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September 7, 2023

British Columbia Utilities Commission
Suite 410, 900 Howe Street
Vancouver, B.C.
V6Z 2N3

Attention: Patrick Wruck, Commission Secretary

Dear Patrick Wruck:

Re: FortisBC Energy Inc. (FEI)

Application for Acceptance of Demand Side Management (DSM) Expenditures Plan for the Period Covering 2024 to 2027 (Application)

Response to the British Columbia Utilities Commission (BCUC) Information Request (IR) No. 1

On July 12, 2023, FEI filed the Application referenced above. In accordance with the regulatory timetable established in BCUC Order G-178-23A for the review of the Application, FEI respectfully submits the attached response to BCUC IR No. 1.

For convenience and efficiency, if FEI has provided an internet address for referenced reports instead of attaching the documents to its IR responses, FEI intends for the referenced documents to form part of its IR responses and the evidentiary record in this proceeding.

If further information is required, please contact Sarah Commander, Regulatory Projects Manager, at (250) 469-6081.

Sincerely,

FORTISBC ENERGY INC.

Original signed:

Sarah Walsh

Attachments

cc (email only): Registered Interveners

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A. THE 2024-2027 DSM PLAN

1.0 Reference: INTRODUCTION

Exhibit B-2 (Application), Section 1.2, p. 4; Section 5.3, p. 23; Appendix A, p. 4; Appendix B-1; Appendix D, pp. viii, 2, 16

Forecast of Advanced DSM Programming

On page 4 of the FortisBC Energy Inc.'s 2024-2027 Demand Side Management (DSM) Expenditures Plan (Application), FortisBC Energy Inc. (FEI) states:

> Consistent with the amendments to the DSM Regulation, the DSM Plan continues many of the cost-effective programs previously accepted in FEI's 2023 DSM Plan, with significant transition to advanced DSM programming, such as gas heat pumps, dual fuel hybrid heating systems and deeper retrofits.

On page 23 of the Application, FEI states:

> FEI will include the recent developments of emerging advanced DSM measures and the changes to the DSM Regulation as part of its next CPR and LTGRP.

In Appendix B-1 to the Application, FEI presents the "Sources for Measure Assumptions" in the Residential, Commercial, Low Income, Indigenous and Legacy program areas.

On page 4 of Appendix A to the Application, FEI presents the approach to develop FEI's DSM Plan and states:

> Reviewed and extracted guidance from 2021 Long Term Gas Resource Plan (LTGRP), 2021 Conservation Potential Report (2021 CPR), and a 2023 modelling refresh of the CPR.

On page viii of Appendix to of the Application, FEI states with respect to the scope of the 2021 CPR:

> Timing: The base year for this study is the 2019 calendar year, where the reference case forecast is from 2020 to 2040 with results calculated for each intervening year.

On page 2 of Appendix D to the Application, Posterity Group states with respect to the caveats and limitations of the 2021 CPR:

> However, given the nature of forecasting, the results in this report should be considered as estimates.
> All potential scenarios in this report are estimated in relation to a "business as usual" reference case scenario. The CPR reference case incorporates FortisBC's account forecast, observed customer consumption trends, and industrial customer demand survey results. <u>By incorporating these sources, the reference case implicitly includes the effects of current policy, but does not adjust for potential future policy changes</u>. Scenarios with specific regulation/policy drivers, including high electrification, are not assessed within the scope of the CPR. High electrification scenarios have been modelled separately, in support of FortisBC's LTGRP. [Emphasis added]

On page 16 of the 2021 CPR in Appendix D to the Application, Posterity Group states with respect to the "Development of Measures List:"

> Measures range from mature and widely known to innovative or enabling technologies. Several behavioural measures (e.g. thermostat setback) are included as well. The team also developed "mature market" versions of several innovative technologies, such as gas heat pumps. These <u>mature market measures assumed that within two to five years, various measures that are currently at an early stage of market entry would have lower costs, improved energy performance, or both</u>. This approach allowed the study team to include these measures in subsequent analysis at a point after the first forecast year (2020) consistent with best estimates of market entry. [Emphasis added]

1.1 Please describe in detail the 2023 updates to the CPR.

<u>Response:</u>

In February 2023, on FEI's instructions, Posterity Group conducted a modelling refresh of the market potential scenarios of FEI's 2021 CPR (originally completed by Posterity Group in May 2021). No changes were made to measure assumptions, participation rates, or incentive levels, nor were any new measures added.

The goal of the modelling refresh was to assess the impact on energy savings potential of:

- Removing conventional gas equipment that is less than 100 percent efficient (e.g., furnaces, boilers, water heaters); and
- Using the Utility Cost Test (UCT) cost-effectiveness metric.

This exercise did not inform a larger scale CPR update or prompt changes to the LTGRP scenarios as: (1) time was limited to undertake the necessary in-depth analysis; and (2) key data was lacking, including the SCOP thresholds which had yet to be confirmed in the amended DSM Regulation. Therefore, FEI undertook a partial update in the interim, with a full update to follow beginning in 2024.

This modelling refresh included the development of two new scenarios:

- **“No <100% Efficient Gas Equipment (MTRC)”:** This is an interim step where conventional gas heating equipment was removed (or in some cases the applicability was reduced) from the original 2021 CPR MTRC model.
- **“No <100% Efficient Gas Equipment (UCT)”:** This was the final step and scenario, which takes the above model, removes the MTRC economic screen, adds UCT in its place, and uses RNG as the avoided cost for gas.

1.1.1 Please provide the updated assumptions to the CPR model.

Response:

The following tables show measures that were either removed or had their applicability reduced (therefore reducing their economic and market potential) in the residential and commercial sectors in the 2023 CPR Refresh models. No changes were made to any measures in the industrial sector.

Table 1: Measures Removed or Reduced in Residential Sector Model

Measure Name	Action
Boiler Early Retirement	Removed
Combination System - Type 1 and 2	Removed
Combination System - Type 1 and 2 Early Retirement	Removed
Combination System - Type 3	Removed
Furnace Early Retirement	Removed
High Efficiency Gas Fireplace or Vertically Direct Vented Fireplace	Removed
High Efficiency Boiler	Removed
High Efficiency Boiler Dual Fuel-Gas Primary	Removed
High Efficiency Furnace	Removed
High Efficiency Furnace Dual Fuel-Gas Primary	Removed
High Efficiency Gas Pool Heater	Removed
High Quality Furnace Installation - ENERGY STAR Verified	Removed
High-Efficiency (ENERGY STAR) Condensing Gas Tankless Water Heater	Removed

Measure Name	Action
High-Efficiency (ENERGY STAR) Condensing Gas Tankless Water Heater - Mature Market Costs	Removed
High-Efficiency (ENERGY STAR) Condensing Gas Water Heater	Removed
High-Efficiency Storage Gas Water Heater	Removed
New Construction - Step 2 Homes	Removed
New Construction - Step 2 Homes - Electric DHW	Removed
New Construction - Step 3 Homes	Removed
New Construction - Step 3 Homes - Electric DHW	Removed
New Construction - Step 4 Homes	Reduced Applicability
New Construction - Step 4 Homes - Electric DHW	Reduced Applicability
New Construction - Step 5 Homes	Reduced Applicability
New Construction - Step 5 Homes - Electric DHW	Reduced Applicability
New Construction - Step 5 Homes - Mature Market Costs	Reduced Applicability

Table 2: Measures Removed or Reduced in Commercial Sector Model

Measure Name	Action
Condensing Boiler (Early)	Removed
Condensing Boiler (ROB)	Removed
Condensing On-Demand DHW	Removed
Condensing Storage DHW	Removed
Condensing Supply Boiler	Removed
Condensing Unit Heater	Kept in for Warehouse only
Condensing Make Up Air Unit (Early)	Removed
Condensing Make Up Air Unit (ROB)	Removed
Direct Vent Fireplace	Removed
Infrared Heaters	Kept in for Warehouse only
NC Step 2 - Com	Removed
NC Step 2 - Non-Step	Removed
NC Step 2 - Res	Removed
NC Step 3 - Com	Reduced Applicability
NC Step 3 - Non-Step	Removed
NC Step 3 - Res	Reduced Applicability
NC Step 4 - Non-Step	Removed
NC Step 4 – Res	Reduced Applicability
Residential Furnace (Early)	Removed
Residential Furnace (ROB)	Removed
Steam to Hot Water	Removed

1.1.2 Please describe the effect of the changes to the CPR modelling on FEI's identification and selection of measures for the current DSM Plan.

Response:

The 2023 CPR modelling refresh did not have any material effect on FEI's identification and selection of measures for the 2024-2027 DSM Plan. Instead, when the CPR refresh was commissioned in February 2023, the upcoming amendments to the DSM Regulation, as understood by FEI at the time, served as inputs to the CPR modelling refresh (i.e., in terms of determining which measures needed to be removed from the model).

1.1.3 Please confirm if the base year to estimate gas savings is 2019.

1.1.3.1 If so, please explain whether FEI considers the use of a 2019 base year relevant for the current Expenditure Schedule.

Response:

The CPR Refresh's base year is 2019. However, for each program year, savings are estimated against reference case consumption estimates for that year, not for 2019.

The reference case begins with the base year values and forecasts natural gas use that follows a "business-as-usual" scenario. The reference case for the CPR is intended to represent the baseline to calculate new potential from. It considers current energy consumption patterns and known future changes, expected customer growth, current and known future changes to codes and standards, and natural replacement of equipment at end of life. The reference case starts with actual 2019 consumption, which includes all DSM activity up to that point.

1.1.4 Please indicate in what year FEI intends to update the CPR.

Response:

FEI intends to begin work on a full update of the CPR in 2024 and anticipates completing the study in 2026.

1.2 Please provide a list of advanced DSM measures in FEI's 2024-2027 Expenditure Schedule.

Response:

The table below presents the list of Advanced DSM Measure Category, Program and Measure that are proposed in the 2024-2027 DSM Plan.

Table 1: Advanced DSM Measures by Program and Category

Advanced DSM Category	Program	Measure
Deep Energy Retrofit	Indigenous Prescriptive	Deep Retrofit Lite / Whole Home Performance (20-40% reduction)
Deep Energy Retrofit	Residential Home Renovation	Whole Home Performance
Gas Heat Pumps	Commercial Prescriptive	Gas Heat Pumps
Gas Heat Pumps	Indigenous Prescriptive	Commercial - Gas Heat Pump
Gas Heat Pumps	Low Income Prescriptive	Commercial - Gas Heat Pump
Hybrid Systems	Commercial Prescriptive	Hybrid Dual Fuel Hydronic Systems
Hybrid Systems	Commercial Prescriptive	Hybrid Dual Fuel RTUs
Hybrid Systems	Indigenous Performance	Step 4 detached home - hybrid
Hybrid Systems	Indigenous Performance	Step 4 row home - hybrid
Hybrid Systems	Indigenous Performance	Step 5 detached home - hybrid
Hybrid Systems	Indigenous Performance	Step 5 row home - hybrid
Hybrid Systems	Indigenous Prescriptive	Commercial - Hybrid Systems
Hybrid Systems	Indigenous Prescriptive	Residential - Hybrid (Dual-Fuel) Systems
Hybrid Systems	Low Income Prescriptive	Commercial - Hybrid Systems
Hybrid Systems	Low Income Prescriptive	Residential - Hybrid (Dual-Fuel) Systems
Hybrid Systems	Residential Home Renovation	Hybrid (Dual-Fuel) Systems
Hybrid Systems	Residential New Home	Step 4 detached home - hybrid
Hybrid Systems	Residential New Home	Step 4 row home - hybrid
Hybrid Systems	Residential New Home	Step 5 detached home - hybrid
Hybrid Systems	Residential New Home	Step 5 row home - hybrid

In addition to the above measures, supporting studies and pilots for advanced DSM measures are proposed within the Innovative Technologies program area.

1.3 Please explain FEI's approach for developing the assumptions for the advanced DSM measures outlined in Appendix B-1, namely: incentives; incremental costs; measure life; participants; and net to gross adjustments such as free ridership and spillover. Where applicable, please explain if there are notable differences in approach for specific measures or types of measures.

Response:

FEI's approach to developing assumptions for the advanced DSM measures outlined in Appendix B-1 are as follows:

Incremental costs, measure life, and savings: These assumptions have primarily come from: feasibility studies and pilots conducted as part of the Innovative Technologies portfolio (please refer to the response to BCUC IR1 1.4); sources identified by the Posterity Group through the CPR; and occasionally through other studies, as identified. Individual sources for all parameters are listed in Appendix B-1 of the Application.

Incentives: FEI develops incentives to cover a percentage of incremental cost that can vary based on where the measure is with respect to its market adoption. There are a few considerations when setting incentives for advanced DSM measures:

- **Market adoption status:** For measures early in their market adoption (which characterizes the proposed advanced DSM measures), incentives are generally set between 50 and 100 percent of the incremental cost of the measure. For example, incentives for dual fuel hybrids in the Home Renovation Program are 60 percent of incremental cost, while incentives for gas heat pumps in the Commercial Prescriptive Program are 90 percent of incremental costs.
- **Cost-effectiveness:** With the shift to the UCT as the cost-effectiveness test, FEI also evaluates the participation, savings, and incentive impacts of new measures to the cost-effectiveness of the program area and portfolio as a whole.
- **Stakeholder feedback:** FEI considers stakeholder feedback to gauge whether a proposed incentive would be reasonable to encourage adoption and ultimately transform the market.
- **Target market:** FEI also considers the target market for the measure incentive. For instance, incentives for low-income customers are higher than other customer segments, as that customer segment generally has less available capital for retrofits and experiences a higher degree of energy poverty.

Participation: FEI develops participation forecasts based on both a review of historical performance data of similar new-to-market measures and stakeholder feedback (particularly feedback from trade allies). In the case of dual-fuel hybrids, significant time was spent workshopping with trade allies to develop proposed incentives and estimate participation amounts. For other measures, like gas heat pumps, there is still limited awareness of the measure in market with less feedback from stakeholders; as such, participation forecasts are more conservative.

Net-to-Gross Ratios: The net-to-gross ratios in the DSM Plan are assigned based on past program evaluations. When a new measure is added to a program, FEI assumes the net-to-gross ratio is equal to the previously evaluated net-to-gross ratio for similar measures for that program. FEI will then revise the net-to-gross ratios over time as regularly scheduled program evaluations are conducted.

FEI employs a consistent approach for the introduction of new measures, including, but not specific to, the advanced DSM measures proposed in the DSM Plan.

1.3.1 Please compare and discuss the relative degree of uncertainty associated with these estimates, compared to the estimates for traditional DSM measures.

Response:

Incremental costs, measure life, and savings: There is a higher degree of uncertainty associated with these parameters compared to traditional DSM measures. When a new measure is introduced, FEI typically uses data from a feasibility study, pilot, or other technical resource manuals (TRM). As a measure matures in a program and is evaluated, the parameters are amended based on actual local market data from program participants.

Incentives: For the purposes of DSM expenditure planning, the incentives FEI used for forecasting are the most reasonable proposed values based on information available at the time of plan drafting but may not represent the final incentive amount when the offer is launched in market. Typically, traditional DSM measure incentives have already been in market; thus, there is a lower deviation expected between the plan and the existing market offer. For new measures, including advanced DSM measures, program design may be ongoing; thus, some changes to the planned incentive are possible.

Participation: Estimating participation of DSM measures, whether traditional or advanced, has a degree of uncertainty based on forecasting market uptake by customers. In the past, existing in-market DSM measures were easier to forecast than new measures. However, with evolving policy and economic challenges, the degree of uncertainty for program participation across all programs is somewhat higher than in the past.

Net-to-Gross: There is a higher degree of uncertainty for the net-to-gross ratios assumptions for advanced DSM measures compared to traditional DSM measures since program evaluation cannot be conducted until the measures have been in market for some time.

1.3.2 For each advanced DSM measure included in the Residential, Commercial, Low Income, Indigenous and Industrial program areas in the Expenditure Schedule, please provide the detailed assumptions and sources used to develop the estimated energy saving.

Response:

The detailed assumptions for energy savings for each advanced DSM measure are included in Appendix B of the Application. The sources for each assumption are presented in Appendix B-1. The table below presents the exhibit and page numbers where the assumptions and data sources for each advanced DSM measure can be found in Appendix B and Appendix B-1.

Table 1: Advanced DSM Measure Assumption Data Sources

Program Area	Program	Measure	Assumptions Appendix B	Data Sources Appendix B-1
Residential	Home Renovation	Whole Home Performance	Exhibit 4 – Page 5	Assumed performance program.
Residential	Home Renovation	Hybrid (Dual-Fuel) Systems	Exhibit 4 – Page 4	Page 53
Residential	New Home	Step 4 detached home - hybrid	Exhibit 6 – Page 7	Page 57
Residential	New Home	Step 4 row home - hybrid	Exhibit 6 – Page 7	Page 57
Residential	New Home	Step 5 detached home - hybrid	Exhibit 6 – Page 7	Page 57
Residential	New Home	Step 5 row home - hybrid	Exhibit 6 – Page 7	Page 57
Commercial	Prescriptive	Hybrid Dual Fuel RTUs	Exhibit 8 – Page 10	Page 63
Commercial	Prescriptive	Hybrid Dual Fuel Hydronic Systems	Exhibit 8 – Page 10	Page 63
Commercial	Prescriptive	Gas Heat Pumps	Exhibit 8 – Page 10	Page 63
Low Income	Prescriptive	Commercial - Gas Heat Pump	Exhibit 24 – Page 27	Page 80
Low Income	Prescriptive	Residential - Hybrid (Dual-Fuel) Systems	Exhibit 24 – Page 28	Page 74
Low Income	Prescriptive	Commercial - Hybrid Systems	Exhibit 24 – Page 28	Page 75
Indigenous	Prescriptive	Commercial - Gas Heat Pump	Exhibit 28 – Page 33	Page 84
Indigenous	Prescriptive	Deep Retrofit Lite / Whole Home Performance (20-40% reduction)	Exhibit 28 – Page 33	Assumptions are based on existing Home Energy Improvement Bonus where customers completed building envelope upgrades only, as well as HOT2000 modelling.
Indigenous	Prescriptive	Residential - Hybrid (Dual-Fuel) Systems	Exhibit 28 – Page 34	Page 85

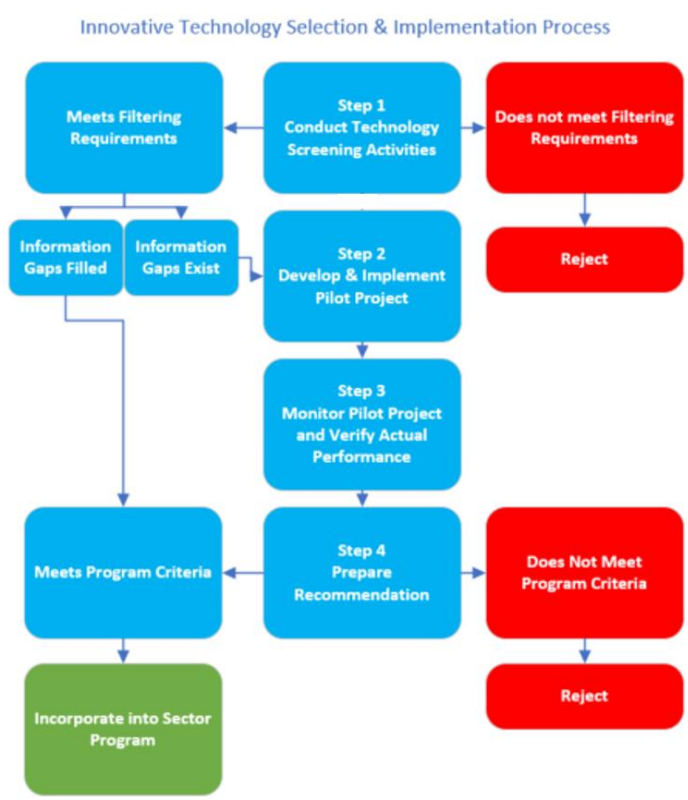
Program Area	Program	Measure	Assumptions Appendix B	Data Sources Appendix B-1
Indigenous	Prescriptive	Commercial - Hybrid Systems	Exhibit 28 – Page 34	Page 86
Indigenous	Performance	Step 4 detached home - hybrid	Exhibit 30 – Page 36	Page 86
Indigenous	Performance	Step 4 row home - hybrid	Exhibit 30 – Page 37	Page 86
Indigenous	Performance	Step 5 detached home - hybrid	Exhibit 30 – Page 37	Page 86
Indigenous	Performance	Step 5 row home - hybrid	Exhibit 30 – Page 37	Page 86

1.4 Please discuss FEI's process and criteria to move a measure from the Innovative Technologies program area to the Residential, Commercial, Low Income, Indigenous and Industrial program areas, including but not limited to considerations such as technological maturity or readiness, level of risk, or level of investment.

Response:

FEI developed the Innovative Technology Selection & Implementation Process, as illustrated in the figure below, to identify new measures for inclusion in FEI's DSM programs.

Figure 1: Innovative Technology Selection & Implementation Process Diagram



Technologies that meet specific criteria are assessed using several technology screening approaches to validate their potential.

Table 1: Technology Filtering and Screening

Technology Filtering Criteria	Technology Screening Activities
• Is not widely adopted in British Columbia • Has the potential to directly or indirectly result in significant reductions of energy use or significantly more efficient use of energy • Does not fuel switch from baseline energy source • Is available to be installed and evaluated in FEI's service territory	• Reviewing third-party Technical Resource Manuals (or similar program measure characterization studies) • Pre-feasibility studies • Lab tests • Pilot demonstrations • Third-party measurement and verification

Technologies that successfully filter through the selection and implementation process are considered for inclusion into new or existing programs.

Table 2: Criteria for Filtering Programs

Program Filtering Criteria
• Measure cost-effectiveness inputs are understood
• Meets DSM Regulation and aligns with approved DSM Expenditure Plan
• Can be incorporated into a new or existing cost-effective program
• Is commercially available and can be implemented in FEI's service territory
• Has a marketing and communication strategy to promote adoption
• Can be reasonably evaluated as part FEI's EM&V Evaluation Framework

After a technology is incorporated into a DSM program, there may be related new solutions and manufacturers that come to market. These may be assessed through the Innovative Technology Selection & Implementation Process to better characterize the measure category and/or further promote its market adoption. FEI will also continue to assess newly added measures through program evaluation activities under the EM&V Framework to determine if adjustments need to be made to measure level assumptions over time.

1.5 Please clarify whether FEI seeks approval from the BCUC before moving measures previously included in the Innovative Technologies program area into the Residential, Commercial, Low Income, Indigenous and Industrial program areas.

Response:

FEI is not specifically seeking BCUC approval to move measures previously included in the Innovative Technologies Program Area into other program areas; however, FEI has included the proposed measure transitions in the 2024-2027 DSM Plan expenditure schedules for which FEI is seeking acceptance. For example:

- Table 4-4 of FEI's 2024-2027 DSM Plan includes dual fuel hybrid heating systems for the Residential Program Area. FEI will utilize findings and recommendations from the hybrid heating early adopter offer pilot under the Innovative Technologies Program Area to support this transition.

As discussed in the response to BCUC IR1 1.4, FEI follows the Technology Screening & Implementation Process involving several screening activities and third-party measurement and verification gates prior to determining the feasibility of transitioning a technology into another program area. Using this process, FEI can fill data and information gaps, including determining the operational performance and cost effectiveness of the measure, customer behaviour and acceptance, contractor training and installation requirements, as well as other program design recommendations that can be employed to address adoption barriers.

Once a technology passes these verification gates, FEI uses its best judgement and consultation with industry partners and external stakeholders, including the Energy Efficiency and Conservation Advisory Group (EECAG), to further gauge measure acceptance and program design approaches.

2.0 Reference: 2024-2027 DSM PLAN REPORT

Exhibit B-2, Section 4.2, Table 4-2, p. 14; Table 4-4, p. 16

2024-2027 DSM Plan Expenditures

Table 4-2 on page 14 of the Application sets out the forecast DSM expenditures for 2024-2027 by program areas, compared to the 2023 DSM Plan expenditures. Expenditures in 2024 are 18 percent higher than the plan for 2023.

Table 4-4 on page 16 of the Application outlines key changes for the 2024-2027 DSM Plan by Program Area, including the following:

- "Substantial" expenditures in dual fuel hybrid system offers across residential programs;"
- Commercial expenditures increase over the plan period primarily due to support for dual fuel hybrid systems and deeper retrofits and gas heat pumps.
- Additional Low Income expenditures including for dual fuel hybrid systems and gas heat pumps;
- Increased Indigenous expenditures are partly driven by increasing expenditures in dual fuel hybrid systems;
- Innovation Technologies Program Area continues support for pilots, including for residential and commercial deep energy retrofits, residential and commercial dual fuel hybrid heating, and residential and commercial heat pumps.

2.1 Please provide a table which provides a breakdown of forecasted expenditures and gas savings, by program into a) traditional DSM and b) advanced DSM.

Response:

Please refer to the table below which provides a forecast of DSM expenditures and gas savings for 2024-2027 broken down by program into either traditional or advanced DSM categories. The expenditures below do not include inflation.

Table 1: Traditional and Advanced DSM Expenditures and Savings by Program Area

Program	Traditional DSM Incentive Expenditures ($)	Advanced DSM Incentive Expenditures ($)	Total Non-Incentive Expenditures ($)[1]	Traditional DSM Incremental Savings (GJ/Year)	Advanced DSM Incremental Savings (GJ/Year)
Residential - Home Renovation	31,372,357	114,827,520	2,822,000	523,403	219,152
Residential - New Home	163,500	17,400,000	2,620,000	3,013	49,993

[1] Includes administration and communication.

Program	Traditional DSM Incentive Expenditures ($)	Advanced DSM Incentive Expenditures ($)	Total Non-Incentive Expenditures ($)[1]	Traditional DSM Incremental Savings (GJ/Year)	Advanced DSM Incremental Savings (GJ/Year)
Residential – Labour & Non-Program Expenses	-	-	8,767,282	-	-
Com - Prescriptive	4,822,400	5,063,000	2,000,000	157,959	66,929
Com - Performance Retrofit	31,457,500	-	400,000	353,564	-
Com - Performance NC	2,400,000	-	600,000	6,682	-
Com - RAP	1,476,021	-	1,600,000	55,240	-
Com - Labour & Non-Program Expenses	-	-	9,934,500	-	-
Industrial - Prescriptive	7,521,908	-	1,280,000	496,286	-
Industrial - Performance	22,174,750	-	320,000	1,254,240	-
Industrial - Labour & Non-Program Expenses	-	-	2,680,000	-	-
Low Income - Self Install	2,677,700	-	576,000	112,368	-
Low Income - Direct Install	20,400,000	-	3,440,000	71,570	-
Low Income - Prescriptive	6,434,550	5,860,500	381,000	33,879	30,026
Low Income - Performance	-	-	-	-	-
Low Income - Support	-	-	750,000	-	-
Low Income - Labour & Non-Program Expenses	-	-	3,599,895	-	-
Indigenous - Self Install	-	-	-	-	-
Indigenous - Direct Install	331,200	-	20,000	935	-
Indigenous - Prescriptive	4,578,500	5,109,900	200,000	26,919	21,926
Indigenous - Performance	856,500	3,630,000	200,000	38,400	6,779
Indigenous – Conservation Education Outreach	-	-	80,000	-	-
Indigenous – Community Energy Specialist	2,280,000	-	40,000	-	-
Indigenous - Labour & Non-Program Expenses	-	-	1,432,900	-	-
Conservation Education and Outreach	-	-	57,898,000	110,000	-
Innovative Technologies	5,375,000	65,357,669	17,457,500	-	-
Enabling	21,435,250	-	27,306,492	-	-
Portfolio	-	-	21,110,566	-	-
Legacy - Residential	22,653,809	-	-	83,795	-
Legacy - Commercial	37,543,000	-	-	156,456	-
Legacy - Low Income	3,005,235	-	-	14,600	-
Legacy - Indigenous	869,800	-	-	2,914	-

Program	Traditional DSM Incentive Expenditures ($)	Advanced DSM Incentive Expenditures ($)	Total Non-Incentive Expenditures ($)[1]	Traditional DSM Incremental Savings (GJ/Year)	Advanced DSM Incremental Savings (GJ/Year)
Legacy - Labour & Non-Program Expenses	-	-	2,713,623	-	-
Total	**229,828,980**	**217,248,589**	**170,229,758**	**3,502,222**	**394,806**

2.2 Given the variability of expenditures between programs from 2023 to 2027, please discuss the risks to FEI of being able to deliver the planned expenditures, in particular the ramp up in residential and commercial expenditures from 2024 to 2027.

Response:

FEI has an established track record of achieving its planned expenditures. As discussed in the response to BCOAPO IR1 2.5, the DSM Plan proposes realistic expenditures based on program development and stakeholder feedback to achieve long-term gas savings. FEI considers it has adequately estimated the time required to further build advanced DSM programming and that timing is reflected in the gradual increasing adoption of newer measures.

Table 1 below shows FEI's planned expenditures compared to actual expenditures for the years 2016 through 2022. This includes periods with equipment regulation, building code and DSM Regulation changes.

Table 1: Plan Versus Actual Expenditures – 2016 to 2022

DSM Portfolio	Expenditures ($000s)						
	2016	2017	2018	2019	2020	2021	2022
Total DSM Expenditure, Actual	$32,165	$34,039	$35,472	$64,495	$75,821	$106,844	$108,070
Total DSM Expenditure, Plan	$35,839	$35,388	$35,874	$64,495	$72,577	$112,397	$111,820
Expenditure as Percentage of Plan	-10%	-4%	-1%	0%	4%	-5%	-3%

Since 2016, no actual FEI DSM program expenditures have had a variance of more than 10 percent below plan expenditures.

FEI recognizes that the amended DSM Regulation results in significant changes for FEI's DSM programming, particularly for the Residential and Commercial program areas. Table 2 presents the risks FEI has identified and the risk mitigation for Residential and Commercial program areas.

Table 2: Identified Risks and Risk Mitigation for the Residential and Commercial Program Areas

Identified Risk to Expenditure	Risk Mitigation
Slower rate of market adoption than anticipated for advanced DSM measures	Consult with industry such as the Trade Ally Network (TAN), collaborate with partners on effective program design, and evaluate marketing strategies including customer education and awareness. Conduct research and attempt to remove barriers to adoption (e.g., increased support for early adopters, case studies, etc.).
Lack of industry capacity throughout the province to support installations for residential and commercial customers with the advanced DSM measures	Work with industry groups, Trade Ally Network, customers, and the engineering consulting community to provide education, awareness and training on installation of advanced DSM measures including dual-fuel hybrid systems and whole home performance upgrades.
Energy policy, changes to regulations, codes, standards, permitting requirements, municipal bylaws, etc.	Engage with policy makers and ensure they are informed about the impact that regulations, codes, etc. can have on energy efficiency programs and the associated GHG emission reductions.
Less than expected energy savings from advanced DSM programming	Evaluate installation quality, control mechanisms, performance and behavioral considerations and modify programming as appropriate.
Lack of product availability for the dual fuel systems, gas heat pumps and deep retrofit measures	Work with the manufacturers and distributors of advanced DSM measures to identify gaps in product availability and help ramp up the production and commercialization of advanced DSM measures. Look at utilizing transfer rules such that underspending in one year can "catch up" in future years of the DSM Plan.
Competing messages in the marketplace could lead to customer confusion and stall adoption	Engage with other organizations offering energy efficiency programs and seek to make programs complimentary rather than competing.

3.0 Reference: 2024-2027 DSM PLAN REPORT

Exhibit B-2, Section 4.2, p. 15; Appendix B, p. 4; Paper by Sustainable Technologies Evaluation Program, *Dual-Fuel Heat Pump Home Heating Systems: Analysis of Control, Approaches, Utility Costs, and Carbon Emission Reductions*, p. 3

Level of Incentive

On page 15 of the Application, FEI states:

> As shown in Table 4-2, the DSM Plan includes initially higher expenditures in 2024, followed by a levelling out of expenditures in 2025 and 2026, before increasing again in 2027. A key driver of the expenditure levels is the amount of support necessary to accelerate the adoption of advanced DSM measures that currently have low rates of market adoption. The incentive levels proposed for advanced DSM measures cover a higher percentage of a project's overall and incremental cost when compared to FEI's past support for conventional high-efficiency gas space and water heating equipment, such as furnaces and boilers. Higher incentive levels for advanced DSM measures are proposed to encourage early adoption and increase participation to drive market transformation and increase accessibility. FEI considers multiple factors when determining incentive levels for measures across various program areas. These factors include influencing the adoption of the measure, assessing the overall cost-effectiveness of programs which may encompass multiple measures, engaging with key stakeholders such as contractors, customers, and interest groups to understand barriers and decision-making criteria while leveraging program expertise to ensure offers are comparable."

On page 4 of Appendix B to the Application, Posterity Group assumes an incremental cost of $17,000 for a residential dual fuel hybrid system, and an incentive of $10,200.

A 2021 study in Ontario by Sustainable Technologies Evaluation Program titled: Dual-Fuel Heat Pump Home Heating Systems: Analysis of Control Approaches, Utility Costs, and Carbon Emission Reductions, [2] found on page 3 that the "incremental cost for the dual-fuel heat pump system in Table 1 is $3,000 but it includes a more efficient furnace, blower, and air-conditioning. It is therefore expected, that the additional cost for a dual-fuel system is less than $3,000 when more comparable equipment is used." Table 1 shows a capital cost for the dual-fuel heat pump system of $9,997, compared to a cost of $6,893 for a conventional furnace and A/C.

3.1 Please discuss and compare the dual-fuel hybrid system proposed by FEI to the system outlined in the Sustainable Technologies paper, including specifications and costs of both the baseline conventional system assumed by FEI, and the dual fuel heat pump system.

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[2] https://sustainabletechnologies.ca/app/uploads/2021/05/DualFuelAnalysis052021.pdf.

Response:

Please refer to the table below for a comparison of the Sustainable Technologies Evaluation Program (STEP) study, FEI's 2022 Hybrid Heating Prefeasibility Study Assumptions, and preliminary data from FEI's Hybrid Heating Early Adopter Offer Pilot (as of August 2023). FEI used the 2022 Hybrid Heating Prefeasibility Study as the basis of the 2024-2027 DSM Plan dual fuel heat pump system assumptions. The preliminary data from FEI's Hybrid Heating Early Adopter Offer Pilot presents FEI's most recent data on dual fuel heat pump systems.

The primary differences between the STEP study and FEI's dual-fuel hybrid heating assumptions are the data sample sizes, heat pump performance ratings, heat pump capacity, and installation costing data, as discussed further below.

1. **Data Sample Size and Technology Representation**

   The STEP study has a limited sample size of three homes and uses equipment from one manufacturer, which can impact confidence in costing data. FEI's costing assumptions are based on the pre-feasibility study, and current pilot program participant data which has reached 200 participants to date. This data gives insight into the BC market as a whole, including the range of manufacturers, average performance ratings and capacity of installed equipment and the impact these factors have on cost.

2. **Heat Pump Performance Ratings and Capacity**

   Both performance rating and capacity will impact equipment costs. FEI proposed greater performance ratings than the STEP study, in alignment with existing requirements for heat pump efficiencies across provincial offers. Further, based on preliminary program data from FEI's ongoing pilot offer, FEI has assumed the average dual-fuel heat pump installation would be a 3-ton system, compared to the STEP study 2-ton system average.

3. **Installation Costing Data**

   In addition to the heat pump performance rating and capacity, FEI believes that the variation in overall installation costing assumptions can be attributed to:

   - The STEP installation costs potentially not reflecting the BC market.
   - The STEP study representing costing data from 2020 that may not be reflective of current costs following a period of significant inflationary pressures that were not present in 2020.
   - The STEP study not including enabling costs such as ductwork modification, that may be required to enable high-efficiency dual fuel systems.

FEI will continue to evaluate measure assumptions over the course of the DSM Plan period and will make adjustments accordingly to support program design and implementation.

Table 1: Comparison of the STEP study, FEI's 2022 Hybrid Heating Prefeasibility Study Assumptions, and FEI's Hybrid Heating Early Adopter Offer Pilot (as of August 2023)

Key Differences	2021 Ontario STEP Study	FEI 2022 Hybrid Heating Systems Prefeasibility Assumptions	FEI Hybrid Heating Early Adopter Offer Pilot[1]
Baseline	Furnace: 95% Annual Fuel Utilization Efficiency (AFUE) Furnace Capacity Average: 60 kBTU Air conditioner: 13 Seasonal Energy Efficiency Ratio (SEER) 1.5 ton	Furnace: 95% AFUE Furnace No air conditioning	Furnace: AFUE Range:95-99% AFUE Average:96% Capacity Average:70 kBTU No air conditioning
Baseline costs	Furnace and air conditioner: $6,893 (did not separate furnace only costs)	Furnace only range: $2500 to $6,000	Furnace only range: $4,000-$8,000 Furnace only average cost: $6,044
Heat pump performance rating	The heat pumps installed have Heating Seasonal Performance Factor (HSPF) ratings of 9.5, 8.2 and 9.0, respectively and SEER ratings of 17.0, 13.0 and 16.0, respectively.	The study assumed a range of: 15 SEER, 9 HSPF to 16 SEER, 9.5 HSPF	The minimum system requirements were: HSPF ≥ 10.00 SEER ≥ 16.00 The actual average rating installed for pilot was: HSPF: 10 SEER: 18
Heat pump capacity	Range: 2-2.5 ton Average capacity installed: 2 ton	Range: 2.5-5 ton	Range: 2-4 ton Average capacity installed: 3 ton
Hybrid Dual Fuel Installation cost	Average cost: $9,997	Range: $18,000 to $21,000	Range: $16,000-$32,000 Average cost: $25,516

Note to Table:

[1] Based on preliminary data from FEI's ongoing hybrid dual fuel pilot offer, August 2023.

3.2 Please discuss FEI's general approach to ensuring that selected DSM measures provide value for FEI ratepayers, for example but not limited to the extent to which FEI: waits for prices of newer technologies to lower before introducing DSM incentives; ensures incentives are not being applied to inflated unit costs; considers existing incentives from other organizations; or otherwise ensures the total costs of DSM to ratepayers are reasonable.

Response:

FEI's general approach to introducing new program measures considers broad market factors, past program experience, and stakeholder feedback to inform a customer-centric program design that ultimately provides value to participants and FEI's customers. At a high level, FEI relies upon assessing a measure's cost-effectiveness, market potential, and stakeholder feedback to determine if a DSM measure has reasonable potential for savings and is desirable for inclusion in the suite of FEI DSM offerings. FEI's Innovative Technology Selection and Implementation Process (as outlined further in the response to BCUC IR1 1.4) identifies supporting information that determines the appropriate time for a measure to enter DSM programs.

FEI would not generally characterize most new measures as having "inflated" unit costs. Rather, as with the adoption of most new technologies, the new measures have yet to benefit from economies of scale, which comes with increased market adoption and which can reduce measure cost over time. DSM incentives and programming are needed precisely because of the need to overcome this type of cost challenge for new measures which might otherwise not be adopted or adopted slowly. As such, FEI typically does not wait for the prices of newer technologies to lower but offers incentives to chosen DSM measures to accelerate market adoption and transform the market. If FEI did wait, two outcomes are possible: (1) the prices do not lower as the technology does not achieve an economy of scale and/or additional inflationary pressures exist; or (2) the prices lower over a longer timeframe, but the opportunity to accelerate market adoption with DSM programs is lost.

FEI considers incentives from other organizations when developing its programs and in particular, its collaboration with program partners such as FortisBC Inc. (FBC), BC Hydro and the Province. FEI works with partners to avoid duplication of expenditures and savings and to simplify the customer journey when a new measure is incorporated into an existing program with multiple partners.

3.3 Please discuss whether and how FEI considers incentives provided by other organizations such as provincial and federal government entities, in the design of demand side measures and programs.

Response:

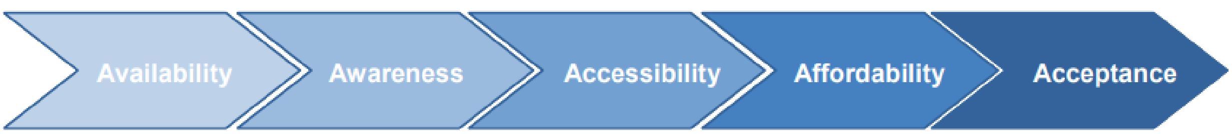
Please refer to the response to BCUC IR1 3.2.

3.4 Please elaborate on whether there are other factors besides high incentives that will affect market transformation.

Response:

Incentives are one strategy to drive market transformation, but there are others. FEI also considers the 5 A's barriers classification and market transformation methodology used by Natural Resources Canada to support effective program design strategies. Each "A" in the framework represents a critical aspect of the market adoption path for a new technology. By considering the full market cycle of a technology from production through to installation and operation, the framework facilitates group discussion and identification of all barriers to market transformation. While the applicability of each of the steps in the cycle will vary depending on the technology or product under review, this approach enhances the analysis by characterizing the market barriers and understanding how the barriers can affect different market participants.

Figure 1: The Stages of the 5 A's Barrier Analysis Tool



Barriers identified using this methodology inform the development of additional tactics to support with:

- Technology availability and access;
- Technology codes and standards;
- Market awareness and education gaps;
- Customer accessibility to access rebates and qualified contractors;
- Technology capital and operating costs with DSM incentives and programs; and
- Market acceptance and growth opportunities to support market transformation.

4.0 Reference: FEI 2024-2027 DSM PLAN REPORT

Exhibit B-2, Section 4.2, p. 16; Appendix A, pp. 11, 15-16, 18

DSM Programs

On page 16 of the Application, FEI states with respect to the Conservation, Education and Outreach program: “FEI has increased investment within this Program Area for online and digital tools to enhance and potentially expand customer engagement and assessment tools.”

On page 11 of Appendix A to the Application, in Exhibit 4 - Portfolio Gas Savings and Cost-Effectiveness by Program Area, FEI states that the Conservation, Education and Outreach program area savings “are attributed to the Customer Engagement Tool measure only.”

On pages 15 and 16 of Appendix A to the Application, FEI states with regards to the Commercial program area:

> **The Performance Program** – Existing Buildings provides incentives to encourage commercial customers to identify, assess, and implement building energy-efficiency projects for existing buildings. The program is administered jointly with FBC and BC Hydro, providing customers with a one-stop program in both the shared FBC/FEI service area and the FEI service territory to evaluate and implement building-scale energy efficiency measures, recommissioning projects, as well as identifying no-cost, low-cost opportunities through a Strategic Energy Management (SEM) offer. FEI staff provide technical and engineering support, customer outreach and engagement for the Performance Program – Existing Buildings. Under the program, smaller commercial customers are also provided with energy assessments and customers with a portfolio of buildings can take advantage of portfolio-wide energy studies…
>
> **The Rental Apartment Efficiency Program (RAP)**, in collaboration with FBC, provides the direct installation of in-suite measures, such as low-flow showerheads, and faucet aerators for rental suites in multi-unit residential buildings (MURBs). This program area also contributes to meeting the “adequacy” component of the DSM Regulation Section 3, whereby a public utility’s DSM portfolio is considered adequate when there is “a demand side measure intended specifically to improve the energy efficiency of rental accommodations”14. There are three components to this program. To start, participants are provided with direct install of in-suite energy efficiency upgrades completed by an agent of FEI. Next, participants are provided with energy assessments, which may recommend building-level energy efficiency upgrades such as high efficiency heating systems and control upgrades. Lastly, participants are provided with support in implementing the energy efficiency recommendations and applying for rebates.

On page 18 of Appendix A to the Application, FEI states with regards to the Industrial program area:

> The Performance Program provides incentives to encourage customers to identify, assess and implement measures that use energy for process-related activities. The program is administered jointly with FBC, providing customers with a one-stop program in the FBC/FEI shared service territory and FEI only service areas to evaluate and implement industrial energy efficiency projects. FEI staff provide customer outreach and engagement for the Performance Program.

On the same page, FEI adds:

> Two separate SEM tracks are as follows:
>
> - Individual Support (Large Customers): FEI continues to provide individual incentives and support for energy modeling, monitoring, targeting, reporting, and coaching for industrial customers that have an existing energy manager.
> - Cohort Support (Medium Customers): For industrial customers without dedicated energy managers, FEI continues to bring together a group of industrial customers to work together and share knowledge related to building energy management in their facilities and receive group energy coaching and training.

4.1 Please explain how FEI estimates the savings associated with the use of the Customer Engagement Tool measure.

Response:

FEI estimates the savings associated with the Customer Engagement Tool program by comparing the change in energy use between customers provided with home energy reports and similarly situated customers that did not receive these reports.

The Customer Engagement Tool program provides home energy reports to a group of randomly selected FEI residential customers. These reports provide an analysis of a customer's energy use patterns and include actionable energy efficiency recommendations to help these customers reduce their energy consumption. The home energy reports allow the participating households to compare their energy usage to similar homes, thus encouraging occupants to change their behaviors and reduce energy consumption compared to their peers.

FEI evaluated savings for the Customer Engagement Tool program using a difference-in-differences (DiD) model approach. The DiD model was selected based on industry best practices and evaluation protocols commonly used in North America to assess the savings resulting from similar residential behavioral programs. The evaluation was conducted by creating two groups: the treatment group and control group. The treatment group consisted of participants who received the home energy reports. The control group consisted of households with similar attributes (e.g., location and square footage) to the treatment group but did not receive home energy reports. The control group served as a comparator group to assess program impacts on customer energy efficiency behavior.

FEI calculated the savings associated with the program by comparing the change in the energy use of the treatment group participants to the change in energy use in the control group. Subtracting the energy consumption change that is not attributable to the Customer Engagement Tool program (represented by the change in control group energy consumption) from the treatment group energy consumption change provides an estimate of the net change in energy consumption directly attributable to the Customer Engagement Tool.

4.2 Please discuss how FEI ensures that Conservation Education and Outreach program activities do not indirectly encourage the adoption of gas-fired equipment.

Response:

FEI's Conservation Education and Outreach programs focus on energy conservation education through behavioural campaigns and outreach initiatives. For initiatives that include education on gas space and water heating measures, FEI will only promote the measures and programs aligned with the amended DSM Regulation.

FEI's existing marketing and education initiatives that are focused on promoting efficient conventional gas-fired equipment and communicating offer end-dates will wrap up before the end of 2023. FEI does not plan to promote conventional gas-fired space and water equipment through its DSM programs after 2023, with the potential exception of audience-targeted messaging for equipment that continues to be allowed under the amended DSM Regulation, such as for conventional water heaters to low income customers.

4.3 Please discuss for programs implemented and/or administered with other utilities, how FEI and the partner entities avoid duplication in the attribution of savings and expenditures.

Response:

FEI avoids duplication in the attribution of expenditures through accounting practices with program partners.

First, with respect to expenditures for joint FEI and FBC programs, the combined FortisBC rebate processing and accounting systems are set up to prevent duplication through audited financial controls.

Second, for partnerships between FEI and other entities, one partner will typically serve as the lead and will invoice other program partners for expenditures incurred, apportioned based on the partnership agreement. An example of this is the joint FortisBC-BC Hydro Continuous Optimization offer under the Performance Program – Existing Buildings program whereby BC Hydro invoices FEI for FEI's portion of incentives. In that program, FEI does not provide incentives in parallel to customers (i.e., BC Hydro is the sole provider of incentives) and thus program controls prevent duplication of expenditures. In both scenarios, each utility would only report on their own respective expenditures.

Program partnerships allow utilities to reduce expenditures, compared to each utility running a similar program separately. FEI, FBC, and BC Hydro each individually monitor their partnership programs and periodically evaluate cost efficiencies achieved.

With respect to the attribution of savings, FEI reports DSM savings as necessary to show that DSM activities comply with its approved DSM Expenditure Plan and the DSM Regulation. Prior to the amended DSM Regulation, FEI's primary cost-effectiveness test was the Total Resource Cost test (TRC). The TRC required FEI to consider both the total gas and other energy savings/impacts for each measure (primarily electricity), including measures that have multiple funding partners. Other utilities offering DSM programs would have to report similarly, so there may be overlap in savings attribution, as necessary, to show compliance with the DSM Regulation. FEI also reported on the Participant Cost Test that similarly requires FEI to account for the impact on other energy sources.

With the amended DSM Regulation changing FEI's primary cost-effectiveness test to the UCT, it is no longer necessary to consider the impact of FEI's DSM activities on other fuels to show compliance with the DSM Regulation.

5.0 Reference: FEI 2024-2027 DSM PLAN REPORT

Exhibit B-2, Appendix A, pp. 32-36; FEI 2019-2022 DSM Expenditures Plan Proceeding, Exhibit B-1, Appendix A, p. 9

Innovative Technologies Program Area

On page 32 of Appendix A to the Application, FEI states:

> The Innovative Technologies Program Area evaluates both pre-commercial and commercially available technologies and conducts pilot studies to validate manufacturers' claims related to equipment and system performance. The program area also assesses actual savings and customer acceptance of these newer technologies or systems of technologies. Technologies that successfully emerge from the Innovative Technologies Program Area are considered for inclusion within the applicable sector programs within the larger C&EM portfolio.

On the same page, FEI states the following regarding the “Technology Screening activity area”:

> Candidate technologies that do not pass the DSM screen are rejected; those that do pass are considered further through the development of a pilot project if information gaps exist and are incorporated into a sector program if the information gaps are filled.

> The Technology Screening activity also incorporates the administration of the Gas Technology Demonstration Program. This program is offered to FEI Energy Specialists to conduct technology studies, demonstrations, and evaluation activities with funding support. Results of these activities are used to inform future DSM programs.

On pages 32 and 33 of Appendix A to the Application, FEI states with regards to Pilot Projects:

> The development and implementation of a typical pilot project for technologies that pass Technology Screening takes approximately one to three years, depending on the complexities of the pilot design, program controls and participation requirements. Results from pilot projects help support the feasibility of developing future DSM programs.

> The Deep Retrofits activities aim to both assess and evaluate energy efficiency technologies, a system of technologies, and or building designs that can reduce GHG [greenhouse gas] emissions by 50% or greater in both residential and commercial buildings. Activities include conducting house-as-a-system technology research to focus on understanding barriers and identifying innovative solutions to support industry and market transformation, executing small and large demonstrations, and partnering with industry stakeholders to educate the market. Results of these activities will be used to inform energy savings and costing

numbers, identify customer adoption barriers, and establish recommendations to support future DSM program offerings.

On page 34 of Appendix A to the Application, FEI includes Exhibit 17, Innovative Technologies Program Area Expenditures by Activity. This shows a total expenditure of $24.8 million on Pilots and $50.6 million on Deep Energy Retrofits over the 2024 to 2027 period.

On page 19 of the Application, FEI includes the Table 4-5: Program Area Structure with a comparison of the breakdown in the 2023 DSM Plan and in the 2024-2027 DSM Plan.

On page 9 of Appendix A of Exhibit B-1 in FEI's 2019-2022 DSM Expenditures Plan Proceeding, FEI stated that deep retrofits were to be encouraged in the Home Renovation Program.

5.1 Please provide the planned expenditures on Pilot Projects in the test period, using the breakdown of the 2023 DSM Plan (i.e. Dual fuel Hybrid Heating, Gas Heat Pump and Other Projects).

Response:

The following table breaks down the planned expenditures for Pilot Projects (Exhibit 17, page 34 of Appendix A to the Application) using the 2023 DSM Plan format.

Table 1: Planned Expenditures for Pilot Projects

Program Area by Activity ($000's)	Incentives				Non-Incentives				Total Expenditures			
	2024	2025	2026	2027	2024	2025	2026	2027	2024	2025	2026	2027
Pilot Projects - Deep Retrofits	25,620	10,163	4,063	5,938	813	1,191	1,666	1,716	26,433	11,354	5,729	7,654
Pilot Projects - Dual Fuel Hybrid Heating	900	1,200	1,200	1,200	50	50	50	50	950	1,250	1,250	1,250
Pilot Projects - Gas Heat Pumps	3,525	4,000	3,400	4,150	406	406	406	431	3,931	4,406	3,806	4,581
Pilot Projects - Other Technologies	925	750	1,250	1,250	50	50	60	60	975	800	1,310	1,310
Technology Screening Studies	300	300	300	300	500	500	500	500	800	800	800	800
Non-Program-Specific Expenses and Labour	0	0	0	0	2,028	1,978	1,998	1,998	2,028	1,978	1,998	1,998
Total(s)	**$31,270**	**$16,413**	**$ 10,213**	**$12,838**	**$3,847**	**$4,175**	**$4,680**	**$4,755**	**$35,117**	**$20,588**	**$14,893**	**$17,593**

Please note that, although some technologies listed are planned to be transitioned into full scale program offerings in 2024 (e.g., Dual Fuel Hybrid heating systems), information gaps and adoption barriers may still exist that require additional research and field work.

5.2 Please explain why Deep Retrofits activities are part of the Innovative Technologies program area, rather than FEI's core program areas such as

Residential. Please include a discussion of the extent to which such activities include DSM measures that could be considered mature, and a comparison with the treatment of Deep Retrofits in previous DSM expenditure schedules.

Response:

FEI offers new support for comprehensive building envelope and mechanical upgrades as part of its core program areas through, for example, proposed enhancements to the Home Renovation Program (Residential Program Area) and the Performance – Existing Buildings Program (Commercial Program Area). These offers support deeper retrofits that can further reduce gas usage compared to past prescriptive and programs. However, there are knowledge gaps that persist in commercializing retrofits that reduce energy and GHG emissions by more than 50 percent in gas connected buildings (referred to as Deep Energy Retrofits). FEI believes that research and pilot projects to fill information gaps associated with Deep Energy Retrofits meet the definition of a "technology innovation program" as defined in the amended DSM Regulation and it is, therefore, appropriate to include in the Innovative Technologies Program Area.

In particular, although some individual DSM measures are well-understood, such as windows, insulation and mechanical upgrades, information gaps exist when conducting larger comprehensive retrofits with the goal to reduce energy and GHG emissions by 50 percent or more. The following key information gaps will be addressed through FEI's Deep Energy Retrofit activities:

- Improved understanding of the overall process for conducting a deep retrofit, such as points of intervention and integration of measures.
- Phasing of assessments and detailed design work.
- Identifying existing or innovative energy efficiency bundles across building archetypes, vintages, and sector.
- Assessing project costs and energy savings for cost benefit calculations.
- Overseeing the construction phase to understand the interconnection between different measure installations and challenges associated with working on an occupied building.
- Assessing and mitigating risks associated with retrofit construction, such as asbestos removal and tenant safety.
- Assessing customer acceptance of deep retrofits.
- Identifying educational gaps across stakeholder groups.
- Ensuring building owners understand the energy savings opportunities and benefits of their project.
- Navigating through financial barriers involved with funding retrofits.
- Training contractors and subtrades to ensure proper execution of retrofit measures.

- Monitoring and verifying the predicted energy savings by overseeing variations in occupant usage patterns or efficiencies of newer technologies.
- Identifying challenges related to procuring the high efficiency materials and equipment for retrofits.

As discussed in the response to RCIA IR1 6.3, there are measures under the Residential Program Area encouraging deeper retrofits that will be incented through the Home Renovation Program. This includes whole home performance and support measures such as building envelope, insulation and prescriptive mechanical upgrades (e.g., dual fuel hybrid heating systems). These measures are set to commence in 2025 after gathering the established results from the ongoing Deep Energy Retrofit pilot, which FEI expects to complete by the end of 2024.

There are also measures under the Commercial Program Area encouraging deeper retrofits that will be incented through the Performance – Existing Buildings Program. This includes the identification and implementation of stand-alone building envelope measures for Part 3 buildings, as well as less complex retrofit bundles incorporating mechanical system upgrades and building envelope measures that are not deemed to be a deep retrofit because they do not achieve the same level of energy savings.

In addition to enhancing existing offers, such as the Home Renovation Program (Residential Program Area) and the Performance – Existing Buildings Program (Commercial Program Area), FEI anticipates that some results may support the expansion or development of larger scale program offerings as FEI continues addressing the above information gaps over the DSM Plan period.

5.2.1 Please provide further explanation of the specific learnings and outcomes from the planned Deep Retrofits activities.

Response:

Over the DSM Plan period, FEI intends to investigate the following specific learnings and outcomes from deep retrofit activities:

- The maximum achievable energy use and GHG emission reduction using a deep energy retrofit methodology and technologies in natural gas connected building;
- The cost efficiency and impact of each measure within the deep energy retrofit measure bundle;
- Industry capacity and availability of expertise and resources;
- Construction challenges and barriers;
- Municipal bylaws, permitting requirements and code compliance;

- Non-energy benefits and social impacts of deep energy retrofit activities;
- Priming the industry and market for future deep energy retrofit rebate programs;
- Developing and commercializing technologies to reduce the cost of implementation of deep energy retrofit projects;
- Occupant behavior influences on the effectiveness of deep energy retrofit measures;
- Potential impact of the deep retrofits on different building archetypes;
- Partnering with the leading industry organizations that work on accelerating deep retrofit efforts;
- Determining potential financing models and strategies for funding deep energy retrofits;
- Assessing the potential of virtual benchmarking data sets and Artificial Intelligence; and
- Assessing embodied carbon and whole building life cycle energy conservation measures.

5.2.2 Please provide further justification for the level of proposed expenditures on Deep Retrofits compared to the remainder of the Innovative Technologies program area.

Response:

Over the DSM Plan period, deep retrofits account for 57 percent of the overall budget for the Innovative Technologies Program Area.

Due to the extensive nature of the upgrades, the financial commitment required to fill information gaps for deep energy retrofit projects is notably higher than looking at other individual end-use technologies, such as dual-fuel hybrid heating or gas heat pumps.

The process of looking at multiple components such as insulation, windows, airtightness, ventilation, and energy systems together demands specialized industry expertise to design tailored solutions and construction techniques that result in higher per participant pilot costs. Given these higher costs, combined with complexities involved with comprehensive upgrades and existing significant adoption barriers, the planned expenditure for deep retrofits is necessary to determine the feasibility of designing and launching a larger scale rebate program. Please refer to the response to BCUC IR1 5.2 for a list of the information gaps FEI has identified.

The total expenditures for deep retrofit activities from the DSM Plan are presented below:

Innovative Technology Deep Energy Retrofit Expenditures by Year ($000s)					
Innovative Technology Program Area Expenditure Activity*	2024	2025	2026	2027	Total
Deep Energy Retrofits	$ 26,433	$ 11,156	$ 5,531	$ 7,456	$ 50,576

** Please note that the expenditures in this table are not adjusted for inflation and do not include: (1) evaluation, as that is accounted for on a portfolio level; and (2) labor, as that is accounted for on a program area level.*

Importantly, the majority, or 52 percent, of the expenditures for deep retrofits occur in 2024 (Year 1), with significantly lower expenditures in the remaining years of the DSM Plan. Expenditures are higher in 2024 due to construction costs associated with fulfilling prior commitments for the Part 3 Deep Energy Retrofit pilot whereby the associated construction schedule spans across 2023-2024. The budget for the subsequent plan years is reduced to explore any other deep retrofit technologies and solutions, as well as different building archetypes that may be used to further address information gaps and address adoption barriers.

5.2.3 Please confirm, or explain otherwise, that FEI does not forecast any gas savings from Deep Retrofits from 2024 to 2027.

<u>Response:</u>

While FEI is aware of deep retrofits typically reducing energy consumption by 50 percent or more, FEI has not included forecast gas savings in the Innovative Technologies Program Area for deep retrofits as FEI lacks the necessary field and measurement data. FEI will need to quantify the actual measured gas savings value through evaluation activities before gas savings can be forecast in a DSM plan. FEI will file the actual gas savings from deep retrofits in future annual reports once the evaluation activities have been completed.

On page 35 of Appendix A to the Application, Posterity Group outlines several potential technologies evaluated for 2024-2027. One of these includes Gas Demand Response (DR): "Digital demand response technologies that can offer pathways to support events to reduce system capacity restraints with customers and reduce energy consumption and related GHG emissions."

5.3 Please further discuss the demand response technologies that are available for gas utilities.

Response:

A study completed by ICF (an energy consultant) identified two main demand response technologies available for gas utilities – smart thermostats and smart water heater controls. Smart thermostats and smart water heater controllers can assist utilities to manage peak loads and demand reductions, though more typically used for electric utility demand response. Although smart thermostats have been used more frequently as part of demand response programs due to their two-way internet-connected capabilities, the market has seen advancements in smart water heater controls with similar communication capabilities.

5.4 Please expand upon the specific learnings and outcomes FEI anticipates with respect to its planned gas demand response activities.

Response:

FEI's planned gas demand response activities are expected to gather details regarding the following:

- The change or shift away from the peak hour demand load;
- Customer engagement and satisfaction with each demand response activity; and
- The behavioral differences driving participation when different event criteria are implemented.

5.5 Please discuss whether such technologies are anticipated to target peak day, peak hour, or both.

Response:

FEI anticipates that demand response technologies will use reduction events to focus on shifting the peak hour load. Each heating day has peak hours prior to, and after, normal working hours. This coincides with when residents begin their day and then when they return home for the evening. Demand response technologies will also provide insight into peak day consumption impacts and if a demand response event can influence the overall daily consumption.

FEI expects that the consumption required to heat a home back to comfort levels after a demand response event may result in the same overall daily consumption. This has been noted in the FBC Demand Response pilot, among others conducted in North America. As such, FEI's focus will be on peak hour load shifting to understand the ability to impact peak hour demand.

Prefabricated Panelized Solutions are also outlined on page 35 of Appendix A to the Application:

> Prefabricated panelized solution is a methodology to reduce the construction time by integrating several thermal performance improvement measures together into a prefabricated wall or roof panel. These panels are fabricated in advance in a controlled environment inside a factory. These prefabricated panels will be attached to the existing building envelope onsite and in a short period of time.

5.6 Please explain the energy savings which are achieved through the use of prefabricated panelized solutions, and why these are considered to be demand side measures.

Response:

Prefabricated panels are factory-made building exterior solutions that integrate insulation, air barrier, rain screen, fire protection and external cladding components. These panels are designed to be installed faster and with a greater improved thermal performance than other envelope upgrades. According to a study by the U.S. Department of Energy's Building Technologies Office, panelized construction methods can lead to energy savings ranging from 10 to 15 percent compared to conventional construction methods. Further pilots and studies are necessary to confirm and quantify these energy savings claims in order to assess the feasibility of including this solution as a future DSM program offering.

Embodies Carbon is also outlined on page 35 of Appendix A to the Application:

> Embodied Carbon is a relatively newer consideration for lowering energy use and its associated GHG emissions in new and existing buildings. FortisBC will explore whether implementing a deep retrofit enhances the life of an existing building as well as the prevention of embodied carbon attached to its demolition.

5.7 Please explain how the concept of embodied carbon results in a reduction of gas consumption, and how this would differ from other deep retrofit measures being considered.

Response:

The primary goal of a deep energy retrofit project is to drive energy efficiency, reduce gas consumption, and reduce GHG emissions through upgrading the building envelope (including windows and insulation) and mechanical systems. To this end, each upgrade measure of a deep energy retrofit project reduces natural gas consumption. However, each upgrade measure also has an associated embodied carbon value, which is the carbon emitted during all other stages of that measure's life, including raw material extraction and processing, transportation and construction, maintenance and operations, and demolition and disposal. For example, according to a study completed by RDH (an engineering consultancy agency specializing in building envelope retrofits), vinyl frames for windows have higher embodied emissions than fibreglass framed windows, while both result in nearly similar energy savings. As it is important to understand these other impacts of the upgrades being installed, FEI intends to conduct further research to better assess the linkage between embodied carbon and different deep energy retrofit bundled energy upgrade solutions.

On page 36 of Appendix A to the Application, in Exhibit 18 – Potential Technologies Evaluated for 2024-2027, FEI states:

Artificial Intelligence-based Energy Performance Evaluation	Artificial Intelligence based energy performance evaluation combines publicly available information with machine learning and provides home energy performance evaluation with current average of 80% accuracy. Leveraging this technology can improve scalability of deep retrofits while driving the cost down.

5.8 With respect to the consideration of Artificial Intelligence-based Energy Performance Evaluation, please explain how FEI defines accuracy and establishes a tool accuracy level.

Response:

A study completed by Posterity Group (an energy consultancy) identified that while EnerGuide evaluation or ASHRAE Level 2 Energy Audits are likely to produce the most accurate assessment of deep retrofit opportunities, they are both costly and impractical. Therefore, other emerging virtual energy assessment tools can offer a suitable solution at scale.

Although the accuracy may vary across virtual energy assessment tools, a white paper completed by Properate (a virtual energy assessment provider leveraging AI-based solutions) highlighted an average weighted accuracy of 92 percent across 6,917 buildings comparing the virtual assessment to an on-site EnerGuide assessment.[3]

Recognizing these results were completed by the virtual energy assessment provider, FEI retained a third party to conduct a further evaluation. This evaluation included cross referencing on-site EnerGuide assessments on 30 homes enrolled in FEI's Part 9 Deep Energy Retrofit pilot with virtual assessments completed through the Properate platform. The evaluation yielded an

[3] "Properate: Property Rating Using A Novel Instant Energy Modeling Approach", Arman Mottaghi, Alex Lavoie, Artur Akhmetgareev, Noura Seifelnasr, November 2022: https://properate.io/content/whitepaper-blog.html.

accuracy level of approximately 80 percent following a similar methodology to that used in the white paper.

Based on reviewing data from both the white paper and the evaluation conducted on the homes enrolled in FEI's Part 9 Deep Energy Retrofit pilot, these tools may result in an average of 80 percent accuracy, although the accuracy will need to be further assessed through future pilots.

6.0 Reference: APPENDIX B

Exhibit B-2, Appendix B, pp. 38-39, 49

Legacy Program – EnerChoice Fireplace Measure

In Exhibit 31 on pages 38 and 39 of Appendix B to the Application, Posterity Group provides the forecast participation for the Legacy Residential EnerChoice fireplace measure as follows:

EnerChoice fireplace (Home Renovation): 600 in 2024 only.
EnerChoice fireplace (New Home): 1,100 in 2024, 350 in 2025, 20 in 2026.

In Exhibit 37 on page 49 of Appendix B to the Application, Posterity Group provides the forecast participation for the Legacy Indigenous measures:

EnerChoice fireplace (Prescriptive): participation of 5 in 2024, 10 per year from 2025 to 2027.

BCUC Staff have compiled the following table from Exhibit 32 and Exhibit 38 of Appendix B for the EnerChoice Fireplace measure:

Legacy EnerChoice Fireplace Measure	Incremental cost ($)	Incentive ($)	Contractor incentive ($)	Annual gas savings	Measure life (years)	Free rider rate
Residential (Home Renovation)	$132	$300	$50	7.4	15	39%
Residential (New Home)	$132	$500	-	5.0	15	39%
Indigenous (prescriptive)	$132	$300	-	7.4	15	-

6.1 Please discuss the differences between the three measures shown in the table above, in particular:

- Why a higher level of incentive is offered to the Residential (New Home) measure.
- Why the Residential (New Home) measure has a lower assumed annual gas savings, and explain what the baseline is for estimating the incremental annual gas savings.
- Why only the Residential (Home Renovation) measure has a contractor incentive.
- Why there is no free-rider assumption for the Indigenous measure.

Response:

The Residential New Home Program fireplace measure was increased to $500 for the "Bigger Rebates" offer, as part of FEI's COVID-19 recovery offers. FEI decided to maintain this incentive level for the following reasons:

1. Industry feedback indicated that due to rising costs of fireplaces, higher incentives were required to sway purchase decisions toward high efficiency heating styles versus lower efficiency decorative models designed for ambiance.
2. To maintain market consistency given the multi-year nature of new construction projects.

Based on industry feedback, in 2023, FEI had intended to align the Home Renovation and Indigenous Prescriptive Program fireplace incentives to match the New Home Program fireplace measure; however, it ultimately decided to maintain the existing incentive levels for program consistency in anticipation of the amended DSM Regulation.

The Residential New Home Program has lower assumed annual gas savings as the baseline is the BC Energy Efficiency Standards Regulation. In contrast, the Residential Home Renovation Program and the Indigenous Prescriptive Program, which incentivize retrofit scenarios, use existing equipment efficiencies as the baseline, which were established in a 2019 study by Building Energy Solutions Ltd.

FEI provides contractor incentives for the Residential Home Renovation Program fireplace measure due to the high level of engagement in the offer, which includes:

1. Promoting available incentives to customers and encouraging the adoption of high efficiency equipment; and
2. Educating customers on program requirements and supporting rebate applications.

This type of contractor engagement is not as typical of the New Home or Indigenous Prescriptive Program fireplace measures and, therefore, contractor incentives were not included.

There is no free rider rate for the Indigenous Prescriptive Program fireplace measure because FEI has deemed all Indigenous energy efficiency improvements, like Low Income improvements, would not occur without the rebate funding support. FEI plans to evaluate that assumption in 2023 and 2024.

6.2 Please discuss whether there are other measures which receive different levels of incentives between program areas. If so, please explain the rationale and provide examples based on measures proposed in the Application.

Response:

Incentives for specific measures may vary across program areas where it has been determined that:

- Higher incentives may be required to overcome barriers to participating in DSM, such as: (1) the availability of capital; (2) access to, and availability of, trades; and (3) limited support to complete enabling projects (e.g., hazardous material removal, structural projects, etc.) that are required to implement an energy efficiency measure. Typically, this occurs within the Low Income and Indigenous customer segments.
- Alignment with program partners (such as BC Hydro and the Province) is beneficial to support provincial consistency for some incentives specific to a particular customer segment.
- Different program delivery methods are required to engage customers. For example, direct install programs typically cover the full measure cost.

As part of program evaluation and ongoing development, FEI will assess incentive levels and adjust for the purpose of program area alignment, provincial alignment, advancing market adoption or a combination thereof.

In the table below FEI provides examples of incentives that vary across program areas and explains the rationale for those variations.

Table 1: Examples of Incentive Levels that Vary Across Program Areas

Measure	Measure Incentives ($)				Rationale for Incentive Variation
	Commercial	Residential	Low Income	Indigenous	
Exterior Wall Insulation	N/A	$1,273	$2,000	$2,000	Increased support for capital costs is required to overcome barriers to adoption of building envelope upgrades for Low Income and Indigenous customers.
Attic Insulation	N/A	$790	$1,200	$1,800	Increased support for capital costs is required to overcome barriers to adoption of building envelope upgrades for Low Income and Indigenous customers. In addition, Indigenous incentives were increased to align with BC Hydro's Indigenous incentives.
Showerheads and Aerators	Full cost (Direct Install)[1]	$8	Full cost (Direct Install)[1]	Full cost (Direct Install)[1]	In the Commercial, Low Income, and Indigenous program areas, showerheads and aerators are offered as a free, directly installed measure in order to increase the likelihood of measure adoption. In the residential program area incentives are instant rebates available at point of sale. Incentive levels typically generally cover 30-50 percent of the incremental cost.

Note to Table:

[1] *Showerheads and aerators are bundled as part of the ECAP measures in the Low Income and Indigenous program areas. In the Commercial Program Area, the measure is bundled as part of the Rental Apartment Program.*

B. REQUIREMENTS OF THE LEGAL FRAMEWORK

7.0 Reference: REQUIREMENTS OF THE LEGAL FRAMEWORK

Exhibit B-2, Section 5.3, p. 23; Table 5-2, p. 24; Section 5.3.1, pp. 24-25

Differences between DSM Plan and LT Gas Resource Plan

On page 23 of the Application, FEI states: "FEI will include the recent developments of emerging advanced DSM measures and the changes to the DSM Regulation as part of its next CPR and LTGRP."

On page 24 of the Application, Table 5-2 below compares the proposed 2024-2027 DSM Plan and the DSM settings explored in FEI's 2022 LTGRP.

Table 5-2: Comparison of 2024-2027 DSM Plan and LTGRP Diversified Energy Planning DSM Settings

Forecast Scenario	Incremental Energy Savings (PJ/yr)				Expenditures, Including Inflation ($Ms)
	Residential[1]	Commercial	Industrial	Total	Total
2024-2027 DSM Plan	1.4	0.8	1.8	**3.9**	**$626.7**
2022 LTGRP Low DSM Setting	0.7	0.9	0.6	**2.1**	**$57.3**
2022 LTGRP Med DSM Setting	2.6	1.0	0.9	**4.3**	**$365.1**
2022 LTGRP High DSM Setting	1.8	2.7	1.3	**5.8**	**$887.2**

[1] Includes savings in the Low Income, Indigenous, Conservation, Education and Outreach Program Areas.

On pages 24 and 25 of the Application, FEI states:

> The overall expenditures proposed in the DSM Plan generally fall between the 2022 LTGRP Medium and High DSM Settings, while the energy savings generally align with the Medium DSM Setting. The DSM Plan expenditures and savings are less than the 2022 LTGRP High DSM Setting from 2024 to 2027 for the following reasons:
>
> - The Roadmap, which was published after the 2022 LTGRP's DSM analysis was completed, signaled a policy shift away from supporting many traditional high-efficiency gas equipment DSM measures and towards advanced DSM activities. While the technical potential for space and domestic water heating measures remains the same, the available measures FEI can incent to meet that potential are early in their commercialization, requiring a period of ramp up and significant expenditure investment to accelerate initial market adoption.
> - The DSM Plan incorporates a faster transition toward more advanced gas DSM measures through higher expenditures for program incentives and innovative technology pilots than was incorporated in the CPR and the 2022 LTGRP DSM

analysis. The faster transition is a direct consequence of the amended DSM Regulation.

- Non-space and non-water heating measures (including the Industrial sector) in the DSM Plan remain consistent with the savings and expenditures assumptions of the High DSM Scenario.
- The 2022 LTGRP analysis provides a long-term outlook of DSM potential, using 2019 as a base year for its analysis. It does not address the design of DSM programs, including ramp up requirements for new measures and programs or potential ramp down of old measures.

7.1 Please provide the average cost of incremental energy savings (in $/GJ) based on the information provided in the Application, in each of the four scenarios shown above.

Response:

The table below presents the average cost of incremental energy savings (in $/GJ) for the DSM Plan and the three LTGRP DSM scenarios stated above.

Table 1: Average Cost of Incremental Energy Savings ($/GJ)

Forecast Scenario	$/GJ
2024-2027 DSM Plan	$159
2022 LTGRP Low DSM Setting	$27
2022 LTGRP Med DSM Setting	$85
2022 LTGRP High DSM Setting	$153

7.2 Please discuss the reasons for the higher per unit cost of energy savings of the 2024-2027 DSM Plan relative to the DSM settings outlined in the 2022 LTGRP, including a discussion of how FEI ensures that non-participating ratepayers receive value for money in return for funding the cost of DSM programs.

Response:

The three key drivers for the higher per unit cost of energy savings of the 2024-2027 DSM Plan relative to the DSM savings outlined in the 2022 LTGRP are:

1. **Conventional space and water heating equipment previously accepted in FEI's 2023 DSM Plan achieved higher energy savings with lower program expenditures:** The amended DSM Regulation phases out incentives for conventional space and water heating equipment. As those measures had higher market adoption and lower incremental cost than some of the newly proposed advanced DSM measures, they required lower incentives for customers to adopt those measures against baseline efficiency models.

Further, measures for conventional space and water heating equipment had been in the market for several years, requiring less marketing and trade ally support to continue momentum in market. The net impact of this change is the removal of lower per unit cost expenditures from the DSM Plan.

2. **Advanced DSM measures require significant supports to encourage early market adoption:** Advanced DSM measures will require significant marketing, trade ally support, and higher customer incentives to achieve early adoption, relative to legacy measures. FEI has seen a similar need for these supports in the past with the introduction of incentives for condensing gas equipment and FBC's incentives for LED lighting. The unit costs per energy savings generally improve over time as market adoption of the new measures grows.

3. **Inflation has increased costs, requiring additional incentives to encourage adoption of all measures:** Beginning in 2022, FEI began hearing feedback from customers that inflationary pressures were delaying or canceling projects and that more incentive support would be required to support projects that were viable prior to 2022. As such, FEI has increased supports for some measures, including incentives in the Custom Efficiency Program and insulation incentives in the Home Renovation Rebate Program.

Non-participating ratepayers receive value for funding the cost of DSM programs in three key ways:

1) **The DSM Plan supports the decarbonization of British Columbia:** Participation in FEI DSM programs lowers GHG emissions in British Columbia and reducing GHG emissions has both a local and global benefit to participating ratepayers and non-participating ratepayers alike. Energy efficiency is also typically a lower cost per tonne GHG reduction tool compared to other methods such as carbon capture and fuel-switching.

2) **Non-participants may become participants in future DSM plans:** Equipment replacement is often done on a 10-to-20-year cycle, with early replacement rarely happening until equipment is at least five years old. Thus, a non-participant as part of this DSM Plan may be interested in future incentives.

3) **The DSM Plan supports future changes in equipment and building code regulations:** The Province has signaled its intent to amend its space and water heating regulations to require equipment to have efficiencies greater than 100 percent in the CleanBC Roadmap to 2030. While the market is not yet ready to make this change, FEI's DSM activities support early adoption, provide market supports and, ultimately, accelerate market transformation for measures that will comply with more stringent future efficiency requirements. Introducing customer education, trade ally supports, and encouraging economies of scale today will reduce non-participant costs in the future when revised regulations are implemented, and FEI is no longer able to provide incentives for all current measures.

7.3 Please provide FEI's views on the advantages and disadvantages of a faster transition to advanced DSM measures in the DSM portfolio of measures, as opposed to a slower transition.

Response:

The following advantages are associated with a faster transition to advanced DSM measures:

- Market transformation reliant on the adoption of advanced DSM measures is achieved in a shorter duration.
- Greenhouse gas reductions from residential, commercial, low-income, and Indigenous customers are achieved more quickly.
- Better prepares the market for anticipated higher equipment energy efficiency standards and code changes.
- Better supports Provincial and municipal greenhouse gas reduction policies and strategies.
- Maintains hard-developed momentum of trade allies towards promoting an energy efficient marketplace by keeping DSM programs and a focus on higher efficiency in market.

The following disadvantages are associated with a faster transition to advanced DSM measures:

- Increased demand for FEI labour and other external program supports.
- Accelerated and more pronounced need for training and education for trade allies and customers regarding advanced DSM measures.
- Increased adoption uncertainty as market factors, such as access to supply, capital, and technical resources, may initially fluctuate as part of the early adoption phase of this transition.

7.4 Please discuss if FEI expects the costs of advanced DSM measures to decline over the 2024-2027 period, and if so, if this cost decline has been factored into the underlying measure assumptions. If not, please discuss why not.

Response:

No, FEI does not expect the costs of most DSM measures, including advanced DSM measures, to decline over the 2024-2027 period. British Columbia continues to experience high inflation and FEI continues to see increasing equipment and labour costs for most DSM projects. While it is possible that costs will decrease, FEI has no evidence to suggest this will happen with a high degree of certainty in the next four years.

8.0 Reference: REQUIREMENTS OF THE LEGAL FRAMEWORK

Exhibit B-2, Section 1.1, p. 3; Section 5.4.1, pp. 27-30; Appendix H, DSM Regulation, Section 1.1.(2)

Amended DSM Regulation Requirements – Class B DSM

On page 3 of the Application, FEI states with respect to the key amendments to the DSM Regulation:

> **Limited Support for High-Efficiency Conventional Gas Space and Water Heating Equipment**: With some limited exceptions, the amended DSM Regulation effectively deems most conventional high-efficiency gas space and water heating equipment or "class B demand-side measures" as not cost effective.[12] Where permitted, FEI has included measures for conventional high-efficiency gas space and water heating equipment within its DSM programs, which are described further in Section 5.4 of the Application.
>
> Footnote 12: A Class B demand-side measure must have a UCT [Utility Cost Test] of 50 or greater to be cost effective.

On pages 28 to 30 of the Application, FEI includes Table 5-4: DSM Plan Compliance with the Definition of Class B Demand-Side Measure.

On page 3 of the Application, FEI states:

> **Addition of Minimum Seasonal Coefficient of Performance (SCOP) Requirement**: The amended DSM Regulation adds a SCOP requirement for dual fuel hybrid systems and gas heat pumps. A SCOP is an average efficiency rating for heat pumps over a full heating season. Previously, there were no minimum requirements for any mechanical systems.

Section 1.1(2) of the amended DSM Regulation outlines several exclusions from the definition of a class B demand side measures, including the following:

> (i) a program that
>
> > (i) encourages the acquisition or installation of integrated dual-energy space heating systems for use in locations in climate zones 4 and 5, but only if all of the integrated dual- energy space heating systems acquired or installed, when considered in aggregate, are, <u>in the commission's opinion</u>, likely to have an annual average seasonal coefficient of performance equal to or greater than 1.5. [Emphasis added]

8.1 Please provide a list of all measures by Program Area that encourage the acquisition or installation of gas fired space or domestic water heating equipment but are excluded from the definition of "class B demand-side measure" in section 1.1 of the DSM Regulation. Please include information on the SCOP for each measure proposed for use in climate zones 4 and 5, and the source of this information, including if based on modelling or field studies.

Response:

Please refer to the table below for the requested list of measures. Please refer to the response to BCUC IR1 8.6 for additional information on the Seasonal Coefficient of Performance (SCOP) of these measures.

Table 1: Measures that Encourage Acquisition or Installation of Gas Fired Space or Domestic Water Heating Equipment by Program Area

Program	Measure
Residential Home Renovation	Hybrid Dual-Fuel Systems
Residential New Home	Step 4 detached home – hybrid dual fuel systems
Residential New Home	Step 4 row home - hybrid dual fuel systems
Residential New Home	Step 5 detached home - hybrid dual fuel systems
Residential New Home	Step 5 row home - hybrid dual fuel systems
Commercial Prescriptive	Hybrid Dual Fuel RTUs
Commercial Prescriptive	Hybrid Dual Fuel Hydronic Systems
Commercial Prescriptive	Gas Heat Pumps
Low Income Prescriptive	Commercial - Gas Heat Pump
Low Income Prescriptive	Residential - Hybrid Dual-Fuel Systems
Low Income Prescriptive	Commercial - Hybrid Systems
Indigenous Prescriptive	Commercial - Gas Heat Pump
Indigenous Prescriptive	Residential - Hybrid Dual-Fuel Systems
Indigenous Prescriptive	Commercial - Hybrid Systems
Indigenous Performance	Step 4 detached home - hybrid
Indigenous Performance	Step 4 row home - hybrid
Indigenous Performance	Step 5 detached home - hybrid
Indigenous Performance	Step 5 row home - hybrid

8.2 Please discuss how FEI estimates the SCOP of dual fuel hybrid systems and gas heat pumps, and FEI's plans to ensure that the estimate is based on the best available data (whether modelled or field).

Response:

FEI will use a source hierarchy to ensure that the SCOP estimate is based on the best available data and intends to use SCOP assumption data sources in the following order of priority as data becomes available:

1. **Desktop Modeling**: If no or limited field data is available, FEI will conduct desktop modeling of the impacted systems using software such as HOT2000, RetScreen, or

custom Excel models to estimate SCOP using the proposed program criteria (including equipment efficiencies, setback temperatures and climate zone information).

2. **Third-party Studies:** FEI may also consider using third-party studies to determine SCOPs if the third-party pilot or program criteria and climate zones are similar to that proposed by FEI.
3. **FEI Pilot Data:** If FEI has conducted a pilot of the proposed measures, but FEI has not evaluated those measures in an in-market program, FEI will use the SCOP evaluated through pilot measurement and verification.
4. **FEI Program Evaluation:** Dual fuel hybrid systems and gas heat pump measures will be introduced as new measures in existing programs. Those programs will continue to be evaluated in accordance with the evaluation strategy noted in Section 7 of the DSM Plan. The evaluations will include representative measurement and verification as part of the impact evaluation to determine an average evaluated SCOP across Climate Zones 4 and 5 for dual fuel hybrids and all Climate Zones for gas heat pumps, in addition to the regular impact evaluation parameters. Please note that Section 1.1(2) of the amended DSM Regulation requires that dual fuel hybrids meet the requirement in aggregate, across both Climate Zone 4 and 5, not individually and gas heat pumps across all Climate Zones, not individually.

SCOP for dual fuel hybrid systems is not as common a performance metric as individual equipment performance metrics, such as Heating Seasonal Performance Factor (HSPF)/HSPF2, for heat pumps and Annual Fuel Utilization Efficiency (AFUE) for furnaces. There is limited third-party data available on the SCOP of dual fuel hybrids. At this time, FEI is relying on a pre-feasibility study that used desktop modeling for its residential dual-fuel hybrid system SCOP assumptions. FEI is currently conducting a pilot on residential dual-fuel hybrid systems and intends to use that data for SCOP assumptions once the pilot evaluation is completed in 2024. The commercial gas heat pump SCOP assumptions use evaluated results from the gas heat pump pilot, with the most recent phase completed in 2021.

FEI intends to submit its sources for SCOP assumption each year as part of its annual DSM reporting, thus enabling the BCUC to confirm that FEI is meeting Section 1.1(2) of the amended DSM Regulation.

8.3 Please elaborate on FEI's process to establish that each of the proposed dual fuel hybrid systems and gas heat pump measures meet the required performance standards to be eligible in each of the climate zones.

Response:

Please refer to the response to BCUC IR1 8.2.

8.4 Please explain how FEI will limit the offer of incentives in specific climate zones when measures do not meet the SCOP requirement.

Response:

FEI does not currently intend to limit the offer of incentives in specific climate zones. Section 1.1(2) of the amended DSM Regulation requires that: (1) dual fuel hybrids meet the SCOP requirement in aggregate across both Climate Zone 4 and 5 (i.e., no SCOP requirements in Climate Zone 6 and above); and (2) gas heat pumps meet the incentive requirements in aggregate across all Climate Zones. Based on its current assumptions, FEI expects that its incentives will meet these requirements in aggregate across the climate zones.

However, if it is not feasible to meet the SCOP requirements after the pilot or program evaluation using current assumptions, FEI would evaluate amending the qualifying criteria to lower the setback temperature (for dual fuel hybrid systems) or increasing the equipment efficiency requirements before considering not offering a measure in a specific climate zone.

8.5 Please elaborate on how FEI ensures that performance-based programs and market supports do not include incentives for conventional gas equipment.

Response:

FEI will ensure that performance-based programs and market supports do not include incentives for conventional gas equipment through program design, eligibility criteria, terms and conditions, and supporting documentation requirements. Performance-based programs and market supports are planned to focus on non-space and water heating measures (including building envelope measures) and space and water heating DSM measures that are permitted to receive incentives under the amended DSM Regulation.

For example, the Commercial Performance – Existing Buildings Program involves a technical review of the participants' identified energy efficiency opportunities, their associated design configurations, and savings opportunities. Based on that information, FEI will determine whether to incent such measures consistent with what is permitted under the amended DSM Regulation. Upon completion of the measure implementation by participants, FEI conducts site visits to verify the proper implementation of the incented measures to ensure they are installed as intended.

8.6 Please file information to enable the BCUC to assess the likely annual average SCOP of all of the integrated dual-energy space heating systems acquired or installed in aggregate.

Response:

FEI is proposing two integrated dual-energy (dual-fuel) space heating systems in the 2024-2027 DSM Plan: (1) residential dual-fuel hybrid systems; and (2) commercial dual-fuel roof top units. Section 1.1(2)(i) of the amended DSM Regulation permits:

> a program that encourages the acquisition or installation of integrated dual-energy space heating systems for use in locations in climate zones 4 and 5, but only if all of the integrated dual-energy space heating systems acquired or installed, when considered in aggregate, are, in the commission's opinion, likely to have an annual average seasonal coefficient of performance equal to or greater than 1.5.

The following tables present the integrated dual-fuel system technology, related FEI program, related measures within program, aggregate SCOP, and respective data sources. Please refer to Attachments 8.6A and 8.6B for a copy of these data sources.

Table 1: Integrated Dual-Fuel System Technology and Related FEI Programs and Measures

Technology	FEI Program	FEI Measure	SCOP Result	Data Sources
Residential dual-fuel hybrid systems	Residential Home Renovation	Hybrid Dual-Fuel Systems	Climate Zone 4: 2.07 Climate Zone 5: 1.12 Aggregate[1]: 1.60	Memo - Dual Fuel Hybrid Heating System Energy Consumption and Efficiency Assumptions, FEI, August 31, 2023.
	Residential New Home	Step 4 detached home – hybrid dual fuel systems		
	Residential New Home	Step 4 row home - hybrid dual fuel systems		
	Residential New Home	Step 5 detached home - hybrid dual fuel systems		
	Residential New Home	Step 5 row home - hybrid dual fuel systems		
	Indigenous Performance	Step 4 detached home - hybrid		
	Indigenous Performance	Step 4 row home - hybrid		
	Indigenous Performance	Step 5 detached home - hybrid		
	Indigenous Performance	Step 5 row home - hybrid		
Commercial dual-fuel roof top units	Commercial Prescriptive	Hybrid Dual Fuel RTUs	Climate Zone 4: 2.86 Climate Zone 5: 2.34 Aggregate[1]: 2.60	Commercial Hybrid RTU Market Research Report, Prism Engineering (Appendix C), August 2, 2023.
	Low Income Prescriptive	Commercial - Hybrid Systems		
	Indigenous Prescriptive	Commercial - Hybrid Systems		

<u>*Note to Table:*</u>

[1] *Assumes 50% participation in Climate Zone 4 and 50% in Climate Zone 5.*

FEI is also proposing to include commercial gas heat pumps with conventional gas backup in the 2024-2027 DSM Plan. Section 1.1(2)(f) of the amended DSM Regulation permits:

> demand-side measure that encourages the acquisition or installation of an integrated hybrid gas-fired heat pump system that has a modelled seasonal coefficient of performance equal to or greater than 1.

Please note that assessed data available is limited to Climate Zone 4. FEI does not expect a material difference in SCOP in colder climate zones due to the relatively inelastic relationship between gas heat pump SCOP and outdoor air temperature.

FEI includes these data sources as Attachment 8.6C to this response.

Table 2: Gas Heat Pumps with Conventional Gas Backup and Related FEI Programs and Measures

Technology	FEI Program	FEI Measure	SCOP Result	Data Sources
Gas heat pumps with conventional gas backup	Commercial Prescriptive	Gas Heat Pumps	Domestic hot water: 1.20 Space heating priority with domestic hot water: 1.18 Ventilation priority with domestic hot water: 1.25 Aggregate[2]: 1.21	Natural Gas Absorption Heat Pump (GAHP) Pilot, Phase 5 (Page 5), Building Energy Solutions Ltd., September 1, 2023.
	Low Income Prescriptive	Commercial – Gas Heat Pump		
	Indigenous Prescriptive	Commercial – Gas Heat Pump		

<u>*Note to Table:*</u>

[1] *Assumes majority participation in Climate Zone 4 with 50% being for domestic hot water, 25% for space heating and 25% for ventilation.*

In direct response to stakeholder feedback, FEI is also proposing to support Hybrid Dual Fuel Hydronic Systems in the Commercial Prescriptive Program. As program design is in the early stages, FEI does not have measure data available to assess the SCOP at this time. However, consistent with FEI's practice of maintaining compliance with the DSM Regulation in the implementation of its DSM Plan, FEI will only proceed with support for Hybrid Dual Fuel Hydronic Systems if it can design a program that meets the SCOP requirements. Assuming FEI is able to proceed with the measure as planned, FEI will submit SCOP data to show compliance with the SCOP requirements of the amended DSM Regulation in its Annual DSM Reports. If FEI is not able to proceed with the measure, FEI will report on this variance from plan in its Annual DSM Report. FEI submits that its commitment to only proceed if it can meet the DSM Regulation requirements and accountability to the BCUC in its Annual Reports should provide the confidence to the BCUC that all of the integrated dual- energy space heating systems acquired or installed, when considered in aggregate, will likely to have an annual average seasonal coefficient of performance equal to or greater than 1.5.

On page 27 of the Application, FEI states:

> FEI's Proposed Non-Legacy Demand-Side Measures Are Excluded from the Definition of Class B Demand-Side Measures.
>
> …
>
> FEI is not proposing any class B demand-side measures, unless they are Legacy Expenditures permitted by section 5 of the DSM Regulation. Outside the Legacy Expenditures program area, all FEI measures that encourage the acquisition or installation of gas fired space or domestic water heating equipment are excluded from the definition of "class B demand-side measure" in section 1.1 of the DSM Regulation.

8.7 Please confirm, or clarify otherwise, that FEI is not proposing Class B measures in the Expenditure Schedule, other than those measures excluded from the definition of Class B outlined in Section 1.1 (2) of the amended DSM Regulation.

Response:

FEI is not proposing Class B measures in the expenditure schedule, apart from measures excluded from the definition of Class B outlined in Section 1.1 (2) of the amended DSM Regulation and Legacy Expenditures allowed under section 5 of the amended DSM Regulation.

On page 30 of the Application, FEI states that to be eligible for incentives in FEI's low-income new construction offers, the buildings will be required to have a dual fuel heating system, gas heat pump or integrated gas heat pump system for space heating.

8.8 Please provide a list of definitions of the various types of dual fuel systems, including FEI's views on which may be included or excluded from the meaning of a class B demand side measure. For example, please explain the differences between a dual fuel heating system, and an integrated, split or hybrid gas heat pump system.

Response:

The following are dual fuel systems that are excluded from the meaning of a Class B demand-side measure:

- **Packaged dual fuel water heating system (Section 1.1(2)(a) of the amended DSM Regulation):** This category generally refers to a dual fuel water system that uses a heat pump water heater and a gas domestic hot water heater. As there are limited examples for this equipment configuration, FEI has not currently proposed any incentives to support these systems.
- **Non-integrated gas heat pump (Section 1.1(2)(b) of the amended DSM Regulation):** This category refers to either a gas absorption heat pump or gas engine-driven heat pumps that are not integrated with a back-up conventional gas system like a boiler or on-demand water heater. FEI has included incentives for these measures in the Commercial program area.
- **Packaged dual fuel hybrid heating system (Section 1.1(2)(e) and (i) of the amended DSM Regulation):** Also referred to as a dual fuel hybrid system or dual fuel system. This category refers to systems such as a furnace-electric heat pump hybrid systems, hybrid heat pump roof top units or other configurations whereby the gas and electric heating systems are integrated in either one unit or as part of one certification (e.g., the AHRI certification of furnace-electric heat pump hybrid systems). FEI has included incentives for these measures in the Residential, Low Income, Indigenous, and Commercial program areas.
- **Integrated gas heat pump system (Section 1.1(2)(f) of the amended DSM Regulation):** This category refers to either gas absorption heat pumps or gas engine-driven heat pumps that are integrated with a back-up conventional gas system like a boiler or on-demand water heater. FEI has included incentives for these measures in the Commercial Program Area.
- **Adding a non-packaged electric space or water heating equipment to an existing gas space and/or water heating system:** While not explicitly referenced in the amended DSM Regulation, this category of space and water heating measures comprise system retrofits that include both gas and electric space and/or water heating equipment but that are not packaged in a hybrid unit, do not have a specific hybrid performance certification, and are a part of a larger and/or more complex system. This generally refers to adding a non-gas space or water heating measure to an existing gas space and/or water heating system to reduce gas usage. Examples include:
    - Adding a heat recovery chiller to a gas boiler hydronic system;
    - Implementing a thermal gradient header system to an existing gas boiler that provides base heating and is supplemented by various electric heat pumps and heat recovery systems;
    - Adding a ground-source heat pump that provides heating to several campus buildings and uses back-up gas boilers; and
    - Adding solar pre-heating to a gas hydronic system.

While FEI can still provide incentives for the non-gas space and water heating measure to reduce gas usage (as it is not a Class B measure), it cannot provide an incentive for higher efficiency conventional gas equipment (a Class B measure not included in any of the allowable exceptions). This could occur where a customer is replacing a standard efficiency gas hydronic boiler and adsorption chiller with a condensing gas hydronic boiler and heat recovery chiller. FEI could provide incentives for the heat recovery chiller (which is not a Class B measure and reduces gas consumption), but could not provide an incentive, or claim savings, for the condensing gas hydronic boiler (which is a Class B measure that is not included in any of the allowable exceptions). These projects are common in FEI's commercial performance programs.

9.0 Reference: REQUIREMENTS OF THE LEGAL FRAMEWORK

Exhibit B-2, Section 5.4, p. 29; Appendix H; BC Building Code, p. 5; FEI 2022 LTGRP Proceeding, Exhibit B-1, p. 2-25

Class B DSM Exclusions

Section 1.1(2)(g) from Appendix H, and as updated in the amended courtesy copy of the DSM Regulation provided to stakeholders by the BC Ministry of Energy, Mines and Low Carbon Innovation refers to:

> (g) a demand-side measure referred to in section 3 (1) (a) or (g)
>
> (i) that encourages the acquisition or installation of gas-fired domestic water heating equipment for use in a building described in Article 1.3.3.3. of the building code, whether or not the building code applies to the building, and
>
> (ii) that does not encourage the acquisition or installation of gas-fired space heating equipment other than
>
> (A) gas-fired space heating equipment described in paragraph (b), (c), (d), (e) or (f), or
>
> (B) by a demand-side measure described in paragraph (h) or (i);

On page 29 of the Application, FEI states with respect to (g) of the DSM Regulation:

> FEI is proposing to include incentives in the Low Income and Indigenous Program Areas for conventional high-efficiency domestic hot water equipment for Part 9 customers, as described in Sections 6 and 7 in Appendix A, and Appendix B to the Application.
>
> Conventional high-efficiency gas-fired domestic hot water incentives are not being proposed for any other customers, except those noted as a "legacy expenditure", as defined in section 5 of the DSM Regulation.

Under the BC Building Code, Part 9 buildings include: "(m)ost buildings three storeys and under in height and with a footprint of 600 square metres or less." [4]

Figure 2-3 on page 2-25 of FEI's 2022 LTGRP (Exhibit B-1) provides an outlook of energy costs.

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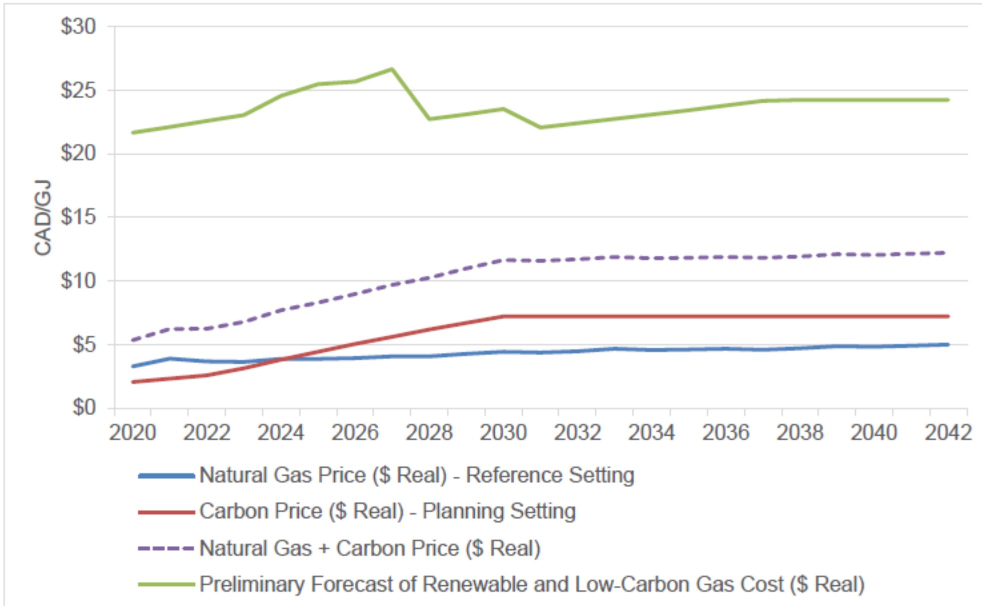
[4] Page 5 of https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/guides/buildingactguide_sectiona1_june2015_web.pdf.

Figure 2-3: Outlook of Energy Costs for Fuel Types Used in the Development of the LTGRP[85,86]



9.1 Please confirm that the exceptions for conventional water heating and space heating equipment provided by sections 1.1(2)(g) and (h) of the Amended DSM regulations applies only to Part 9 buildings, or explain otherwise.

Response:

Confirmed.

9.2 When offering incentives to participants in the Low Income and Indigenous Programs, please explain if FEI provides participants with information on long-term bill impacts which take into account future possible increases in the gas price over the assumed lifetime of the measure.

Response:

While FEI does not provide participants in Low Income and Indigenous program areas with bill impact analyses when offering incentives to participants, FEI supports customers in making informed energy decisions by providing resources such as fuel cost comparison data, a home energy calculator tool, and education on managing high bills. DSM rebates and incentives are intended to support energy efficiency and reduce the costs of highest efficiency equipment for Low Income and Indigenous participants.

9.3 Please provide the bill impact to a typical Part 9 Low Income or Indigenous customer of installing a new hybrid dual fuel system, for example, compared to installing new conventional high-efficiency equipment.

Response:

FEI does not conduct bill impact analyses specific to Low Income or Indigenous customers. As part of the ongoing hybrid dual fuel pilot, FEI is planning to assess bill impacts for residential customers in Part 9 buildings. FEI aims to better understand the operating costs and efficiencies associated with hybrid dual fuel heating systems that will better serve to inform actual performance of this equipment in Part 9 residential customer homes.

The table below compares the estimated bill impacts of a new hybrid dual fuel system[5] compared to new conventional high-efficiency equipment.

Please note that the operating costs included in the table are based on modelled values and should be interpreted as being a general indication of the energy consumption associated with high-efficiency heat pumps, furnaces, and hybrid dual fuel systems. The assumptions made may vary significantly depending on the housing stock, equipment used, local climate, and switchover temperature of the proposed project and it is possible that the energy used in each project may be substantially different than the findings from this study. Many of the inputs come from studies with small sample sizes, engineering calculations, and assumptions that may not be indicative of actual system performance.

Table 1: Comparison of Estimated Bill Impacts of New hybrid Dual Fuel System to New Conventional High-Efficiency Equipment

Equipment	Operating Costs[1,2] ($/heating season)	Installation Costs	FortisBC Incentive[3]	Net Installation Cost
Climate Zone 4				
Electric air source heat pump	$936	$13,000	$5,000	$8,000
Natural gas furnace	$823	$6,000	$2,000-3,000	$3,000-4,000
Hybrid dual fuel heating system (Switchover at 5°C)	$918	$24,500	$10,000-12,000	$12,500-14,500
Climate Zone 5				
Electric air source heat pump	$1,141	$12,500	$5,000	$7,500
Natural gas furnace	$808	$5,000	$2,000-3,000	$2,000-3,000
Hybrid dual fuel heating system (Switchover at 2°C)	$854	$24,000	$10,000-12,000	$12,000-14,000

Notes to Table:

[1] *Costs are assuming rates of $0.14 per kWh and $10.23 per GJ.*

[2] *Costs are provided per month for heating season.*

[3] *FortisBC incentives for natural gas furnaces are considered legacy. Further, incentives for electric air source heat pumps are only available to customers in the FortisBC electric service territory.*

[5] Note that this equipment follows the definition specified for "Packaged dual fuel hybrid heating system (Section 1.1(2)(e) and (i) of the amended DSM Regulation)" in the response to BCUC IR1 8.8.

For additional background on how the operating costs were determined for each heating system, please refer to Attachment 8.6 in the response to BCUC IR1 8.6.

9.4 Please discuss if FEI has considered providing higher incentives for Low Income and Indigenous communities to support earlier adoption of advanced DSM measures as opposed to conventional high-efficiency gas-fired space and water heating equipment, and if not, why not.

Response:

FEI's intention is to provide incentives which enable Low Income and Indigenous customers to adopt advanced DSM measures. FEI takes multiple factors into consideration when determining incentive levels for measures under these program areas. These factors include:

- comparative incentives and participation data;
- cost-effectiveness of measures and program(s);
- stakeholder feedback, including barriers and decision-making criteria;
- program design to ensure offers are relevant and accessible; and
- where applicable, consistency with other utilities or governmental agencies' offers.

As part of program design and ongoing performance tracking, FEI will further assess the incentive levels and adjust incentives as needed to aid the adoption of advanced DSM measures. In some instances, incentives for Low Income and/or Indigenous customers may fully cover or exceed the incremental cost for a given measure.

In the interim, FEI has proposed to continue incentives for conventional high efficiency equipment for these groups, in accordance with the DSM Regulation. This recommendation stems from the acknowledgement that Low Income and Indigenous customers face unique barriers to participating in DSM programs and adopting new measures. Further, the current market for water heating is limited in terms of advanced DSM. Therefore, continuing to offer incentives for conventional high-efficiency gas water heating equipment ensures equitable access to energy efficiency programs.

10.0 Reference: ADDITIONAL COST-EFFECTIVENESS RESULTS AND MEASURE DETAILS REPORT

Exhibit B-2, Appendix A, pp. 17, 31, 43; Appendix B, pp. 38-39, 43, 49; Appendix H

Legacy Measures

The Ministerial Order M193 (Appendix H to the Application), section 5(1) defines "Legacy measure" as a demand-side measure in relation to which an expenditure is included in a pre-filed expenditure schedule.

On page 17 of Appendix A to the Application, FEI states that "(l)egacy expenditures decline from 2024 to 2027 as expenditures in this Program Area have already been committed and there are no new commitments or offers being proposed on conventional high-efficiency gas space and water heating equipment."

On page 31 of Appendix A to the Application, FEI states it intends to support two types of legacy expenditures:

a) Those for customers with written commitments from FEI made prior to December 31, 2023 for class B demand-side measures.

b) Those for customers participating in DSM programs that do not provide written commitments but meet the program terms and conditions and purchase and/or install a class B demand-side measure before December 31, 2023.

Further, on page 31 of the Application, FEI states: "No new written commitments will be made for class B demand-side measures after December 31, 2023. Class B demand-side measures purchased and/or installed after December 31, 2023 from programs that do not have written commitments will similarly not be eligible for incentives."

10.1 Please confirm FEI's intentions with respect to the advertising of legacy expenditures, and when FEI expects to stop advertising these measures or otherwise ramp down advertising in 2023. If there is no intent to ramp down the marketing of legacy expenditures during 2023, please discuss why not.

Response:

Marketing and advertising are not included as part of the Legacy Expenditures in the DSM Plan. FEI's late 2023 rebate awareness advertising will include advising customers that incentives for Legacy measures will be discontinued in 2023. Advertising began in late August and is planned to end by December 2023. Since many customers have historically considered FEI rebates in their budgeting and planning processes, it is important to inform customers of the application deadlines for measures that will no longer be available pursuant to the amended DSM Regulation.

On page 43 of Appendix A to the Application, FEI presents Exhibit 21 – Legacy Program Area Expenditures ($000s), Not Including Inflation and Exhibit 22 – Legacy Gas Savings and Cost-Effectiveness.

On pages 38, 39, 43 and 49 of Appendix B to the Application, FEI presents the following Exhibits:

Exhibit 31 – Legacy Residential Forecasted Participation by Measure;

Exhibit 33 – Legacy Commercial Forecasted Participation by Measure; and

Exhibit 37 – Legacy Indigenous Forecasted Participation by Measure.

Some residential New Home measures extend into 2025 and 2026.

10.2 Please explain why expenditures on certain legacy measures for the Residential, Commercial and Indigenous program areas extend to all or most of the period covered by the Expenditure Schedule, including a discussion on the relevant types of legacy measures.

Response:

Legacy measures are incentives which were committed under the previous DSM Plan period but are expected to be completed or paid within the 2024-2027 DSM Plan period. These commitments include two streams:

- Eligible purchases from 2023, including those where a customer applies by the end of 2024 per the existing terms and conditions of the program; or
- Have a written commitment to an incentive for 2024 onwards.

These streams can be retrofits or new construction. The Residential New Home, Commercial Performance Program – Existing and New Buildings, Low Income Commercial Non-Profit bundled measures provide additional multi-year commitments, ranging from eighteen months to five years. Therefore, participation is reflected in several years within the DSM Plan.

FEI anticipates that the volume of applications will decrease between 2024-2027 as projects conclude.

10.3 Please confirm if the measures that include written commitments from FEI correspond for actions beyond December 2023 apply only to new construction. If not, discuss further what measures and customers include written commitments from FEI and provide a breakdown of expenditures and savings associated with new construction related measures vs other types of measures.

Response:

Legacy measures with written commitments from FEI apply to both new construction and retrofit applications for residential and commercial customers. In both circumstances, written commitments are provided in accordance with existing program terms and conditions for the purpose of fostering confidence and reducing risk for customers undertaking energy efficiency projects which may be more complex and require more time to complete. The table below provides a summary of measures with written commitments by program area, including DSM Plan expenditures and energy savings.

Table 1: Legacy Measures with Written Commitments

Program Area	Retrofit or New Construction	Measure	Expenditures ($000s)	Energy Savings (GJ)
Residential	New Construction	STEP 2 – Single Family Dwelling (New Home)	$1,650	2,640
	New Construction	STEP 2 – Townhome/Row Home (New Home)	$1,215	2,966
	New Construction	STEP 3 – Single Family Dwelling (New Home)	$6,560	15,955
	New Construction	STEP 3 – Townhome/Row Home (New Home)	$2,998	8,508
	New Construction	STEP 4 – Single Family Dwelling (New Home)	$2,430	7,638
	New Construction	STEP 4 – Townhome/Row Home (New Home)	$1,215	3,032
	New Construction	STEP 5 – Single Family Dwelling (New Home)	$305	1,164
	New Construction	STEP 5 – Townhome/Row Home (New Home)	$68	196
	New Construction	Condensing Storage Tank Water Heater (New Home)	$10	80
	New Construction	Condensing Tankless Water Heater (New Home)	$1,315	11,843
	New Construction	EnerChoice Fireplace (New Home)	$735	4,484
	New Construction	Combination System (New Home)	$912	3,204
Commercial	Retrofit	Capital Upgrades (Retrofit)	$11,780	88,114
	New Construction	Step Code – Whole Building (New Construction)	$12,680	31,657
	New Construction	Non Step Code – Whole Building (New Construction)	$12,680	31,657
Low Income	Retrofit	Commercial – Non-Profit Bundled Measures (Prescriptive)	$175	3,325
	Retrofit	Energy Conservation Assistance Program (ECAP) (Direct Install)	$1,422	774
Indigenous	New Construction	STEP 2 – Single Family Dwelling (Performance)	$12	22
	New Construction	STEP 2 – Townhome/Row Home (Performance)	$8	17
	New Construction	STEP 3 – Single Family Dwelling (Performance)	$25	57
	New Construction	STEP 3 – Townhome/Row Home (Performance)	$25	92
	New Construction	STEP 4 – Single Family Dwelling (Performance)	$24	45
	New Construction	STEP 4 – Townhome/Row Home (Performance)	$32	153
TOTAL			**$58,276**	**217,623**

10.4 Please explain if FEI anticipates any legacy expenditures after fiscal year 2027.

Response:

FEI anticipates some limited legacy expenditures after the end of 2027 under the Performance Program - New Buildings. The terms and conditions of the program allow projects to complete up to 5 years after initial commitment, aligning with common construction schedules. Therefore, customers who applied to the program in 2023 would have until 2028 to complete their project and apply for an incentive. No other programs would have legacy expenditures after 2027.

C. COST EFFECTIVENESS

11.0 Reference: LEGACY EXPENDITURES COST-EFFECTIVENESS METHODOLOGY

Exhibit B-2, Section 6.2, p. 36; Appendix E, pp. 21-23; FEI Application for Acceptance of Demand-Side Management Expenditures Plan for 2023 Decision and Order

G-45-23 (FEI 2023 DSM Decision), p. 16; BC Hydro 2021 IRP Proceeding, Exhibit B-39,

Appendix L1, p. 1

Modified Total Resource Cost Test

On page 36 of the Application, FEI states: "The Legacy Expenditures proposed result in a Program Area blended TRC test cost-effectiveness of 1.5."

In Appendix E to the Application, FEI presents the Legacy Expenditures Cost-Effectiveness Methodology.

On page 21 of Appendix E to the Application, FEI states: "FEI's proposed DSM portfolio for 2023 is cost effective, with a Portfolio (TRC/MTRC [Total Resource Cost/ Modified Total Resource Cost] hybrid) cost effectiveness result of 1.4 based on the methodology set out in section 4 of the [Prior to June 2023] DSM Regulation."

On page 22 of Appendix E to the Application, FEI states: "To ensure that the portfolio meets a combined TRC/MTRC of 1 on an annual basis, FEI will continue its practice of monitoring DSM programs on a monthly basis."

On page 23 of Appendix E to the Application, FEI states: [6]

> At the time of writing, the ZEEA value used in the MTRC calculation is $106/MWh[15], or 29.45/GJ. The source for this number is BC Hydro's Waneta 2017 Transaction Application to the BCUC that established BC Hydro's LRMC at $106/MWh in F2018$.[16] This value is consistent with the value used to calculate the MTRC for FEI's DSM 2021 Annual Report. For Low Income programs the ZEEA is applied when calculating the TRC (see Section 7.1.2).

On the same page, FEI states:

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6 According to the Guide to the DSM Regulation, p. 5, the calculation of the MTRC uses a Zero-Emission Energy Supply Alternative or ZEEA to determine the avoided cost of energy which is applied to the energy savings to determine the overall customer benefits. Section 4(1.1)(a) of the DSM Regulation before the June 2023 amendment, described the ZEEA as the amount the BCUC "is satisfied represents [BC Hydro's] long-run marginal cost of acquiring electricity generated from clean or renewable resources in British Columbia."

FEI notes that BC Hydro has suggested a new, lower LRMC value in their 2021 Integrated Resource Plan, but since BC Hydro's Integrated Resource Plan remains under review by the BCUC, FEI has not included it for the purposes of the one-year DSM Plan, as it has yet to be determined, per the DSM Regulation, that "the commission is satisfied" that this new value "represents the authority's long-run marginal cost of acquiring electricity generated from clean or renewable resources in British Columbia".

On page 16 of the FEI 2023 DSM Decision, the BCUC stated with respect to the ZEEA value:

> The Panel does not consider that the $54/MWh lower cost point of marginal cost is a reasonable value for the purposes of the ZEEA, as that figure was provided as a range of $54 to $80/MWh in BC Hydro F2022 Revenue Requirement Application. The Panel prefers to consider the more recent ZEEA estimate of $65/MWh in the IRP Application. Regardless, we consider that the DSM Portfolio is cost-effective under the three options put forward in this proceeding – the FEI value in the Application of $106/MWh, the $67/MWh mid-value of the range of values from the BC Hydro F2022 Revenue Requirement Application, and the value in the most recent BC Hydro 2021 IRP of $65/MWh.

In Appendix L of the recent Signposts Update (Exhibit B-39) in the BC Hydro 2021 IRP Proceeding, BC Hydro has provided an updated long run marginal cost of $70/MWh.

11.1 Please confirm, or explain otherwise, that FEI used a ZEEA value of $106/MWh to calculate the mTRC for the Legacy Program Area.

Response:

Confirmed. FEI used a ZEEA value of $106/MWh, or $29.45/GJ, to calculate the mTRC for the Legacy Program Area.

11.2 Assuming ZEEA values of both $106 and $70/MWh, please provide the TRC and MTRC results in a table for:

- the Legacy program area overall, and
- for the subcategories Residential, Commercial, Low Income and Indigenous programs.

Response:

The table below provides the TRC and mTRC results for the Legacy Program Area as well as the requested subcategory programs using ZEEA values of both $106/MWh and $70/MWh.

Table 1: Legacy Program Area TRC and MTRC Results

	$106/MWh		$70/MWh	
	TRC	MTRC	TRC	MTRC
Legacy Residential	0.3	1.3	0.3	0.8
Legacy Commercial	0.6	1.6	0.5	1.1
Legacy Low Income	2.5	2.5	1.7	1.7
Legacy Indigenous	1.1	1.1	0.7	0.7
Legacy Program Area	**0.5**	**1.5**	**0.4**	**1.0**

As shown in the table above, the proposed Legacy Expenditures portfolio in the 2024-2027 DSM Plan is cost-effective as it has a blended program area TRC of 1.0 at $70/MWh ZEEA.

11.3 Please indicate the proportion of the Legacy expenditures that rely on the MTRC to achieve a score of 1.0 or above.

Response:

In the Legacy Program Area, only the Legacy Residential and Legacy Commercial programs rely on the mTRC. The mTRC is not applicable to and, therefore, not calculated for, the Legacy Low Income and Legacy Indigenous programs. However, as the Legacy Residential and Legacy Commercial programs make up 90 percent of the Legacy Program Area's budget, the proportion of the Legacy expenditures that rely on the mTRC to achieve a score of 1.0 or above is 90 percent. Further, the mTRC expenditures are less than 10 percent of the overall DSM Plan portfolio.

11.4 Please provide a legacy expenditures portfolio broken down by subcategories (e.g. residential, commercial, etc.) that considers a ZEEA value of $70/MWh and that has a cost-effectiveness (blended TRC/MTRC) of at least 1.0.

Response:

The proposed Legacy Expenditures Program Area continues to be cost-effective using a ZEEA of $70/MWh. The Legacy Program Area expenditures would remain unchanged from what is presented in Exhibit 21 of the DSM Plan Report in Appendix A.

11.5 Please elaborate on the consequences for FEI or to its customers if FEI does not honour its DSM commitments covered by the Legacy program area.

Response:

FEI intends to honor its commitments, as enabled under section 5 of the amended DSM Regulation, through the 2024-2027 DSM Plan. The following consequences would occur if FEI did not honor the commitments covered by the Legacy Program Area:

- Loss of forecast FEI energy savings and emission reductions with lost participation.
- Loss of forecast FEI expenditures with lost participation.
- Planned projects may not go forward or backslide into lesser efficient options without expected incentives.
- Direct financial impact to customers who have paid for legacy energy efficiency projects assuming an incentive was available at the time of their purchasing decision.
- Loss of customer trust and likely lower future participation from customers having a negative experience being deterred from participating in FEI programs or other energy efficiency and decarbonization programs.
- Loss of trade ally trust and likely lower future participation from trade allies having a negative experience with promoting FEI programs or other energy efficiency and decarbonization programs to their customers.
- Larger disturbance in the market for trades and contractors, with mixed messaging and short notice.
- Slower uptake in advanced measures that come into market, as there will be a gap with program offers. This was experienced when FBC's electric DSM offers were removed from market with short notice. It took several years to regain similar participation numbers after they were reintroduced.

12.0 Reference: THE DSM PLAN IS COST-EFFECTIVE

Exhibit B-2, Section 3, p. 9; Section 6.1, pp. 33-34; Appendix A, p. 7; Appendix B-1

Cost-Effectiveness: Utility Cost Test

On page 9 of the Application, FEI states:

> In accordance with section 3 of the June 2023 update to the DSM Regulation, the avoided cost of gas that FEI used to calculate cost-effectiveness in the DSM Plan (with the exception of Legacy Expenditures) is equal to $34.07 per GJ in the 2023/2024 fiscal year (and <u>increases each year by the annual average All-items Consumers Price Index for British Columbia</u>), plus the avoided cost which is calculated based on the estimated avoided cost of distribution in 2023 of $0.59/GJ (increases by 2.4 percent each year to account for estimated inflation). [Emphasis added]

On page 7 of Appendix A to the Application, Posterity Group states:

> The avoided cost of renewable natural gas (RNG), as well as hydrogen, synthesis gas and lignin (together, referred to as renewable and low-carbon gas) is calculated based on the $34.07/GJ maximum cost under Section 9 of the Greenhouse Gas Reduction Regulation (GGRR) (converted to F24), <u>increased by 2.4% to account for estimated inflation in 2024</u>.
>
> The avoided cost of distribution starts at $0.60/GJ in Year 1 (2024). The avoided cost is calculated based on the estimated avoided cost of distribution in 2023 of $0.59/GJ, increased by 2.4 percent to account for estimated inflation in 2024. [Emphasis added]

On the same page, Posterity Group adds:

> The inflation rate is assumed to be 2% for administration, communications, and evaluation expenditures for all years. For labour expenditures, the inflation rate for each year is assumed to be 3.3% (2025), 3.0% (2026) and 3.0% (2027). Note that the inflation rate was only applied to non-incentive expenditure. Incentive expenditures are forecasted for the year they are provided and do not inflate.

On page 33 of the Application, FEI states:

> FEI's proposed DSM portfolio for 2024-2027 is cost effective, with a portfolio UCT cost-effectiveness result of 2.1 based on the methodology set out in section 4 of the DSM Regulation. A score of 2.1 passes the threshold of 1.0 at the portfolio level, meaning the benefits from DSM to the avoided acquisition of renewable and low-carbon gases exceed the Utility's incentive and administration cost for the proposed DSM portfolio of programs.

On pages 33 and 34 of the Application, FEI states:

The UCT is calculated as follows:

$$UCT = \frac{\sum_{2024}^{2027}[NPV\ of\ NG\ Savings\ Using\ Avoided\ Cost\ of\ RNG\ Energy\ \&Distribution(\$)]}{\sum_{2024}^{2027}[Incentives + Non\ Incentive\ Costs\ (\$)]}$$

The first UCT formula uses the "NPV of natural gas savings using the avoided cost of RNG Energy & Distribution ($)," which is calculated for each year from 2024-2027 as follows:

$NPV\ of\ NG\ Savings\ Using\ Avoided\ Cost\ of\ RNG\ Energy\ \&\ Distribution$ ($)

= $NG\ Savings\ (GJ) \times Cumulative\ Cost\ of\ RNG\ at\ the\ Measure\ Lifetime$ ($)

In Appendix B-1 to the Application, FEI presents the "Sources for Measure Assumptions" which includes gas and electricity savings.

12.1 Please clarify whether the update of the avoided cost of gas used the annual average All-items Consumers Price Index for British Columbia or if it used another measure of inflation equivalent to 2.4 percent.

Response:

As stated in the Application at Section 3, page 9, FEI used the All-items Consumer Price Index (CPI) for the avoided cost of renewable and low-carbon gas energy and distribution.

12.2 Please discuss FEI's rationale for using multiple rates of inflation (one rate for administration, communications and evaluation, another rate for labour, and no inflation for incentive expenditures), the sources of information to forecast these distinct levels of inflation and the calculation of average inflation.

Response:

Consistent with past approved DSM expenditure plans, incentive expenditures are not affected by inflation, thus no inflation factor was applied. For non-incentive expenditures, which are affected by inflation, FEI uses the forecast of BC-CPI for non-labour related costs, such as administration, communication, and evaluation costs and uses the forecast of BC AWE for labour (i.e., salary) related costs.

The BC-CPI forecast is based on the average forecast from Canadian Chartered banks (including TD Bank, Royal Bank of Canada, Bank of Nova Scotia, Bank of Montreal, and Canadian Imperial Bank of Canada) as of April 2023, the Conference Board of Canada (CBOC) long-term forecast

(2023), and BC Ministry of Finance (2023 Budget). The annual inflation forecast of 2 percent also agrees with the inflation control target set by the Bank of Canada.[7]

The BC-AWE forecast is based on the forecast from the CBOC as well as the BC Ministry of Finance (2023 Budget).

12.3 Please explain how FEI determines the avoided cost of distribution.

Response:

The avoided cost of distribution is a per gigajoule cost and is a proxy for the avoided incremental system improvement costs associated with adding additional load. The calculation for the avoided cost of distribution is consistent with the System Improvement (SI) factor in FEI's Main Extension (MX) Test.

The table below shows the calculation for the avoided cost of distribution for 2023.

Table 1: Avoided Cost of Distribution Calculation

Line	ITEM	2023	Reference
1	Increase to Peak Day 5 Year Forecast - TJs	67.0	
2	System Improvement 5 Year Forecast - $millions	62.287	
3	Investment Cost per GJ of Peak Capacity - $/GJ	$ 929.66	Line 2 / Line 1
4	5 Year Average Forecast Load Factor	0.301	
5	Investment Cost per GJ of Annual Capacity - $/GJ	$ 8.45	Line 3 / (Line 4 *365)
6	Carrying Cost per $1000	$ 69.67	
7	Levelized Distribution Cost Avoided - $/GJ	$ 0.59	Line 5 x (Line 6 / 1000)

12.4 Please elaborate on whether FEI considers electricity savings or increases in its calculation of UCT, and, if so, explain how. If not, please discuss whether and how FEI assesses the extent to which a measure leads to a reduction in overall energy consumption.

Response:

No, FEI's UCT calculation does not consider electricity savings or increases. However, FEI does capture the savings and increases of electricity, and other energy sources, for all measures so

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[7] https://www.bankofcanada.ca/rates/indicators/key-variables/inflation-control-target/.

that it can calculate other cost-effectiveness tests and assess whether a measure leads to a reduction in overall energy consumption.

12.5 Please explain how FEI calculates cost-effectiveness of measures that use dual or multi-fuel systems, including assumptions regarding the "baseline" equipment or system which might otherwise be in use...

Response:

Please refer to Section 6.1 of Appendix A to the Application which describes how FEI calculates the UCT cost-effectiveness.

FEI calculates the cost-effectiveness of measures that use dual or multiple-fuel systems using the same approach as other DSM measures. Assumptions regarding baseline equipment vary by project scenario. For example, for end-of-life retrofits and new construction, baseline equipment will be the minimum code-complaint gas equipment. In contrast, for early replacement projects, baseline equipment will typically be the existing gas equipment.

For the UCT and RIM, the only savings in the equation are the gas savings. The annual gas savings are equal to the annual gas consumption of the baseline measure, less the annual gas consumption of the dual or multiple-fuel systems. For TRC and PCT, the electricity and other fuel savings, as well as the additions of the dual or multi-fuel system, must also be considered.

12.6 Please discuss how FEI calculates cost-effectiveness of measures that may lead to natural gas and/or electricity energy savings due to improvements in the building envelope, insulation, or similar.

Response:

Please refer to Section 6.1 of Appendix A to the Application which describes how FEI calculates the UCT cost-effectiveness.

FEI calculates the cost-effectiveness of building envelope measures using the same approach as other DSM measures. There are two key methods of estimating the gas savings of building envelope measures:

1. **Prescribed:** For smaller, simpler building envelope retrofits, FEI programs generally use a prescribed savings approach. Deemed gas and/or electricity savings values are assigned to common, known retrofits that have been extensively studied and/or evaluated from existing studies, technical resource manuals, and/or program evaluations. An

example of this would be blown-in attic insulation under the Home Retrofit Renovation Program. For that measure, FEI employs climate zone-dependent gas and electricity savings values for a known R-value and installation area.

2. **Modeled:** For larger, more complex building envelope retrofits, FEI programs typically require the customer to provide a study or evaluation of the proposed building retrofit project that is completed by a qualified professional. For these projects, FEI may conduct additional evaluation on the studies or evaluations for reasonableness and accuracy and then calculates the gas and/or electricity savings by subtracting the modeled post-retrofit savings from the existing pre-retrofit consumption.

12.7 Please provide per program area, the UCT scores with a subtotal for advanced DSM measures.

Response:

The table below provides the UCT for program areas that report energy savings, with a subtotal for advanced DSM measures provided in the right-most column.

Table 1: Program Area UCT and Advanced DSM Measures UCT

Program Area	Program Area UCT	Program Area UCT (Advanced DSM Measures Only)
Residential	2.0	1.2
Commercial	4.5	4.9
Industrial	11.0	-
Low Income	2.4	2.3
Indigenous	3.2	2.5
Legacy Expenditures	2.3	-

13.0 Reference: COST EFFECTIVENESS

Exhibit B-2, Appendix B, p. 1; National Energy Screening Project, *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources*, Appendix E, August 2020, pp. E4-E5

Participant Cost Test

In Exhibit 1 of Appendix B to the Application, Posterity Group provides a Participant Cost Test (PCT) score of 0.9 for the overall DSM Portfolio.

In Exhibit 2 of Appendix B to the Application, the PCT score is 0.8, 1.6, 1.4 and 1.1 for the Residential, Commercial, Industrial and Legacy Expenditures respectively.

According to the National Standard Practice Manual, [8] the PCT is intended to indicate whether the benefits of a DSM program will exceed its costs from the perspective of the program participant. It includes all costs incurred by the host customer to install, operate and maintain the measure, and all benefits including incentives, bill savings and non-energy benefits. The PCT can have value for the purpose of informing program design (e.g. the level of incentives to offer prospective participants and/or the need for marketing to better inform participants of non-energy benefits that may add value) by providing insight into energy bill impact on participants.

13.1 Please clarify if the PCT score includes only incentives payable from FEI, or if other incentives payable to the participant are also included.

<u>Response:</u>

The calculation of PCT for FEI's DSM programs only considers incentives payable from FEI to the participant.

13.2 Where the PCT score for residential participants is below 1.0, please provide FEI's view on the impact this may have on participation rates, and in turn on the achievability of the forecasted expenditures and gas savings.

<u>Response:</u>

Please refer to the corrected values for the Portfolio PCT provided in the Errata to the Application filed concurrently with these responses. FEI notes an error in the calculation of the Portfolio PCT provided in Exhibit 1 of Appendix B-1 to the Application. The error was a result of a cell reference error in the cost-effectiveness calculation.

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8 National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources, Appendix E, pp. E4-E5, https://www.nationalenergyscreeningproject.org/national-standard-practice-manual/.

The PCT is a purely economic screen of FEI incentives versus the cost and the anticipated energy savings of the measure. In many cases the measure may still be a net benefit to the customer. The following are some other considerations that can make a lower PCT measure a net benefit to customers:

- **Third Party Incentives:** Customers may access third party incentives that improves the net economic benefit of a measure, but FEI does not consider these incentives in its PCT calculation. Please refer to the response to BCUC IR1 3.2 that details why it is challenging for FEI to rely on third party incentive programs to assess the economic viability of its incentives.
- **Non-Economic Benefits:** The PCT ignores other externalities like comfort, resilience, environmental benefits, benefits of adding space cooling, and other customer preferences. These all have value but are difficult to quantify and are also not included in the National Standard Practice Manual PCT methodology.
- **Alternative Measure Comparators:** Cost-effectiveness tests, including the PCT, compare a measure against a similar code-compliant gas alternative, but ignore other market alternatives, such as fuel-switching measures. In addition, some municipalities may have by-law restrictions that restrict the implementation of the base case measure.
- **Conservative Costing:** FEI takes a conservative approach with assessing the costs and savings of measures, particularly for newer measures. These conservative values are appropriate in DSM planning but should not be considered a surrogate for a detailed customer evaluation of project economics.

Ultimately, the PCT can be used as an economic screen for customer acceptance but should not be used as the sole indicator of whether incenting a measure is in the customer's best interest. If all other factors are equal, measures with a lower PCT may have lower participation than measures with a higher PCT. However, the participation numbers forecasted in the DSM Plan, which underly the expenditures and savings assumptions, are based directly on customer and trade ally feedback. This includes measures and programs that have lower PCT values.

13.3 Please discuss whether it is in the interests of persons that receive service from FEI for FEI to offer DSM programs that may not provide a net benefit to participants.

<u>Response:</u>

Please refer to the response to BCUC IR 13.2.

13.4 Please discuss the extent to which FEI's previous DSM expenditure schedules have forecasted PCT scores of below 1.0 at a portfolio or measure level.

Response:

The 2019-2022 DSM Plan period was the first period where FEI forecasted and reported PCT at the portfolio, program area, program and measure level. Since 2019, FEI has not forecasted a PCT score below 1.0 at the portfolio, program area or program level. However, FEI has included some measures in programs as part of the 2023 DSM Plan that estimated a PCT below 1.0. These measures include:

Residential

- Mid-efficiency furnaces
- Boilers
- High performance windows and doors

Low Income

- Boiler
- Small Commercial New Construction
- Step 5 New Construction - Single Family Dwelling

Commercial

- Mid-efficiency furnaces
- Kitchen Demand-Control Ventilation
- Condensing Unit Heaters
- Gas Heat Pump
- Small Commercial New Construction

13.5 Please provide a table showing the PCT results for the advanced DSM measures contemplated by FEI such as gas heat pumps, dual fuel hybrid heating systems and deeper retrofits.

Response:

FEI provides a table showing the PCT results for the advanced DSM measures below.

Table 1: PCT Results for Advanced DSM Measures

Program	Measure	PCT
Residential Home Reno	Whole Home Performance	1.3
Residential Home Reno	Hybrid (Dual-Fuel) Systems	0.8
Residential New Home	Step 4 detached home - hybrid	0.6
Residential New Home	Step 4 row home - hybrid	0.7
Residential New Home	Step 5 detached home - hybrid	0.5
Residential New Home	Step 5 row home - hybrid	0.6
Commercial Prescriptive	Hybrid Dual Fuel RTUs	1.3
Commercial Prescriptive	Hybrid Dual Fuel Hydronic Systems	3.3
Commercial Prescriptive	Gas Heat Pumps	1.4
LI Prescriptive	Commercial - Gas Heat Pump	1.3
LI Prescriptive	Residential - Hybrid (Dual-Fuel) Systems	1.8
LI Prescriptive	Commercial – Hybrid (Dual-Fuel) Systems	1.7
Indigenous Prescriptive	Commercial - Gas Heat Pump	0.9
Indigenous Prescriptive	Whole Home Performance	1.2
Indigenous Prescriptive	Residential - Hybrid (Dual-Fuel) Systems	1.5
Indigenous Prescriptive	Commercial - Hybrid (Dual-Fuel) Systems	1.0
Indigenous Performance	Step 4 detached home - hybrid	0.8
Indigenous Performance	Step 4 row home - hybrid	0.9
Indigenous Performance	Step 5 detached home - hybrid	0.6
Indigenous Performance	Step 5 row home - hybrid	0.7

14.0 Reference: Cost Effectiveness

Exhibit B-2, Appendix B, p. 1; National Energy Screening Project, *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources*,

Appendix E, August 2020, pp. E5-E6

Ratepayer Impact Measure

Exhibit 1 on page 1 of Appendix B to the Application shows an overall Ratepayer Impact Measure (RIM) score of 0.7 for the portfolio.

Exhibit 2 on page 1 of Appendix B to the Application shows RIM scores of 0.7, 0.8, 0.9 and 0.1 for the Residential, Commercial, Industrial and Legacy Expenditures respectively.

According to the National Standard Practice Manual, [9] the purpose of the RIM test is to indicate whether a resource will increase or decrease rates. This test includes all the benefits and costs of the UCT, plus estimates of the utility lost revenues created by DER programs. The RIM test is designed to address rate impacts and therefore answers fundamentally different questions than a cost-effectiveness analysis (such as the UCT). It indicates only whether long-term rates will increase or decrease on average.

14.1 Please discuss why the RIM result for Legacy expenditures is so much lower than the other programs.

Response:

FEI notes an error in the calculation of the RIM values provided in Exhibit 1 and 2 of Appendix B-1 to the Application. The error was a result of a cell reference error in the cost-effectiveness calculation. FEI has issued an Errata to the Application filed concurrently with these responses. FEI has not made any changes to the way the RIM is calculated between this Application and earlier DSM Expenditure Schedules.

The pre- and post-correction RIM values are presented in the table below.

Table 1: RIM Values Pre- and Post-Correction

RIM	Before Correction	After Correction
Portfolio	0.7	0.3
Residential	0.7	0.2
Commercial	0.8	0.5
Industrial	0.9	0.8
Legacy	0.1	0.3

[9] National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources, Appendix E, pp. E5-E6, https://www.nationalenergyscreeningproject.org/national-standard-practice-manual/.

Please note that the RIM scores (both pre- and post-correction) above use the avoided cost of conventional gas to calculate the utility benefits of energy savings. The last column in the table below shows the RIM scores if the avoided cost of RNG was used to calculate the benefits instead. RIM using the avoided cost of conventional gas can be considered an evaluation of how the rates are impacted in the short-term, while RIM using the avoided cost of RNG can be considered an evaluation of how the rates may be impacted in the long-term as FEI transitions its energy supply to be predominantly renewable and low-carbon gases.

Table 1: RIM Values Post-Correction Using Avoided Cost of Conventional Gas and Avoided Cost of RNG

RIM	Post-Correction – Using Avoided Cost of Natural Gas	Post- Correction – Using Avoided Cost of RNG	2022 FEI DSM Annual Report	2023 FEI DSM Expenditure Plan
Portfolio	0.3	1.6	0.5	0.4
Residential	0.2	1.5	0.4	0.3
Commercial	0.5	2.7	0.2	0.7
Industrial	0.8	4.6	0.8	1.0
Legacy	0.3	Not applicable	Not applicable	Not applicable

The corrected RIM for Legacy Expenditures is in line with the RIM of other program areas. The corrected RIM is also similar to the RIM reported in the 2022 FEI Annual DSM Report and forecasted in the 2023 FEI DSM Expenditures Plan.

14.2 Given the low RIM result for the legacy expenditures, please explain why it is in the interests of persons served by FEI to fund legacy expenditures.

Response:

Please refer to the response to BCUC IR1 14.1 and Errata to the Application which provides updated Legacy Expenditure RIM results. Please also refer to the response to BCUC IR1 11.5 for further information regarding the consequences of not honoring legacy commitments.

FEI notes the amended DSM Regulation does not permit the BCUC to use the RIM to assess cost-effectiveness, and therefore the BCUC may not disallow legacy expenditures based on RIM results.

14.3 Please clarify if FEI had made any changes to the way the RIM is calculated between this Application and earlier DSM Expenditure Schedules.

Response:

Please refer to the response to BCUC IR1 14.1.

D. EVALUATION, MEASUREMENT AND VERIFICATION

15.0 Reference: Evaluation, Measurement and Verification

Exhibit B-2, Section 7, p. 37; Appendix F, Table F-1, p. 3

Evaluation

On page 37 of the Application, FEI states that:

> as more programs reach maturity and enough program data becomes available, FEI will complete more program impact and process evaluations at a schedule consistent with the EM&V Framework. …In Appendix F to the Application, FEI provides its DSM Evaluation Plan covering 2024-2027 and addressing EM&V activities, including evaluations for process, impact, market analysis and communications, as well as measurement and verification activities for its current and planned DSM programs and pilots. The total proposed expenditure for the program evaluation and M&V activities to be conducted from 2024-2027 is approximately $11.3 million or 2 percent of FEI's overall planned portfolio expenditures.

Table F-1 on page 3 of Appendix F to the Application outlines the type of evaluation of activities for each program.

15.1 Please provide the earliest anticipated timing for each of the evaluation activities in Table F-1.

Response:

FEI's timing for program evaluation activities varies and is generally staggered. Evaluations can span multiple years from start to completion. FEI provides a revised version of Table F-1 below, including two columns for "Previous Evaluation Dates" and "Earliest Planned Project Timing".

1

Program	Previous Evaluation Dates	Earliest Planned Project Timing	Program Area	Type of Evaluation or Activities	Program Partners	Proposed 4 Year Budget (000's)
Home Renovation Rebate Program	2023	2025	Residential	Evaluation Studies, Market Studies, Process & Impact	BC Hydro, FortisBC Inc., Municipal, Provincial and Federal Government	$608
New Home Program	2023	2025	Residential	Market Studies, Process & Impact	BC Hydro, FortisBC Inc., NRCan, Provincial and Municipal Government	$80
Prescriptive Program	2022	2024	Commercial	Market Studies, Process & Impact	FortisBC Inc.	$200
Performance Program - Existing Buildings	2023	2025	Commercial	Process & Impact, Measurement & Verification	FortisBC Inc.	$600
Performance Program - New Buildings	2023	2025	Commercial	Process & Impact, Measurement & Verification	FortisBC Inc.	$400
Rental Apartment Efficiency Program	2023	2025	Commercial	Process & Impact	FortisBC Inc.	$188
Performance Program	2023	2025	Industrial	Process, Measurement & Verification	FortisBC Inc.	$500
Prescriptive Program	2023	2025	Industrial	Measurement & Verification	FortisBC Inc.	$100
Direct Install Program	2023	2025	Low Income	Process & Impact, Evaluation Studies	BC Hydro, FortisBC Inc.	$1,792
Self Install Program	2023	2025	Low Income	Process & Impact	BC Hydro, FortisBC Inc.	$80

Program Name	Previous Evaluation Dates	Earliest Planned Project Timing	Program Area	Type of Evaluation or Activities	Program Partners	Proposed 4 Year Budget (000's)
Prescriptive Program	2023	2025	Low Income	Process & Impact	None	$128
Support Program	N/A	2024	Low Income	Process	None	$12
Performance Program	N/A	2024	Low Income	Process & Impact	None	$0
Prescriptive Program	N/A	2024	Indigenous	Process & Impact	FortisBC Inc.	$70
Performance Program	N/A	2024	Indigenous	Process & Impact	FortisBC Inc.	$70
Customer Education and Outreach Programs	2023	2025	Customer Education and Outreach	Process & Impact	FortisBC Inc.	$1,003
Pilot Projects	2023	2025	Innovative Technology	Measurement & Verification	None	$2,930
Customer Research	2023	2025	Enabling Activities	Communications	None	$700
Commercial Energy Specialist	2023	2025	Enabling Activities	Process & Impact	FortisBC Inc.	$215
Community Energy Specialist	2022	2024	Enabling Activities	Process & Impact	FortisBC Inc.	$140
Codes & Standards	2023	2025	Enabling Activities	Process	none	$284
Trade Ally Network	2023	2025	Enabling Activities	Evaluation Studies	none	$1,260

15.2 Please discuss if FEI conducts evaluations of new measures individually, and if not, why not.

Response:

No, FEI only conducts program-focused process and impact evaluations on existing programs as per the EM&V Framework. FEI evaluates new measures within the context of evaluating the in-market programs themselves.

Please refer to the response to BCUC IR1 1.4 for a description of how new measures are assessed and incorporated into programs.

15.3 Please explain if and when FEI intends to undertake reviews of advanced DSM measures such as gas heat pumps, and integrated dual fuel systems.

Response:

FEI intends to conduct evaluation activities for programs that include advanced DSM measures in accordance with the EM&V Framework and the proposed DSM Evaluation Plan for 2024-2027. Please refer to the response to BCUC IR1 15.1 for the anticipated timing for evaluating FEI programs.

15.4 Please describe the review FEI undertakes of new measures, such as advanced DSM after the pilot stage, and how the results of these reviews are used to adjust the measure-level assumptions.

Response:

Please refer to the response to BCUC IR1 1.4 for how FEI undertakes the review of new measures.

FEI typically adjusts measure-level assumptions over time through program evaluation activities conducted in accordance with the EM&V Framework. For several advanced DSM measures early in their market adoption (e.g., gas heat pumps, dual-fuel hybrid heat pumps and deep retrofits), pilots are on-going after their initial review to continue to improve measure-level assumptions and better characterize technical and market barriers. This is typically done to reflect new models and evaluate better operational and control strategies for those measures.

E. ADDITIONAL APPROVALS SOUGHT

16.0 Reference: ADDITIONAL APPROVALS SOUGHT

Exhibit B-2, Section 8.1.3, pp. 40–41; Appendix C; FEI Application for Acceptance of Demand-Side Management Expenditures Plan for 2023, Decision and Order G-45-23 (FEI 2023 DSM Decision), pp. 22-23

Total Portfolio Variance Allowance

On page 40 of the Application, FEI states:

> FEI is seeking approval to continue the allowed variance of no more than five percent above the accepted DSM expenditures amount in the final year of a DSM expenditures schedule without prior approval from the BCUC. This was previously approved as part of its 2023 DSM Plan in Order G-45-23. In the case of the DSM Plan, this would mean FEI has flexibility to vary from the 2027 approved expenditures by up to $31.3 million.

On pages 40 and 41 of the Application, FEI adds:

> Therefore, FEI is requesting to continue the following variance allowance rule for the DSM Plan:
>
> > *FEI is permitted to exceed total accepted expenditures in the final year of a DSM expenditure schedule by no more than five percent without prior approval from the BCUC.*
>
> Overall, the funding transfer rules and the variance allowance described above will all serve to provide FEI with the flexibility to manage its DSM portfolio more effectively.

In Appendix C to the Application, FEI's proposed draft order, FEI proposes the following language for the approval request: "FEI is approved to exceed total accepted expenditures by no more than 5% without prior approval from the BCUC for the final year of the 2024-2027 DSM Expenditure Schedule."

On pages 22 and 23 of the FEI 2023 DSM Decision, the BCUC stated:

> **FEI is approved to exceed total accepted expenditures, in respect of the final year of the 2023 DSM Expenditure Schedule only, by no more than five percent without prior approval from the BCUC.**
>
> Given that this application is for a one-year period, the request for a variance allowance is different from the other changes sought to the transfer rules in that it may have more of an impact on programs than if it was for a multi-year expenditure schedule. FEI, in this Application, is seeking the BCUC's general approval for creation of a total portfolio variance of not more than five percent in the final year

> of a DSM expenditure schedule. However, this Application is limited to acceptance of only a one-year DSM expenditure schedule. While the Panel approves the variance sought in the context this Application, it is not comfortable with approving the variance on a general basis as applying to DSM expenditure schedules which are for longer than a one-year term. Such a general variance, should, in the Panel's view, be determined in the context of the evidence and submissions made on an application for a multi-year DSM expenditure schedule. This approval for one year will also provide a trial period for considering the impact of such a variance. [Emphasis added]

16.1 Please clarify if FEI is requesting a total portfolio variance allowance of 5 percent over the 2024-2027 DSM Expenditure Schedule or if it is requesting a variance allowance of 5 percent over the proposed final year of the 2024-2027 DSM Expenditure Schedule. Please also confirm the maximum amount in dollars that FEI is requesting as a variance allowance.

Response:

FEI clarifies that the 5 percent variance is over the proposed final year of the 2024-2027 DSM Expenditure Schedule. The $31.3 million figure in the Application was calculated in error and should be a variance request of $8.2 million (5 percent of the 2027 forecast expenditures of $164.8 million). Please refer to the corrected value provided in the Errata to the Application filed concurrently with these responses.

16.2 Please provide the rate impact of the proposed variance allowance in the event that FEI exceeds the approved expenditures by the full 5 percent (of the forecast 2027 expenditures, and total expenditures over the test period if appliable).

Response:

Please refer to the response to BCUC IR1 16.1 in which FEI clarifies that the proposed variance allowance is 5 percent of the final year of the 2027 DSM Expenditure (i.e., approximately $8.2 million).

Please refer to Table 1 below which shows that the delivery rate impact in 2028 would be approximately 0.12 percent when compared to FEI's approved 2023 delivery margin[10] if the proposed 2027 expenditure is overspent by 5 percent (i.e., approximately $8.2 million). For the average residential customer with consumption of 90 GJ per year, this is equivalent to a bill impact of approximately $0.86 in 2028, when compared to current 2023 approved rates.

[10] Approved on an interim basis by Order G-352-22.

Table 1: Delivery Rate Impact of 5 Percent Overspend of the 2027 DSM Plan Expenditure

Line	Particular	Reference	2027	2028
1	**Rate Base DSM Deferral Account**			
2	Opening ($000s)	Prior Year, Line 8	-	-
3	Adjustments	Transfer from non-rate base	-	6,182
4	Gross Additions		-	-
5	Tax	-Line 4 x 27%	-	-
6	Net Additions	Line 4 + Line 5	-	-
7	Amortization	Amortization Period @ 10 years	-	(618)
8	Closing ($000s)	Line 2 + Line 6 + Line 7	-	5,564
9				
10	Mid-Year Rate Base ($000s)	(Line 2 + Line 8) / 2	-	5,873
11				
12	**Non-Rate Base EEC Incentive Deferral**			
13	Opening Deferral	Prior Year, Line 19	-	6,182
14	Adjustments	Transfer to rate base	-	(6,182)
15	Gross Additions		8,242	-
16	Tax	-Line 15 x 27%	(2,225)	-
17	AFUDC	((Line 15 + Line 16) / 2) x 5.50%	165	-
18	Net Additions	Line 15 + Line 16 + Line 17	6,182	-
19	Closing Deferral	Line 13 + Line 14+ Line18	6,182	-
20				
21				
22	**Incremental Revenue Requirement**			
23	Amortization	-Line 7	-	618
24	Earned Return	Line 10 x FEI's Rate Base Return @ 6.23% (2023 Approved)	-	366
25	Income Tax Expense	(Line 10 x 8.75% x 38.5% + Line 23) / (1 - 27%) x 27%	-	302
26	Total ($000s)	Sum of Line 23 to 25	-	1,286
27				
28	2023 Approved Delivery Margin - Non-bypass ($000s)	G-352-22	1,044,103	1,044,103
29	Incremental Rate Impact (%)	Line 26 / Line 28	0.00%	0.12%

As approved by Order G-45-23, FEI records $60 million in the rate base DSM deferral account, effective 2023, with the remaining balance of the DSM expenditure recorded in the non-rate base DSM deferral account. As such, the 5 percent variance of approximately $8.2 million would be captured in the non-rate base DSM deferral account and would be transferred to the rate base DSM deferral account in the subsequent year (i.e., 2028) for recovery from customers through amortization; therefore, there would be no impact to 2027 rates.

17.0 Reference: ADDITIONAL APPROVALS SOUGHT

Exhibit B-2, Section 8.2 p. 41

Accounting Treatment

On page 41 of the Application, FEI states:

> Under the current approved treatment, $60 million of expenditures are forecast in the rate base DSM deferral account each year and the difference between the $60 million forecast and actual/projected expenditure levels, up to the approved amount, are accounted for in FEI's non-rate base DSM deferral account, attracting a weighted average cost of capital (WACC) return…. FEI's expenditures are forecast to continue to exceed $60 million for all years of the DSM Plan and FEI expects that at least that level of expenditures to be maintained for the foreseeable future.

17.1 Please explain the risk that FEI does not spend over $60 million per year in light of the changes to the Expenditure Schedule portfolio.

<u>Response:</u>

The risk of FEI not achieving DSM expenditures greater than $60 million per year is low. FEI's DSM expenditures have been consistently greater than $60 million every year since 2019. Additionally, there is no risk to FEI's customers in terms of rate impact if FEI does not spend over $60 million per year. As noted in the preamble, FEI is approved to include a *<u>forecast</u>* of $60 million of DSM expenditures in the rate base deferral account each year with the difference between the $60 million forecast and actual/projected spending of each year captured in the non-rate base deferral account. Therefore, if FEI does spend less than $60 million in any given year of the 2024-2027 DSM Plan, FEI will true-up the actual spending through the non-rate base deferral account, such that only the actual spending will be amortized into customer rates over a 10-year period. For example, if FEI incurs $40 million in actual expenditures in any given year, a credit of $20 million will be captured in the non-rate base deferral account such that only $40 million (i.e., $60 million forecast in the rate base deferral less $20 million credit in the non-rate base deferral[11]) will be amortized to customers in the following 10 years.

[11] Balance of non-rate base deferral will be transferred to rate base as opening balance adjustment in the following year.

Attachment 8.6

FORTIS BC

MEMO

To: C&EM Program Managers	**Date:** August 31, 2023
	From: Max Mathies P.Eng
Re. Dual Fuel Hybrid Heating System Energy Consumption and Efficiency Assumptions	**CC:** Mehmud Iqbal, Juan Mani, Bryce Millman

The purpose of this memo is to outline the assumptions and caveats associated with FEI's determination of the operating costs and system efficiencies for residential dual fuel hybrid heating systems included in the 2024-2027 DSM Plan. This memo shows how FEI's residential dual fuel hybrid systems offers show preliminary compliance with the seasonal coefficients of performance requirements of dual fuel hybrid systems in the amended DSM regulation. This memo will also compare dual fuel hybrid heating systems against a conventional high-efficiency furnace and fully electrified heat pump system.

To determine the energy consumption and efficiency of dual fuel hybrid heating systems, FEI created an artificial model based on actual measured data from high efficiency equipment, available Climate Zone 4 and 5 weather data, and first-principle engineering calculations. This model takes a conservative approach to the calculation of SCOP (i.e. may result is a lower value) in consideration of the number of independent variables from third-party sources considered.

Inputs and Assumptions

Where possible, inputs for the model came from empirical sources or studies performed by third party consultants. The following studies and data sources were referenced in these calculations:

- Heat pump coefficients of performance (COPs) were based on a recent study by the Government of Yukon evaluating the performance of cold climate central heat pumps in the Yukon.[1] Heat pump COP varies with outdoor air temperature, with the lowest temperature in this analysis being -14°C. While some heat pumps studies suggest higher COPs closer to the nameplate values, the Government of Yukon study appeared to apply an IPMVP-compliant methodology suitable for a conservative assumption.
- Furnace performance was taken to be 92%, from the steady state efficiency for a 96% efficient furnace at high fire at -12°C combustion air temperature[2]. This a conservative assumption.
- The average heating load for an average single-family home was taken from FEI's 2022 Residential End-Use Study (REUS), prepared by Sampson Research Inc.
- Weather data was retrieved from Natural Resources Canada (NRCan) weather stations 1108395 (Vancouver) and 1123939 (Kelowna), which were considered to be representative cities for Climate Zone 4 and Climate Zone 5, respectively.
- The price of natural gas was taken to be the sum of delivery, storage and transport, and cost of gas charges, per GJ, currently set for residential FEI customers of $10.23/GJ.

[1] Air-Source Heat Pump Monitoring Project Technical Report for 2021-2022, Government of Yukon. https://yukon.ca/sites/yukon.ca/files/emr/emr-air-source-heat-pump-monitoring-project-technical-report-2021-2022.pdf

[2] The Effect of Combustion Air Temperature on Gas Appliance Efficiency, prepared by CanmetENERGY for FortisBC.

- The current carbon tax was applied to the gas consumption, at the current price of $3.2384/GJ.
- The price of electricity was taken to be the Step 2 cost of electricity currently set by BC Hydro of $0.14/kWh.
- For the hybrid dual fuel system, switchover temperatures required by CleanBC were used: 5°C for Climate Zone 4, and 2°C for Climate Zone 5.
- An average indoor temperature was assumed to be 21°C during the heating season, which was defined as October 1 – April 30. This is a conservative assumption.
- Electricity consumption due to fan usage was not considered for any equipment due to lack of available data and comparable consumption across all three scenarios.

Approach

1. The baseline heating type was assumed to be a natural gas furnace, based on results from the FEI 2022 REUS. The heating load requirements were assumed to be equivalent to the current Primary Gas Space Heating unit energy consumption UEC (GJ/yr) as defined for single family detached homes in Table 217 of the FEI 2022 REUS, after adjusting for furnace efficiency. For Climate Zone 4, an average of results from the Lower Mainland and Vancouver Island were used. For Climate Zone 5, the value for the Interior region was used.
2. From NRCan, three years of hourly weather data was collected for Vancouver (Climate Zone 4) and Kelowna (Climate Zone 5). Where gaps in the data existed, the value was assumed to be the average of the next to closest actual values. The three years were averaged for each climate zone.
3. For each hour in the heating season, a temperature differential was taken between the indoor temperature and the outdoor temperature, and then divided by the total temperature differential to create an estimate of what percentage of the entire heating season would be required each hour. This value was then multiplied by the heating load requirements defined in the first step to create an estimate of the heating load required each hour.
4. From Figure 4 in the Yukon Cold Climate Heat Pump study, the average COP for each Participant was recorded for temperatures of -14°C to 10°C. For temperatures above 10°C, where empirical data was not available, the heat pump COP was extrapolated based on of the performance curve.
    a. Note that the BC Cold Climate Heat Pump study was not used for this analysis due to only having a single participant with a variable speed central heat pump, with the remaining being ductless heat pumps.
5. When estimating the heat pump performance, the outdoor air temperature during each given hour was used to develop the heat pump's COP based on the COP-temperature curve. The COP in turn was used to determine how much energy was required to provide the amount of heat in a given hour.
6. For each hour in the heating season, a check was made to see if the temperature was at, or above, the switchover temperature. If so, the heating load requirement for that hour was met with the heat pump using the approach defined in Step 5. If the outdoor temperature was below the switchover, the requirement was modelled as met by the furnace.
7. The operating costs were then taken by multiplying the kWh and GJ requirements by current utility rates and carbon tax, where applicable.

8. To estimate the SCOP for the hybrid dual fuel system, the total heating requirement for the heating season was divided by the sum of the combined electricity and natural gas consumption of the system.

Results

Equipment	Electricity Consumption (kWh/yr)	Gas Consumption (GJ/yr)	Est. Operating Costs ($/heating season)	Est. SCOP
Climate Zone 4				
New cold climate air source heat pump	6,688	0	$936	2.34
New variable speed modulating furnace	0	61	$823	N/A
New hybrid dual fuel system (switchover @ 5°C)	6,043	5	$918	2.07
Climate Zone 5				
New cold climate air source heat pump	8,149	0	$1,141	1.88
New variable speed modulating furnace	0	60	$808	N/A
New hybrid dual fuel system (switchover @ 2°C)	2,107	42	$854	1.12

Section 1.1 (2)(i) of the amended DSM Regulation requires that dual-fuel systems are required to have an aggregate SCOP greater than 1.5. If FEI conservatively assumes that at least 50% of participants will be from Climate Zone 4, the aggregate COP would be greater than 1.60. The result thus shows that residential dual fuel systems may be compliant with the SCOP requirements of the DSM regulation.

Limitations

This study should be interpreted as being a general indication of the energy consumption associated with high-efficiency heat pumps, furnaces, and hybrid dual fuel systems. The assumptions made may vary significantly depending on the housing stock, equipment used, and local climate of the proposed project and it is possible that the energy used in a given project may differ substantially from the findings from this study. Many of the inputs come from studies with small sample sizes, engineering calculations, and assumptions that may not be indicative of actual system performance.

FEI currently has pilots underway to better understand the operating costs and efficiencies associated with hybrid dual fuel heating systems that will better serve to inform actual performance of this equipment in Part 9 residential customer homes.

Commercial Hybrid RTU Market Research Report

FortisBC

Date: August 2, 2023

Project #: 2023151

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1. EXECUTIVE SUMMARY

This report summarizes a market research study of hybrid dual fuel rooftop units (RTUs). The study was conducted by Prism Engineering Limited (Prism) for FortisBC in support of the development of a prescriptive hybrid dual fuel rooftop unit rebate program for Part 3 buildings in British Columbia.

The objective of this study is to identify hybrid dual fuel rooftop units commercially available and to summarize the technical performance of these products. In addition to rated performance commonly reported with RTU products, the total heating system efficiency is defined by Prism in this study as the combined annual efficiency of the hybrid system.

This report provides a summary of hybrid dual fuel RTUs available in British Columbia at the time of this study, presents the technical characteristics of these units, and presents the methodology developed by Prism for determining total heating system efficiency of hybrid dual fuel RTUs across BC's climate zones.

In British Columbia, seven manufacturers offer hybrid dual fuel RTUs with standard efficiency gas heating, and one manufacturer offers dual fuel RTUs with high efficiency, condensing gas heating. There are also standard and condensing efficiency dual fuel RTUs that have optional heat recovery features.

The calculated total heating system efficiency of all RTUs included in this study reached over ~100% across all relevant climate zones. In the mildest climate zone (CZ 4), efficiency values reached up to 250%, while in a colder climate zone (C7 7B), efficiency values were approximately 100%. These efficiency values were calculated using lowest allowable heat pump enable/disable temperatures listed by manufacturers (-5 °C and below for all models). If a minimum heating system efficiency of 150% is a requirement of the program in milder climate zones (CZ-4 and 5), these lockout temperatures could be raised to around 3 °C in CZ-4 and -2 °C in CZ-5. If a minimum heating system efficiency of 100% is a requirement of the program in colder climate zones (CZ-6, 7A, 7B, 8), these lockout temperatures should be kept at the lowest lockout temperatures listed by the manufacturer (-5 °C and below).

The dual-fuel RTU with condensing efficiency gas-heating (RUPP) had higher performance values than the average of all standard efficiency dual-fuel units. The higher GAS heating efficiency provides some benefit, but other technical characteristics of this model also contribute to the higher total heating system performance.

Heat recovery also provides potential benefits on total heating system efficiency; however, as discussed in this report, the feasibility of heat recovery is largely dependent on building's air distribution configuration.

The findings of this study support the following recommendations for a prescriptive incentive program in British Columbia:

- Most hybrid dual fuel RTUs commercially available in British Columbia at the time of this study would be suitable for an incentive program that requires heating efficiency of at least 150% in CZ-4 and 5 and at least 100% in CZ-6, 7A, 7B, and 8.
- Units with condensing efficiency gas heating provide greater total heating system performance, but since standard-efficiency units already provide high performance, incentivizing the cost premium for condensing-efficiency units may not be justified.

- Total heating system efficiency and gas savings that a dual-fuel RTU can provide are sensitive to heat pump lockout temperature; therefore, if a goal of the program is to maximize gas savings or achieve minimum heating performance, prescribing a lockout temperature could support such a goal.
- Heat recovery is suitable for makeup air unit and typically required for heat pumps serving makeup air units. For RTUs, heat recovery can provide limited energy saving and performance benefits. In addition, feasibility of heat recovery depends largely on on-site conditions (and not the RTU itself) and may be suitable for a custom rebate program.

2. BACKGROUND AND METHODOLOGY

2.1 Contact Information

Client and consultant contacts pertinent to this project are in Appendix A.

2.2 Objectives

The objective of this market research study is to identify off-the-shelf and/or custom-made commercial hybrid dual fuel rooftop units (RTU) currently available and to characterize the RTUs according to pre-defined criteria. Beyond standard technical characteristics of RTUs, an objective of the study is to determine a total heating system efficiency value for dual fuel RTUs across relevant climate zones.

The findings from this market research will ultimately support the development of a prescriptive hybrid dual fuel rooftop unit rebate program for Part 3 buildings in British Columbia.

2.3 Future Project Phases

This market research report is Phase 1 of 3 of a larger project to provide FortisBC with consulting services for the development of Hybrid Dual Fuel RTU Program.

In Phase 2 of this project, Prism is using the dual fuel RTU project being implemented at 101 Martin Street in Penticton for the Regional District of Okanagan-Similkameen (RDOS) as a test project to evaluate real world performance of three condensing gas dual fuel RTUs.

The installation of these dual fuel RTUs is set for Fall 2023, at which point Prism will be conducting measurement and verification work to calculate the energy and greenhouse gas emissions savings resulting from dual fuel units.

Following Phase 1 and 2, a Program Recommendations Report will be developed by Prism for FortisBC, which will use the data and information collected during Phases 1 and 2 to provide recommendations for the development of a hybrid dual fuel RTU rebate program.

3. ANALYSIS METHODOLOGY

The study included product research, a review of technical characteristics, modelling of total heating system efficiency (combined heat pump and gas efficiencies) for all relevant Climate Zones, and cost estimation for equipment and installation.

3.1 Product Research & Technical Characteristics Review

Hybrid Dual Fuel Rooftop Units identified are categorized into the following efficiency options:

- Hybrid dual fuel RTU – Standard Efficiency gas heating
- Hybrid dual fuel RTU – Standard Efficiency gas heating with heat recovery
- Hybrid dual fuel RTU – Condensing Efficiency gas heating
- Hybrid dual fuel RTU – Condensing Efficiency gas heating with heat recovery

FortisBC and Prism collaboratively identified criteria by which to compare units identified. Technical specifications and equipment costing was gathered from suppliers. The technical characteristics reported for each RTU are described in the following sections.

Baselines for Hybrid Dual Fuel Rooftop Units

In the analysis of hybrid dual fuel RTUs, baseline units are standard-efficiency, gas-fired units with direct expansion (DX) cooling. The dual fuel and the baseline unit will have the same cooling capacity, which limits the capacity of the heat pump. Both units are assumed to have the same gas heating capacity, though the baseline unit is assumed to have standard efficiency (80%), while dual fuel units with both standard and condensing (90%) are compared.

Gas Heating Capacity and Efficiency

The available capacity and efficiency (annual fuel utilization efficiency (AFUE)) of the gas component in each dual fuel rooftop unit is reported.

Electrical Requirements

Available voltage, frequencies, and current ratings of the units are reported.

Heat Pump Cooling Capacity and Performance

Rated cooling capacity (in TonsR and MBH) and widely accepted performance metrics were acquired for the RTUs: Energy Efficiency Ratio (EER) and Seasonal Energy Efficiency Ratio (SEER) or Integrated Energy Efficiency Ratio (IEER). From the EER, the heat pump's cooling Coefficient of Performance (COP) was calculated and is reported.

Heat Pump Heating Capacity and Performance vs Outdoor Air Temperature

The heat pump's heating capacity and coefficient of performance (COP) is graphed as a function of outdoor air temperature (OAT). The performance reported and graphed includes the impact of defrost cycles.

Heating System Switch Over Temperatures and Sequence of Operation

The heat pump heating enabled/disabled switchover and defrost cycles enabled temperatures are reported. The sequence of operation, describing how the gas and heat pump heating modules are controlled (sequenced), is also summarized in the report where information was available at the time of this study. This sequence was built into the total heating system efficiency models for each RTU.

Total Heating System Efficiency

The key benefit of dual fuel RTUs compared to standard gas fired RTUs are higher efficiency and reduced greenhouse gas emissions associated with *heating*. Cooling systems will be essentially the same as non-hybrid units, since in both cases, a heat pump is used for cooling. In dual fuel units, the heat pump is also used for heating.

Total heating system efficiency was modelled according to the methodology outlined in Section 3.2.

An analysis was also done for RTUs with heat recovery option to model the impact on the total heating system efficiency.

Measured Life

Expected rooftop units useful service life is not reported by manufacturers; however, ASHRAE provides expected lifetime for various HVAC equipment, including rooftop air conditioners, which have an estimated lifetime of **15 years**[1].

Cost of Equipment and Installation

Prism obtained costing quotes from local suppliers for hybrid dual fuel RTUs to generate costs of standard and condensing efficiency units. The cost estimation is presented as $/tonR. Costs for a recent Prism RTU replacement project is also reported.

3.2 Total Heating System Efficiency

Hybrid Dual Fuel RTU total heating system efficiency is described in this study as the heating performance of the combined gas and heat pump performance. Therefore, total heating system efficiency is impacted by many of the RTU characteristics explored in this study, including:

- Gas heating efficiency;
- Heat recovery;
- Heat pump capacity and performance;
- Lockout temperature – the temperature below which heat pump heating is disabled; and
- Sequence of operation – when and how the RTU will operate heat pump and gas heating.

Total heating system efficiency will also vary by climate zone, as performance is impacted by:

- Outdoor air temperature, and
- The hours in a year spent at very cold outdoor air temperatures.

To determine a value for the total heating system efficiency of dual fuel RTUs that incorporates all the factors listed above, a novel methodology was developed for this study by Prism and is

[1] https://www.naturalhandyman.com/iip/infhvac/ASHRAE_Chart_HVAC_Life_Expectancy.pdf

presented below. Inputs and assumptions used for determining total heating system efficiency are provided in **Appendix B**.

1. Heating Demand Models for Relevant Climate Zones

A heating demand curve was created for each climate zone; these curves are shown in Figure 1. The curves represent the heating demand required per 1000 m^2 in a commercial building as ambient temperatures change throughout the year. See **Appendix B** for the inputs and assumptions used to create these curves.

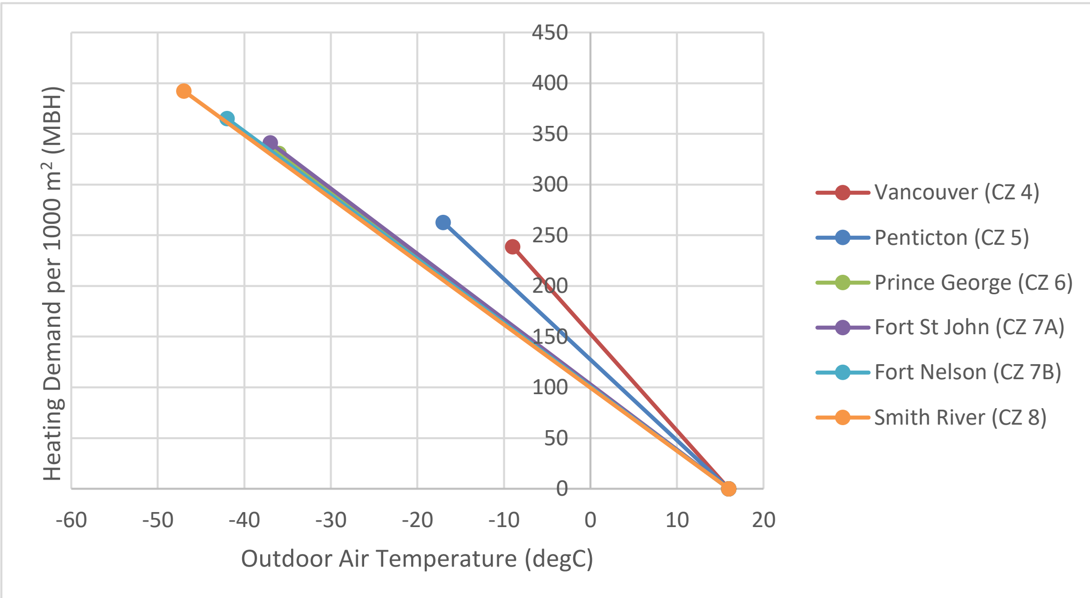

Figure 1. Building Heating Demand Curves by Climate Zone

2. RTU Sizing

The heat pump size is an important design consideration in the evaluation of RTU heating performance. A larger heat pump can produce more heat and can therefore displace a greater amount of gas throughout a heating season. In this analysis, heat pump capacity in each climate zone is sized for cooling.

To determine RTU cooling capacities required at each climate zone, the heat pump cooling capacity designed for the 101 Martin Street RTU replacement project was scaled to the other climate zones' design temperatures. Design temperatures and heat pump sizes used in this analysis for each climate zone are presented below in Table 1.

Table 1. Dual Fuel RTU Design Heat Pump Capacities by Climate Zone

Climate Zone	HDDs	City	July Design Temp (Dry Bulb, degC)[2]	Heat Pump Cooling Capacity (tonR)
4	< 3,000	Vancouver (City Hall)	28	**5.0**
5	3,000 to 3,999	Penticton	33	**7.5**
6	4,000 to 4,999	Prince George	28	**5.0**
7A	5,000 to 5,999	Fort St John	26	**4.0**
7B	6,000 to 6,999	Fort Nelson	28	**5.0**
8	> 7,000	Smith River	26	**4.0**

** Based on 101 Martin Street RTU Replacement Project*

3. RTU Heating Performance Models

Heating performance was modelled as a function of OAT for each RTU model available on the market. The models considered heat pump performance, gas heating efficiency, and sequence of operation. The models also incorporate the effect of defrost cycles on RTU heating capacity and performance. See Appendix B for more details on the inputs and assumptions used to create heating performance models.

4. Weighted Average Total Heating Performance

With RTU total heating system efficiency and heating demand, both as a function of outdoor air temperature, the total heat delivered by the RTU's different heating components (gas, heat pump) across a calendar year was found. This allowed for a single, total heating system COP value weighted by heat delivered, for each climate zone. For more details on this weighted average, see Appendix B.

3.3 Heating Gas and Electricity Consumption

Using the heating demand model and dual-fuel RTU heating models (as described in Section 3.2 and Appendix B), base case and post-implementation gas and electricity consumption values were found for each climate zone. The base case is based on a standard efficiency (80% AFUE) gas fired RTU. The "post-implementation" case is taken as the average gas and electricity consumption values found for all the dual-fuel RTU models developed in the study.

The gas and electricity consumption values for the base case and post-implementation cases are presented per tonR of RTU heat pump heating capacity. Total gas and electricity consumption values calculated for each climate zone are divided by the RTU heat pump capacity modelled for each climate zone (Table 1) to achieve gas and electricity consumption values on a per-tonR basis.

An analysis was also done to show how the gas and electricity consumption change with a varying heat pump enable/disable temperature. Lockout temperatures were selected to achieve at least total heating system efficiency of 150% in CZ's 4 and 5, and 100% in CZ's 6, 7A, 7B, and 8 (see Section 3.1).

[2] Source: BC Building Code 2018, Division B – Appendix C Climatic and Seismic Information for Building Design in Canada

4. SUMMARY OF FINDINGS

4.1 Product Research & Technical Characteristics

Table 2 presents the Hybrid Dual Fuel RTUs available in British Columbia at the time of this study. Most available units have standard efficiency gas heating (only one model is condensing efficiency). Most RTUs on the market are available in capacities of 2 to 20 tonR, and all have electrical configurations suitable for installation in British Columbia.

Heat recovery is optional on half the units on the market, though it should be noted that the feasibility of heat recovery is largely dependent on the building systems and the areas they serve, not on the RTU model.

Table 2. Summary of Available Hybrid Dual Fuel Rooftop Units

Make	Model	Gas Heating Efficiency: Standard (80% AFUE)	Gas Heating Efficiency: Condensing (90% AFUE)	Heat Recovery Available?	Heat Pump Sizes (tonR)	Electrical Requirements
Goodman	GPD	●			2 - 4	208-230/60/1
Carrier	48VT	●			2 - 5	3-208/230-1-60; 5-208/230-3-60
York	PHG	●			2 - 5	208/230-1-60, 208/230-3-60, 460-3-60
Trane	DHC	●			3 - 25	208-230/60/3, 460/60/3, 575/60/3
Allied	LDT	●		●	2 – 5 6.5 - 20	208-230/60/3or1, 460/60/3, 75/60/3 208-230/60/3, 460/60/3, 575/60/2
Daikon	Rebel	●		●	3 - 20	208-230/60/3, 460/60/3, 575/60/3
Aaon	RN/ RQ	●		●	2 - 140	208-230/60/3or1,460/60/3, 575/60/3
RUPP[3]			●	●	5 – 20	208 V, 3 Phase

Heat Pump's Cooling Capacity and Performance

Table 3 presents the rated cooling capacity and performance of the RTU's heat pump. Most RTU models have similar cooling performance values, with COPs between 3 and 4.

[3] RUPP condensing efficiency gas heating is only available for units up to 20 tonR. Above this, standard efficiency gas heating is available.

Table 3. Heat Pump Cooling Capacity and Performance

Make	Model	Heat Pump Cooling	
		Capacity (tonR)	Cooling COP (average of all sizes)
Goodman	GPD	2 - 4	3.3
Carrier	48VT	2 – 5	3.4
York	PHG	2 – 5	3.5
Trane	Precedent	3 - 25	3.3
Allied	LDT	2 - 20	3.4
Daikon	Rebel	3 - 20	3.6
Aaon	RN/RQ	2 - 140	3.9
RUPP		5 - 20	5.6

Heat Pump's Heating Capacity and Performance vs Outdoor Air Temperature

The heat pump's heating coefficient of performance (COP) as a function of outdoor air temperature is graphed below in Figure 2. As shown in Figure 2, published heat pump performance varies across the different RTUs available on the market.

The heat pump's COP is not the total heating system efficiency, though it is a factor that influences total heating system efficiency.

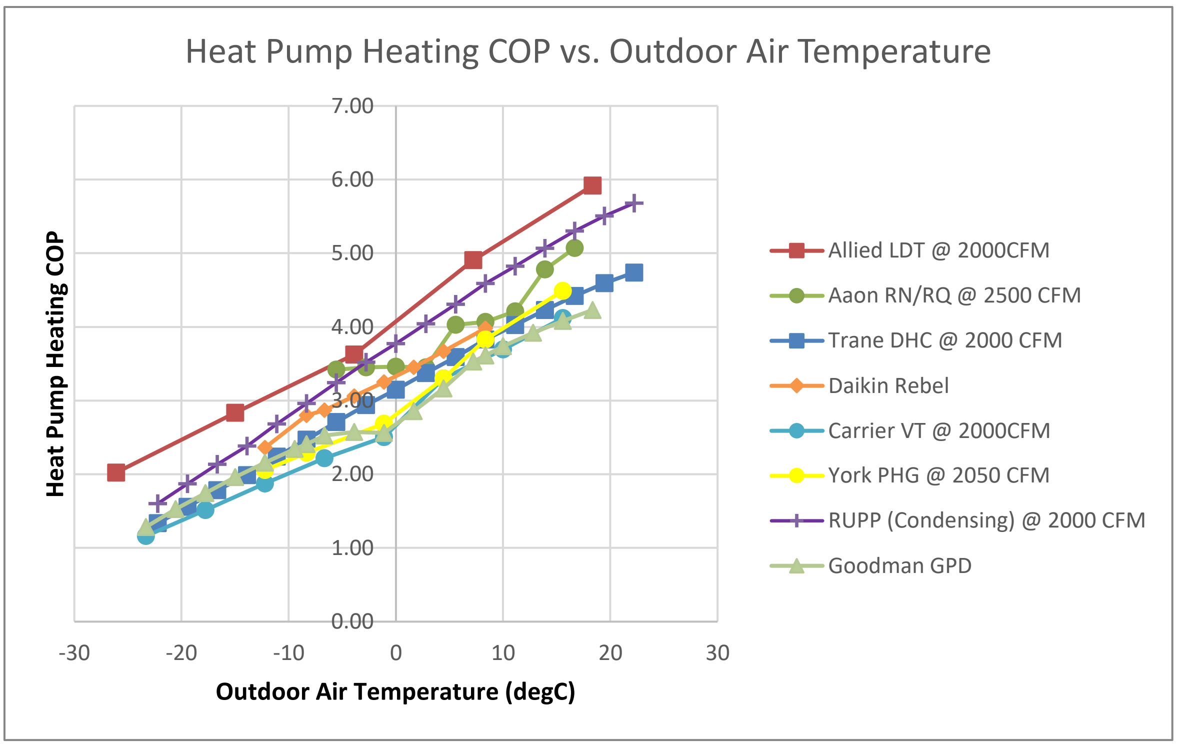

Figure 2. Heat Pump Coefficienct of Performance vs. Outdoor Air Temperature Graphs

The heat pump's heating capacity as a function of outdoor air temperature is graphed below in Figure 3. Heating capacity of the HP's are an important factor in determining overall performance. A heat pump's ability to meet the heating demand will drive the switchover to gas operation. Generally, for a heat pump of a given size, heating capacity as a function of outdoor air was similar for all models.

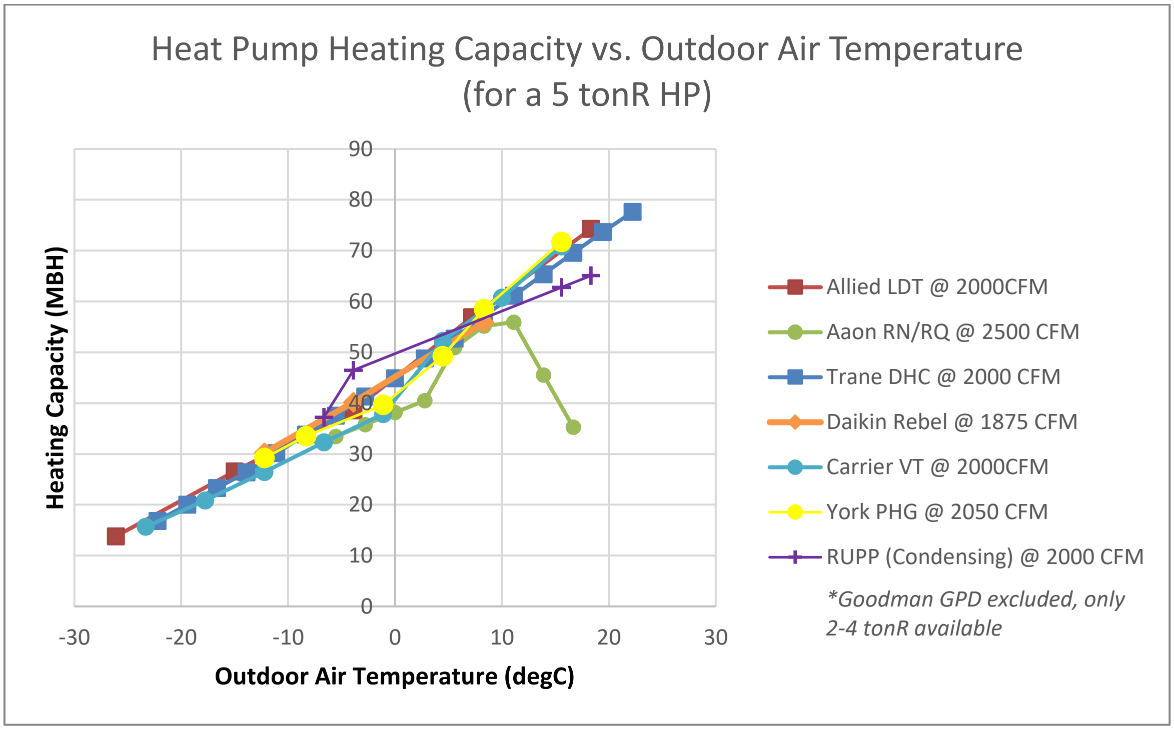

Figure 3. Heat Pump Heating Capacity vs. Outdoor Air Temperature Graphs

Heating System Switch Over Temperatures and Sequence of Operation

The mechanical heating lockout temperature varied between models, though most could maintain heat pump operation down to around -10°C. In a couple cases, the lockout temperature came with a factory default of around 0°C but could be adjusted lower or higher.

The sequence of operation, which defines when heating is provided by the heat pump or gas component, is similar in all units: if the outdoor air is above the lockout temperature, the heat pump would provide first stage heating, with gas providing supplemental heating when heating demand is not maintained. There is some difference across the units when the heating demand exceeds heating capacity of the heat pump: in most cases, gas will provide additional heat to top up what the heat pump can provide, but in one case (Allied LDT), once the heat pump cannot meet full heating demand, it shuts off and gas provides all heating.

Lockout temperature and onboard sequence of operation of each RTU model are summarized in Table 4.

Table 4. Heating System Lockout Temperature and Oboard Sequence of Operation

Make	Model	Heat Pump Enable/Disable Temperature (Cold Temperature Lockout)	Onboard Sequence of Operation*
Goodman	GPD		
Carrier	48VT	0°F (-17.8°C) when equipped with accessory low ambient temperature kit.	
York	PHG	-10°F (-23°C).	
Trane	Precedent	Default 30°F (-1°C); Adjustable 15°F to 45°F (-9°C to 7°C).	Hybrid
Allied	LDT	Default 35°F (2°C); Adjustable 10°F to 76°F (-12°C to 24°C).	Switchover
Daikin	Rebel	45°F (7°C); preheating used when outdoor air is as low as -4°F (-20°C).	Hybrid
Aaon	RN/RQ	17°F (-8°C); can be lowered with preheating.	Hybrid
RUPP		15°F (-9°C).	

Note: grey cells indicate information not available at time of market research.
** **Hybrid** – If HP cannot provide sufficient heating, gas will supplement. **Switchover** - If HP cannot provide sufficient heating, HP is disabled and gas provides all heating*

4.2 Total Heating System Efficiency

Table 5 presents the total heating system efficiency values for the hybrid dual fuel RTU models across BC's climate zones. These values were calculated according to the methodology outlined in Section 3.2, using the lowest lockout temperatures listed by manufacturers (shown in Table 4).

In all climate zones, all RTU models achieved total heating system efficiency values of at least 1. In the coldest climate zone (CZ 7B), performance is around 100%, and in the mildest zone (CZ 4), performance values reach around 250%. These performance values can be compared to a baseline performance of 81%, the heating efficiency of standard efficiency, gas-fired RTUs.

Table 5. Total Heating System Efficiency Values for Hybrid Dual Fuel Rooftop Units at Lowest Lockout Temperature Listed by Manufacturer.

CZ	Trane (DHC)	Allied (LDT)	Goodman (GPD)	Daikon (Rebel)	Carrier (VT)	Aaon (RN,RQ)	York (PHG)	Average **(Standard Efficiency)**	RUPP **(Condensing Efficiency)**
4	2.70	2.44		2.68	2.68	3.08	2.81	**2.86**	**3.65**
5	2.20	2.64		2.07	2.07	2.40	2.20	**2.35**	**2.84**
6	1.43	1.46		1.65	1.65	1.50	1.82	**1.61**	**1.78**
7A	1.15	1.07		1.31	1.31	1.15	1.46	**1.26**	**1.41**
7B	1.00	0.98		1.16	1.16	1.02	1.30	**1.11**	**1.19**
8	1.04	0.93		1.22	1.22	1.02	1.32	**1.14**	**1.23**

Note: Goodman GPD excluded from this analysis; only 2-4 tonR HP available. Values calculated with minimum lockout temperatures as listed by manufacturers.

Analysis was done to show the heat pump heating enabled/disabled switchover required to achieve total heating system efficiency values of 150% in milder climate zones (CZ 4, 5). The highest lockout temperatures that will achieve values of at least 150% in milder climate zones (CZ 4, 5) are presented in Table 6 below.

Table 6. Prescriptive Lockout Temperatures Required to Achieve 150% Efficiency in Climate Zones 4 and 5

CZ	Prescribed Highest Heat Pump Enable/Disable Temperature	Resulting Total Heating System Efficiency (Average of All Models)	Prescribed Heat Pump Enable/Disable Temperature	Resulting Total Heating System Efficiency (RUPP Only)
	Standard Efficiency		Condensing Efficiency	
4	**3 °C**	**1.58**	**5 °C**	**1.52**
5	**-3 °C**	**1.58**	**-1 °C**	**1.60**

4.3 Heating Gas and Electricity Consumption

The modelled annual gas consumption values for the base case (standard efficiency, gas-fired RTU) and the dual-fuel RTU models identified in this study are presented in Figure 4. Table 7 shows the average gas consumption values of dual fuel RTUs and gas savings they offer over the base case standard efficiency gas fired RTU. In milder climate zones, dual fuel RTUs can provide more than 90% fuel savings over standard gas-fired units. In colder climate zones, gas savings are only 30% for standard-efficiency dual-fuel units, though condensing efficiency units can provide around 40% savings.

Note that these results are presented per tonR HP capacity. Note that results are built on the heating models outlined in Appendix B; savings will only scale linearly with tonR heat pump size at the specific RTU capacity-to-service area ratio defined by the 101 Martin Street model.

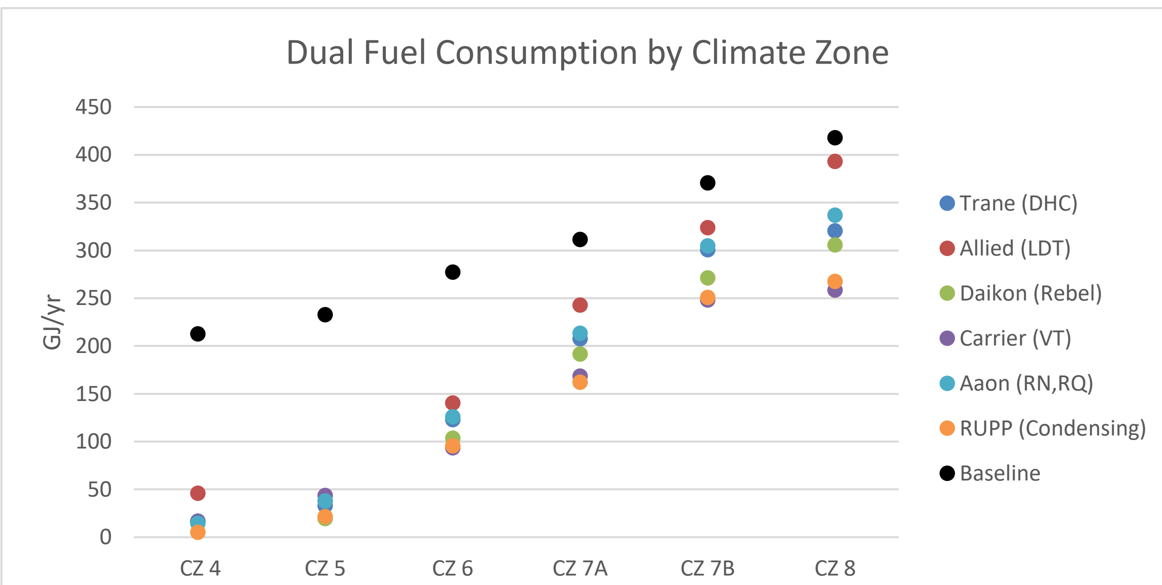

Figure 4. Base Case and Dual Fuel RTUs Annual Gas Consumption

Table 7. Gas consumption of standard efficiency and condensing efficiency dual-fuel RTUs at Lowest Lockout Temperatures Listed by Manufacturer

CZ	Gas Consumption (GJ) - Base Case	Gas Consumption (GJ) - Post Implementation	Gas Savings (GJ)	Gas Savings (%)	Gas Consumption (GJ) - Post Implementation	Gas Savings (GJ)	Gas Savings (%)
		Standard Efficiency			Condensing Efficiency		
4	47	4	43	91%	1	46	98%
5	35	5	30	87%	3	32	92%
6	62	23	38	62%	19	43	69%
7A	87	51	35	41%	41	46	53%
7B	82	58	24	30%	50	32	39%
8	116	81	35	30%	67	49	42%

The base case for heating-related electricity consumption is assumed 0 kWh per year, since all heating is provided by a gas burner. Therefore, in all cases, electricity consumption increases. Table 8 shows the expected average electricity consumption values of dual fuel RTUs. As with the gas consumption results, **the electricity consumption results are specific to the RTU capacity-to-service area ratio defined by the 101 Martin Street model.**

Table 8. Electricity Consumption of Standard Efficiency and Condensing Efficiency Dual-Fuel RTUs at Lowest Lockout Temperatures Listed by Manufacturer

CZ	Electricity Consumption (kWh) - Base Case	Electricity Consumption (kWh) - Post Implementation	Electricity Consumption Savings (kWh)	Electricity Consumption (kWh) - Post Implementation	Electricity Consumption Savings (kWh)
		Standard Efficiency		Condensing Efficiency	
4	0	267	-267	259	-259
5	0	204	-204	194	-194
6	0	264	-264	248	-248
7A	0	247	-247	257	-257
7B	0	180	-180	169	-169
8	0	264	-264	266	-266

Table 9 and Table 10 present the impact on energy use from increasing the heat pump enable/disable temperatures (to the temperatures specified in Table 6).

Table 9. Gas consumption of standard efficiency and condensing efficiency dual-fuel RTUs at Prescriptive Lockout Temperatures

CZ	Gas Use. (GJ) - Base Case	Heat Pump Enable/Disable Temp	Gas Use (GJ) - Post Impl.	Gas Savings (GJ)	Gas Savings (%)	Heat Pump Enable/Disable Temp	Gas Use (GJ) - Post Impl.	Gas Savings (GJ)	Gas Savings (%)
		Standard Efficiency				Condensing Efficiency			
4	47	**3 °C**	18	29	62%	**5 °C**	21	27	56%
5	35	**-3 °C**	12	22	64%	**-1 °C**	13	21	61%

Table 10. Electricity Consumption of Standard Efficiency and Condensing Efficiency Dual-Fuel RTUs at Prescriptive Lockout Temperatures

CZ	Elec Use (kWh) - Base Case	Heat Pump Enable/Disable Temp	Electricity Use (kWh) - Post Imp	Electricity Use Savings (kWh)	Heat Pump Enable/Disable Temp	Electricity Use (kWh) - Post Imp	Electricity Use Savings (kWh)
		Standard Efficiency			Condensing Efficiency		
4	0	**3 °C**	176	-176	**5 °C**	259	-259
5	0	**-3 °C**	148	-148	**-1 °C**	194	-194

4.4 Costing

Cost of equipment was acquired from suppliers for both condensing and standard efficiency units, and a base case RTU (standard efficiency, gas-fired). Figure 5 presents costs per unit tonR of capacity (condensing efficiency in blue, standard efficiency in green).

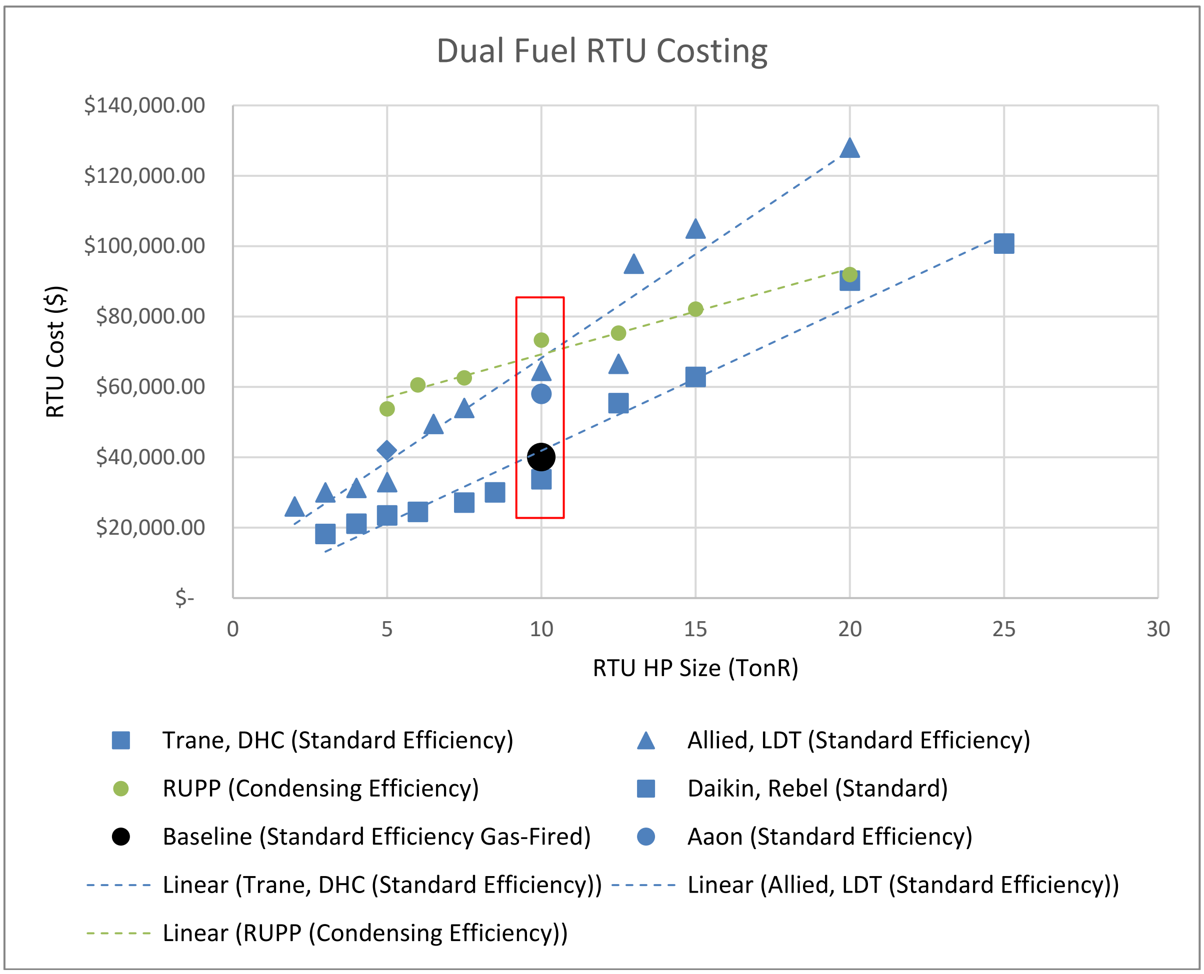

Figure 5. Cost of Hybrid Dual Fuel RTUs at Standard Efficiency (Green), Condensing Efficiency (Blue), and a Standard-Efficiency Gas-Fired RTU (Black)

Incremental costs per TonR of dual fuel units are calculated using the costing data for 10 tonR units, and shown in Table 11.

Table 11. Incremental Costs of Standard and Condensing Effiency Dual Fuel RTUs

Baseline Equipment Cost ($/TonR)	Incremental Equipment Cost ($/TonR)	Incremental Equipment Cost ($/TonR)
	Standard Efficiency	Condensing Efficiency
$4,000	$0 - $2,450	$3,330

Cost and technical feasibility of heat recovery depends on the existing air distribution configuration, and as such, cost estimates for heat recovery could not be defined within the scope of this market research project. Based on information from one supplier, heat recovery has a **cost premium of $1000 per tonR** HP capacity.

Total project costs for replacing existing gas-fired RTUs was reviewed from a recent project that Prism has done in the Vancouver area. Quotes from contractors showed that on average, base case total project cost of replacing a gas-fired RTU with a dual-fuel RTU is approximately $11,800 per tonR of RTU heat pump capacity. In this project, a simple like-for-like replacement (gas-fired replaced with gas-fired) is approximately $2,000 per tonR more expensive than the dual fuel option. Project costs include demolition of existing units, new material, labour, and installation costs. Based on the quotes received for this specific project, a significant premium on dual-fuel RTU installation over standard gas-fired RTUs cannot be confirmed.

5. DISCUSSION

There are several factors that impact heating system performance, including sequence of operation, lockout temperatures, heat recovery, and heat pump COP. The following sections discuss these factors and considerations for establishing a minimum system performance.

5.1 Gas Heating Efficiency

In this study, dual fuel RTUs with standard efficiency (80% annual fuel utilization efficiency AFUE) and condensing efficiency (90% AFUE) are assessed.

As was shown in Table 5, the average performance of standard-efficiency gas heating dual-fuel RTUs is lower than the performance of the condensing-efficiency RUPP unit. In the colder climate zones (CZ-6, 7A, 7B, and 8), it provides total heating system efficiency values that are 10% higher than standard-efficiency units. Higher performance is the result multiple technical characteristics of the RUPP unit, including:

- Higher gas-burner efficiency
- Higher than average heating capacity values in the temperature range of approximately -5 °C to 5°C (which results in more hours where no auxiliary gas heating is required)
- Higher than average heat pump COP values across all temperatures
- The capability to run the HP and gas heating components simultaneously (unlike the Allied model, which shuts off the heat pump once gas heating is required).

As shown in Figure 6 below, when total heating system efficiency of the RUPP condensing-efficiency unit is compared with the efficiencies of the standard-efficiency Trane and Allied units, gas AFUE values only provide some of the benefit seen in total heating system efficiency.

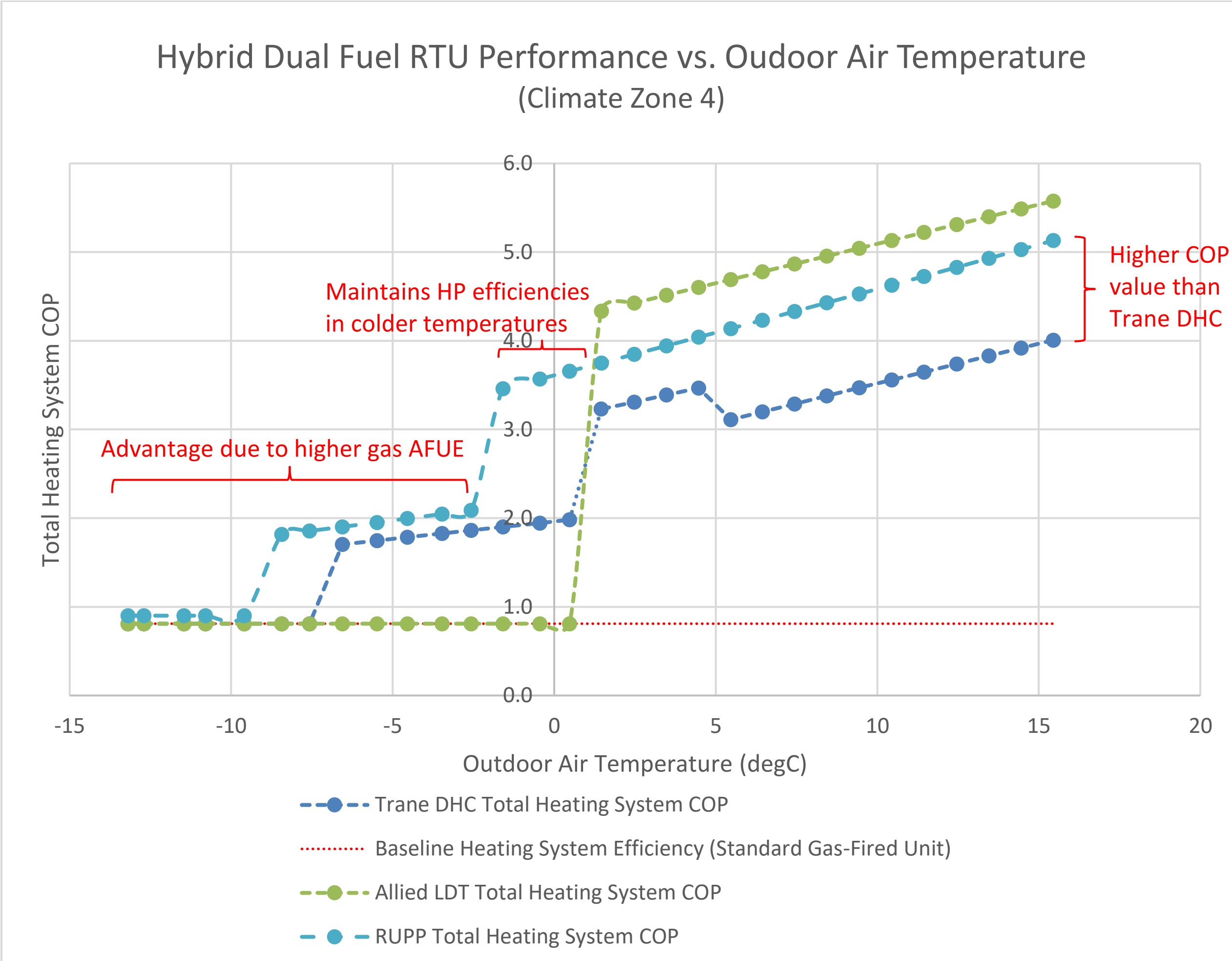

Figure 6. Total Heating System Efficiency of Condensing and Standard Efficiency RTUs at various design temperatures

5.2 Heat Recovery

In this study, dual fuel RTUs with and without heat recovery were assessed. As shown in Table 2, there are standard and condensing efficiency RTUs compatible with heat recovery options.

RTU heat recovery is dependant on site specific ventilation systems and space use. Feasibility and effectiveness will depend on system characteristics such as occupancy and fresh air requirements, and how air is exhausted (through the RTU unit or distributed exhaust).

For this analysis, which is intended to provide some insight into potential benefits of heat recovery, it was assumed that the RTU is responsible for all exhaust air, that make up air consists of 20% outdoor air, and that the heat recovery technology can extract 50% of the heat energy from the exhaust air. Figure 7 shows the difference in total heating system efficiency when the effects of heat recovery are incorporated into the model with the discussed assumptions. **Given the sensitivity of these results to assumptions made about site conditions, these results cannot be tied to specific RTU products; true impact of heat recovery will need to be assessed on a project basis.**

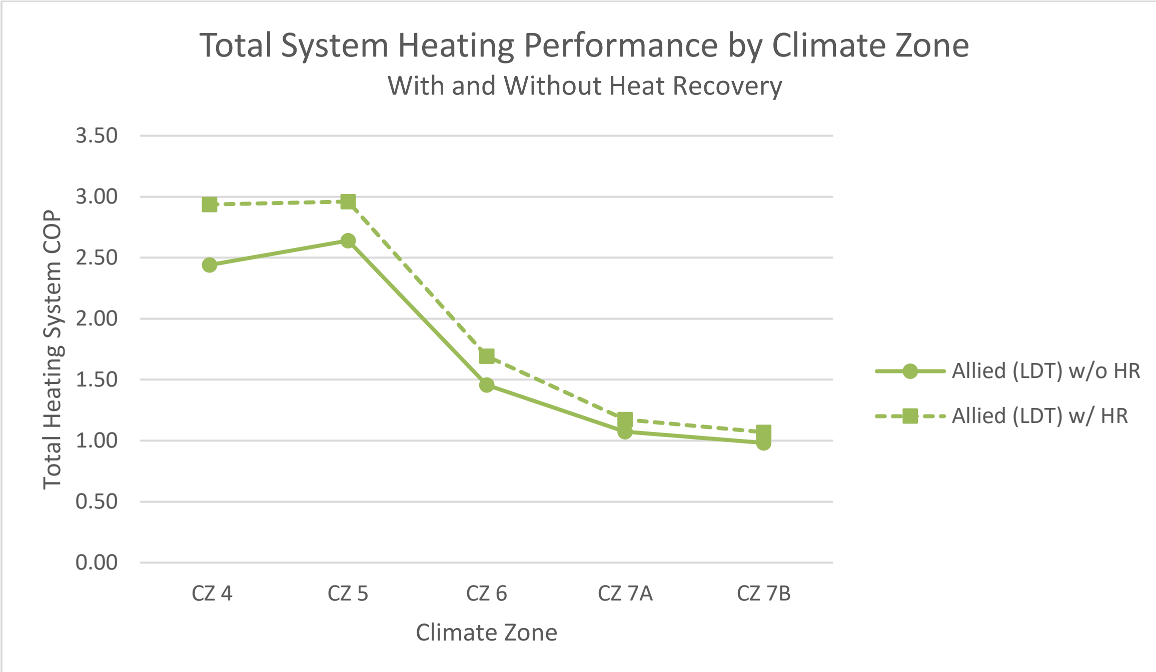

Figure 7. Total Heating System Efficiency with heat recovery (HR) by Climate Zone

5.3 Lockout Temperature

The heat pump heating enabled/disabled switchover (or lockout) temperature defines the outdoor air temperature at which the heat pump is disabled. Generally, RTU heat pumps were found capable of operating as low as -10°C to -15°C.

Higher lockout temperatures result in running gas heating at temperatures where the heat pump COP would be well above the gas heating efficiency of 81%. Therefore, lowering lockout temperatures as much as possible will result in greater total heating system efficiency.

The total heating system performance values and gas and electricity consumption values presented in Table 5, Table 7, and Table 8 are the result of modelling RTU performance with the minimum lockout temperatures listed by manufacturers. The lockout temperature values specified by manufacturers (between -5°C to -20°C, see Table 4) achieved total heating system efficiency values of at least 100% in colder climates (CZ-6, 7A, 7B, and 8), and values of around 250% in milder climate zones (CZ-4 and 5).

To achieve total heating system performance values of at least 150% in the milder climate zones, the lockout temperatures programmed for RTUs should be no higher than 3 °C in CZ-4 and -3 °C in CZ-5.

Figure 8 shows how performance of the Trane DHC RTU is impacted by lockout temperature. Trane specifies that the lockout temperature can be as low as approximately -7.5 °C. In CZ-4, this results in a total heating system efficiency value of 270% for the Trane DHC model. If the lockout temperature increased to 3 °C, heat delivered between outdoor temperatures of 3°C and -7.5°C will be provided at 80% efficiency, even when the heat pump could provide heat at efficiencies greater than 300%. The resulting total heating system efficiency of the Trane unit when a 3 °C lockout temperature is applied is 165%.

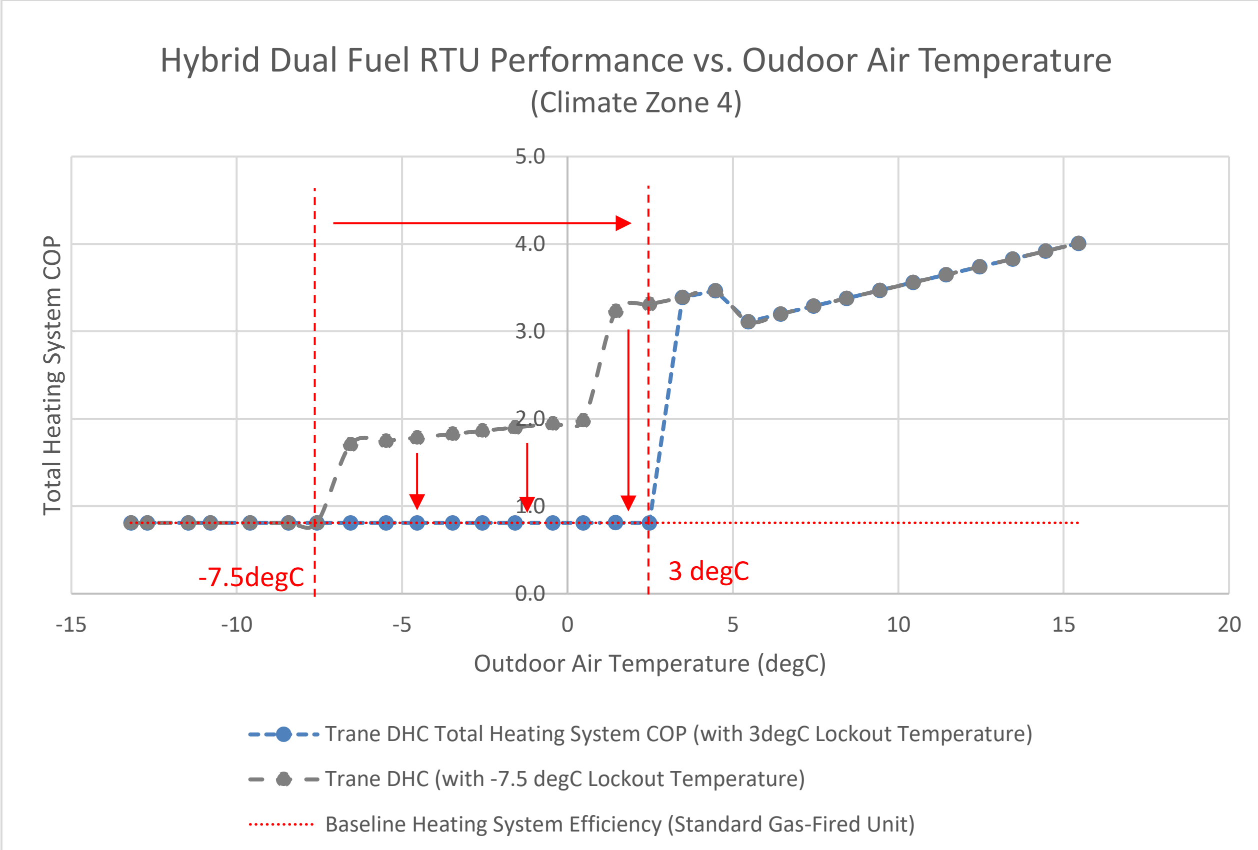

Figure 8. Total Heating System COP for Trane DHC with varying heat pump enable/disable temperatures

5.4 Impact of Sequence of Operation

In this study, the sequence of operation was used to describe the onboard settings that define when heat is provided by the heat pump and gas components of the RTU.

When outdoor air temperature is greater than the unit's lockout temperature, but the demand for heating exceeds the heat pump's capacity, the total heating system efficiency will be impacted by the sequence of operation. Units that operate the heat pump and the gas section simultaneously to meet demand can take advantage of heat pump COP for a greater portion of that year, compared to units that shut heat pump heating down once gas heating in engaged. The difference in total heating system efficiency as a function of outdoor air temperature between these kinds of units is shown below in Figure 9.

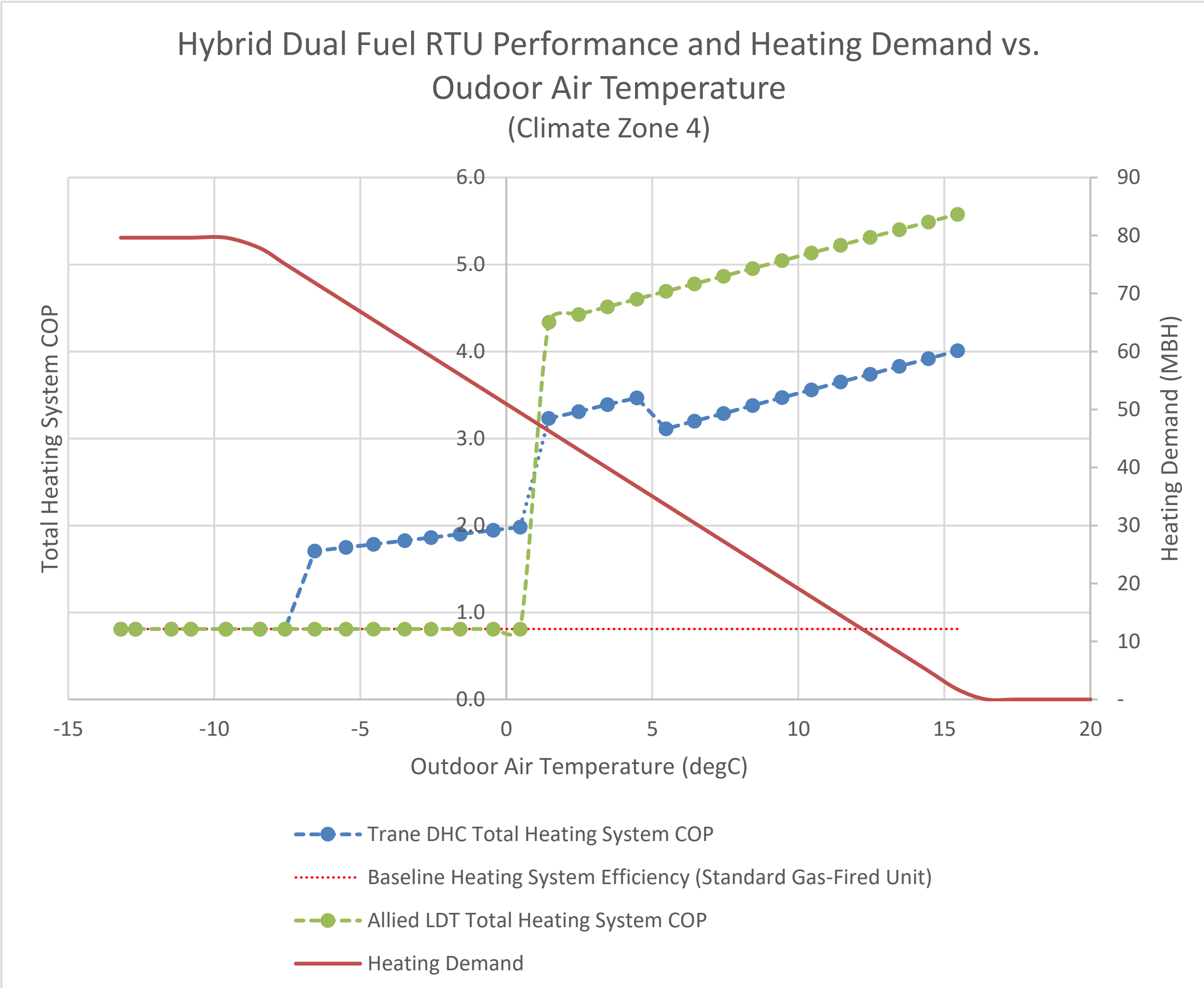

Figure 9. Rooftop Unit Efficiency curves for an RTU that runs in hybrid mode (heat pump and gas components providing heat simultaneously), and an RTU that does not.

The performance curves in Figure 9 show the Allied LDT model has significantly higher heat pump performance than the Trane model. However, between about 0°C to -7°C, where heating demand exceeds the heat pump capacities, the Trane model has performance advantage because its heat pump continues to supply heat, resulting in a higher combined performance.

6. RECOMMENDATIONS

From the results of this analysis, the following recommendations are made to support the development of a prescriptive hybrid dual fuel rooftop unit rebate program:

- **Products Suitable for Performance Based Rebate Program**

  Total heating system efficiency varied across the models (with varying sequence of operation, lockout temperatures, heat pump COP, etc.). All products (except the Allied LDT model) achieved efficiency values of around 100% in the coldest climate zone, and efficiency values of around 250% in the mildest climate zone.

  The Allied LDT model is the only product with calculated total heating system efficiency less than 100% in the coldest climates. It is also the only model that does not run a hybrid system: only gas or heat pump heating is provided at one time, and they are never run together.

  These results suggest that if the goal of the program is to incentivize products with total heating system performance values of at least 100%, the program should only include dual-fuel RTUs that can run hybrid heating (heat pump and gas simultaneously).

- **Operational Requirements of Dual-Fuel Rooftop Units**

  Total heating system performance of dual-fuel RTUs is sensitive to heat pump enable/disable (lockout) temperature. To ensure a desired total heating system efficiency or annual fuel savings is achieved, prescribing a lockout temperature according to the findings of this study can help ensure highly efficient operation. Note that this was found true only for dual fuel RTUs that can run hybrid heating (heat pump and gas heating simultaneously).

- **Incentivizing Condensing Efficiency**

  Condensing efficiency RTUs increase total heating system efficiency but come at a cost premium over the most cost-effective standard efficiency RTUs. In the pilot project at 101 Martin Street, it was determined that the energy savings of condensing over standard efficiency was not worth the cost premium.

  Given that most standard-efficiency dual-fuel RTUs can achieve sufficient performance (100% efficiency in CZ-6, 7A, 7B, 8, and 150% efficiency in CZ-4, 5), it is not recommended that the cost premium of condensing efficiency dual-fuel RTUs be incentivized above the cost of standard efficiency dual-fuel RTUs.

- **Incentivizing Heat Recovery**

  Heat recovery can provide an increase in total heating system efficiency, but its feasibility is entirely dependant on site conditions, and not on the RTUs themselves. Therefore, an incentive for heat recovery is not recommended in the current prescriptive program and might be better suited for a custom incentive program.

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Appendix B: Inputs & Assumptions for Total Heating System Efficiency

BC Climate Zones Weather Data

In British Columbia, there are six climate zones that the BC Building Code uses to set energy performance targets for buildings. Figure 10 shows a map of BC's climate zones.

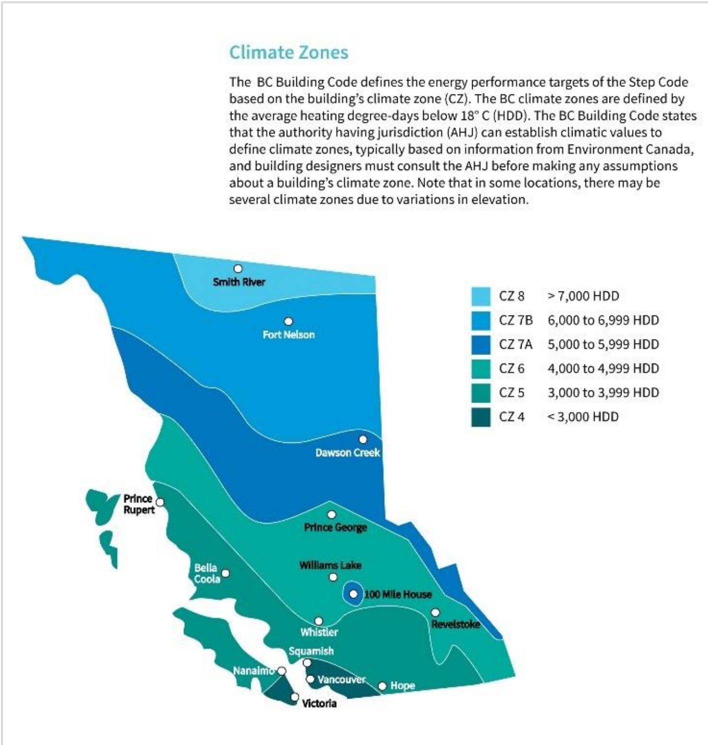


Figure 10. BC Climate Zones Map and the Cities Within Each Zone[4]

For the purposes of this analysis, one city from each climate zone was selected to represent their respective zone. The cities selected for the analysis and summary of weather characteristics are summarized in Table 12.

Table 12. Climate Zones Representative Cities used in Total heating system efficiency Analysis.

Climate Zone	Representative City	Annual HDD (below 18°C)	July Design Temperature (Dry, °C)	January Design Temperature (1%, °C)
4	Vancouver	2825	28	-9
5	Penticton	3350	33	-17
6	Prince George	4720	28	-36
7A	Fort St John	5750	26	-37
7B	Fort Nelson	6710	28	-42
8	Smith River	7100	26	-47

Source: BC Building Code 2018, Division B – Appendix C Climatic and Seismic Information for Building Design in Canada

[4] Source: https://www.betterhomesbc.ca/faqs/climate-zone/

For each city representing climate zones 4 to 8, a bin analysis of daily dry bulb outdoor air temperature was acquired, showing hours of the year (2022) that the city experienced a range of outdoor air temperatures[5]. A sample of the bin analysis data, comparing the mildest climate zone (CZ 4) and the second coldest climate zone (CZ 7B), is shown below in Figure 11.

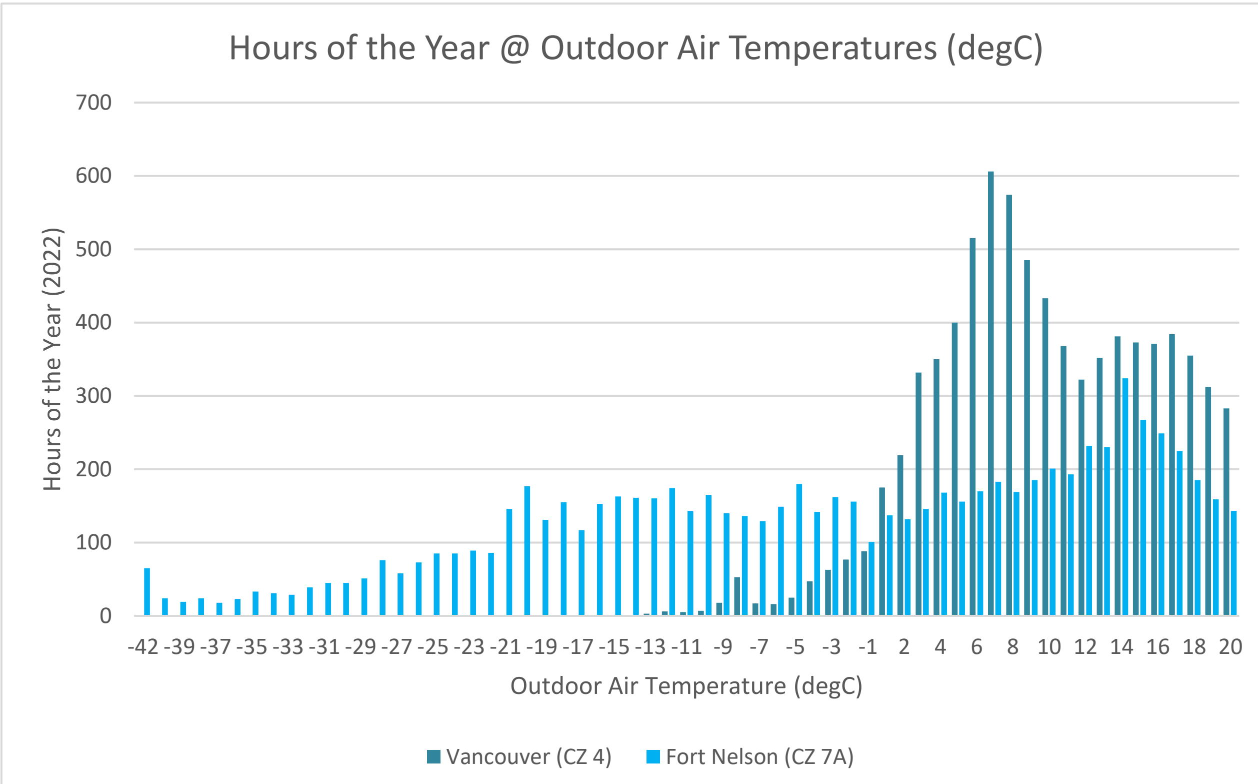


Figure 11. Bin Analysis of outdoor air temperature (dry bulb, °C) of a milder city (Vancouver) and colder city (Fort Nelson) used in the Climate Zone models, for the year 2022.

Model Building and RTU System (101 Martin Street, Penticton, BC)

Both the climate and the building system that a RTU exists in will impact the operation and performance of an RTU. Therefore, to analyse the impact of climate alone, a fixed building system model is established, with heating requirements of that building archetype adjusted to the design temperatures of BC's climate zones.

101 Martin Street, the head office of the Regional District of Okanagan-Similkameen (RDOS), is currently undergoing a replacement of three gas-fired RTUs with three hybrid dual-fuel RTUs. The RTU replacement project, led by Prism Engineering, is selected as a pilot project to evaluate the performance of dual-fuel RTUs.

To compare dual-fuel RTU performance across climate zones, the standard system model for this analysis is based on the RTU heating system at 101 Martin Street:

[5] For Climate Zones 4 to 7B, bin analysis was done with hourly data from Environment Canada (https://weather.gc.ca/). For Climate Zone 8, bin analysis was done with daily weather data from NASA database.

- 1000 m^2 building located in Penticton, BC, within CZ 5.
- Three existing gas-fired RTUs provide all building heating, and it is assumed that the heat load is provided for equally by the three RTUs.
- Each existing RTU will be replaced with a hybrid dual-fuel RTUs, with the heat pump component sized to match the existing unit's cooling capacity.

Climate Zone Building Heating Models

Dual-fuel RTU performance will depend on the building heating load and the heating capacity of the unit's heat pump unit.

For this analysis, the model building's design heating load in each climate zone was found by applying the representative cities' January design temperatures to the RETScreen Building Heating Load Chart, shown below in Figure 12.

For all climate zones, a thermal balance temperature—above which no heating is required—was assumed 16°C.

From these heating limits, heating demand (for each RTU) vs. outdoor air temperature curves were created for all climate zones, presented in Section 3.1

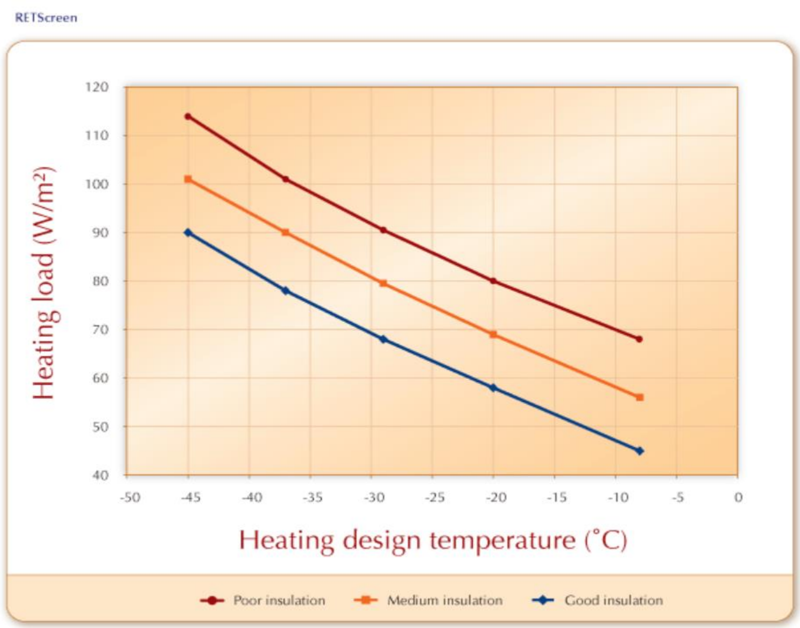


Figure 12. RETScreen Building Heating Load Chart.
Note: these values are better suited to residential buildings[6]

Impact of Defrost

Some manufacturers report heat pump heating performance data as it is impacted by defrost cycles. This data is generally called "integrated heating capacity" or "integrated performance". If

[6] Source: https://publications.gc.ca/collections/Collection/M39-119-2005E.pdf

there was no evidence of defrost cycles being included in performance data, the impact of defrost was added to our models using defrost correction factors published by LG[8].

[8] https://a1ac1dcb67cc9f847a73-0b6da349d0197cd2922796e57d5f1d84.ssl.cf5.rackcdn.com/CMSFiles/PMAssets/PMAssets/Resource/general/1864/MultiV5_575V_Performance_Table_20181030.pdf

Appendix C: Summary Table of Key Results

Climate Zone	Total Heating System Efficiency (COP)*	Total Heating System Efficiency (COP)	Gas Consumption (GJ) - Base Case	Gas Consumption (GJ) - Post Implementation	Gas Savings (GJ)	Gas Savings (%)	Gas Consumption (GJ) - Post Implementation	Gas Savings (GJ)	Gas Savings (%)
	Standard Efficiency	Condensing Efficiency		Standard Efficiency			Condensing Efficiency		
4	2.86	3.65	47	4	43	91%	1	46	98%
5	2.34	2.77	35	5	30	87%	3	32	92%
6	1.61	1.78	62	23	38	62%	19	43	69%
7A	1.26	1.41	87	51	35	41%	41	46	53%
7B	1.11	1.19	82	58	24	30%	50	32	39%
8	1.14	1.23	116	81	35	30%	67	49	42%

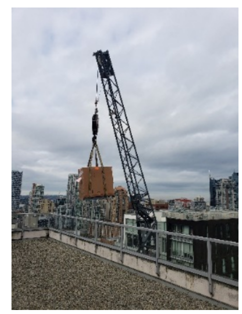
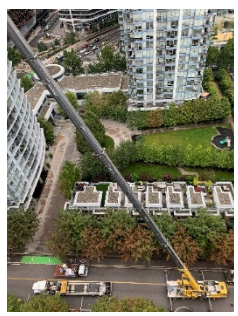
* Total Heating System Efficiency (COP) includes both Heat Pump COP and Gas AFUE effects

Climate Zone	Total Heating System Efficiency (COP)	Total Heating System Efficiency (COP)	Electricity Consumption (kWh) - Base Case	Electricity Consumption (kWh) - Post Implementation	Electricity Consumption Savings (kWh)	Electricity Consumption (kWh) - Post Implementation	Electricity Consumption Savings (kWh)
	Standard Efficiency	Condensing Efficiency		Standard Efficiency		Condensing Efficiency	
4	2.86	3.65	0	267	-267	257	-257
5	2.34	2.77	0	204	-204	192	-192
6	1.61	1.78	0	264	-264	248	-248
7A	1.26	1.41	0	247	-247	257	-257
7B	1.11	1.19	0	180	-180	169	-169
8	1.14	1.23	0	264	-264	266	-266

Measured Life (years)	Baseline Equipment Cost ($/TonR)	Incremental Equipment Cost ($/TonR)	Incremental Equipment Cost ($/TonR)
		Standard Efficiency	Condensing Efficiency
15	$4,000	$0 - $2,450	$3,330

FORTIS BC™

MEASUREMENT & VERIFICATION REPORT
(DRAFT REPORT)


NATURAL GAS ABSORPTION HEAT PUMP (GAHP) PILOT PHASE 5

SEPTEMBER 1ST 2023

BES
BUILDING ENERGY SOLUTIONS LTD.

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EXECUTIVE SUMMARY

1.1 Overview

BES-Building Energy Solutions Ltd, worked with Campbell Scientific and Synertek Automation (monitoring specialist contractors) and FortisBC, on an M&V (Measurement and Verification) study to investigate the performance of a GAHP (Natural Gas Absorption Heat Pump) in DHW (Domestic Hot Water) applications at seven (7) test facilities. Of the seven (7) test facilities, five (5) were MURB's (Multi Unit Residential Buildings) and two (2) were secondary school facilities. The primary objectives of the M&V study were:

- Validate performance;
- Investigate energy savings and economic analysis;
- Assess customer acceptance behavior;
- Identify issues associated with the installation and operation of the GAHPs.

Each site had two (2) Robur GAHP-A units installed, each with a rated capacity of approximately 36kW each. The GAHP DHW heating systems were installed in parallel to the existing DHW heaters primarily for two reasons. Firstly, during the project to switch intermittently between the two (2) DHW heating systems to perform direct comparison under different ambient conditions. Secondly, in the event where the GAHP systems could not fully meet the 60°C (140°F) setpoint for DHW as specified in the BC Building Code, the existing boiler/s could provide the necessary energy to maintain the setpoint to acceptable conditions. Therefore, in the GAHP heating mode, the GAHP and existing boiler were essentially installed in series. The GAHP heating systems were tested intermittently over several test periods from October 2019 to March 2020. Due to the impact of COVID-19, the tests were stopped abruptly in early March. After detailed risk assessments were performed, testing resumed in July 2020.

The major findings from the pilot highlighted an increased inefficiency of the existing boiler system, which was created by the installation of the GAHPs. i.e. Each test site had standard efficiency boilers varying in age. These older boiler systems have a poor turndown ratio and do not operate efficiently when cycled at part load. When the GAHPs were operating, the existing boiler fired to top up the DHW temperature to 60°C (140°F). As the GAHP system took load off the boiler, the short cycling effect was exaggerated causing further drop in boiler efficiency and thus reducing the system efficiency. It is recommended to install new boilers with a high turndown ratio to maintain efficiency during part load application. This will increase the overall system efficiency.

In addition, A more advanced control system that is capable of integrating both the GAHPs and existing system will provide superior sequencing and improved GAHP and system efficiency through better flow sequencing and temperature differential management.

Whilst the original pilot focused on decoupled DHW systems, it was also shown that GAHP technology can be used for other hot water heating purposes, where the energy efficiency could be greater, and the installation costs could be lower. This could produce better simple paybacks than currently observed. For example, those hot water systems that require a constant low hot water supply temperature such a swimming pool heating would be extremely suitable. This type of installation has a consistent, controllable load.

In view of the original pilots' major findings regarding further GAHP efficiency improvement, a third and fourth phase GAHP pilot was developed with a view to supporting the Pan Canadian Framework for efficiencies greater than 100%.

Phase 3 of the pilot saw the replacement of the existing standard efficiency gas fired DHW equipment with new high efficiency condensing DHW equipment. The new equipment also incorporated burner modulation technology so that the firing rate of the boiler would match the variable load of the DHW system.

Phase 4 of the pilot integrated the GAHP technology to a constant flow hydronic hot water system.

Both of these additional phases of the pilot proved reasonable energy avoidance and ghg emission savings over the test period. However, in respect to phase 4, limited testing was performed on the heating system due to the narrow operating windows available to operate the GAHP system in heating mode. i.e. The GAHP system had insufficient output to meet the building heating load when the outdoor temperature was lower than 15°C (59°F).

In view of this, a phase 5 was proposed for site GAHP #17 to further prove the theory that a constant demand ventilation system connected to rightly sized GAHP and hot water heating delivery (hydronic coil) equipment would result in greater energy saving potential and increased system efficiency.

As with the original pilot, the baseline natural gas consumption for site #17 was calculated as the weather normalized natural gas consumption. Weather normalization provides a means to remove seasonal peaks tied to climate conditions. The data in the table below summarizes the overall performance of the GAHP systems over the project duration. The avoided energy was calculated based on the natural gas savings per day of GAHP operation during the test periods performed over three-four (3-4) months, which is then pro-rated to right sizing. The test site shows good avoided energy with the GAHP operation when connected to the ventilation and DHW systems. These savings are reasonable due to the fact that the DHW consumption only makes up a fraction of natural gas use over the test period. It must also be noted that the existing boilers were required to top up the DHW temperature to 60°C (140°F).

1.2 Financial Performance

The table below illustrates the overall avoided energy and ghg emissions at the site, together with the simple payback.

Table 1: Summary of Energy & Greenhouse Natural gas Emissions Avoidance

Test site	Predicted Annual Avoided Energy (w/o losses) (GJ)	Percentage of site total natural gas consumption	Percentage of Ventilation Natural Gas Consumption	GHG savings (tCO2e)	Natural gas utility savings	Annual Carbon tax savings ($)	Capital Cost ($)	Simple Payback
GAHP-17	150.50	3.6%	44.0%	7.46	$1,196.48	$298.59	$29,342.00	19.6

1.3 Technical Performance

Integration of advanced controls has given excellent insight into the operation of the GAHP systems, over and above those findings in the original M&V pilot.

The control system allows the staging of each GAHP unit depending on the thermal energy load of the ventilation system and the DHW system, whereby the control system can determine when to load share between the ventilation system and the DHW system or prioritize either system. i.e. manage the optimum system temperature differential (DT). Two (2) of the most important control parameters of the GAHP equipment are the heating (temperature) setpoint and the deadband. A deadband or dead-band (also known as a dead zone or a neutral zone) is a band of input values in the domain of a transfer function in a control system or signal processing system where the output is zero (the output is 'dead' - no action occurs). These parameters determine when the unit is operating or not. It is important to note the heating outlet temperature limitation of the GAHP is generally in the region of 55-58°C (131-136°F). Previously, the GAHPs had been operating to a setpoint of 60°C (140°F). Before this point was reached the GAHP would shut off due to internal limits.

Over the test period the GUE was calculated and compared to the differential temperature from the data obtained through the new control system. The data shows a linear correlation between the differential temperature and the GUE. To achieve a GUE greater than 1.0, it is essential to have a differential temperature across the GAHP of greater than 6.5-7°C. At a differential temperature greater than 8°C, the unit can reach a GUE of 1.2 to 1.4.

The graph below illustrates those efficiency increases across the different phases of the pilot. Phase 5 saw GAHP efficiencies reach a COP of 1.25.

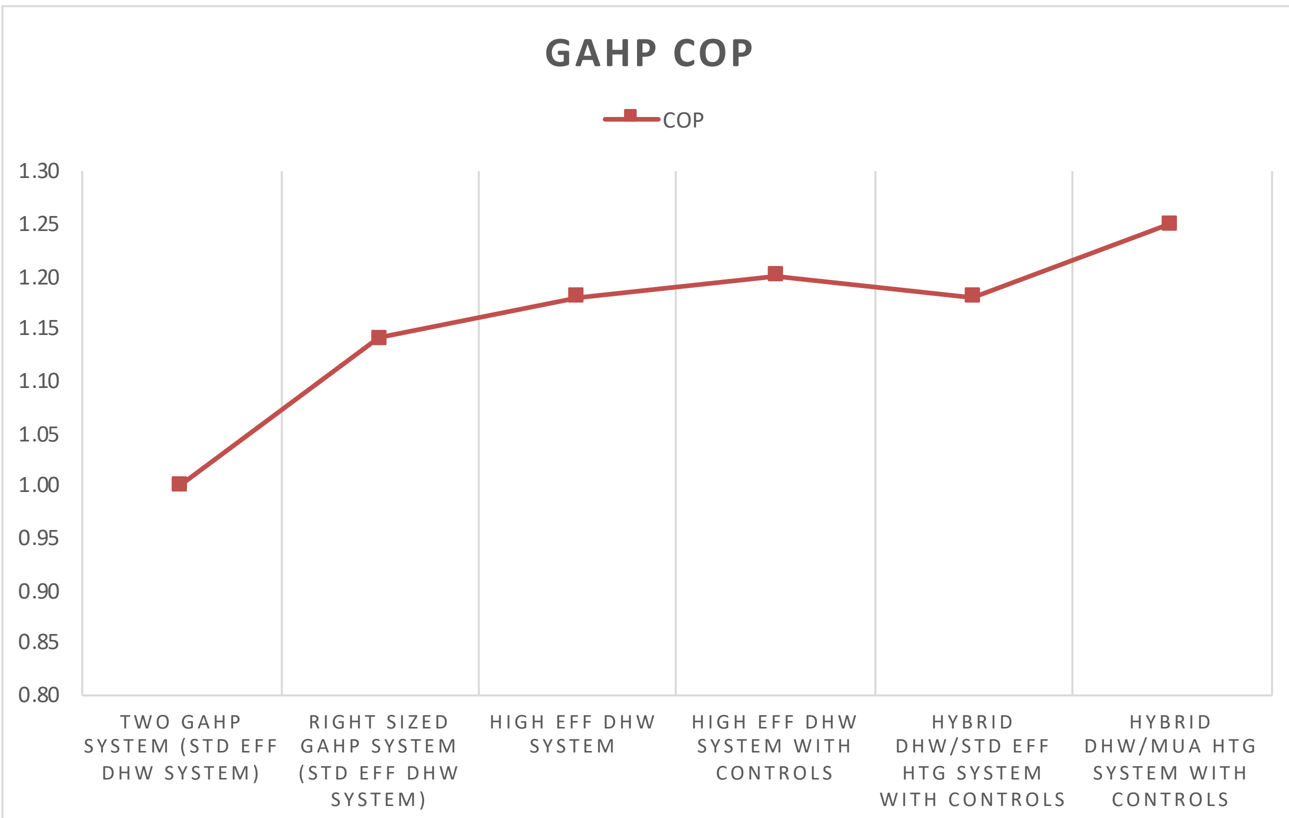

Figure 1: GAHP COP measured at different phases of the pilot

The measurement and verification data demonstrates the positive effect of the constant load provided by the MUA heating (SAT SP) requirement, when there is a greater than 5°C supply air temperature rise requirement. During these times, system efficiencies of 125% (GUE 1.25) were consistently measured.

1.4 Recommendations for Next Steps

- Replace the existing DHW boilers at GAHP #17 with a condensing boiler with burner modulation to further improve DHW system efficiencies and substantiate the findings from phase 3 of the pilot.
- Replace the existing hot water heating boilers at GAHP #17 with a hybrid condensing boiler and GAHP system. The system would essentially become a hybrid system where the GAHPs could perform stage 1 of heating with the condensing boilers providing peak load heating hot water.

The figure below shows the proposed system boundary for the recommended next steps:

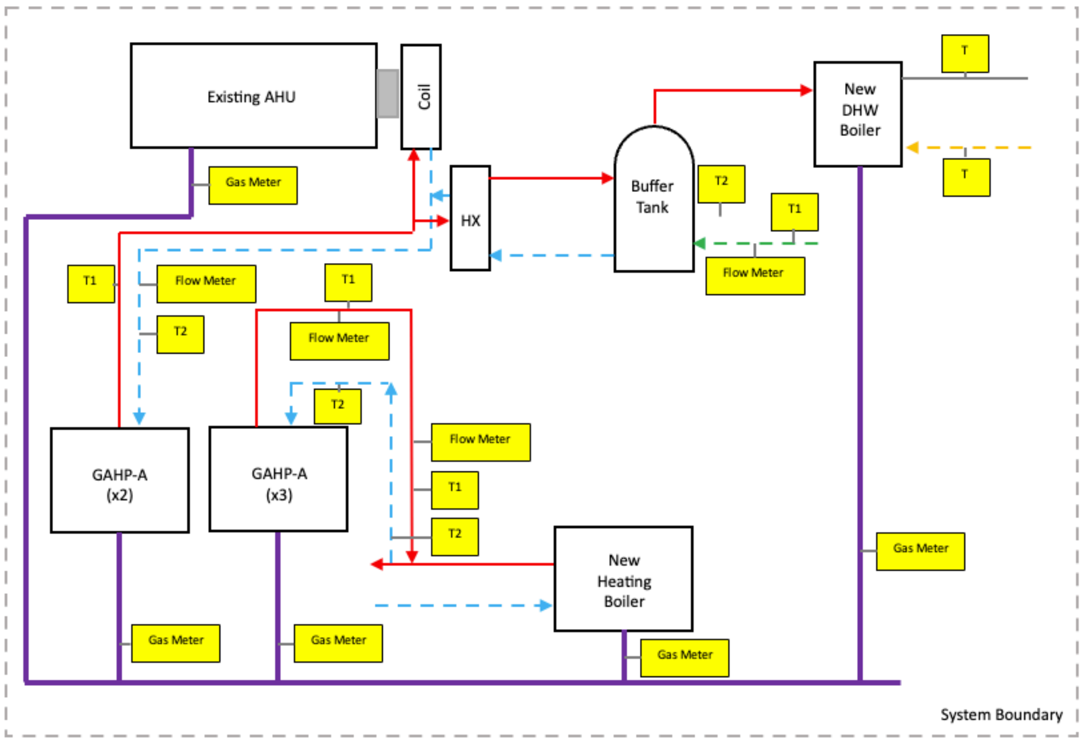

Figure 2: GAHP Pilot Future Phases (System Boundary)

1.5 Considerations for Prescriptive Programs

- Correct sizing of the GAHP is crucial to the system efficiency. Correct sizing the system includes the GAHP units (input/output/quantity), buffer tank and circulation pumps.
  - Additional incentives for DHW load profile will assist in the correct sizing procedure.
- Incentives for flow sequencing and more advanced control of the unit is required to maintain high efficiency and should be considered.
- Additional incentives for combination with a condensing boiler/s retrofit provides additional energy savings and improves overall system average efficiency.
- Bundled incentive offers whereby ‘top-up’ incentive rebates would provide a more attractive offer to prospective clients and contractors alike whom seek assistance with energy efficiency upgrades.

TERMINOLOGY

FEI	FortisBC Energy Inc.
DHW	Domestic Hot Water.
DCW	Domestic Cold Water
Business As Usual	(Also referred to as predicted Business as Usual) The Participant behavior and subsequent energy use measured during the Baseline Period and then predicted to continue if the Project were not implemented for the Test Period.
Climate Normal	For this report, the Vancouver Climate Normal used was from Energy Plus Weather file used for engineering design, which is compiled using 50 years of data, 1969-2019.
BTU	British thermal unit Measures the amount of heat required to raise or lower the temperature of one pound of water one degree Fahrenheit.
BTU/h	British Thermal Units per hour
kWh	Kilowatt hour (standard unit for power consumption, equivalent to 1,000-watt hours
GJ	Unit of energy, Giga joules.
e-kWh	Equivalent Kilowatt hours; often used to compare natural gas to electricity in equivalent units.
COP	Coefficient of Performance
GUE	Natural Gas Utilization Efficiency.
GAHP	Natural Gas Absorption Heat Pumps, supplied by ROBUR, Model #: GAHP-A.
DDC (Direct Digital Control)	System used to automate functions in a building, including HVAC systems and Lighting systems etc.
Heating Season	For this report, the heating season started November 1, 2019 and ended March 31, 2020 in the Lower Mainland.
Installation Period	The period during which the new GAHP units were installed.
Manual Control	Manual Control (Manual) was used to refer to participant use of the DHW heating boiler by manually switching the boiler ON or OFF.
MUA	Makeup Air Unit
MURB	Multi Unit Residential Building

Normalized Heating Season	Weather normalized natural gas and energy consumption for facilities. The site historical natural gas consumption was normalized using heating degree days to show a true average independent of short-term climate events.
O&M	Operation and Maintenance
Participant	Refers to each site / building which allowed the pilot program to be carried out.
Post-Test Period Participant Survey	The survey issued to participants to collect feedback on the Test Period.
Project	The installation of GAHP-A units as a primary DHW system.
Survey Respondents	The subset of Participants who responded to the Post-Test Period Participant and Contractor Survey's.

2 PROJECT OVERVIEW

2.1 Project Objectives

The Natural Gas Absorption Heat Pump (GAHP) measurement and verification Pilot conducted by FortisBC, and BES-Building Energy Solutions (BES) concluded in August 2020. The purpose of the original pilot was to study and investigate the system performance in DHW (Domestic Hot Water applications at seven (7) test facilities. The detailed report provided several conclusions and considerations for future pilot programs, which included:

- "Right Sizing" (engineering) of the GAHPs is critical for optimum performance and resultant energy savings.
  - Manual adjustments were made during the original pilot to identify those energy saving potential to prove and quantity this theory.
- Energy Penalties were also observed through inefficient 'short-cycling' of existing DHW boiler equipment. This was directly tied to the DHW load reduction caused by the installation of the GAHPs.
  - Although the existing DHW boiler nameplate efficiency was typical 80%, they were operating less efficiently under normal baseline conditions. There was also measurable efficiency decreases when the GAHPs were operating. It was believed that existing boiler short cycling is the root cause for this efficiency decrease i.e. the existing boilers have limited burner turndown ratio which causes the boilers to operate for less than two (2) minutes at a time during non-peak DHW load. During these times boiler combustion efficiency can be as low as 50%.
  - It was therefore suggested that replacement of the existing DHW boiler equipment should be ideally done when installing suitably sized GAHPs. The replacement equipment should be at a minimum, high efficiency condensing DHW boiler/s and should incorporate a minimum 5:1 burner turndown ratio.
- Whilst this pilot focused on decoupled DHW systems, it was determined that GAHP technology could be used for other hot water heating purposes, where energy efficiency could be greater, and the installation costs could be lower. For example, those hot water systems that require a constant flow hot water supply temperature such a swimming pool heating would be extremely suitable. This type of installation has a consistent, controllable load.
- Flow sequencing and more advanced control of the unit is required to maintain high efficiency. As the DHW load fluctuates, the system performance also fluctuates. A control system capable of sequencing the GAHPs and the existing boiler equipment and varying the flow rate through the heap pumps or the boiler is required to maintain a system efficiency (COP) greater than 1.0. The test data showed the GAHPs continuing to operate and consume natural gas at times with little or no heating load. A more advanced control system capable of integrating both the GAHPs and existing system could provide superior sequencing and improved GAHP and system efficiency.

3 ENERGY CONSERVATION MEASURE INTENT

3.1 Phasing Summary

In view of the conclusions summarized above, FortisBC engaged BES to work with Campbell Scientific and Synertek Automation (monitoring specialist contractors) to investigate the performance of a GAHP system on three (3) subsequent phases:

- Phase 3: Integrated into a high efficiency on demand condensing DHW system complete with new controls.
- Phase 4: Integrated into a hot water heating system and DHW system complete with new controls.
- Phase 5: Integrated into a constant volume gas fired make up air unit (ventilation system) and DHW system complete with new controls.

3.2 Phase 5: On Demand Condensing DHW Boiler and Controls Integration

For Phase 5, existing GAHP site #17 was selected as an optimum candidate to explore the energy saving potential of a GAHP system connected in parallel to a DHW system and ventilation system incorporating smart controls. This site was chosen for its simplicity and ease of retrofit. The following provides a summary of the baseline system, the new GAHP system and the new integrated ventilation system and GAHP system:

GAHP Site #17: (MURB)

Baseline System: A natural gas fired standard efficiency (80%) makeup air unit provides corridor ventilation to the building 24/7. The MUA incorporates a 400 MBH gas burner to maintain supply air temperature setpoint.

Existing Makeup Air Unit

Existing HX and Pumps

Installation of Outdoor Units on the Roof

Figure 3: GAHP Site #17 – Existing System

GAHP Installation: A stair climber and hoists were used to lift the new hydronic hot water coil through the stairwell to the roof. The new coil was installed in the horizontal section of the existing makeup air unit and connected to the existing GAHP piping system. The new coil was connected on the glycol (source) side of the existing heat exchanger to ensure freeze protection of the new hot water coil. Equipment start-up and commissioning were completed to ensure the installation was in line with design intent and the M&V plan. Control valves were installed for to allow switch over between the DHW and ventilation systems and to also maintain the supply air temperature setpoint of the MUA. The following shows the installed GAHP system:

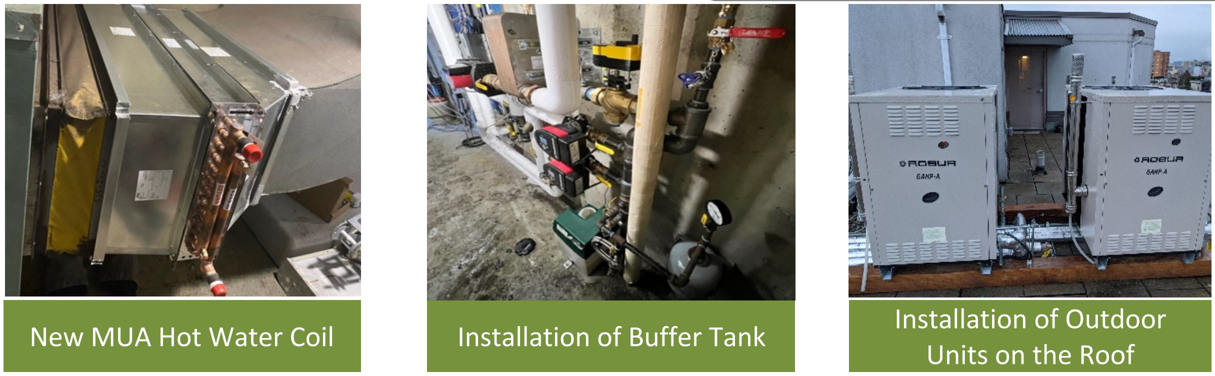

Figure 4: GAHP Site #17 – GAHP System Installation

The diagram below shows the partial integration of the new hot water coil in the existing MUA and into the existing DHW system at GAHP Site #17.

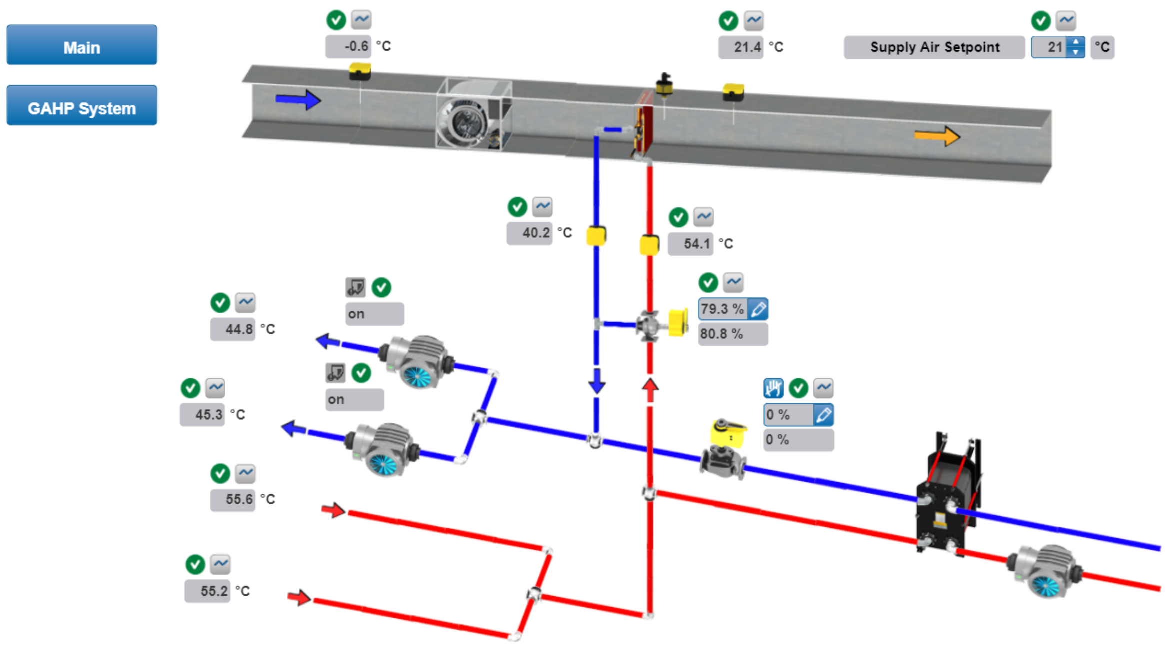

Figure 5: GAHP Site #17 – GAHP and DHW/MUA System Integration DDC Screenshot

3.3 Overview of Control System

As identified in the previous GAHP measurement and verification pilot report, it was determined that advanced controls that automatically sequence, schedule and change setpoints of the GAHPs and those systems that they are interconnected to offer additional potential energy savings and greater efficiency. The Sauter control system, by Synertek Automation was selected for this pilot due to their familiarity with the GAHP system. This is described in extended detail below:

The control system for the Robur GAHP-A units requires integration of a number of communication protocols as represented in Figure 6. The GAHP-A units are connected to the Robur Master DDC controller over a CANbus communication chain. The serial connection daisy chains to each unit and the master controller configures the units as a central plant. Communication to the plant controller was established over an RS-485 bus with a Modbus RTU protocol. The Modbus communication is then interfaced with a BACnet native building automation controller which is scalable to control all building equipment and infrastructure.

Figure 6: Protocol integration of the control system developed by Synertek Automation

The Modbus RTU integration to the master controller uses the following parameters:

- Coils (R/W bit oriented I/O)
- Discrete Input (R/O bit oriented input)
- Input Registers (R/O word oriented input)
- Holding Registers (R/W word oriented I/O)

The default status of the configured system is that the GAHP system is to have all units enabled and operating in parallel. Over the initial test period, Synertek Automation performed advanced testing to fully understand how control of individual units, setpoints, deadbands, status and alarms work. This required several prolonged periods of testing under different conditions to operate the units as required. After these test periods to investigate control functionality of the plant system, control was achieved for the following:

- Heating plant remote enable/disable
- Individual unit status
- Individual unit control through exclusion from plant
- Fluid inlet and outlet temperatures from each module
- Status of pump and fan status/speed within each unit
- Plant hot water setpoint temperature
- Plant dead band temperature control
- Control of GAHP circulation pumps
- Control of control valves for switch over and SAT
- Plant temperature sensors
- GAHP gas meter digital input

3.4 Phase 5: GAHP Site #17

The GAHP equipment at Site #17 serves as a preheat system for the DHW load of the building.

This phase of the project focused on the overall system efficiency of the system by implementing control of the GAHP equipment and installation/integration of a hot water heating system to the existing corridor ventilation MUA.

The control system on the GAHP interfaced with the master controller and enabled control of each heat pump. The two (2) GAHP circulation pumps were also integrated to the control system, together with the new control valves to the MUA hot water coil. The control system graphics are shown in the Figures below.

It should be noted that full control of the GAHP system required prolonged testing to correctly map communication protocols, verify control input and output variables of the individual units and the overall system. The final commissioning and optimization of the controls was performed in March 2022. Utility savings and data analysis following this, are discussed in this report.

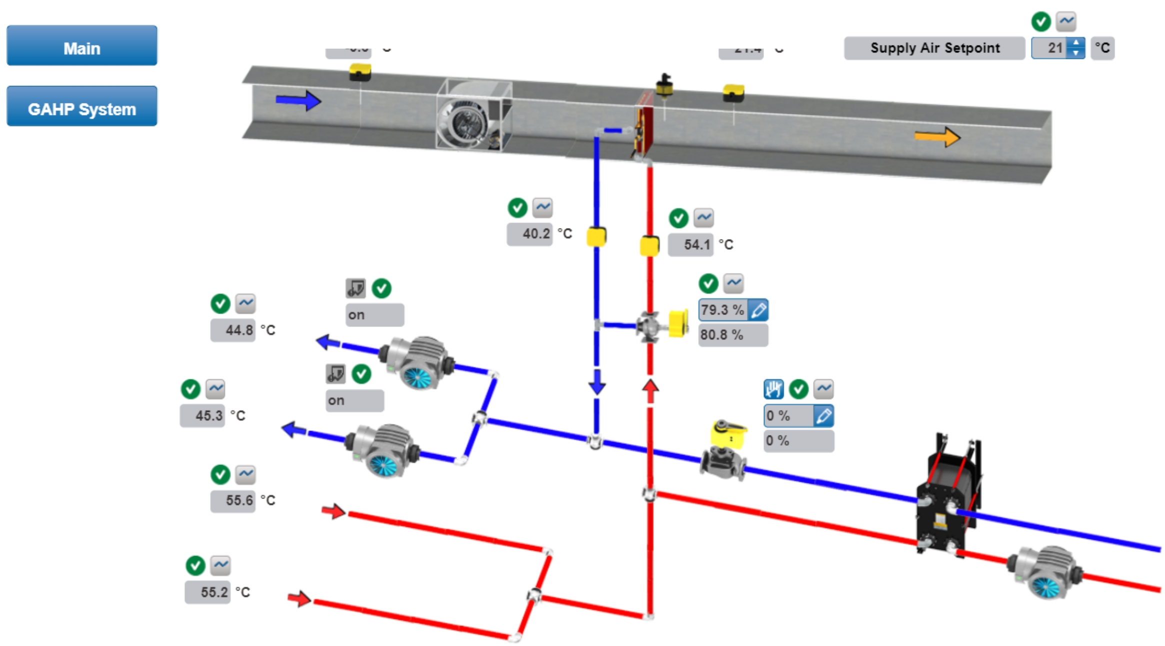

Figure 7: GAHP Site #17 – Control Graphic – System Overview

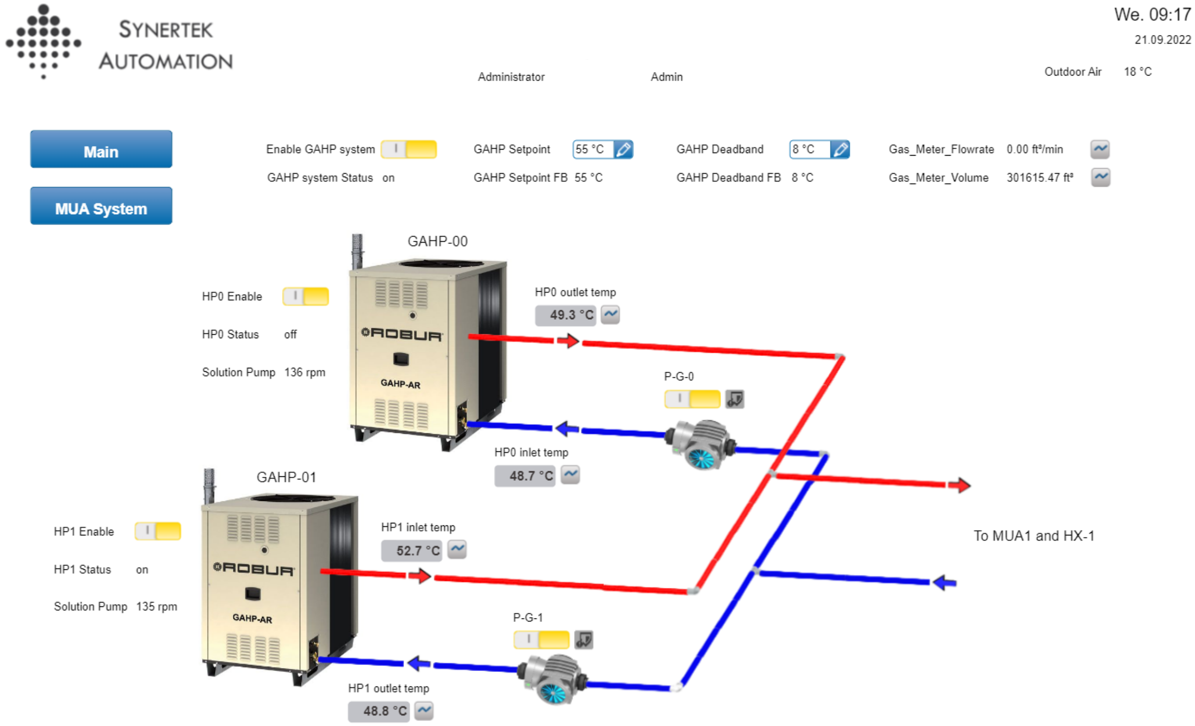

Figure 8: GAHP Site #17 – Control graphic – GAHP Equipment

4 FINDINGS

4.1 Summary of Energy Savings

The modifications to the GAHP systems at the test site (#17) was implemented across January and optimized during the pilot to verify the efficiency interactions of the control systems. March of 2022 is the first month of utility data with the new systems implemented.

The project at site #17 includes the GAHP system with advanced controls and new hot water heating MUA. The utility data shows good energy savings for the gas consumption associated with the ventilation system. The energy savings for 2022 were 44% compared to the historical average for ventilation air heating. The utility savings ultimately reflect an increase in the system efficiency. This increase in system efficiency is two-fold, the increase associated with the MUA heating (existing burner ≈70% efficient) and the improved performance of the GAHP equipment with advanced controls. Prior to the upgrade, the DHW system efficiency (Existing standard efficiency boiler and GAHPs) calculated in the previous phases was approximately 75-80%. This was due to short cycling of an old inefficient boiler and constant cycling and lack of optimization of the GAHP units. Based on these initial results, the MUA and DWH Preheat system efficiency has increased. At certain intervals system efficiencies over >100% were seen.

4.2 Detailed Energy Savings

The table below gives an overall summary of the avoided energy for phase 5 (#17) based on data obtained during the test periods. The avoided energy is also expressed as a percentage of the site total. The technical items discussed in the subsequent section give some insight to the system efficiency.

Table 2: Overall Summary of Project Savings

Test site	Extrapolated Annual Avoided Energy (GJ)	Percentage of Site Total Natural Gas Consumption[1]	Percentage of DHW Natural Gas Consumption	Percentage of Ventilation Natural Gas Consumption
Phase 3: GAHP-17	150.5	3.6%	-	44.0%

[1] Based on predicted annual avoided energy accounting for right sizing and excluding thermal losses.

4.3 Technical Performance Analysis

As identified within the original pilot scope, the overall system efficiency is essentially the ratio of useful work done by the GAHP system, to the energy input to the system (natural gas and electricity). The useful work done by the system is proportional to the temperature rise of the water and the flow rate through the system. The critical temperature differential is the temperature rise from the DCW added to the buffer tank to the water leaving the buffer tank. The GAHPs reject heat to the buffer tank through a double wall heat exchanger. Approximately 3.7% thermal losses are experienced across this heat exchanger. The system efficiency accounts for such thermal losses. This is still present when the GAHPs provide DHW preheat.

Integration of advanced controls has given excellent insight into the operation of the GAHP systems, over and above those findings in the original M&V pilot. The challenges of control integration were previously discussed, with those issues having been resolved throughout the measurement period. Control integration provides close monitoring of each individual piece of equipment and its operating status including the internal fluid temperatures of the machine itself. These temperatures are important from a control perspective as these are what the on-board equipment controllers use to operate the equipment.

The control system allows the staging of each GAHP unit depending on the thermal energy load. Two (2) of the most important control parameters of the GAHP equipment are the heating (temperature) setpoint and the deadband. A deadband or dead-band (also known as a dead zone or a neutral zone) is a band of input values in the domain of a transfer function in a control system or signal processing system where the output is zero (the output is 'dead' - no action occurs). These parameters determine when the unit is operating or not. It is important to note the heating outlet temperature limitation of the GAHP is generally in the region of 55-58°C (131-136°F). Previously, the GAHPs had been operating to a setpoint of 60°C (140°F). Before this point was reached the GAHP would shut off due to internal limits.

Understanding these insights, led to phase 5, whereby a rightly size hydronic hot water coil was integrated into an existing constant volume MUA and DHW preheat system. Through the measurement and verification period, it was determined that the MUA should have priority for all GAHP heat energy production in order to maintain the SAT of the ventilation system. By rightly sizing the hot water coil, conducive to the GAHP operation parameters (temp delivery, temp differential and flowrate), greater system efficiencies and resultant energy/ghg emission savings were seen.

When the MUA load reduces, the system modulates to become a hybrid heating system where the GAHPs heat the supply air and also provide DHW preheat. In doing so, the required supply and return temperature differential (6°C minimum) can be maintained, thus maintaining system efficiencies above 100%.

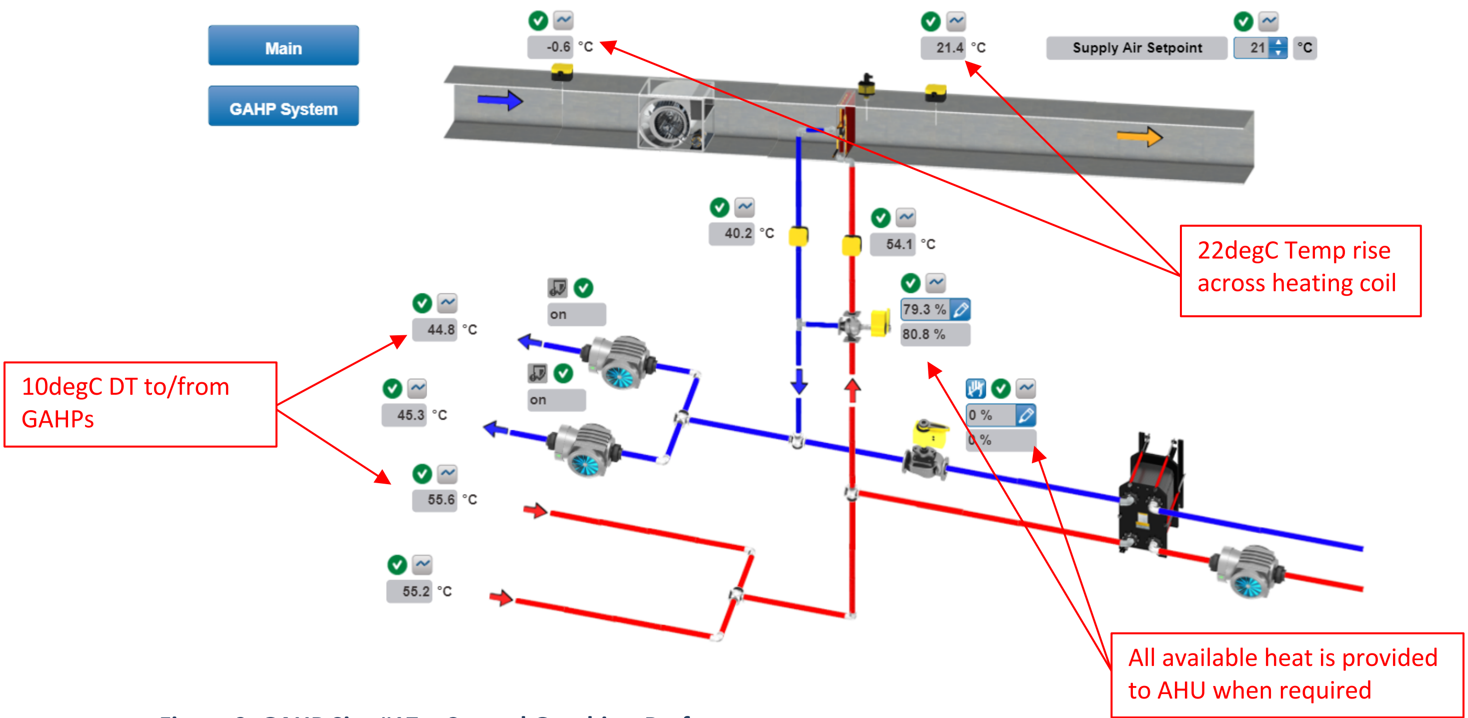

Figure 9: GAHP Site #17 – Control Graphic – Performance

When OAT approaches the setpoint, the GAHP system switches to full DHW preheating as per the original phases of the pilot.

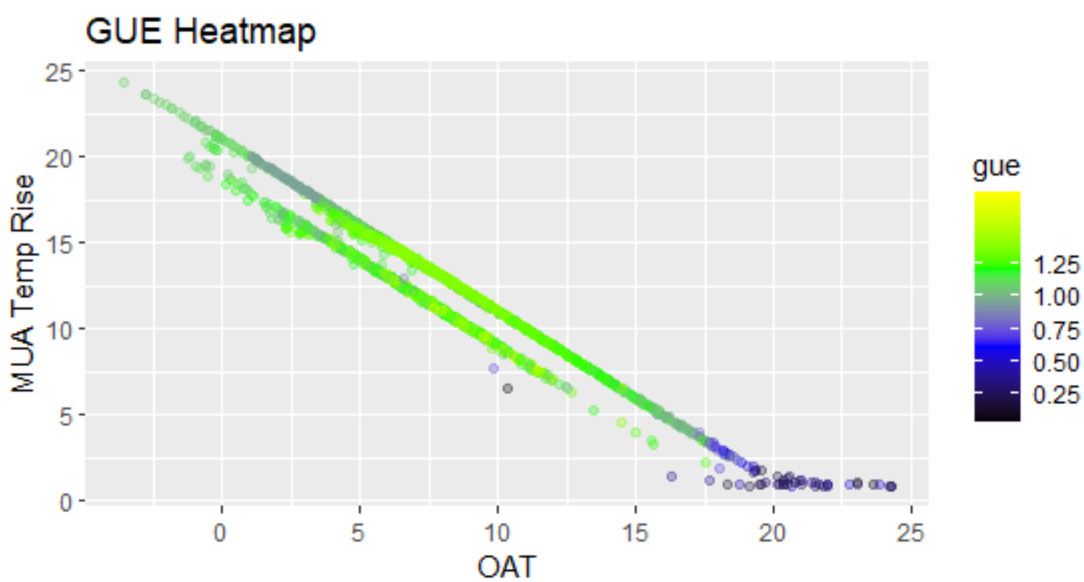

Figure 10: Relationship between the MUA supply air temperature rise and the GUE

When MUA load is high, GAHPs operate in almost steady state condition with constant load. This results in superior performance and efficiency versus just DHW heating which is very intermittent.

The measurement and verification data plotted in figure 11 demonstrates the positive effect of the constant load provided by the MUA heating (SAT SP) requirement when there is a greater than 5ºC supply air temperature rise requirement. During these times, system efficiencies of 125% (GUE 1.25) were consistently measured.

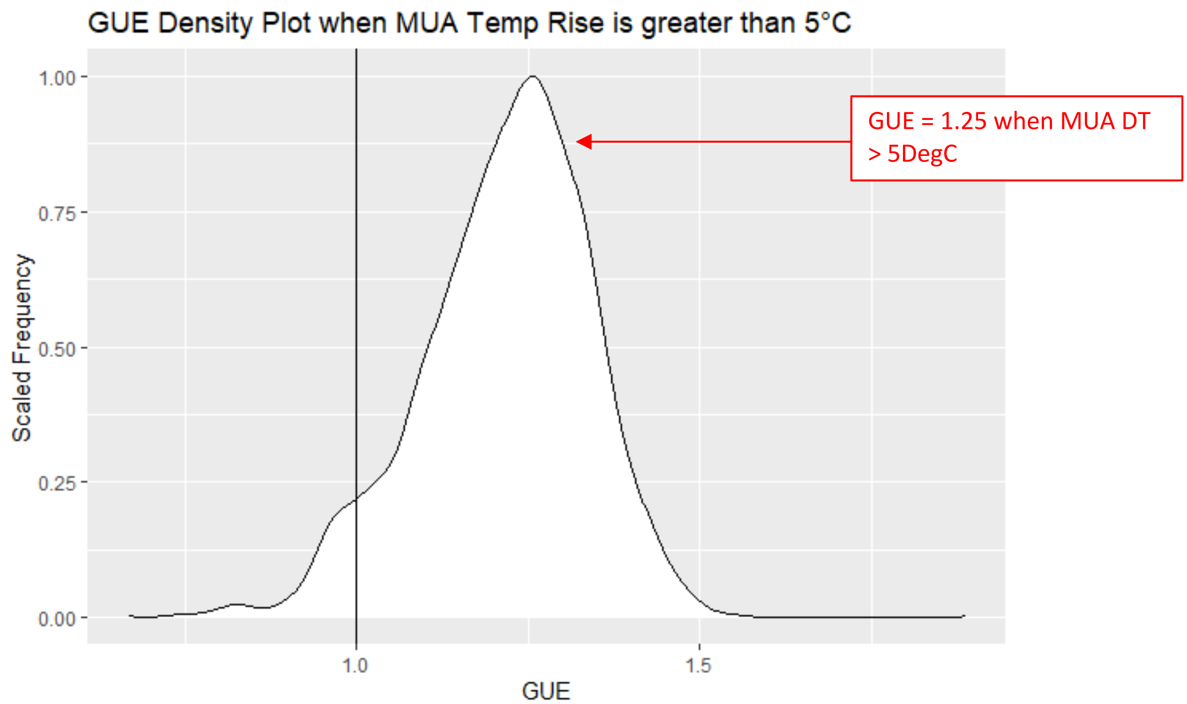

Figure 11: The effect of the MUA SAT temperature increase on the GUE (Gas Usage Effectiveness)

In a contrasting way, the figure below shows the effects of the constant load provided by the MUA heating (SAT SP) requirement when there is a lower than 5ºC supply air temperature rise requirement. During these times, system efficiencies of 118% (GUE 1.18) were consistently measured. It should be noted that this is an efficiency increase compared to the original pilot phases 1 and 2 which saw GAHP efficiencies of 1.14 for DHW preheat only, utilizing the existing standard efficiency equipment for peaking/top up heating.

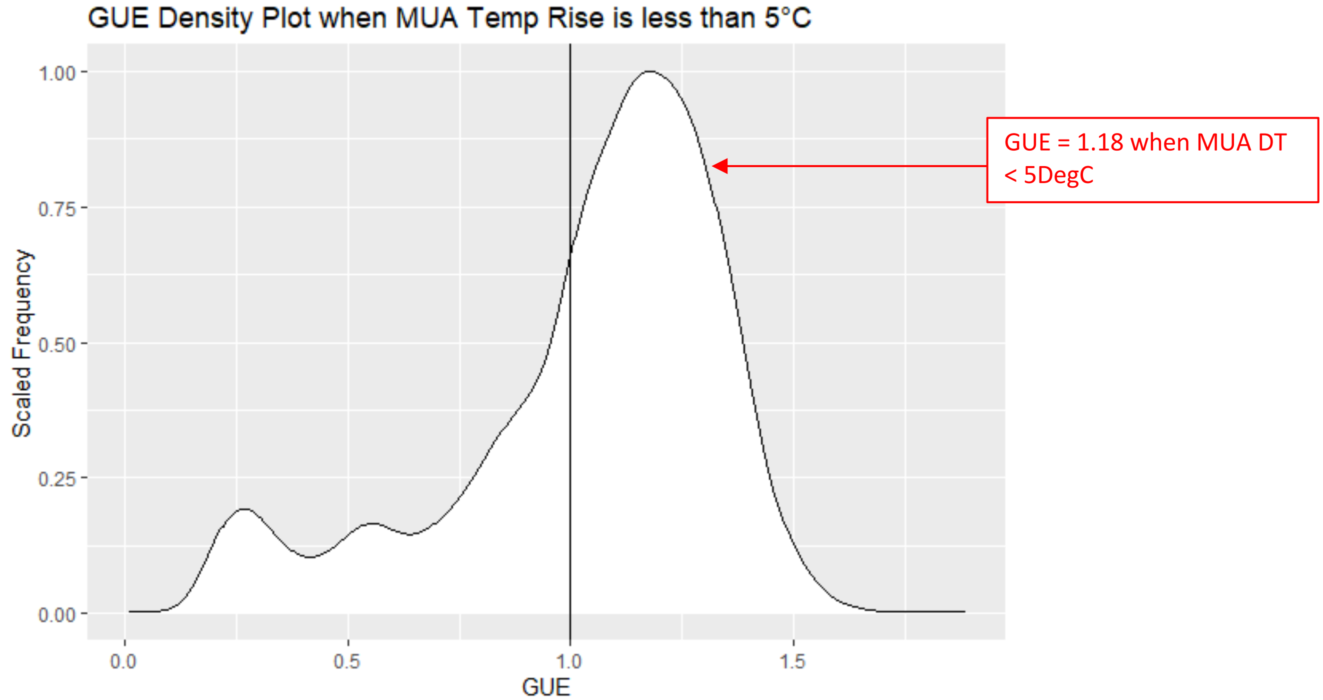

Figure 12: The effect of the MUA SAT temperature increase on the GUE (Gas Usage Effectiveness)

Over the measurement period the GUE was calculated and compared to the GAHP differential temperature and outdoor air temperature from the data obtained through the new control system. The data shows a clear correlation between the outdoor air temperature and the GUE. To achieve a GUE greater than 1.0, it is essential to have a differential temperature across the GAHP of greater than 6.5-7°C, which correlates to an outdoor air temperature between 0-15°C (32-59°F).

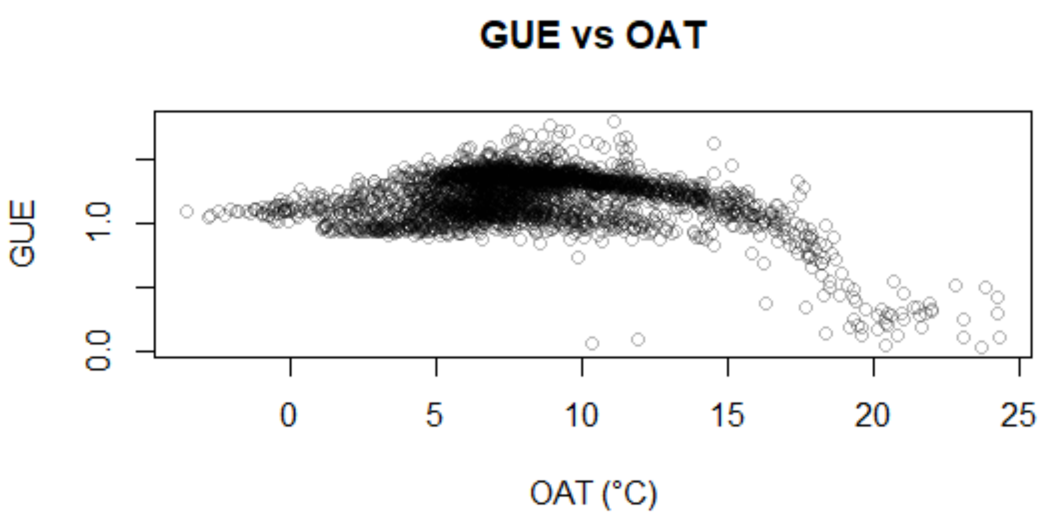

Figure 13: The effect of the outdoor air temperature on the GUE (Gas Usage Effectiveness)

This is an extremely important finding for the overall project and future roll-out of an incentive based retrofit or new construction program. With the data plots having been verified, GAHPs require a relatively large and consistent differential temperature or consistent load. For future deployment there two essential steps required to maintain high efficiency levels:

1. Right sizing of the plant for the thermal energy load. The units are not well suited to the intermittent nature of DHW loads. However, during times of high usage, high efficiency operation has been demonstrated and proven. In the case where the equipment was tested with an existing heating system, the GAHP plant is undersized and cannot maintain the heating internal temperature requirements consistently. Therefore, right sizing and low temperature hot water heating is essential for efficient operation.
2. Control system integration. Dynamic control of the plant heating setpoint and deadband as well as temperature and status monitoring with the advanced controls system is essential to maintain efficient operation. Wider scale deployment of the technology would likely require a hybrid system consisting of a GAHP(s) combined with condensing boiler(s). Control would be essential in this case to maintain high efficiency and system optimization.

4.4 Project Financial Analysis

The financial analysis for phase 5 is shown in incremental cost as 'additions' to a GAHP retrofit i.e., if they were installed as part of an already existing/ongoing retrofit. To analyze them as standalone retrofits does not provide a true and accurate picture. If they were to be installed as a standalone system, the cost effectiveness may not be sufficient for the project business case.

The table below summarizes the average project cost for the test site.

Table 3: Summary of Project Costs

Description	Phase 5
GAHPs	-
Hot Water Coil	$4,130.00
Pumps	$0.00
Electrical/Controls	$13,700.00
Buffer Tank	$0.00
Labour	$2,400.00
Cranage/Hoisting	-
Structural base for GAHPs	-
Out of Hours connection to existing	-
Sheet Metal	$1,570.00
piping to/from HX	$2,800.00
Thermal Insulation	$1,500.00
Glycol/Commissioning	-
Misc./Permits/Manuals/Warranty etc.	$200.00
Labour	$7,400.00
Total Project Cost	**$33,700.00**

Based on the above, we estimate that the retrofit project costs and incremental project costs could be reduced in the future, especially if the MUA was scheduled to be upgraded as part of the client's asset management plan. In dialogue with the installation contractors several suggestions should be considered to minimize capital cost expenditure for this type of retrofit.

The table below summarizes the anticipated costs for a make up air unit integration project whereby two (2) GAHPS are integrated to a standard efficiency gas fired make up air system.

Table 4: Summary of Hot Water Heating System Integration Project Costs

Description	Std Eff MUA Installation (ex GST) (Base Case)	Condensing MUA (CMUA) Installation (ex GST) (Adjusted Base Case)	GAHP and CMUA Install (ex GST)	GAHP Retrofit to Existing (ex GST)
Ventilation (MUA) Integration	$67,470.00	$85,540.00	$158,953.34	$115,182.34
Percentage Difference from Base Case	N/A	26.8%	85.8%	34.7%

In the table, incremental costs have been determined as the difference between the adjusted base case system and a GAHP installation. Whereby the adjusted base case system is a gas fired condensing make up air unit (CMUA) installation. The GAHP installation includes for two (2) GAHPs in combination with a new CMUA and as an alternative; two (2) GAHPs in combination with an existing standard efficiency gas fired make up air unit.

In this regard, it has been determined that a GAHP and CMUA retrofit is $158,953.34, which is 85.8% more than a CMUA installation. More cost effectively, it has been determined that a GAHP retrofit to an existing make up air unit is less than 35% additional incremental cost.

4.4.1 Project Financial Analysis

The Net Present Value and Internal Rate of Return on the project's incremental costs has been completed using the following assumptions:

a) Natural gas cost escalation rate of 2% annually

b) Incremental project cost of $29,342 to account for the range of installation costs i.e. difference between GAHP retrofit into an existing ventilation system and CMUA Retrofit.

Table 5: Twenty-Year Net Present Value (NPV) and Internal Rate of Return (IRR) on Incremental Costs[2]

Site #	20-Year NPV	20-Year Rate of Internal Rate of Return
GAHP-17	$642.59	2%

[6] The incremental cost of the GAHP has been compared to a typical on-demand DHW boiler system retrofit consisting of two condensing DHW boilers and one storage/buffer tank. The incremental cost for the condensing boilers has been compared to a std efficiency boiler retrofit. The integration to the heating system has been compared to a low load condensing boiler installation.

4.4.2 Simple Payback

The table below summarizes the preliminary energy avoidance and simple payback based on incremental cost. For clarity, the incremental cost has been compared to the difference between GAHP retrofit into an existing ventilation system and CMUA Retrofit.

Table 6: Summary of Avoided Energy and Simple Payback

Test site	Predicted Annual Avoided Energy (w/o losses) (GJ)	Percentage of site total natural gas consumption	GHG savings (tCO2e)	Natural gas utility savings	Annual Carbon tax savings ($)	Capital Cost ($)	Simple Payback
GAHP-17	150.50	3.6%	7.46	$1,196.48	$298.59	$29,342.00	19.6

5 CONCLUSION

BES-Building Energy Solutions Ltd, worked with Campbell Scientific and Synertek Automation (monitoring specialist contractors) and FortisBC to implement a GAHP (Natural gas Absorption Heat Pump) M&V (measurement and verification) study to further investigate additional system retrofits when combined to a GAHP. This additional investigation formed phase 5 of the pilot:

- Phase 3: Integrated into a constant volume standard efficiency ventilation system complete with new controls.

The primary objectives of this phase was to:

- Validate performance;
- Investigate energy savings and economic analysis;
- Assess customer acceptance behavior;
- Identify issues associated with the installation and operation of the GAHPs.

5.1 Project Financial Performance

A twenty-year assessment of financial performance of the project's incremental costs reveals some important findings:

1) Additional energy savings and system efficiencies were realized that provided an increase on the modest Internal Rate of Return on project incremental costs.
2) Exploration of these savings on larger constant demand or ventilation dominant building would yield a greater IRR based on similar incremental costs.

5.2 Energy Use

As with the original pilot, the baseline natural gas consumption for site #17 was calculated as the weather normalized natural gas consumption. Weather normalization provides a means to remove seasonal peaks tied to climate conditions. The data in the table below summarizes the overall performance of the GAHP systems over the project duration. The avoided energy was calculated based on the natural gas savings of GAHP operation during the test period. The test site shows good avoided energy with the GAHP operation when connected to the ventilation and DHW systems. These savings are reasonable due to the fact that the DHW consumption only makes up a fraction of natural gas use over the test period. It must also be noted that the existing DHW boiler was required to top up the DHW temperature to 60°C (140°F).

The table below illustrates the overall avoided energy on the test site.

Table 7: Summary of Energy & Greenhouse Natural gas Emissions Avoidance

Test site	Extrapolated Annual Avoided Energy (GJ)	Percentage of Site Total Natural Gas Consumption[3]	Percentage of DHW Natural Gas Consumption	Percentage of Ventilation Natural Gas Consumption
Phase 3: GAHP-17	150.5	3.6%	-	44.0%

For Phase 5, GAHP #17, the results demonstrate that the DHW system efficiency has increased by 4-11% over and above that of the original pilot when MUA heating is required. The system efficiency is therefore above 100% under normal operation when there is a heating load requirement of the MUA. This correlates to an outdoor air temperature between 0-15°C (32-59°F). Further, under heavy peak load usage, when the MUA is SAT differential from the outdoor air is > 5°C, system efficiencies of 125% (GUE 1.25) were consistently measured. In contrast the nameplate efficiency of a condensing makeup air unit serving the same ventilation purpose is between 94-96% efficient. This correlates to an approximate 30% increase in efficiency when compared to the industry standard base case installation of a condensing makeup air unit.

The effects of advanced controls were duly investigated and optimized and data shows that the result of staging the GAHPs and changing the deadband and supply water temperature setpoint saw an increase in efficiency and allowed the GAHPs to operate >1.2 for longer durations than the original pilot. This also had the effect of increasing the average efficiency >1.14 to approximately 1.25.

Further consideration and trials are ongoing in regard to testing variable flow GAHP systems. Constant flow through the GAHP is preferred to eliminate 'spikes' in temperature and nuisance locking out problems.

It was also determined that there is a correlation between GAHP efficiency and OAT.

- At low OAT, performance/efficiency reduces.
- At high OAT, there is no MUA heating load so performance varies wildly due to the intermittent DHW load.

5.3 Further Considerations

In addition to those considerations presented in the original measurement and verification report, the following considerations were determined:

- Individual control of each GAHP in the overall system is important for energy efficiency. This can include operation at different stages on demand or rotated as necessary.
- Dynamic control of the system/GAHP setpoint and deadband for optimum performance over different seasons.
- Advanced monitoring of each GAHP including fluid inlet and outlet temperature, status, pump speed, fan status and alarms.
- Control of circulation pumps to optimize overall energy performance.
- Potential for variable volume control of the system to optimize the critical operating differential temperature.
- User interface graphics with status and operating data for facility managers and service technicians.
- Potential integration for cloud monitoring and optimization solutions including predictive maintenance.

[3] Based on predicted annual avoided energy accounting for right sizing and excluding thermal losses.

- MUA's are typically located on the roof, near where GAHPs could be installed to reduce capital costs and increase business cases
- 20% of commercial gas consumption is attributed to ventilation systems.
- Minimal reduction in GAHP performance in cold climate (Electric HP's fail <5DegC)
- Even with Robur efficiency reduction (technical literature) at low OAT, A GAHP would still be more efficient than Condensing MUA.

In view of the above, recommendations for future testing include:

- Replace the existing DHW boilers at GAHP #17 with a condensing boiler with burner modulation to further improve DHW system efficiencies and substantiate the findings from phase 3 of the pilot.
- Replace the existing hot water heating boilers at GAHP #17 with a hybrid condensing boiler and GAHP system. The system would essentially become a hybrid system where the GAHPs could perform stage 1 of heating with the condensing boilers providing peak load heating hot water.

The figure below shows the proposed system boundary for the recommended next steps:

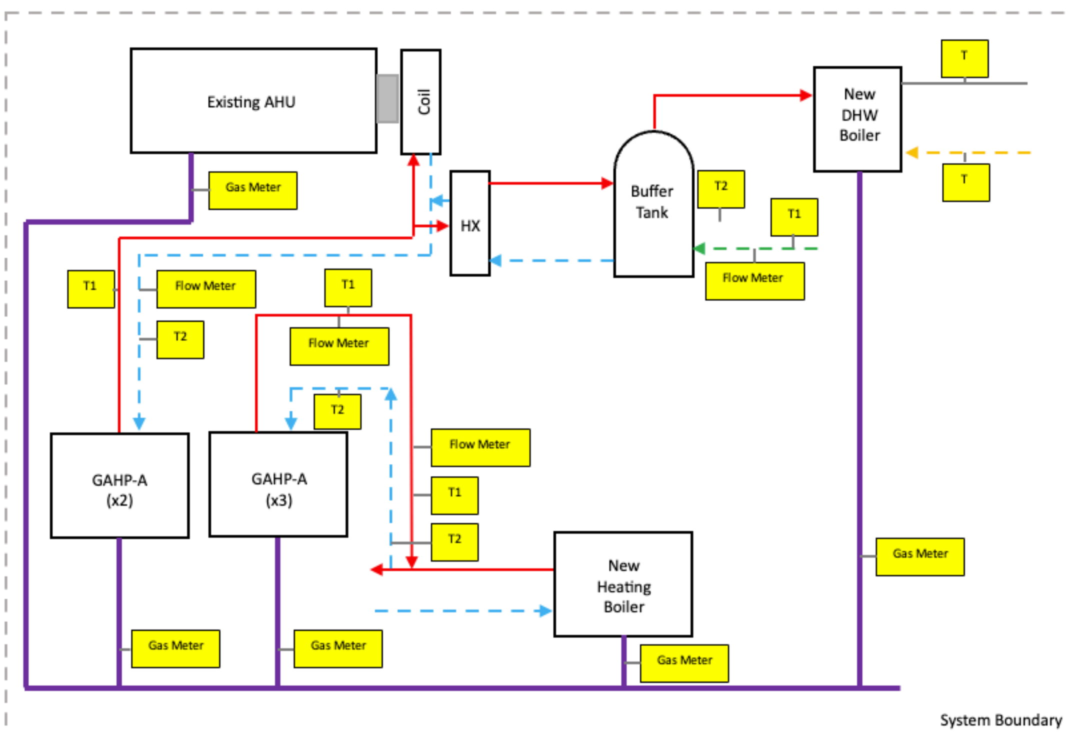

Figure 14: GAHP Pilot Future Phases (System Boundary)