at calculated SAR levels of 0.001 W/kg, 0.03 W/kg, or 0.1 W/kg. A partial summary of the results was selected by the authors for publication (Falcioni et al., 2018). The exposures were planned to simulate RF field exposures in the environment from a fixed mobile phone base station, not a mobile phone. The rats were exposed in cages with 5 rats per cage, with a minimum of approximately 200 rats per sex per group. Body temperature was not measured.

The investigators did not report that they had randomly assigned the rats to the control and treatment conditions, which is a major flaw in the design of the experiment (Hooijmans et al., 2014). No effects on food or water intake, body weight, or survival in male or female rats were reported. The investigators reported 120 additional statistical calculations to describe the potential differences between groups of rats exposed or not exposed to RF fields on numerous measures. Using a criterion of $p < 0.05$, one would expect about six statistically significant differences to be reported just by chance alone in the two tables of data presented, but from all the calculations, only one single table entry indicated a statistically significant difference. In male rats at the highest exposure of 50 volts per meter (said to correspond to an SAR of 0.1 W/kg), 1.4% were diagnosed with a schwannoma in the heart, whereas no rats were diagnosed with this tumor among the control rats. No other differences in the entire report were statistically significant.

If these calculations had been even partially corrected for multiple comparisons, as had been done in some of the analyses in the NTP study, there would be no statistical differences at all between the groups exposed to RF fields and the control group. Moreover, the claim of the investigators that the large number of rats in each group makes it a better study than that of the NTP study is undercut because the rats were exposed in cages with five rats in each. Therefore, the cage, and not the individual rat, should have been considered the experimental unit for analysis, and the sample size for all the analyses should have been divided by five for the calculations of statistical significance. Still other shortcomings of the statistical analysis have led some to fault the Falcioni et al. (2018) report and call for "*a major revision of their conclusion*" (Sara et al., 2020). The response of the authors to this criticism was that the study nominally complied with OECD (2012) guidelines and addressed the lack of transparency about the statistical analysis by stating that additional data "*will be published in the forthcoming publication*" (Belpoggi et al., 2021). While Belpoggi et al. (2021) responded primarily to issues of form, their response did not mitigate the potentially more serious statistical limitations to the results of the Falcioni et al. (2018) report.

The EPA has criticized the Ramazzini Institute's assessments of histological data and has "*decided not to rely on RI [Ramazzini Institute] data on lymphomas and leukemias in IRIS [Integrated Risk Information System] assessments*" (USEPA, 2013). Further, they have warned risk assessors about problems with the cancer bioassays conducted by the Ramazzini Institute, including the accuracy of the cancer diagnoses; the categorization of tumors; errors in identifying cellular changes such as leukemia/lymphoma in certain tissues that appear to be due to infections and tissue inflammation; an unexplained significant rise in the incidence of leukemia/lymphomas over time in control groups unrelated to the exposure under study; the lack of complete reporting and documentation of analytical specifications; failure to control or analyze for potential litter effects; and the use of common controls for multiple studies (Gift et al., 2013). These concerns all pose additional reasons to be cautious regarding the Ramazzini Institute study data.

In May 2020, ICNIRP published a brief summary and evaluation of the NTP and Ramazzini Institute studies (ICNIRP, 2020b). Overall, ICNIRP concluded:

> *Although NTP … [2018c] and Falcioni et al. (2018) both reported significantly elevated rates of carcinogenic outcomes in male rats, their results are not consistent with each other, nor with the NTP (2018b) mouse or female rat results, nor with the RF cancer literature generally (SCENIHR 2015; HCN 2016; SSM 2018). The NTP's outlying finding is further complicated by important methodological limitations, including the effect of the greater lifespans of the exposed rats on the statistical analyses, lack of blinding in the pathological analyses, and a failure to account sufficiently for chance in the statistical analyses. Collectively these two studies' limitations preclude drawing conclusions about carcinogenicity in relation to RF EMFs* (pp. 530-531).

A scientist involved in the NTP study before he retired replied to criticisms of the study from ICNIRP (2019, 2020b) and others (Melnick, 2019, 2020). While Melnick argued for his view, ICNIRP's response to Melnick was factual (ICNIRP, 2020c) and provides justification for current plans for the NTP[28] as well as Japan and Korea, to attempt to replicate and improve upon the NTP study.

In a statement issued in November 2018 on the NTP studies, the Director of the FDA's Center for Devices and Radiological Health opined that the findings of the NTP studies "*should not be applied to human cell phone usage*." The FDA further concluded that "*[b]ased on our ongoing evaluation of this issue, the totality of the available scientific evidence continues to not support adverse health effects in humans caused by exposures at or under the current radiofrequency energy exposure limits. We believe the existing safety limits for cell phones remain acceptable for protecting the public health*" (FDA, 2018).

A third commentary on these studies was offered in a newsletter by a group of scientists assembled by the Swiss Federal Office for the Environment (BERENIS, 2018). The limited commentary reported on selected aspects of these studies and pointed out that "*the results of the NTP study are mostly relevant for the exposure situation when using a mobile phone close to the body. In contrast, the Ramazzini study observed carcinogenicity at levels as high as the environmental exposure limits, with no statistically significant effect at lower doses*" (p. 7).

In their 2019 report, SSM reviewed the NTP studies. The SSM's conclusions were as follows:

> *Two studies on carcinogenesis have a number of positive aspects, including their size and the duration of the exposure and the attempts to provide a comprehensive analysis of the pathology. However, the results are inconsistent between the studies in terms of the exposure levels where increased tumour incidences are observed, and the main endpoint, schwannoma of the heart, is only a very rare tumour in humans and therefore, likely, the public health relevance is not very high. Moreover, it is a tumour that has never been reported in experimental RF cancer studies, so it is peculiar at the least that it now appears in two studies that were published at the same time, and that it shows up only in rats and not in mice. A discussion on the effects of heating at*

[28] https://ntp.niehs.nih.gov/whatwestudy/topics/cellphones/index.html Accessed April 13, 2021.

> *the high exposure level in male rats is missing. Altogether the Council does not feel that these studies can be considered as clear indications for carcinogenicity of RF fields in humans* (p. 56).

Another in-depth review of the NTP studies was performed by the German Federal Office for Radiation Protection (BfS, 2019). The scientists noted several methodological weaknesses and inconsistencies in the NTP study results that "*clearly limit the meaningfulness of the study*," including many of the same limitations that were noted by ICNIRP, FDA, and SSM above. The scientists of the Federal Office for Radiation Protection concluded that the NTP study findings did not support the designation of *clear evidence* or *some evidence for a carcinogenic effect* and that the animals' exposures were much higher than human exposure limits and thus not directly relevant to human exposure to RF fields from mobile phones:

> *… after careful analysis of the various results, [the Federal Office] sees indications but neither a clear nor some evidence for a carcinogenic effect at high whole-body exposures - which were clearly above the limit values …* (BfS, 2019, p. 1)

The evidence for the interpretation that thermoregulatory stress explains the response of male rats in the NTP study (NTP, 2018c) was further buttressed in a study published by five scientists in the Federal Office for Radiation Protection in Germany. Kuhne et al. (2020) provided detailed analyses of temperature measurements reported for male rats in the NTP study. These analyses showed that the rise in the body temperature of male rats was much greater than acknowledged in the NTP report and provided "*evidence that for most of the main 2-year study, the average SC body temperature fluctuation of male rats in the 6 W/kg exposure group was higher than reported in the pilot studies…*" (Kuhne et al., 2020, p. 475). This explains the higher incidence of cardiomyopathy and schwannoma in aged male rats, which have reduced thermoregulatory control because of heavier body weights and a lesser ability to dissipate heat by vasodilation of the tail.

Summary of chronic exposure animal studies

The newest animal studies of chronic exposure to RF fields do not alter the weight of evidence accumulated from previous research reviewed by scientific agencies indicating that RF fields at very low levels are not harmful. The NTP reports suggest potential adverse effects of short- and long-term exposure to RF fields at levels at or above historically-recognized thresholds for causing increases in body temperatures and adverse effects upon which exposure standards are based. Further, the results of the Ramazzini Institute study are consistent with there being no effect of RF fields at exposure levels that are about 100-fold lower than those of the NTP study, a finding consistent with prior research. In a health risk assessment based on a review of the literature that accompanied its latest standard, ICNIRP (2020a) concluded:

> *A few animal studies on the effect of radiofrequency EMF exposure on carcinogenesis have reported positive effects, but, in general, these studies either have shortcomings in methodology or dosimetry, or the results have not been verified in independent studies. Indeed, the great majority of studies have reported a lack of carcinogenic effects in a variety of animal models… Thus, when considered either in isolation (e.g., ICNIRP 2019) or within the context of other animal and human carcinogenicity research (HCN 2014, 2016), their [NTP and Ramazzini] findings do not provide evidence that radiofrequency EMFs are carcinogenic* (p. 152).

Cancer assessment of animals after short-term RF field exposure

Studies of short duration are commonly performed to determine if the development of an already established tumor type is increased following exposure to the agent under study. Two studies of this design were reviewed.

- **Lerchl et al. (2015)** attempted to replicate an earlier study from his laboratory (Tillmann et al., 2010) that reported effects of RF field exposure on the development of tumors initiated by the carcinogen ethylnitrosourea (ENU) because the interpretation of the results in the earlier study were clouded by an infection of *Helicobacter hepaticus* that affected the mice in the study.

From the offspring of the mothers, 4 groups of 96 mice were assembled; sham + ENU; 0.040 W/kg RF + ENU; 0.4 W/kg + ENU; and 2 W/kg + ENU. The mice were exposed for 23.5 hours per day for 72 weeks to 3G mobile phone Universal Mobile Telecommunications System (UMTS) 1,996 MHz RF fields. The characteristics of the signals were not included in the paper but were imputed for the analysis here from the previous study. The investigators performed histopathological analyses of the brain, kidney, spleen, liver, lymph nodes, and lungs that were confirmed in an independent review. Exposure to RF + ENU significantly increased tumors of the lungs (adenomas and carcinomas) and carcinomas in the liver, a result confirmed by Bayesian analysis of SAR exposures at 0.4 W/kg. The survival times were not affected by exposure to RF fields. These findings were similar to their previous study; however, in either study the incidence of tumors was not clearly proportional to exposure, and they were similar for exposures that varied by 50-fold. Although this study was reviewed SSM (2016), SSM did not point out that the mice were not randomly allocated to treatment groups, the sham groups were older than the other treatment groups, and the analysis was not blinded.

- **Ouadah et al. (2018)**, like in a number of previous studies, examined the effects of RF field exposure on the development of glioblastoma multiforme (GBM) tumors initiated in rats by injection into the brain. In this study, 30-day old male Wistar rats were injected with C6 tumor cells whose development into tumors mimics GBM in humans. Seven days after injection, the rats were randomly assigned to cage control or sham control (n=15), and the groups of rats were exposed to 0.25 W/kg (n=18) or 0.5 W/kg (n=39) 5 days per week for 45 minutes until death or sacrificed 30 days after injection. RF field exposure had no effect on tumor size, location, proportion of dividing cells (Ki67 protein marker), or vascularization (CD31 marker). The brains of rats injected with tumor cells and exposed to RF fields, however, had lower semi-quantitative ratings of immune cell invasion and CC3 immunoreactivity indicative of apoptosis (programmed cell death marker CC3). The stress of restraint of the rats in the sham group did not result in different outcomes from the cage control group. The study authors were careful to blind the investigators during each step of the experiment as to the groups to which the samples belonged to avoid any potential bias. While RF field exposure had no effect on tumor development, the clinical significance of a change in a marker for apoptosis is not known and the authors concluded that "*[f]urther replication studies are needed to confirm these observations*" (p. 539).

Summary of short-term cancer studies

SCENIHR (2015) concluded in its review of long- and short-term *in vivo* animal studies that "*[o]verall, because a considerable number of well-performed studies using a wide variety of animal models have been mostly negative in outcome, the animal studies are considered to provide strong evidence for the absence of an effect.*" (p. 86).

The results of the subsequent studies do not clearly complement any previous work by other investigators or break new ground as to potential effects of RF field exposure on the development of specific tumor types and are consistent with SCENIHR's earlier conclusion.

Studies of DNA and chromosome damage in animals

Although lifetime studies of animals exposed to physical or chemical agents are regarded as the gold standard for the assessment of potential effects of exposure on the development of cancer, health and scientific agencies also look to shorter-term *in vivo* studies of genetic (DNA and chromosome) effects to assess these as potential mechanisms for the initiation of tumors. Such studies are frequently undertaken to confirm indications of genetic or chromosomal damage reported from EMF exposure of isolated cells *in vitro*.

The most widely used and validated tests for the detection of DNA damage and mutation are performed on bacteria and yeast organisms. Overall, the absence of any "*signal*" from these tests is quite clear—RF fields are not mutagenic (IARC, 2013). Other tests with lesser validation have been applied to human and animal cells but many such *in vitro* studies have reported mixed results; the differences between exposed and control groups were often small, and as reported in two large meta-analyses of such studies (Vijayalaxmi and Prihoda, 2008; Vijayalaxmi and Prihoda, 2012), the variations were almost always within historically-reported levels measured in unexposed control cells. Based on this analysis, Vijayalaxmi (2016) laid out minimum criteria for the design and performance of cell, human, and animal studies. Further, in a comprehensive and updated meta-analysis of 225 *in vitro* studies published in 2017, the previously-reached conclusions were confirmed by Vijayalaxmi and Prihoda (2019). Their analyses demonstrated that 30% to 50% of the studies of RF exposure on indicators of genotoxic effects in mammalian cells failed to control any of four variables affecting overall study quality: blind analyses often were not included, adequate descriptions of exposure dosimetry were not provided, positive controls were not mentioned, and it was often not stated if unexposed cells were treated in exactly the same manner as exposed cells with the exception of RF field exposure. To this list of deficiencies, others have added the misinterpretation of statistics and the pre-specification of analyses (Foster et al., 2019). To overcome issues relating to the quality of the methods used to assess SSBs, Schuermann et al. (2020), in an attempt to replicate key studies from two universities, were unable to repeat effects of GSM 1,950 MHz at a SAR of 2 W/kg on measurements of SSBs in two human cell lines or to identify effects of UMTS, Wi-Fi or RF-identified modulated fields on DNA and DNA repair. Tests for DNA damage that might be expressed as an increase in sister chromatid exchange also were negative following exposure to a 4.9 W/kg UMTS-modulated signal. The authors thus concluded that "*[c]lassical and advanced genotoxicity testing and DNA repair assessment produce no conclusive evidence for a disturbance of DNA integrity or changes in the DNA repair capacity, following wEMF (modulated electromagnetic field) exposure*" (p 14). Despite the high sensitivity of new methods of detecting damage to DNA, there are recognized problems regarding the variability in the results of the comet assay; for example, differences between replicate samples analyzed within and between laboratories, and in the interpretation of comet assays has impeded its acceptance as a reliable tool (Langie et al., 2015; Forchhammer et al., 2012).

To uncover the reasons for the inconsistency in the reported *in vitro* genotoxicity studies of exposure to RF fields, a protocol has been published by European agencies for a systematic review of this research according to guidelines recommended by the NTP Office of Health Assessment and Translation (Romeo et al., 2021).

Despite the absence of convincing evidence for effects of RF fields on the DNA or chromosomes of human and animal cells *in vitro*, other *in vivo* experimental studies of animals exposed to RF fields have looked for alterations in the double-strand DNA structure of single cells as measured by the alkaline comet assay and fragmentation of chromosomes containing DNA by the detection of MN within blood cells. Another assay used in some studies as a surrogate indicator of DNA damage measures the conversion of deoxyguanosine in DNA to 8-OHdG, which is a major product of oxidative damage. Although measurements of other aspects of cell function often related to oxidant and antioxidant indicators are typically reported in such studies, they were not the focus of this assessment.

- **Furtado-Filo et al. (2014)** reported that 12 pregnant rats were exposed for 0.5 hours per day to 950 MHz RF fields at SAR levels of 0.03 to 0.01 W/kg during gestation. After delivery, the pups were allocated to a sham group and exposure continued for 0.5 hours daily for 0, 6, 15, and 30 days at which time six rats from each exposure group were decapitated and the livers removed for analyses of DNA damage (comet assay), fatty acid content, lipid peroxidation, catalase, and protein oxidation. The SAR exposures were: neonates, 0.88 W/kg; 6-day-old rats, 0.51 W/kg; 15-day-old rats, 0.18 W/kg; and 30-day-old rats, 0.06 W/kg. They reported that damage to DNA in exposed rats, as measured by the alkaline comet assay, was the same as in controls at birth or 6 days later, but was less at 15 days and greater at 30 days of age (both $p < 0.05$). The control rats were sham-exposed and the exposures varied from 0.51 to 0.88 W/kg at 0 and 6 days after birth, respectively, and declined to 0.18 W/kg at 15 days and 0.06 W/kg at 30 days due to the increase in body mass with age. Only 100 cells from each tissue were analyzed, but results were averaged with those of a duplicate slide. The authors regarded these results as "*very peculia*r" and speculated that the results reflected age differences in sensitivity, a decline in repair capacity at 30 days of age or "*artifact of the technique.*" The control rats were sham-exposed, but the authors did not report that the rats were randomly allocated to treatment groups or that precautions were taken to minimize bias (e.g., by coding the samples so that the investigators performing the analysis were blinded as to source or history of the samples).

- **Furtado-Filo et al. (2015)** was similar in design to the previous Furtado-Filo et al. (2014) study, except that the exposure of the six rats in each groups ended at birth or 6 days thereafter and the analysis was limited to the right and left hemispheres of the brain. The SAR exposures were calculated to range from 0.44 W/kg during gestation to 0.35 W/kg on day 6 after birth. The SAR values above that appear in the paper are less than the range described in the paper's abstract (1.14 to 1.32 W/kg). Exposure of the sham-control rats was reported at far lower levels, ~ 2 x 10^{-5} W/kg. The authors report that they found no statistical difference between the levels of SSBs in the brains of the exposed and sham-control rats as measured by the alkaline comet assay. Only 100 cells from each tissue were analyzed, but results were averaged with those of a duplicate slide.

- **Deshmukh et al. (2015)** exposed male Fischer-344 rats (150 to 200 grams [g]) in groups of six to RF fields at 900, 1800, 2450 MHz, or control conditions for 180 days at the same SAR level of 0.00006 W/kg. The investigators assessed the brain tissue concentration of heat shock protein (hsp70) and amount of DNA damage, as measured using the comet assay. While the methods for exposing the rats to RF fields in a transverse electromagnetic (TEM) cell are well-known, the rats were exposed in groups while restrained, which can result in stress and DNA damage (Consiglio et al., 2010). The body temperature of the rats was measured before and after exposure to RF fields. Behavioral tests also were performed but are not relevant and therefore not discussed further. While the samples from the exposed groups and the sham control group were coded and assessed in a blinded fashion to prevent bias, the animals were not randomly assigned to these treatment groups to prevent systematic bias related to body size or housing history. No change in body temperature was reported (data not shown), but statistically significant increases in hsp70 and DNA damage were reported. The differences between the groups for four computed indices of SSBs (Olive tail moment, tail moment, percent of DNA in head, and tail length) were larger with groups exposed to 1,800 MHz and 2,400 MHz, roughly 25% greater than those reported at 900 MHz.

  The interpretation of these data is clouded because the investigators did not express these measures in units that account for the amount of tissue contained in each sample, such as per gram of tissue or per milligram of protein. Any variation in the size of the brain tissue analyzed between animals would appear as a difference in the concentration in the extract, even if the concentrations of hsp70 or DNA in the living tissue were the same. The differences between hsp70 values across all groups were very small, and the effective size of the groups is n=1 because of group exposures, so the result is null and the statistical differences between the groups is overstated. The differences between the groups for four indices of DNA damage were larger, with groups exposed to 1,800 MHz and 2,400 MHz roughly 25% greater than reported at 900 MHz. These results are virtually the same as the results these investigators published in other studies in which rats were exposed for 30 days (Deshmukh et al., 2013), 60 days (Megha et al., 2015), and 90 days (Deshmukh et al., 2016). In fact, the results appear to be exactly the same in some respects. For example, the percent tail DNA in the hippocampus for sham exposed, and those exposed to 1,800 MHz and 2,450 MHz in a 180-day experiment (Figure 5A in Deshmukh et al. [2015]) differed by less than 2.7% from the values reported for a 30-day experiment (Figure 2 in Deshmukh et al. [2013]). Similarly, the difference between each of the four groups in the 30-day experiment differed from those in a 60-day experiment by less than 2.2%. Given the small number of animals in each group, the inherent variability of samples over time, and some expected error in measurement of values across the published papers, the close similarity of values from different experiments is not credible. The authors reported "*[i]mages from 100 cells (50 from each replicate slide) were analyzed*" (p. 286).

- **Zong et al. (2015)**, in previous research, reported that exposure of mice to 900 MHz RF fields at SAR levels of 5.48 mW/kg, 54.8 mW/kg, and 548 mW/kg provided protection against subsequent sub-lethal or lethal ionizing gamma radiation (Cao et al., 2010, 2011; Jiang et al., 2012, 2013), an effect replicated by other investigators. In the most recent study (Zong et al., 2015), male ICR mice (25 g) were individually exposed to 900 MHz RF fields at a SAR of 0.0548 W/kg in a TEM cell for 1 hour per day for 7 days. Blood samples from each group of eight mice were analyzed for SSBs using the alkaline comet assay. Mice exposed to RF fields did not produce higher levels of SSBs as measured by tail moment or tail length compared to sham-exposed controls.

  Four hours later, other groups of mice were injected with bleomycin (BLM), a chemical known to damage DNA, some of which were sham-exposed (sham + BLM) or RF-exposed (RF + BLM). Starting 20 minutes after injection, one mouse from each group was removed at 30-minute intervals to see how exposure to RF fields affected DNA repair in white blood cells due to BLM treatment. Following injection of BLM, all mice showed increased SSBs, but the mice previously exposed to RF + BLM showed significantly lower SSB levels ($p<0.0001$) than mice injected with the BLM alone or sham + BLM, showing that exposure to RF fields prior to chemically-induced DNA damage speeded up repair of damaged DNA.

Measurements of other indices of oxidative damage in the blood, liver, and lungs of control, sham, and RF-exposed groups did not differ. In groups treated with BLM, pre-exposure to RF fields produced significant reductions in the oxidative damage marker malondialdehyde (MDA) in the liver, while the lungs exhibited a significant increase in the concentration of superoxide dismutase, an anti-oxidative enzyme. These data demonstrate that RF fields did not cause DNA damage or increase oxidative stress but accelerated the repair of DNA damage by BLM in the liver and lung. The investigators randomized mice to the treatment groups and conducted all analyses blind. The inclusion of BLM in this study qualifies as a "*positive*" control to demonstrate that the assay was capable of detecting SSBs. The authors reported "*[f]or each animal and for each exposure, 50 comets were analyzed for comet tail length (microns) and tail moment (ratio)*" (p. 272).

- **Sahin et al. (2016)** measured an indicator of DNA damage (8-OHdG) and an indicator of lipid peroxidation (MDA) in the brains of female rats exposed in groups of 9 to 2.1 GHz RF fields at a calculated SAR level of 0.4 W/kg for 6 hours per day (5 days per week) for 10 and 40 days. Identical measurements were made of brain tissue from groups of six female rats placed in the exposure apparatus without exposure to RF fields (sham control) for these same periods. Compared to the sham-exposed groups, the authors reported a statistically significant increase in DNA damage of the exposed rats after 10 days, but a statistically significant reduction in DNA damage after 40 days of exposure. No sense can be made of these data, however, because the amount of DNA damage observed in the control groups was so discrepant: the average DNA damage in the 40-day control group was 150% greater than in the 10-day control group, and similar to the levels observed in the 10-day RF-exposed group. MDA levels were higher in brains of the 40-day control rats than in the brains of RF-exposed rats. No differences in the MDA levels of exposed and control rats were seen in the 10-day exposure groups. The differences between control groups kept under similar conditions indicate that factors unrelated to RF field exposure confounded the results. In addition, since the rats were exposed in groups, they shared a common experience and thus their data were not independent, as required by the statistical method applied. Although the rats were properly allocated to the treatment by a randomized procedure, the investigators were not reported to be blinded as to the identity of the specimens during the analysis of the results.

- **Akdag et al. (2016)** compared the average level of SSBs (via comet assay) in the brain, kidney, liver, testes, and skin of male albino rats exposed for 12 months to 2.4 GHz RF fields at average SAR (0.0001414 W/kg) and maximum SAR (0.007127 W/kg) levels to a sham-exposed control group. Eight rats were assigned to each group and the rats were exposed in these groups without restriction on their movement. No statistically significant differences between these groups were reported, with the exception of in the testes, where an increase of approximately 20% was reported. The exposure system was better described than in most studies and evaluated by both measurements and calculations. The interpretation of the study is limited, however, because the rats were not randomly assigned to groups, no information regarding the health status and development of the animals was provided, and the analysis of the data was not blinded. In addition, the statistical assumptions of the Mann-Whitney test for differences between groups were not fulfilled because the rats assigned to each group were not randomly allocated and the exposures and housing of the groups violated the assumption that the results obtained from each rat were independent of those obtained from others in each group. Only 50 randomly selected cells from each tissue were selected for DNA analysis.

- **Güler et al. (2016)** examined the brain tissues of male and female rabbits randomly allocated to four groups each containing nine rabbits per sex. Group I served as a sham-control group; the other groups were exposed to simulated 1,800 MHz GSM signals at an estimated SAR of 0.018 W/kg either beginning 1 month after birth (Group II), for a 7-day period in gestation (Group III) or both. However, exactly how exposures were done is unclear. Specifically, it is reported that the rabbits were exposed for 15 minutes per day for 7 days (females) or for 14 days (males); this suggests that the females could not have been exposed in both periods. Further, the duration of extrauterine exposure after 1 month was not stated. At the end of the exposures, measurements in the brain were made of oxidative DNA damage via the TUNEL method, 8-OHdG (a DNA damage marker), and MDA (a marker of lipid oxidation); visual histological examination of the brain tissue was also done. No differences between males and females were reported for 8-OHdG or MDA. Despite the description of the results provided by the authors to the contrary, the levels of 8-OHdG also were almost identical for all four exposure groups. Semi-quantitative ratings of cellular changes were virtually nil in Groups I and II; more mild and moderate changes, most consistently described as gliosis, were reported in Group III and IV. Staining of cells in TUNEL treatments did not show that apoptotic degenerating cells were present. Although the TUNEL analysis was reported to have been done in a blinded fashion, it was not clear whether the other analyses were performed on coded samples.

- **Jeong et al. (2018)** studied the brains of young and aged C57BL/6 female mice for changes in biochemical indicators of the aging process, including markers of oxidative damage to lipids and proteins, damage to DNA, cell-initiated death (apoptosis), and neuroinflammation. Aged mice (12 per group) were randomly assigned to either sham-exposure or 1,950 MHz RF fields at an SAR of 5 W/kg for 2 hours per day, 5 days per week for 8 weeks (from age 14 to 22 months). The exposures took place in a reverberation chamber specially designed to produce uniform, reproducible exposures (Lee et al., 2012). Another group of unexposed 3-month old mice were included as young controls. The analyses were performed blind. The investigators reported that 16 of the 19 markers of aging were statistically greater in the aged mice than in young control mice, sometimes up to 10 times greater. When the brains of aged rats exposed to RF fields or sham conditions were compared, however, no statistically significant differences between these groups were observed, including quantification of protein expression of 8-OHdG, a marker of DNA damage in histological sections of the brain. The total number of cells examined and the number of cells staining for 8-OHdG were not specified.

- **Jonwal et al. (2018)** divided 16 male Swiss mice into 2 groups—8 mice exposed to 2.45 GHz RF fields with a calculated power density of 0.25 mW/cm^2 and an estimated SAR exposure of 0.09 W/kg; and 8 mice placed in a similar chamber without exposure (sham control). Two mice were placed in each chamber for 2 hours each day for 30 consecutive days. The ratio of polychromatic erythrocytes to normochromatic erythrocytes in the blood was measured at the end of the 30-day period. Although a lowering of this ratio is sometimes considered as a marker for MN, this is an overinterpretation and only can be considered as an indicator of differences in the maturation of red blood cells (Vijayalaxmi and Prihoda, 2019). Other evaluations were conducted of serum testosterone levels and oxidative stress markers in the testes (reactive oxygen species; MDA; and related enzymes glutathione peroxidase, superoxide dismutase, and catalase); testis histopathology was also examined. The exposed group showed more MN than the control group ($p<0.001$), which was suggested to be consistent with markers of histological and oxidative damage indicators in the testes. The authors did not report how the mice were allocated to the treatment groups, whether the mice were exposed in groups, or if blinded procedures were used to prevent bias in the analyses of the data. The number of cells upon which the results reported as ratios obtained by flow cytometry analyses was not specified, but the numbers would be expected to be thousands of cells.

- **Alkis et al. (2019a**) assessed the potential linkage between measures of DNA damage and multiple indicators of oxidation processes. Male Sprague-Dawley rats (n=7 per group) were randomly assigned to sham, 900 MHz, 1,800 MHz, and 2,100 MHz RF exposures at intensities between of 0.638, 0.166, and 0.174 W/kg, respectively; these exposures occurred in a plastic carousel chamber for 2 hours per day for 6 months. The authors reported an increase in SSBs in the brains of the rats exposed to 2,100 MHz RF fields, as measured by comet tail intensity, but no increase in SSBs as measured by tail moment in any other group exposed to different frequencies of RF fields. In contrast, statistically significant increases in the levels of 8-OHdG, another indicator of DNA damage, were reported with exposure to all three RF field levels. The levels of five other indicators of oxidative stress generally increased in a manner similar to that of 8-

OHdG. The authors did not explain the discordance between the measurements of DNA damage using different metrics, and the magnitude of the effects were inversely related to the intensity of exposure as measured by SAR. A number of the experimental procedures were not described, including whether the rats were continuously housed in the exposure chamber or were only maintained in there during the 2 hours of exposure. The analysis of the data was not reported to have been blinded as to the exposure status of the sample. The authors analyzed 100 cells for DNA and 1 test for 8-OHdG from the brain.

- **Alkis et al. (2019b)** performed a study similar in design to the previous study (Alkis et al., 2019a), except in this study, the investigators made measurements on the testes of rats following exposures that were the same as in the previous study: RF fields at frequencies of 900, 1,800 MHz, and 2,100 MHz, and SAR levels of 0.638, 0.166, and 0.174, respectively. The sham and RF field exposures were applied to rats for 2 hours per day for 6 months. Tissue samples were processed and 100 nuclei randomly selected from each tissue sample were analyzed for SSBs by the comet assay and for 8-OHdG for oxidative damage. Measurements of tail intensity were statistically higher in the groups exposed to 1,800 MHz and 2,100 MHz, but not 900 MHz. The exposed groups showed no significant differences from the sham-control group for SSBs measured by tail moment. The levels of 8-OHdG in the exposed groups were significantly greater than that of the control. The levels increased with frequency, but were inversely related to the calculated SAR levels. No measures to prevent bias in the handling and analysis of samples were described.

- **Houston et al. (2019)** reported on multiple aspects of the testis and sperm of male mice exposed to 905 MHz at 2.2 W/kg SAR for 12 hours per day for 1, 3, or 5 weeks. No gross histologic changes were seen in the control or exposed groups; nor did the testis from these groups exhibit cells with damaged double-stranded DNA (as stained by anti-γH2AX antibody).

  In contrast, sperm showed small increases in fragmented DNA (halo assay) that became statistically significant only in the group exposed for 5 weeks. Increases in 8-OH-dG oxidative damage in weeks 1, 3, and 5, and SSB in the comet assay also were reported. The OECD (2015), however, states that the comet assay for SSBs is "*not considered appropriate to measure DNA strand breaks in mature germ cells (i.e., sperm)*" (p. 16).

Despite the findings above, the investigators reported that assessments of sperm health and *in vitro* fertilization of eggs did not reveal any impairment of the fertilization process.

The authors noted that, in contrast to some previous reports, they observed no structural disorganization within the testis and that an earlier study had reported no harm to fertility with life-long exposure over four generations of mice. The authors appropriately minimized systematic error by randomly assigning mice to the exposure groups and used hydrogen peroxide as a positive control to assure the proper detection of an agent known to damage DNA in the comet assay. However, for some of the results discussed above, the observations were made on as few as three mice and up to five mice, and no sample coding procedures were described to minimize potential bias in the analysis. Additionally, during exposure, two rats were exposed together, so the results should have been aggregated together for the statistical analyses.

- **Lerchl et al. (2020)** followed up on a hypothesis arising from their 2015 study (discussed above) that exposure to RF fields might promote the development of tumors initiated by a chemical carcinogen. In this study, three groups of pregnant female mice were exposed in individual cages to 0 (sham control), 0.04 W/kg, or 0.4 W/kg SAR at 1,960 MHz RF fields for 24 hours per day beginning on day 7 post-conception. On day 14 post-conception, the pregnant mice were injected with the chemical carcinogen ENU, and at 24, 36, and 72 hours later, the fetuses were removed and the tissues stained to reveal DNA damage. The fluorescence of DNA adducts was measured in 10 cells per slide of brain, liver, and lung tissue, and many slides were reviewed so that about 84,000 cells in the entire study were evaluated. The authors concluded that "*RF-EMF exposure does not trigger increased DNA damage in the fetal brain, lung, and liver*" above the damage caused by ENU. Although the overall results show no deviations attributable to RF field exposure (either additive or multiplicative effects), the statistical analysis should have considered that the number of experimental units is not the number of fetuses, but the number of pregnant mothers (n=3) that contributed fetuses to each experimental group (Lazic, 2010). The statistical error that arises by exposing rats in groups, however, was avoided by exposing each pregnant rat individually.

- **Sharma and Shukla (2020)** cited studies of RF fields on some behavioral and cognitive processes in protozoa and earthworms as the basis to study such processes in rats. In this experiment, groups of rats were exposed to 900 MHz RF fields at SAR intensity of 0.231 W/kg calculated at the brain for 1, 2, or 4 hours each day for 90 days, and their behavior and biochemistry was compared to sham-controls. After completion of the behavioral studies, the brain was assayed for multiple indicators of oxidative stress, glutathione metabolism, and the activity of an enzyme that regulates levels of acetylcholine, a neurotransmitter. A histological examination of the hippocampus of the brain was supplemented by measurement of DNA damage via the comet assay. The length of the comets on 50 cells was measured. Unlike some other studies reviewed, the tail length, tail momement, and percent of cells detected as comets were all extraordinarily similar across the different durations of daily exposure (1 to 4 hours) and increased above that observed in sham controls in a monotonic fashion. Results presented for the other biochemical measurements made in the study showed a similar appearance. Although the rats were randomly allocated to the experimental groups (n=6/group), they were confined together in groups of four during exposure. Additionally, the investigators did not indicate if the rats were restrained in the experimental chambers for 90 days or were returned to home cages after each period of exposure. From the limited description of the experimental procedure, it appeared that the six rats assigned to the sham-control group did not have the same test experience as the rats in the exposed groups. This may have meant that only two sham control rats were matched to six exposed rats at each period of exposure duration. The 50 cells examined is far fewer than the 150 cells the OECD recommends to be analyzed per sample. Finally, the investigators did not describe any procedures to prevent inadvertent bias by coding the animals and tissues to hide their group identity.

- **Smith-Roe et al. (2020)** reported on the results of a secondary study to the NTP mobile phone project described above in which rats were exposed according to the same parameters as in the main studies, but instead of continuing for 2 years, the animals were euthanized at 19 weeks (rats) and 14 weeks (mice). The results were also reported in final technical reports from NTP (NTP, 2018c, 2018d). Samples from three brain regions, the liver, and blood were analyzed for SSB damage; the blood also was analyzed for MN. Each group consisted of five rats or five mice of each sex. The same sham exposure group was used for both GSM and CDMA exposures. The authors stated that "*the only clear positive result [for SSBs] was observed in the hippocampus cells of male rats exposed to the CDMA modulation when evaluated using the 100-cell scoring approach*" (p. 7); however, that result was not confirmed when 150 cells per sample were evaluated. Equivocal results were reported for the frontal cortex of the same rats. No increase in SSB levels was observed in the cerebellum of the brain or in the liver of male rats and no increase in SSBs was seen in any tissue evaluated in female rats exposed to GSM RF fields.

  Statistically significant increases in SSBs were reported to occur in the hippocampus and frontal cortex of male mice in both the GSM and CDMA groups and in the white blood cells of female mice (CDMA only). Effects of CDMA exposure on the liver of female mice did not meet the criteria for statistical significance. No effects of GSM exposures were reported in any tissues of female mice. The results described above were based on analyses of 150 cells per sample. A comparison of the results of analyses of 100- and 150-cell samples revealed variability, but this appeared to be explained by the inclusion of other aspects of DNA damage, not just SSBs. For some tissues, considerable inter-animal variability was observed that "*exceeded 30% in some cases*," but this variability was much less in samples from white blood cells. No clear or large effects of exposure were reported for MN in either rats or mice.[29] An important aspect not discussed in this

[29] *"To maintain the overall significance level at 0.05, the trend as well as the pairwise differences from the sham control group were declared statistically significant if P<0.025. A result was considered positive if the trend test was significant and if at least one exposed group was significantly elevated over the sham control group, or if two or more exposed groups were significantly increased over the corresponding sham control group. A response was considered equivocal if only the trend test was significant or if only a single exposed group was significantly increased over the sham control"* (NTP, 2019c, p. 250; NTP, 2019d, p. 162).

report was that the few increases in SSBs reported in male rats only occurred at the highest SAR level, 6 W/kg CDMA, and in male mice at 5 W/kg and 10 W/kg CDMA and at 10 W/kg GSM.

While the reputation and methodology of the NTP is highly regarded, this study did not fully describe how mice or rats were randomly allocated to treatment or control groups or that the analysis of the samples was conducted in a blinded fashion. Other scientists (Vijayalaxmi et al., 2020) have pointed out that the observed variability in measured SSBs is a likely consequence of a delay between death and removal of the brain, a serious concern. The NTP admitted that "*[t]he possibility that the longer interval from exposure cessation to tissue collection for the female rats may have been a factor in the absence of any detectable exposure-related increases in DNA damage cannot be ruled out due to the increased opportunity for DNA repair during this interval*" (NTP, 2019c, p. 115). Other concerns raised by Vijayalaxmi et al. (2020) were that positive controls were not included as required by standard protocols; that there was an overreliance on statistical p-value analyses without correction for multiple comparisons; that the authors relied on data from a single rat for a significant elevation of SSBs in the hippocampus with CDMA exposure at 6 W/kg; that there was "*an anomalously low value*" of SSBs in males exposed to CDMA accounting for differences at all three exposure levels; and that the occurrence of SSBs is not related to the DNA magnitude of exposure (i.e., the SAR). The concern raised by Vijayalaxmi et al. (2020) about the method and timing of obtaining samples has a general application to all the studies that measured SSBs by the comet assay. In any study that did not rapidly sacrifice the animals by decapitation in a random order unrelated to the treatment group, large differences in SSBs could be expected whether or not any RF field exposure had occurred.

- **Alkis et al. (2021)** This study is similar to that of Alkis et al. (2019a), except that it presented data on the liver of rats exposed to RF fields at two frequencies that also differed in SAR levels: 1800 MHz at 0. 62/W/kg; and 2100 MHz at 0.2 W/kg. The rats were exposed for 2 hours/day for 7 months and compared to sham-control rats. The comet assay was used to measure DNA damage, and 8-OHdG was measured to assess oxidative DNA damage. Other assays evaluated various oxidative stress indicators.

None of the exposures increased DNA damage as indexed by the tail moment, but the tail intensity index was increased by exposure to both frequencies. The levels of 8-OHdG increased significantly with frequency and SAR. The rats were randomly assigned to exposure groups and the tests and analyses were performed in a blind fashion. Only 100 cells per rat were examined in the comet assay.

Summary of DNA and chromosome damage in animals

The BCCDC summarized the status of research in this area in 2013 as:

> *Results of studies of DNA damage, micronucleus formation, apoptosis, production of reactive oxygen species, gene expression changes, and other genotoxic effects carried out using RF exposure of animal models (mice and rats) tend to be contradictory. Positive results found in one species are usually not replicated. Overall, the criteria important in establishing a causal relationship between short-term or long-term RF exposure and changes in gene expression, apoptosis, production of reactive oxygen species and other potential biologic changes in animal physiology are lacking. Such criteria include consistency of results over several studies among similar animals and strong associations between exposure and response with control for potential confounding factors. This lack of consistent evidence reduces the likelihood that significant adverse physiologic effects occur in animal models due to RF exposure* (BCCDC, 2013, p. 149).

SCENIHR (2015) concluded that "*Overall, because a considerable number of well-performed studies using a wide variety of animal models have been mostly negative in outcome, the animal studies are considered to provide strong evidence for the absence of an effect*" (p. 86).

A considerable number of new studies have assessed the potential effects of RF exposure on DNA and chromosomes in rats and mice, although prior studies of isolated cells *in vitro* provide scant *a priori* justification for conducting more *in vivo* experiments. The range of exposures between the lowest and highest SAR was over 70,000-fold and the duration of exposure ranged from 7 days to as long as 1 year. Few studies were of high quality, as indicated by elementary failures to randomly allocate animals to treatment groups, to conduct analyses of the data in a manner that was blinded as to the history and treatments of individual animals, to include positive controls to demonstrate that the assays were working properly, and to perform statistical analyses that treated group exposures differently from individual animal exposures. An additional limitation is that few studies except those conducted by the NTP collected data at multiple levels of exposure to assess dose-response relationships. Several studies by Alkis et al. (2019a, 2019b, 2021) assessed effects of exposures to RF fields at multiple levels of exposure measured by SAR. Similarly, another group of investigators (Deshmukh et al., 2015, 2016; Megha et al., 2015) assessed effects at multiple levels of SAR. Both groups of investigators, however, varied the SAR levels at the same time they varied the frequency of the RF field. Studies by the Alkis group all reported a lowering of DNA damage levels as SAR levels increased, perhaps a non-intuitive finding. In contrast, the Deshmukh group of investigators, reported an increase in levels of DNA damage over a range of increasing SAR levels. The interpretation of these trends in SAR reported by both groups of investigators are confounded by the potential role of frequency. Although results reported by Smith-Roe (2019) for the NTP study do include tests for dose response in four tissues and blood,[30] and two brain regions for analyses of 100 cells in male rats exposed to CDMA-modulated fields. Since two of these three trends were driven by SAR exposures at 6 W/kg and one at 3 W/kg, there is scant evidence for any effects at lower SAR levels.

Most studies focused on brain tissue because of the IARC's attention to the statistical associations reported in several large epidemiologic studies between high mobile phone use and tumors of the brain. For indicators of possible DNA damage, few dose-response relationships with SAR were evident across these studies reviewed. In the group of studies conducted by NTP, however, some statistically significant dose-response trends were found, but in individual comparisons of exposed and control groups at specific SAR levels, the SSBs measured by the comet assay were only statistically different at SAR levels of 5 W/kg in mice and 6 W/kg in rats, which are well above the permitted whole body exposures of the general public of

[30] "*A result was considered positive if the trend test was significant and at least one dose group was significantly elevated over the control, or if two or more dose groups were significantly increased over the corresponding control*" (Smith-Roe et al., 2019, p. 5).

0.08 W/kg in Canada, the United States, and Europe. One study reported mixed effects in liver tissue where both an increase and a decrease in SSBs were reported, but no such response was reported in the NTP study. A few other studies also reported mixed results for the testis.

Summary of in *vivo studies* of cancer

The cross-sectional observational studies in which characteristics of volunteer subjects were categorized by presumed or measured RF field exposure and measured SSBs or MN were overall of poor quality with regard to exposure assessment, sample size, and methods to minimize potential biases and confounding by other factors, and standards for the detection of these markers of damage to DNA. In addition, by their design such studies are not suitable for assessing causal hypotheses.

The results of two studies that evaluated survival and histopathological analyses of multiple organs reported by the NTP and the Ramazzini Institute provided outlier findings compared to multiple previous studies of long-term exposure that had reported no effect of RF field exposure on the development of tumors. Despite the large number of animals in these studies, limitations in the design and interpretation of them preclude any straight-forward interpretation of the results. Comprehensive reviews to date have not concluded that these studies provide support for the idea that RF field exposure causes cancer. Additional studies are planned to address issues raised by these studies.

Two other studies that evaluated the effects of RF field exposure on the development of tumors initiated by the injection of a chemical carcinogen (Lerchl et al., 2015) or grafted small tumors into the brain of healthy animals reported mixed results (Ouadah et al., 2018). The former suggested a greater effect on tumor development with RF field exposure while the latter suggested no effect. Both studies had significant limitations in the methodology and analysis of the data.

Tests for DNA damage in the comet assay, chromosome damage in the MN assay, measurements of 8-OHdG, and cytotoxic damage were conducted in 16 experimental studies of animals. The results are summarized in Appendix 1. Eight experiments were reported by investigators in the NTP study (Smith-Roe et al., 2020). In the NTP study, the effects on measured SSBs reported at the stated cut-off value of $p<0.025$ were in the brains of male rats exposed to 900 MHz CDMA signals at 6 W/kg, and in male mice exposed to 1,900 MHz CDMA signals at 5 W/kg and 10 W/kg, or to 1,900 MHz GSM signals at 10 W/kg. No evidence of damage to chromosomes from RF field exposure was evident in measures of MN. No evidence of cytotoxicity (necrosis or apoptosis) to the brain or liver was reported (NTP, 2018c, 2018d).

In the other 15 studies carried out by diverse investigators, the evidence for effects was scattered, with 5 studies reporting no effect, 3 studies reporting increases in an indicator, and 7 studies reporting both increases and decreases depending upon tissue and indicator. Given that the exposure systems, number of animals tested per group, histopathology experience, exposure levels, and procedures to minimize bias of these studies do not match the characteristics of the NTP study, it is unreasonable to ascribe those reported effects to RF field exposure, particularly as the effects were not clearly tied to the level of exposure in a dose-related fashion. The rationale for emphasizing factors other than RF field exposure as the likely explanation for their results also is justified because the exposure levels in the non-NTP studies at which effects on DNA indicators were reported were up to 70,000-fold lower than the highest SAR levels in the NTP study. In the one study that could be considered a partial replication of the NTP mouse study, since it tested exposures at an SAR of 5 W/kg, no increase in SSBs was reported in contrast to the NTP report. It also is important to note that, as with human biomarker studies, none of the experimental animal studies that reported increases in SSBs or MN met the criteria for a positive determination of DNA damage. The one laboratory that had a history of expertise in the measurement of SSBs and met other qualifications required by the OECD to be regarded as a high quality study did not report any effect of RF field exposure on measures of SSBs (Zong et al., 2015).

In addition, the NTP study reported that the lowest specific RF exposure level at which a potential adverse effect on DNA and chromosomes was in male mice at 5 W/kg. This level is higher than the accepted threshold of 4 W/kg for disruption of body homeostasis for temperature in rats and humans, a level above which core body temperature could be expected to be raised by about 1°C (ICES, 2019; ICNIRP, 2020a). In the short-term studies reviewed in this report, only Deshmukh et al. (2015) measured the temperature of the animals, but the SAR level was so low that no temperature elevation was observed (nor expected). In the NTP genetic studies, no measurements of body temperature were taken. In the NTP pilot studies, the only recordings of body temperature were from sensors implanted under the skin, which could give lower readings than core body temperature. Given the variability of exposure and the size and behavior of animals, it is quite possible that the exposures in the NTP genetic studies and in the main study could very well have raised the body temperature of some animals by 1°C or more. This point is made by SCENIHR, which noted that effects of exposure to RF that are not related to tissue heating are difficult to interpret, except where exposures are very low.

> *... the (macroscopic) biochemical and physiological responses depend on temperature. Most chemical properties, chemical reaction kinetics and cellular processes are temperature dependent. Therefore, any claimed borderline between thermal and non-thermal effects necessarily needs to be defined with regard to specific effects such as triggering the onset of thermoregulatory reactions. Therefore, to generally claim that effects observed below exposure limits would necessarily be non-thermal is misleading and ignores this basic relationship* (SCENIHR, 2015, p. 58).

A prior in-depth review of genetic measures of rats and mice by IARC concluded:

> *Approximately half of the laboratory studies of genetic damage in mammalian systems, generally rats and mice, had limitations related to reporting on the exposure system, small sample sizes and exposures that induced thermal effects, or that were so low as to be no challenge to the animals. Of the remaining studies, many were satisfactory and of comparable quality, but showed contradictory results. [and] concluded that there was weak evidence that RF radiation is genotoxic, and no evidence for the mutagenicity of RF radiation* (IARC, 2011, pp. 414-415).

A review of genotoxic research that included exposures to RF fields provided the caveat that while the literature included reports as described above for SSBs and other parameters, the evidence that these lead to downstream mutations has not been confirmed. Lai et al. (2021) stated, "*available data do not suggest mutagenic effects after RFR (radiofrequency radiation) exposure*" (p. 2).

Non-specific symptoms

The primary focus for this section of the report is on the recent studies of low-level, far-field exposures to RF fields and non-specific symptoms related to well-being. The WHO identifies electromagnetic hypersensitivity (EHS) as applying to "*some individuals [who] report mild symptoms and react by avoiding the fields as best they can, [and] others [who] are so severely affected that they cease work and change their entire lifestyle.*"[31] A WHO Working Group subsequently suggested that the term EHS be replaced by Idiopathic Environmental Intolerance attributed to Electromagnetic Fields (IEI-EMF) because of a lack of evidence for any clear link of effects from electromagnetic field exposure (Hillert et al., 2006).

Epidemiologic studies and human experimental studies have evaluated whether exposure to relatively low levels of RF energy can cause short-term and long-term symptoms. The scientific literature includes studies of exposure from sources that are both near-field (i.e., mobile phones) and far-field (i.e., wireless LANs, base stations, and advanced meters). Some studies include methods to assess whether people can perceive RF field exposure at these low levels.

Summary of prior reviews

Advisory Group on Non-ionising Radiation Protection

AGNIR (2012) provided the following summary regarding symptoms of well-being:

> *Although numerous observational studies have attempted to assess the association between exposure to RF fields and symptoms, many of these have suffered from important methodological deficits. In particular, the common reliance upon self-reported exposure measures or limited spot measurements within a single place in the home, together with the frequent failure to account for potentially important confounders, makes it impossible to draw any firm conclusions from many of the studies* (AGNIR, 2012, p. 252).

31 https://www.who.int/peh-emf/publications/facts/fs296/en/ (Accessed April 13, 2021).

British Columbia Centre for Disease Control

In general, subjects who are self-declared with 'EHS' do not reliably detect RF when blinded to the source, and RF fails to trigger symptoms in self-declared EHS individuals in a reliable, reproducible, and consistent way. However, provocation studies are limited to examining acute (short-term) exposure to RF, and acute symptoms and the effects of cumulative, chronic exposure to RF on persistent human health symptoms have not been studied thoroughly (BCCDC, 2013, p. 5).

Royal Society of Canada

The panel of scientists convened by the Royal Society of Canada reported that taken together, research in the past ten years does not provide "*firm evidence for the hypotheses that people with IEI-EMF can perceive RF energy at levels below the limits in SC6 or that there is a causal link between exposure to RF energy and their symptoms*" (RSC, 2014, p. 18).

Scientific Committee on Emerging and Newly Identified Health Risks

SCENHIR's conclusion regarding symptoms attributable to IEI-EMF stated:

The symptoms that are attributed by people to RF EMF exposure can sometimes cause serious impairments to a person's wellbeing. However, research conducted since the previous Opinion adds weight to the conclusion that RF EMF exposure is not the cause of these symptoms. This applies to the general public, children and adolescents, and to people with IEI-EMF. Recent meta-analyses of observational and provocation data support this conclusion (SCENIHR, 2015, p. 143).

International Commission on Non-Ionizing Radiation Protection

In summary, no reports of adverse effects of radiofrequency EMF exposures on symptoms and wellbeing have been substantiated, except for pain, which is *related to elevated temperature at high exposure levels (from both direct and indirect radiofrequency EMF exposure)* (ICNIRP, 2020a, p. 519).

Swedish Radiation Safety Authority

In their Thirteenth Report on Recent Research on EMF and Health Risk in 2019, SSM concluded:

In terms of symptoms, several studies reported associations with self-reported mobile phone use but not for exposure from transmitters. These studies may indicate that other aspects related to frequent mobile phone use (e.g. distraction or stress) than RF-EMF exposure may have an impact on health-related quality of life (SSM, 2019, p. 49).

In the most recent Fourteenth Report in 2020, the SSM stated the following:

New studies on mobile phone use and media use in relation to health-related quality of life, cognitive function and behaviour of children and adolescents often report associations. Some studies point to other exposures related to media use, but not RF-EMF, as a causal factor since the strongest associations were found with e.g. texting, which causes minimal amounts of exposure. These studies show that it is challenging to separate effects from RF-EMF exposure from other aspects of mobile phone use such as being woken up during night, blue light exposure or addictive behaviour. This is especially the case when dealing with outcomes like health-related quality of life, cognitive functions or behaviour (SSM, 2020, p. 46).

World Health Organization

A number of studies have investigated the effects of radiofrequency fields on brain electrical activity, cognitive function, sleep, heart rate and blood pressure in volunteers. To date, research does not suggest any consistent evidence of adverse health effects from exposure to radiofrequency fields at levels below those that cause tissue heating. Further, research has not been *able to provide support for a causal relationship between exposure to electromagnetic fields and self-reported symptoms, or "electromagnetic hypersensitivity.*[32]

Experimental studies

Since the SCENIHR (2015) review, several studies have been published, many of which have been reviewed by SSM (e.g., 2015, 2016, 2018, 2019, 2020). Therefore, those will not be reviewed in detail but will be referenced as appropriate in the context of more recent studies. New studies not reviewed elsewhere are discussed below.

- **Andrianome et al. (2019)** is part of a larger research program by these investigators on the issue of IEI-EMF. Previously, they reported that the levels of alpha amylase, an enzyme in saliva that breaks down starches and has been suggested by some to be an indicator of general stress levels, were higher in IEI-EMF persons than control subjects (Andrianome et al., 2019).

  The purpose of the study was to identify a biomarker for IEI-EMF and responses to environmental stimuli that persons had suggested were the cause of their symptoms. Ten of the subjects from the previous study (eight women and two men), who identified themselves as having IEI-EMF symptoms for the past 2.4 to 21.3 years were included in the study. Each subject reported symptoms (not specified) prior to this study as occurring in response to any one of five specific RF wireless signals. None disclosed having psychiatric conditions or taking medications. They agreed not to drink coffee or alcohol for the 24 hours before testing sessions and not to brush their teeth or exercise within 1 hour of the test session.

  Subjects were tested in two sessions about 1 week apart: a sham-exposure session and an RF-exposure session. In both sessions, saliva samples were collected at the beginning of the session and after each 5-minute period in which they were exposed to 900 MHz

[32] https://www.who.int/en/news-room/fact-sheets/detail/electromagnetic-fields-and-public-health-mobile-phones. Accessed April 13, 2021.

GSM signals, 1,800 MHz GSM signals, 2.45 GHz Wi-Fi signals, DECT signals,[33] or sham exposures. RF signals were presented at an intensity of "*about 1 V/m*" at the head and body. The 10-minute periods between exposures were used for the collection of samples, which were analyzed for levels of alpha amylase, immunoglobulin A (a major component of the immune antibody system that protects against infection), and cortisol. The study was planned so that neither the subjects nor the investigators analyzing the data were aware of the exposure conditions during the study or prior to its conclusion (i.e., a double-blind procedure). Only 3 of the 10 subjects correctly guessed whether RF exposure or no exposure was administered on test days. The investigators found no effect of RF field exposure on levels of alpha amylase, immunoglobulin A, or cortisol in the saliva of the subjects. These results indicate that exposure to RF fields of varying frequency or modulation does not affect these biomarkers or produce generalized stress in IEI-EMF subjects. The strength of the study is that it was designed to be double-blind to prevent awareness of the exposure conditions from affecting the behavior or actions of the subjects or the experimenters. The number of subjects, however, was small, the individual RF field exposures were of short duration and not described in detail, and the study did not include subjects who identified as having no IEI-EMF symptoms.

- **Selmaoui et al. (2018)** sought to determine whether variations in the conductivity of the skin,[34] interpreted as a measure of sympathetic autonomic activity, is affected by RF field exposure. Twenty-eight male and female volunteers were recruited for the study. The mean age of study subjects was 24 ± 3 years, and the subjects did not differ with regard to blood pressure, body mass index, or age. Inclusion criteria included regular sleep habits, absence of medications, being a non-smoker, and no neurological or psychiatric illness. Subjects were requested to avoid alcohol, coffee, or stimulants for 24 hours prior to testing, and to avoid mobile phones for 2 hours prior to testing. The subjects were tested in two sessions, sham exposure or RF field exposure, according to a counterbalanced, randomized design. Neither the study nor the investigators were aware

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[33] Frequency was not specified, but likely to be 1,880 MHz to 1,900 MHz.

[34] This is sometimes called the galvanic skin response because it reflects a change in current flow across the skin when a constant voltage is applied that occurs due to changes in conductance related to the activity of sweat glands.

of the exposure conditions (double-blinded) until after data analysis. The exposure consisted of 26 minutes of sham exposure or 26 minutes of RF field exposure using a 900 MHz GSM mobile phone at 0.93 W/kg attached to the left ear. The galvanic skin response (GSR) was recorded as the voltage measured between electrodes attached to two fingers of the left hand. Signal audio tones at an intensity of 60 decibels on the A-weighted scale initiated the recording of GSR for 2.75 minutes at intervals of 6 minutes. Recordings of the subjects taking deep breaths were made to confirm the expected GSR response. Although differences in tonic and phasic GSR responses were measured between sessions, these differences were present both before and after exposures, so could not have been a result of either sham or RF field exposures. The authors did not replicate a reported effect of mobile phone RF fields on the latency of the GSR response of IEI-EMF persons to stimuli (Johansson et al., 2008), but did confirm the absence of an effect of mobile phone RF fields on GSR, as reported in other studies (Wilén et al., 2006, Andrianome et al., 2017; Eltiti et al., 2009; Stevens, 2001).

Summary of experimental studies

Reviews by health and scientific agencies of experimental studies of IEI-EMF up to 2015 have not concluded that exposure to RF signals from mobile phones or other sources can be detected by persons or that such exposures cause symptoms or disturbances to well-being. That conclusion is not changed by the results of more recent studies published since 2015, including those reviewed by scientists in SSM's Scientific Council on Electromagnetic Fields reports or by the results of two more recent experimental studies reviewed above.

Epidemiologic studies

As noted above, many of the experimental and epidemiologic studies published since the SCENIHR (2015) report were reviewed by SSM (2016, 2018, 2019, 2020). Some of the epidemiologic studies on IEI-EMF that were reviewed in recent SSM reports included investigations into the potential association between actual and perceived exposure to EMF/RF fields and non-specific physical symptoms (NSPS) in the Netherlands (Baliatsas et al., 2015, 2016), mobile phone use and non-specific symptoms in South Korea (Cho et al., 2016, 2017), modeled and perceived exposure to RF fields from mobile phone base stations and non-specific symptoms and sleep disturbances in the Netherlands (Martens et al., 2017, 2018), and the use of wireless communication devices and symptoms in Switzerland (Schoeni et al., 2016, 2017). The SSM Council's review of these and other studies resulted in the Council's most recent conclusions that "*other aspects related to frequent mobile phone use (e.g. distraction or stress) than RF-EMF exposure may have an impact on health-related quality of life*" (SSM 2019, p. 49) and that "*[s]ome studies point to other exposures related to media use, but not RF-EMF, as a causal factor since the strongest associations were found with e.g. texting, which causes minimal amounts of exposure*" (SSM 2020, p. 46).

- **Ikinci Keleş and Uzun Şahin (2021)** conducted a cross-sectional survey in Turkey to investigate cell phone use behaviors and reported changes in health following exposure to RF fields. The authors administered a questionnaire to 1,019 university students, age 18 to 24, that collected self-reported information on the participants' cell phone usage, "*general health problems*," "*sleep problems*," and "*health problems arising after cell phone use in the previous six months*" (Ikinci Keleş and Uzun Şahin, 2021, p. 140). The survey results indicated that students spent an average of 4 to 8 hours per day on their cell phones. Duration of daily cell phone use was significantly associated with the self-reported symptoms of headache, carelessness, fatigue, numbness, and feeling tired on awakening, but was not associated with other symptoms, including dizziness, lack of concentration, and sleep onset latency. The participants were also asked whether they knew their cell phones' SAR value; only 2% of respondents correctly identified this value for their cell phone. Limitations of this study include the inability to establish a temporal relationship between the exposure and outcomes of interest (i.e., failing to demonstrate that the cell phone use occurred prior to the onset of the reported health symptoms), the lack of personal RF exposure measurements, the reliance on self-reported symptoms, and the potential for confounding.

- **Kacprzyk et al. (2021)** conducted a meta-analysis of six epidemiologic studies to investigate the association between mobile phone use and tinnitus. The included studies varied by study design (cohort, case-control, and cross-sectional) and exposure assessment method and were therefore assessed separately. Two cohort studies assessed exposure to mobile phones using network operator data; no significant association was observed between tinnitus and high exposure to mobile phones (defined using the highest exposure category in each study) compared to low exposure. Similarly, no significant associations were reported in analyses that included studies of self-reported exposure. Limitations include the small number of studies included in the analysis and the variability in study design and exposure assessment methods, as well as the use of self-reported exposure data in the majority of the studies.

- **Lopez et al. (2021)**, in a cross-sectional survey, examined the relationship between select health indicators and electromagnetic radiation measurements in a neighborhood in Spain concerned about the surrounding telephone antennas. The study was conducted "*at the request of a neighborhood association… concerned about the proximity of the [telephone] antennas to their homes*" (Lopez et al., 2020, p. 2). The authors designed a survey to collect information on "*health indicators that may be sensitive to RF electromagnetic radiation*" including headaches, dizziness, and parameters related to sleep and tiredness. The survey also collected information on the amount of time the participant had lived in the home. A total of 268 surveys were conducted, including 174 surveys from participants living in the exposed area and 94 living in a control area (defined based on a cutoff distance to the antennas of approximately 300 meters). In addition, a total of 105 indoor and outdoor measurements were collected at the residences using a spectrum analyzer and isotropic antenna (frequency range: 700 MHz to 6 GHz). For the statistical analyses, the authors categorized the resulting power density measurements into three bins: low exposure (7-1,775 microwatts per square meter [$\mu W/m^2$]), medium exposure (>1,775-3,543 $\mu W/m^2$), and high exposure (>3,543-5,311 $\mu W/m^2$). A statistically significant association was reported between medium or high exposure and headache intensity, frequency of dizziness, number of hours slept per day, and several of the tiredness indicators. The authors also noted that the prevalence of cancer in the study population was 5.6%, which they reported was significantly higher than that of the total Spanish population. Limitations of the study include its cross-sectional study design, the inclusion of a non-random sample of concerned study subjects who are more likely to report having the symptoms of interest (i.e., selection bias), the use of an unvalidated survey to collect health information, and the lack of personal measurements to capture the participants' true exposure levels. These limitations result in the study being of limited scientific value.

- **Meng et al. (2021)** conducted a cross-sectional survey to investigate mobile phone use characteristics and sleep quality among 4,234 medical students in China. Mobile phone use characteristics and sleep quality data were collected via questionnaire from December 2016 to January 2017; the questionnaire collected mobile phone use information that included purpose of use (e.g., entertainment, work, information), posture during use (e.g., sitting, standing, lying down), distance between the user's eyes and the screen, daily cumulative use time, and use time before bed. The authors reported that 100% of the participants used mobile phones frequently (defined as an accumulated daily use time of greater than 1 hour). Poorer sleep quality was associated with increased daily accumulated use time (>5 hours) and increased use time before bed with the lights off (>30 minutes). Limitations of this study include its cross-sectional design, the lack of information on potential confounders not related to mobile phone use that may impact sleep quality (e.g., physical or mental conditions, environmental exposures) and the use of self-reported exposure data. The cross-sectional design of the study also means that a causal relationship between mobile phone use and sleep quality cannot be established.

- **Caumo et al. (2020)** examined the use of electronic devices among adolescents in Brazil and the potential impact on sleep quality. The study included 177 students, ranging in age from 11 to 18, from six public schools in Porto Alegre. Use of electronic devices (grouped by television/computer monitors; tablets/portable video games; and mobile phones) was assessed using an electronic usage diary. A high prevalence of device use at night-time (after 8:00 PM) was observed; approximately 70% of participants reported night-time mobile phone use. For mobile phones, both higher duration of night-time use and later final-use time were associated with worse sleep quality. Poor sleep quality was also associated with shorter sleep duration on school days and a delayed midpoint of sleep on weekends. Limitations of this study include the lack of personal RF field exposure measurements and the potential for findings to be a result of reverse causality (i.e., that participants who have difficulty sleeping may be more likely to use their devices when they cannot sleep, rather than the use of device being the cause of sleeping issues). Potential confounding by underlying psychological conditions is another concern in the study.

- **Bolte et al. (2019)** examined whether NSPS reported in persons with self-reported sensitivity to RF fields were associated with measured RF field exposure levels in the Netherlands. The study included 57 participants, ranging in age from 16 to over 65, who were equipped with a personal dosimeter worn for 5 consecutive days and measuring 12 different frequency bands (i.e., FM radio [88-108 MHz], TV3 [174-233 MHz], TETRA [380-400 MHz], TV4 and TV5 [470-830 MHz], GSM uplinks [880-915 MHz], GSM downlinks [925-960 MHz], data collection system [DCS] uplinks [1,710-1,785 MHz], DCS downlinks [1,805-1,880 MHz], DECT [1,880-1,900 MHz], UMTS uplinks [1,920-1,980 MHz], UMTS downlinks [2,110-2,170 MHz], and Wi-Fi [2,400-2,500 MHz]), as well as a global positioning system logger and an electronic diary that collected information on NSPS. The authors analyzed the data using time-weighted average exposures and two different time lags (0-1 hours and 1-4 hours after exposure); associations were assessed on both the group level and individual level. No statistically significant associations were observed at the group level between measured personal exposure and NSPS. In a sub-analysis of 36 participants who attributed their most important health complaint to a measurable RF source, statistically significant associations were observed for only one participant (between Wi-Fi and total NSPS score and severity). Observed significant associations were not always consistent between the two different time lags. Among the 36 participants included in the sub-analysis, Wi-Fi exposure was the self-declared most important source of health complaints; of the 21 participants who were excluded from the sub-analysis, 16 could not name the RF source or frequency band attributed to their health complaints, and 4 attributed their complaints to a source that was actually ELF-EMF. The authors acknowledged that the observed associations at the individual level may be due to residual confounding and thus "*the outcomes have to be regarded very prudently*" (p. 1).

- **Cabré-Riera et al. (2019)** investigated the association between cordless and mobile phone use and sleep quality in adolescents in Spain. The cross-sectional study included

258 participants, age 17 to 18. Information on the use of phone and screen devices (e.g., laptop, tablet, television, or video game consoles) was collected from self-reported questionnaire data; the Mobile Phone Problematic Use Scale was used to assess "*problematic*" (as defined by the Use Scale tool) mobile phone use dependency. Sleep quality was assessed both subjectively (using a sleep quality index) and objectively (using actigraphy data collected for 7 nights). The authors reported that habitual (defined as the 15^{th} to 80^{th} percentile of use) or frequent (>80^{th} percentile) "*problematic*" mobile phone use was associated with lower sleep quality compared to occasional (<15^{th} percentile) use; lower sleep quality was also associated with one or more cordless phone calls per week. No associations were observed between sleep quality and mobile or cordless phone call duration. Both decreased sleep efficiency and increased minutes of wake time after sleep onset were associated with higher tablet use; no associations were observed between other devices and any of the sleep measures assessed. The authors concluded that "*sleep displacement, mental arousal, and exposure to blue light screen emission might play a more important role on sleep than a high RF-EMF exposure to the brain*" (p. 341). Limitations of this study are similar to those noted for Caumo et al. (2020) in that they lacked personal RF exposure measurements for the participants, there was the potential for reverse causality of the findings, and there was potential for confounding.

- **Elliot et al. (2019)** investigated the association between TETRA radio use (380-400 MHz) and absence due to sickness among British police officers in the Airwave Health Monitoring Study. The study included 32,102 participants; personal radio use was estimated using self-reported information combined with a call data record database and was linked to records of absence due to sickness. No significant differences in risk of absence due to sickness were observed between personal radio users versus non-users, including for several sub-analyses, and users had a statistically significant lower rate of absence due to sickness compared to non-users. For most causes of absence due to sickness, the risk of absence was lower among users than non-users. Among users only, slight significant associations were observed between a doubling of radio use and the risk and rate of absence due to sickness. The authors concluded that the results showed "*similar or lower risks of sickness absence in TETRA radio users compared with non-*

users" and that the highest risk of absence due to sickness observed in users with greater radio use "*may reflect working pattern differences among police personnel rather than effects of radiofrequency exposure*" (p. 148).

- **Wdowiak et al. (2019)** assessed the relationship between RF field exposure and emotional disorders in Polish women employed in two specific industries. The study included 200 women, half of whom worked in the health service sector, while the other half worked as shop assistants in shopping centers. Physical activity and symptoms of depression and anxiety were assessed using self-reported questionnaires. RF field exposure was assessed using a dosimeter worn for 10 hours on the participants' left arm, which measured electromagnetic fields in the following ranges: GSM 900 (880-960 MHz), GSM 1800 (1,710-1,880 MHz), UMTS (1,920-2,170 MHz), DECT (1,880-1,900 MHz), and WLAN (2.4-2.43 GHz). The authors used the dosimeter readings to determine if the source of the fields was a base station or mobile phone device. Women working in shopping centers were observed to spend significantly more time per day using a mobile phone compared to women working in the health service. Increased daily mobile phone use time was correlated with decreased feelings of depression and increased anxiety in women working in the health services sector, increased daily Internet use time via the mobile phone was correlated with increased feelings of depression for women working in the shopping centers. No consistent patterns were observed between depression or anxiety symptoms, or with individual ranges of RF field levels. When assessing other risk factors, correlations were observed between anxiety level and level of education in women in the health service industry and between level of depression and physical activity in women working in shopping centers.

Summary of epidemiologic studies

Reviews by health and scientific agencies of epidemiologic studies of IEI-EMF up to 2015 did not conclude that exposure to RF signals from mobile phones or other sources cause symptoms or disturbances to well-being. That conclusion is not changed by the results of more recent studies published since 2015, including those reviewed by scientists in SSM's recent Scientific Council on Electromagnetic Fields reports and those summarized above. Several recent cross-sectional studies were conducted in which information on mobile phone use and various health symptoms were collected via questionnaire or electronic diary. While some of the studies reported an association between various metrics of mobile phone use and self-reported symptoms, such as headache and fatigue (Ikinci Keleş and Uzun Şahin, 2021) or poor sleep quality (Caumo et al., 2020; Meng et al., 2021), the cross-sectional design of these studies means that a causal relationship between mobile phone use and the health outcomes of interest cannot be established. These studies also had other important limitations, including the lack of personal RF exposure measurements, the reliance on self-reported symptoms rather than clinical evaluations, the potential for confounding, and the potential for reverse causality in the observed relationships. The one recent study that collected RF exposure measurements using personal dosimeters (Bolte et al., 2019) found no statistically significant overall associations between measured personal exposure and non-specific physical symptoms. Taken together, the results of recent epidemiologic studies of IEI-EMF do not change the conclusions of the scientific and health agencies that have previously reviewed the research in this area.

Other health conditions studied

A number of additional health conditions have been investigated in the scientific literature to assess whether RF field exposure could contribute to these conditions. These health outcomes include, but are not limited to, nervous system and neurobehavioral effects (e.g., neurological diseases, effects on cognitive function, impacts on hearing or vision), cardiovascular conditions, reproductive and developmental effects, and various conditions of the head and neck region (including disorders of the eye). While studies investigating these outcomes are not covered in this report, they have been reviewed by the expert panels established by several of the scientific and health organizations previously discussed (ICNIRP, 2009; AGNIR, 2012; SCENIHR, 2015; SSM, 2016, 2018, 2019, 2020). The overall conclusions of these review panels remain consistent, that the scientific evidence does not confirm that exposure to RF fields below scientifically-based exposure guidelines cause or contribute to the development of any adverse health effects, including chronic diseases and other health conditions as listed above.

Specific conclusions of the SCENIHR (2015) report related to these health conditions include the following (p. 6):

Overall, there is a lack of evidence that mobile phone RF EMF affects cognitive functions in humans.

Human studies on neurological diseases and symptoms show no clear effect, but the evidence is limited.

The previous SCENIHR Opinion concluded that there were no adverse effects on reproduction and development from RF fields at non-thermal exposure levels. The inclusion of more recent human and animal data does not change this assessment.

Human studies on child development and behavioural problems have conflicting results and methodological limitations. Therefore, the evidence of an effect is weak.

Studies on male fertility are of poor quality and provide little evidence.

Effects of exposure on foetuses from mother's mobile phone use during pregnancy are not plausible owing to extremely low foetal exposure.

7. Conclusion

In this report, recent scientific research related to RF field exposure and human health has been reviewed to determine whether the findings impact the conclusions reached in comprehensive reviews completed by scientific and health organizations, including the 2015 review by SCENIHR. Many of these agencies, including SCENIHR, use a weight-of-evidence approach to critically evaluate the scientific literature, which aims to ensure that all relevant studies are considered, regardless of their conclusions or support for (or against) any particular hypothesis. Based on their reviews, these organizations have concluded that research does not confirm that RF fields at the levels we encounter in our everyday environment are a cause of cancer, chronic disease, or other adverse health effects.

This report focused primarily on epidemiologic and experimental studies of cancer and symptoms of well-being. Although many studies on RF exposure and health have been published in the last decade, the findings from these studies did not provide sufficient evidence to alter the overall conclusions of health and scientific organizations. When evaluated against established scientific criteria for assessing causality (i.e., the Bradford-Hill criteria), the reviewed studies did not provide evidence in support of a causal relationship between RF field exposure and adverse health effects. Research studies of the poorest quality were identified but not considered in this report, which is consistent with the approach taken in reviews conducted by SCENIHR and SSM.

Several factors contribute to a person's exposure to RF fields, including frequency and intensity of the RF field, duration of exposure, and distance from the source of the field. Most of the epidemiologic studies on RF field exposure and health focus on exposures from mobile phones and hand-held communicators that are held close to the body during use. In contrast, the components of the FlexNet system will be located at considerably farther distances from a person's body. Although fewer recent epidemiologic studies examined exposure from distant sources of RF fields, none concluded that exposure from these sources was associated with cancer. In addition, the wireless signals from the proposed FlexNet system are transmitted infrequently and only for fractions of a second. Overall, the RF field exposure outdoors from any of the FlexNet meters are estimated to be more than 3,000-fold lower than the levels at which biological and health effects have been evaluated in this report, and when deployed, will produce RF fields at levels far lower than other existing sources.

In summary, neither the reviews conducted by scientific and health organizations nor the recently published research provide a reliable scientific basis to conclude that the operation of FortisBC's proposed FlexNet system will cause or contribute to adverse health effects or physical symptoms in the general population. Exposures to RF fields from the proposed Sonix IQ gas meters are significantly lower than the levels at which biological and health effects have been studied and are substantially lower than the exposure levels produced by other common sources of RF fields.

8. References

Literature cited

Advisory Group on Non-ionising Radiation (AGNIR). Health Effects from Radiofrequency Electromagnetic Fields. HPA, 2012.

Akdag MZ, Dasdag S, Canturk F, Karabulut D, Caner Y, Adalier N. Does prolonged radiofrequency radiation emitted from Wi-Fi devices induce DNA damage in various tissues of rats? J Chem Neuroanatomy 75:116-122, 2016.

Akdag M, Dasdag S, Canturk F, Akdag MZ. Exposure to non-ionizing electromagnetic fields emitted from mobile phones induced DNA damage in human ear canal hair follicle cells. Electromagn Biol Med 37(2):66-75, 2018.

Alkis ME, Bilgin HM, Akpolat V, Dasdag S, Yegin K, Yavas MC, Akdag MZ. Effect of 900-, 1800-, and 2100-MHz radiofrequency radiation on DNA and oxidative stress in brain. Electromagn Biol Med 38(1):32-47, 2019a.

Alkis ME, Akdag MZ, Dasdag S, Yegin K, Akpolat V. Single-strand DNA breaks and oxidative changes in rat testes exposed to radiofrequency radiation emitted from cellular phones Biotechnol Equi. 33:1733-1740, 2019b.

Alkis ME, Akdag MZ, Dasdag S. Effects of low-intensity microwave radiation on oxidant-antioxidant parameters and DNA damage in the liver of rats. Bioelectromagnetics. 42:76-85, 2021.

Ames BN, Shigenaga MK, Hagen TM. Oxidants, antioxidants, and the degenerative diseases of aging. Proc Natl Acad Sci USA 90(17):7915-7922, 1993.

Andrianome S, Gobert J, Hugueville L, Stephan-Blanchard E, Telliez F, Selmaoui B. An assessment of the autonomic nervous system in the electrohypersensitive population: a heart rate variability and skin conductance study. J Appl Physiol (1985) 123:1055-1062, 2017.

Andrianome S, Yahia-Cherif L, Selmaoui B. Effect of short exposure to radiofrequency electromagnetic fields on saliva biomarkers: A study on the electrohypersensitive individuals. Int J Radiat Biol 95:788-792, 2019.

Baliatsas C, Bolte J, Yzermans J, Kelfkens G, Hooiveld M, Lebret E, van Kamp I. Actual and perceived exposure to electromagnetic fields and non-specific physical symptoms: an epidemiological study based on self-reported data and electronic medical records. Int J Hyg Environ Health 218:331-344, 2015.

Baliatsas C, van Kamp I, Bolte J, Kelfkens G, van Dijk C, Spreeuwenberg P, Hooiveld M, Lebret E, Yzermans J. Clinically defined non-specific symptoms in the vicinity of mobile phone base stations: A retrospective before-after study. Sci Total Environ 565:714-720, 2016.

Banerjee S, Singh NN, Sreedhar G, Mukherjee S. Analysis of the genotoxic effects of mobile phone radiation using buccal micronucleus assay: a comparative evaluation. J Clin Diagn Res 10 (3):ZC82-ZC85, 2016.

Belpoggi F, Falcioni L, Panzacchi S, Sgargi D, Mandrioli D. Response to "Cancerogenic effects of radiofrequency radiation: A statistical reappraisal." Environ Res 197:111067, 2021.

Bolte JFB, Clahsen S, Vercruijsse W, Houtveen JH, Schipper CMA, van Kamp I, Bogers R. Ecological momentary assessment study of exposure to radiofrequency electromagnetic fields and non-specific physical symptoms with self-declared electrosensitivities. Environ Int 131:104948, 2019.

Bonassi S, Coskun E, Ceppi M, Lando C, Bolognesi C, Burgaz S, Holland N, Kirsh-Volders M, Knasmueller S, Zeiger E, Carnesoltas D, Cavallo D, da Silva J, de Andrade VM, Demircigil GC, Domínguez Odio A, Donmez-Altuntas H, Gattas G, Giri A, Giri S, Gómez-Meda B, Gómez-Arroyo S, Hadjidekova V, Haveric A, Kamboj M, Kurteshi K, Martino-Roth MG, Montero Montoya R, Nersesyan A, Pastor-Benito S, Favero Salvadori DM, Shaposhnikova A, Stopper H, Thomas P, Torres-Bugarín O, Yadav AS, Zúñiga González G, Fenech M. The HUman MicroNucleus project on eXfoLiated buccal cells (HUMN(XL)): The role of life-style, host factors, occupational exposures, health status, and assay protocol. Mutation Res 728:88-97, 2011.

Bortkiewicz A, Gadzicka E, Szymczak W. Mobile phone use and risk for intracranial tumors and salivary gland tumors: A meta-analysis. Int J Occup Med Environ Health 30:27-43, 2017.

British Columbia Centre for Disease Control (BCCDC). Radiofrequency Toolkit for Environmental Health Practitioners. Vancouver, British Columbia: BCCDC, 2013. http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/EH/EH/RadiofrequencyToolkit_v5_26032014.pdf. Accessed April 2021.

British Columbia Centre for Disease Control (BCCDC). 2016 Review: Radiofrequency and Health. Vancouver, British Columbia: BCCDC, 2016. http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/EH/RPS/BCCDC%20RF%20Health%20Report.pdf. Accessed April 2021.

Bundesamt für Strahlenschutz (BfS). Technical statement of the Federal Office for Radiation Protection on the results of the NTP study. BfS, 2019. Available from: https://www.bfs.de/EN/bfs/science-research/statements/emf/ntp-study/ntp-study-statement/ntp-statement.html. Accessed April 2021.

Bungum M. Sperm DNA Integrity assessment: A new tool in diagnosis and treatment of fertility. Obset Gynecol Int 531042:1-6, 2012.

Cabré-Riera A, Torrent M, Donaire-Gonzalez D, Vrijheid M, Cardis E, Guxens M. Telecommunication devices use, screen time and sleep in adolescents. Environ Res 171:341-347, 2019.

Carlberg M and Hardell L. Decreased survival of glioma patients with Astrocytoma Grade IV (Glioblastoma Multiforme) associated with long-term use of mobile and cordless phones. Int J Environ Res Public Health 11:10790-10805, 2014.

Carlberg M and Hardell L. Pooled analysis of Swedish case-control studies during 1997-2003 and 2007-2009 on meningioma risk associated with the use of mobile and cordless phones. Oncol Rep 33:3093-3098, 2015.

Carlberg M, Söderqvist F, Hansson Mild K, Hardell L. Meningioma patients diagnosed 2007-2009 and the association with use of mobile and cordless phones: a case-control study. Environ Health 12(1):60, 2013.

Carlberg M, Hedendahl L, Ahonen M, Koppel T, Hardell L. Increasing incidence of thyroid cancer in the Nordic countries with main focus on Swedish data. BMC Cancer 16:426, 2016.

Carlberg M, Koppel T, Hedendahl LK, Hardell L. Is the Increasing Incidence of Thyroid Cancer in the Nordic Countries Caused by Use of Mobile Phones? Int J Environ Res Public Health. 17(23):9129, 2020.

Carlson ML and Link MJ. Vestibular Schwannomas. N Engl J Med 384:1335-1348, 2021.

Cao Y, Xu Q, Jin ZD, Zhang J, Lu MX, Nie JH, Tong J. Effects of 900-MHz microwave radiation on gamma-ray-induced damage to mouse hematopoietic system. J Toxicol Environ Health A 73(7):507-513, 2010.

Cao Y, Xu Q, Jin ZD, Zhou Z, Nie JH, Tong J. Induction of adaptive response: pre-exposure of mice to 900 MHz radiofrequency fields reduces hematopoietic damage caused by subsequent exposure to ionising radiation. Int J Radiat Biol 87(7):720-728, 2011.

Caumo GH, Spritzer D, Carissimi A, Tonon AC. Exposure to electronic devices and sleep quality in adolescents: a matter of type, duration, and timing. Sleep Health 6(2):172-178, 2020.

Chapman S, Azizi L, Luo Q, Sitas F. Has the incidence of brain cancer risen in Australia since the introduction of mobile phones 29 years ago? Cancer Epidemiol 42:199-205, 2016.

Chen F, Wang P, Lan J, Hu M, Zheng J, Li Y, Hou C, Zhou D. Wireless phone use and adult meningioma risk: a systematic review and Meta-analysis. Br J Neurosurg. 11:1-7, 2020.

Cho YM, Lim HJ, Jang H, Kim K, Choi JW, Shin C, Lee SK, Kwon JH, Kim N. A cross-sectional study of the association between mobile phone use and symptoms of ill health. Environ Health Toxicol 31:e2016022, 2016.

Cho YM, Lim HJ, Jang H, Kim K, Choi JW, Shin C, Lee SK, Kwon JH, Kim N. A cross-sectional study of the association between mobile phone use and symptoms of ill health. Environ Health Toxicol 31:e2016022, 2016. Choi YJ, Moskowitz JM, Myung SK, Lee YR, Hong YC. Cellular Phone Use and Risk of Tumors: Systematic Review and Meta-Analysis. Int J Environ Res Public Health 17(21):8079, 2020.

Consiglio AR, Ramos AL, Henriques JA, Picada JN. DNA brain damage after stress in rats. Prog Neuropsychopharmacol Biol Psychiatry 34(4):652-656, 2010.

D'Andrea JA. Behavioral effects of microwave irradiation. Bioelectromagnetics 20: 64-74, 1999.

Dabouis V, Arvers P, Debouzy JC, Sebbah C, Crouzier D, Perrin A. First epidemiological study on occupational radar exposure in the French Navy: A 26-Year cohort study. Int J Environ Health Res 26:131-144, 2016.

Daroit NB, Visioli F, Magnusson AS, Vieira GR, Rados PV. Cell phone radiation effects on cytogenetic abnormalities of oral mucosal cells. Braz Oral Res 9:1-8, 2015.

Davis FG, Smith TR, Gittleman HR, Ostrom QT, Kruchko C, Barnholtz-Sloan JS. Glioblastoma incidence rate trends in Canada and the United States compared with England, 1995-2015. Neuro Oncol 22:301-302, 2020.

de Oliveira FM, Carmona AM, Ladeira C. Is mobile phone radiation genotoxic: An analysis of micronucleus frequency in exfoliated buccal cells. Mut Res 822:41-46, 2017a.

de Oliveira FM, Carmona AM, Ladeira C. Genotoxicity assessment data for exfoliated buccal cells exposed to mobile phone radiation. Data in Brief 15:344-347, 2017b.

Deshmukh PS, Megha K, Banerjee BD, Ahmed RS, Chandna S, Abegaonkar MP, Tripathi AK. Detection of Low Level Microwave Radiation Induced Deoxyribonucleic Acid Damage Vis-à-vis Genotoxicity in Brain of Fischer Rats. Toxicol Int 20(1):19-24, 2013.

Deshmukh PS, Nasare N, Megha K, Banerjee BD, Ahmed RS, Singh D, Abegaonkar MP, Tripathi AK, Mediratta PK. Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation. Int J Toxicol 34:284-290, 2015.

Deshmukh PS, Megha K, Nasare N, Banerjee BD, Ahmed RS, Abegaonkar MP, Tripathi AK, Mediratta PK. Effect of Low Level Subchronic Microwave Radiation on Rat Brain. Biomed Environ Sci 29(12):858-867, 2016.

de Siqueira EC, de Souza FTA, Gomez RS, Gomes CC, de Souza RP. Does cell phone use increase the chances of parotid gland tumor development? A systematic review and meta-analysis. J Oral Pathol Med 46:480-483, 2017.

dos Santos MAL, de Santana FS, Soares AF, de Sousa SF, Menezes L, Takeshita WM. Genotoxic and cytotoxic effects of mobile phone use on the oral epithelium: a systematic review with meta-analysis. Gen Dentistry 68:70-74, 2020.

de Vocht F. Analyses of Temporal and Spatial Patterns of Glioblastoma Multiforme and Other Brain Cancer Subtypes in Relation to Mobile Phones Using Synthetic Counterfactuals. Environ Res 168:329-335, 2019.

Elliott P, Aresu M, Gao H, Vergnaud AC, Heard A, McRobie D, Spear J, Singh D, Kongsgård HW, Mbema C, Muller DC. Use of TETRA personal radios and sickness absence in the Airwave Health Monitoring Study of the British police forces. Environ Res 175:148-155, 2019.

Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, Fox E. Short-term exposure to mobile phone base station signals does not affect cognitive functioning or physiological measures in individuals who report sensitivity to electromagnetic fields and controls. Bioelectromagnetics 30:556-563, 2009.

Exponent, Inc. (Exponent). Radiofrequency Fields in the Environment and from Advanced Metering Infrastructure. Bowie, MD: Exponent, May 3, 2021.

Falcioni L, Bua L, Tibaldi E, Lauriola M, De Angelis L, Gnudi F, Mandrioli D, Manservigi M, Manservisi F, Manzoli I, Menghetti I, Montella R, Panzacchi S, Sgargi D, Strollo V, Vornoli A, Belpoggi F. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. Environ Res 165:496-503, 2018.

Federal Communications Commission (FCC). Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields. Edition 97-01, OET Bulletin 65. Washington, D.C.: Federal Communications Commission, 1997.

Fletcher J. Subgroup analyses: how to avoid being misled. BMJ 335(7610):96-97, 2007.

Food and Drug Administration (FDA). Statement for Jeffrey Shuren, M.D., J.D., Director of the FDA's Center for Devices and Radiological Health on the National Toxicology Program's Report on Radiofrequency Energy Exposure. FDA Center for Devices and Radiological Health, 2018. https://www.fda.gov/news-events/press-announcements/statement-jeffrey-shuren-md-jd-director-fdas-center-devices-and-radiological-health-national. Accessed April 2021.

Food and Drug Administration (FDA). Review of Published Literature between 2008 and 2018 of Relevance to Radiofrequency Radiation and Cancer. FDA Center for Devices and Radiological Health, 2020.

Forchhammer L, Ersson C, Loft S, Möller L, Godschalk RW, van Schooten FJ, Jones GD, Higgins JA, Cooke M, Mistry V, Karbaschi M, Collins AR, Azqueta A, Phillips DH, Sozeri O, Routledge MN, Nelson-Smith K, Riso P, Porrini M, Matullo G, Allione A, Stępnik M, Komorowska M, Teixeira JP, Costa S, Corcuera LA, López de Cerain A, Laffon B, Valdiglesias V, Møller P. Inter-laboratory variation in DNA damage using a standard comet assay protocol. Mutagenesis 6:665-672, 2012.

Foster KR, Simkó M, Verschaeve L. Confronting risk of bias in RF bioeffects research. Comments on two papers by Vijayalaxmi and Prihoda. Radiat Res 192(4):363-366, 2019.

Furtado-Filho OV, Borba JB, Dallegrave A, Furtado-Filho OV, Borba JB, Dallegrave A, Pizzolato TM, Henriques JA, Moreira JC, Saffi J. Effect of 950 MHz UHF electromagnetic radiation on biomarkers of oxidative damage, metabolism of UFA and antioxidants in the livers of young rats of different ages. Int J Radiat Biol 90(2):159-168, 2014.

Furtado-Filho OV, Borba JB, Maraschin T, Souza LM, Henriques JA, Moreira JC, Saffi J. Effects of chronic exposure to 950 MHz ultra-high-frequency electromagnetic radiation on reactive oxygen species metabolism in the right and left cerebral cortex of young rats of different ages. Int J Radiat Biol 91:891-897, 2015.

Gandhi G, Kaur G, and Nisar U. A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station. Electromagn Biol Med 34:344-354, 2015.

Gao H, Aresu M, Vergnaud AC, McRobie D, Spear J, Heard A, Kongsgård HW, Singh D, Muller DC, Elliott P. Personal radio use and cancer risks among 48,518 British police officers and staff from the Air wave Health Monitoring Study. Br J Cancer 120(3):375-378, 2019.

Gift JS, Caldwell JC, Jinot J, Evans MV, Cote I, Vandenberg JJ. Scientific considerations for evaluating cancer bioassays conducted by the Ramazzini Institute. Environ Health Perspect 121(11-12):1253-1263, 2013.

Gonzalez-Rubio J, Arribas E, Ramirez-Vazquez R, Najera A. Radiofrequency electromagnetic fields and some cancers of unknown etiology: An ecological study. Sci Total Environ 599-600:834-843, 2017.

González C, Nájera O, Cortés E, Toledo G, López L, Betancourt M, Ortiz R. Susceptibility to DNA damage induced by antibiotics in lymphocytes from malnourished children. Teratog Carcinog Mutagen 22:147-158, 2002.

Güler G, Ozgur E, Keles H, Tomruk A, Vural SA, Seyhan N. Neurodegenerative changes and apoptosis induced by intrauterine and extrauterine exposure of radiofrequency radiation. J Chem Neuroanat 75:128-133, 2016.

Gulati S, Yadav A, Kumar N, Kanupriya, Aggarwal NK, Kumar R, Gupta R. Effect of GSTM1 and GSTT1 polymorphisms on genetic damage in humans [*sic*] populations exposed to radiation from mobile towers. Arch Environ Contam Toxicol 70(3):615-625, 2016.

Hardell L and Carlberg M. Mobile phone and cordless phone use and the risk for glioma - Analysis of pooled case-control studies in Sweden, 1997-2003 and 2007-2009. Pathophysiology 22(1):1-13, 2015.

Hardell L and Carlberg M. Mobile phones, cordless phones and rates of brain tumors in different age groups in the Swedish National Inpatient Register and the Swedish Cancer Register during 1998-2015. PLoS One 12(10):e0185461, 2017.

Hardell L, Näsman A, Påhlson A, Hallquist A, Hansson Mild K. Use of cellular telephones and the risk for brain tumours: A case-control study. Int J Oncol 15(1):113-116, 1999.

Hardell L, Nasman A, Pahlson A, Hallquist A. Case-control study on radiology work, medical x-ray investigations, and use of cellular telephones as risk factors for brain tumors. Med Gen Med 2(2):E2, 2000.

Hardell L, Mild KH, Påhlson A, Hallquist A. Ionizing radiation, cellular telephones and the risk for brain tumours. Eur J Cancer Prev 10(6):523-529, 2001.

Hardell L, Mild KH, Carlberg M. Case-control study on the use of cellular and cordless phones and the risk for malignant brain tumours. Int J Radiat Biol 78(10):931-936, 2002a.

Hardell L, Hallquist A, Mild KH, Carlberg M, Påhlson A, Lilja A. Cellular and cordless telephones and the risk for brain tumours. Eur J Cancer Prev 2002;11(4):377-386, 2002b.

Hardell L, Mild KH, Carlberg M. Further aspects on cellular and cordless telephones and brain tumours. Int J Oncol 22(2):399-407, 2003.

Hardell L, Carlberg M, Hansson MK. Pooled analysis of two case-control studies on the use of cellular and cordless telephones and the risk of benign brain tumours diagnosed during 1997-2003. Int J Oncol 28:509-518, 2006a.

Hardell L, Carlberg M, Hansson MK. Pooled analysis of two case-control studies on use of cellular and cordless telephones and the risk for malignant brain tumours diagnosed in 1997-2003. Int Arch Occup Environ Health 79:630-639, 2006b.

Hardell L, Carlberg M, Hansson Mild K. Mobile phone use and the risk for malignant brain tumours: A case-control study on deceased cases and controls. Neuroepidemiology 35:109-114, 2010.

Hardell L, Carlberg M, Mild KH. Pooled analysis of case-control studies on malignant brain tumours and the use of mobile phone and cordless phones including living and deceased subjects. Int J Oncol 38:1465-1474, 2011.

Hardell L, Carlberg M, Söderqvist F, Hansson Mild K. Case-control study of the association between malignant brain tumours diagnosed between 2007 and 2009 and mobile and cordless phone use. Int J Oncol 43:1833-1845, 2013.

Health Canada. Human Health Risk Assessment for Priority Substances. Environmental Health Directorate. Canadian Environmental Protection Act. Ottawa, Ontario: Health Canada, 1994.

Health Canada. Health Canada Decision-Making Framework for Identifying, Assessing, and Managing Health Risk. Ottawa, Ontario: Health Canada, 2000.

Health Canada. Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 KHz to 200 GHz. Safety Code 6 (2015). Ottawa, Onatario: Health Canada, 2015.

Health Council of the Netherlands (HCN). Mobile Phones and Cancer. Part 1: Epidemiology of Tumours in the Head. The Hague, Netherlands: HCN, 2013.

Health Council of the Netherlands (HCN). Mobile Phones and Cancer. Part 2: Animal Studies on Carcinogenesis. The Hague, Netherlands: HCN, 2014.

Health Council of the Netherlands (HCN). Mobile Phones and Cancer. Part 3: Update and Overall Conclusions from the Epidemiological and Animal Studies. The Hague, Netherlands: HCN, 2016.

Hill AB. The environment and disease: Association or causation? Proc R Soc Med 58(5):295-300, 1965

Hillert L, Leitgeb N, Meara J. Working Group Report. pp. 15–26. In Hansson Mild K, Repacholi M, van Deventer E, Ravazzani P (eds.). Electromagnetic Hypersensitivity. Proceedings: International Workshop on EMF Hypersensitivity. Prague: WHO, 2006.

Hooijmans CR, Rovers MM, de Vries RB, Leenaars M, Ritskes-Hoitinga M, Langendam MW. SYRCLE's risk of bias tool for animal studies. BMC Med Res Methodol 14:43, 2014.

Houston BJ, Nixon B, McEwan KE, Martin JH, King BV, Aitken RJ, De Iuliis GN. Whole-body exposures to radiofrequency-electromagnetic energy can cause DNA damage in mouse spermatozoa via an oxidative mechanism. Sci Rep 9:17478, 2019.

İkinci Keleş A, Uzun Şahin C. Exposure to electromagnetic field, cell phone use behaviors, SAR values, and changes in health following exposure in adolescent university students. Arq Neuropsiquiatr 79(2):139-148 2021.

Innovation, Science and Economic Development Canada (ISED). TN-261 — Safety Code 6 (SC6) Radio Frequency Exposure Compliance Evaluation Template (Uncontrolled Environment Exposure Limits). Issue 3, March, 2015. https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf09976.html. Accessed April 27, 2021.

International Agency for Research on Cancer (IARC). Mechanisms of Carcinogenesis in Risk Identification. Lyon, France: IARC Press, 1992.

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Volume 102: Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. Lyon, France: IARC Press, 2011.

International Agency for Research on Cancer (IARC). Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 102. Lyon, France: IARC Press, 2013.

International Agency for Research on Cancer (IARC). IARC Monographs on the Identification of Carcinogenic Hazards to Humans, Preamble. Lyon, France: IARC Press, 2019.

International Agency for Research on Cancer (IARC). Agents Classified by the IARC Monographs, Volumes 1-129. Lyon, France: IARC, 2021. https://monographs.iarc.fr/agents-classified-by-the-iarc/. Accessed April 2021.

Institute of Electrical and Electronics Engineers (IEEE). IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 0 kHz to 300 GHz. New York, NY: IEEE, 2019.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys 74:494-522, 1998.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Exposure to High Frequency Electromagnetic Fields, Biological Effects and Health Consequences (100 kHz-300 GHz). Oberschleißheim, Germany: ICNIRP, 2009.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP note: Critical evaluation of two radiofrequency electromagnetic field animal carcinogenicity studies published in 2018. Health Phys 118: 525-532, 2019.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Guidelines for Limiting Exposure to Electromagnetic Fields (100 kHz to 300 GHz). Health Phys 118:483-524, 2020a.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP Note: Critical evaluation of two radiofrequency electromagnetic field animal carcinogenicity studies published in 2018. Health Phys 118:525-532, 2020b.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). Response to Melnick (2020). Health Phys 118(6):683-685, 2020c

INTERPHONE Study Group. Brain tumor risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Int J Epidemiol 39:675-694, 2010.

INTERPHONE Study Group. Acoustic neuroma in relation to mobile telephone use: Results of the INTERPHONE international case-control study. Cancer Epidemiol 35(5):453-464, 2011.

Jeong YJ, Son Y, Han NK, Hoi HD, Pack JK, Kim N, Lee YS, Lee HJ. Impact of Long-Term RF-EMF on Oxidative Stress and Neuroinflammation in Aging Brains of C57BL/6 Mice. Int J Mol Sci 19(7):2103, 2018.

Jiang B, Nie J, Zhou Z, Zhang J, Tong J, Cao Y. Adaptive response in mice exposed to 900 MHz radiofrequency fields: primary DNA damage. PLoS One 7(2):e32040, 2012.

Jiang B, Zong C, Zhao H, Ji Y, Tong J, Cao Y. Induction of adaptive response in mice exposed to 900 MHz radiofrequency fields: application of micronucleus assay. Mutat Res 751(2):127-129, 2013.

Johansson A, Forsgren S, Stenberg B, Wilén J, Kalezic N, Sandström M. No effect of mobile phone-like RF exposure on patients with atopic dermatitis. Bioelectromagnetics 29(5):353-362, 2008.

Jonwal C, Sisodia R, Saxena VK, Kesari KK. Effect of 2.45 GHz microwave radiation on the fertility pattern in male mice. Gen Physiol Biophys 37(4):453-460, 2018.

Kacprzyk A, Stefura T, Krzysztofik M, Rok T, Rokita E, Tatoń G. The Impact of Mobile Phone Use on Tinnitus: A Systematic Review and Meta-Analysis. Bioelectromagnetics 42(2):105-114, 2021.

Karipidis K, Elwood M, Benke G, Sanagou M, Tjong L, and Croft RJ. Mobile phone use and incidence of brain tumour histological types, grading or anatomical location: A population-based ecological study. BMJ Open 8:e024489, 2018.

Keinan-Boker L, Friedman E, Silverman BG. Trends in the incidence of primary brain, central nervous system and intracranial tumors in Israel, 1990-2015. Cancer Epidemiol 56:6-13, 2018.

Khalil AM, Abu Khadra, KM, Aljaberi AM, Gagaa MH, Issa HS. Assessment of oxidant/antioxidant status in saliva of cell phone users. Electromagn Biol Med 33:92-97, 2014.

Khalil AM, Alemam IF, Al-Qaoud KM. Association between mobile phone using and DNA damage of epithelial cells of the oral mucosa. J Biotechnol Biomed 3:050-066, 2020.

Kim SJ, Ioannides SJ, and Elwood JM. Trends in incidence of primary brain cancer in New Zealand, 1995 to 2010. Aust N Z J Public Health 39:148-152, 2015.

Kuhne J, Schmidt, J-A, Geschwentner G, Pophof B, Siegelberger G. Thermoregulatory stress as potential mediating factor in the NTP cell phone tumor study. Bioelectromagnetics 41:471-479, 2020.

Lagorio S and Röösli M. Mobile phone use and risk of intracranial tumors: A consistency analysis. Bioelectromagnetics 35:79-90, 2014.

Lahkola A, Auvinen A, Raitanen J, Schoemaker MJ, Christensen HC, Feychting M, Johansen C, Klaeboe L, Lonn S, Swerdlow AJ, Tynes T, Salminen T. Mobile phone use and risk of glioma in 5 North European countries. Int J Cancer 120:1769–1775, 2007.

Lai H. Genetic effects of non-ionizing electromagnetic fields. Electromagn Biol Med 2021 Feb 4:1-10. doi: 10.1080/15368378.2021.1881866. Epub ahead of print.

Langie SAS, Azqueta A, Collins, AR. The comet assay: past, present, and future. Front Genet 6:266, 2015.

Lazic SE. The problem of pseudoreplication in neuroscientific studies: is it affecting your analysis? BMC Neuroscience 2010, 11:5, 1-17, 2010.

Lee HJ, Jin YB, Kim TH, Pack JK, Kim N, Choi HD, Lee JS, Lee YS. The effects of simultaneous combined exposure to CDMA and WCDMA electromagnetic fields on rat testicular function. Bioelectromagnetics 33: 356-364, 2012.

Lerchl A, Klose M, Grote K, Wilhelm AF, Spathmann O, Fiedler T, Streckert J, Hansen V, Clemens M. Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans. Biochem Biophys Res Commun 459:585-590, 2015.

Lerchl A Klose M, Drees(née Grote) K. No increased DNA damage observed in the brain, liver, and lung of fetal mice treated with ethylnitrosourea and exposed to UMTS radiofrequency electromagnetic fields. Bioelectromagnetics 41:611-616, 2020.

Li K, Lu D, Guo Y, Wang C, Liu X, Liu Y, Liu D. Trends and patterns of incidence of diffuse glioma in adults in the United States, 1973-2014. Cancer Med 7(10):5281-5290, 2018.

López I, Félix N, Rivera M, Alonso A, Maestú C. What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid. Environ Res 194:110734, 2021.

Luo J, Deziel NC, Huang H, Chen Y, Ni X, Ma S, Udelsman R, and Zhang Y. Cell phone use and risk of thyroid cancer: A population-based case-control study in Connecticut. Ann Epidemiol 29:39-45, 2019.

Luo J, Li H, Deziel NC, Huang H, Zhao N, Ma S, Ni X, Udelsman R, Zhang Y. Genetic susceptibility may modify the association between cell phone use and thyroid cancer: A population-based case-control study in Connecticut. Environ Res 182:109013, 2020

Martens AL, Slottje P, Timmermans DRM, Kromhout H, Reedijk M, Vermeulen RCH, Smid T. Modeled and perceived exposure to radiofrequency electromagnetic fields from mobile-phone base stations and the development of symptoms over time in a general population cohort. Am J Epidemiol 186:210-219, 2017.

Martens AL, Reedijk M, Smid T, Huss A, Timmermans D, Strak M, Swart W, Lenters V, Kromhout H, Verheij R, Slottje P, Vermeulen RCH. Modeled and perceived RF-EMF, noise and air pollution and symptoms in a population cohort. Is perception key in predicting symptoms? Sci Total Environ 639:75-83, 2018.

Megha K, Deshmukh PS, Banerjee BD, Tripathi AK, Ahmed R, Abegaonkar MP. Low intensity microwave radiation induced oxidative stress, inflammatory response and DNA damage in rat brain. Neurotoxicology 51:158-165, 2015.

Melnick RL. Commentary on the utility of the National Toxicology Program study on cell phone radiofrequency radiation data for assessing human health risks despite unfounded criticisms aimed at minimizing the findings of adverse health effects. Environ Res 168:1-6, 2019.

Melnick R. Regarding ICNIRP'S Evaluation of the National Toxicology Program's Carcinogenicity Studies on Radiofrequency Electromagnetic Fields. Health Phys 118:678-682, 2020.

Meng J, Wang F, Chen R, Hua H, Yang Q, Yang D, Wang N, Li X, Ma F, Huang L, Zou Z, Li M, Wang T, Luo Y, Li Y, Liu Y. Association between the pattern of mobile phone use and sleep quality in Northeast China college students. Sleep Breath 2021 Feb 2. doi: 10.1007/s11325-021-02295-2. Epub ahead of print.

Moon IS, Kim BG, Kim J, Lee JD, Lee WS. Association between vestibular schwannomas and mobile phone use. Tumour Biol 35:581-587, 2014.

National Research Council (NRC). Committee on the Possible Effects of Electromagnetic Fields on Biologic Systems. Possible Health Effects of Exposure to Residential Electric and Magnetic Fields. Washington DC: National Academies Press, 1997.

National Research Council (NRC). Reference Manual on Scientific Evidence. Third Edition. Washington, DC: The National Academies Press, 2011.

National Toxicology Program (NTP). DRAFT NTP Technical Report on the Toxicology and Carcinogenesis Studies in Hsd: Sprague Dawley SD Rats Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Research Triangle Park, NC: NTP, 2018a.

National Toxicology Program (NTP). DRAFT NTP Technical Report on the Toxicology and Carcinogenesis Studies in B6C3F1/N Mice Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Research Triangle Park, NC: NTP, 2018b.

National Toxicology Program (NTP). NTP Technical Report on the Toxicology and Carcinogenesis Studies in Hsd: Sprague Dawley SD Rats Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Research Triangle Park, NC: NTP, 2018c.

National Toxicology Program (NTP). NTP Technical Report on the Toxicology and Carcinogenesis Studies in B6C3F1/N Mice Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Research Triangle Park, NC: NTP, 2018d.

National Toxicology Program (NTP). Handbook for Conducting a Literature-Based Health Assessment Using OHAT Approach for Systematic Review and Evidence Integration. Office of Health Assessment and Translation (OHAT), Division of the National Toxicology Program, 2019.

Natukka T, Raitanen J, Haapasalo H, Auvinen A. Incidence trends of adult malignant brain tumors in Finland, 1990-2016. Acta Oncol 58:990-996, 2019.

Nilsson J, Jaras J, Henriksson R, Holgersson G, Bergstrom S, Estenberg J, Augustsson T, and Bergqvist M. No Evidence for Increased Brain Tumour Incidence in the Swedish National Cancer Register between Years 1980-2012. Anticancer Res 39:791-96, 2019.

Organization for Economic Cooperation and Development (OECD). Guidance Document 116 on the Conduct and Design of Chronic Toxicity and Carcinogenicity Studies, Supporting Test Guidelines 451, 452 and 453, Second Edition. Paris: OECD, 2012.

Organization for Economic Cooperation and Development (OECD). Guidance Document on Revisions to OECD Genetic Toxicity Test Guidelines. Paris: OECD, 2015.

Olsson A, Bouaoun L, Auvinen A, Feychting M, Johansen C, Mathiesen T, Melin B, Lahkola A, Larjavaara S, Villegier AS, Byrnes G, Deltour I, Schuz J. Survival of glioma patients in relation to mobile phone use in Denmark, Finland and Sweden. J Neurooncol 141:139-149, 2019.

Ouadah NS, Lecomte A, Robidel F, Olsson A, Deltour I, Schüz J, Blazy K, Villégier AS. Possible effects of radiofrequency electromagnetic fields on in vivo C6 brain tumors in Wistar rats. J Neurooncol 140(3):539-546, 2018.

Philips A, Henshaw DL, Lamburn G, O'Carroll MJ. Brain tumours: Rise in glioblastoma multiforme incidence in England 1995-2015 suggests an adverse environmental or lifestyle factor. J Environ Public Health 2018:7910754, 2018a.

Philips A, Henshaw DL, Lamburn G, O'Carroll MJ. Authors' Comment on "Brain tumours: Rise in glioblastoma multiforme incidence in England 1995-2015 suggests an adverse environmental or lifestyle factor." J Environ Public Health 2018:2170208, 2018b.

Prasad M, Kathuria P, Nair P, Kumar A, Prasad K. Mobile phone use and risk of brain tumours: a systematic review of association between study quality, source of funding, and research outcomes. Neurol Sci 38:797-810, 2017.

Radwan M, Jurewicz, J, Merecz-kot, D, Sobala W, Radwon P, Hanke W. Sperm DNA damage—the effect of stress and everyday life factors. Int J Impot Res 28:148-154, 2016.

Revanth MP, Aparna S, Madankumar PD. Effects of mobile phone radiation on buccal mucosl cells: A systematic review. Electromagn Biol Med 39:273-281, 2020.

Romeo S, Zeni O, Sannino A, Lagorio S, Biffoni M, Scarfì MS. Genotoxicity of radiofrequency electromagnetic fields: Protocol for a systematic review of in vitro studies. Environ Int 148106386, 2021.

Röösli M, Lagorio S, Schoemaker MJ, Schüz J, Feychting M. Brain and Salivary Gland Tumors and Mobile Phone Use: Evaluating the Evidence from Various Epidemiological Study Designs. Ann Rev Public Health. 40:221-238, 2019.

Ros-Llor I, Sanchez-Siles M, Camacho-Alonso F, Lopez-Jornet P. Effect of mobile phones on micronucleus frequency in human exfoliated oral mucosal cells. Oral Dis 18:786-792, 2012 [erratum: Oral Dis 19:109-110, 2013].

Rothman KJ and Greenland S. Modern Epidemiology. Philadelphia: Lippincott Williams and Wilkins, 1998.

Royal Society of Canada (RSC) Expert Panel (with Paul Demers [chair], Richard Findlay, Kenneth R. Foster, Bryan Kolb, John Moulder, Anne-Marie Nicol, Frank Prato, Rianne Stam). A Review of Safety Code 6 (2013): Health Canada's Safety Limits for Exposure to Radiofrequency Fields. Ottawa, Ontario: Royal Society of Canada, 2014.

Sahin D, Ozgur E, Guler G, Tomruk A, Unlu I, Sepici-Dincel A, Seyhan N. The 2100 MHz radiofrequency radiation of a 3G-mobile phone and the DNA oxidative damage in brain. J Chem Neuroanat 75:94-98, 2016.

Sara G, Stefano M, Mariagrazia B, Paola T. Cancerogenic effects of radiofrequency radiation: A statistical reappraisal. Environ Res 191:10233, 2020.

Sato Y, Kiyohara K, Kojimahara N, Yamaguchi N. Time trend in incidence of malignant neoplasms of the central nervous system in relation to mobile phone use among young people in Japan. Bioelectromagnetics 37:282-289, 2016.

Sato Y, Kojimahara N, Yamaguchi N. Analysis of mobile phone use among young patients with brain tumors in Japan. Bioelectromagnetics 38(5):349-355, 2017.

Satta G, Mascia N, Serra T, Salis A, Saba L, Sanna S, Zucca MG, Angelucci E, Gabbas A, Culurgioni F, Pili P, Mura E, Cappai M, Ennas MG, Cocco P. Estimates of environmental exposure to radiofrequency electromagnetic fields and risk of lymphoma subtypes. Radiat Res 189:541-547, 2018.

Schoeni A, Roser K, Bürgi A, Röösli M. Symptoms in Swiss adolescents in relation to exposure from fixed site transmitters: a prospective cohort study. Environ Health 15(1):77, 2016.

Schoeni A, Roser K, Roosli M. Symptoms and the use of wireless communication devices: A prospective cohort study in Swiss adolescents. Environ Res 154:275-283, 2017.

Schuermann D, Ziemann C, Barekati Z, et al. Assessment of genotoxicity in human cells exposed to modulated electromagnetic fields of wireless communication devices. Genes (Basel) 11(4):347, 2020.

Scientific Committee on Health, Environmental and Emerging Risks (SCHEER). Memorandum of weight of evidence and uncertainties Revision 2018. Brussels, Belgium: European Commission, 2018.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). Health Effects of Exposure to EMF. Brussels, Belgium: European Commission, 2009.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). Memorandum on the Use of the Scientific Literature for Human Health Risk Assessment Purposes – Weighting of Evidence and Expression of Uncertainty. Brussels, Belgium: European Commission, 2012.

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). Opinion on Potential Health Effects of Exposure to Electromagnetic Fields (EMF). Brussels, Belgium: European Commission, 2015.

Selmaoui B, Andrianome S, Ghosn R, de Seze R. Effect of acute exposure to radiofrequency electromagnetic fields emitted by a mobile phone (GSM 900 MHz) on electrodermal responsiveness in healthy human. Int J Radiat Biol 94(10):890-895, 2018.

Senturk E, Tugrul S, Dog˘an R, Eren SB, Ozturan O, Koçyiğit A, Kesgin S. Effect of radiofrequency on DNA damage and oxidative status in patients with turbinate hypertrophy. Indian J Otolaryngol Head Neck Surg. 71(Suppl 3):S1810-S1815, 2019.

Shaikh A, Khichada K, Chandel D. Effect of cell phone radiation on buccal mucosa cells. World J Environ Biosci 5(1):9-17, 2016

Sharma S, Shukla S. Effect of electromagnetic radiation on redox status, acetylcholine esterase activity and cellular damage contributing to the diminution of the brain working memory in rats. J Neurochem Anat 106:101784, 2020.

Shih YW, O'Brien AP, Hung CS, Chen KH, Hou WH, Tsai HT. Exposure to radiofrequency radiation increases the risk of breast cancer: A systematic review and meta-analysis. Exp Ther Med 21(1):23, 2021a.

Shih YW, O'Brien AP, Hung CS, Chen KH, Hou WH, Tsai HT. [Retracted]. Exposure to radiofrequency radiation increases the risk of breast cancer: A systematic review and meta-analysis. Exp Ther Med. 21(5):472, 2021b.

Singh NP, McCoy, MT, Tice RR, Schneider EL. A simple technique for quantitation of low levels of DNA damage in individual cells. Exper Cell Res 75:184-191, 1988.

Shrestha M, Raitanen J, Salminen T, Lahkola A, Auvinen A. Pituitary tumor risk in relation to mobile phone use: A case-control study. Acta Oncol 54:1159-1165, 2015.

Smith-Roe SL, Wyde ME, Stout MD, Winters JW, Hobbs CA, Shepard KG, Green AS, Kissling GE, Shockley KR, Tice RR, Bucher JR, Witt KL. Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure. Environ Mol Mutagen 61(2):276-290, 2020.

Stevens P. Effects of 5 s exposures to a 50 microT, 20 Hz magnetic field on skin conductance and ratings of affect and arousal. Bioelectromagnetics 22:219-223, 2001.

Sun X, Briel M, Brusse JW, You JJ, Akl EA, Mejza F, Bala MM, Bassler D, Mertz D, Diaz-Granados N, Vandvik PO, Malaga G, Srinathan SK, Dahm P, Johnston BC, Alonso-Coello P, Hassouneh B, Walter SD, Heels-Ansdell D, Bhatnagar N, Altman DG, Guyatt GH. Credibility of claims of subgroup effects in randomised controlled trials: systematic review. BMJ 344:e1553, 2012.

Swedish Radiation Safety Authority (SSM). Research 2016:15. Recent Research on EMF and Health Risk - Eleventh report from SSM's Scientific Council on Electromagnetic Fields, 2016. Including Thirteen years of electromagnetic field research monitored by SSM's Scientific Council on EMF and health: How has the evidence changed over time? Stockholm, Sweden: Swedish Radiation Safety Authority (SSM), 2016.

Swedish Radiation Safety Authority (SSM). Research 2018:09. Recent Research on EMF and Health Risk - Twelfth report from SSM's Scientific Council on Electromagnetic Fields, 2017. Stockholm, Sweden: Swedish Radiation Safety Authority (SSM), 2018.

Swedish Radiation Safety Authority (SSM). Research 2019:08. Recent Research on EMF and Health Risk - Thirteenth report from SSM's Scientific Council on Electromagnetic Fields, 2018. Stockholm, Sweden: Swedish Radiation Safety Authority (SSM), 2019.

Swedish Radiation Safety Authority (SSM). Research 2020:04. Recent Research on EMF and Health Risk - Fourteenth report from SSM's Scientific Council on Electromagnetic Fields, 2019. Stockholm, Sweden: Swedish Radiation Safety Authority (SSM), 2020.

Swiss Expert Group on Electromagnetic Fields and Non-ionising Radiation (BERENIS). Evaluation of the NTP and Ramazzini Studies. Newsletter Special Issue, November 2018. https://www.bafu.admin.ch/bafu/en/home/topics/electrosmog/newsletter-of-the-swiss-expert-group-on-electromagnetic-fields-a.html. Accessed April 2021.

Tillmann T, Ernst H, Streckert J, Zhou Y, Taugner F, Hansen V, Dasenbrock C. Indication of cocarcinogenic potential of chronic UMTS-modulated radiofrequency exposure in an ethylnitrosourea mouse model. Int J Radiat Biol 86(7):529-541, 2010.

US Environmental Protection Agency (USEPA). Reference Dose (RfD): Description and Use in Health Risk Assessments. Washington, DC: USEPA, 1993.

US Environmental Protection Agency (USEPA). Proposed Guidelines for Carcinogen Risk Assessments. EPA/600/P-92/003C. Washington, DC: USEPA, 1996.

US Environmental Protection Agency (USEPA). A Review of the Reference Dose and Reference Concentration Processes. EPA/630/P-02/002F. Washington, DC: USEPA, 2002.

US Environmental Protection Agency (USEPA). Guidelines for carcinogen risk assessment and supplemental guidance for assessing susceptibility from early-life exposure to carcinogens. EPA/630/P-03/001F. Washington, DC: USEPA, 2005.

U.S. Environmental Protection Agency (USEPA). Update on Ramazzini Institute Data in IRIS Assessments. Washington, DC: USEPA, 2013. https://www.epa.gov/iris/update-ramazzini-institute-data-iris-assessments. Accessed April 2021.

Vanishree M, Mavvikar V, Rudraraju A, Reddy RKMP, Kumar NHP, Quandri SJM. Significance of micronuclei in buccal smears of mobile phone users: A comparative study. J. Oral Maxillofacial Pathol 22:448-452, 2018.

Vila J, Bowman JD, Figuerola J, Moriña D, Kincl L, Richardson L, Cardis E. Development of a source-exposure matrix for occupational exposure assessment of electromagnetic fields in the INTEROCC study. J Expo Sci Environ Epidemiol 27(4):398-408, 2017 (Erratum in: J Expo Sci Environ Epidemiol 29:731, 2019; Erratum in: J Expo Sci Environ Epidemiol 29:860, 2019).

Vila J, Turner MC, Gracia-Lavedan E, Figuerola J, Bowman JD, Kincl L, Richardson L, Benke G, Hours M, Krewski D, McLean D, Parent ME, Sadetzki S, Schlaefer K, Schlehofer B, Schüz J, Siemiatycki J, van Tongeren M, Cardis E; INTEROCC Study Group. Occupational exposure to high-frequency electromagnetic fields and brain tumor risk in the INTEROCC study: An individualized assessment approach. Environ Int 119:353-365, 2018.

Vijayalaxmi and Prihoda TJ. Genetic damage in mammalian somatic cells exposed to radiofrequency radiation: a meta-analysis of data from 63 publications (1990-2005). Radiat Res 169(5):561-574, 2008.

Vijayalaxmi. Biological and health effects of radiofrequency fields: Good study design and quality publications. Mutat Res 810:6-12, 2016.

Vijayalaxmi and Prihoda TJ. Genetic damage in human cells exposed to non-ionizing radiofrequency fields: a meta-analysis of the data from 88 publications (1990-2011). Mutat Res 749(1-2):1-16, 2012.

Vijayalaxmi and Prihoda TJ. Comprehensive Review of Quality of Publications and Meta-analysis of Genetic Damage in Mammalian Cells Exposed to Non-Ionizing Radiofrequency Fields. Radiat Res 191(1):20-30, 2019.

Vijayalaxmi, Foster KR, Miyakoshi J, Verschaeve L. Comments on the "Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure" by Smith-Roe et al. Environ Mol Mutagen 61(2):291-293, 2020.

Wang R, Lagakos SW, Ware JH, Hunter DJ, Drazen JM. Statistics in medicine--reporting of subgroup analyses in clinical trials. N Engl J Med 357(21):2189-2194, 2007.

Wang Y and Guo X. Meta-analysis of association between mobile phone use and glioma risk. J Cancer Res Ther 12:C298-c300, 2016.

Wang P, Hou C, Li Y, Zhou D. Wireless phone use and risk of adult glioma: Evidence from a meta-analysis. World Neurosurg 115:e629-e36, 2018.

Wdowiak A, Błachnio A, Raczkiewicz D, Misztal-Okońska P, Iwanowicz-Palus G, Bień A, Zybała M, Bojar I. The influence of electromagnetic fields generated by wireless connectivity systems on the occurrence of emotional disorders in women: A preliminary report. Neuro Endocrinol Lett 39(8):550-560, 2019.

Wilén J, Johansson A, Kalezic N, Lyskov E, Sandstrom M. Psychophysiological tests and provocation of subjects with mobile phone related symptoms. Bioelectromagnetics 27:204-214, 2006.

World Health Organization (WHO). International Programme on Chemical Safety (IPCS). Environmental Health Criteria 170; Assessing Human Health Risks of Chemicals: Derivation of Guidance Values for Health-Based Exposure Limits. Geneva: WHO, 1994.

World Health Organization (WHO). WHO Human Health Risk Assessment Toolkit: Chemical Hazards. Geneva: WHO, 2010.

World Health Organization (WHO). Draft WHO Environmental Health Criteria Monograph on Radiofrequency Fields released for Consultation. Geneva: WHO, 2014.

Wright C, Milne S, Leeson H. Sperm DNA damage caused by oxidative stress: modifiable clinical, lifestyle and nutritional factors in male infertility. Reprod Biomed Online 28:684-703, 2014.

Yang M, Guo W, Yang C, Tang J, Huang Q, Feng S, Jiang A, Xu X, Jiang G. Mobile phone use and glioma risk: A systematic review and meta-analysis. PLoS One 12:e0175136, 2017.

Yoon S, Choi JW, Lee E, An H, Choi HD, Kim N. Mobile phone use and risk of glioma: A case-control study in Korea for 2002-2007. Environ Health Toxicol 30:e2015015, 2015.

Zong C, Ji Y, He Q, Zhu S, Qin F, Tong J, Cao Y. Adaptive response in mice exposed to 900 MHz radiofrequency fields: Bleomycin-induced DNA and oxidative damage/repair. Int J Radiat Biol 91:270-276, 2015.

Zothansiama, Zosangzuali M, Lalramdinpuii M, Jagetia GC. Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile base stations. Electromagn Biol Med 36:295-305, 2017.

Literature identified but not cited

As SCENIHR notes, "*In some areas where the literature is particularly scarce, it has been considered important to explain why the results of certain studies do not add useful information to the database*" (SCENIHR, 2015, p. 22). Identified studies that have not been considered in this report because they did not fulfill quality criteria are listed below:

Experimental Studies

Reference	Reason Not Included
Erdem Koç G, Kaplan S, Altun G, Gümüş H, Gülsüm Deniz Ö, Aydin I, Emin Onger M, Altunkaynak Z. Neuroprotective effects of melatonin and omega-3 on hippocampal cells prenatally exposed to 900 MHz electromagnetic fields. Int J Radiat Biol 92(10):590-595, 2016.	Incomplete data analysis; This study was rejected for review by SSM (2018) because of incomplete dosimetry.
Ibitayo AO, Afolabi OB, Akinyemi AJ, Ojiezeh TI, Adekoya KO, Ojewunmi OO. RAPD Profiling, DNA Fragmentation, and Histomorphometric Examination in Brains of Wistar Rats Exposed to Indoor 2.5 Ghz Wi-Fi Devices Radiation. Biomed Res Int 2017:8653286, 2017.	No exposure description, no randomized assignment to treatment, no blinding, no quantitative analyses.
Kivrak EG, Altunkaynak BZ, Alkan I, Yurt KK, Kocaman A, Onger ME. Effects of 900-MHz radiation on the hippocampus and cerebellum of adult rats and attenuation of such effects by folic acid and *Boswellia sacra*. J Microsc Ultrastruct 5(4):216-224, 2017.	No sham control and multiple other problems
Pandey N and Giri S. Melatonin attenuates radiofrequency radiation (900 MHz)-induced oxidative stress, DNA damage and cell cycle arrest in germ cells of male Swiss albino mice. Toxicol Ind Health 34(5):315-327, 2018.	No sham control.
Pandey N, Giri S, Das S, Upadhaya P. Radiofrequency radiation (900 MHz)-induced DNA damage and cell cycle arrest in testicular germ cells in swiss albino mice. Toxicol Ind Health 33(4):373-384, 2017.	No sham control.
Prado PGS, Santos MALD, de Sousa, AFSSF, Coelho M, Takeshita, WM. Evaluation of genotoxic and cytotoxic effects between different smart phone brands in the oral mucosa epithelium. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 130,: e273-e274, 2020.	Abstract only.
Shahabi S, Hassanzadeh Taji I, Hoseinnezhaddarzi M, Mousavi F, Shirchi S, Nazari A, Zarei H, Pourabdolhossein F. Exposure to cell phone radiofrequency changes corticotrophin hormone levels and histology of the brain and adrenal glands in male Wistar rat. Iran J Basic Med Sci 21(12):1269-1274, 2018.	Poor exposure, no randomized assignment to treatment, no blinding.
Yilmaz A, Yilmaz N, Serarslan Y, Aras M, Altas M, Özgür T, Sefil F. The effects of mobile phones on apoptosis in cerebral tissue: an experimental study on rats. Eur Rev Med Pharmacol Sci 2014;18(7):992-1000.	Poor exposure; no randomized assignment to treatment; no blinding.
Gandi, G, Singh P, Kaur G. Perspectives revisited – the buccal cytome assay in mobile phone users. Int. J Hum Genet. 15:173-182, 2015b.	Paper appears to be reanalysis of data presented in Gandhi and Singh (2005) and response to criticism by Vijayalaxi et al. (2007), IARC (2013), and Revanth et al. (2020).

Epidemiologic Studies

Reference	Reason Not Included
Al-Qahtani K. Mobile Phone Use and the Risk of Parotid Gland Tumors: A Retrospective Case-Control Study. Gulf J Oncolog 1(20):71-78, 2016.	Not a peer-reviewed publication; this study was rejected by SSM (2018).
Carlberg M and Hardell L. Evaluation of Mobile Phone and Cordless Phone Use and Glioma Risk Using the Bradford Hill Viewpoints from 1965 on Association or Causation. Biomed Res Int 2017:9218486, 2017.	This publication was rejected by SSM (2019) for being a narrative review (i.e., secondary research).
Hallberg O. Cancer incidence vs. FM radio transmitter density. Electromag Biol Med 35:343-347, 2016a; Hallberg, O. Cancer versus RM radio polarization types. Eur J Cancer Prev 25:357-360, 2016b.	In their 2017 review, SSM noted that *"[d]ue to unclear methods (unclear selection of areas in Sweden, unclear selection of European countries), undefined source of transmitter data, undefined source and undefined underlying types of cancer data, lack of individual exposure estimates, the study is not informative as to an association of FM radio transmitters and the types of cancer in question"* (p. 72).
Kjellqvist A, Palmquist E, Nordin S. Psychological symptoms and health-related quality of life in idiopathic environmental intolerance attributed to electromagnetic fields. J Psychosom Res 2016;84:8-12.	Did not include any form of RF exposure assessment; this study was rejected by SSM (2018) for not in any way studying the association between RF fields and a health outcome.
Lin JC. Mobile-phone RF/Microwave exposure and memory performance scores in adolescents. Radio Science Bulletin 366:32-35, 2018.	Not a peer-reviewed publication.
Martens AL, Slottje P, Smid T, Kromhout H, Vermeulen RCH, Timmermans DRM. Longitudinal associations between risk appraisal of base stations for mobile phones, radio or television and non-specific symptoms. J Psychosom Res 112:81-89, 2018.	Study of associations between risk appraisal of base stations and non-specific symptoms; this study was rejected by SSM (2020) for not studying non-ionizing electromagnetic fields

Appendix 1

Summary of Animal DNA and Chromosome Studies

Study	Species	Sex (Weight, g)	N/group	Frequency	SAR (W/kg)	Duration	Cytogenetic	Comet Assay (SSB)				Oxidation (8-OHdG)
								Brain	Liver	Blood	Testes/Lung	
Furtado-Filho et al. (2014)	Rat	M+ F (?) M Day 0 (5-6) Day 6 (10-12) Day 15 (22-32) Day 30 (46-78)	6	950 MHz	Prenatal 0.03-0.01 0 days 0.88 6 DAYS 0.51 15 days 0.18 30 days 0.06	0.5 hr x (21 prenatal + 0, 6, 15, 30 days)			NO 0 days 6 days ↓15 days ↑30 days			
Furtado-Filho et al. (2015)	Rat	M+ F (?) M Day 0 (5-6) Day 5 (10-12)	6	950 MHz	Prenatal 0.35-0.55 0 days 1.32 6 days 1.14	0.5 hr x (21 + 0, 6 days)		NO				
Deshmukh et al. (2015)		M (150-200)		900, 1,800, or 2,450 MHz	0.0005953 0.0005835 0.0006672	180		√				
Zong et al. (2015)	Mouse	M (25)	8	900 MHz	0.0548	7			NO	NO		
Sahin et al. (2016)	Rat	F (200–256)	6-9	2.1 GHz	0.4	10, 40		√				↑10 days ↓40 days
Akdag et al. (2016)	Rat	M (313)	8	2. GHz	0.0001414	12 mo		NO	NO		√-Testis/No-Lung	
Güler et al. (2016)	Rabbit	M, F	9	1.800 MHz	0.018	15 min/day 1 mo +		NO- Brain NO-TUNEL				
Jeong et al (2018)	Mouse	F ?	14	1,950 MHz	5	22 mo		NO				NO
Jonwal et al (2018)	Mouse	F ?	12	2.45 GHz	0.09	30						NO
Alkis et al. (2019a)	Rat	M (283)	7	900 MHz, 1,800 MHz, 2,100 MHz	0.638 0.166 0.174	2 hr/day 6 mo		NO NO √				√ √ √
Alkis et al. (2019b)	Rat	M (~282)	7	900 MHz, 1,800 MHz, 2,100 MHz	0.638 0.166 0.174	2 hr/day 6 months					NO-tm, ti/ NO-tm,√-ti/ NO-tm,√-ti/	√ √ Testes √
Houston et al. (2019)	Mouse	M (30-33)	3 ? 3	905 MHz	2.2	12 hr/day 1, 3, 5 wks	Testis – NO Sperm				NO- γH2AX/ NO tail intensity/ √ -Halo/	√ -Sperm
Lerchl et al. (2020)	Mouse	M/F (20)	3-6 (pregnant mice)	Ethylnitrosourea + 1,960 (UMTS)	0.04 0.4	24 hr 36 hr 72 hr	NO NO NO	NO NO NO	NO NO NO		/NO /NO /NO	
Sharma and Shukla (2020)	Rat	M (120-150)	6	900 MHz	0.231	1 hr/day 2 hr/day 4 hr/day 90 days	√ √ √	√ tm, tl, % cells √ tm, tl, % cells √ tm, tl, % cells				
Smith-Roe et al., 2020*	Mouse	F	5C 15E	1,900 MHz (GSM)	2.5-10	14 wk	NO#	NO	NO	NO		
Smith-Roe et al., 2020*	Mouse	F	5C 15E	1,900 MHz (CDMA)	2.5 10	14 wk	NO#	NO	NO	NO		

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Study	Species	Sex (Weight, g)	N/group	Frequency	SAR (W/kg)	Duration	Cytogenetic	Comet Assay (SSB)				Oxidation (8-OHdG)
								Brain	Liver	Blood	Testes/Lung	
Smith-Roe et al., 2020*	Mouse	M	5C 15E	1,900 MHz (GSM)	2.5 10	14 wk	NO[#]	√ (only 10 W/kg)	NO	NO		
Smith-Roe et al., 2020*	Mouse	M	5C 15E	1,900 (CDMA)	2.5-10	14 wk	NO[#]	√ (only 5, 10 W/kg)	NO	NO		
Smith-Roe et al., 2020*	Rat	M	5C 15E	900 (CDMA)	1.5-6	19 wk	NO[#]	√ (only 6 W/kg) (only Hippocampus)	NO	NO		
Smith-Roe et al., 2020*	Rat-	M	5C 15E	900 (GSM)	1.5-6	19 wk	NO[#]	NO	NO	NO		
Smith-Roe et al., 2020*	Rat	F	5C 15E	900 (CDMA)	1.5-6	19	NO[#]	NO	NO	NO		
Smith-Roe et al., 2020*	Rat	F	5C 15E	900 (GSM)	1.5-6	19	NO[#]	NO	NO	NO		
Alkis et al., 2021	Rat	M (280)	6	1,800 MHz, 2,100 MHz	0.62 0.2	2 hr/day 7 months			NO-tm, √-ti NO-tm, √-ti			√-Liver

*Results also reported in NTP (2018a, 2018b, 2018c, 2018d); # Cytogenetic analyses not reported in Smith Roe et al. (2020) but in NTP (2018a, 2018b, 2018c, 2018d).

Acronyms and Abbreviations: √-, Yes, reported; ti, comet tail intensity; tm, comet tail intensity; hr, hour; C, control; E, exposed.

Appendix 2

Curriculum Vitae of
Pamela Dopart, Ph.D., CIH, and
William H. Bailey, Ph.D.

Appendix G

FINANCIAL SCHEDULES

FILED CONFIDENTIALLY

Appendix G-1

AMI COST INPUTS

FILED CONFIDENTIALLY

Appendix G-2

BASELINE COST INPUTS

FILED CONFIDENTIALLY

Appendix G-3

AMI FINANCIAL SCHEDULES

FILED CONFIDENTIALLY

Appendix G-4

BASELINE FINANCIAL SCHEDULES

FILED CONFIDENTIALLY

Appendix G-5

INCREMENTAL FINANCIAL SCHEDULES

FILED CONFIDENTIALLY

Appendix H
CONSULTATION AND ENGAGEMENT

Appendix H-1

CONSULTATION, ENGAGEMENT AND COMMUNICATIONS PLAN

Advanced Gas Meters project

Consultation, Engagement and Communications Plan – Project Regulatory Phase

Overview

The Advanced Gas Meters project (AMI) proposes to upgrade FortisBC's (FEI) gas meters to new advanced meters. FEI recognizes the importance of meaningful consultation, engagement and communication on its projects. This is particularly true for AMI, as it includes upgrading the meters used by almost all its natural gas customers.

This plan intends to guide consultation, engagement and communication tactics throughout the project's early planning, public announcement and regulatory stages. Further consultation, engagement and communications plans to cover future project stages will be developed pending a British Columbia Utilities Commission decision.

Consultation, Engagement and Communication Objectives

To create awareness of AMI with customers, stakeholders, Indigenous communities and the public;

- Ensure balanced and objective information is available, promoted and understood.
- Communicate and engage effectively on the benefits of the new meters, and address concern or provide explanations when unable to do so.
- Create opportunities for customers, communities and stakeholders to provide feedback.

Sequencing

Subject	Process	Timeline
Pre-announcement consultation	• September 2019: Initial outreach to municipal partners and Indigenous communities.	Sept to Oct 2019

Launch project	• October 3, 2019: Publicly announce project including;
	  ○ news release and website
	  ○ notification letters to MLAs, municipal partners and Indigenous communities
		Oct 2019

Information sessions	• October 11, 2019: Government telephone town halls • October 15 - November 20, 2019: In-person public information sessions across FEI's service territory, promoted via digital and newspaper ads, social media and outreach to media outlets, as well as on FEI channels such as Energy Moment and on its online bill payment platform • February 18, 2021: Virtual information session for provincial, municipal and regional governments • February 23 & 24, 2021: Public virtual information sessions, promoted via newspaper and social media ads, as well as on FEI channels such as Energy Moment and on its online bill payment platform	Oct 2019 to Project Completion
Post-announcement consultation	• Ongoing consultation and engagement, including responding to customer inquiries, presenting to Indigenous communities when requested, and municipal discussions regarding joint-use opportunities • March and September 2020: Project updates (meter survey), via FEI channels • February 4, 2021: Notification letters to MLAs, municipal partners and Indigenous communities	Oct 2019 to March 2021
Regulatory filing	• Customer, Indigenous community, and public notifications that application has been filed, including details on getting involved in the process	April 2021

Appendix H-2

STAKEHOLDER AND GOVERNMENT CONSULTATION LOG

Advanced Gas Meters - Stakeholder and Government Consultation Log

Date	Consultation Type	External Representatives	FEI Representatives	Summary
25-Sep-19	In-Person Meeting	Lyn Hall, Mayor of Prince George	Matt Mason, Community and Indigenous Relations Manager	UBCM - FEI discussed the pre-CPCN activities with the Mayor. Advised Mayor Hall FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
25-Sep-19	In-Person Meeting	Colin Basran (Mayor of Kelowna), Councillors Maxine DeHart, Gail Given, Brad Selbert, Loyal Woolridge, Ryan Donn and Genelle Davidson	Shelley Martens, Community and Indigenous Relations Manager	UBCM - Preliminary discussion advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
25-Sep-19	In-Person Meeting	Spencer Coyne (Mayor), Councillor George Elliot and CAO Lyle Thomas	Shelley Martens, Community and Indigenous Relations Manager	UBCM - Preliminary discussion advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
25-Sep-19	In-Person Meeting	Municipality of Oliver Councillor Petra Veintimilla	Shelley Martens, Community and Indigenous Relations Manager	UBCM - Preliminary discussion advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
25-Sep-19	In-Person Meeting	City of Salmon Arm Councillor Kevin Flynn	Shelley Martens, Community and Indigenous Relations Manager	UBCM - Preliminary discussion advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
25-Sep-19	In-Person Meeting	City of Kamloops Mayor Ken Christian	Matt Mason, Community and Indigenous Relations Manager	UBCM - Mentioned the scope of the Advanced Gas Meters Project to the Mayor of Kamloops. Discussed the potential impact to the community and reassured the Mayor that FEI would proactively reach out to customers and address concerns.
25-Sep-19	In-Person Meeting	City of Mackenzie, Joan Atkinson (Mayor) and CAO Dean McKinley	Matt Mason, Community and Indigenous Relations Manager	UBCM - Spoke to the District about the scope of the Advanced Gas Meters Project and the estimated timelines.
26-Sep-19	In-Person Meeting	City of Pitt Meadows, CAO Mark Roberts	Darin Wong, Community and Indigenous Relations Manager	UBCM - Preliminary discussion advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
26-Sep-19	In-Person Meeting	City of Maple Ridge, Mike Morden (mayor)	Darin Wong, Community and Indigenous Relations Manager	UBCM - Preliminary discussion advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
30-Sep-19	Email	City of Burnaby James Lota, Deputy Director - Engineering	Darin Wong, Community and Indigenous Relations Manager	Preliminary notification advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
30-Sep-19	Email	City of Port Coquitlam Pardeep Purewal, Communications Manager	Darin Wong, Community and Indigenous Relations Manager	Preliminary notification advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
30-Sep-19	Email	City of Port Mody, Kate Zanon, General Manager of Community Services	Darin Wong, Community and Indigenous Relations Manager	Preliminary notification advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
30-Sep-19	Email	District of Mission, Michael Boronowski, Manager of Civic Engagement and Corporate Initiatives	Darin Wong, Community and Indigenous Relations Manager	Preliminary notification advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
30-Sep-19	Email	City of Abbotsford, Peter Sparanese, City Manager/CAO	Darin Wong, Community and Indigenous Relations Manager	Preliminary notification advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
30-Sep-19	Email	District of North Vancouver, David Stuart, City Manager/CAO	Darin Wong, Community and Indigenous Relations Manager	Preliminary notification advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
30-Sep-19	Email	City of North Vancouver, Leanne McCarthy, City Manager/CAO	Darin Wong, Community and Indigenous Relations Manager	Preliminary notification advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
30-Sep-19	Email	District of West Vancouver, Nina Leemhuis, City Manager/CAO	Darin Wong, Community and Indigenous Relations Manager	Preliminary notification advising that FEI would be announcing the Advanced Gas Meters Project. No further follow-up at this time.
3-Oct-19	Email	MLAs in FortisBC Service Territory	Vanessa Connolly – Sr. Manager, External Relations	FEI emailed Project announcement letters to MLAs in FEI gas service territory (Appendix X-2). The letter introduced the Project, and provided information on Project timeline and FEI's public engagement intentions. The letter included an invitation to take part in a telephone town hall session with FEI's Project Directors and External Relations senior leadership to learn more about the Project. Copy of the letter can be found in Appendix X-4. Conference call scheduled for Friday, October 10th at 9AM PST
3-Oct-19	Email	Chief Administrative Officers and City Managers in FortisBC Service Territory	Vanessa Connolly – Sr. Manager, External Relations	FEI emailed Project announcement letters to Chief Administrative Officers and City Managers in FEI's gas service territory (Appendix X-2). The letter introduced the Project, and provided information on Project timeline and FEI's public engagement intentions. The letter included an invitation to participate in a telephone town hall session with FEI Project directors and External Relations senior leadership to learn more about the Project. A copy of the letter can be found in Appendix X-4. Conference call scheduled for Friday, October 10th at 1PM PST.
4-Oct-19	In-Person Meeting	Melissa Sanderson, Sr. Ministerial Assistant to Minister Michelle Mungall - Ministry of Energy, Mines and Petroleum Resources	Jordan Bell, Government Relations and Public Affairs Manager	Provided a high-level overview of this Project as part of a discussion of FEI's resiliency initiatives across the Province. Provided copies of letters sent to MLAs and Indigenous communities. Questions raised by the Ministry regarded FEI's preparedness to engage the public. FEI assured the Ministry it had developed a comprehensive communications and engagement plan. FEI offered a follow-up meeting to discuss project details, which was accepted by the Ministry. Follow-up meeting scheduled for November 18, 2019
10-Oct-19	Telephone Town Hall (MLA)	Donna Barnett, MLA Cariboo-Chilcotin, Laurie Throness, MLA Chilliwack-Kent, Angelika Brunner, MLA Assistant to Katie Conroy Kootenay West.	Darren Julyan – Director Energy Measurement and Technology, Paul Kitchener – Project Director, Vanessa Connolly – Sr. Manager, External Relations, Blake Mansbridge – Manager, Community Relations	Questions from attendees included Project timelines, future consultation activities, potential rate impacts and meter technology. A copy of the presentation can be found in Appendix X-16.
10-Oct-19	Telephone Town Hall (Municipal)	Freya Phillips, Kootenay Boundary – Sr. Energy Specialist, David Reid, Grand Forks – CAO, Jason Ho, City of Richmond – Manager, Engineering, Randy Evans, Pitt Meadows – Manager Parks and Operations, Ellen McAvany, Chetwynd – Economic Development Manager.	Darren Julyan – Director Energy Measurement and Technology, Paul Kitchener – Project Director, Vanessa Connolly – Sr. Manager, External Relations, Blake Mansbridge – Manager, Community Relations	One question raised inquiring about estimated Project cost and any potential for cost savings. Explained that FEI is in the process of establishing this information along with Project costs. FEI encouraged attendees to be involved in the application process once it is submitted which will provide more information. A copy of the presentation can be found in Appendix X-16.
18-Nov-19	In-Person Meeting	Paul Wieringa – Executive Director, Electricity Branch, Katherine Rowe - Director, Jennifer Davison – Policy Analyst - Ministry of Energy, Mines and Petroleum Resources	Jordan Bell - Government Relations and Public Affairs Manager, Vanessa Connolly – Sr. Manager, External Relations and Communications	The meeting was part of a larger FEI major projects discussion. Questions from the Ministry focused on meter technology and resiliency, such as the ability to remotely shut-off meters in the event of an emergency and potential for remote reconnection as well. The meeting was positively received and no further follow-up meetings were scheduled to discuss the Project. No further follow-up at this time.
12-Dec-19	In-Person Meeting	City of Williams Lake, Walter Cobb, Mayor, and Milo MacDonald, City Manager	Matt Mason - Community and Indigenous Relations Manager, Ian Turnbull – Damage Prevention & Emergency Services Manager.	Provided an overview of the Project and the timing of filing the application. The City has expressed interest in collaborating with FEI in the future for water metering/network leasing opportunities. No further follow-up at this time.
21-Feb-20	In-Person Meeting	BC Hydro and Power Authority - Greg Alexis - Manager of Public Affairs and Community Relations Site C, Johnson Lee	Blake Mansbridge – Manager, Community Relations, Antonio Bebic - Community Relations Liaison	Met with BC Hydro and Power Authority subject matter experts on the BC Hydro Smart Meter program. Discussion revolved around lessons learned and engagement opportunities for the BCHydro smart meter program and general knowledge sharing as it relates to the advanced gas meters project.

Date	Consultation Type	External Representatives	FEI Representatives	Summary
18-Mar-20	Virtual Meeting	City of Burnaby Johan Steenkamp, Sr.Project Manager Engineering, Jonathan Helmus, Director of Infrastructure	Paul Kitchener – Project Director, Mike Bains – Community & Indigenous Initiatives Manager, Darin Wong – Community & Indigenous Relations Manager, Blake Mansbridge – Manager, Community Relations Major Projects	City of Burnaby proactively contacted FEI to discuss potential third-party network use to support future commercial and residential water metering deployment. Discussions included network capabilities, operating models and interest in potential street and traffic light systems upgrades. The City of Burnaby sought follow-up meetings with FEI for further discussion. Follow-up meeting to be scheduled.
13-May-20	Virtual Meeting	City of Surrey, Yonatan Yohannes, Manager General Utilities, Tara Macrae, Manager Water Utilities, Sig Bernat, Superintendent Water Metering	Paul Kitchener – Project Director, Mike Bains – Community & Indigenous Initiatives Manager, Darin Wong – Community & Indigenous Relations Manager, Antonio Bebic – Community Relations Liaison, Major Projects	FEI met with the City of Surrey, as there is interest in joint-use of the Advanced Gas Meters network that could be shared by the City of Surrey as they look to move forward with remote water meters. Meeting served as a general Project overview discussion and preliminary discussions on what joint-use models may look like. City of Surrey will schedule a follow-up meeting for further discussion. Follow-up meeting to be scheduled.
1-Jun-20	Virtual Meeting	City of Nanaimo, Bill Sims, Manager Engineering and Public Works, Mike Squire, Manager Water Works, Paul Rosen, Director Engineering, John Elliot, Director Public Works	Paul Kitchener – Project Director, Mike Bains – Community & Indigenous Initiatives Manager, Carmen Driechel – Community & Indigenous Relations Manager, Antonio Bebic, Community Relations Liaison Major Projects.	Preliminary meeting to discuss network sharing potential with FEI. Questions asked by the City of Nanaimo staff were regarding technical aspects of the meter fleet. City of Nanaimo staff also outlined the City's plan for future water metering. Follow-up meeting to be scheduled to discuss further. Follow-up meeting to be scheduled
8-Jun-20	Virtual Meeting	City of Campbell River, Deb Sargent, City Manager, Ron Neufeld, Deputy City Manager, Drew Hadfield, Manager Utilities, Warren Kalyn, IT Manager	Darren Julyan – Director Energy Measurement and Technology, Paul Kitchener – Project Director, Mike Bains – Community & Indigenous Initiatives Manager, Carmen Driechel – Community & Indigenous Relations Manager, Antonio Bebic, Community Relations Liaison Major Projects.	Preliminary meeting to discuss network sharing potential with FEI. Meeting discussed current status of water metering in Campbell River and how FEI could support a water metering deployment with network sharing. Follow-up meeting to be scheduled for further discussions with the Municipality. Follow-up meeting to be scheduled.
25-Jun-20	Virtual Meeting	City of Kamloops, Greg Wightman, Utility Manager, Augie Carusi, Operations supervisor	Paul Kitchener – Project Director, Mike Bains – Community & Indigenous Initiatives Manager, Matt Mason – Community & Indigenous Relations Manager.	Preliminary meeting with City of Kamloops to discuss joint-use potential with FEI's Advanced Gas Meters wireless network to support municipal water metering. The City of Kamloops is still evaluating options, but remains interested in potential partnerships. Follow-up meetings to be scheduled to discuss further with FEI technical staff. Follow-up meeting to be scheduled.
10-Nov-20	Virtual Meeting	Institure for Catastrophic Loss Reduction (ICLR)	Blake Mansbridge – Manager, Community Relations, Jordan Bell - Government Relations & Public Affairs Manager, Tracy Hon - Insurance Manager	Met with members from the ICLR who provided an overview of the work they do in assessing risks associated with natural disasters and disaster prevention research and communication. Discussion focused primarily on the scope of the advanced meters project and safety benefits proposed with the remote shut-off capability. The ICLR appreciated all the safety enhancements proposed by the Project, and recommended that FEI investigate the option of including seismic shut-off valves within the meter. FEI appreciated the information provided, and will explore seismic valves for the Project.
4-Feb-21	Email	MLAs in FortisBC Service Territory	Antonio Bebic, Community Relations Liaison	FEI emailed Project update letters to MLAs in the FEI gas service territory (Appendix X-2). The letter included a Project update, engagement activities since Project launch and FEI's intention to file the Application. The letter included an invitation to take part in a virtual information session with FEI's Project Directors and External Relations representatives to learn more about the Project. Copy of the letter can be found in Appendix X-22. Virtual Information Session scheduled for Thursday, February 18th at 3PM PST.
4-Feb-21	Email	Chief Administrative Officers and City Managers in FortisBC Service Territory	Antonio Bebic, Community Relations Liaison	FEI emailed Project update letters to Chief Administrative Officers and City Managers in the FEI gas service territory (Appendix X-2). The letter included a Project update, engagement activities since Project launch and FEI's intention to file the Application. The letter included an invitation to take part in a virtual information session with FEI's Project Directors and External Relations representatives to learn more about the Project. Copy of the letter can be found in Appendix X-23. Virtual Information Session scheduled for Thursday, February 18th at 1PM PST.
18-Feb-21	Virtual Information Session	City of Vancouver - Brandon Hildebrandt, Andrea Becker, Hammad Qazi, Echo Liao, Carole Noble. Metro Vancouver - George Friedrich, Adrian Lynch, City of Parksville - Guy Martin, City of Trail - Craig Speers, City of Port Coquitlam - Rana McLean, City of Courtenay - Rodney Armstrong, Cowichan Valley Regional District - Austin Tokarek, Village of Belcarra - Stewart Novak, City of Delta - Evan Chrystall.	Darren Julyan – Director Energy Measurement and Technology, Paul Kitchener – Project Director, Joel Lindsay - Project Director, Sarah Wager - Regulator, Antonio Bebic - Community Relations Liaison, Blake Mansbridge – Manager, Community Relations, Darin Wong - Community and Indigenous Relations Manager, Greg Edgelow - Indigenous Relations Manager	Presentation provided to attendees regarding Project scope, timeline and details about the proposed meter and joint-use opportunities. A number of technical questions received about the proposed network and what joint-use opportunities can be offered to Municipalitles seeking to leverage the proposed network to support water meter deployments. All questions were addressed and no further follow-up required. A copy of the presentation can be found in Appendix X-24
18-Feb-21	Virtual Information Session	MLA Jordan Sturdy, Angelika Brunner - Assistant to MLA Katrine Conroy, MLA Ben Stewart, MLA Henry Yao, MLA Michael Lee, Sherill Gullickson - Assistant to MLA Aman Singh, Karynn Carveth - Assistant to MLA John Horgan	Darren Julyan – Director Energy Measurement and Technology, Paul Kitchener – Project Director, Joel Lindsay - Project Director, Sarah Wager - Regulator, Antonio Bebic - Community Relations Liaison, Blake Mansbridge – Manager, Community Relations, Darin Wong - Community and Indigenous Relations Manager, Greg Edgelow - Indigenous Relations Manager	Presentation provided to attendees regarding project scope, timeline and details about the proposed meter and joint-use opportunities. Single question received regarding how FEI will use the customer data provided by the meters. All questions were addressed and no further follow-up required. A Copy of the presentation can be found in Appendix X-24
19-Feb-21	Virtual Meeting	MLA Janet Routledge - Burnaby North	Darin Wong - Community and Indigenous Relations Manager, Blake Mansbridge - Manager, Community Relations, Antonio Bebic - Community Relations Liaison	Presentation (Appendix X-24) provided to MLA Routledge who requested a private meeting to learn more about the proposed Project. General Project questions were addressed, along with other inquiries by the MLA regarding other FEI initiatives underway. No follow-ups required following the meeting.
2-Feb-21	Virtual Meeting	MLA Pam Alexis - Abbotsford/Mission, Jo-Anne Chadwick - Assistant to MLA Pam Alexis	Darin Wong - Community and Indigenous Relations Manager, Antonio Bebic - Community Relations Liaison, Izzah Khan - Public Policy Analyst	Presentation (Appendix X-24) provided to MLA Routledge who requested a private meeting to learn more about the proposed Project. General Project questions were addressed, along with other inquiries by the MLA regarding other FEI initiatives underway. No follow-ups required following the meeting.

Advanced Gas Meters - Project Phone and Email Inquiries					
Date of Inquiry	Engagement Type	Primary Concern/Interest	Secondary Concern/Interest	Inquiry	Responded
3-Oct-19	Email	Safety		Inquiry about safety features of the proposed meter.	Y
4-Oct-19	Email	Technical/Meter	Safety	Inquiry about safety features of the proposed meter and how it will be powered.	Y
4-Oct-19	Email	Health	Radio Off	Concerns raised about potential health impacts from network, requesting to have radio-off.	Y
5-Oct-19	Email	Safety		Inquiry about safety features of the proposed meter.	Y
8-Oct-19	Email	Deployment		Inquiry regarding what deployment will look like if approved.	Y
9-Oct-19	Email	N/A		Customer inquired about meter exchange, unrelated to AMI	Y
12-Oct-19	Email	Rates		Lives in condo. Strata related question.	Y
15-Oct-19	Email	Supportive		Inquiry seeking early adopter opportunity, supportive of the project and benefits.	Y
15-Oct-19	Phone/VM	Consultation		VM regarding information session locations.	Y
16-Oct-19	Email	Technical/Meter		question about battery	Y
15-Oct-19	Email	Supportive		inquiry about early adopter opportunities and support for the project.	Y
15-Oct-19	Email	Deployment		Inquiry regarding what deployment will look like if approved.	Y
15-Oct-19	Email	Radio Off		Inquiry if FEI will be offering a radio-off function for the meters.	Y
15-Oct-19	Email	Supportive		early adoption request	Y
18-Oct-19	Email	Supportive		early adoption request	Y
16-Oct-19	Email	Other		request to move meter. Responded with available options.	Y
18-Oct-19	Phone/VM	Deployment	Health	VM. asked about the project and expressed concerns about health.	Y
22-Oct-19	Phone/VM	Deployment		VM. Asked about deployment and timeline.	Y
19-Oct-19	Phone/VM	Deployment		VM. Asked about project timeline and general information.	Y
21-Oct-19	Email	Technical/Meter	Rates	Inquiry about the meter/how it will be powered and if there will be rate impacts.	Y
23-Oct-19	Email	Safety		Inquiry about safety features proposed and remote shut-off capabilities.	Y
21-Oct-19	Phone/VM	Consultation		VM. Requested information about information sessions.	Y
21-Oct-19	Email	Radio Off		Requesting to opt-out	Y
22-Oct-19	Email	Health	Radio Off	Email citing health concerns about the proposed network, requesting for radio-off.	Y
22-Oct-19	Email	Safety	Consultation	Inquiry about safety features proposed and where the information sessions are taking place.	Y
24-Oct-19	Email	Supportive		Email supporting the project and looking forward to benefits that will be available.	Y
24-Oct-19	Email	Consultation		requested location of information sessions	Y
24-Oct-19	Email	Technical/Meter		queston about battery	Y
25-Oct-19	Email	Technical/Meter		question about battery	Y
25-Oct-19	Email	Technical/Meter		transmission/frequency question.	Y
28-Oct-19	Email	Jobs		email received from Olameter meter reader	Y
25-Oct-19	Email	Rates		Question regarding potential rate impacts	Y
28-Oct-19	Email	Rates		Question regarding potential rate impacts	Y
27-Oct-19	Phone/VM	Health	Consultation	VM. Expressed RF concerns, and where info sesions will be	Y
28-Oct-19	Phone/VM	Consultation		VM. Asked about context of information sessions.	Y
29-Oct-19	Phone/VM	Consultation		VM. Asked about context of information sessions.	Y
29-Oct-19	Email	Deployment		Inquiry about what deployment will look like, and how regions will be scheduled.	Y
29-Oct-19	Phone/VM	Supportive		VM about procurement potential	Y
30-Oct-19	Email	Technical/Meter	Rates	Inquiry about technical aspects of the meter.	Y
30-Oct-19	Email	Supportive		early adoption request	Y
30-Oct-19	Email	Radio Off	Health	Email citing health concerns about the proposed network, requesting for radio-off.	Y
30-Oct-19	Phone/VM	Deployment		VM. Question about deployment and future appointments	Y
30-Oct-19	Phone/VM	Health		VM. Customer expressed concerns about RF and emissions.	Y
30-Oct-19	Email	Technical/Meter		Email regarding how the meter will be powered.	Y
31-Oct-19	Email	Consultation		request infrmation session locations and impact to stratas	Y
31-Oct-19	Email	Technical/Meter		asked how meters are powered	Y
31-Oct-19	Email	Deployment		Impact on strata buildings	Y
31-Oct-19	Email	N/A		question about meter exchanges unrelated to AMI.	Y
31-Oct-19	Email	Technical/Meter		multiple questions about meter specs and technology	Y
31-Oct-19	Email	Technical/Meter	Supportive	Inquiry about how the meters will be powered and offering support for the project.	Y
1-Nov-19	Email	N/A		confused about the project. - Not related to the project	Y
1-Nov-19	Email	Rates	Jobs	Inquiry about potential rate and job impacts	Y

Date of Inquiry	Engagement Type	Primary Concern/Interest	Secondary Concern/Interest	Inquiry	Responded
1-Nov-19	Email	Rates		Inquiry about potential rate impacts	Y
4-Nov-19	Email	Other		request for alteration - not related to the project	Y
4-Nov-19	Phone/VM	Other		VM. General project information request	Y
4-Nov-19	Email	Health		Email discussing potential health impacts from wireless networks	Y
4-Nov-19	Email	Technical/Meter		List of technical questions about the meter	Y
4-Nov-19	Email	Technical/Meter		question about how meter will be powered	Y
4-Nov-19	Email	Health	Rates	Email about RF emissions	Y
5-Nov-19	Email	Rates		Inquiry about potential rate impacts	Y
5-Nov-19	Phone/VM	Other		VM. Question about stratas.	Y
6-Nov-19	Email	Supportive	Deployment	Early adopter request	Y
7-Nov-19	Email	Supportive	Deployment	Early adopter request	Y
7-Nov-19	Email	Health		Email regarding RF emissions	Y
7-Nov-19	Email	Supportive		Note of support for the project	Y
8-Nov-19	Email	Deployment	Rates	Inquiry about what deployment will look like, and how regions will be scheduled.	Y
8-Nov-19	Phone/VM	Safety		VM. Question about remote disconnection	Y
8-Nov-19	Email	Health		Email regarding RF emissions	Y
8-Nov-19	Phone/VM	Consultation		VM. Question about info session locations	Y
9-Nov-19	Email	Deployment		Question about when the meters will be changed in his area.	Y
9-Nov-19	Email	Other		questionabout stratas and deployment	Y
9-Nov-19	Email	Deployment		Question if there will be pipeline work involved	Y
10-Nov-19	Email	Supportive		early adoption request	Y
10-Nov-19	Email	Supportive		Note of support for the project, looking forward to proposed benefits	Y
10-Nov-19	Email	Consultation	Rates	inquiry about information session locations/dates and potential rate impacts from the project	Y
10-Nov-19	Email	Other		Question regarding strata implementation	Y
12-Nov-19	Email	Technical/Meter		question about appliances	Y
12-Nov-19	Phone/VM			VM. Question about their bill	Y
13-Nov-19	Email	Technical/Meter		Question about how meter will be powered	Y
13-Nov-19	Email	N/A		requesting general contact information	Y
14-Nov-19	Phone/VM	Health	Radio Off	VM. Customer expressed several health concerns about the project and wireless technology	Y
14-Nov-19	Email	Supportive		Early adopter request, note of support for the project.	Y
14-Nov-19	Email	Technical/Meter	Opt-Out	technical quetsions about the meter and if opt-out is possible	Y
15-Nov-19	Phone/VM	Safety		VM. Question about safety features in the meter	Y
16-Nov-19	Email	Safety		question about remote shutoff ability	Y
16-Nov-19	Email	Safety		question about remote shutoff ability	Y
16-Nov-19	Email	Jobs	Safety	questions about workforce, safety	Y
19-Nov-19	Email	Supportive	Other	Suggestions on how to improve roll out and meters compared to Hydro	.
19-Nov-19	Email	Supportive		Very supportive	Y
19-Nov-19	Email	Jobs	Health	multiple questions about meter specs,technology and workforce	Y
20-Nov-19	Email	Health		Health questions	Y
21-Nov-19	Email	Technical/Meter		Questions about battery	Y
21-Nov-19	Email	Deployment		Early adopter	Y
21-Nov-19	Email	Health		Health questions	Y
25-Nov-19	Email	Health		Radio off option	Y
25-Nov-19	Email	Safety		Different safety features	Y
25-Nov-19	Email	Health		Customer expressed several health concerns about the project	Y
25-Nov-19	Phone/VM	Deployment		VM. Customer had questions about deployment.	Y
26-Nov-19	Email	Deployment		Customer had questions about deployment	Y
27-Nov-19	Phone/VM	Opt-Out		VM. Customer had concerns about deployment and his expereince with BCHydro	Y
27-Nov-19	Email	Health		Health questions	Y
28-Nov-19	Email	Health	Opt-Out	Health questions	Y
29-Nov-19	Email	Deployment		Customer had questions about deployment.	Y
30-Nov-19	Email	Rates		Customer had questions about the cost of the project.	Y
30-Nov-19	Email	Other		Real time use feature	Y
2-Dec-19	Email	Technical/Meter		How will the meter be powered	Y

Date of Inquiry	Engagement Type	Primary Concern/Interest	Secondary Concern/Interest	Inquiry	Responded
5-Dec-19	Email	Technical/Meter		How will the meter be powered	Y
5-Dec-19	Email	Technical/Meter		How will the meter be powered	Y
30-Nov-19	Email	Other		Inquired about TOU application for project.	Y
1-Dec-19	Email	Technical/Meter		How will the meter be powered	Y
5-Dec-19	Email	Supportive		Offered notes of support and suggestions on carrying out the meter deployment	Y
5-Dec-19	Email	Rates		customer concerned about rate increases due to the project	Y
6-Dec-19	Email	Technical/Meter		Customer inquired about RF interference with other equipment in house.	Y
13-Dec-19	Email	Safety		Question if the meter will have auto-shutoff capability	Y
18-Dec-19	Email	Supportive		Employment opportunities request.	Y
23-Dec-19	Email	Technical/Meter		Information about RF and frequency	Y
31-Dec-19	Email	Opt-Out		Request to opt-out, no reason provided	Y
3-Jan-20	Email	Opt-Out	Health	Requesting to opt-out due to wireles sensitivity	Y
13-Jan-20	Email	Opt-Out	Health	Requesting to opt-out due to wireles sensitivity	Y
14-Jan-20	Email	Opt-Out	Health	Requesting to opt-out due to wireles sensitivity	Y
17-Jan-20	Email	Opt-Out		Request to opt-out, no reason provided	Y
22-Jan-20	Email	Safety		Question regarding auto-shutoff in event of emergencies.	Y
28-Jan-20	Email	Deployment		question about appointment booking process	Y
12-Feb-20	Email	Technical/Meter		Questions regarding testing of meters and developer	Y
26-Feb-20	Email	Other		NZ utility requesting info on FEI communications strategy for AMI.	Y
1-Mar-20	Email	Technical/Meter		Inquired what kind of network FEI will be using.	Y
3-Mar-20	Email	Deployment		Inquired about installation timeline and potential costs.	Y
12-Mar-20	Email	Safety		Information on earthquake safety	Y
14-Mar-20	Email	Safety		Info request about remote shut-off capability for emergencies.	Y
15-Mar-20	Email	Deployment		Info regarding future appointment bookings.	Y
16-Mar-20	Email	Radio Off		Inquiring about fees for radio-off	Y
17-Mar-20	Email	Deployment		Would like to inform he is installing a seismic valve	Y
20-Mar-20	Email	Technical/Meter		Inquired about wireless frequency	Y
25-Mar-20	Email	Safety		Inquired how the remote shut-off/leak detection works.	Y
1-Apr-20	Email	Opt-Out		Would not like a new meter.	Y
9-Apr-20	Email	Technical/Meter		Inquired about regulators on new meters and how they impact BTU ratings.	Y
11-Apr-20	Email	Technical/Meter		Inquired about what the wireless frequency will be.	Y
16-Apr-20	Email	Radio Off		Requests a radio-off option for new meter.	Y
27-Apr-20	Email	Opt-Out		Does not want a new meter.	Y
5-May-20	Email	Technical/Meter		Inquired about sesmic shuf-off valves, and the stratas plans on installing them in the future.	Y
26-May-20	Email	Technical/Meter		Additional inquiry about seismic valve upgrades.	Y
10-Jun-20	Email	Technical/Meter		Strata president, inquired about futures seismic valve installations for the building.	Y
15-Jun-20	Email	Technical/Meter		Inquired about installing seismic valve on home/safety features of the new meter.	Y
3-Jul-20	Email	Supportive		Would like to be an early adopter.	Y
9-Aug-20	Email	Deployment		Wanted to know if he could have the meter installed soon. Replied with general project information.	Y
26-Aug-20	Email	Technical/Meter		technical questions about the new meters and the existing meter fleet his company looks after (strata's).	Y
1-Sep-20	Email	Deployment		Customer wanted to know when deployment would begin in Vancouver proper.	Y
10-Sep-20	Phone/VM	N/A		VM - Billing inquiry, forwarded to customer service for follow-up	N
14-Sep-20	Phone/VM	Deployment		VM - Customer inquired about meter survey. Attempted multiple callbacks with no response.	N
15-Sep-20	Phone/VM	Other		VM - Customer called to inquire about meter survey. Advised there is a locked gate and wanted to ensure meter is accessible for technicians	Y
17-Sep-20	Phone/VM	Deployment		VM - General inquiry about the project and upcoming meter survey. All questions were addressed, no follow-up.	Y
18-Sep-20	Phone/VM	Other		VM - Customer inquired about project and upcoming meter survey. All questions were addressed, no follow-up.	Y
18-Sep-20	Phone/VM	Deployment		VM - General inquiry about the project and upcoming meter survey. All questions were addressed, no follow-up.	Y
24-Sep-20	Phone/VM	Deployment		VM - General inquiry about the project and upcoming meter survey. All questions were addressed, no follow-up.	Y
25-Sep-20	Phone/VM	Deployment		VM - General inquiry about the project and deployment in his area (Kelowna). All questions addressed, no further follow-up.	Y

Date of Inquiry	Engagement Type	Primary Concern/Interest	Secondary Concern/Interest	Inquiry	Responded
25-Sep-20	Phone/VM	Other	Health	VM - General inquiry about the project, potential health concerns, and upcoming meter survey. All questions were addressed, no follow-up.	Y
25-Sep-20	Email	Deployment		Interested in deployment timelne in her area and potential cost.	Y
25-Sep-20	Email	Other	Supportive	Inquired about regulatory process and why it will take as long as required for a decision.	Y
28-Sep-30	Email	Opt-Out	Rates	Customer emailed outlining opposition to the project. No response as customer did not request reply.	N
29-Sep-20	Phone/VM	Deployment		Customer inquired about deployment timelines and when we would be installing meters in her area (Ashcroft).	Y
30-Sep-20	Phone/VM	Deployment		Customer inquired about deployment timeline and if there is a cost associated with installations.	Y
30-Sep-20	Phone/VM	Deployment		Attempted call back 3x. No VM available and no answer from customer.	N
30-Sep-20	Phone/VM	Health		Attempted call back 3x. No answer, line keeps ringing busy.	N
1-Oct-20	Phone/VM	Deployment		Attempted call back 3x. No answer.	N
1-Oct-20	Phone/VM	Deployment	Other	General project inquiry and timeline of installs. Also discussed other FEI work that took place on his property.	Y
3-Oct-20	Phone/VM	Deployment		Inquired about deployment timeline for his area (Vancouver) and what work is anticipated to happen.	Y
5-Oct-20	Phone/VM	Deployment	Radio Off	Wanted to know if she could have the radio-off and what the project timeline looked like. All questions were addressed.	Y
6-Oct-20	Phone/VM	Deployment		General project inquiry and timeline of deployment. Addressed all concerns and discussed project in more detail.	Y
6-Oct-20	Email	Opt-Out		Email from customer they do not wish to have the meter on their home.	Y
7-Oct-20	Phone/VM	Opt-Out		Customer expressed they do not wish to have the meter installed on their home. Attempted call back several times with no answer.	Y
7-Oct-20	Phone/VM	Other		Question about the meter placement on her house - forwarded to CC for further follow-up.	Y
20-Oct-20	Phone/VM	Meter Survey		General inquiry about the project. Project overview and timelines provided.	Y
23-Oct-20	Email	Deployment		general project inquiry regarding timelines, project overview and consultation activity to date.	Y
25-Oct-20	Email	N/A		Customer received letter regarding annual meter exchange program - referred to contact centre for futher information	Y
26-Oct-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
29-Oct-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
30-Oct-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
2-Nov-20	Email	Health		Email regarding health concerns related to the project.	Y
5-Nov-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
10-Nov-20	Phone/VM	Health		Customer expressed concerns about the project and percieved health impacts.	Y
24-Nov-20	Email	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
26-Nov-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
26-Nov-20	Email	Technical/Meter		Inquiry about network deployment and if meters will operate in more remote areas.	Y
3-Dec-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
10-Dec-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
10-Dec-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
10-Dec-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
10-Dec-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
15-Dec-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
18-Dec-02	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y

Date of Inquiry	Engagement Type	Primary Concern/Interest	Secondary Concern/Interest	Inquiry	Responded
18-Dec-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
18-Dec-20	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
29-Dec-20	Phone/VM	Meter Survey	Opt-Out	VM - Advised surveyor visited home and that they do not wish to have the meter installed. Attempted call back several time with no contact.	Y
31-Dec-20	Phone/VM	Meter Survey		VM - Customer called to confirm survey worker was part of the project. Multiple contact attempts made with no answer.	Y
31-Dec-20	Phone/VM	Meter Survey	Other	VM - Customer advised they had a surveyor visit the property. Inquired if they could have the new meter installed soon. Discussed project overview and timeline with customer.	Y
31-Dec-20	Phone/VM	Meter Survey		VM - Customer wanted confirmation on meter survey work. Discussed survey work with customer.	Y
5-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
8-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
14-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
14-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
15-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
19-Jan-21	Email	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
20-Jan-21	Email	Other	Emplyment	Email received inquiring about job opportunities for the Project. Forwarded to appropriate department for further follow-up.	Y
21-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
25-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
27-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
29-Jan-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
29-Jan-21	Phone/VM	Opt-Out	Radio Off	Customer called to advise they would not like the proposed meter.	Y
2-Feb-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
3-Feb-21	Email	Other	Health	Email received regarding annual meter exchange program confirmation and health concerns about the proposed Project.	Y
8-Feb-21	Email	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
8-Feb-21	Phone/VM	Opt-Out		Customer expressed they did not want the proposed meter. Provided information about the Project scope and timeline	Y
9-Feb-21	Email	Safety		Email inquiring whether proposed meters will include earthquake valves.	Y
9-Feb-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
10-Feb-21	Email	Radio Off	Health	Email received regarding customer expressing they would like the radio-off option on the meter.	Y
11-Feb-21	Phone/VM	Radio Off		Customer advsied they would like to have the radio-off option if the Project is approved.	Y
12-Feb-21	Email	Technical/Meter	Deployment	Customer inquired about what data customers will be able to see with the new meters.	Y
16-Feb-21	Email	Jobs		Email inquiry about job impacts resulting from the Project.	Y
17-Feb-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
19-Feb-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
22-Feb-21	Email	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
23-Feb-21	Email	Other	Radio Off	Customer advsied they would like to have the radio-off option if the Project is approved.	Y

Date of Inquiry	Engagement Type	Primary Concern/Interest	Secondary Concern/Interest	Inquiry	Responded
24-Feb-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
24-Feb-21	Email	Supportive		Email offered support for the Project.	Y
24-Feb-21	Email	Other		Customer requested copy of the presentation provided at the virtual public information session	Y
24-Feb-21	Email	Safety	Deployment	Email inquiring about proposed safety benefits and Project timeline.	Y
24-Feb-21	Email	Radio Off	Safety	Email supportive of the Project and requests to have radio-off option if approved.	Y
25-Feb-21	Phone/VM	Meter Survey		Customer noticed survey contractor conducting survey work in the neighbourhood, called to confirm.	Y
25-Feb-21	Email	Technical/Meter	Other	Email inquiring about proposed meter make and model.	Y
25-Feb-21	Email	Other		Email requesting copy of presentation provided at virtual public information session.	Y

Advanced Gas Meters - Public Information Session Log							
Date	Engagement Type	External Representatives	FEI Representatives	Location	Type	Summary	Key Themes Discussed
15-Oct-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Matt Mason, Blake Mansbridge, Clint Panton, Antonio Bebic, Tika Singh, Kira Bennett	Prince George	Public/Customers	Two attendees.	Job opportunities and meter information.
16-Oct-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Matt Mason, Blake Mansbridge, Clint Panton, Antonio Bebic, Tika Singh, Kira Bennett	Fort Nelson	Public/Customers	Four attendees.	Meter information and rate impacts.
22-Oct-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Matt Mason, Alex Munro, Clint Panton, Antonio Bebic, Debbie Kondro, Jo Hunton-Sehdev	Kelowna	Public/Customers	Eight attendees and four surveys completed. Conversations generally lasted 15-20 minutes each.	Project scope and schedule, meter information, public engagement process.
23-Oct-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Matt Mason, Alex Munro, Clint Panton, Antonio Bebic, Debbie Kondro, Jo Hunton-Sehdev	Vernon	Public/Customers	11 attendees., four surveys completed.	RF and health, and privacy.
24-Oct-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Matt Mason, Alex Munro, Clint Panton, Antonio Bebic, Debbie Kondro, Jo Hunton-Sehdev	Kamloops	Public/Customers	Four attendees, no surveys completed.	Meter information, general questions about FortsisBC,
28-Oct-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Clint Panton, Blake Mansbridge, Tika Singh, Scott Neufeld,Kira Bennett	Cranbrook	Public/Customers	Four attendees,	Project details, opportunities to participate in pilots/meter tests, CE&M programs we would be offering, and rates.
29-Oct-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Clint Panton, Blake Mansbridge, Tika Singh, Scott Neufeld,Kira Bennett	Castlegar	Public/Customers	Three attendees.	RF and health, and FortisBC electric AMI deployment (support).
30-Oct-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Clint Panton, Blake Mansbridge, Tika Singh, Scott Neufeld,Kira Bennett	Oliver	Public/Customers	No attendees.	n/a
4-Nov-19	Information Session	Public	Darren Julyan, Paul Kitchener, Clay Stooshnoff, Clint Panton, Debbie Kondro, Jo Hunton-Sehdev, Courtney Hodson	Courtenay	Public/Customers	Three attendees.	Project details and support, RF and health.
5-Nov-19	Information Session	Public	Darren Julyan, Joel Lindsay, Paul Kitchener, Clay Stooshnoff, Clint Panton, Blake Mansbridge, Jo Hunton-Sehdev, John Himmel, Alex Munro, Antonio Bebic, Debbie Kondro	Victoria	Public/Customers	14 attendees and six surveys completed.	RF and health, project details, meter information and safety functions, and CE&M and customer benefits.
13-Nov-19	Information Session	Public	Joel Lindsay, Paul Kitchener, Alex Munro, Antonio Bebic,Tika Singh, Randy Sharpe, Darrin Wong, Kevin Harms , Debbie Kondro and Karmyn Ayn	Burnaby	Public/Customers	10 attendees and four surveys completed. Average conversation length 30-45 minutes.	RF and health, safety concerns, and conservation and the environment.
18-Nov-19	Information Session	Public	Joel Lindsay, Paul Kitchener, Blake Mansbridge,Tika Singh, Darrin Wong, Debbie Kondro , Clint Panton and Karmyn Ayn	Abbotsford	Public/Customers	Two attendees.	Project schedule, and old versus new meters.
23-Feb-21	Virtual Information Session	Public	Darren Julyan, Paul Kitchener, Joel Lindsay,Karmyn Ayn, Darin Wong, Antonio Bebic, Alex Munro, Jessica Williams	FortisBC Surrey Operations	Public/Customers	32 attendees	Six questions received inquiring about Project timelines, costs, opportunities for early adopters and technical meter/network questions. All questions were addressed during the session.
24-Feb-21	Virtual Information Session	Public	Darren Julyan, Paul Kitchener, Joel Lindsay,Karmyn Ayn, Darin Wong, Antonio Bebic, Alex Munro, Jessica Williams	FortisBC Surrey Operations	Public/Customers	39 attendees	25 questions received regarding early adopter opportunities, safety (such as remote shut-off capabilities and leak detection), costs and what deployment will look like. All questions were addressed in the session except for one which was not directed accordingly to the presenter. Follow-up email was sent to the attendee to address the question about the meter battery. No additional follow-ups were required.

Municipal Contact List - 2019

Name	Title	Municipality/Region	Jurisdiction	Date of Letter Sent	Received
Douglas Holmes	Chief Administrative Officer	Alberni-Clayoquot	Regional District	03.10.2019	Yes
Tim Pley	Chief Administrative Officer	Port Alberni	City	03.10.2019	Yes
Bob Lapham	Chief Administrative Officer	Capital	Regional District	03.10.2019	Yes
Patrick Robins	Chief Administrative Officer	Central Saanich	District	03.10.2019	Yes
Robert Earl	Chief Administrative Officer	Colwood	City	03.10.2019	Yes
Laurie Hurst	Chief Administrative Officer	Esquimalt	Township	03.10.2019	Yes
Loranne Hilton	Chief Administrative Officer / Chief Financial Officer	Highlands	District	03.10.2019	Yes
Darren Kiedyk	Chief Administrative Officer	Langford	City	03.10.2019	Yes
Lisa Urlacher	Chief Administrative Officer	Metchosin	District	03.10.2019	Yes
Tanton Tim	Chief Administrative Officer	North Saanich	District	03.10.2019	Yes
Lou Varela	Interim Chief Administrative Officer	Oak Bay	District	03.10.2019	Yes
Paul Thorkelsson	Chief Administrative Officer	Saanich	District	03.10.2019	Yes
Randy Humble	Chief Administrative Officer	Sidney	Town	03.10.2019	Yes
Norm McInnis	Chief Administrative Officer	Sooke	District	03.10.2019	Yes
Jocelyn Jenkyns	City Manager	Victoria	City	03.10.2019	Yes
Kim Anema	Chief Administrative Officer	View Royal	Town	03.10.2019	Yes
John MacLean	Chief Administrative Officer	Cariboo	Regional District	03.10.2019	Yes
Roy Scott	CAO / Director of Corporate Administration	100 Mile House	District	03.10.2019	Yes
Byron Johnson	Chief Administrative Officer	Quesnel	City	03.10.2019	Yes
Milo Macdonald	Chief Administrative Officer	Williams Lake	City	03.10.2019	Yes
Stuart Horn	Chief Administrative Officer	Central Kootenay	Regional District	03.10.2019	Yes
Chris Barlow	Chief Administrative Officer	Castlegar	City	03.10.2019	Yes
Mike Moore	Chief Administrative Officer	Creston	Town	03.10.2019	Yes
Kevin Cormack	City Manager	Nelson	City	03.10.2019	Yes
Anne Williams	Chief Administrative Officer	Salmo	Village	03.10.2019	Yes
Brian Reardon	Chief Administrative Officer	Central Okanagan	Regional District	03.10.2019	Yes
Doug Gilchrist	City Manager	Kelowna	City	03.10.2019	Yes
Alberto De Feo	Chief Administrative Officer	Lake Country	District	03.10.2019	Yes
Elsie Lemke	Chief Administrative Officer	Peachland	District	03.10.2019	Yes
Paul Gipps	Chief Administrative Officer	West Kelowna	City	03.10.2019	Yes
Charles Hamilton	Chief Administrative Officer	Columbia Shuswap	Regional District	03.10.2019	Yes
Carl Bannister	Chief Administrative Officer	Salmon Arm	City	03.10.2019	Yes
Russell Dyson	Chief Administrative Officer	Comox Valley	Regional District	03.10.2019	Yes
David Allen	Chief Administrative Officer	Courtenay	City	03.10.2019	Yes
Brian Carruthers	Chief Administrative Officer	Cowichan Valley	Regional District	03.10.2019	Yes
Peter de Verteuil	Chief Administrative Officer	Duncan	City	03.10.2019	Yes
Guillermo Ferrero	Chief Administrative Officer	Ladysmith	Town	03.10.2019	Yes
Ted Swabey	Chief Administrative Officer	North Cowichan	District	03.10.2019	Yes
Shawn Tomlin	Chief Administrative Officer	East Kootenay	Regional District	03.10.2019	Yes
David Kim	Chief Administrative Officer	Cranbrook	City	03.10.2019	Yes
Terry Melcer	Interim CAO, Director of Corporate Services	Elkford	District	03.10.2019	Yes
Suzanne Garand	Director of Corporate Administration Services	Fernie	City	03.10.2019	Yes
Scott Sommerville	Chief Administrative Officer	Kimberley	City	03.10.2019	Yes
Michele Schalekamp	Chief Administrative Officer	Sparwood	District	03.10.2019	Yes
Jennifer Kinneman	Acting CAO/Director of Corporate Affairs	Fraser Valley	Regional District	03.10.2019	Yes
Peter Sparanese	City Manager	Abbotsford	City	03.10.2019	Yes
Peter Monteith	Chief Administrative Officer	Chilliwack	City	03.10.2019	Yes
Madeline McDonald	Chief Administrative Officer	Harrison Hot Springs	Village	03.10.2019	Yes
John Fortoloczky	Chief Administrative Officer	Hope	District	03.10.2019	Yes
Wallace Mah	Chief Administrative Officer	Kent	District	03.10.2019	Yes
Mike Younie	Chief Administrative Officer	Mission	District	03.10.2019	Yes
Dean McKinley	Chief Administrative Officer	Mackenzie	District	03.10.2019	Yes
Kathleen Soltis	City Manager	Prince George	City	03.10.2019	Yes
Jim Martin	Chief Administrative Officer	Fraser-Fort George	Regional District	03.10.2019	Yes
Mark Andison	Chief Administrative Officer	Kootenay Boundary	Regional District	03.10.2019	Yes
Michael Maturo	Chief Administrative Officer	Fruitvale	Village	03.10.2019	Yes
Daniel Drexler	Corporate Officer & Manager of Information Technology	Grand Forks	City	03.10.2019	Yes
Wendy Higashi	Chief Administrative Officer	Greenwood	City	03.10.2019	Yes
Penny Feist	Chief Administrative Officer	Midway	Village	03.10.2019	Yes
Larry Plotnikoff	CAO / CFO / Approving Officer	Montrose	Village	03.10.2019	Yes
Bryan Teasdale	Chief Administrative Officer	Rossland	City	03.10.2019	Yes
David Perehudoff	CAO / Financial Administrator	Trail	City	03.10.2019	Yes

MLA Contact List - 2019

MLA	Constituency	Date of Letter Sent	Received
Katrine Conroy	Kootenay West	03.10.2019	Yes
Michelle Mungall	Nelson - Creston	03.10.2019	Yes
Tom Shypitka	City of Cranbrook	03.10.2019	Yes
Ronna-Rae Leonard	Comox Valley	03.10.2019	Yes
Sonia Furstenau	Cowichan Valley	03.10.2019	Yes
Mitzi Dean	Esquimalt - Royal Roads	03.10.2019	Yes
John Horgan	City of Duncan	03.10.2019	Yes
Leonard Eugene Krog	Nanaimo	03.10.2019	Yes
Douglas Routley	Nanaimo - North Cowichan	03.10.2019	Yes
Claire Trevena	North Island	03.10.2019	Yes
Dr. Andrew Weaver	Oak Bay - Gordon Head	03.10.2019	Yes
Michelle Stilwell	Parksville - Qualicum	03.10.2019	Yes
Nicholas Simons	Powell River - Sunshine Coast	03.10.2019	Yes
Adam Olsen	Saanich North and the Islands	03.10.2019	Yes
Lana Popham	Saanich South	03.10.2019	Yes
Carole James	Victoria - Beacon Hill	03.10.2019	Yes
Rob Fleming	Victoria - Swan Lake	03.10.2019	Yes
Scott Fraser	Alberni - Pacific Rim	03.10.2019	Yes
Ravi Kahlon	Delta North	03.10.2019	Yes
Ian Paton	District of Delta	03.10.2019	Yes
John Yap	Richmond - Steveston	03.10.2019	Yes
Jas Johal	Richmond - Queensborough	03.10.2019	Yes
Teresa Wat	Richmond North Centre	03.10.2019	Yes
Linda Reid	Richmond South Centre	03.10.2019	Yes
Dr. Darryl Plecas	Abbotsford South	03.10.2019	Yes
Michael de Jong, Q.C.	Abbotsford West	03.10.2019	Yes
Simon Gibson	Abbotsford-Mission	03.10.2019	Yes
Anne Kang	Burnaby - Deer Lake	03.10.2019	Yes
Raj Chouhan	Burnaby - Edmonds	03.10.2019	Yes
Katrina Chen	Burnaby - Lougheed	03.10.2019	Yes
Janet Routledge	Burnaby North	03.10.2019	Yes
John Martin	Chilliwack	03.10.2019	Yes
Dr. Laurie Throness	Chilliwack - Hope	03.10.2019	Yes
Joan Isaacs	Coquitlam - Burke Mountain	03.10.2019	Yes
Selina Robinson	Coquitlam - Maillardville	03.10.2019	Yes
Rich Coleman	Fort Langley - Aldergrove	03.10.2019	Yes
Mary Polak	Langley	03.10.2019	Yes
Bob D'Eith	Maple Ridge - Mission	03.10.2019	Yes
Lisa Beare	Maple Ridge - Pitt Meadows	03.10.2019	Yes
Judy Darcy	New Westminster	03.10.2019	Yes
Bowinn Ma	North Vancouver - Lonsdale	03.10.2019	Yes
Jane Thornthwaite	North Vancouver - Seymour	03.10.2019	Yes
Mike Farnworth	Port Coquitlam	03.10.2019	Yes
Rick Glumac	Port Moody - Coquitlam	03.10.2019	Yes
Marvin Hunt	Surrey - Cloverdale	03.10.2019	Yes
Jagrup Brar	Surrey - Fleetwood	03.10.2019	Yes
Rachna Singh	Surrey - Green Timbers	03.10.2019	Yes
Harry Bains	Surrey - Newton	03.10.2019	Yes
Jinny Sims	Surrey - Panorama	03.10.2019	Yes
Hon. Stephanie Cadieux	Surrey - South	03.10.2019	Yes
Garry Begg	Surrey - Guildford	03.10.2019	Yes
Bruce Ralston	Surrey - Whalley	03.10.2019	Yes
Tracy Redies	Surrey - White Rock	03.10.2019	Yes
George Heyman	Vancouver - Fairview	03.10.2019	Yes
Sam Sullivan	Vancouver - False Creek	03.10.2019	Yes
George Chow	Vancouver - Fraserview	03.10.2019	Yes
Shane Simpson	Vancouver - Hastings	03.10.2019	Yes
Mable Elmore	Vancouver - Kensington	03.10.2019	Yes
Adrian Dix	Vancouver - Kingsway	03.10.2019	Yes
Michael Lee	Vancouver - Langara	03.10.2019	Yes
Melanie Mark	Vancouver - Mount Pleasant	03.10.2019	Yes
David Eby	Vancouver - Point Grey	03.10.2019	Yes

Name	Title	Municipality/Region	Jurisdiction	Date of Letter Sent	Received
Juli Halliwell	Chief Administrative Officer	Anmore	Village	03.10.2019	Yes
Lorna Dysart	Chief Administrative Officer	Belcarra	Village	03.10.2019	Yes
Lambert Chu	City Manager	Burnaby	City	03.10.2019	Yes
Peter Steblin	City Manager	Coquitlam	City	03.10.2019	Yes
Sean McGill	City Manager	Delta	City	03.10.2019	Yes
Mark Bakken	Administrator	Langley	Township	03.10.2019	Yes
Francis Cheung	Chief Administrative Officer	Langley	City	03.10.2019	Yes
Kelly Swift	Acting Chief Administrative Officer	Maple Ridge	City	03.10.2019	Yes
Lisa Spitale	Chief Administrative Officer	New Westminster	City	03.10.2019	Yes
Leanne McCarthy	CAO	North Vancouver	City	03.10.2019	Yes
David Stuart	Chief Administrative Officer	North Vancouver	District	03.10.2019	Yes
Mark Roberts	Chief Administrative Officer	Pitt Meadows	City	03.10.2019	Yes
Kristen Dixon	Chief Administrative Officer	Port Coquitlam	City	03.10.2019	Yes
Tim Savoie	City Manager	Port Moody	City	03.10.2019	Yes
George Duncan	Chief Administrative Officer	Richmond	City	03.10.2019	Yes
Vince Lalonde	City Manager	Surrey	City	03.10.2019	Yes
Sadhu Johnston	City Manager	Vancouver	City	03.10.2019	Yes
Nina Leemhuis	Chief Administrative Officer	West Vancouver	District	03.10.2019	Yes
Dan Bottrill	Chief Administrative Officer	White Rock	City	03.10.2019	Yes
Carol Mason	Commissioner/CAO	Metro Vancouver	Regional District	03.10.2019	Yes
Phyllis Carlyle	Chief Administrative Officer	Nanaimo	Regional District	03.10.2019	Yes
Ronald Campbell	Chief Administrative Officer	Lantzville	District	03.10.2019	Yes
Jake Rudolph	Chief Administrative Officer	Nanaimo	City	03.10.2019	Yes
Keeva Kehler	Chief Administrative Officer	Parksville	City	03.10.2019	Yes
Daniel Sailland	Chief Administrative Officer	Qualicum Beach	Town	03.10.2019	Yes
David Sewell	Chief Administrative Officer	North Okanagan	Regional District	03.10.2019	Yes
Kevin Bertles	Chief Administrative Officer	Armstrong	City	03.10.2019	Yes
Trevor Seibel	Chief Administrative Officer	Coldstream	District	03.10.2019	Yes
Tate Bengtson	Chief Administrative Officer	Enderby	City	03.10.2019	Yes
Tom Kadla	Chief Administrative Officer	Lumby	Village	03.10.2019	Yes
Doug Allin	Chief Administrative Officer	Spallumcheen	Township	03.10.2019	Yes
Will Pearce	Chief Administrative Officer	Vernon	City	03.10.2019	Yes
Bill Newell	Chief Administrative Officer	Okanagan-Similkameen	Regional District	03.10.2019	Yes
Marg Coulson	Chief Adminstrative Officer	Keremeos	Village	03.10.2019	Yes
Cathy Cowan	Chief Administrative Officer	Oliver	Town	03.10.2019	Yes
Allan Chabot	Chief Administrative Officer	Osoyoos	Town	03.10.2019	Yes
Donny van Dyk	Chief Administrative Officer	Penticton	City	03.10.2019	Yes
Lyle Thomas	Chief Administrative Officer	Princeton	Town	03.10.2019	Yes
Anthony Haddad	Chief Administrative Officer	Summerland	District	03.10.2019	Yes
Carol Newsom	Chief Administrative Officer	Chetwynd	District	03.10.2019	Yes
Chris Cvik	Chief Administrative Officer	Hudson's Hope	District	03.10.2019	Yes
Scott Barry	Chief Administrative Officer	Northern Rockies	Regional Municipality	03.10.2019	Yes
Russell Brewer	Chief Administrative Officer	Powell River	City	03.10.2019	Yes
Lynda Flynn	Chief Administrative Officer	Squamish-Lillooet	Regional District	03.10.2019	Yes
Linda Glenday	Chief Administrative Officer	Squamish	District	03.10.2019	Yes
Mike Furey	Chief Administrative Officer	Whistler	Resort Municipality	03.10.2019	Yes
Dave Leitch	Chief Administrative Officer	Strathcona	Regional District	03.10.2019	Yes
Deborah Sargent	City Manager	Campbell River	City	03.10.2019	Yes
Mark Brown	Interim Chief Administrative Officer	Sunshine Coast	Regional District	03.10.2019	Yes
Emanuel Machado	Chief Administrative Officer	Gibsons	Town	03.10.2019	Yes
Andrew Yeates	Chief Administrative Officer/Deputy Corporate Officer	Sechelt	District	03.10.2019	Yes
Sukh Gill	Chief Administrative Officer	Thompson-Nicola	Regional District	03.10.2019	Yes
Michelle Allen	Chief Administrative Officer	Ashcroft	Village	03.10.2019	Yes
Martin Dalsin	Chief Administrative Officer	Cache Creek	Village	03.10.2019	Yes
Joni Heinrich	Chief Administrative Officer	Chase	Village	03.10.2019	Yes
Monika Schittek	Chief Administrative Officer	Clinton	Village	03.10.2019	Yes
David Trawin	Chief Administrative Officer	Kamloops	City	03.10.2019	Yes
Randy Lambright	Chief Administrative Officer	Logan Lake	District	03.10.2019	Yes
Scott Hildebrand	Chief Administrative Officer	Merritt	City	03.10.2019	Yes
General Administration	Administration	Warfield	Village	03.10.2020	Yes
General Administration	Administration	Comox	Town	03.10.2021	Yes
General Administration	Administration	Cumberland	Village	03.10.2022	Yes

MLA	Constituency	Date of Letter Sent	Received
Andrew Wilkinson	Vancouver - Quilchena	03.10.2019	Yes
Spencer Chandra Herbert	Vancouver - West End	03.10.2019	Yes
Ralph Sultan	West Vancouver - Capilano	03.10.2019	Yes
Jordan Sturdy	West Vancouver - Sea to Sky	03.10.2019	Yes
Coralee Oakes	Cariboo North	03.10.2019	Yes
Donna Barnett	Cariboo - Chilcotin	03.10.2019	Yes
Jackie Tegart	Fraser - Nicola	03.10.2019	Yes
Peter Milobar	City of Kamloops	03.10.2019	Yes
Todd Stone	Kamloops - South Thompson	03.10.2019	Yes
Dan Davies	Peace River - North	03.10.2019	Yes
Mike Bernier	Peace River - South	03.10.2019	Yes
Mike Morris	Prince George - Mackenzie	03.10.2019	Yes
Shirley Bond	Prince George - Valemount	03.10.2019	Yes
Linda Larson	Boundary - Similkameen	03.10.2019	Yes
Norm Letnick	Kelowna - Lake Country	03.10.2019	Yes
Steve Thomson	Kelowna - Mission	03.10.2019	Yes
Dan Ashton	Penticton	03.10.2019	Yes
Greg Kyllo	Shuswap	03.10.2019	Yes
Eric Foster	Vernon - Monashee	03.10.2019	Yes
Ben Stewart	Kelowna West	03.10.2019	Yes

Municipal Contact List - 2021

Name	Title	Municipality/Region	Jurisdiction	Date of Letter Sent	Received
Roy Scott	CAO / Director of Corporate Administration	100 Mile House	District	04.02.2021	Yes
Peter Sparanese	City Manager	Abbotsford	City	04.02.2021	Yes
Douglas Holmes	Chief Administrative Officer	Alberni-Clayoquot	Regional District	04.02.2021	Yes
Juli Halliwell	Chief Administrative Officer	Anmore	Village	04.02.2021	Yes
Kevin Bertles	Chief Administrative Officer	Armstrong	City	04.02.2021	Yes
Daniela Dyck	Chief Administrative Officer	Ashcroft	Village	04.02.2021	Yes
Lorna Dysart	Chief Administrative Officer	Belcarra	Village	04.02.2021	Yes
Lambert Chu	City Manager	Burnaby	City	04.02.2021	Yes
Martin Dalsin	Chief Administrative Officer	Cache Creek	Village	04.02.2021	Yes
Deborah Sargent	City Manager	Campbell River	City	04.02.2021	Yes
Bob Lapham	Chief Administrative Officer	Capital	Regional District	04.02.2021	Yes
John MacLean	Chief Administrative Officer	Cariboo	Regional District	04.02.2021	Yes
Chris Barlow	Chief Administrative Officer	Castlegar	City	04.02.2021	Yes
Stuart Horn	Chief Administrative Officer	Central Kootenay	Regional District	04.02.2021	Yes
Brian Reardon	Chief Administrative Officer	Central Okanagan	Regional District	04.02.2021	Yes
Christine Culham	Chief Administrative Officer	Central Saanich	District	04.02.2021	Yes
Joni Heinrich	Chief Administrative Officer	Chase	Village	04.02.2021	Yes
Carol Newsom	Chief Administrative Officer	Chetwynd	District	04.02.2021	Yes
Peter Monteith	Chief Administrative Officer	Chilliwack	City	04.02.2021	Yes
Murray Daly	Chief Administrative Officer	Clinton	Village	04.02.2021	Yes
Trevor Seibel	Chief Administrative Officer	Coldstream	District	04.02.2021	Yes
Charles Hamilton	Chief Administrative Officer	Columbia Shuswap	Regional District	04.02.2021	Yes
Robert Earl	Chief Administrative Officer	Colwood	City	04.02.2021	Yes
Jordan Wall	Chief Administrative Officer	Comox	Town	04.02.2021	Yes
Russell Dyson	Chief Administrative Officer	Comox Valley	Regional District	04.02.2021	Yes
Peter Steblin	City Manager	Coquitlam	City	04.02.2021	Yes
Trevor Kushner	Chief Administrative Officer (Interim)	Courtenay	City	04.02.2021	Yes
Brian Carruthers	Chief Administrative Officer	Cowichan Valley	Regional District	04.02.2021	Yes
Mark Fercho	Chief Administrative Officer	Cranbrook	City	04.02.2021	Yes
Mike Moore	Chief Administrative Officer	Creston	Town	04.02.2021	Yes
Clayton Postings	Chief Administrative Officer	Cumberland	Village	04.02.2021	Yes
Sean McGill	City Manager	Delta	City	04.02.2021	Yes
Peter de Verteuil	Chief Administrative Officer	Duncan	City	04.02.2021	Yes
Shawn Tomlin	Chief Administrative Officer	East Kootenay	Regional District	04.02.2021	Yes
Tyler Madsen	Chief Administrative Officer, Deputy Director of Corporate Services, Approving Officer	Elkford	District	04.02.2021	Yes
Tate Bengtson	Chief Administrative Officer	Enderby	City	04.02.2021	Yes
Laurie Hurst	Chief Administrative Officer	Esquimalt	Township	04.02.2021	Yes
Michael Boronowski	Chief Administrative Officer	Fernie	City	04.02.2021	Yes
Jennifer Kinneman	Chief Administrative Officer	Fraser Valley	Regional District	04.02.2021	Yes
Jim Martin	Chief Administrative Officer	Fraser-Fort George	Regional District	04.02.2021	Yes
Emanuel Machado	Chief Administrative Officer	Gibsons	Town	04.02.2021	Yes
Duncan Redfearn	Chief Administrative Officer	Grand Forks	City	04.02.2021	Yes
Wendy Higashi	Chief Administrative Officer	Greenwood	City	04.02.2021	Yes
Madeline McDonald	Chief Administrative Officer	Harrison Hot Springs	Village	04.02.2021	Yes
Loranne Hilton	Chief Administrative Officer / Chief Financial Officer	Highlands	District	04.02.2021	Yes
John Fortoloczky	Chief Administrative Officer	Hope	District	04.02.2021	Yes
Chris Cvik	Chief Administrative Officer	Hudson's Hope	District	04.02.2021	Yes
David Trawin	Chief Administrative Officer	Kamloops	City	04.02.2021	Yes
Doug Gilchrist	City Manager	Kelowna	City	04.02.2021	Yes
Wallace Mah	Chief Administrative Officer	Kent	District	04.02.2021	Yes
Marg Coulson	Chief Adminstrative Officer	Keremeos	Village	04.02.2021	Yes
Scott Sommerville	Chief Administrative Officer	Kimberley	City	04.02.2021	Yes
Mark Andison	Chief Administrative Officer	Kootenay Boundary	Regional District	04.02.2021	Yes
Allison McCarrick	Chief Administrative Officer	Ladysmith	Town	04.02.2021	Yes
Alberto De Feo	Chief Administrative Officer	Lake Country	District	04.02.2021	Yes
Darren Kiedyk	Chief Administrative Officer	Langford	City	04.02.2021	Yes
Francis Cheung	Chief Administrative Officer	Langley	City	04.02.2021	Yes
Mark Bakken	Administrator	Langley	Township	04.02.2021	Yes
Ronald Campbell	Chief Administrative Officer	Lantzville	District	04.02.2021	Yes
Dan Leighton	Interim Chief Administrative Officer / Approving Officer / Fire Chief / Emergency Coordinator	Logan Lake	District	04.02.2021	Yes
Tom Kadla	Chief Administrative Officer	Lumby	Village	04.02.2021	Yes

MLA Contact List - 2021

MLA	Constituency	Date of Letter Sent	Received
Bruce Banman	Kootenay West	04.02.2021	Yes
Michael de Jong, Q.C.	Nelson - Creston	04.02.2021	Yes
Pam Alexis	City of Cranbrook	04.02.2021	Yes
Roly Russell	Comox Valley	04.02.2021	Yes
Anne Kang	Cowichan Valley	04.02.2021	Yes
Raj Chouhan	Esquimalt - Royal Roads	04.02.2021	Yes
Katrina Chen	City of Duncan	04.02.2021	Yes
Janet Routledge	Nanaimo	04.02.2021	Yes
Lorne Doerkson	Nanaimo - North Cowichan	04.02.2021	Yes
Coralee Oakes	North Island	04.02.2021	Yes
Dan Coulter	Oak Bay - Gordon Head	04.02.2021	Yes
Kelli Paddon	Parksville - Qualicum	04.02.2021	Yes
Doug Clovechok	Powell River - Sunshine Coast	04.02.2021	Yes
Fin Donnelly	Saanich North and the Islands	04.02.2021	Yes
Selina Robinson	Saanich South	04.02.2021	Yes
Ronna-Rae Leonard	Victoria - Beacon Hill	04.02.2021	Yes
Sonia Furstenau	Victoria - Swan Lake	04.02.2021	Yes
Ravi Kahlon	Alberni - Pacific Rim	04.02.2021	Yes
Ian Paton	Delta North	04.02.2021	Yes
Mitzi Dean	District of Delta	04.02.2021	Yes
Jackie Tegart	Richmond - Steveston	04.02.2021	Yes
Peter Milobar	Richmond - Queensborough	04.02.2021	Yes
Todd Stone	Richmond North Centre	04.02.2021	Yes
Norm Letnick	Richmond South Centre	04.02.2021	Yes
Renee Merrifield	Abbotsford South	04.02.2021	Yes
Ben Stewart	Abbotsford West	04.02.2021	Yes
Tom Shypitka	Abbotsford-Mission	04.02.2021	Yes
Katrine Conroy	Burnaby - Deer Lake	04.02.2021	Yes
John Horgan	Burnaby - Edmonds	04.02.2021	Yes
Andrew Mercier	Burnaby - Lougheed	04.02.2021	Yes
Megan Dykeman	Burnaby North	04.02.2021	Yes
Bob D'Eith	Chilliwack	04.02.2021	Yes
Lisa Beare	Chilliwack - Hope	04.02.2021	Yes
Josie Osborne	Coquitlam - Burke Mountain	04.02.2021	Yes
Sheila Malcolmson	Coquitlam - Maillardville	04.02.2021	Yes
Douglas Routley	Fort Langley - Aldergrove	04.02.2021	Yes
Brittny Anderson	Langley	04.02.2021	Yes
Jennifer Whiteside	Maple Ridge - Mission	04.02.2021	Yes
Michele Babchuk	Maple Ridge - Pitt Meadows	04.02.2021	Yes
Bowinn Ma	New Westminster	04.02.2021	Yes
Susie Chant	North Vancouver - Lonsdale	04.02.2021	Yes
Murray Rankin	North Vancouver - Seymour	04.02.2021	Yes
Adam Walker	Port Coquitlam	04.02.2021	Yes
Dan Davies	Port Moody - Coquitlam	04.02.2021	Yes
Mike Bernier	Surrey - Cloverdale	04.02.2021	Yes
Dan Ashton	Surrey - Fleetwood	04.02.2021	Yes
Mike Farnworth	Surrey - Green Timbers	04.02.2021	Yes
Rick Glumac	Surrey - Newton	04.02.2021	Yes
Nicholas Simons	Surrey - Panorama	04.02.2021	Yes
Mike Morris	Surrey - South	04.02.2021	Yes
Shirley Bond	Surrey - Guildford	04.02.2021	Yes
Aman Singh	Surrey - Whalley	04.02.2021	Yes
Kelly Greene	Surrey - White Rock	04.02.2021	Yes
Teresa Wat	Vancouver - Fairview	04.02.2021	Yes
Henry Yao	Vancouver - False Creek	04.02.2021	Yes
Adam Olsen	Vancouver - Fraserview	04.02.2021	Yes
Lana Popham	Vancouver - Hastings	04.02.2021	Yes
Greg Kyllo	Vancouver - Kensington	04.02.2021	Yes
Mike Starchuk	Vancouver - Kingsway	04.02.2021	Yes
Jagrup Brar	Vancouver - Langara	04.02.2021	Yes
Rachna Singh	Vancouver - Mount Pleasant	04.02.2021	Yes

Name	Title	Municipality/Region	Jurisdiction	Date of Letter Sent	Received
Al Horsman	Chief Administrative Officer	Maple Ridge	City	04.02.2021	Yes
Sean Smith	Chief Administrative Officer	Merritt	City	04.02.2021	Yes
Lisa Urlacher	Chief Administrative Officer	Metchosin	District	04.02.2021	Yes
Jerry Dobrovolny	Commissioner/CAO	Metro Vancouver	Regional District	04.02.2021	Yes
Penny Feist	Chief Administrative Officer	Midway	Village	04.02.2021	Yes
Mike Younie	Chief Administrative Officer	Mission	District	04.02.2021	Yes
Larry Plotnikoff	CAO / CFO / Approving Officer	Montrose	Village	04.02.2021	Yes
Phyllis Carlyle	Chief Administrative Officer	Nanaimo	Regional District	04.02.2021	Yes
Jake Rudolph	Chief Administrative Officer	Nanaimo	City	04.02.2021	Yes
Kevin Cormack	City Manager	Nelson	City	04.02.2021	Yes
Lisa Spitale	Chief Administrative Officer	New Westminster	City	04.02.2021	Yes
Ted Swabey	Chief Administrative Officer	North Cowichan	District	04.02.2021	Yes
David Sewell	Chief Administrative Officer	North Okanagan	Regional District	04.02.2021	Yes
Tim Tanton	Chief Administrative Officer	North Saanich	District	04.02.2021	Yes
Leanne McCarthy	CAO	North Vancouver	City	04.02.2021	Yes
David Stuart	Chief Administrative Officer	North Vancouver	District	04.02.2021	Yes
Scott Barry	Chief Administrative Officer	Northern Rockies	Regional Municipality	04.02.2021	Yes
Lou Varela	Chief Administrative Officer	Oak Bay	District	04.02.2021	Yes
Bill Newell	Chief Administrative Officer	Okanagan-Similkameen	Regional District	04.02.2021	Yes
Cathy Cowan	Chief Administrative Officer	Oliver	Town	04.02.2021	Yes
Allan Chabot	Chief Administrative Officer	Osoyoos	Town	04.02.2021	Yes
Keeva Kehler	Chief Administrative Officer	Parksville	City	04.02.2021	Yes
Joe Mitchell	Chief Administrative Officer	Peachland	District	04.02.2021	Yes
Donny van Dyk	Chief Administrative Officer	Penticton	City	04.02.2021	Yes
Mark Roberts	Chief Administrative Officer	Pitt Meadows	City	04.02.2021	Yes
Tim Pley	Chief Administrative Officer	Port Alberni	City	04.02.2021	Yes
Kristen Dixon	Chief Administrative Officer	Port Coquitlam	City	04.02.2021	Yes
Tim Savoie	City Manager	Port Moody	City	04.02.2021	Yes
Russell Brewer	Chief Administrative Officer	Powell River	City	04.02.2021	Yes
Walter Babicz	City Manager (Acting)	Prince George	City	04.02.2021	Yes
Lyle Thomas	Chief Administrative Officer	Princeton	Town	04.02.2021	Yes
Al Radke	Chief Administrative Officer	qathet	Regional District	04.02.2021	Yes
Daniel Sailland	Chief Administrative Officer	Qualicum Beach	Town	04.02.2021	Yes
Byron Johnson	Chief Administrative Officer	Quesnel	City	04.02.2021	Yes
George Duncan	Chief Administrative Officer	Richmond	City	04.02.2021	Yes
Bryan Teasdale	Chief Administrative Officer	Rossland	City	04.02.2021	Yes
Paul Thorkelsson	Chief Administrative Officer	Saanich	District	04.02.2021	Yes
Anne Williams	Chief Administrative Officer	Salmo	Village	04.02.2021	Yes
Carl Bannister	Chief Administrative Officer	Salmon Arm	City	04.02.2021	Yes
Andrew Yeates	Chief Administrative Officer and Deputy Corporate Officer	Sechelt	District	04.02.2021	Yes
Randy Humble	Chief Administrative Officer	Sidney	Town	04.02.2021	Yes
Norm McInnis	Chief Administrative Officer	Sooke	District	04.02.2021	Yes
Doug Allin	Chief Administrative Officer	Spallumcheen	Township	04.02.2021	Yes
Michele Schalekamp	Chief Administrative Officer	Sparwood	District	04.02.2021	Yes
Linda Glenday	Chief Administrative Officer	Squamish	District	04.02.2021	Yes
Melany Helmer	Chief Administrative Officer	Squamish-Lillooet	Regional District	04.02.2021	Yes
Dave Leitch	Chief Administrative Officer	Strathcona	Regional District	04.02.2021	Yes
Anthony Haddad	Chief Administrative Officer	Summerland	District	04.02.2021	Yes
Dean McKinley	Chief Administrative Officer	Sunshine Coast	Regional District	04.02.2021	Yes
Vince Lalonde	City Manager	Surrey	City	04.02.2021	Yes
David Perehudoff	CAO / Financial Administrator	Trail	City	04.02.2021	Yes
Sadhu Johnston	City Manager	Vancouver	City	04.02.2021	Yes
Will Pearce	Chief Administrative Officer	Vernon	City	04.02.2021	Yes
Jocelyn Jenkyns	City Manager	Victoria	City	04.02.2021	Yes
Kim Anema	Chief Administrative Officer	View Royal	Town	04.02.2021	Yes
Lila Cresswell	Chief Administrative Officer	Warfield	Village	04.02.2021	Yes
Paul Gipps	Chief Administrative Officer	West Kelowna	City	04.02.2021	Yes
Virginia Cullen	Chief Administrative Officer	Whistler	Resort Municipality	04.02.2021	Yes
Guillermo Ferrero	Chief Administrative Officer	White Rock	City	04.02.2021	Yes

MLA	Constituency	Date of Letter Sent	Received
Garry Begg	Vancouver - Point Grey	04.02.2021	Yes
Harry Bains	Vancouver - Quilchena	04.02.2021	Yes
Jinny Sims	Vancouver - West End	04.02.2021	Yes
Stephanie Cadieux	West Vancouver - Capilano	04.02.2021	Yes
Bruce Ralston	West Vancouver - Sea to Sky	04.02.2021	Yes
Trevor Halford	Cariboo North	04.02.2021	Yes
Lou Varela	Cariboo - Chilcotin	04.02.2021	Yes
George Heyman	Fraser - Nicola	04.02.2021	Yes
Brenda Bailey	City of Kamloops	04.02.2021	Yes
George Chow	Kamloops - South Thompson	04.02.2021	Yes
Niki Sharma	Peace River - North	04.02.2021	Yes
Mable Elmore	Peace River - South	04.02.2021	Yes
Adrian Dix	Prince George - Mackenzie	04.02.2021	Yes
Michael Lee	Prince George - Valemount	04.02.2021	Yes
Melanie Mark	Boundary - Similkameen	04.02.2021	Yes
David Eby	Kelowna - Lake Country	04.02.2021	Yes
Andrew Wilkinson	Kelowna - Mission	04.02.2021	Yes
Spencer Chandra Herbert	Penticton	04.02.2021	Yes
Harwinder Sandhu	Shuswap	04.02.2021	Yes
Grace Lore	Vernon - Monashee	04.02.2021	Yes
Rob Fleming	Kelowna West	04.02.2021	Yes
Karin Kirkpatrick	West Vancouver - Capilano	04.02.2021	
Jordan Sturdy	West Vancouver - Sea to Sky	04.02.2021	

Appendix H-3

PROJECT INTRODUCTION NOTIFICATION LETTER 2019 - MUNICIPALITIES

FortisBC
1-(833) 592-7937
fortisbc.com/advancedgasmeters
advancedgasmeters@fortisbc.com

October 3, 2019

CONTACT INFO – Municipalities

Greetings,

FortisBC pursuing Advanced Gas Meters project
FortisBC is looking at upgrading its customers' natural gas meters to new advanced meters, as we explore ways to modernize and strengthen our system, and add new customer benefits.

We are beginning the process of applying to the British Columbia Utilities Commission (BCUC) for this project, which includes engaging with communities and customers. We expect to file the application with the BCUC in early 2020. If approved, we anticipate upgrading residential and commercial customers to advanced gas meters between 2022-26.

Why advanced gas meters
The gas meter technology currently used in B.C. has not fundamentally changed in more than 100 years. The new meters are smaller, have no moving parts and are expected to last longer than existing meters. They use sound waves to measure gas use and send the information to FortisBC through a wireless network, meaning FortisBC would no longer need to read individual meters manually. The new meters will also allow us to add new safety features, such as the ability to remotely detect and respond to gas leaks.

The new meters would offer benefits for customers such as access to daily updates on gas use and the convenience of not having their gas service shut off during future meter exchanges.

FortisBC welcomes your input
We would like to extend an invitation for you or your representative, to participate in a telephone town hall on Friday, October 11 at 1:00 p.m. (PST). We will provide a brief project overview and answer your questions. Please RSVP to advancedgasmeters@fortisbc.com if you are interested in participating. If you are unable to attend but want to learn more, please visit fortisbc.com/advancedgasmeters. Alternatively, you are welcome to reach out to me directly at Vanessa.Connolly@fortisbc.com and we would be pleased to assist with your inquiry.

In the coming weeks, we will be hosting a series of public information sessions throughout FortisBC's natural gas service area and sharing more information with our customers. Details for our information sessions are available at fortisbc.com/advancedgasmeters, including local sessions near you.

Sincerely,

Vanessa Connolly

Appendix H-4

PROJECT INTRODUCTION NOTIFICATION LETTER 2019 - MLA

FortisBC
1-(833) 592-7937
fortisbc.com/advancedgasmeters
advancedgasmeters@fortisbc.com

October 3, 2019

CONTACT INFO – MLA's

Greetings,

FortisBC pursuing Advanced Gas Meters project
FortisBC is looking at upgrading its customers' natural gas meters to new advanced meters, as we explore ways to modernize and strengthen our system, and add new customer benefits.

We are beginning the process of applying to the British Columbia Utilities Commission (BCUC) for this project, which includes engaging with communities and customers. We expect to file the application with the BCUC in early 2020. If approved, we anticipate upgrading residential and commercial customers to advanced gas meters between 2022-26.

Why advanced gas meters
The gas meter technology currently used in B.C. has not fundamentally changed in more than 100 years. The new meters are smaller, have no moving parts and are expected to last longer than existing meters. They use sound waves to measure gas use and send the information to FortisBC through a wireless network, meaning FortisBC would no longer need to read individual meters manually. The new meters will also allow us to add new safety features, such as the ability to remotely detect and respond to gas leaks.

The new meters would offer benefits for customers such as access to daily updates on gas use and the convenience of not having their gas service shut off during future meter exchanges.

FortisBC welcomes your input
We would like to extend an invitation for you or your representative, to participate in a telephone town hall on Friday, October 11 at 9:00 a.m. (PST). We will provide a brief project overview and answer your questions. Please RSVP to advancedgasmeters@fortisbc.com if you are interested in participating. If you are unable to attend but want to learn more, please visit fortisbc.com/advancedgasmeters. Alternatively, you are welcome to reach out to me directly at Vanessa.Connolly@fortisbc.com and we would be pleased to assist with your inquiry.

In the coming weeks, we will be hosting a series of public information sessions throughout FortisBC's natural gas service area and sharing more information with our customers. Details for our information sessions are available at fortisbc.com/advancedgasmeters, including local sessions near you.

Sincerely,

Vanessa Connolly

Appendix H-5

ADVANCED GAS METERS RESEARCH SUMMARY

Memo

To: Roy Mokha, FortisBC

From: Adam DiPaula, Sentis

Date: September 26, 2019

Re: FortisBC AMI Survey – Summary

*NOTE: The results in this summary based on unweighted data. The final results may change somewhat after a weight variable is applied to ensure the correct customer representation by region.

Survey Administration

- A phone recruit-to-online methodology was used to collect the data from FortisBC residential and commercial natural gas customers.
- In order to qualify for the survey, customers had to confirm that they are responsible for paying the natural gas bill and making choices about their (home's/organization's) energy use.
- The data were collected between September 3 and September 24, 2019
- Total completed surveys: Residential: 505; Commercial 217

Familiarity with Advanced Meters

Only two-in-ten residential and commercial customers expressed that they are *very familiar* with advanced meters. Most customers indicated that they've either heard of advanced meters (but aren't familiar with them) or that they're only somewhat familiar with them (Residential: 67%; Commercial: 61%).

Are you familiar with a device used by utility companies called an advanced meter or smart meter?			
		Residential	Commercial
	Yes, I'm very familiar with advanced meters	20%	18%
	Yes, I'm somewhat familiar with advanced meters	42%	38%
	No, I'm not familiar with advanced meters, but have heard of them	25%	23%
	No, I've never heard of advanced meters	13%	21%

Awareness of Having an Advanced Electricity Meter Installed

Four-in-ten residential customers (43%) indicated that they are certain that they have an advanced electricity meter installed, and another 44% indicated either that they assume they have one installed but aren't certain (24%) or that they don't know (20%).

Commercial customers are more uncertain than residential customers regarding whether or not they have an advanced electricity meter installed. Only two-in-ten commercial customers (22%) indicated that they are certain that they have an advanced electricity meter installed, and 67% indicated either that they assume that they have one installed but aren't certain (27%) or that they don't know (40%).

Do you have an advanced meter installed?	Residential	Commercial
Yes, we do	43%	22%
Assume we do, but not certain	24%	27%
No, we do not have one installed	13%	11%
Don't know	20%	40%

Only a very small percentage of residential (8%) and commercial customers (6%) indicated that they are dissatisfied with their advanced meter. The majority (58% among residential customers; 52% among commercial customers) rated their satisfaction as 'neutral', probably because many have not had an opportunity to interact with the meter or the data it collects.

Just under half of residential and commercial customers (46%) indicated that they know that their advanced meter automatically transmits electricity consumption information to the utility company – another half aren't sure but assume that their meter does this. This leaves only a very small percentage of residential (3%) and commercial customers (4%) who indicated that they have chosen to have their meter read manually.

Does your advanced meter automatically transmit electricity consumption information to the utility company or is your meter read manually?	Residential	Commercial
Yes, it transmits automatically	46%	46%
Not sure, but assume it transmits automatically	51%	50%
I chose to have my meter read manually each month	3%	4%

Potential Usefulness of Advanced Natural Gas Meter Features

Customers find the features that minimize the potential for harm – enabling leak detection and remote automatic gas shut-off – to be the most useful.

However, they also find the features that facilitate energy use monitoring and management – e.g., access to more accurate, daily updates, alerts regarding usage – as relatively important. Residential customers were somewhat more likely to rate these features as useful than commercial customers were.

Percentage Rating Each Advanced Meter Feature as Either Very or Somewhat Useful

		Residential	Commercial
	Enabling FortisBC to better detect and respond to possible gas leaks.	87%	83%
	Enabling FortisBC to remotely and automatically shutoff gas supply if needed in the event of an emergency.	82%	80%
	Lowering emissions by reducing meter reader vehicles on the road.	68%	67%
	No longer having your gas service turned off during routine maintenance.	65%	68%
	Ability to access more accurate, daily updates to better understand and manage your gas use.	65%	60%
	Ability to access more accurate, daily updates to inspire more mindful choices such as upgrading to higher efficiency appliances	64%	56%
	The potential to receive email or text message alerts when your gas use reaches a certain threshold during a billing period.	63%	59%
	Reducing FortisBC's need to regularly access your property for meter reading.	58%	50%
	Being able to choose your own billing date.	56%	55%

Choice Regarding Wireless Transmission of Gas Use Information

In line with their current choice for their advanced electricity meter, only a very small percentage of residential (7%) and commercial customers (9%), indicated that they would choose to have the wireless transmission turned off for their advanced natural gas meter. Over two-thirds of residential customers (69%) and 64% of commercial customers would choose to have the wireless transmission turned on.

While all customers would have an advanced natural gas meter installed at their home/businesses, customers could choose to have the wireless transmission feature of their meter turned off. This means the meter would not be able to wirelessly send gas use information to FortisBC, and that: A FortisBC representative would come to your property to manually read your meter and your bill may include an additional amount to cover administration and manual meter reading costs

Which option are you likely to choose?

		Residential	Commercial
	Wireless transmission turned on	69%	64%
	Wireless transmission turned off	7%	9%
	Don't know/ Not sure	24%	27%

Effectiveness of Ways of Informing Customers About the Advanced Natural Gas Meter Project

Customers view bill inserts and a project-specific website as the most effective ways of keeping customers informed about the advanced natural gas meter project. Residential customers generally view in-person information sessions, open-houses, paid FortisBC advertising and online discussion forums as equally effective. Commercial customers tend to view project website, utility commission regulatory processes such as open houses and online discussion forums as less effective than residential customers do.

Percentage Rating Each Way of Keeping Customers Informed About the Project as Very Effective or Somewhat Effective

		Residential	Commercial
	Direct customer communications such as an insert in your bill.	72%	69%
	A project website, where questions and comments can be submitted to FortisBC via email.	70%	60%
	In-person information sessions with FortisBC representatives.	52%	48%
	BC Utilities Commission regulatory processes such as open houses.	47%	36%
	Paid advertising by FortisBC.	45%	42%
	Online discussion forums with FortisBC representatives.	46%	36%

Appendix H-6

COMMUNICATION METRICS

Category	Metric	Details	Oct	Nov	Dec	Jan-20	Feb	March	April	May	June	July	August	Sept/Oct	Nov/Dec	21-Jan	21-Feb	TOTALS
Website	Unique page views	Measure volume of web traffic to Talking Energy website	3,799	4,915	681	321	288	2,139	225	135	140	122	129	565	341	255	8,335	**22,390**
	Time on page	Percentage of traffic on the Advanced Gas Meters project page for 30 seconds or longer	40%	38%	43%	57%	43%	40%	55%	51%	56%	52%	60%	68%	28%	26%	5%	**44%**
	New vs returning users	Provide % of new site users to returning site users	New users: 71% Returning users: 29%	New users: 59% Returning users: 41%	New users: 19% Returning users: 81%	New users: 55% Returning users: 45%	New users: 67% Returning users: 33%	New users: 70% Returning: 30%	New users: 53% Returning: 47%	New users: 56% Returning: 44%	61% new 39% returning	55% new 45% returning	58% new 42% returning	55% new 45% returning	56% new and 44% returning	53% new and 47% returning	80% new and 20% returning	**n/a**
	Newsletter/e-blast	Number of subscribers at end of month and average open rate	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**
	Referral sources	Identify top-3 sources driving traffic to the Advanced Gas Meters project page.	Weather Network (35%), unknown (20%), Accounts Online (9%)	Unknown (48%), Weather Network (25%), Organic (6%)	Unknown (60%), Organic (17%), Accounts Online/collaterial (7% each)	Organic (39%), Accounts Online (25%), Unknown (18%)	Accounts Online (39%), Organic (29%), Unknown (14%)	Bill insert (e-bill) (60%), Accounts Online (17%), Energy Moment (10%)	Organic (35%), collateral (20%), e-bill email (20%)	Organic (44%), collateral (20%), unknown (17%)	Organic (70%), unknown (11%), collateral (9%)	Organic (65%), collateral (13%), unknown (10%)	Organic (47%), unknown (28%), collateral (17%)	Organic (53%); collateral [bill insert] (39%); unknown (4%)	Organic (66%); collateral (19%); unknown (5%)	Organic (61%); collateral (19%); unknown (8%)	Facebook (87%); Twitter (7%); account online (2%); organic (2%); collateral (2%)	**n/a**
Social media	Posts	Posts to social media, including Facebook, Twitter, Instragram, LinkedIn.	26	6	0	0	8	0	0	0	0	0	0	0	0	0	8	**48**
	Awareness	Estimated impressions over Twitter, Facebook, LinkedIn, Instagram, IG stories.	50,706	59,475	0	0	3,961	0	0	0	0	0	0	123	0	0	1,108,085	**1,222,350**
	Engagement	Measuring interaction withy social media posts (can include shares, mentions, comments, or click-throughs dependeing on platform). For Facebook, Twitter, Instagram, LinkedIn, IG stories.	154	16	0	0	162	0	0	0	0	0	0	0	0	0	26,338	**26,670**
	Responses (reactive)	How many public inquiries we've responded to via social media.	3	0	0	0	0	0	0	0	0	0	0	1	3	1	21	**29**
	Referral traffic	The number of click-throughs traffic directed to the Advanced Gas Meters project page by social media. (collected from digital)	116	10	0	2	1	0	1	2	2	3	1	0	4	22	7,900	**8,064**
Ad campaigns	Awareness and reach	Number of people who have seen the ads, combined across print, broadcast, digital and social media	Print: 1,066,019 Digital: 1,630,815 Twitter: 109,475	Print: 1,066,019 Digital: 1,630,815 Twitter: 109,475	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	TBC (waiting for final report)	**TBC**
	Time in market	Dates and time that the ad campaign was in market	5 weeks Oct 15 - Nov 20	5 weeks Oct 15 - Nov 20	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	TBC (waiting for final report)	**TBC**
Media relations	Media proactive	Number of media outlets proactively contacted.	57	23	0	0	0	0	0	0	0	0	0	0	0	0	0	**80**
	Media reactive	Number of media inquiries reactively responded to.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	News mentions	Number of news stories that mentioned the project	61	4	0	0	0	0	0	0	0	0	0	0	1	0	4	**70**
	Audience (estimated reach)	Monitor news coverage using Cision to determine # of readers/viewers (reach)	658,300	38,800	0	0	0	0	0	0	0	0	0	0	0	0	9,402	**706,502**
	Audience (potential digital reach)	Potential audience reached via digital news sites (UVPM), as measured by Cision	5,300,000	97,600	0	0	0	0	0	0	0	0	0	0	0	0	50,816	**5,448,416**
	Ad value	Overall monetary value of news media coverage as measured by Cision	$16,100	$479	0	0	0	0	0	0	0	0	0	0	0	0	$179.31	**$16,758**
	Tone	Overall tone of media coverage as measured by Cision	Positive: 62.3% Negative: 0% Neutral: 37.7%	Positive: 50% Negative: 0% Neutral: 50%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Neutral: 100%	n/a	Positive: 66.7% Negative: 0% Neutral: 33.3%	**n/a**

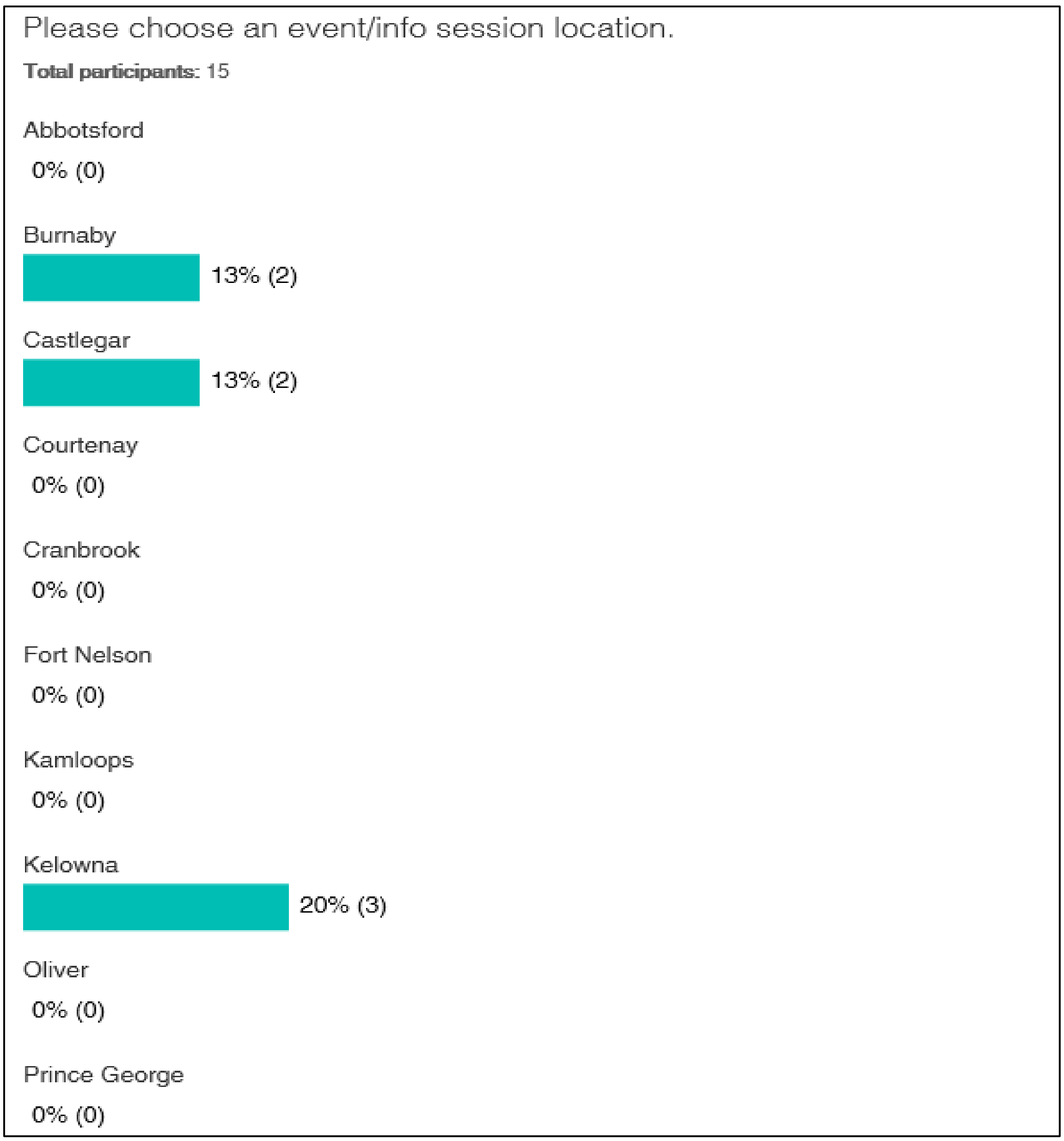
Appendix H-7

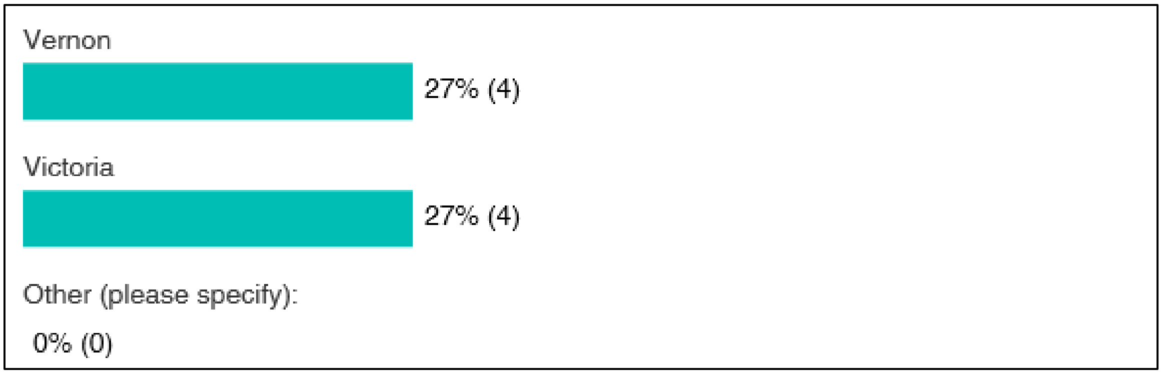
ADVANCED GAS METER INFORMATION SESSION SURVEY

Advanced Gas Meter Event Survey Results

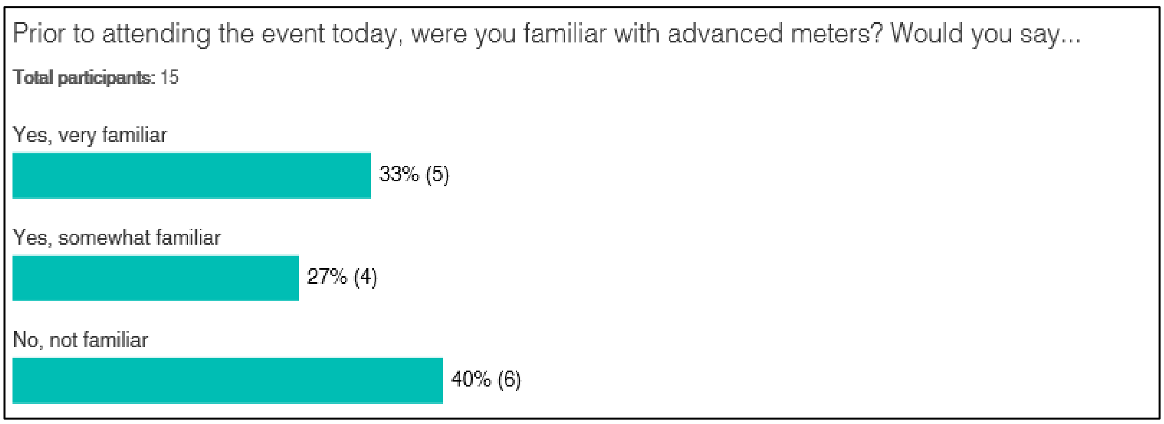
Please note: percentages derived from "actual" base sizes of less than 100 respondents should be interpreted with caution, while percentages derived from "actual" base sizes of less than 50 respondents should be interpreted with extreme caution. Due to the limited responses, the results should be considered as directional feedback only. The results are in no way representative of the entire sample population.

Event Location

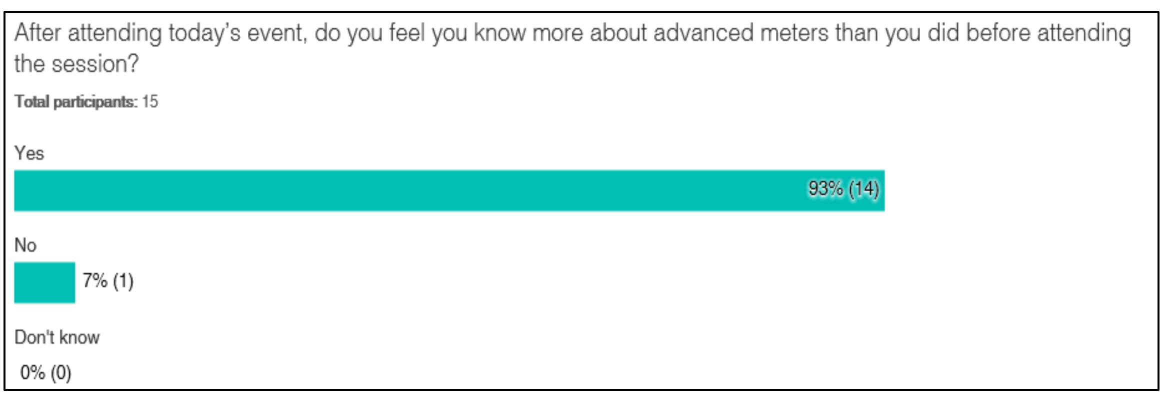




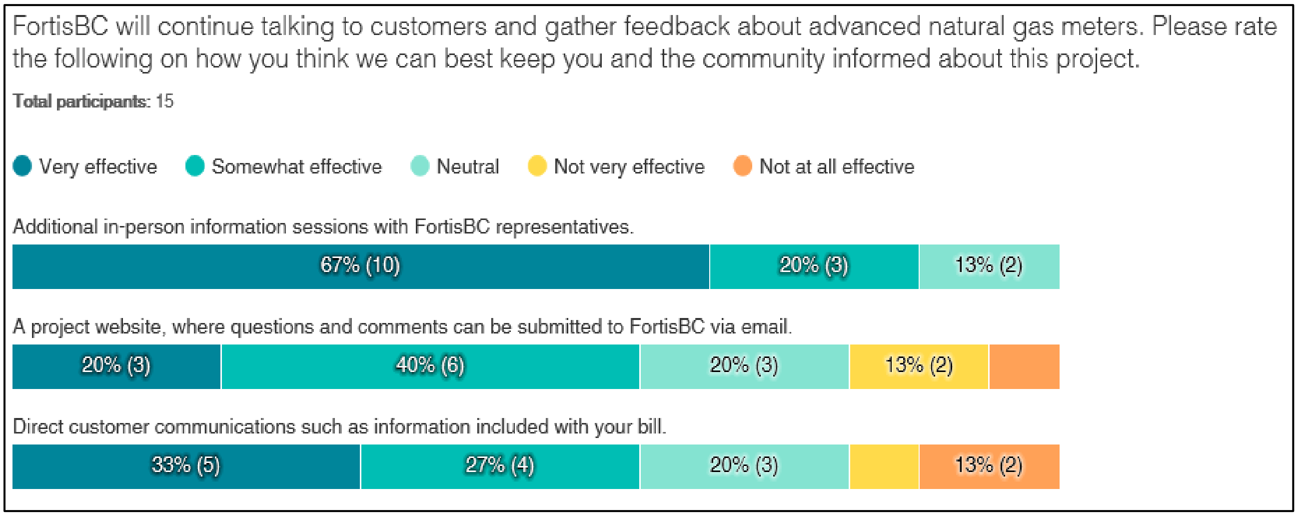
Question 1



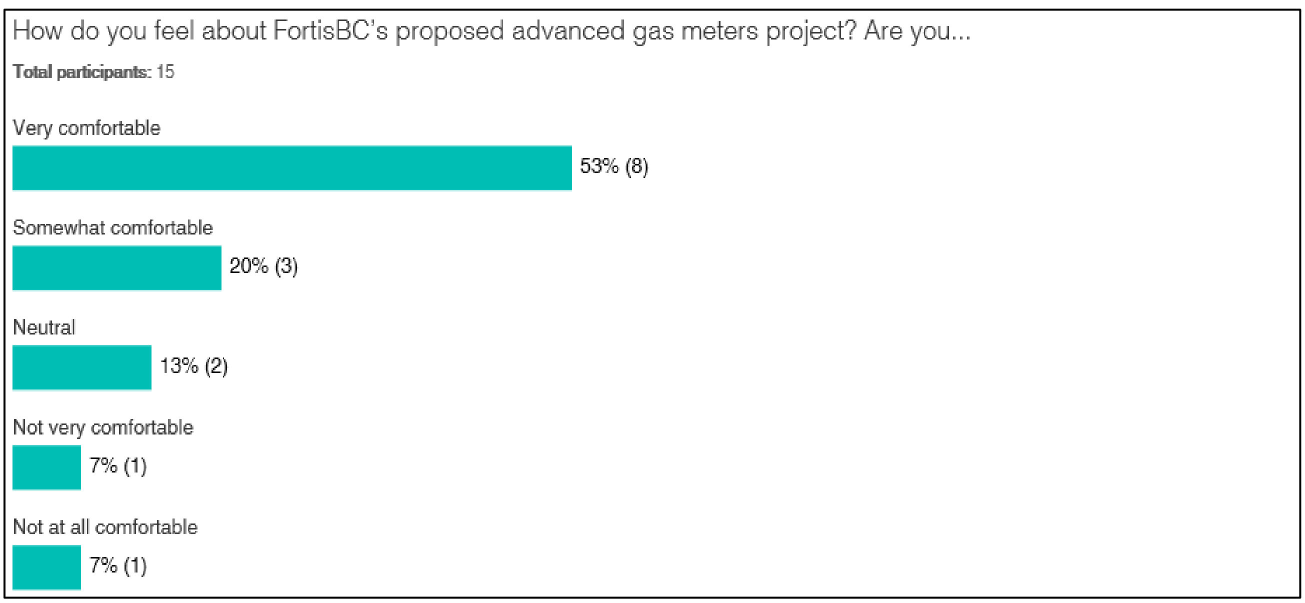
Question 2



Question 3



Question 4



Question 5

And lastly, is there anything specific that you'd like to share with us regarding advanced meters, or this event?

Total participants: 15

1. Ensure to speak with technical safety bc, be proactive with gas fitters in the field on education etc.
2. Our biggest concern is in respect to radiation emissions.
   We only found out about this event in our Morningstar newspaper today. More advanced notice would be appreciated.
3. Thanks for making the effort to engage with the public
4. Not at this time
5. No more RF.
6. I am very concerned about the health effects of radio frequency radiation. The WHO has been criticized by scientists around the world for the conflict of interest of the committee setting their policy, and for ignoring the rating of the International Agency on Cancer Research Class 2b Possible Carcinogen. Health Canada also has failed to recognize non thermal health effects. I will send references to your website email.
7. Wasn't aware of the network upgrade, very interested in learning more about this.
8. No comments at this time
9. You must have a real public consultation. More people than blue shirts. With representation from city council and staff.
   Make a concerted effort of moving away from or transitioning quickly away from fossil fuels. Researching and developing new technologies and investing money into that.

Appendix H-8

MEDIA COVERAGE, CISION REPORT

Prominence and Impact

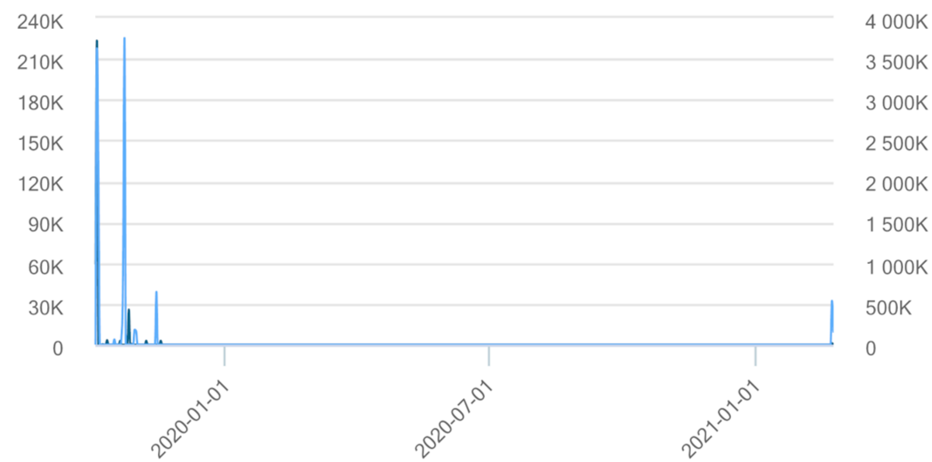
Top Articles

HEADLINES	OUTLET	REACH
FortisBC applying to install 1M wireless gas meters across B.C.	Global News Online	3,315,253
Modernizing British Columbias gas system, Business World:	Newkerala.com	430,134
Your gas meter may be upgraded soon if FortisBC's project is approved	CFCF-DT (CTV Montreal)	383,543
Modernizing British Columbia's gas system	Canada NewsWire	348,934
Modernizing British Columbia's gas system	Futures TradingCharts	331,507
More than a million people in b.c. Will likely be getting new gas meters in the next few years and to show customers it's new technology, fortis b.c. Held an	CHBC-DT (Global	225,300
fortis bc is applying to roll out new smart metres but the devices' method of measurement may prove contentious.	CHAN-TV (Global BC)	110,700
Modernizing British Columbia's gas system - Commodities (COMMODIT) News	InvestorPoint.com	82,761
Modernizing British Columbia's gas system - Energy (ENERGY01) News	InvestorPoint.com	82,761
fortisbc is applying to roll out new smart meters, but the devices' method of measurement may prove contentious. The utility says the new meters will use	CHAN-TV (Global BC)	75,900
Modernizing British Columbia's gas system	CEO CA	64,752
Business news. Fortis b. C. Says it will apply next year for regulatory approval for what it says is the first fundamental technology upgrade of b. C. Gas	CKNW-AM (Global News	62,900
FortisBC plans to replace gas meters	Alaska Highway News	55,971
Fortis bc is applying to roll out smart meters, but the device's method of measurement may prove contentious. The utility say it will use sound waves to	CHAN-TV (Global BC)	53,000
FortisBC pitches replacing all Burnaby natural gas meters	Burnaby Now Online	48,772
FortisBC info session looks at plan to install new gas meters	Abbotsford News Online,	48,414
Vernon up for advanced gas meters project	Morning Star Online, The	47,651

Mentions

Total Mentions

Reach



Value of Coverage

Appendix H-9

2019 ADVERTISING CAMPAIGN REPORT

FortisBC
AMI
Wrap Report
December 2,2019

Campaign Parameters

- **Target Audience:**
  - Natural Gas customers through the province in B.C.

- **Timing**:
  - Info sessions go from October 15 – November 20th
  - We would like the ads to be live 1 week prior to each information session

- **Markets**:
  - **Specifically target cities hosting info sessions including:** Prince George, Fort Nelson, Kelowna, Armstrong, Kamloops, Cranbrook, Castlegar, Osoyoos, Victoria, Comox, Burnaby, Chilliwack

- **KPI:**
  - Clicks to our landing page/sign ups for information sessions
  - Attendees at information sessions

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Connections Strategy

- Generate awareness using a mix of localized print and digital to each region hosting info sessions
  - **Digital:** Targetable medium that will provide reach into the specific areas and will direct users with one click to the landing page where they can learn more
  - **Print:** Community-based vehicle and provides a news environment for the message

WASSERMAN + PARTNERS ADVERTISING

Blocking Chart

Campaign	Element	Market	Description	Size	Event Date	October				November				# of Weeks	# of Units
						30	7	14	21	28	4	11	18		
GROUP ONE	Newspaper	Prince George	Prince George Citizen	4.86"w x 6.61"h	Oct 15		Th							1	1
	Newspaper	Dawson Creek	Alaska Highway News	4.851" w x 9.714" h			Th							1	1
	Newspaper	Fort Nelson	Fort Nelson News	5.124" w x 10.71" h	Oct 16		We							1	1
	Digital	Prince George, Fort Nelson, Quesnel, Williams Lake	Weather Network	728x90, 300x250, 320x50										1	
	Digital	Prince George, Fort Nelson, Quesnel, Williams Lake	Glacier	300x250, 728x90, 320x50, 300x50										1	
GROUP TWO	Newspaper	Kelowna	Kelowna Capital News	5.111" w x 6" h	Oct 21			Fr						1	1
	Newspaper	Kelowna	Kelowna Daily + Extra	5.167" w x 10.71" h	Oct 21			We						1	1
	Newspaper	Armstrong / Enderby	Okanagan Advertiser	5.84" w x 7" h	Oct 22			Th						1	1
	Newspaper	Kamloops	Kamloops This Week	5.83" w x 7" h	Oct 23			Fr						1	1
	Newspaper	Oliver	Oliver Chronicle	5.08" w x 7" h				Th						1	1
	Newspaper	Salmon Arm	Lakeshore Shuswap News	5.111" w x 6" h				Fr						1	1
	Newspaper	Penticton	Penticton Western News	5.111" w x 6" h				Fr						1	1
	Newspaper	Okanagan	Okanagan Saturday	5.167" w x 10.71" h				Sat						1	1
	Newspaper	Vernon	Vernon Morning Star	5.111" w x 6" h				Fr						1	1
	Digital	Kelowna, Salmon Arm, Penticton, Vernon	Black Press	300x250, 320x50, 970x90, 300x50, 300x600										1	
	Digital	Kelowna, Armstrong, Enderby, Kamloops, Oliver, Salmon Arm, Penticton, Vernon	Weather Network	728x90, 300x250, 320x50										1	
	Digital	Okanagan	Castanet	300x250, 728x90, 300x600										1	
GROUP THREE	Newspaper	Cranbrook	Cranbrook Townsman	5.111" w x 6" h	Oct 28				We					1	1
	Newspaper	Kimberly	Kimberley Bulletin	5.111" w x 6" h					Fr					1	1
	Newspaper	Castlegar	Castlegar News	5.111" w x 6" h	Oct 29				Th					1	1
	Newspaper	Nelson	Nelson Star	5.111" w x 6" h					Th					1	1
	Newspaper	Osoyoos	Osoyoos Times	5.08" w x 7" h	Oct 30				Th					1	1
	Newspaper	Creston	Creston Advance	5.111" w x 6" h					Th					1	1
	Newspaper	Grand Forks	Grand Forks Gazette	5.111" w x 6" h					We					1	1
	Newspaper	Elkford / Sparwood	Fernie Free Press	5.111" w x 6" h					Th					1	1
	Newspaper	Greenwood	Greenwood Boundary Times	5.111" w x 6" h					Th					1	1
	Newspaper	Princeton	Princeton Spotlight	5.111" w x 6" h					Th					1	1
	Digital	Cranbrook, Kimberly, Castlegar, Nelson, Creston, Grand Forks, Fernie, Greenwood, Princeton, Trail	Black Press	300x250, 320x50, 970x90, 300x50, 300x600										1	
	Digital	Cranbrook, Kimberly, Castlegar, Nelson, Osoyoos, Creston, Grand Forks, Elkford, Sparwood, Greenwood, Princeton, Trail	Weather Network	728x90, 300x250, 320x50										1	
GROUP FOUR	Newspaper	Victoria	Victoria Times Colonist	5.208" w x 10.71" h	Nov 5					Thu				1	1
	Newspaper	Oak Bay	Oak Bay News	5.111" w x 6" h						We				1	1
	Newspaper	Saanich	Saanich News	5.111" w x 6" h						We				1	1
	Newspaper	Ladysmith	Ladysmith Chronicle	5.111" w x 6" h						Th				1	1
	Newspaper	Cowichan	Cowichan Valley Citizen	5.111" w x 6" h						We				1	1
	Newspaper	Comox	Comox Valley Record	5.111" w x 6" h	Nov 6					Th				1	1
	Newspaper	Campbell River	Campbell River Mirror	5.111" w x 6" h						Fri				1	1
	Newspaper	Nanaimo	Nanaimo News Bulletin	5.111" w x 6" h						Th				1	1
	Newspaper	Port Alberni	Alberni Valley News	5.111" w x 6" h						We				1	1
	Newspaper	Parksville	Parksville News	5.111" w x 6" h						Th				1	1
	Digital	Victoria Region, Nanaimo, Ladysmith, Duncan Cowichan, Comox, Campbell River, Alberni, Parksville	Black Press	300x250, 320x50, 970x90, 300x50, 300x600										1	
	Digital	Victoria, Goldstream, Peninsula, Oak Bay, Sooke, Saanich, Nanaimo, Ladysmith, Cowichan, Powell River	Weather Network	728x90, 300x250, 320x50										1	
	Digital	Victoria, Goldstream, Peninsula, Oak Bay, Sooke, Saanich, Nanaimo, Ladysmith, Cowichan, Powell River	Google Display	300x250, 728x90, 320x50											
GROUP FIVE	Newspaper	Burnaby	Burnaby Now	5.083" w x 7" h	Nov 13						Thu			1	1
	Newspaper	Whistler	Pique News	4.48" w x 6.15" h							Thu			1	1
	Newspaper	Squamish	Squamish Chief	4.85" w x 7" h							Thu			1	1
	Newspaper	Richmond	Richmond News	5.083" w x 7" h							Thu			1	1
	Newspaper	Vancouver	Vancouver Courier	5.083" w x 7" h							Thu			1	1
	Newspaper	North/West Vancouver	North Shore News	5.083" w x 7" h							Fri			1	1
	Newspaper	New Westminster	New West Record	5.083" w x 7" h							Thu			1	1
	Newspaper	Coquitlam	Tricity News	5.083" w x 7" h							Thu			1	1
	Newspaper	White Rock	Peace Arch News	5.111" w x 6" h							Fri			1	1
	Newspaper	Delta	Delta Optimist	5.083" w x 7" h							Thu			1	1
	Newspaper	Delta	North Delta Reporter	5.111" w x 6" h							Thu			1	1
	Newspaper	Surrey / Cloverdale	Surrey Now Leader	5.111" w x 6" h							Fri			1	1
	Newspaper	Chilliwack	Chilliwack Progress	5.111" w x 6" h	Nov 20							Fri		1	1
	Newspaper	Abbotsford / Mission	Abbotsford News	5.111" w x 6" h								Wed		1	1
	Newspaper	Maple Ridge	Maple Ridge News	5.111" w x 6" h								Fri		1	1
	Newspaper	Aldergrove	Aldergrove Star	5.111" w x 6" h								Thu		1	1
	Newspaper	Langley	Langley Times	5.111" w x 6" h								Fri		1	1
	Newspaper	Hope	Hope Standard	5.111" w x 6" h								Thu		1	1
	Digital	Lower Mainland	Weather Network	728x90, 300x250, 320x50										2	
	Digital	Lower Mainland	Postmedia	300x250, 728x90, 300x600										2	
	Digital	Lower Mainland	Google Display	300x250, 728x90, 320x50										2	
	Digital	All Markets	Boosting FortisBC Tweet	n/a										6	
	Digital	All Markets	Ad Serving	n/a											

Newspaper

- **Period Timing: Oct 7 - Nov 17, 2019**
- **Ad Size:**
  - o Quarter Page, BW
- **Number of Publications**: 50
- **Number of Ads:** 50
- **Impressions:** 1,066,019

List of Publications

Campaign	Market	Description
GROUP ONE	Prince George	Prince George Citizen
	Dawson Creek	Alaska Highway News
	Fort Nelson	Fort Nelson News
GROUP TWO	Kelowna	Kelowna Capital News
	Kelowna	Kelowna Daily + Extra
	Armstrong / Enderby	Okanagan Advertiser
	Kamloops	Kamloops This Week
	Oliver	Oliver Chronicle
	Salmon Arm	Lakeshore Shuswap News
	Penticton	Penticton Western News
	Okanagan	Okanagan Saturday
	Vernon	Vernon Morning Star
GROUP THREE	Cranbrook	Cranbrook Townsman
	Kimberly	Kimberley Bulletin
	Castlegar	Castlegar News
	Nelson	Nelson Star
	Osoyoos	Osoyoos Times
	Creston	Creston Advance
	Grand Forks	Grand Forks Gazette
	Ellkford / Sparwood	Fernie Free Press
	Greenwood	Greenwood Boundary Times
	Princeton	Princeton Spotlight
GROUP FOUR	Victoria	Victoria Times Colonist
	Oak Bay	Oak Bay News
	Saanich	Saanich News
	Ladysmith	Ladysmith Chronicle
	Cowichan	Cowichan Valley Citizen
	Comox	Comox Valley Record
	Campbell River	Campbell River Mirror
	Nanaimo	Nanaimo News Bulletin
	Port Alberni	Alberni Valley News
	Parksville	Parksville News
GROUP FIVE	Burnaby	Burnaby Now
	Whistler	Pique News
	Squamish	Squamish Chief
	Richmond	Richmond News
	Vancouver	Vancouver Courier
	North/West Vancouver	North Shore News
	New Westminster	New West Record
	Coquitlam	Tricity News
	White Rock	Peace Arch News
	Delta	Delta Optimist
	Delta	North Delta Reporter
	Surrey / Cloverdale	Surrey Now Leader
	Chilliwack	Chilliwack Progress
	Abbotsford / Mission	Abbotsford News
	Maple Ridge	Maple Ridge News
	Aldergrove	Aldergrove Star
	Langley	Langley Times
	Hope	Hope Standard

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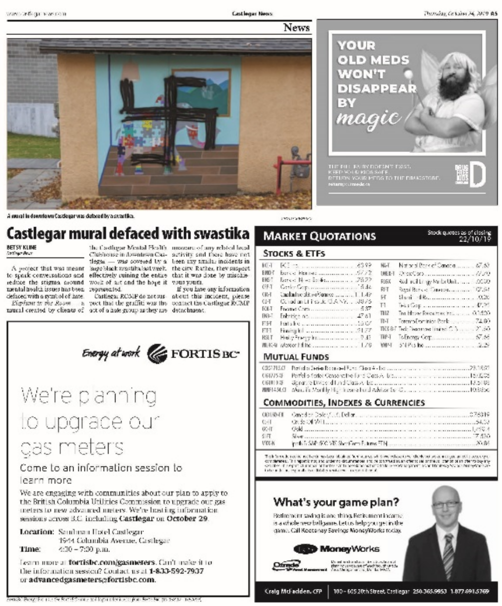
Tearsheets – Newspaper



Castlegar News – Oct 24, 19

Surrey Now – Nov 8, 19

Cowichan Valley Citizen – Oct 30, 19

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Digital – Front End Results – Display

BC Market					Front End						
Site	**Tactic**	**Geo**	**Flight Dates**	**Reporting Period**	**Impressions Delivered**	**Clicks**	**CTR**	**Landing Page (advanced_meters) VTs**	**Response Rate (VTs + Clicks / Impressions)**	**Planned Impressions /Clicks**	**Pacing %**
Pelmorex	Geotarget - Weather Network - City Pages	Prince George, Fort Nelson, Dawson Creek, Quesnel, Williams Lake	Oct 7 - Oct 13	Oct 7 - Oct 13	130,567	282	0.22%	5	0.22%	1,161,000	93.94%
		Kelowna, Armstrong, Enderby Kamloops, Oliver, Salmon Arm, Penticton, Vernon	Oct 14 - Oct 20	Oct 14 - Oct 20	129,781	262	0.20%	5	0.21%		
		Cranbrook, Kimberly, Castlegar, Nelson, Osoyoos, Creston, Grand Forks, Elkford, Sparwood, Greenwood, Princeton, Trail	Oct 21 - Oct 27	Oct 21 - Nov 3	129,025	308	0.24%	3	0.24%		
		Victoria, Goldstream, Peninsula, Oak Bay, Sooke, Saanich, Nanaimo, Ladysmith, Cowichan, Powell River	Oct 28 - Nov 3	Oct 21 - Nov 3	311,390	621	0.20%	3	0.20%		
		Lower Mainland, Squamish, Whistler, Fraser Valley	**Nov 4 - Nov 17**	**Nov 4 - Nov 17**	**389,874**	**884**	**0.23%**	**4**	**0.23%**		
					1,090,637	2,357	0.22%	10		1,161,000	94%
PostMedia	ROS - Van Sun, Province	Lower Mainland, Squamish, Whistler, Fraser Valley	Nov 4 - Nov 17	**Nov 4 - Nov 17**	**467,512**	**283**	**0.06%**	**5**	**0.06%**	300,000	155.84%
					467,512	283	0.06%			300,000	155.84%

- Pelmorex delivered the top front-end performance, achieving 2,357 clicks overall and an average CTR of 0.22%

Digital – Back End Results – Display

BC Market					Back End				
					All Visits		Non-Bounce		
Site	Tactic	Geo	Flight Dates	Reporting Period	Pages / Visit	Bounce Rate	Sessions	Pages / Visit	Avg. Session Duration
Pelmorex	Geotarget - Weather Network - City Pages	Prince George, Fort Nelson, Dawson Creek, Quesnel, Williams Lake	Oct 7 - Oct 13	Oct 7 - Oct 13	1.09	93.55%	18	2.39	0:05:12
		Kelowna, Armstrong, Enderby Kamloops, Oliver, Salmon Arm, Penticton, Vernon	Oct 14 - Oct 20	Oct 14 - Oct 20	1.20	91.51%	23	3.30	0:05:38
		Cranbrook, Kimberly, Castlegar, Nelson, Osoyoos, Creston, Grand Forks, Elkford, Sparwood, Greenwood, Princeton, Trail	Oct 21 - Oct 27	Oct 21 - Nov 3	1.09	94.12%	19	2.53	0:05:57
		Victoria, Goldstream, Peninsula, Oak Bay, Sooke, Saanich, Nanaimo, Ladysmith, Cowichan, Powell River	Oct 28 - Nov 3	Oct 21 - Nov 3	1.15	94.14%	37	3.57	0:07:14
		Lower Mainland, Squamish, Whistler, Fraser Valley	**Nov 4 - Nov 17**	**Nov 4 - Nov 17**	**1.07**	**90.60%**	**88**	**1.74**	**0:04:38**
							185		
PostMedia	ROS - Van Sun, Province	Lower Mainland, Squamish, Whistler, Fraser Valley	Nov 4 - Nov 17	**Nov 4 - Nov 17**	**1.06**	**92.24%**	**18**	**1.83**	**0:03:55**
							18		

- Pelmorex delivered the most back end non-bounce sessions
- Both vendors delivered qualified audience, exceeding 3 minutes in average session duration

Google Display – Front End Results

BC Market					Front End						
Site	**Tactic**	**Geo**	**Flight Dates**	**Reporting Period**	**Impressions Delivered**	**Clicks**	**CTR**	**Landing Page (advanced_meters) VTs**	**Response Rate (VTs + Clicks / Impressions)**	**Planned Impressions /Clicks**	**Pacing %**
Google Display	Google Content Network - Keywords	Victoria, Goldstream, Peninsula, Oak Bay, Sooke, Saanich, Nanaimo, Ladysmith, Cowichan, Powell River	Oct 28 - Nov 3	Oct 21 - Nov 3	9,822	4	0.04%	[redacted]	0.04%	500,000	0.02%
		Lower Mainland, Squamish, Whistler, Fraser Valley	Nov 4 - Nov 17	**Nov 4 - Nov 17**	**62,844**	**75**	**0.12%**		**0.12%**		
					72,666	79	0.11%			500,000	0.02%

- Google display did not achieve the projected impressions - the hope was that the buy would accelerate over time but the condensed schedule ultimately was not able to deliver

WASSERMAN PARTNERS ADVERTISING

Google Display – Back End Results

BC Market					Back End				
					All Visits		Non-Bounce		
Site	Tactic	Geo	Flight Dates	Reporting Period	Pages / Visit	Bounce Rate	Sessions	Pages / Visit	Avg. Session Duration
Google Display	Google Content Network - Keywords	Victoria, Goldstream, Peninsula, Oak Bay, Sooke, Saanich, Nanaimo, Ladysmith, Cowichan, Powell River	Oct 28 - Nov 3	Oct 21 - Nov 3	1.00	100.00%	0	0.00	0:00:00
		Lower Mainland, Squamish, Whistler, Fraser Valley	Nov 4 - Nov 17	**Nov 4 - Nov 17**	**1.12**	**88.24%**	**2**	**2.00**	**0:01:22**
							2		

- Google display delivered minimal activity on the back-end as a result of the lack of impressions volume
- Recommended not to use Google Display in the future for campaigns with tight timing that restricts the ability to make optimizations

Social – Front End Results – Display

BC Market					Front End							
Site	Tactic	Geo	Flight Dates	Reporting Period	Impressions Delivered	Clicks	CTR	Landing Page (advanced_meters) VTs	Response Rate (VTs + Clicks / Impressions)	Planned Impressions /Clicks	Pacing %
Twitter	Boosted Posts		Oct 5 - Nov 17	Oct 5 - Oct 20	42,104	470	1.12%	[redacted]	1.12%	N/A	
				Oct 21 - Nov 3	35,829	492	1.37%		1.37%		
				Nov 4 - Nov 17	**31,542**	**401**	**1.27%**		**1.27%**		
					109,475	1,363	1.25%			0	

- Twitter was the only digital tactic that ran across all regional groups and delivered a healthy 1.25% CTR overall

WASSERMAN + PARTNERS ADVERTISING

Social – Back End Results – Display

BC Market					Back End				
					All Visits		Non-Bounce		
Site	Tactic	Geo	Flight Dates	Reporting Period	Pages / Visit	Bounce Rate	Sessions	Pages / Visit	Avg. Session Duration
Twitter	Boosted Posts		Oct 5 - Nov 17	Oct 5 - Oct 20	1.09	95.29%	4	3.00	0:02:37
				Oct 21 - Nov 3	1.09	91.18%	6	2.00	0:11:07
				Nov 4 - Nov 17	**1.12**	**75.00%**	**14**	**1.50**	**0:02:35**
							24.00		

- Twitter improved its back-end numbers as the campaign progressed

Campaign Learnings

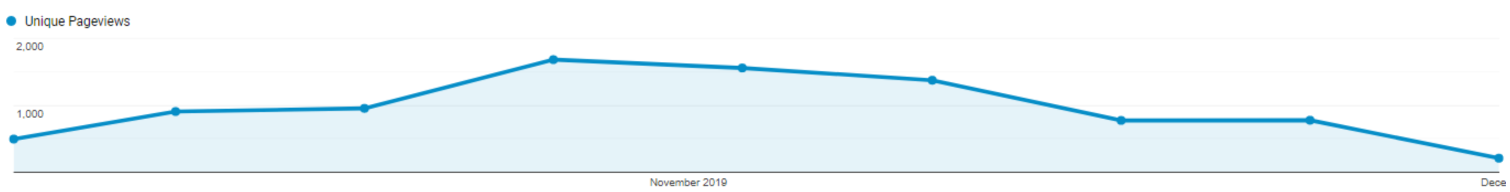
- For campaigns of this nature, that drive users to find out about info sessions on a particular topic, the combination of print and digital was effective in generating awareness for the message within informational environments and highlighting the URL
  - The Pelmorex Weather Network delivered the best performance, and presented a good example of the impact of contextual relevance to the message given that usage correlates with weather patterns
- FortisBC to provide information on the attendance numbers for the different regions

WASSERMAN + PARTNERS ADVERTISING

Analytics

General insights (Oct 7-Dec 3)

- 8,719 unique pageviews
- 40% of traffic is on page for 30 seconds or longer
- Limited engagement with the tabs; "Timeline" tab most clicked
  - As with other campaigns, desktop users are more engaged
- /gasmeters used 406 times
- /advancedgasmeters used 173 times
- 10 related site searches



Energy at work FORTIS BC™

Analytics – Flight 1

Flight 1: Oct 7-13
Markets: Prince George, Dawson Creek, Fort Nelson, Quesnel, Williams Lake
Media: newspaper, boosted tweets, Weather Network, Glacier

Flight 1	
Unique pageviews	556
30 sec timers	162 (29%)
Entrances	95%
Exits	88%
% visits from target area	64%

Energy at work FORTIS BC™

Analytics – Flight 1

Top traffic sources

Source	Unique pageviews	% of traffic
Weather Network	278	50%
Account Online	85	15%
Glacier	63	11%
Organic	36	7%
Twitter	33	6%
Collateral	24	5%
Unknown	12	2%

Analytics – Flight 2

Flight 2: Oct 14-20
Markets: Kelowna, Armstrong, Kamloops, Oliver, Salmon Arm, Penticton, Okanagan, Vernon
Media: newspaper, boosted tweets, Black Press, Weather Network, Castanet

Flight 2	
Unique pageviews	925
30 sec timers	399 (443%)
Entrances	98%
Exits	89%
% visits from target area	47%

Energy at work FORTIS BC™

Analytics – Flight 2

Top traffic sources

Source	Unique pageviews	% of traffic
Weather Network	264	29%
Energy Moment	233	25%
Castanet	109	12%
Account Online	97	11%
Black Press	93	10%
Organic	27	3%
Twitter	27	3%
Collateral	25	3%
Unknown	17	2%
Paid	7	1%

Analytics – Flight 3

Flight 3: Oct 21-27
Markets: Cranbrook, Kimberly, Castlegar, Nelson, Osoyoos, Creston, Grand Forks, Elkford/Sparwood, Greenwood, Princeton, Trail
Media: newspaper, boosted tweets, Black Press, Weather Network

Flight 3	
Unique pageviews	954
30 sec timers	420 (44%)
Entrances	95%
Exits	89%
% visits from target area	30%

Energy at work FORTIS BC™

Analytics – Flight 3

Top traffic sources

Source	Unique pageviews	% of traffic
Weather Network	320	35%
Unknown	289	32%
Account Online	81	9%
Black Press	52	6%
Organic	41	4.5%
Twitter	25	3%
Collateral	26	3%
Energy Moment	15	1.5%
Paid	9	1%

Analytics – Flight 4

Flight 4: Oct 28-Nov 3
Markets: Victoria, Goldstream, Peninsula, Oak Bay, Sooke, Saanich, Nanaimo, Ladysmith, Cowichan, Powell River
Media: newspaper, boosted tweets, Black Press, Weather Network, Google display

Flight 4	
Unique pageviews	1,751
30 sec timers	712 (41%)
Entrances	96%
Exits	87%
% visits from target area	30%

Analytics – Flight 4

Top traffic sources

Source	Unique pageviews	% of traffic
Weather Network	617	37%
Unknown	527	31%
Black Press	275	16%
Organic	74	4.5%
Paid	33	2%
Twitter	28	1.5%
Collateral	26	1.5%
Account Online	17	1%
Energy Moment	8	0.5%

Analytics – Flight 5

Flight 5: Nov 4-20
Market: Lower Mainland
Media: newspaper, boosted tweets, Weather Network, Post Media, Google display

Flight 5	
Unique pageviews	3,240
30 sec timers	1,212 (37%)
Entrances	96%
Exits	88%
% visits from target area	70%

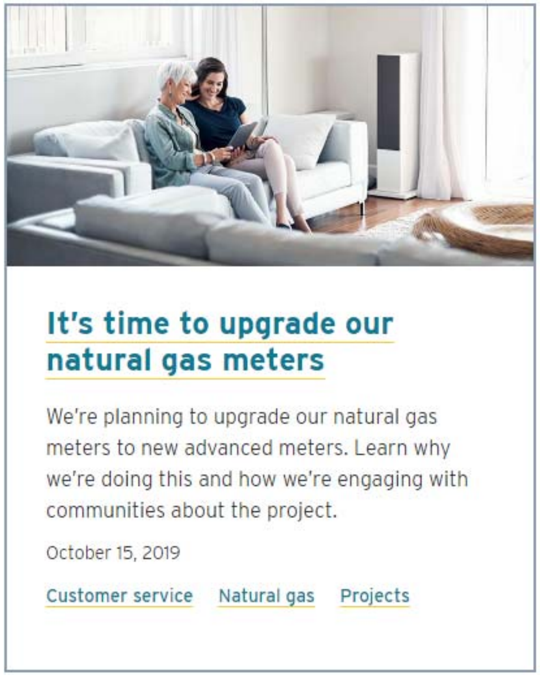
Analytics – Flight 5

Top traffic sources

Source	Unique pageviews	% of traffic
Unknown	1,335	43%
Weather Network	938	30%
Post Media	232	7%
Organic	209	7%
Twitter	52	2%
E-bill email	51	2%
Account Online	49	2%
Collateral	48	2%
Paid	42	1%
Energy Moment	13	<1%

Analytics - Blog

- 345 unique pageviews to Dec 3
- 61 clicks to the AMI webpage
- Top traffic sources:
  - 87 organic
  - 24 Facebook
  - 20 unknown
  - 10 Twitter
- Top cities:
  - 39 Vancouver
  - 30 Nanaimo
  - 25 Surrey
  - 19 Kelowna
  - 17 Burnaby
  - 13 North Vancouver
  - 11 Victoria
  - 11 Coquitlam
  - 5 Penticton



Analytics – Organic social media

Twitter overview

# of Tweets	Impressions	Engagements	RT's	Likes	URL clicks
35	28, 136	378	2	40	116

Facebook overview

# of Posts	Reach	Engagements	Shares	Likes
2	741	25	0	6

Energy at work FORTIS BC™

Analytics – Organic social media

Twitter

	Average Impressions	Average Engagements	Average RT's	Average Likes	Average URL Clicks
Real-time photo tweets	957.8	22.8	2	2.4	6.3
Info tweets	747.5	3.8	0	.3	1.7

- Post taken with a real-time, authentic photos outperformed informational tweets in every category.

Energy at work FORTIS BC™

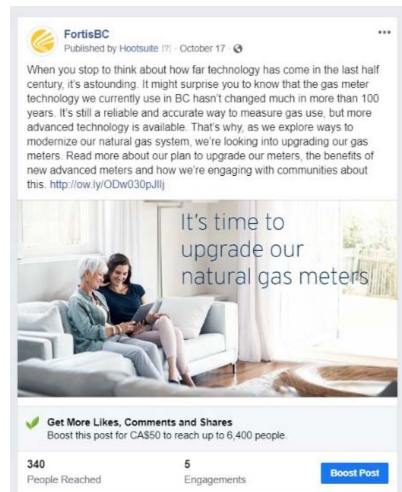
Analytics – Organic social media

Facebook

Both Facebook posts achieved little organic reach. However, the initial announcement post on October 4th achieved far more engagement than the follow up post on October 17.

October 4
- Total engagements = 20
  - 6 likes, 1 comment, 13 post clicks

October 17
- Total engagements = 5
  - 1 like, 4 post clicks



Energy at work FORTIS BC™

GLOSSARY

Front-End Reporting Terms

- **Impressions:** The number of times an ad has been served.
- **Clicks:** Count of clicks on an ad creative
- **View-through (VT):** When a user views but does not click on an ad and still ends up on the destination website, the last ad viewed gets the credit for the view-through
- **Post Click (PC):** When a user clicks on an ad and ends up on the destination website, the last ad clicked gets the credit for the postclick
- **Response Rate % :** Number of responses to ad (clicks + VTs + PCs) / number of impressions, as a percentage
- **Click-through Rate % :** Number of clicks / number of impressions, shown as a percentage
- **Completion Rate % :** Number of video completions / number of impressions delivered, shown as a percentage

WASSERMAN + PARTNERS ADVERTISING

Back-End Reporting Terms

- **Visit:** A visit consists of a series of page-views that a single visitor makes during a period of activity. A visit ends after the visitor either closes the browser, clears cookies, or is inactive for 30 minutes. (The timeout length is customizable in the tracking code settings)
- **Pages/Visit:** Page-views divided by visits. This metric shows the average number of pages viewed per visit.
- **Average Session Duration:** This is the sum of the time on page for all page-views in a visit. Or, more accurately, it is the difference between the time they viewed the first page and last page in a visit.
- **Bounce:** A visit with one page-view. It doesn't matter how long the visitor was on the page or how they left.
- **Page View:** A page-view is recorded every time a page is viewed.
- **Time on Page:** Time on page is measured by subtracting the time a visitor hit a page from the time they hit the next page. (e.g. If they hit Page 1 at 12:00 and hit Page 2 at 12:03, time on Page 1 is three minutes.) This means that the time on page for the last page in a visit is always zero because Google Analytics doesn't track pages being closed.

WASSERMAN + PARTNERS ADVERTISING

Appendix H-10

NEWS RELEASE – MODERNIZING BRITISH COLUMBIA'S GAS SYSTEM

FORTIS BC™

News Release

FOR IMMEDIATE RELEASE

Modernizing British Columbia’s gas system

Upgrading to advanced gas meters will improve reliability and customer benefits

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SURREY, B.C., October 3, 2019 – FortisBC is starting community engagement on a proposal to upgrade its gas meters to new advanced meters, as it explores ways to improve the reliability of its system and add new customer benefits.

The Advanced Gas Meters project would upgrade the meters of more than one million natural gas customers between 2022 and 2026.

“This project would help us build a stronger, more reliable system to deliver natural gas to homes and businesses across British Columbia,” said Douglas Stout, FortisBC vice-president of market development and external relations. “Upgrading to advanced meters would modernize our gas infrastructure. The new meters would allow us to better monitor and manage our system – for example FortisBC could remotely detect and respond to gas leaks.”

The project is one of a number of upgrades FortisBC is exploring to improve the resiliency of the system that supplies B.C. homes and businesses with natural gas.

The gas meter technology currently used in B.C. has not fundamentally changed in more than 100 years. The new meters are smaller, have no moving parts and are expected to last longer than existing meters. They use sound waves to measure gas use and send the information to FortisBC through a wireless network, meaning FortisBC would no longer need to read individual meters manually.

The new meters would offer benefits for customers such as access to daily updates on gas use and the convenience of not having their gas service shut off during future meter exchanges.

FortisBC will be holding information sessions across B.C. in October and November. To learn more about the Advanced Gas Meters project including details on information sessions visit FortisBC.com/advancedgasmeters.

FortisBC will file an application for British Columbia Utilities Commission approval in 2020. If approved, installation of new meters is expected to start in 2022.

MEDIA CONTACT:
Alex Munro
Corporate Communications Advisor
FortisBC Energy Inc.
T: 604-230-5295
alex.munro@fortisbc.com
fortisbc.com
24-hour media line: 1-855-322-6397

FORTIS BC™

Backgrounder

By the numbers

- **100**, years at least since the existing gas meter technology fundamentally changed
- **130,000**, approximate number of FortisBC customers already using advanced meters for electricity
- **1,100**, estimated tonnes per year of greenhouse gas emissions eliminated by no longer having to manually read meters

Existing gas meter and advanced gas meter

What's new about advanced gas meters?

Old	Gas meters	New
✓	Reliable way to measure energy usage	✓
	View your energy use at any time, helping you manage your energy bills	✓
	Enhanced safety features such as the ability to remotely detect and respond to gas leaks	✓
	No mechanical components and a longer operating life	✓

Advanced Gas Meters project proposed timeline

Fall 2019	Q1 2020	Q1 2021	2022 to 2023	2022 to 2026	2027
Public consultation begins	File BCUC application	Anticipated BCUC decision	Network installation	Meter installation	Project completion

FORTISBC

FortisBC Energy Inc. is a regulated utility focused on providing safe and reliable energy, including natural gas, propane and thermal energy solutions. FortisBC Energy Inc. employs more than 1,800 British Columbians and serves approximately 1,008,400 customers in 135 B.C. communities. FortisBC Energy Inc. owns and operates approximately 49,000 kilometres of natural gas transmission and distribution pipelines. FortisBC Energy Inc. is a subsidiary of Fortis Inc., a leader in the North American regulated electric and gas utility industry. For further information, visit www.fortisinc.com.

FortisBC Inc. and FortisBC Energy Inc. do business as FortisBC. The companies are indirect, wholly owned subsidiaries of Fortis Inc. FortisBC uses the FortisBC name and logo under license from Fortis Inc.

Forward-Looking Information

Certain statements in this news release contain forward-looking information within the meaning of applicable securities laws in Canada ("forward-looking information"). The purpose of the forward-looking information is to provide management's expectations regarding results of operations, performance, business prospects and opportunities, and it may not be appropriate for other purposes.

All forward looking information is given pursuant to the safe harbour provisions of applicable Canadian securities legislation. The words "anticipates", "believes", "budgets", "could", "estimates", "expects", "forecasts", "intends", "may", "might", "plans", "projects", "proposes", "schedule", "should", "will", "would" and similar expressions are often intended to identify forward-looking information, although not all forward-looking information contains these identifying words. The forward-looking information in this news release includes, but is not limited to, statements regarding FortisBC's estimated timeframes and proposed benefits of installing advanced gas meters at our customers' properties (the "Advanced Gas Meter project"). The forward-looking information also includes the timing and the possible approval of the Advanced Gas Meter project by the British Columbia Utility Commission ("BCUC"). The forward-looking information reflects management's current beliefs and is based on assumptions developed using information currently available to the Corporation's management. Assumptions, which include, but are not limited to, receipt of applicable regulatory approvals and requested rate orders. Although FortisBC believes that the forward-looking statements are based on information and assumptions which are current, reasonable and complete, these statements are necessarily subject to a variety of risks and uncertainties. For additional information on risk factors that have the potential to affect the Corporation, reference should be made to the Corporation's continuous disclosure materials filed from time to time with Canadian securities regulatory authorities and to the heading "Business Risk Management" in the Corporation's annual and quarterly Management Discussion and Analysis. Except as required by law, the Corporation undertakes no obligation to revise or update any forward-looking information as a result of new information, future events or otherwise after the date hereof.

Appendix H-11

AMI PROJECT WEBSITE

Advanced gas meters

FortisBC is working to build a more reliable natural gas system for our more than one million customers across B.C. That's why we're preparing to apply to our regulator, the British Columbia Utilities Commission, to upgrade our natural gas meters as part of the Advanced Gas Meters project.

Overview

Upgrading to advanced gas meters will modernize our gas infrastructure. The new meters will allow us to measure customer gas use over a wireless network. This will allow us to better monitor and manage our system, for example we will be able to remotely detect and respond to gas leaks.

It will also eliminate the need for us to enter customers' property regularly to read meters.

Benefits Timeline FAQ Gas meter survey Contact us

Advanced gas meter benefits

Advanced gas meters will offer customers a number of benefits:

Old	Gas meters	New
✓	Reliable way to measure energy usage	✓
	View your energy use at any time, helping you manage your energy bills	✓
	Enhanced safety features such as the ability to remotely detect and respond to gas leaks	✓
	No mechanical components and a longer operating life	✓

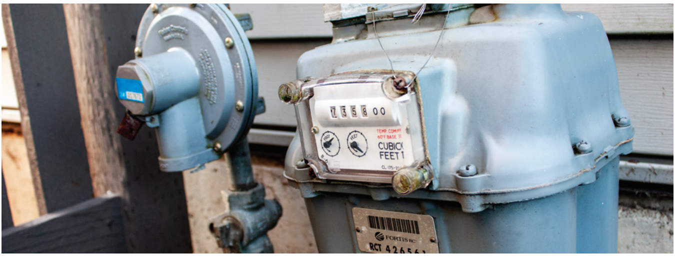
Switching to advanced meters will mean fewer cars on the road as we will no longer need to manually read individual meters, eliminating an estimated 1,100 tonnes of greenhouse gas emissions per year.

Appendix H-12

BILL INSERTS, NOVEMBER 2019 AND MARCH 2020

Energy at work FORTIS BC™

We're planning to survey our natural gas meters



FortisBC contractors will be visually inspecting and taking photos of our in-service gas meters this year. Here's what you need to know:

- Similar to our regular meter-reading program, customers will not need to be home or take any action.
- Contractors will carry ID cards clearly identifying them as FortisBC representatives.
- This survey is being done to support our Advanced Gas Meters project. The information we gather will help us complete the proposed meter upgrade.
- We plan on applying to our regulator, the B.C. Utilities Commission later this year. If approved, we anticipate upgrading residential and commercial customers to new advanced meters between 2022 and 2025.

Learn more about our gas meter survey at **fortisbc.com/advancedgasmeters**.

Why we want to upgrade our gas meters

The way gas use is measured in North America hasn't fundamentally changed in more than 100 years.

We're applying to upgrade our gas meters to new advanced meters, as we explore ways to improve our system and add new customer benefits.

Advanced meters use sound waves to measure gas use and would send this information to FortisBC through a wireless network. This technology offers a number of new benefits:

- We would no longer need to read individual meters manually.
- The meters would allow us to remotely detect and respond to gas leaks, including in the event of an emergency.
- Customers would be able to access daily updates on their gas use.

Learn more about the Advanced Gas Meters Project at **fortisbc.com/advancedgasmeters**.

Connect with us

FORTIS BC™

Energy at work

(20-053.2 02/2020) *MCC# 903936*

Energy at work FORTIS BC™

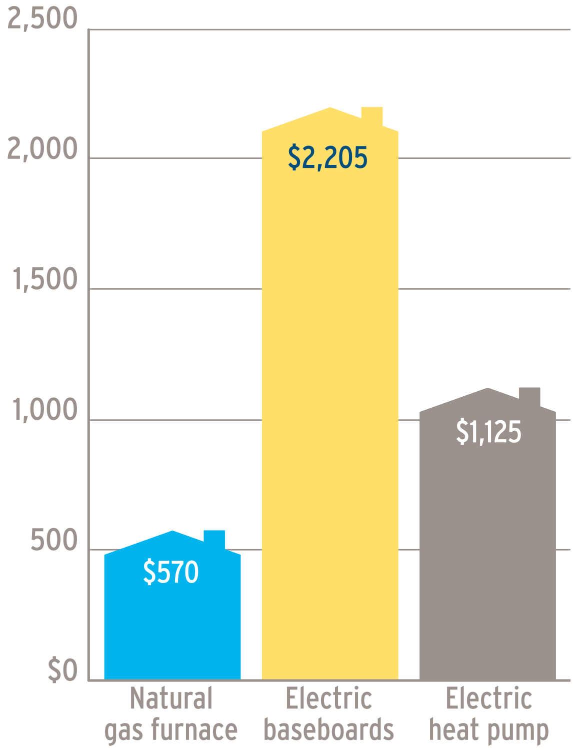
You know you're an adult when...

...you're thrilled to stay cosy at home instead of going out to a club. And with high-efficiency natural gas heating, you're keeping warm for less.

Learn more at **fortisbc.com/homeheating.**

MCC# 903852

Natural gas is less than one third the cost of electricity:



Average annual space heating cost comparison for Lower Mainland and Squamish.

Save even more, with our energy conservation tips

Wear a sweater: make this your first step, before turning up your thermostat

Program your thermostat: 17 °C when you're out and asleep, 20 °C when you're home and awake

Draftproof and insulate: learn how to prevent cold air from getting into your home at **fortisbc.com/savingenergy**

We can help you save energy and improve comfort

Free energy-saving upgrades for income-qualified households

The Energy Conservation Assistance Program offers personalized advice and the installation of energy-saving products in your home—at no cost to income-qualified participants.[1] Some households may even qualify for a new ENERGY STAR® certified fridge, insulation or a high-efficiency natural gas furnace.[2]

Increased rebates on high-efficiency space and water heating

If your old natural gas furnace, boiler or water heater needs to be replaced and you meet income qualifications, you could get rebates of up to $3,000 on eligible high-efficiency equipment[3] for your home. Plus, you can bundle your rebates and get a $300 bonus for installing both a water heater and furnace or boiler, plus a $150 rebate on a connected thermostat.

Terms and conditions apply. Learn more at **fortisbc.com/incomequalified**.

We're working together to help B.C. save energy

FORTIS BC™ Energy at work | BC Hydro Power smart | cleanBC BETTER HOMES

We're planning to upgrade our gas meters

We're preparing to file an application with our regulator, the British Columbia Utilities Commission, to upgrade our gas meters to new advanced gas meters. This project would modernize our natural gas system, improving its reliability and adding new customer benefits.

Visit **fortisbc.com/advancedgasmeters** to learn more. Questions? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

[1]Income qualified means that the resident's total household income from all sources (including rental and/or foreign income) is within program limits. For example, a household of four people with a combined total income under $62,600 would qualify. Please be prepared to provide proof of income.

[2]Products installed depend on the individual characteristics of the home and other program criteria. Only FortisBC natural gas heated, FortisBC electrically heated or BC Hydro electrically heated single family homes, townhouses and duplexes may be eligible for insulation upgrades. In addition, only FortisBC natural gas heated homes may be eligible for furnace replacement. Other program criteria apply. Apartment units and mobile homes are not eligible for insulation or furnaces. Programs may be cancelled or modified at any time without notice.

[3]The Income Qualified Space and Water Heating Program is funded in part, by the Province of British Columbia and the Government of Canada.

FortisBC Energy Inc. does business as FortisBC. The company is an indirect, wholly owned subsidiary of Fortis Inc. FortisBC uses the FortisBC name and logo under license from Fortis Inc.

(19-245 10/2019)

FORTIS BC™ Energy at work

Appendix H-13

MEDIA OUTREACH FOR 2019 INFORMATION SESSIONS

Type	Outlet	Coverage (if available)
	Prince George, Fort Nelson (week of Oct 7)	
Print/digital	Prince George Citizen	
	Alaska Highway News	https://www.alaskahighwaynews.ca/regional-news/fort-nelson/fortisbc-plans-to-replace-gas-meters-1.23974641
	Fort Nelson News	http://www.fnnews.ca/2019/10/17/fridge-list-october-16th-2019/
Broadcast	Jim Pattison Broadcast Group news	
	CBC (Day Break North)	
	Kelowna, Vernon, Kamloops (week of Oct 14)	
Print/digital	Kamloops this Week	
	Merritt Herald	
	Okanagan Advertiser	
	Salmon Arm Observer	
	KamloopsBCNow	
	Kelowna Daily Courier	Oct 22 coverage (https://app.cision.com/#/news/files?eid=7goxQUmqY9pODAMTR0CRO%2BXjen5R61zfCbvLNl1RljY%3D)
	Penticton Herald	
	Osooyoos Times	
	Peachland View	
	Black Press digital	https://www.vernonmorningstar.com/news/vernon-up-for-advanced-gas-meters-project/
	Oliver Chronicle Castanet	
Broadcast	CBC Kamloops	
	News Kelowna AM 1149	Oct 22 coverage (http://clipping.ca.cision.com/bowdensASP/MediaPlayer/Player.aspx?d3e=8VdeDdaF9l9jaU9kAv9J9u9f9J8uDjcYaf9i9Y9i9k9I9k8vcMclAhcJdlCz8XdiDvaE9l)
	Beach Radio (Vernon)	Oct 23 coverage (https://vernonmatters.ca/2019/10/21/vernon-on-list-for-advanced-gas-meter-project/)
	Global News Okanagan	Oct 23 coverage (http://clipping.ca.cision.com/bowdensASP/MediaPlayer/Player.aspx?d3e=8VdeDdaF9l9jaUakAv9W9k9f9K9j8xdHcyAe9L9w9i9J9l9i8VclCvaFcjDkdF8vDidUah9j)
	Cranbrook, Castlegar, Oliver (week of Oct 21)	
Print/digital	Creston Valley Advance	
	Nelson Star	
	Crankbook Townsman	
	Columbia Valley Pioneer	
	Kimberley Bulletin	
	Fernie Free Press	
	Rossland News	
	Trail Times	
	Castlegar News	
	Grand Forks Gazette	
	Broadcast	
	EZ Rock Kootenays - Wayne & Jayne Show	
	Goat FM/My Kootenay Now	
	Juice FM (Nelson)/2Day FM	https://www.myeastkootenaynow.com/2568/fortisbc-seeking-approval-to-upgrade-gas-meters-in-bc/
	Juice FM (Creston)	
	Juice FM (Grand Forks)	
	The Drive FM/B-104 (Cranbrook)	https://www.thedrivefm.ca/2019/10/28/187021/
	Courtenay, Victoria (Vancouver Island) (week of Oct 28)	
Print/digital	Powell River Peak	
	Victoria Times Colonist	
	Victoria News	
	Nanaimo News Bulletin	
	Parksville Qualicum Beach News	
	Cowichan Valley Citizen	
	Lake Cowichan Gazette	
	Alberni Valley News	
	Ladysmith Chronicle	
	Chemainus Valley Courier	
	Vancouver Island Free Daily	
	Oak Bay News	
	Saanich News	
	Comox Valley Record	
	Campbell River Mirror	
Broadcast	CBC Radio 1 Victoria	
	AM Victoria 1069	Oct 30 coverage (http://clipping.ca.cision.com/bowdensASP/MediaPlayer/Player.aspx?d3e=8VdeDdaF9l9jaXak9m9V9u9f9L8uDjcYaf9i9Y9i9k9I9k8vcMclAhcJdlCz8XdiDvaE9l)
	The Wolf Nanaimo	
	The Eagle, Comox Valley FM radio	
	CHEK-TV	
	Burnaby, Abbotsford (weeks of Nov 4 and 11)	
Print/digital	Vancouver Sun/The Province	
	Fraser Valley News Sports and Entertainment	
	Burnaby Now/New West Record	https://www.burnabynow.com/news/fortisbc-pitches-replacing-all-burnaby-natural-gas-meters-1.23999844
	Vancouver Courier	

Type	Outlet	Coverage (if available)
	Vancouver is Awesome	
	Tri-City News	
	Richmond News	
	Delta Optimist	
	North Shore News	
	Surrey Now Leader	
	Chilliwack Progress	
	Abbotsford News	Nov 15 coverage (https://app.cision.com/#/news/files?eid=7goxQUmqY9pODAMTR0CROyZcZo5LO5LYl2877MgVK7U%3D)
	Mission City Record	
	Agassiz Harrison Observer	
Broadcast	Global News	
	OMNI CBC	
	CTV	
	CityTV	
	News1130	
	CKNW	
	Fairchild CHMB- 1320 AM	

Appendix H-14

PRINT ADS, 2019 AND 2021

Energy at work FORTIS BC™

Upgrading our natural gas meters

You're invited to a virtual information session

We're moving forward with plans to modernize our system by upgrading our natural gas meters to new advanced meters. Advanced gas meters will allow us to add new safety features and customer benefits, including the ability to remotely detect and respond to gas leaks, as well as provide you daily updates on gas use.

We're inviting the community to join us at virtual information sessions on February 23 and 24 to learn more about this exciting project. For details and to register, visit **fortisbc.com/gasmeters**.

Connect with us

We're planning to upgrade our gas meters

Come to an information session to learn more

FortisBC is exploring ways to modernize our natural gas system and add new customer benefits. One of the ways we're proposing to do this is by upgrading our gas meters to new advanced meters. Before we file our application with the British Columbia Utilities Commission, we are engaging with communities.

We're hosting information sessions across B.C. including in **Prince George** on **October 15** and **Fort Nelson** on **October 16**.

For more information on the Advanced Gas Meters project, and to register for a session, visit **fortisbc.com/gasmeters**. Can't make it to an info session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including in **Prince George** on **October 15**.

Location: Ramada Plaza, 444 George Street, Prince George
Time: 4:30 – 7:30 p.m.

To learn more about the Advanced Gas Meters Project, visit **fortisbc.com/gasmeters**. Can't make it to the info session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

We're engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including in **Kamloops** on **October 24**.

Location: Coast Kamloops Hotel & Conference Centre
1250 Rogers Way, Kamloops

Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including in **Kelowna** on **October 22**.

Location: Delta Hotels by Marriott Grand Okanagan Resort
1310 Water Street, Kelowna
Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

FortisBC is exploring ways to modernize our natural gas system and add new customer benefits. One of the ways we're proposing to do this is by upgrading our gas meters to new advanced meters. Before we file our application with the British Columbia Utilities Commission, we are engaging with communities.

We're hosting information sessions across B.C. including: **Kelowna**, **October 22**; **Vernon**, **October 23**; **Kamloops**, **October 24**; and **Oliver, October 30**.

For more information on the Advanced Gas Meters project, and to register for a session, visit **fortisbc.com/gasmeters**. Can't make it to an info session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

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Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

We're engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including in **Vernon** on **October 23**.

Location: Prestige Hotel Vernon
4411 32 Street, Vernon
Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Castlegar** on **October 29**.

Location: Sandman Hotel Castlegar
1944 Columbia Avenue, Castlegar
Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

We're engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including in **Cranbrook** on **October 28**.

Location: Prestige Rocky Mountain Resort
209 Van Horne Street South, Cranbrook
Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

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Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Cranbrook** on **October 28** and **Castlegar** on **October 29**.

Learn more at **fortisbc.com/gasmeters**. Can't make it to an information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

19-188.17_AMI_G3_KimberleyBulletin_ad_5.111x6-P2.indd 1 10/10/2019 2:12:20 PM

Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including: **Kelowna**, **October 22**; **Vernon**, **October 23**; **Kamloops**, **October 24** and **Oliver**, **October 30**.

Learn more at **fortisbc.com/gasmeters**. Can't make it to an information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Courtenay** on **November 4**.

Location: The Westerly Hotel
1590 Cliffe Avenue, Courtenay
Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Victoria** on **November 5**.

Location: Cedar Hill Golf Course
1400 Derby Road, Victoria
Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our meters to new advanced gas meters. We're hosting information sessions across B.C. including **Courtenay**, **November 4** and **Victoria**, **November 5**.

Learn more at **fortisbc.com/gasmeters**. Can't make it to an information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Victoria** on **November 5**.

Location: Cedar Hill Golf Course
1400 Derby Road, Victoria
Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Courtenay** on **November 4**.

Location: The Westerly Hotel
1590 Cliffe Avenue, Courtenay
Time: 4:30 – 7:30 p.m.

Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Victoria** on **November 5**.

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Learn more at **fortisbc.com/gasmeters**. Can't make it to the information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Burnaby** on **November 13** and **Abbotsford** on **November 20**.

Learn more at **fortisbc.com/gasmeters**. Can't make it to an information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

19-188.17_AMI_G5_DeltaOptimist_ad_5.083x7-P2.indd 1 10/10/2019 2:22:57 PM

19-188.17_AMI_G5_NDeltaReporter_ad_5.111x6-P2.indd 1 10/10/2019 2:24:02 PM

Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Burnaby** on **November 13** and **Abbotsford** on **November 20**.

Learn more at **fortisbc.com/gasmeters**. Can't make it to an information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

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Energy at work FORTIS BC™

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Learn more at **fortisbc.com/gasmeters**. Can't make it to an information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

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Energy at work FORTIS BC™

We're planning to upgrade our gas meters

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We are engaging with communities about our plan to apply to the British Columbia Utilities Commission to upgrade our gas meters to new advanced meters. We're hosting information sessions across B.C. including **Burnaby** on **November 13** and **Abbotsford** on **November 20**.

Learn more at **fortisbc.com/gasmeters**. Can't make it to an information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

Connect with us

Energy at work FORTIS BC™

We're planning to upgrade our gas meters

Come to an information session to learn more

FortisBC is exploring ways to modernize our natural gas system and add new customer benefits. One of the ways we're proposing to do this is by upgrading our gas meters to new advanced meters. Before we file our application with the British Columbia Utilities Commission, we are engaging with communities.

We're hosting information sessions across B.C. including in **Burnaby** on **November 13** and **Abbotsford** on **November 20**.

For more information on the Advanced Gas Meters project, and to register for a session, visit **fortisbc.com/gasmeters**. Can't make it to an information session? Contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

19-188.17_AMI_G5_VancouverCourier_ad_5.083x7-P2.indd 1 10/10/2019 2:27:40 PM

Appendix H-15

DIGITAL ADS FOR 2019 INFORMATION SESSIONS

Appendix H-16

SOCIAL MEDIA ADS FOR 2021 INFORMATION SESSIONS

FortisBC
5 February at 14:05 ·

Advanced meters will modernize our system, adding safety features & customer benefits. Attend a virtual info session.

FORTISBC.COM

Upgrading our gas meters

Details and registration

Learn More

[redacted] and 264 others

401 comments 24 shares

Like Comment Share

FortisBC
@FortisBC

We're planning to modernize the system we use to deliver natural gas to customers across BC by upgrading to advanced gas meters. These meters will offer new safety features and customer benefits. Learn more at our upcoming virtual information sessions.

fortisbc.com

10:59 AM · Feb 7, 2021 · Twitter for Advertisers

8 Retweets 6 Quote Tweets 95 Likes

Appendix H-17

TOWN HALL PRESENTATION – ADVANCED GAS METERS PROJECT

Advanced Gas Meters Project

October 11, 2019

Agenda

- Introductions
- Project Overview
- Advanced Gas Meter Infrastructure
- Benefits
- Public Engagement
- Questions

Introductions

Vanessa Connolly

- Senior Manager – External Relations

Paul Kitchener

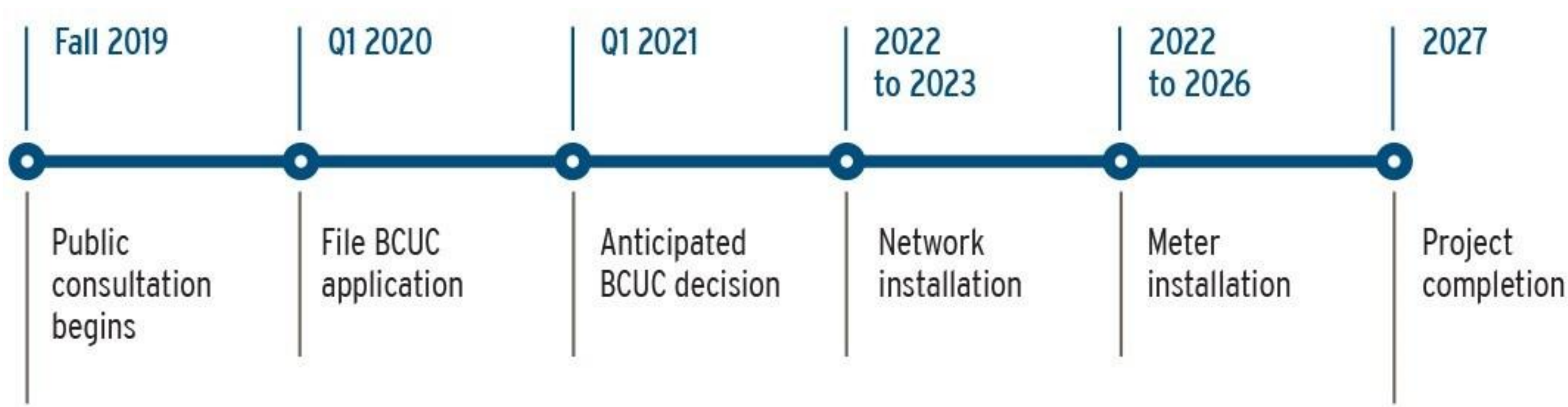
- Operations Manager – Metro Vancouver, Interior North & Island Operations

Blake Mansbridge

- Manager – Community Relations

Project Overview

We are filing an application with our regulator, the British Columbia Utilities Commission (BCUC), to upgrade our more than one million residential and commercial gas meters to new advanced meters.



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Advanced Gas Meter Infrastructure

Advanced gas meters will help us build a stronger, more reliable system to deliver natural gas homes and businesses across British Columbia

- The new meters will allow us to measure customer has use through a wireless network.
- They have no moving parts and are expected to last longer than existing meters.
- Existing meter technology has not fundamentally changed in more than 100 years.

A new wireless network would be built

- FortisBC will build and own this network.
- The network will be encrypted and will wirelessly send customer consumption data.

Energy at work FORTIS BC™

Existing Meter and Advanced Meter

Energy at work FORTIS BC™

Benefits

The project will help improve the resiliency of the system that supplies B.C. homes and businesses with natural gas

- We could remotely detect and respond to gas leaks.

Advanced gas meters also offer a number of new benefits

- Customers will be able to access daily updates on their gas use.
- FortisBC will no longer need to regularly enter customers' properties to read meters.
- FortisBC will no longer have to shut off gas service during meter exchanges, reducing inconvenience.

There are already about 130,000 FortisBC electric customers using advanced meters

Energy at work FORTIS BC™

Public Engagement

Before we file our application with the BCUC, we are engaging with the community.

- October 3: Project launch
- October/November: Information sessions throughout B.C.
- Public can also contact us directly with questions or comments

Location	Date	Location	Date
Prince George	October 15	**Castlegar**	October 29
Fort Nelson	October 16	**Oliver**	October 30
Kelowna	October 22	**Courtenay**	November 4
Vernon	October 23	**Victoria**	November 5
Kamloops	October 24	**Lower Mainland (Burnaby)**	November 13
Cranbrook	October 28	**Fraser Valley (Abbotsford)**	November 20

Energy at work FORTIS BC™

Advanced Gas Meters project

FortisBC.com/advancedgasmeters

1-833-592-7937

advancedgasmeters@fortisbc.com

Energy at work FORTIS BC™

Thank you

Energy at work FORTIS BC™

For further information, please contact:

Vanessa Connolly, Senior Manager, External Relations

Find FortisBC at:

Fortisbc.com

talkingenergy.ca

604-576-7000

Appendix H-18

INFORMATION SESSION DISPLAY BOARDS

Visible Area
33″ x 87″

Total print size
33″ x 93″

Creative DISPLAY

33″ ZAP Banner Stand

Built at 1/4 scale
Please ensure Raster images are 300 ppi
Supply Linked images – DO NOT EMBED
Convert fonts to outline or supply fonts
If you have any questions call our
Design Department: **204.957.7050**

FORTIS BC™
Energy at work

What's new about advanced gas meters?

Advanced gas meters measure gas use through a wireless network, instead of manually reading individual meters.

Old	Gas meters	New
✓	Reliable way to measure energy usage	✓
	View your energy use at any time, helping you manage your energy bills	✓
	Enhanced safety features such as the ability to remotely detect and respond to gas leaks	✓
	No mechanical components and a longer operating life	✓

Bleed

1/4 Scale

*Please match FortisBC logo to:
PMS 123 and PMS 2955

Visible Area
33″ x 87″

Total print size
33″ x 93″

Creative DISPLAY

33″ ZAP Banner Stand

Built at 1/4 scale
Please ensure Raster images are 300 ppi
Supply Linked images – DO NOT EMBED
Convert fonts to outline or supply fonts
If you have any questions call our
Design Department: **204.957.7050**

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Energy at work

We're planning to upgrade our gas meters

FortisBC is exploring ways to modernize our natural gas system and add new customer benefits for more than one million homes and businesses across B.C.

One of the ways we're proposing to do this is by upgrading our gas meters to new advanced gas meters.

Bleed

1/4 Scale

*Please match FortisBC logo to:
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Visible Area
33" x 87"

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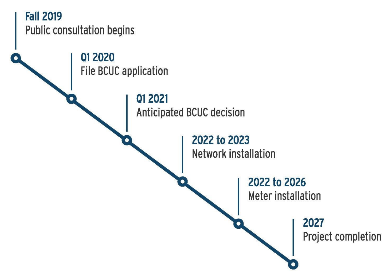
Supply Linked images – DO NOT EMBED
Convert fonts to outline or supply fonts
If you have any questions call our
Design Department: **204.957.7050**

FORTIS BC™
Energy at work

How to get involved

Before we file our application with our regulator, the British Columbia Utilities Commission (BCUC), we will be engaging with communities.



Visit **fortisbc.com/advancedgasmeters** to learn more about our project.

Call us **1-833-592-7937**

Email us **advancedgasmeters@fortisbc.com**

Bleed

1/4 Scale

*Please match FortisBC logo to:
PMS 123 and PMS 2955

Visible Area
33″ x 87″

Total print size
33″ x 93″

33″ ZAP
Banner Stand

Built at 1/4 scale
Please ensure Raster images are 300 ppi
Supply Linked images – DO NOT EMBED
Convert fonts to outline or supply fonts
If you have any questions call our
Design Department: **204.957.7050**

FORTIS BC™

Energy at work

Safety

It's at the core of everything we do.

Upgrading our natural gas meters to new advanced gas meters will allow us to better monitor and manage our system, including remotely detecting and responding to gas leaks.

Bleed

1/4 Scale

*Please match FortisBC logo to:
PMS 123 and PMS 2955

Appendix H-19

ADVANCED GAS METERS INFORMATION CARD

Energy at work FORTIS BC™

We're planning to upgrade our gas meters

FortisBC is exploring ways to modernize our natural gas system for more than one million homes and businesses across B.C. One of the ways we're proposing to do this is by upgrading our gas meters to new advanced gas meters.

Advanced gas meters will allow us to measure customers' gas use over a wireless network. This will help us to better monitor and manage our system and improve its reliability. The project also offers our customers a number of new benefits:

- Customers can access daily updates on their gas use.
- We can remotely detect and respond to gas leaks.
- We'll no longer need to enter customers' properties regularly to read meters.
- Future meter exchanges will be possible without interruption to gas service.

Advanced Gas Meters project proposed timeline

Fall 2019	2020	2021	2022 to 2023	2022 to 2025	2026
Public consultation begins	File BCUC application	Anticipated BCUC decision	Network installation	Meter installation	Project completion

Before we file our application with the British Columbia Utilities Commission, we will be engaging with the community. Meeting the energy needs of British Columbians is at the heart of everything we do.

That's energy at work.

Visit **fortisbc.com/advancedgasmeters** to learn more.

Call us **1-833-592-7937**
Email us **advancedgasmeters@fortisbc.com**

(20-053.8 03/2020)

FORTIS BC™
Energy at work

Appendix H-20

ENERGY MOMENT NEWSLETTER, OCTOBER 2019, JANUARY AND MARCH 2020

From: FortisBC <no-reply@email.myfortisbc.com>
Sent: Tuesday, October 15, 2019 1:56 PM
To:
Subject: Your Energy Moment, a source for rebates, contests, safety and energy-saving tips (MERGED VERSION)

Introducing our 30BY30 Target, what it means and why it's a big deal

We're thinking differently about how we deliver energy today and tomorrow. We've established our first ever emissions reduction goal, representing one of the most ambitious reduction targets in the Canadian utility sector. We call it our **30BY30 Target**.

Essentially, we'll work to reduce the greenhouse gas emissions associated with our customers' energy use by 30 per cent overall by the year 2030. A 30 per cent reduction aligns with the government's CleanBC plan, is the next phase of our own Clean Growth Pathway and sets the path to achieving deep reductions that support the goals of the Paris Agreement by 2050.

"As the foremost energy provider to British Columbians, we have the opportunity to advance a cleaner energy future for the province and do our part in the global campaign against climate change," said Roger Dall'Antonia, president and CEO of FortisBC.

Learn how we're moving ever-closer to a lower-carbon energy future and our 30BY30 Target.

New rebates can help you take charge

Thinking of driving electric? We've teamed up with CleanBC and BC Hydro to help you make the switch to an electric vehicle (EV).

We now offer rebates of up to $350* on the purchase and installation costs of a Level 2 electric charger for your home. Plus, up to $2,000* on a Level 2 charging station for condos, apartment buildings, high-rises and eligible workplaces.

Working with the government to enable customers who want to install EV charging equipment at home is another way we're driving towards our 30BY30 Target – investing in low and no-carbon vehicle infrastructure.

**Conditions apply.*

New public access CNG-fuelling station now open in Kelowna

(L to R) Danny Ardellini, founder and CEO of E360S, Sarah Smith, director of NGT, regional LNG and RNG with FortisBC, and Norm Letnick, MLA, Kelowna-Lake Country, celebrate the opening.

BC's transportation industry is responsible for the largest share of provincial greenhouse gas emissions. Fuelling fleets with compressed natural gas (CNG) is one way to reduce those emissions.

So we're thrilled to open a public access, CNG-fuelling station in Kelowna. Environmental 360 Solutions (E360S), a waste-hauling company, is also on site and fuels its fleet from a dedicated system while public access is available for anyone to use, 24 hours a day. Learn about the new station and benefits to the community. And check out our photos of the opening event on Facebook.

Having fleets use CNG rather than diesel or gasoline helps improve air quality and reduces greenhouse gas emissions by up to 30 per cent. Such meaningful reductions align well with FortisBC's new 30BY30 Target.

Did you know? E360S picks up residential curbside garbage and delivers it to the Glenmore Landfill, which is one of our suppliers of Renewable Natural Gas, a carbon-neutral fuel. Cool, eh?

Giving back where we live and work

Each year, we invite local government officials from across BC to nominate a charity or non-profit project for our Community Giving Awards.

“Investing in the towns and cities we work in helps improve the long-term health and vitality of these communities,” explains Judit Horvath, our community and Indigenous relations manager.

Congratulations to this year’s recipients! The **West Creston Fire Protection Society** will build a new protection and safety centre. **Len Wood Middle School** and surrounding communities will get a new playground. And the **Hulitan Family & Community Services Society** in Langford, that serves numerous Indigenous communities, will host a community celebration in honour of its 10-year anniversary. See more about these recipients and the important work they’re doing.

Time to prepare for heating season

Just like us, your natural gas heating appliances and systems need regular checkups too. Getting your furnace, boiler and fireplace serviced now means you’ll be prepared for chillier temperatures.

Annual servicing by a licensed natural gas contractor helps maintain the life expectancy of your appliances and ensures they’re operating safely and efficiently. Know more about how to prepare for heating season.

Up to $135* in rebates

Until November 30, 2019, you could be eligible for up to $135 in rebates when you have your natural gas furnace or boiler, fireplaces and tankless water heater serviced.

**Conditions apply*

We're planning to upgrade our gas meters

FortisBC is exploring ways to modernize our natural gas system and add new customer benefits for the more than one million homes and businesses across BC that use natural gas. One of the ways we're planning to do this is by upgrading our gas meters to new advanced meters.

Join us at our information sessions

Our plan is to apply to our regulator the BC Utilities Commission next year, and are now talking with communities as part of this process. We're hosting information sessions across BC in October and November and we'd love to see you.

Get more information about the Advanced Gas Meters project and register for a session. Can't make it to an information session? Contact us at **1-833-592-7937** or advancedgasmeters@fortisbc.com.

Zoom in to win contest*

Tell us what this is for a chance to win a $50 Visa® gift card:

For your chance to win this month's challenge, email us your guess of this month's close-up. *Hint:* this item can be used as a word to describe the new greenhouse gas emissions reduction goal that we call our 30BY30 __________.

Enter by October 31, 2019.

Congratulations to last month's winners: **James A.**, **Barb C.**, **Tanya C.**, **Colleen D.** and **Teresa L.**, who correctly identified the close-up as a faucet. To improve your water efficiency, simply install an aerator. Get more energy-saving tips for your home.

Connect with us

Hi, just a reminder that you're receiving this email newsletter because you have provided your email address to FortisBC. FortisBC Inc. and FortisBC Energy Inc. do business as FortisBC. The companies are indirect, wholly owned subsidiaries of Fortis Inc. FortisBC uses the FortisBC name and logo under license from Fortis Inc.

*The Prize consists of one (1) of five (5) Visa gift cards, each with a value of CDN $50. The chances of winning depend on the number of entries received. The contest will have monthly draws and October's contest closes on October 31, 2019 at 11:59 p.m. Pacific Daylight Time. To win, entrants must correctly identify the image promoted in the monthly Energy Moment enewsletter. No purchase necessary. See full contest rules.

16705 Fraser Hwy, Surrey, BC V4N 0E8

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From: FortisBC <no-reply@email.myfortisbc.com>
Sent: Friday, January 17, 2020 9:43 AM
To:
Subject: Your Energy Moment, a source for rebates, contests, safety and energy-saving tips (MERGED VERSION)

2020-01-17

FORTIS BC™
Energy at work

Understanding your winter energy use

When winter sets in, especially a cold snap, we tend to turn up the thermostat and run our furnaces, fireplaces or baseboards. We also tend to keep them cranked, running longer or more often, to keep our homes consistently warm and cosy.* Yet this means we're using more natural gas or electricity to keep warm.

In fact, FortisBC typically sees the use of natural gas – the most commonly used energy for space or home heating – triple in winter compared to summer months.* And, electricity use for home heating can increase by about 80 per cent in winter over summer.**

The good news is there are ways to manage your energy use including programmable thermostats and weatherizing (where you seal up those nasty drafts and reduce your heat loss). We're also here to help with energy-saving rebates, energy use monitoring tools, payment plans and programs.

Learn more about home energy use and how to manage it.

Put some purpose and passion into your New Year's resolutions

Making your resolutions meaningful is the trick to making them stick. For example, if your goals are to clean up, get organized and save money, give them purpose and passion by connecting them with larger goals like reducing your carbon footprint and contributing to a cleaner, healthier province. Here are some simple steps to get you started.

How to prevent carbon monoxide exposure

Carbon monoxide is a colourless, odourless and toxic gas that's produced when fuels such as natural gas, propane, wood, tobacco and gasoline are burned incompletely. Preventative maintenance of your gas appliances by a licensed gas contractor can help keep you and your loved ones safe this heating season.

See our three easy tips to help reduce your risk of exposure.

Your energy rates changed as of Jan. 1

If you're a residential natural gas customer, your annual bill decreased by about two per cent or $18 for the year. Get all the details.

As a residential electricity customer, you'll see a one per cent interim increase as we continue to phase out the two-tiered rates. This increase is the first one since 2017 and means you'll see an average increase of just over one dollar per month. Find out more.

New year, new upgraded appliances?

You know you're an adult when… a lot of your conversations with friends and colleagues are about renovations and appliances. Yeah, it's still pretty darn cold out, but spring (AKA reno season) is just around the corner. Time to start thinking about which appliances need to be upgraded to energy-efficient models. Check out our appliance rebates.

If a new energy-efficient heating system is on your wish list, we've got some tips for you: 4 things you need to know to save money on home heating.

Why advanced meters are the next step for BC's energy system

We all enjoy the benefits of a modern, safe and resilient energy system that delivers the natural gas we use when we need it. A lot of upgrades were made to the system over the last century, but one thing that hasn't changed much is how natural gas use is measured in BC. Until now.

We plan on seeking regulatory approval to upgrade our natural gas meters to advanced meters. This is so we can better monitor and manage our system and offer you a number of new benefits, including new safety features and daily updates on gas use. See how far we've come and how advanced meters will benefit you.

Zoom in to win contest*

Tell us what this is for a chance to win a $50 Visa® gift card:

For your chance to win this month's challenge, **email us** your guess of this month's close-up. *Hint:* this is something you might wear to keep warm, rather than cranking the heat up.

Enter by January 31, 2020***

Congratulations to last month's winners: **Mike G.**, **Fred L.**, **Julie M.**, **Meghan S.** and **Renee S.** who correctly identified LED lights as the energy-efficient item that can help save on your electricity use.

Connect with us

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* Based on an average of FortisBC's customer's natural gas usage over three years.
** Source: National Resources Canada, Office of Energy Efficiency, Comprehensive Energy Use Database, Residential Sector, British Columbia, Table 2, Secondary Energy Use Shares, 2016.
*** The Prize consists of one (1) of five (5) Visa gift cards, each with a value of CDN $50. The chances of winning depend on the number of entries received. The contest will have monthly draws and January's contest closes on January 31, 2020 at 11:59 p.m. Pacific Standard Time. To win, entrants must correctly identify the image promoted in the monthly Energy Moment enewsletter. No purchase necessary. See full contest rules.

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From: FortisBC <no-reply@email.myfortisbc.com>
Sent: Friday, March 13, 2020 11:03 AM
To:
Subject: Your Energy Moment, a source for rebates, contests, safety and energy-saving tips

2020-03-13

FORTIS BC™
Energy at work

Meet Mila. She's working hard to help you save energy and money.

Marysol Escamilla and Mila Barbour (right), FortisBC program specialists, stand in front of a commercial natural gas heat pump being piloted. Preliminary results show the pump has already performed over 100 per cent efficiency in -8 °C weather.

From home heating technologies that are more than 100 per cent efficient to resurfacing ice rinks without hot water, the potential for innovation in energy efficiency is only as limited as our imaginations. And we've got big ones!

Mila is part of our innovative technologies team that works hard to find new high-efficiency technologies – ones that use less natural gas and electricity. Why do we search for new technologies like a natural gas heat pump? We're always looking for ways to help you save energy and money – while reducing greenhouse gas emissions for a healthier BC. (Have your heard about our 30BY30 target?)

Get to know Mila and see if you want to participate in our pilot programs.

5 family-friendly things to do in the dark during Earth Hour

Did you know it's Earth Hour at 8:30 p.m. on Saturday, March 28? Earth Hour originated in Australia in 2007 as a symbolic lights-out event and is now a global grassroots environmental movement.

To show our love for the planet, let's turn off the lights, put on a sweater, turn down the heat and enjoy 60 minutes without screens and appliances.

Check out these great ideas on how to spend your time.

Greater Victoria roads get a bit cleaner with CNG

FortisBC and BC Transit celebrate BC Transit's recent award from the Canadian Natural Gas Vehicle Alliance for their commitment to putting more buses on the road fuelled by natural gas.

Do you live in the Greater Victoria area, or plan to visit anytime soon? Keep an eye out for BC Transit's new buses fuelled with FortisBC's compressed natural gas (CNG).

Seventy-one new buses are hitting the roads fuelled with CNG instead of diesel, which means reduced greenhouse gas emissions and lower operating costs. A big thank you to BC Transit for their partnership in building a healthier future for BC. (This is BC Transit's fourth fleet to use CNG, joining those serving Whistler, Nanaimo and Kamloops.)

Know someone who has a fleet of their own? Think pickup trucks, cargo vans, forklifts or heavier-duty vehicles. Find out how natural gas and our rebates can help fleets reduce costs and emissions.

We're planning to survey our natural gas meters

We're exploring ways to modernize our natural gas system for more than one million homes and businesses across BC. As part of this effort, we'll be seeking regulatory approval to upgrade our natural gas meters to advanced meters.

To prepare for the upgrade, we need to survey the gas meters in service sometime this year. This means FortisBC contractors will do outdoor visual inspections and take photos of the meter that delivers your natural gas. Our contractors will carry ID cards identifying them as FortisBC representatives.

No appointments are necessary and you won't need to be home, at your place of business, or take any action. Get more survey details and learn how advanced meters will benefit you.

Your most popular questions answered

Do you have questions about your natural gas or electricity account? What about billing and payment options or who should service your appliances? If you're not sure where to find answers, no worries.

We've collected the questions you most often ask our customer service team and put them all in one spot. Take a look at our new Q&A blog and see if we've answered your question.

Be part of BC's energy future

Although International Women's Day just passed, we couldn't miss the opportunity to recognize the talented women we work with every day at FortisBC like Roxanne, a biologist who works as our environmental program lead.

The women who work as program leads, engineers, technicians, directors and vice presidents are critical to our success as an energy company serving you and the province.

As we reinvent the future of energy, our inclusive and diverse team will continue to create, solve and lead the way for a healthier BC.

Come join us!

Zoom in to win contest*

Tell us what this is for a chance to win a $50 Visa® gift card:

For your chance to win this month's challenge, **email us** your guess of this month's close-up. *Hint:* don't let energy vampires in your home drain power – even when your appliances are turned off. If you aren't using that coffee maker, TV, game console or charger simply unplug them from this: ____________________.

Enter by March 27, 2020

Congratulations to last month's winners: **Krystal A.**, **Mavis C.**, **Trevor G.**, **Katrina L.** and **Travis W.** who correctly identified that you could use a natural gas stove or cooktop to melt chocolate without fear of scorching. It's the even heat distribution and precise temperature control that makes a difference when working with tricky ingredients like chocolate. That's why chefs prefer cooking with natural gas, according to the Canadian Gas Association.

Connect with us

Hi, just a reminder that you're receiving this email newsletter because you have provided your email address to FortisBC. FortisBC Inc. and FortisBC Energy Inc. do business as FortisBC. The companies are indirect, wholly owned subsidiaries of Fortis Inc. FortisBC uses the FortisBC name and logo under license from Fortis Inc. (20-014.3 03/2020)

*The Prize consists of one (1) of five (5) Visa gift cards, each with a value of CDN $50. The chances of winning depend on the number of entries received. The contest will have monthly draws and January's contest closes on March 27, 2020 at 11:59 p.m. Pacific Standard Time. To win, entrants must correctly identify the image promoted in the monthly Energy Moment enewsletter. No purchase necessary. See full contest rules.

View in a browser.
Unsubscribe from this mailing list.
Manage my preferences.

16705 Fraser Hwy, Surrey, BC V4N 0E8

From: FortisBC <no-reply@email.myfortisbc.com>
Sent: Friday, February 19, 2021 11:07 AM
To:
Subject: Your Energy Moment, a source for rebates, contests, safety and energy-saving tips

2021-02-19

Winter savings you'll warm up to

Have you noticed a change in your winter energy use because of cooler temperatures? We understand it can be difficult to know how much more energy you're using and what actions you can take to reduce it, but we're here to help.

Everyone uses energy differently so thinking about how your household uses it every day, especially during cold weather, can help you find ways to save. For example, has it been colder than normal? Have you added any new appliances? Have your appliances been serviced? Are you staying home more due to COVID-19 safety measures? We have online tools and energy-saving tips to help you manage your winter energy bills.

Great ideas for family fun—beyond Family Day

It’s important to make the most of family time, especially this year. So, even though Family Day has come and gone, we wanted to share a list of family activities that will help keep everyone safe, won’t break the bank and can also help you create lasting memories.

5 exciting ways we’re getting renewable energy from waste

You might have heard us talk about how we’re working with farms and landfills to create Renewable Natural Gas from agricultural and municipal waste. But that was just the beginning: we’ve now teamed up with several municipalities and commercial partners across the province to turn more waste into energy that British Columbians can use in their homes and businesses.

See all the ways we’re putting waste to work—which support our 30BY30 target of reducing our customers’ greenhouse gas emissions by 30 per cent by 2030.

Energy Leaders lessons now available in French

FortisBC Energy Leaders is a free online education platform for BC teachers and parents that provides engaging lesson plans about energy conservation, energy solutions and safety. Developed by BC teachers, these ready-to-use lessons are based on BC's current curriculum. Due to popular demand, we've translated our distance learning lessons and select regular lesson materials for grades 1 to 10 into French. Translated lessons for grades 11 and 12 are coming soon. Let's get started! Download free lessons in English or French for in-class or home-based learning now.

Join us virtually to learn more about plans to upgrade our gas meters

Did you know the technology we use to measure your natural gas hasn't fundamentally changed in more than 100 years? We're in the process of applying to our regulator, the British Columbia Utilities Commission, to upgrade customer gas meters to new advanced meters.

Advanced meters will allow us to introduce new features such as daily updates on your gas use, as well as safety enhancements including the ability to remotely detect and respond to gas leaks. You're invited to join us at virtual information sessions on February 23 or 24 where you can learn more and ask any questions you have.

FortisBC supports the well-being of marine animals at the Vancouver Aquarium

While COVID-19 forced the Vancouver Aquarium to close its doors to the general public, their diverse array of marine life continues to need care and support. That's why we donated three used high-efficiency natural gas boilers from a recent project, worth approximately $60,000 in total, to heat the various animal habitats. The Aquarium is also receiving further support through rebates for different projects such as custom design retrofits and heat recovery, which comes from participating in our energy-efficiency programs. Read more about how we're helping over 70,000 aquatic animals.

Zoom in to win contest**

Tell us what this is for a chance to win a $50 Visa® gift card:

For your chance to win this month's challenge, **email us** your guess of this month's close-up. *Hint:* It's a type of waste that will be turned into Renewable Natural Gas at a new facility in Fruitvale, BC.

Enter by February 28, 2021.

Congratulations to last month's winners: **Tracy T.**, **Violet D.**, **Harman G.** and **Denise D.** who correctly identified the close-up as a fireplace screen or hearth guard, which can help keep small children, pets and combustible materials away from the glass panels of your fireplace.

Connect with us

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*Offer ends April 30, 2021. Rebate amount will be deducted after applicable taxes. Conditions apply and program may be modified or be cancelled at any time. Draftproofing is limited to products designed specifically for sealing windows, doors and other exterior penetrations. Caulking for general purpose indoor use, kitchens, baths, plumbing and any other use not related to weatherization is not eligible.

**The Prize consists of one (1) of five (5) Visa gift cards, each with a value of CDN $50. The chances of winning depend on the number of entries received. The contest will have monthly draws and February's contest closes on February 28, 2021, at 11:59 p.m. Pacific Standard Time. To win, entrants must correctly identify the image promoted in the monthly Energy Moment enewsletter. No purchase necessary. See full contest rules.

Appendix H-21

BILL INSERT, SEPTEMBER 2020

Energy at work FORTIS BC

Let's get ready for fall: have your natural gas appliances serviced

Save up to $150![1]

Annual servicing helps maintain the life expectancy of your appliances and also ensures they're operating safely and efficiently. To learn more and apply online for your rebate, visit **fortisbc.com/servicerebate**.

That's energy at work.

MCC# 904116

To qualify for the rebate, you must hire a gas contractor licensed with Technical Safety BC to service the appliances. Find one through our Trade Ally Network online directory at **fortisbc.com/gascontractor.**

*[1]Maximum rebate is $150 when you have either a furnace or boiler, two fireplaces and one tankless water heater serviced. [2]Conditions apply. Full terms and conditions are available at **fortisbc.com/servicerebate**. FortisBC may modify or terminate the program at any time and for any reason.*

Billing support for customers affected by COVID-19

We realize that COVID-19 has affected many of our customers' livelihoods, and bills can cause additional stress. We're here to help. If you need support, please reach out to our customer service team at **1-888-224-2710** and they'll work with you to assess your options and provide customized solutions.

Learn more about how we can work with you at **fortisbc.com/billingsupport**.

Free kit: save money and energy

Free for income-qualified households,* the Energy Saving Kit contains easy-to-install products that can help you reduce emissions and save energy costs, such as:

- LED night light and LED light bulbs
- a water-efficient showerhead
- kitchen and bathroom faucet aerators
- weatherstripping
- window film
- outlet and switch sealers

Instructions are included. For more information and to apply online, visit **fortisbc.com/freekit** or call FortisBC at **1-866-436-7847** or BC Hydro at **1-800-224-9376**.

Applicants must have an electricity account with BC Hydro, FortisBC, New Westminster, Grand Forks, Summerland, Penticton or Nelson Hydro. Income qualifications apply so please be prepared to tell us your total household income and utility account number. Limit one kit per household once every five years. Visit **fortisbc.com/freekit for complete terms and conditions and eligibility requirements.*

We're working together to help B.C. save energy.

FORTIS BC™ Energy at work | BC Hydro Power smart

Gas meter upgrade project progress

We're expecting to file the BC Utilities Commission application for our Advanced Gas Meters project in September. This project would modernize our natural gas system, improve its reliability and benefit customers. We'll be conducting a survey of our existing meters starting this fall. Learn more at **fortisbc.com/advancedgasmeters**, and if you have questions, contact us at **1-833-592-7937** or **advancedgasmeters@fortisbc.com**.

We've got

On furnaces, water heaters, insulation and more.
fortisbc.com/rebates

FORTIS BC™
Energy at work

(20-137.1 08/2020)

Appendix H-22

PROJECT UPDATE NOTIFICATION LETTER 2021 - MLA

FortisBC
1-(833) 592-7937
fortisbc.com/advancedgasmeters
advancedgasmeters@fortisbc.com

February 4, 2021

CONTACT INFORMATION – MLA

Greetings,

FortisBC – committed to working together towards a better future
Every day we deliver natural gas, electricity and innovative energy solutions to approximately 1.2 million customers in 135 communities throughout the province – including yours.

We're rethinking the energy we deliver today and into the future. By focusing on our climate leadership role as we move towards British Columbia's lower carbon future, we have set one of the most ambitious reduction targets in the Canadian utility sector. Our 30BY30 target sets an achievable, affordable path to reducing our customers' greenhouse gas emissions by 30 per cent by 2030.

Our work extends beyond 2030 as well and our Clean Growth Pathway plan outlines several strategies that align with the province's 2050 climate targets. This plan shows how we can reach our emission reduction targets using both the existing natural gas and electric systems. We're committed to partnering with customers, communities, industry and all levels of government to reduce greenhouse gas emissions and this work is already underway. We would welcome the opportunity to discuss these initiatives with you or your representative at your convenience.

Advanced Gas Meters project update
One of the other projects we are pursuing is our Advanced Gas Meters project. We are moving forward with plans to upgrade our customers' natural gas meters to new advanced meters, as we explore ways to modernize our system. Work on this project has been ongoing since we publicly announced it in October 2019 and we are pleased to announce that we expect to file for regulatory approval with the British Columbia Utilities Commission in spring 2021.

Our Advanced Gas Meters project will add new safety features such as the ability to remotely detect and respond to gas leaks, and customer benefits including access to daily updates on gas use. We believe that giving our more than one million natural gas customers access to more information will help them better understand and manage their use, and empower them to reduce energy consumption.

Ongoing consultation and joint-use opportunities
We're committed to ongoing engagement with customers and stakeholders across the province on the project. This includes public information sessions held throughout the province in late 2019 and virtual information sessions planned for later this month, responding to regular customer inquiries via email and telephone, and providing project updates as work progresses.

A number of municipalities have shown interest in gaining access to the network, which we are creating to support our advanced gas meters, for their own remote metering programs such as water metering. This collaborative approach could also help municipalities with additional conservation efforts. We encourage you to attend our upcoming virtual information session or contact us directly for more information.

Upcoming information session
We would like to extend an invitation for you or your representative to participate in a virtual information session on Thursday, February 18, at 1 p.m. (PST), where we will provide a project update and answer questions. Please RSVP to advancedgasmeters@fortisbc.com.

If you are unable to attend but want to learn more, please visit fortisbc.com/advancedgasmeters or reach out to us directly at advancedgasmeters@fortisbc.com. More information on the public virtual information sessions occurring later this month is also available on our project website.

Sincerely,

Antonio Bebić

Antonio Bebić,
External Relations, FortisBC

Appendix H-23

PROJECT UPDATE NOTIFICATION LETTER 2021 - MUNICIPALITIES

FortisBC
1-(833) 592-7937
fortisbc.com/advancedgasmeters
advancedgasmeters@fortisbc.com

February 4, 2021

CONTACT INFORMATION – Municipalities

Greetings,

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Every day we deliver natural gas, electricity and innovative energy solutions to approximately 1.2 million customers in 135 communities throughout the province – including yours.

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Sincerely,

Antonio Bebić

Antonio Bebić,
External Relations, FortisBC

Appendix H-24

VIRTUAL INFORMATION SESSION PRESENTATION – MUNICIPALITIES AND MLA

Advanced Gas Meters Project

Virtual Information Session

February 18, 2021

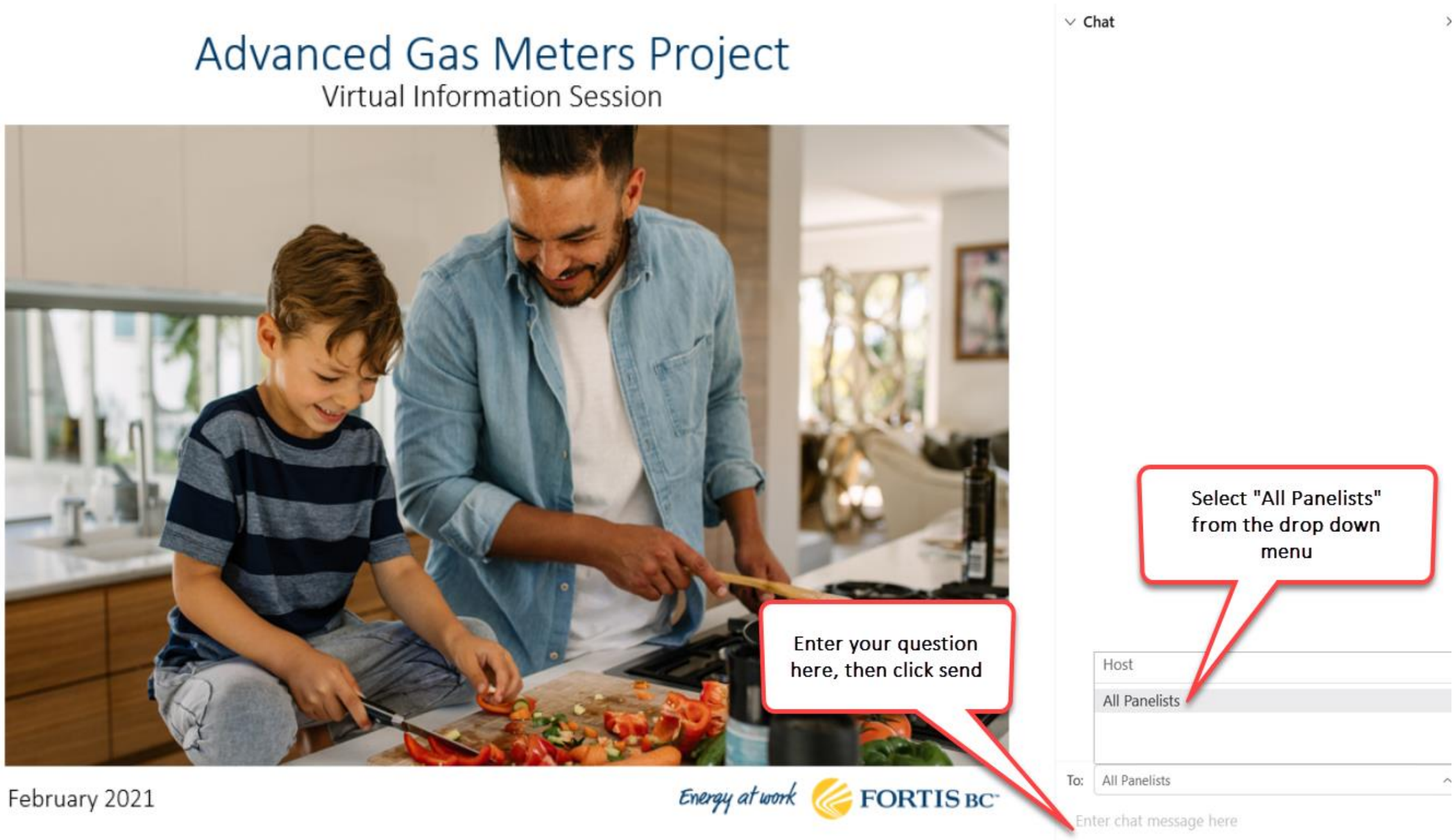
Energy at work FORTIS BC™

Agenda

- Who is FortisBC
- Project Overview
- Why Advanced Gas Meters
- About Advanced Gas Meters
- What You Can Expect
- Next Steps
- Q+A

Energy at work FORTIS BC™

Submitting Your Questions

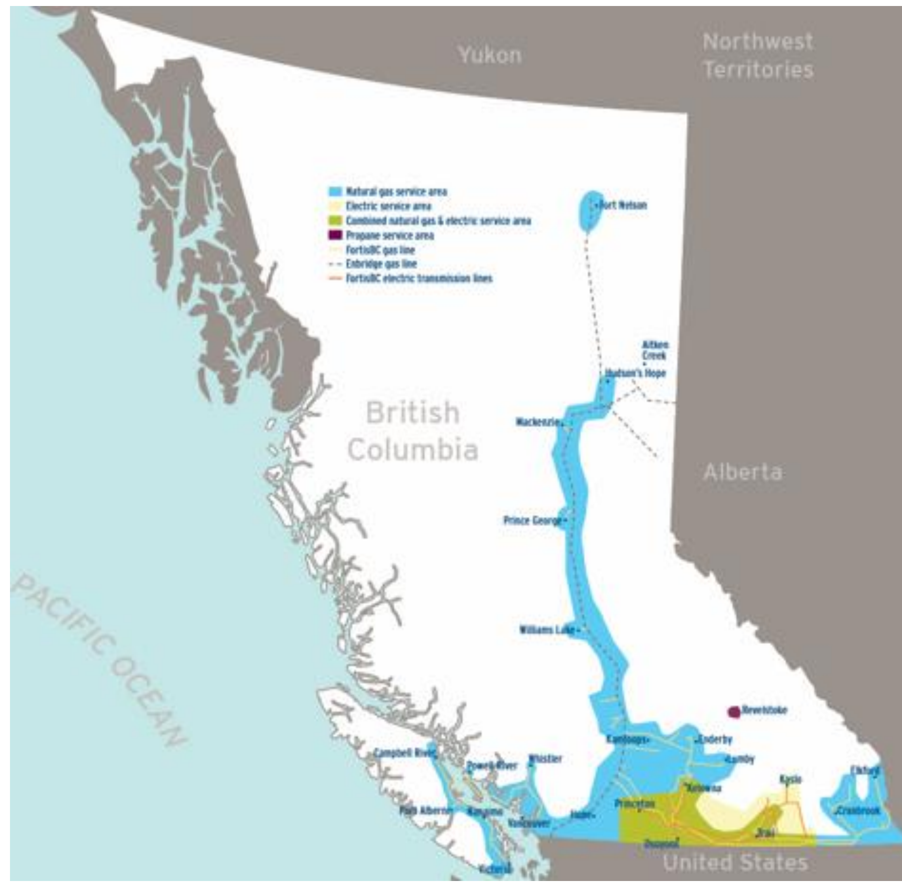


Who is FortisBC

Photo taken pre-Covid19

Our more than 2,400 employees serve approx. 1.2 million customers in 135 communities, whether its delivering electricity, natural gas or propane

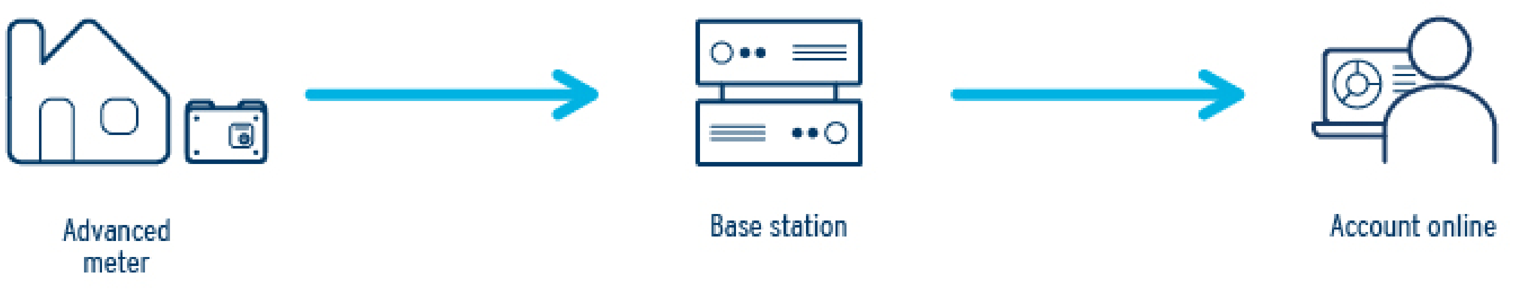
30BY30 – Our target aims to reduce our customers GHG emissions by 30% overall by 2030



Project Overview

- We are filing an application with our regulator, the British Columbia Utilities Commission (BCUC), to upgrade our more than one million residential and commercial gas meters to new advanced meters

- Establish a secure, FortisBC-owned communications network throughout our service territory to support the advanced gas meters



Why Advanced Gas Meters

Upgrading to advanced gas meters will modernize our system, providing important enhancements in:

Customer Experience

- Access to daily usage data

Safety

- Enhancing safety for our customers, employees and public

Gas System Resiliency

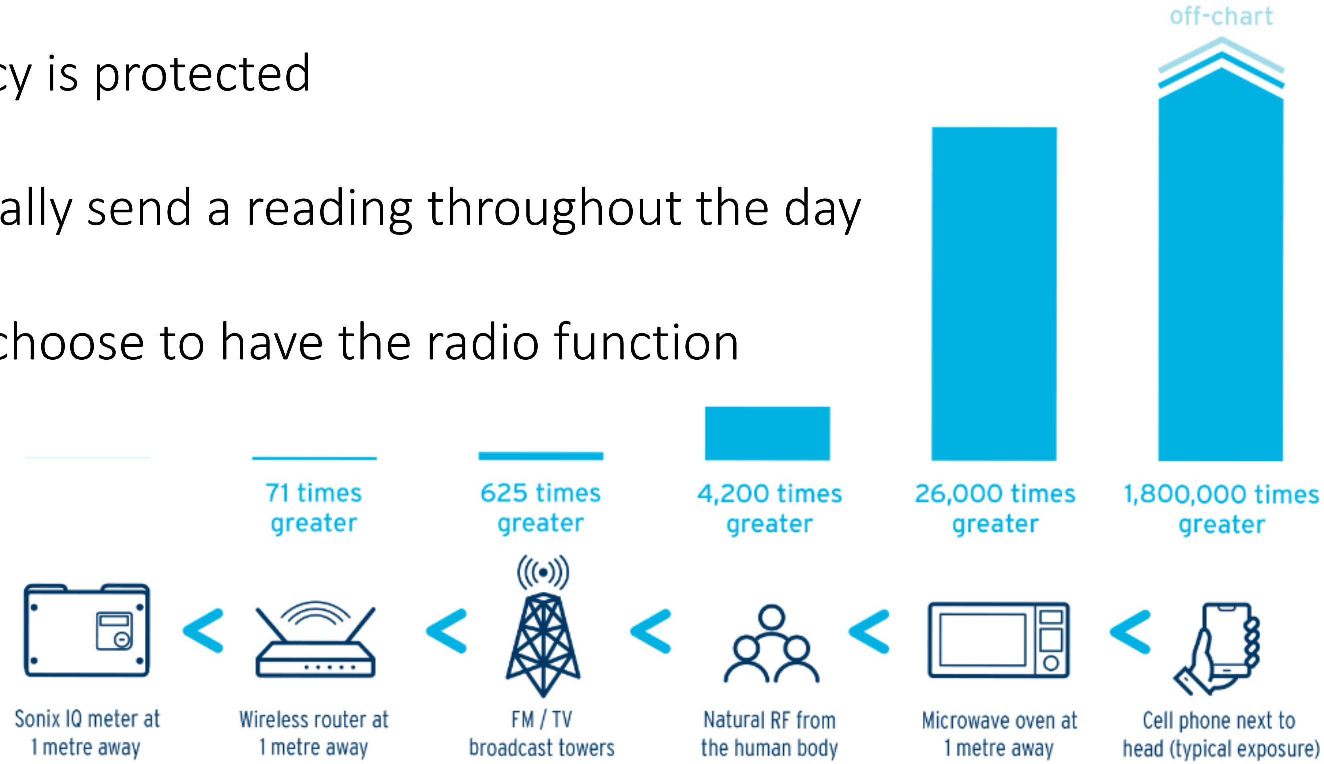
- How we ensure reliability of service for you

About Advanced Gas Meters

- Contain no moving parts
- Instant on/off service
- 20yr battery life
- Built-in diagnostics such as:
  - Meter Health
  - Tampering & Theft Detection
  - Leak Alarms

More About Advanced Gas Meters

- A FortisBC-owned network will be installed to support the advanced gas meters
    - *Explore network sharing opportunities with municipalities*
- Customer privacy is protected
- Meters periodically send a reading throughout the day
- Customers can choose to have the radio function turned off



Based on **Radiofrequency Fields in the Environment and from Advanced Metering Infrastructure** study commissioned by FortisBC and completed by Exponent, 2020

What You Can Expect

- Continue to engage the community throughout the project's lifespan
- Project phone line and email
- Provide project updates on **fortisbc.com/advancedgasmeters**

Photo taken pre-Covid19

Next Steps

- File an Application with the BCUC spring, 2021
- Continue to work collaboratively with stakeholders and Indigenous communities
- Continue the dialogue with our customers

Fall 2019	2021	2022	2022 to 2023	2023 to 2025	2026
Public consultation begins	File BCUC application	Anticipated BCUC decision	Network installation	Meter installation	Project completion

Thank you

**For further information,
please contact:**

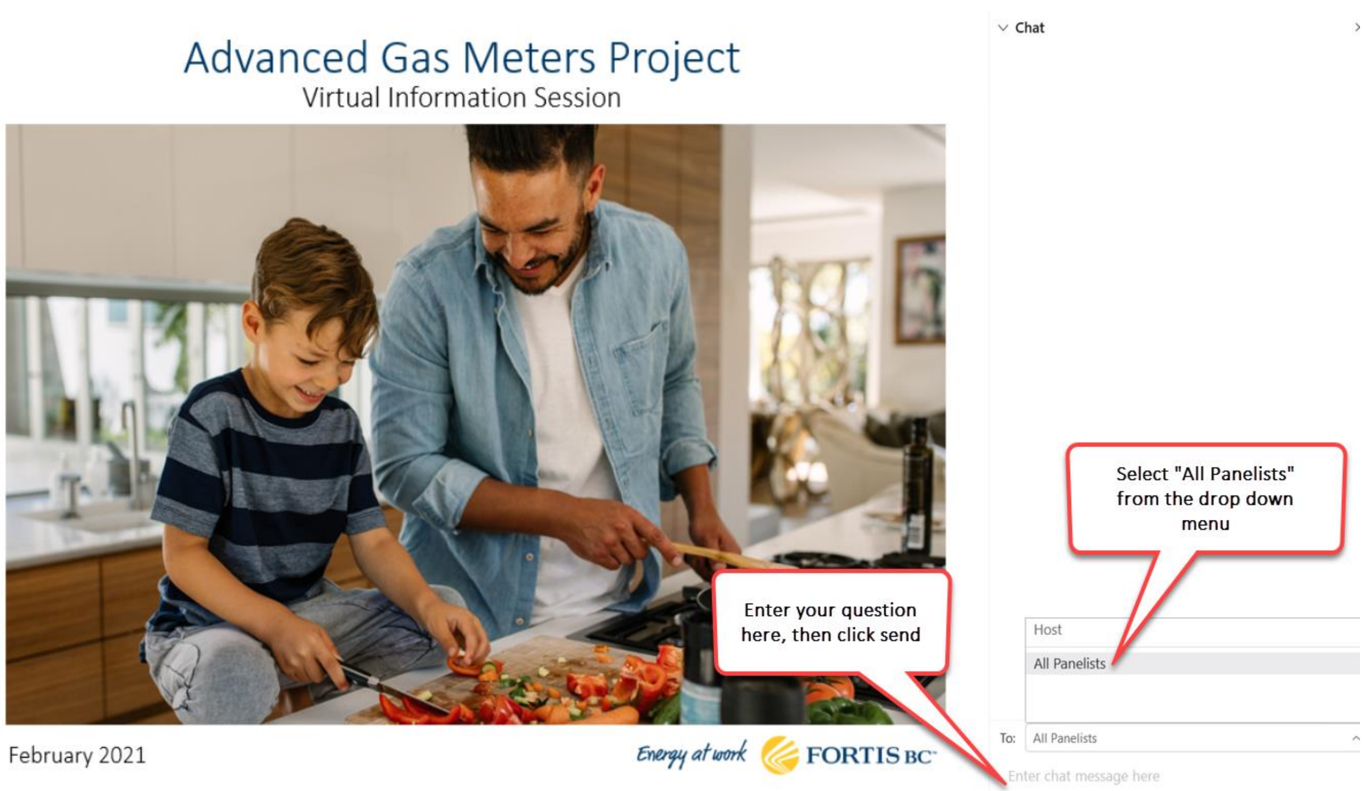
Project Phone Line: 1-833-592-7937

Project Email: advancedgasmeters@fortisbc.com

Project Website: fortisbc.com/advancedgasmeters

Submitting Your Questions

Darren Julyan - Director, Energy Measurement & Technology
Paul Kitchener - Project Director - Deployment
Joel Lindsay - Project Director & Engineer - Technology
Darin Wong - Manager, Community Relations
Blake Mansbridge - Manager, External Relations
Mike Bains – Manager, Community Relations



Thank you

For further information, please contact:

Project Phone Line: 1-833-592-7937

Project Email: advancedgasmeters@fortisbc.com

Project Website: fortisbc.com/advancedgasmeters

Appendix H-25

VIRTUAL INFORMATION SESSION PRESENTATION - PUBLIC

Advanced Gas Meters Project

Virtual Information Session

February 23 & 24, 2021

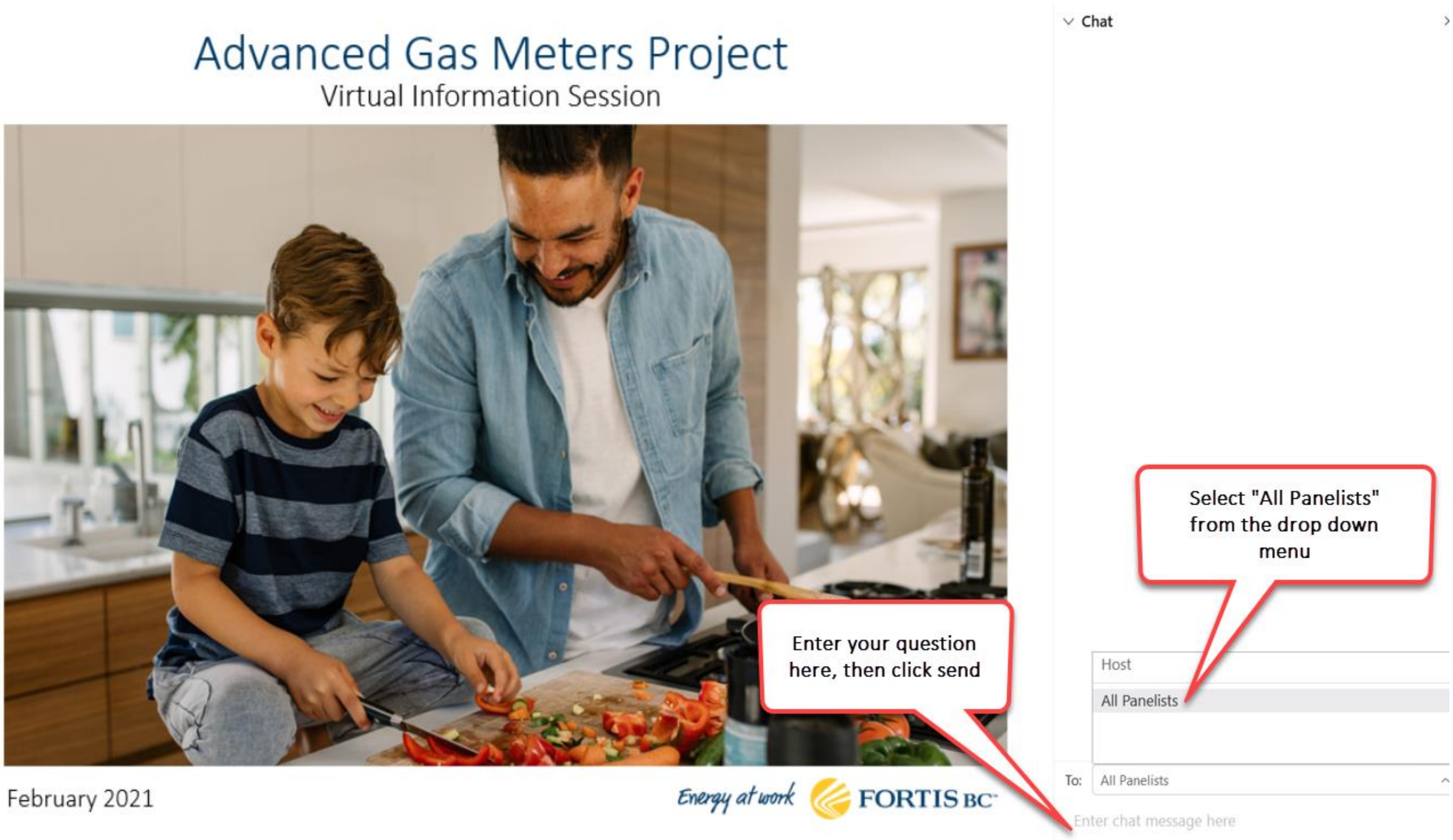
Energy at work FORTIS BC

Agenda

- Who is FortisBC
- Project Overview
- Why Advanced Gas Meters
- About Advanced Gas Meters
- What You Can Expect
- Next Steps
- Q+A

Energy at work FORTIS BC™

Submitting Your Questions



Who is FortisBC

Photo taken pre-Covid19

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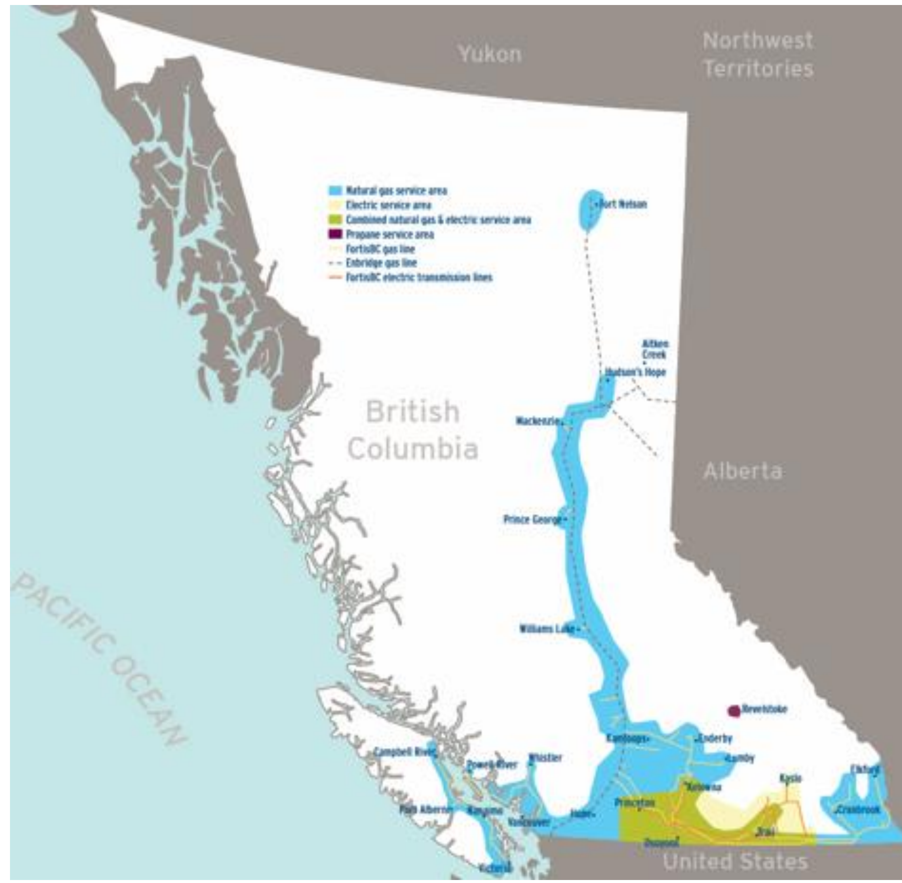
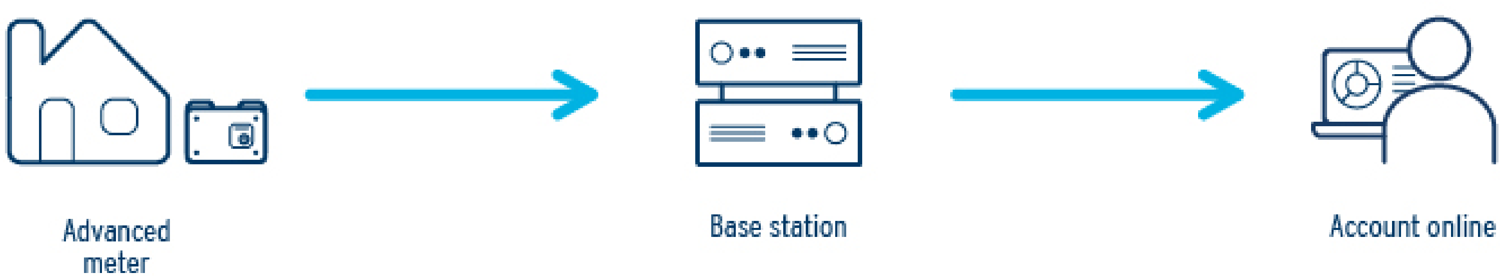


Project Overview

- We are filing an application with our regulator, the British Columbia Utilities Commission (BCUC), to upgrade our more than one million residential and commercial gas meters to new advanced meters

- Establish a secure, FortisBC-owned communications network throughout our service territory to support the advanced gas meters



Why Advanced Gas Meters

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Customer Experience

- Access to daily usage data

Safety

- Enhancing safety for our customers, employees and public

Gas System Resiliency

- How we ensure reliability of service for you

About Advanced Gas Meters

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- Instant on/off service
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More About Advanced Gas Meters

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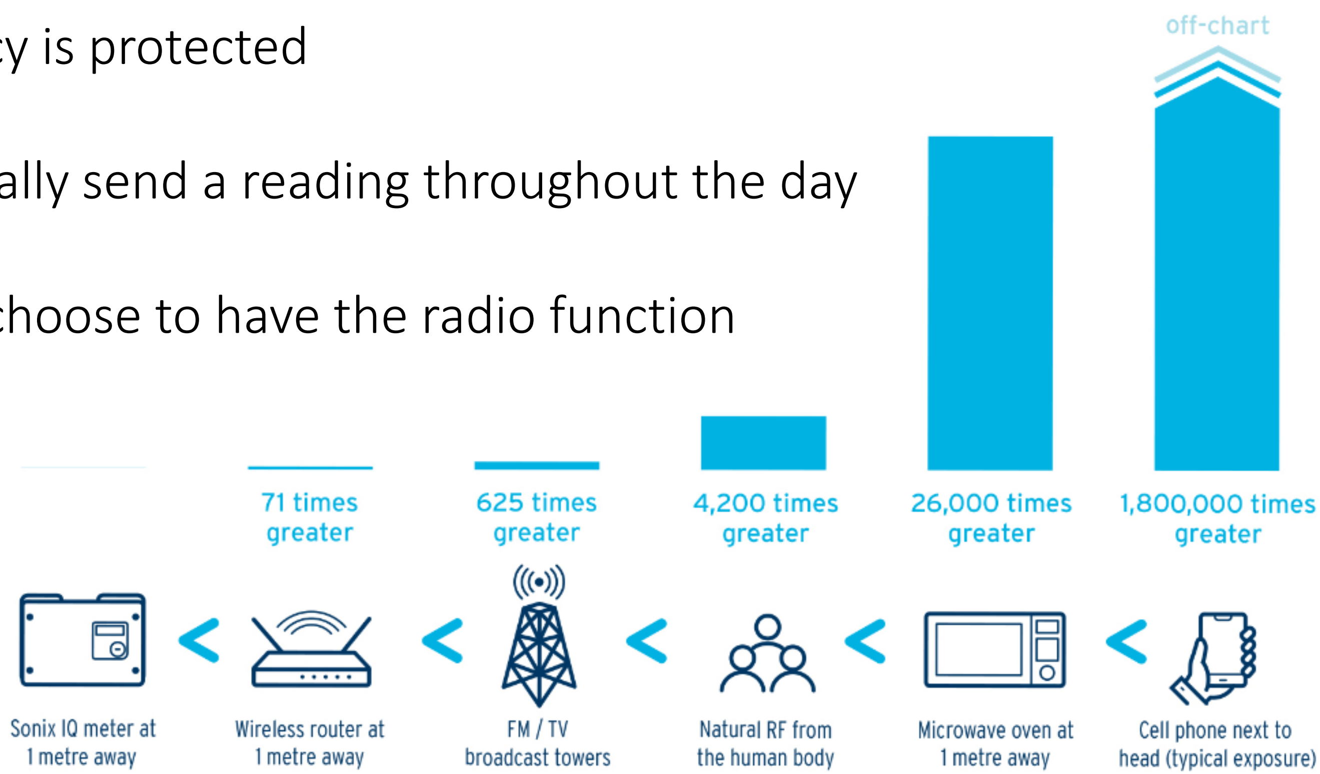


Based on **Radiofrequency Fields in the Environment and from Advanced Metering Infrastructure** study commissioned by FortisBC and completed by Exponent, 2020

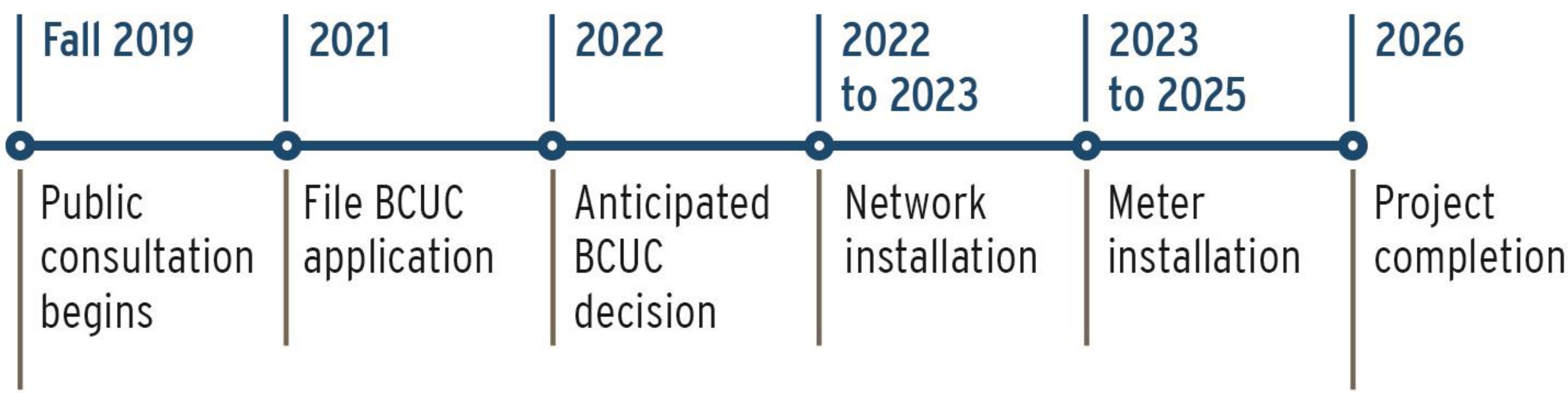
What You Can Expect

- Continue to engage the community throughout the project's lifespan
- Project phone line and email
- Provide project updates on **fortisbc.com/advancedgasmeters**

Photo taken pre-Covid19

Next Steps

- File an Application with the BCUC spring, 2021
- Continue to work collaboratively with stakeholders and Indigenous communities
- Continue the dialogue with our customers



Energy at work FORTIS BC™

Thank you

For further information, please contact:

Project Phone Line: 1-833-592-7937

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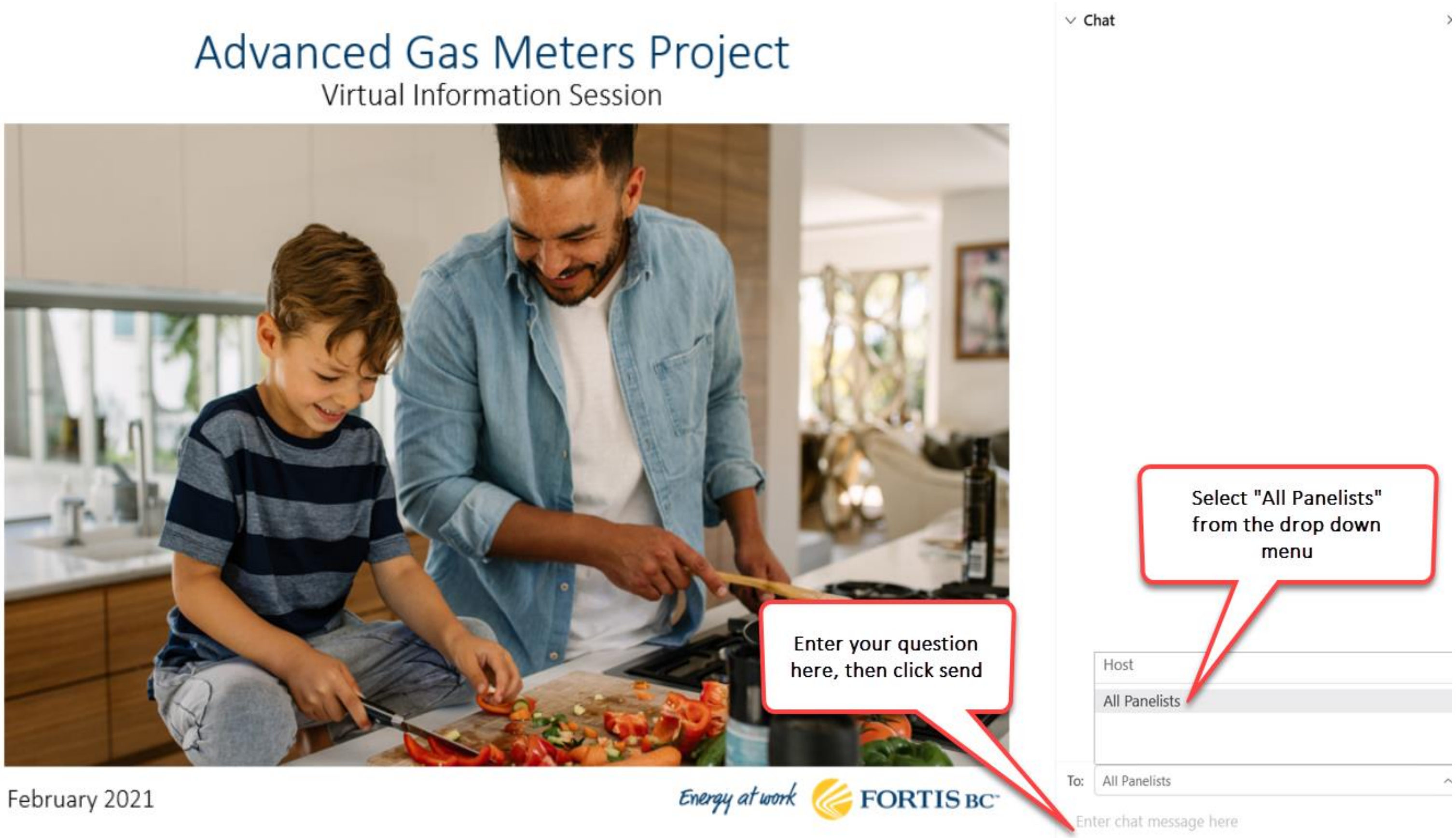
Submitting Your Questions



Appendix H-26

2021 VIRTUAL INFORMATION SESSION ONLINE BILL PAYMENT PLATFORM NOTIFICATION

[redacted]

FORTIS BC *Energy at work* **Account Online**

Help FAQ

Accounts summary

Click on the account number for full account details.

Natural g[redacted]

Service address:

[redacted]

Pay by credit card*

*Service charges will apply

Current amount due:

$92.10

Last bill due on Feb 11, 2021

Last payment:

$55.32

On Jan 8, 2021

Account options

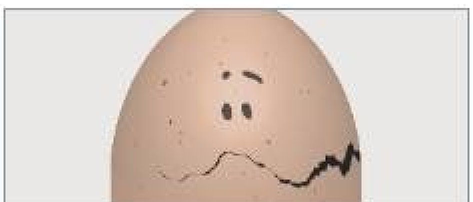
+ Setup Paperless billing
+ Setup Equal Payment Plan
✓ Alerts & subscriptions
✓ Pre-authorized Payment Plan

Need help with this page?

We're planning to upgrade our gas meters

Advanced meters will add safety features and customer benefits, including remote leak detection and access to daily updates on your gas use. Learn more and ask questions at virtual information sessions on February 23 and 24.

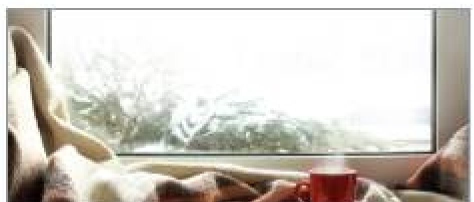
Join us!



Smell rotten eggs?

If you smell rotten eggs or hear the sound of escaping gas, it could be a natural gas leak. Stop what you're doing, go outside and call our 24-hour emergency line at 1-800-663-9911 or call 911.

Learn more



7 ways to help you manage winter energy bills

As temperatures drop across BC, our heating systems are working overtime to keep us warm and cosy. Here's some tips to help you use less energy in your home and avoid a higher than average monthly bill.

Have you tried any of these tips yet?

Appendix I

INDIGENOUS ENGAGEMENT

Appendix I-1

STATEMENT OF INDIGENOUS PRINCIPLES

FortisBC
Statement of Indigenous Principles

FortisBC is committed to building effective Indigenous relationships and to ensuring we have the structure, resources and skills necessary to maintain these relationships.

To meet this commitment, the actions of the company and its employees will be guided by the following principles:

- *FortisBC companies acknowledge, respect and understand that Indigenous Peoples have unique histories, cultures, protocols, values, beliefs and governments.*
- *FortisBC supports fair and equal access to employment and business opportunities within FortisBC companies for Indigenous Peoples.*
- *FortisBC will develop fair, accessible employment practices and plans that ensure Indigenous Peoples are considered fairly for employment opportunities within FortisBC.*
- *FortisBC will strive to attract Indigenous employees, consultants and contractors and business partnerships.*
- *FortisBC is committed to dialogue through clear and open communication with Indigenous communities on an ongoing and timely basis for the mutual interest and benefit of both parties.*
- *FortisBC encourages awareness and understanding of Indigenous issues within its work force, industry and communities where it operates.*
- *To achieve better understanding and appreciation of Indigenous culture, values and beliefs, FortisBC is committed to educating its employees regarding Indigenous issues, interests and goals.*
- *FortisBC will ensure that when interacting with Indigenous Peoples, its employees, consultants and contractors demonstrate respect, and understanding of Indigenous Peoples' culture, values and beliefs.*
- *To give effect to these principles, each of FortisBC's business units will develop, in dialogue with Indigenous communities, plans specific to their circumstances.*

Appendix I-2

INDIGENOUS COMMUNITIES ENGAGEMENT LOG

AMI Indigenous Engagement Log

Indigenous Groups	Date	Engagement Type	FEI Contact	Location	Initiated By	Summary	Follow-Up Required?	Follow-Up Completed? (date)	Additional Comments
All Indigenous Groups	3-Oct-19	Mailed Letter	Vanessa Connolly	54 Indigenous Groups	FEI	Mailed Project Initial Notification letter	Yes	Yes; Oct-19-Nov-19	Follow up phone calls and emails
Aitchelitz Band	15-Oct-19	E-Mail	Vanessa Connolly	Chilliwack	External	Skowkale, Aitchelitz and Yakweakwioose (SAY) Lands Office contacted FEI 15-Oct-19 requesting meeting	Yes	Yes; 23-Oct-19	Waiting to hear back from SAY about best date/time for meeting. Additional follow-up required.
Skowkale First Nation	15-Oct-19	E-Mail	Amar Athwal	Sardis	External	SAY Lands Office contacted FEI 15-Oct-19 requesting meeting	Yes	23-Oct-19	Waiting to hear back from SAY Land Office about best date/time for meeting.
Yakweakwioose Indian Band	15-Oct-19	E-Mail	Amar Athwal	Sardis	External	SAY Lands Office contacted FEI 15-Oct-19 requesting meeting	Yes	Yes; 23-Oct-19	Waiting to hear back from SAY about best date/time for meeting. Additional follow-up required.
Okanagan Indian Band	16-Oct-19	E-Mail	Vanessa Connolly	Vernon	External	On16-Oct-19 requested meeting on 7-Nov-19 to discuss AMI	Yes	Yes; 1-Nov-19 meeting	7-Nov-19 meeting confirmed (FortisBC Indigenous Relations & Community Investment to attend)
Okanagan Indian Band	16-Oct-19	E-Mail	Shelley Martens	Vernon	FEI	Meeting confirmed for 7-Nov-19	No	N/A	
Coldwater Indian Band	21-Oct-19	E-Mail	Amar Athwal	Merritt	External	Meeting request for 27-Nov-21 (Chief and Council Mtg.)	Yes	Yes; 27-Nov-19 Mtg. was tentatively confirmed in 22-Oct-19 email	
Coldwater Indian Band	22-Oct-19	E-Mail	Amar Athwal	Merritt	FEI	27-Nov-19 Mtg. confirmed	No	N/A	
Aitchelitz Band	23-Oct-19	E-Mail	Amar Athwal	Chilliwack	FEI	Followed up about potential meeting dates (no reply)	Yes	Yes; 1-Nov-19	Waiting to hear back from SAY about best date/time for meeting. Additional follow-up required.
Coldwater Indian Band	23-Oct-19	E-Mail	Amar Athwal	Merritt	FEI	Email to clarify time of 27-Nov-19 meeting	No	N/A	
Osoyoos Indian Band	23-Oct-19	Phone Call	Amar Athwal	Oliver	FEI	Spoke to reception 29-Oct-19 who indicated letter should be sent	Yes	Yes; Letter sent	Letter sent as requested
Penticton Indian Band	23-Oct-19	Phone Call	Amar Athwal	Penticton	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Skowkale First Nation	23-Oct-19	E-Mail	Amar Athwal	Chilliwack	FEI	Followed up about potential meeting dates (no reply)	No	N/A	Waiting to hear back from SAY Land Office about best date/time for meeting.
Williams Lake Indian Band	23-Oct-19	E-Mail	Vanessa Connolly	Williams Lake	External	Email received on 23-Oct-19 requesting discussion of potential community engagement meeting	Yes	Yes; 23-Oct-19	No response received back regarding potential community engagement
Williams Lake Indian Band	23-Oct-19	E-Mail	Amar Athwal	Williams Lake	FEI	Follow-up email sent requesting potential dates for meeting/discussion (no reply)	Yes	Yes; 01-Nov-19	No response received back regarding potential community engagement
Yakweakwioose Indian Band	23-Oct-19	E-Mail	Amar Athwal	Chilliwack	FEI	Followed up about potential meeting dates (no reply)	Yes	Yes; 1-Nov-19	Waiting to hear back from SAY about best date/time for meeting. Additional follow-up required.
Coldwater Indian Band	24-Oct-19	Email	Amar Athwal	Merritt	External	Reply from Coldwater Indian Band, indicating time of meeting would be known closer to date of meeting	No	N/A	
Adams Lake Indian Band	28-Oct-19	Phone Call	Amar Athwal	Chase	FEI	Requested e-copy of AMI letter	Yes	Yes; 28-Oct-19	
Chawathil First Nation	28-Oct-19	Phone Call	Amar Athwal	Hope	FEI	Discussed. No concerns at the moment.	No	N/A	
Cheam First Nation	28-Oct-19	Phone Call	Amar Athwal	Rosedale	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Coldwater Indian Band	28-Oct-19	Phone Call	Amar Athwal	Merritt	External	On 21-Oct-19, requested meeting - presentation to Chief Council on 27-Nov-19	Yes	Yes; 27-Nov-19 meeting	On 22-Oct-19, the 27-Nov-19 meeting was confirmed. Time of meeting to be determined in coming weeks.
Cowichan Tribes	28-Oct-19	Phone Call	Amar Athwal	Duncan	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Esquimalt Nation	28-Oct-19	Phone Call	Amar Athwal	Victoria	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Fort Nelson First Nation	28-Oct-19	Phone Call	Amar Athwal	Fort Nelson	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Halalt First Nation	28-Oct-19	Phone Call	Amar Athwal	Chemainus	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Hupacasath First Nation	28-Oct-19	Phone Call	Amar Athwal	Port Alberni	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Katzie First Nation	28-Oct-19	Phone Call	Amar Athwal	Pitt Meadows	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
K'ómoks First Nation	28-Oct-19	Phone Call	Amar Athwal	Courtenay	FEI	Left message with reception	No	N/A	
Kwaw Kwaw Apilt First Nation	28-Oct-19	Phone Call	Amar Athwal	Chilliwack	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Lheidli T'enneh First Nation	28-Oct-19	Phone Call	Amar Athwal	Prince George	FEI	Requested e-copy of AMI letter	Yes	Yes ; 28-Oct-19	

Indigenous Groups	Date	Engagement Type	FEI Contact	Location	Initiated By	Summary	Follow-Up Required?	Follow-Up Completed? (date)	Additional Comments
Lhtako Dene First Nation	28-Oct-19	Phone Call	Amar Athwal	Quesnel	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Matsqui First Nation	28-Oct-19	Phone Call	Amar Athwal	Matsqui	FEI	Left message with reception	No	N/A	
Musqueam Indian Band	28-Oct-19	Phone Call	Amar Athwal	Vancouver	FEI	Requested e-copy of letter to forward to Chief/Council	Yes	Yes ; 28-Oct-19	
Neskonlith Indian Band	28-Oct-19	Phone Call	Amar Athwal	Chase	FEI	Indicated that letter should be sent.	Yes	Yes; 30-Oct-19	Sent email copy of AMI letter on 29-Oct-19 as requested
Prophet River First Nation	28-Oct-19	Phone Call	Amar Athwal	Fort Nelson	FEI	Requested e-copy of AMI letter	Yes	Yes ; 28-Oct-19	
Seabird Island Indian Band	28-Oct-19	Phone Call	Amar Athwal	Agassiz	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Semiahmoo First Nation	28-Oct-19	Phone Call	Amar Athwal	Surrey	FEI	Requested e-copy of AMI letter	Yes	Yes ; 28-Oct-19	Sent email copy of AMI letter as requested
Shíshálh First Nation	28-Oct-19	Phone Call	Amar Athwal	Sechelt	FEI	Requested e-copy of AMI letter	Yes	Yes ; 28-Oct-19	
Shxwhá:y Village (skyway)	28-Oct-19	Phone Call	Amar Athwal	Chilliwack	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Skeetchestn Indian Band	28-Oct-19	Phone Call	Amar Athwal	Savona	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Skwah First Nation	28-Oct-19	Phone Call	Amar Athwal	Chilliwack	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Snuneymuxw First Nation	28-Oct-19	Phone Call	Amar Athwal	Nanaimo	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Songhees First Nation	28-Oct-19	Phone Call	Amar Athwal	Victoria	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Soowahlie Indian Band	28-Oct-19	Phone Call	Amar Athwal	Cultus Lake	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Splatsin First Nation	28-Oct-19	Phone Call	Amar Athwal	Enderby	FEI	Request to email AMI letter	Yes	Yes; 29-Oct-19	
Squiala First Nation	28-Oct-19	Phone Call	Amar Athwal	Chilliwack	FEI	Left message with reception	No	N/A	
Stz'uminus First Nation	28-Oct-19	Phone Call	Amar Athwal	Ladysmith	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Sumas First Nation	28-Oct-19	Phone Call	Amar Athwal	Abbotsford	External	Sumas Administrative office requested e-copy of AMI letter	Yes	Yes ; 28-Oct-19	
Sumas First Nation	28-Oct-19	Email	Amar Athwal	Abbotsford	FEI	E-copy of AMI letter sent to Sumas Administrative office requested	No	N/A	
T'Sou-ke First Nation	28-Oct-19	Phone Call	Amar Athwal	Sooke	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Tk'emlúps te Secwépemc	28-Oct-19	Phone Call	Amar Athwal	Kamloops	FEI	Left message with reception	No	N/A	
Tsartlip First Nation	28-Oct-19	Phone Call	Amar Athwal	Brentwood Bay	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Tsawwassen First Nation	28-Oct-19	Phone Call	Amar Athwal	Delta	FEI	Left message with reception; requested e-copy of letter	No	Yes ; 28-Oct-19	Sent email copy of AMI letter as requested 8-Oct -19
Tseshaht First Nation	28-Oct-19	Phone Call	Amar Athwal	Port Alberni	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Tseycum First Nation	28-Oct-19	Phone Call	Amar Athwal	Sidney	FEI	Left message with reception	No	N/A	
Tzeachten First Nation	28-Oct-19	Phone Call	Amar Athwal	Chilliwack	FEI	No answer. Unable to leave message (did not go to voicemail)	No	N/A	
Union Bar Indian Band	28-Oct-19	Phone Call	Amar Athwal	Hope	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Wei Wai Kum Nation	28-Oct-19	Phone Call	Amar Athwal	Campbell River	External	Wei Wai Kum administration office requested e-copy of AMI letter	Yes	Yes ; 28-Oct-19	
Wei Wai Kum Nation	28-Oct-19	Email	Amar Athwal	Campbell River	FEI	Sent e-copy of AMI letter	No	N/A	
Westbank First Nation	28-Oct-19	Phone Call	Amar Athwal	Westbank	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
ʔaq'am (St. Mary's Indian Band)	28-Oct-19	Phone Call	Amar Athwal	Cranbrook	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Little Shuswap Lake Indian Band	29-Oct-19	Phone Call	Amar Athwal	Chase	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Lower Nicola Indian Band	29-Oct-19	Phone Call	Amar Athwal	Merritt	FEI	Email received in response to Oct. 29 voicemail requesting follow-up	Yes	Yes; 30-Oct-19	Sent email copy of AMI letter on 30-Oct-19
Osoyoos Indian Band	30-Oct-19	E-Mail	Vanessa Connolly	Oliver	External	Email to Vanessa Connolly requesting meeting with Chief/Council for 25-Nov-19	Yes	Yes; 25-Nov-19 meeting was tentatively scheduled	
Tseshaht First Nation	31-Oct-19	Phone Call	Amar Athwal	Port Alberni	External	Received phone call on 31-Oct-19 regarding AMI. Requested e-copy of letter. They will follow-up if needed.	Yes	Yes; 31-Oct-19	
Tseshaht First Nation	31-Oct-19	Phone Call	Amar Athwal	Port Alberni	External	E-copy of AMI letter sent 31-Oct-19	No	N/A	

Indigenous Groups	Date	Engagement Type	FEI Contact	Location	Initiated By	Summary	Follow-Up Required?	Follow-Up Completed? (date)	Additional Comments
Aitchelitz Band	1-Nov-19	E-Mail	Amar Athwal	Chilliwack	FEI	Followed up about potential meeting dates. Indicated she will follow-up with dates week of 4-Nov-19	No	N/A	
Osoyoos Indian Band	1-Nov-19	E-Mail	Amar Athwal	Oliver	FEI	Follow-up email sent on 1-Nov-19 meeting tentatively scheduled for 25-Nov-19 with Chief and Council	No		
Skowkale First Nation	1-Nov-19	E-Mail	Amar Athwal	Chilliwack	FEI	Followed up about potential meeting dates. Indicated will follow-up with dates week of 4-Nov-19	No	N/A	
Williams Lake Indian Band	1-Nov-19	E-Mail	Amar Athwal	Williams Lake		2nd follow-up email sent requesting potential dates	No	N/A	No response received yet
Yakweakwioose Indian Band	1-Nov-19	E-Mail	Amar Athwal	Chilliwack	FEI	Followed up about potential meeting dates. Indicated will follow-up with dates week of 4-Nov-19	No	N/A	
Okanagan Indian Band	7-Nov-19	In-Person Meeting	Amar Athwal; Shelley Martens	Vernon	External	Met with OKIB to have initial conversation about AMI Project. OKIB had a number of questions we said we would follow-up on.	Yes	Yes; 29-Nov-19 email	
Coldwater Indian Band	13-Nov-19	E-mail	Amar Athwal	Merritt	FEI	Follow-up to check 27-Nov-19 meeting time	No	N/A	
Coldwater Indian Band	14-Nov-19	E-mail	Amar Athwal	Merritt	External	Meeting time (7pm) confirmed for 27-Nov-19 meeting	No	N/A	
Coldwater Indian Band	14-Nov-19	Email	Amar Athwal	Merritt	FEI	Request to postpone meeting until 2020	No	N/A	
Coldwater Indian band	14-Nov-19	Email	Amar Athwal	Merritt	External	Request to postpone meeting until 2020 acknowledged	Yes	Yes; new meeting scheduled for 8-Apr-20	
Osoyoos Indian Band	19-Nov-19	E-Mail	Amar Athwal	Oliver	FEI	25-Nov-19 meeting date pushed to early 2020	Yes	Yes; 17-Dec-19 email	
Tsawout First Nation	21-Nov-19	Phone Call	Amar Athwal	Saanichton	FEI	Left Voicemail indicating FEI open to answering questions on AMI	No	N/A	
Squamish Nation	26-Nov-19	E-Mail	Amar Athwal	North Vancouver	FEI	Emailed SN with follow-up on Oct. letter, indicating would be happy to answer any questions about AMI	No	N/A	
Tsleil-Waututh First Nation	26-Nov-19	E-Mail	Amar Athwal	North Vancouver	FEI	Emailed TWN with follow-up on 3-Oct-19 letter, indicating would be happy to answer any questions about AMI	No	N/A	
Okanagan Indian Band	29-Nov-19	E-Mail	Amar Athwal	Vernon	External	Email providing response to inquiries raised at 7-Nov-19 meeting	No	N/A	
Coldwater Indian Band	17-Dec-19	E-Mail	Amar Athwal	Merritt	FEI	New meeting dates requested	No	N/A	
Coldwater Indian Band	17-Dec-19	E-Mail	Amar Athwal	Merritt	External	Potential meeting dates proposed for January/February	Yes	Yes; Followed-up in 13-Jan-19 E-Mail	
Osoyoos Indian Band	17-Dec-19	E-Mail	Amar	Oliver	FEI	FEI requested potential meeting dates. No reply received	Yes	Yes; 24-Jan-20 email	
Coldwater Indian Band	13-Jan-20	E-Mail	Amar Athwal	Merritt	FEI	Due to weather conditions alternative dates requested for meeting deeper into Q1 2020	Yes	Yes; 14-Jan-20	
Coldwater Indian band	14-Jan-20	E-Mail	Amar Athwal	Merritt	External	Propose 26-Feb-20 at 6pm as new meeting date	Yes	Yes; 14-Jan-20	Confirm new meeting dates
Coldwater Indian Band	14-Jan-20	E-Mail	Amar Athwal	Merritt	FEI	26-Feb-20 meeting date confirmed	Yes	Yes; 7-Feb-20	Confirm meeting dates
Aitchelitz Band	24-Jan-20	E-Mail	Amar Athwal	Chilliwack	FEI	Followed up to inquire if there was still interest in a meeting.	No	N/A	
Osoyoos Indian Band	24-Jan-20	E-Mail	Amar Athwal	Oliver	FEI	Follow-up email to see if there is still interest in meeting on AMI. No reply received	No	N/A	
Skowkale First Nation	24-Jan-20	E-Mail	Amar Athwal	Chilliwack	FEI	Alpha	No	N/A	
Williams Lake Indian Band	24-Jan-20	E-Mail	Amar Athwal	Williams Lake	FEI	Followed up to inquire if there was still interest in a meeting.	No		
Yakweakwioose Indian Band	24-Jan-20	E-Mail	Amar Athwal	Chilliwack	FEI	Followed up to inquire if there was still interest in a meeting.	No	N/A	
Coldwater Indian Band	7-Feb-20	E-Mail	Amar Athwal	Merritt	FEI	Re-confirming 26-Feb-20 meeting date	No	N/A	
Coldwater Indian Band	7-Feb-20	E-Mail	Amar Athwal	Merritt	External	26-Feb-20 is re-confirmed by Coldwater Indian Band	No	N/A	
Coldwater Indian band	21-Feb-20	E-Mail	Amar Athwal	Merritt	External	Request from Coldwater to re-schedule 26-Mar-20 meeting	Yes;	Yes; Followed-up Feb. 24, 26, 2020	
Coldwater Indian Band	24-Feb-20	E-Mail	Amar Athwal	Merritt	FEI	Additional discussion regarding potential meeting dates	No	N/A	
Coldwater Indian Band	26-Feb-20	E-Mail	Amar Athwal	Merritt	External	Additional meeting dates proposed	Yes	Yes; Followed-up on 26-Feb-20 to confirm new meeting date	
Coldwater Indian Band	26-Feb-20	E-Mail	Amar Athwal	Merritt	FEI	Request to confirm 8-Apr-20, 7pm as revised meeting date	No	N/A	

Indigenous Groups	Date	Engagement Type	FEI Contact	Location	Initiated By	Summary	Follow-Up Required?	Follow-Up Completed? (date)	Additional Comments
Coldwater Indian Band	26-Feb-20	E-Mail	Amar Athwal	Merritt	FEI	8-Apr-20 Meeting date confirmed	No	N/A	
Coldwater Indian Band	3-Mar-20	E-Mail	Amar Athwal	Merritt	External	Coldwater requested postponement of 8-Apr-20 Meeting due to COVID. They will follow up with alternative dates	No	N/A	Awaiting Coldwater to contact FEI with alternative dates for meeting.
Coldwater Indian Band	11-May-20	E-Mail	Amar Athwal	Merritt	External	Coldwater requested13-May-20 Meeting	Yes	Yes; 13-May-20 Meeting	Coldwater sent Zoom e-invite to FEI
Coldwater Indian Band	13-May-20	Conference Call	Amar Athwal	Merritt	External	Telephone meeting with Coldwater on 13-May-20 Meeting with Chief & Council. Provided current details on the Project and addressed questions.	Yes	Yes; 24-Feb-21 (update letter)	Questions on issues related to safety and access and were addressed by FEI during the call. Coldwater Indian Band also indicated a preference for working through a community appointed liaison during deployment and FEI was able to confirm that this can be arranged if the Project proceeds. Further engagement closer to deployment.
All Indigenous Groups	9-Feb-21	Emailed Letter	Greg Edgelow	54 Indigenous Groups	FEI	Emailed Project Notification letter that included information about the Feb 23 and Feb 24, 2021 Public Information Sessions	Yes	No; <30-Apr-21	Follow up prior to 30-Apr-21 to touch base with Indigenous groups to solicit any questions to date and provide any further updates
Stz'uminus First Nation	10-Feb-21	Email	Greg Edgelow	Ladysmith	External	Maureen Tommy inquired about how many FEI gas customers resided in Stz'uminus First Nation community	Yes	Yes; 19-Feb-21	
Union Bar Indian Band	15-Feb-21	Phone Call	Greg Edgelow	Hope	FEI	Left voicemail regarding the 23-Feb-21 & 24-Feb-21 Public Information Sessions	No	N/A	
Union Bar Indian Band	18-Feb-21	Email	Greg Edgelow	Hope	FEI	Sent 2nd AMI update letter via email to economic development representative for Union Bar (Vivian Ferguson, Sto: lo Tribal Council)	No	N/A	Sent 2nd AMI update letter via email to Vivian Ferguson of Stolo Tribal Council as indicated on the Union Bar Indian Band website
Stz'uminus First Nation	19-Feb-21	Email	Greg Edgelow	Ladysmith	FEI	Informed Maureen Tommy that a new GIS report did not identify any customers, but we were reviewing the community boundaries to confirm	Yes	Yes; 26-Feb-21	Followed up with FortisBC GIS team to confirm community boundaries and gas customers
Skeetchestn Indian Band	23-Feb-21	Email	Greg Edgelow, Antonio Bebic	Savona	External	Rochelle Porter, Public Works & Housing Manager, requested 24-Feb-21 Public Information Session registration	Yes	Yes: 24-Feb-21	
Skeetchestn Indian Band	24-Feb-21	Email	Greg Edgelow	Savona	FEI	24-Feb-21 Public Information Session registration sent to Rochelle Porter	No	N/A	
Skeetchestn Indian Band	24-Feb-21	Email	Greg Edgelow	Savona	External	Rochelle Porter requested PDF of Public information Session 24-Feb-21 presentation	Yes	Yes; Mar-3-21	Sent PDF of Public information Session 24-Feb-21 presentation
Squiala First Nation	24-Feb-21	Email	Greg Edgelow, Antonio Bebic	Chilliwack	External	Request from Nikki Jackson, Lands Assistant, for 24-Feb 21 Public Information Session	Yes	Yes; 24-Feb 21	Registration URL sent for 24-Feb-21 Public Information Session
Squiala First Nation	24-Feb-21	Email	Greg Edgelow, Antonio Bebic	Chilliwack	FEI	Sent URL for 24-Feb 21 Public Information Session as request by Nikki Jackson, Lands Assistant	No	N/A	
Stz'uminus First Nation	26-Feb-21	Email	Greg Edgelow	Ladysmith	FEI	Informed Maureen Tommy that our GIS records indicated that there are no FEI gas customers in their community	No	N/A	
Skeetchestn Indian Band	3-Mar-21	Email	Greg Edgelow	Savona	FEI	PDF of 24-Feb-21 Pubic Information Session presentation sent to Rochelle Porter	No	N/A	

Appendix I-3

INTRODUCTION LETTER TO INDIGENOUS COMMUNITIES, OCTOBER 3, 2019

FortisBC
1-(833) 592-7937
fortisbc.com/advancedgasmeters
advancedgasmeters@fortisbc.com

October 3, 2019

CONTACT INFO – Indigenous Communities

Greetings,

FortisBC pursuing Advanced Gas Meters project
FortisBC is looking at upgrading its customers' natural gas meters to new advanced meters, as we explore ways to modernize and strengthen our system, and add new customer benefits.

We acknowledge you and your community as rights holders and value you as customers of FortisBC. This is why we are reaching out early in this process with the intention of beginning these conversations.

We are beginning the process of applying to the British Columbia Utilities Commission (BCUC) for this project, which includes engaging with communities and customers. We expect to file the application with the BCUC in early 2020. If approved, we anticipate upgrading residential and commercial customers to advanced gas meters between 2022-2026.

Why advanced gas meters
The gas meter technology currently used in B.C. has not fundamentally changed in more than 100 years. The new meters are smaller, have no moving parts and are expected to last longer than existing meters. They use sound waves to measure gas use and send the information to FortisBC through a wireless network, meaning FortisBC would no longer need to read individual meters manually. The new meters will also allow us to add new safety features, such as the ability to remotely detect and respond to gas leaks.

The new meters would offer benefits for customers such as access to daily updates on gas use and the convenience of not having their gas service shut off during future meter exchanges.

Engaging with your community
In the upcoming weeks, we will be hosting a series of public information sessions throughout FortisBC's natural gas service area so we can speak with communities about this project. Details for these information sessions and more information about the project are available at fortisbc.com/advancedgasmeters. If preferred, we would be happy to hold an information session for your community about this proposed project, or meet directly with Chief and Council or your designated representatives.

If you have questions, or would like more information, please feel free to reach out to me directly, at Vanessa.Connolly@fortisbc.com or via 1-833-592-7937. We look forward to continuing the conversation with your community and welcome the opportunity to discuss the project in more detail at a time and place convenient for you.

Sincerely,

____
Vanessa Connolly

Appendix I-4

PROJECT UPDATE NOTIFICATION LETTER TO INDIGENOUS COMMUNITIES, FEBRUARY 8, 2021

FortisBC
1-(833) 592-7937
fortisbc.com/advancedgasmeters
advancedgasmeters@fortisbc.com

February 8, 2021

Dear Chief and Council,

FortisBC – committed to working together towards a better future
Every day we deliver natural gas, electricity and innovative energy solutions to approximately 1.2 million customers in communities throughout the province – including yours.

We're rethinking the energy we deliver today and into the future. By focusing on our climate leadership role as we move towards British Columbia's lower carbon future, we have set one of the most ambitious reduction targets in the Canadian utility sector. Our 30BY30 target sets an achievable, affordable path to reducing our customers' greenhouse gas emissions by 30 per cent by 2030.

Our work extends beyond 2030 as well and our Clean Growth Pathway plan outlines several strategies that align with the province's 2050 climate targets. This plan shows how we can reach our emission reduction targets using both the existing natural gas and electric systems. We're committed to partnering with customers, communities, industry and all levels of government, including Indigenous, to reduce greenhouse gas emissions and this work is already underway. We would welcome the opportunity to discuss these initiatives with you or your community.

Advanced Gas Meters project update
One of the other projects we are pursuing is our Advanced Gas Meters project. We are moving forward with plans to upgrade our customers' natural gas meters to new advanced meters, as we explore ways to modernize our system. Since October 2019, when we first reached out to your community regarding this project, work has been ongoing. We expect to file an application with the British Columbia Utilities Commission in spring 2021. If approved, we anticipate upgrading residential and commercial customers to advanced gas meters between 2023-2026.

Our Advanced Gas Meters project will add new safety features such as the ability to remotely detect and respond to gas leaks, and customer benefits including access to daily updates on gas use. We believe that giving our more than one million natural gas customers access to more information will help them better understand and manage their use, and empower them to reduce energy consumption. Additionally, after the installation of the new advanced meters, we will no longer need to access physical properties to read meters.

Upcoming information session
FortisBC will be hosting two online customer information sessions about this project (Tuesday Feb 23, 2021 at 6 p.m. & Wednesday Feb 24, 2021 at 4 p.m. PST). Please RSVP to advancedgasmeters@fortisbc.com and indicate the date you would like to attend. Details for these information sessions and more information about the project are available at fortisbc.com/advancedgasmeters. If interested, we are also happy to provide an information session specifically for your community.

We look forward to continuing to engage with your community and welcome the opportunity to discuss the project at a time and manner that is convenient for you. If you have questions, or would like more information, please feel free to reach out to me directly, at Greg.Edgelow@fortisbc.com or via 1-833-592-7937.

Sincerely,

Greg Edgelow

Greg Edgelow
Indigenous Relations Manager

Appendix I-5

OKANAGAN INDIAN BAND PRESENTATION, NOVEMBER 2019

Energy at work FORTIS BC™

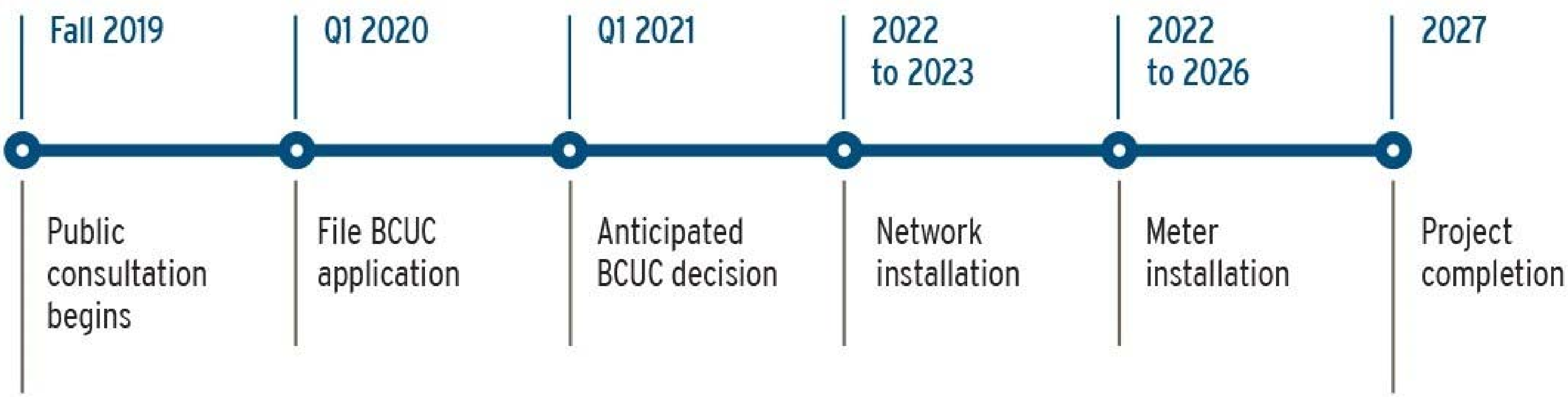
Advanced Gas Meters Project

Presentation to: Okanagan Indian Band

November 7, 2019

Project Overview

We are filing an application with our regulator, the British Columbia Utilities Commission (BCUC), to upgrade our more than one million residential and commercial gas meters to new advanced meters.



Energy at work FORTIS BC™

Advanced Gas Meter Infrastructure

Advanced gas meters will help us build a stronger, more reliable system to deliver natural gas homes and businesses across British Columbia

- The new meters will allow us to measure customer has use through a wireless network.
- They have no moving parts and are expected to last longer than existing meters.
- Existing meter technology has not fundamentally changed in more than 100 years.

A new wireless network would be built

- FortisBC will build and own this network.
- The network will be encrypted and will wirelessly send customer consumption data.

Energy at work FORTIS BC™

Existing Meter and Advanced Meter

Energy at work FORTIS BC™

Benefits

The project will help improve the resiliency of the system that supplies B.C. homes and businesses with natural gas

- We could remotely detect and respond to gas leaks.

Advanced gas meters also offer a number of new benefits

- Customers will be able to access daily updates on their gas use.
- FortisBC will no longer need to regularly enter customers' properties to read meters.
- FortisBC will no longer have to shut off gas service during meter exchanges, reducing inconvenience.

There are already about 130,000 FortisBC electric customers using advanced meters

Advanced Gas Meters project

FortisBC.com/advancedgasmeters

1-833-592-7937

advancedgasmeters@fortisbc.com

Energy at work FORTIS BC™

Thank you

Energy at work FORTIS BC™

For further information, please contact:

Amar Athwal, Indigenous Relations manager

Find FortisBC at:

Fortisbc.com

talkingenergy.ca

604-576-7000

Appendix J

LIST OF ACRONYMS

LIST OF ACRONYMS

Acronym	Definition
AACE	Association for the Advancement of Cost Engineering
Advanced Meter	A meter that contains a device that receives, records, displays and transmits data and provides other advanced utility functions.
AMI	Advanced Metering Infrastructure
AMI Project	FEI's natural gas AMI project
AMI-SEC	Advanced Metering Infrastructure Security
AMI System	Means a collection of hardware, software and communications systems that enable remote two-way communications and control with meters and allow for data storage and retrieval.
AMR	Automatic Meter Reading
AMRD	Automated Meter Reading Devices
Application	FEI Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure Project
Backhaul	The wide area network that transmits data between the collectors and the head end system.
Base station	The long-range radio transceiver that aggregates data from multiple meters and other endpoint devices, and provides two-way communication via the WAN to the HES.
BC Hydro	BC Hydro and Power Authority
BCUC	British Columbia Utilities Commission
CEA	*Clean Energy Act*. Enacted by the Government of British Columbia in 2010, the CEA contains 16 specific energy objectives for the Province of British Columbia and provides a guide to help the Province meet its self-sufficiency goals, and to reduce GHG emissions.
CCA	Capital Cost Allowance
CCE	Customer Care Enhancement
C&EM	Conservation & Energy Management
CIS	Customer Information System
Company	FortisBC Energy Inc. (FEI)
COS	Cost of Service
CPCN	Certificate of Public Convenience and Necessity
DBRS	Dominion Bond Rating Service
Diaphragm meter	A positive displacement instrument used to measure the volume of natural gas that passes through it and is also known as a positive displacement meter.
DSM	Demand Side Management and refers to programs that help customers manage their natural gas consumption through energy efficiency improvements.
EGIA	*Electricity and Gas Inspection Act*
EMF	Electromagnetic Frequency and is a physical field produced by electrically charged objects.

Acronym	Definition
End Point	The Project contains the following End Points: Sensus FlexNet Gateways; Sensus SonixIQ™ advanced meters; Sensus FlexNet SmartPoint® modules; and Sensus FlexNet SentryPoints.™
FEI	FortisBC Energy Inc.
FAN	Field Area Network
FortisBC Energy Inc. service territory	The geographical area in which FEI has active customers.
GHG	Greenhouse gas that absorbs infrared radiation (net heat energy) emitted from Earth's surface and reradiates it back, contributing to the greenhouse effect.
GT&C's	FEI's General Terms and Conditions
HES	Head End System and is the AMI system component that manages the network infrastructure, customer meters and other endpoint devices.
Insights Matter Survey	Independent third-party survey of other Canadian natural gas utility companies to determine the level of progress towards automated metering for each utility.
IR	Information Request
IS	Information System
Itron	Itron Inc.
LTGRP	Long Term Gas Resource Plan and is FEI's roadmap for securing safe, reliable, and cost-effective energy resources to meet their customers' energy needs.
MDMS	Meter Data Management System which receives daily reading and alarm data from the HES, performs analytics on the data and delivers bill-ready data to downstream systems.
MLA	Members of the Legislative Assembly
MRP	FEI and FortisBC Inc.'s Multi-Year Rate Plan for the Years 2020 through 2024
NGT	Natural Gas for Transportation
NPV	Net Present Value
O&M	Operations and Maintenance
Peak	The period of highest system demand.
PG&E	Pacific Gas and Electric Company
Pilot	FEI's natural gas AMI pilot project in 2017 and 2018.
PIPA	British Columbia's *Personal Information Protection Act* and describes how all private sector organizations must handle the personal information of its employees and their customers.
PIPEDA	*Personal Information Protection and Electronic Documents Act*
QRA	Quantitative Risk Analysis
RF	A measurement representing the oscillation rate of an electromagnetic radiation spectrum or electromagnetic radio waves.
RFP	Request for Proposal
RNG	Renewable Natural Gas and is an upgraded biogas with a quality similar to fossil natural gas. It is also referred to as sustainable natural gas or biomethane.

Acronym	Definition
RNI	Regional Network Interface and is the name of the Sensus head-end system.
Rotary meter	A highly machined precision natural gas meter capable of handling higher volumes and pressures than diaphragm meters.
RTO	Recovery Time Objective
SA	Sensus Analytics and is the name of the Sensus MDMS.
SaaS	Software as a Service and is a method of software delivery and licensing.
Sensus	Sensus Canada Inc.
Spartan	Spartan Controls Ltd.
tCO2e	Tonnes of Carbon Dioxide equivalent
TLSE Project Application	Tilbury Liquefied Natural Gas Storage Expansion Project
Turbine meter	A natural gas meter that infers natural gas volume by determining the speed of the natural gas moving through the meter.
UCA	*Utilities Commission Act*
UL	Underwrites Laboratories Inc.
Util-Assist	Util-Assist Inc.
Util-Assist Report	Report detailing the gas utility Automation projects across Canada and the US, including identifying the form of Automation.
WACC	Weighed Average Cost of Capital
WAN	Wide Area Network and is a secure two-way telecommunications network between the collectors and the HES. Also known as backhaul.

Appendix K

DRAFT ORDERS

Appendix K-1

DRAFT PROCEDURAL ORDER

bcuc
British Columbia
Utilities Commission

Suite 410, 900 Howe Street
Vancouver, BC Canada V6Z 2N3
bcuc.com

P: 604.660.4700
TF: 1.800.663.1385
F: 604.660.1102

ORDER NUMBER
G-xx-xx

IN THE MATTER OF
the *Utilities Commission Act*, RSBC 1996, Chapter 473

and

FortisBC Energy Inc.
Application for a Certificate of Public Convenience and Necessity for the Advance Metering Infrastructure Project

BEFORE:
[Panel Chair]
Commissioner
Commissioner

on Date

ORDER

WHEREAS:

A. On May 5, 2021, FortisBC Energy Inc. (FEI) filed an application (Application) with the British Columbia Utilities Commission (BCUC) for a Certificate of Public Convenience and Necessity (CPCN) pursuant to sections 45 and 46 of the *Utilities Commission Act* (UCA) for FEI's Advanced Metering Infrastructure (AMI) Project (AMI Project);

B. The AMI Project includes the following:

   i. Installation of approximately 1,100,000 residential, commercial, and industrial advanced meters and meter retrofits of communication modules capable of remote gas consumption measurement;

   ii. Installation of approximately 1,100 communication modules on the gas network to increase operational awareness of the gas system state; and

   iii. Installation of the AMI network and infrastructure to communicate with customer meters and other communication modules on the FEI gas network.

C. In the Application, FEI also requests approval, pursuant to sections 59 to 61 of the UCA, to create 4 new asset accounts with associated depreciation and net salvage rates for the proposed meters to be installed as part of the AMI Project, as follows:

   i. 478-10 / AMI Meter Hardware, with a depreciation rate set to 5 percent, with no net salvage;

   ii. 474-00 / AMI Meter Installation, with a depreciation rate set to 5 percent, with 1.58 percent net salvage;

iii. 402-06 / AMI Software, with a depreciation rate set to 10 percent; and

iv. 488-30 / AMI Communications and Equipment, with a depreciation rate set to 6.67 percent, with no net salvage;

D. FEI also seeks approval, pursuant to sections 59 to 61 of the UCA, to create 4 new deferral accounts as follows:

i. A non rate base AMI Application and Feasibility cost deferral account attracting a weighted average cost of capital return until it is placed into rate base, to capture development and application costs for the AMI Project, to be amortized over 3 years;

ii. A non rate base AMI Foreign Exchange (FX) Mark to Market Valuation deferral account to isolate the impact of any foreign exchange hedging used to reduce foreign exchange risk of the AMI Project;

iii. A rate base Existing Meter Cost Recovery deferral account to capture the remaining costs of the meters to be exchanged as part of the AMI Project with a rolling 5 year amortization period; and

iv. A rate base Previously Retired Meter Cost Recovery deferral account to capture the remaining rate base value of previously retired meters with an amortization period of 10 years;

E. The BCUC has commenced review of the Application and considers that the establishment of a public hearing is warranted.

NOW THEREFORE the BCUC orders as follows:

1. A public hearing is established for the review of the Application in accordance with the regulatory timetable as set out in Appendix A to this order.

2. FEI must publish the Public Notice, attached as Appendix B to this order, in print/display-ad format in appropriate news publications, such as but not limited to, local and community newspapers to provide adequate notice to those parties who may have an interest in or be affected by the Application, as soon as reasonably possible, but no later than [DATE].

3. As soon as practicable, but not later than [DATE], FEI must publish notice of this Application on its website and social media platforms. It must also publish weekly reminder notices on each platform until the conclusion of the intervener registration period on [DATE].

4. FEI must provide an electronic copy of the Application and this order by no later than [DATE] to registered interveners in the FEI Annual Review for 2020 and 2021 Delivery Rates proceeding.

5. Persons who wish to actively participate in this proceeding must complete a Request to Intervene Form, available on the BCUC's website at https://www.bcuc.com/get-involved/get-involved-proceeding.html, by [DATE] as established in the Regulatory Timetable, and in accordance with the BCUC's Rules of Practice and Procedure attached to Order G-15-19.

DATED at the City of Vancouver, in the Province of British Columbia, this (XX) day of (Month Year).

BY ORDER

(X. X. last name)
Commissioner

Attachment

FortisBC Energy Inc.
Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure Project

REGULATORY TIMETABLE

Action	Date (2021)
FEI to publish Notice	Wednesday, July 7
Registration of Interveners	Wednesday, August 11
BCUC Information Request (IR) No. 1	Wednesday, August 11
Intervener IR No. 1	Wednesday, August 18
FEI Response to IR No. 1	Wednesday, September 15
BCUC and Intervener IR No. 2	Wednesday, October 6
FEI Response to IR No. 2	Wednesday, November 3
Submissions on further process	Wednesday, November 17

bcuc
British Columbia
Utilities Commission

PUBLIC NOTICE

FortisBC Energy Inc.'s Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure Project

On May 5, 2021, FortisBC Energy Inc. filed its Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure (AMI) Project (Application). The purpose of the project is to automate the meter reading process for all of FEI's natural gas customers. In addition to other benefits, the AMI Project will provide a cost-effective, long-term solution to alleviate the cost and service risks of manual reading. The Application includes replacing most existing customer natural gas meters with advanced meters, retrofitting meters that are not replaced with AMI communication modules, installing the associated AMI network and infrastructure to support delivery of hourly gas consumption and other metering information from the advanced meters/modules at customer premises back to FEI, and installing communication modules on the gas network and pipeline assets to enable the remote collection of information on FEI's gas system integrity. The estimated total cost of the project in as-spent dollars is $638.4 million, which includes Allowance for Funds Used During Construction.

HOW TO PARTICIPATE

- **Submit a letter of comment**
- **Register as an interested party**
- **Request intervener status**

IMPORTANT DATES

1. **[DATE]** – Deadline to register as an intervener with the BCUC.

For more information about the Application, please visit the Proceeding Webpage on bcuc.com under "Regulatory Activities – Current Proceedings". To learn more about getting involved, please visit our website (www.bcuc.com/get-involved) or contact us at the information below.

GET MORE INFORMATION

FortisBC Energy Inc. Regulatory Affairs

16705 Fraser Highway
Surrey, BC Canada V4N 0E8

E: gas.regulatory.affairs@fortisbc.com

British Columbia Utilities Commission

Suite 410, 900 Howe Street
Vancouver, BC Canada V6Z 2N3

E: Commission.Secretary@bcuc.com

P: 1-833-592-7937

P: 604.660.4700

Appendix K-2

DRAFT FINAL ORDER

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Utilities Commission

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ORDER NUMBER
C-xx-xx

IN THE MATTER OF
the *Utilities Commission Act*, RSBC 1996, Chapter 473

and

FortisBC Energy Inc.
Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure Project

BEFORE:
[Panel Chair]
Commissioner
Commissioner

on Date

ORDER

WHEREAS:

A. On May 5, 2021, FortisBC Energy Inc. (FEI) filed an application (Application) with the British Columbia Utilities Commission (BCUC) pursuant to sections 45 and 46 of the Utilities Commission Act (UCA), seeking approval of a Certificate of Public Convenience and Necessity (CPCN) for the Advanced Metering Infrastructure (AMI) Project (AMI Project);

B. The AMI Project includes the following:

   1. Installation of approximately 1,100,000 residential, commercial, and industrial advanced meters and meter retrofits of communication modules capable of remote gas consumption measurement;

   2. Installation of approximately 1,100 communication modules on the gas network to increase operational awareness of the gas system state; and

   3. Installation of the AMI network and infrastructure to communicate with customer meters and other communication modules on the FEI gas network.

C. In the Application, FEI also requests approval, pursuant to sections 59 to 61 of the UCA, to create 4 new asset accounts with associated depreciation and net salvage rates for the proposed meters to be installed as part of the AMI Project, as follows;

   1. 478-10 / AMI Meter Hardware, with a depreciation rate set to 5 percent, with no net salvage;

2. 474-00 / AMI Meter Installation, with a depreciation rate set to 5 percent, with 1.58 percent net salvage;

3. 402-06 / AMI Software, with a depreciation rate set to 10 percent; and

4. 488-30 / AMI Communications and Equipment, with a depreciation rate set to 6.67 percent, with no net salvage;

D. FEI also seeks approval, pursuant to sections 59 to 61 of the UCA, to create 4 new deferral accounts as follows:

1. A non rate base AMI Application and Feasibility cost deferral account attracting a weighted average cost of capital return until it is placed into rate base, to capture development and application costs for the AMI Project, to be amortized over 3 years;

2. A non rate base AMI Foreign Exchange (FX) Mark to Market Valuation deferral account to isolate the impact of any foreign exchange hedging used to reduce foreign exchange risk of the AMI Project;

3. A rate base Existing Meter Cost Recovery deferral account to capture the remaining rate base value of the meters to be exchanged as part of the AMI Project with a rolling amortization period of 5 years; and

4. A rate base Previously Retired Meter Cost Recovery deferral account to capture the remaining rate base value of previously retired meters with an amortization period of 10 years;

E. By Order G-#-##, dated [DATE], the BCUC established a regulatory timetable for the review of the Application which consisted of intervener registration and # round(s) of information requests (IRs);

F. The BCUC has considered the Application, evidence and submissions from the parties and finds that public convenience and necessity require that the Project proceed and the following determinations to be warranted.

NOW THEREFORE pursuant to sections 45 to 46 and 59 to 61 of the UCA and for the reasons set out in the decision issued concurrently with this order, the BCUC orders as follows:

1. A CPCN is granted to FEI for the AMI Project.

2. FEI is approved to establish four new asset accounts to be amortized as follows:

   a. 478-10 / AMI Meter Hardware, with a depreciation rate set to 5 percent, with no net salvage;

   b. 474-00 / AMI Meter Installation, with a depreciation rate set to 5 percent, with 1.58 percent net salvage;

   c. 402-06 / AMI Software, with a depreciation rate set to 10 percent; and

   d. 488-30 / AMI Communications and Equipment, with a depreciation rate set to 6.67 percent, with no net salvage.

3. FEI is approved to establish the 4 new deferral accounts to be amortized as follows:

    a. A non rate base AMI Application and Feasibility cost deferral account attracting a weighted average cost of capital return until it is placed into rate base, to capture development and application costs for the AMI Project, to be amortized over three years;

    b. A non rate base AMI Foreign Exchange (FX) Mark to Market Valuation deferral account to isolate the impact of any foreign exchange hedging used to reduce foreign exchange risk of the AMI Project;

    c. A rate base Existing Meter Cost Recovery deferral account to capture the remaining rate base value of the meters to be exchanged as part of the AMI Project with a rolling amortization period of 5 years; and

    d. A rate base Previously Retired Meter Cost Recovery deferral account to capture the remaining rate base value of previously retired meters with an amortization period of 10 years.

4. FEI is directed to file with the BCUC the following reports:

    a. Quarterly Progress Reports on the AMI Project showing planned vs. actual schedule, planned vs. actual costs, and any variances or difficulties that the AMI Project may be encountering. The Quarterly Progress reports are to be prepared in the same format as the FortisBC Inc. Advanced Metering Infrastructure CPCN quarterly reports, as directed by BCUC Order C-7-13, and are to be filed within 30 days of the end of each reporting period.

    b. A Final Report on the AMI Project schedule and costs within six months of the end or substantial completion of the AMI Project that provides a complete breakdown of the final costs of the AMI Project, compares these costs to the cost estimate in the Application, and provides a detailed explanation and justification for all material cost variances.

DATED at the City of Vancouver, in the Province of British Columbia, this (XX) day of (Month Year).

BY ORDER

(X. X. last name)
Commissioner

Appendix K-3

CONFIDENTIALITY DECLARATION AND UNDERTAKING FORM

Confidentiality Declaration and Undertaking Form

In accordance with the British Columbia Utilities Commission (BCUC) Rules of Practice and Procedure, please provide a completed form to the party who filed the confidential document and copy Commission Secretary at commission.secretary@bcuc.com. If email is unavailable, please mail the form to the address above.

Undertaking

I, ____________________________, am representing the party ______________________________ in the matter of

FortisBC Energy Inc. Application for a Certificate of Public Convenience and Necessity for the Advanced Metering Infrastructure Project.

In this capacity, I request access to the confidential information in the record of this proceeding. I understand that the execution of this undertaking is a condition of an Order of the BCUC, and the BCUC may enforce this Undertaking pursuant to the provisions of the *Administrative Tribunal Act*.

Description of document:	Documents filed confidentially in the proceeding, in unredacted form.

I hereby undertake:

(a) to use the information disclosed under the conditions of the Undertaking exclusively for duties performed in respect of this proceeding;

(b) not to divulge information disclosed under the conditions of this Undertaking except to a person granted access to such information or to staff of the BCUC;

(c) not to reproduce, in any manner, information disclosed under the conditions of this Undertaking except for purposes of the proceeding;

(d) to keep confidential and to safeguard and protect the information disclosed under the conditions of this Undertaking;

(e) to return to the applicant, FortisBC Energy Inc. , all documents and materials containing information disclosed under the conditions of this Undertaking, including notes and memoranda based on such information, or to destroy such documents and materials within fourteen (14) days of the BCUC's final decision in the proceeding; and

(f) to report promptly to the BCUC any violation of this Undertaking.

Signed at _______________________ this ________day of____________________.

Signature: _______________________________

Name (please print): _______________________________

Representing (if applicable): ____