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August 4, 2022

Coalition to Reduce Electropollution
126-102 Forestbrook Place
Penticton, BC V2A 7N4

Attention: Mr. Hans Karow

Dear Mr. Karow:

Re: FortisBC Energy Inc. (FEI)

Project No. 1599211

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

Response to Coalition to Reduce Electropollution (CORE) Information Request (IR) No. 3 on Rebuttal Evidence

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On May 5, 2021, FEI filed the Application referenced above. In accordance with the regulatory timetable as amended in British Columbia Utilities Commission Order G-206-22 for the review of the Application, FEI respectfully submits the attached response to CORE IR No. 3 on Rebuttal Evidence.

For convenience and efficiency, FEI has occasionally provided an internet address for referenced reports instead of attaching lengthy 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 the undersigned.

Sincerely,

FORTISBC ENERGY INC.

Original signed:

Diane Roy

Attachments

cc (email only): Commission Secretary
Registered Parties

CORE-FEI-2022JULY14-001

Reference: FEI Rebuttal Evidence, Exhibit B-26 PDF page 2

Issue: On page 2 (PDF page 2) of its cover letter to the BCUC, FEI states, in part:

In the expert report of Dr. Magda Havas, Appendix D to Exhibit C7-12-1, Dr. Havas, at page 76, states that, "I have been informed that these proposed 'smart' gas meters also work in conjunction with WiFi hubs and towers. If this is indeed the case, then people will be expose to additional, unnecessary radiation non-consensually, they are not informed of the risk". Dr. Havas does not provide the source of her information for this hearsay statement or state that she believes it to be true. There is no evidentiary foundation for the related opinion.

The infrastructure upon which the Sensus/Flexnet program is built is comprised of various cellular towers, base stations, etc., regardless of the terminology used.

1.a Does Fortis not consider the 170 base stations which will be installed on poles, towers buildings, similar to existing cell tower installations to be wireless towers?

Response:

FEI disagrees with the characterization of Dr. Havas' prior evidence in the preface to CORE IR3 1.a as referring to "*existing cell tower installations*." The quotation from her report above states that *"I have been informed that these proposed 'smart' gas meters also work in conjunction with WiFi hubs and towers"* which FEI does not consider to be the equivalent of *"existing cell tower installations".*

The following additional response has been provided by Exponent.

The base stations that are part of FEI's proposed AMI network are not similar to *"WiFi hubs and towers"* cited by Dr. Havas.

Notwithstanding the above, the question of exposure from FEI base stations is already answered in Exponent's RF Technology report at p. 19:

> …the base stations will typically send four messages per minute with a minimum of one message per minute for synchronization of devices.[1] While the base stations transmit much more frequently than the various End Points, there are very few of them and they are all located tens of meters above ground. Base stations operate at similar power levels as many cell phone transmitters, but there will be only 170 in the entire FEI network area compared to approximately 68,000 cell phone transmitters at more than 6,900 locations throughout British Columbia (see

[1] There is a separate dedicated radio channel used for critical data like alarms, which would be used infrequently.

> [Exponent RF Technology Report] Appendix A, Figure A-1).[2] The relatively short transmission times and limited number mean that base stations will contribute little to overall RF exposures (footnotes 1 and 2 are in the original).

Thus, although installed high above the ground on poles and with a generally similar power level as many cell phone transmitters, the Base Stations, with a maximum duty cycle of approximately 1.67 percent (refer to Exponent RF Technology Report, Table B-2 at pp B-3) are not similar to existing cell tower installations from the important aspect of potential exposure (i.e., how rarely they transmit relative to a cell phone base station).

1.b In its application (see Exhibit wiB-1 *[sic]*, PDF pages 336 to 337) Fortis states that the majority of base stations will transmit in all directions to about 60,000 end points. This is the source. Is Fortis now saying that Dr. Havas was wrong in considering this information?

Response:

FEI agrees that Exponent's RF Technology report submitted as Exhibit F-1 to FEI's Application states:

> The majority of base stations will transmit equally in all directions (isotropic antennas), although some will transmit only in specific directions (directional antennas), and each is designed to communicate with up to approximately 60,000 End Points. (pp. 18-19).

Such data are open for consideration by anyone, including Dr. Havas. However, FEI considers that Dr. Havas was incorrect to state that the proposed AMI gas meters *"work in conjunction with WiFi hubs and towers"* as discussed in the response to CORE IR3 1.a. In any event, the RF exposures associated with FEI base stations were evaluated by Exponent as summarized in the Exponent RF Technology Report, Table B-2 at pp. B-3.

[2] Source: Government of Canada Spectrum Management System Data (http://sms-sgs.ic.gc.ca/eic/site/sms-sgs-prod.nsf/eng/h_00010.html); SCADACore Canadian Cell Tower Map (https://www.scadacore.com/tools/rf-path/cell-tower-map-canada/). Accessed April 27, 2021.

CORE-FEI-2022JULY14-002

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 15, Section 2.4 (Project Alternatives)

Issue: On PDF page 15 (lines 15-27) of FEI's Rebuttal Evidence, FEI states in part, the following, in response to Q7:

[…]

How do you respond to these statements?

The analysis of a wired AMI solution was provided in FBC's responses to information requests in its 2012 application for a CPCN for its AMI Project. Although FBC's AMI project was for the installation of electric AMI meters, the challenges and costs associated with a wired AMI meter option are similar and relevant to FEI's AMI Project. In response to the Citizens for Safe Technology (CSTS)'s IR1 12.5 in that proceeding, FBC set out a cost analysis for fibre optic alternatives. While the cost analysis is limited to FBC's service territory, the considerations are relevant to FEI. While fibre infrastructure is often already in place throughout urban areas "to the curb" or "to the neighbourhood", it is likely that a small length of fibre cable to the customer's gas meter is still needed. FEI would be required to enter into agreements for leasing this existing fibre network.

In more rural areas, it has been cost prohibitive to extend fibre networks, and this option likely does not exist for FEI's rural customers. FEI would be required to build fibre in order to access those meters.

2.a Does FEI agree that Fiber optic cable has many advantages over wireless communication in so far as it is faster than wireless? If not, why not?

Response:

Please refer to the response to BCUC IR3 3.1.

2.b Will Fortis investigate the feasibility of being one of the first utilities in Canada to use fiber optic cable for its smart meters?

Response:

Please refer to the response to BCUC IR3 3.1.

CORE-FEI-2022JULY14-003

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 41, Section 2.1 (Status of the Research), Q 4.

Issue: On PDF page 41 (lines 10-15), FEI provides the following response, in part, to Q4:

Is an Environmental Assessment of the proposed AMI Gas Metering proposal warranted?

Scientists from Leiden University and the National Institute for Public Health and the Environment in the Netherlands published a systematic review of more than 113 peer reviewed studies and existing reviews on the potential ecological effects of RF/microwave electromagnetic fields in the range of 10 MHz to 3.6 Gigahertz (GHz). Their main conclusion was that "No clear dose- effect relationship could be discerned" (Cucurachi et 15 al., 2012, p. 116).

3.a Is Exponent familiar with the recent 3-part article published in the international peer- reviewed journal *Reviews on Environmental Health* in 2021-22 by co-authors Dr. Henry Lai, Albert M. Manville and Blake Levitt, entitled "Effects of non-ionizing electromagnetic fields on flora and fauna, part 1. Rising ambient EMF levels in the environment", "Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: how species interact with natural and man-made EMF" and "Effects of non-ionizing electromagnetic fields on flora and fauna, Part 3. Exposure standards, public policy, laws, and future directions" respectively? (available online: https://pubmed.ncbi.nlm.nih.gov/34047144/, https://pubmed.ncbi.nlm.nih.gov/34243228/ and https://pubmed.ncbi.nlm.nih.gov/34563106/)

Response:

The following response is provided by Exponent.

Yes, Exponent is familiar with the cited articles.

3.b If FEI is familiar with these articles, would FEI agree that these articles detail the many biological effects reported and confirmed by independent experts related to exposure to radiation from devices such as wireless smart meters? If not, why not?

Response:

The following response is provided by Exponent.

The article, whose first author B. Blake Levitt is a journalist, not a scientist, was published in three parts. The article discusses electromagnetic fields across a very wide swath of the frequency spectrum including studies of much lower frequencies (down to extremely low frequency [< 300 Hz]) and static fields [0 Hz]), as well as much higher frequencies—millimeter and other 5G technology frequencies—than the 900 MHz signals from the Sensus FlexNet meters.

Part 1 focuses mostly on measurements of the levels of radiofrequency (RF) fields in the environment and millimeter waves and 5G technologies. Part 2 focuses a great deal on topics not specifically related to potential effects of RF fields on ecosystems. Part 3 focuses on exposure standards, public policy, laws, and future directions.

Part 2 is of the greatest potential interest, but much of the text relevant to ecosystems provides only superficial discussions of research on avians, insects, and spiders, as well as fruit flies, beetles, ants, ticks, monarch butterflies, bees and wasps, aquatic organisms, etc. These discussions are presented without regard to the frequency of exposure or consistency of specific effects at any specific frequency range, including RF. For example, the discussion of Monarch butterflies only discussed static magnetic fields, mostly from the earth itself. The review also was not scientific in that the article did not focus on the strengths and weaknesses of studies evaluated. In a rare example, Part 2 discusses one of the better studies of a 900 MHz source in some detail:

> Vijver et al. [408][3] however challenged the accuracy of distance from towers that is often used as a proxy for EMF gradients such as the study above. In a field study in The Netherlands, the researchers tested exposure to RFR from a cell base station (GSM 900 MHz) on the reproductive capacity of small virgin invertebrates during the most sensitive developmental periods spanning preadolescent to mating stages when reproductive effects would most likely be seen.
>
> ... After complex data synthesis, no significant impact from the exposure conditions, measures of central tendency, or temporal variability of EMF on reproductive endpoints were found although there was some variability between insect groups.
>
> They also noted that the organisms selected in the study were small in size . . . Due to size, limited absorption and little energy uptake capacity, <u>none of these insects are efficient wholebody receptors for 900 MHz waves</u> with a wavelength of approximately 13 in (33 cm) (p. 36, Underlining added).

However, the authors of Part 2 did not apply the insightful dosimetry of Vijver et al. (2013) to their assessment of other studies of insects and this dosimetry consideration is part of the reason that small organisms, like insects, are unlikely to be severely impacted by direct exposure to RF fields.

[3] Vijver MG, Bolte JFB, Evans TR, Tamis WLM, Peijnenburg WJGM, Musters CJM, et al. Investigating short-term exposure to electromagnetic fields on reproductive capacity of invertebrates in the field situation. Electromagn Biol Med 33:21-28, 2013.

Exponent agrees that the large literature on RF field includes studies that have reported statistical associations or differences between areas or species that may have been regarded as having higher or lower exposures to RF fields. As stated in the scientific reviews cited in Exponent's Rebuttal Evidence, scientists have not found much consistency, replication of findings or demonstration of dose-response relationships that would support the broad claim that there are *"many biological effects reported and confirmed by independent experts"* or if perhaps *"related to"* were unequivocally demonstrated to be caused by some *"radiation"* of undetermined frequency or intensity independent of other factors or conditions.

Overall, the review in three parts cited in the preamble to CORE IR3 above adds little to our knowledge, and the relevance of the RF exposures in the studies cited in the three-part article to those of the FEI gas meters has not been established.

3.c Would FEI agree that many independent, peer-reviewed studies show deleterious effects on insects, flora and fauna? If yes, why has Exponent not referenced any of these studies in the Exponent RF Health Report filed as Appendix F-2 to Exhibit B- 1?

Response:

The following response is provided by Exponent.

No, please refer to the responses to CORE IR3 3b, CEC IR3 8.1, and Exhibit B-26, Exponent Rebuttal Evidence, Q4.

CORE-FEI-2022JULY14-004

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 44, Section 2.2(Characteristics of Radiofrequency Signals), Q6.

Issue: In reply to CORE's response to BCSEA IR1 2.2, FEI states, in part, at PDF page 44 (lines 3-19) as follows:

At a distance of approximately 20 cm from the Sonix IQ meter, the power density is highly non-uniform, so spatial averaging is required to assess the exposure. In this situation, spatial averaging of measurements or a specific absorption rate (SAR) evaluation demonstrates compliance with SC 6.

The time factor only comes into play when measurements are taken to assess compliance with the standard. Persons can be exposed at or below 100% of the limit indefinitely. Exposure to levels above 100% can be permitted provided the duration is sufficiently short. This is because the absorption of RF energy by the body, and therefore the effects of RF exposure, are described by an intensity x time relationship. SC 6 allows short-term exposures higher than 100% of the reference level power density if the time-weighted average during any 6-minute period does not exceed the SC 6 reference level. Essentially, the total absorbed energy must not exceed the product of intensity and time.

It may be easier to understand the concept if we envision the accumulation of RF energy in tissue like water flowing into a small container. In this case the reference level states that the bucket cannot overflow. Different rates of water filling and time durations all will meet the standard as long as the total amount of water or energy deposited in a 6-minute period does not exceed the capacity of the container to accept flow without "spilling over."

4.a Does FEI agree that SAR is the measurement used to measure thermal heating only, and usually is used for devices that are usually within 20 cm of the human body? If not, why not?

Response:

The following response is provided by Exponent.

No. The specific absorption rate (i.e., SAR) is defined in the SC 6 Standard (2015) as:

A measure of the rate at which energy is absorbed by the body (or a discrete tissue volume) when exposed to a radiofrequency (RF) field. SAR is expressed in units of watts per kilogram (W/kg), and can be calculated from the product of the tissue conductivity (S/m) and the square of the RMS electric field strength induced in the tissue (V/m), divided by the mass density (kg/m^3) of the tissue (p. 14).

SAR is a measure of exposure to RF energy whereas *"thermal heating"* referred to in the IR is a biological response to SAR. If there are other biological effects of RF fields, besides heating of tissues, then they too should be related to exposures quantified by SAR.

The IR also appears to refer to several sentences in SC 6:

> The SAR should be determined for situations where exposures occur at a distance of 0.2 m or less from the source. In all cases, the values in Table 2 shall not be exceeded. For conditions where SAR determination is impractical, external unperturbed field strength or power density measurements shall be carried out and the limits outlined in Section 2.2 shall be respected. (p. 5).

This is consistent with the response in Exponent's Rebuttal Evidence cited in the IR above, which states that "[a]t a distance of approximately 20 cm from the Sonix IQ meter … a specific absorption rate (SAR) evaluation demonstrates compliance with SC 6." There is no reason why SAR cannot be used to describe exposure at any distance because distance is not part of its definition. SAR measurements are not often performed at distances > 20 cm because it is unnecessary to do so. When exposure is evaluated at distances > 20 cm, it is most often performed using Reference Levels simply because it is easier to evaluate compliance of unperturbed electromagnetic fields based on the known physics of electromagnetics than the more complicated and costly evaluation of SAR. However, in all cases the Basic Restriction (which is based upon SAR) is the controlling metric used to evaluate compliance with SC 6.

4.b Does FEI agree that manufacturer measurements may assume a homogenous laboratory model, which does not account for energy absorption "hot spots", and that they may conduct their measurements at different distances from the head or body? If not, why not?

Response:

The following response is provided by Exponent.

Measurements of RF sources are determined for a wide variety of purposes and at a wide variety of distances. Measurements made for the purposes of compliance testing of sources with SC 6 may not describe all aspects of the interactions of RF fields that might be of engineering or scientific interest. Evaluation of compliance with SC 6 is based upon the intended use and exposure scenarios relevant to a particular source. For example, it makes no sense to evaluate the compliance of an 88.5-kilowatt broadcast station (such as CBUT-DT) at a distance of 20 cm because the location of interest is typically at ground level, hundreds or thousands of meters (or more) from the station.

The occurrence of localized areas of exposure in a human body, where SAR can be calculated to be higher than that for a homogeneous model of the human body, is well known and accurately described by modeling and verified in some cases by direct measurements. Comprehensive national and international standards consider such phenomena when setting standards for whole body and partial body "peak" exposures. Refer also to the response to CORE IR3 4.c.

4.c Does FEI agree that because SAR measures absorption over 1 gram of tissue (or 10 grams in Europe), this may effectively average out hot spots? If not, why not?

Response:

The following response is provided by Exponent.

No, as described above, comprehensive national and international standards consider such phenomena when setting standards for whole body and partial body "peak" exposures.

Safety Code 6 explains:

> Basic restrictions on peak spatially-averaged SAR have also been established in Safety Code 6 to avoid adverse thermal effects in localized human tissues (hot-spots). The peak spatially-averaged SAR limits reflect the highly heterogeneous nature of typical RF field exposures and the differing thermoregulatory properties of various body tissues. The peak spatially-averaged SAR limits pertain to discrete tissue volumes (1 or 10 g, in the shape of a cube), where thermoregulation can efficiently dissipate heat and avoid changes in body temperature that are greater than 1^{o}C (p. 3)

IEEE Std. C95.1-2019 also explains:

> The extensive review of both the low-level and high-level RF biological effects literature has established that RF exposure results in adverse health effects only when the exposure results in a detrimental temperature increase … When a small region is heated, it rapidly transfers heat to cooler surrounding regions and its temperature does not rise appreciably. On the other hand, when a large volume is heated, the rapid local transfer of heat tends to produce a uniformly elevated temperature throughout. <u>These observations support the use of a volume-averaged SAR</u> if the volume is chosen small enough to avoid excessive temperature gradients over its extent and yet large enough to obtain an average SAR that corresponds well to the actual temperature increase throughout the volume (Section B.7.5, pp 139-140, emphasis added).

The IEEE standard provides further detail regarding what volumes are appropriate for ensuring averaging will not result in *"hot spots"* concluding that *"[b]oth a 1 g and a 10 g averaging volume are adequate to limit excessive local SAR"* (IEEE Std. C95.1-2019, emphasis added).

4.d Does FEI agree that because of the pulsed nature of the signals, the average power can remain low whereas the individual bursts are very high? If not, why not?

Response:

The following response is provided by Exponent.

No, the characterization of the communication signals from the Sensus FlexNet meters as "pulsed" is not accurate. Please refer to Exponent Rebuttal Evidence, p. 9, A7. Additionally, as with all intermittent signals, the average power is necessarily lower than the peak power. Particularly for a signal that is *"off"* the vast majority of the time (such as the Sonix IQ gas meters with typical duty cycle of 0.00039 percent), the ratio of peak to average power will be high. This does not make the signal any stronger (or exposure higher) when it is *"on"*, it simply means there is zero exposure when it is *"off".*

4.e Does FEI agree that manufacturers can use various distances when determining SAR? If not, why not?

Response:

The following response is provided by Exponent.

Apart from distances at which regulatory agencies may require measurements of RF fields from devices or determined in professional standards (e.g., IEEE Std. 1528), there may be a variety of reasons and distances that manufacturers may choose to measure SAR for different purposes.

4.f Why has SAR been used by Exponent rather than power density to compare with Safety Code 6 limits?

Response:

The following response is provided by Exponent.

At a frequency of 900 MHz, SAR is the basic restriction against which compliance with SC6 is evaluated. As stated:

> While compliance with the basic restrictions is required, non-compliance with the reference levels does not necessarily mean that the basic restrictions are not respected. In such cases, additional measurements or calculations may be required to assess compliance (SC 6, p. 3).

For demonstrating compliance with SC 6, it is always valid (but not necessary) to compare to the Basic Restriction, and compliance with Reference Levels can also more easily demonstrate compliance in many situations. Please also refer to the responses to CORE IR3 4.a and 4.b.

CORE-FEI-2022JULY14-005

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 45, Section 2.4 (Project Alternatives), A7.

Issue: On PDF page 45 (lines 19-25), Exponent provides the following response to Q7:

> Neither Dr. Héroux nor Dr. Havas have provided scientific evidence that would support their distinction between biological effects of sources of modulated or unmodulated RF signals. The mere adding of adjectives such as "spurious,"[3] "natural,"[4] "pulsed,"[5,6] and "chaotic" to describe RF signals from the Sensus FlexNet meters or other sources does not provide evidence for or against the potential effects of RF exposure on the body. Nowhere in their reports do they cite a body of peer-reviewed studies that support their claims in the text cited above.

5.a What definitions of "spurious", "natural", "pulsed" and "chaotic" does Exponent rely upon to make this statement?

Response:

The following response is provided by Exponent.

IEEE Standard C95.1-2019 defines a *"pulse-modulated field"* as:

> An electromagnetic field characterized by a form of amplitude modulation in which a continuous wave is abruptly shifted in amplitude from zero to a level at or near the maximum and returning to zero; often characterized by a series of such shifts in a repeated pattern (IEEE Std. C95.1, p. 32, emphasis added).

The Sensus FlexNet meters do not meet this definition, they are *"on"* for a time period of approximately 55 milliseconds followed by several hours of being *"off,"* after which they briefly transmit again on a pseudo-random schedule. They also are not amplitude modulated. They therefore do not produce a *"pulse-modulated field."*

American National Standards Institute (ANSI) Standard C63.14-2014 defines a *"spurious emission"* as:

> Any electromagnetic emission at a frequency or frequencies that are outside the range of the necessary emission bandwidth, the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include parasitic emissions and intermodulation products but exclude emissions in the immediate vicinity of the necessary emission bandwidth that are a result of the modulation process and are necessary for the transmission of information (p. 52, emphasis added).

1 The transmissions from the Sensus FlexNet meters do not meet this definition; the signals are
2 the desired signals from the function of the device and hence are not *"spurious."*

3 Exponent has no technical definitions for the other non-technical terms used by Dr. Héroux or Dr.
4 Havas.

5

CORE-FEI-2022JULY14-006

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 17, Section 2.5 (Legal Matters), Q 9.

Issue: At PDF page 17 (lines 24-26), FEI provides the following response to Q9:

> No, FEI does not agree with these characterizations of Safety Code 6 as being "voluntary", "not a health standard but rather a guideline", and being applicable only to "federally regulated sites" and not the "homes" of FEI's customers.

6.a Does Health Canada in the Preface to Safety Code 6 (2015) include the statement that it applies to all "individuals working at or visiting federally regulated sites" and then they refer to the code as a "guideline"?

Response:

Yes, Safety Code 6 (2015) includes the quoted language; however, as explained in FEI's Rebuttal Evidence (Ex. B-26) at Appendix A, p. 11-12, A9, Safety Code 6 also contains language to the effect that the RF standards it contains are mandatory in circumstances where Safety Code 6 is applicable. As further explained in FEI's Rebuttal Evidence, regulations enacted under the *Radiocommunication Act*, in particular RSS-102, require the proposed AMI meters to comply with Safety Code 6. The language from Safety Code 6 cited in the IR does not change FEI's understanding, consistent with the BCUC's 2013 decision in respect of FortisBC Inc.'s AMI project, that compliance with Safety Code 6 is mandatory in respect of the gas meters in issue.

CORE-FEI-2022JULY14-007

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 63, Section 5.1 (Comparisons to Blackbody Radiation), Q 25.

Issue: On PDF page 63 (lines 2-14), Exponent provides the following response to Q25:

First, Dr. Havas contradicts herself in her response to FEI IR1 8.2 (copied from Wikipedia) stating that:

> *A black-body is an idealised object which absorbs and emits all radiation frequencies. Near thermodynamic equilibrium, the emitted radiation is closely described by Planck's law and because of its dependence on temperature, Planck radiation is said to be thermal radiation, such that the higher the temperature of a body the more radiation it emits at every wavelength* [emphasis added].

While it is true that *the majority* of the electromagnetic energy emitted by the earth and humans is in the infrared portion of the electromagnetic spectrum, these black bodies also emit electromagnetic energy in the RF/microwave portion of the electromagnetic spectrum (i.e., 3 kHz–300 GHz) that are covered by standards such as SC 6, ICNIRP (2020), and ICES (2019).

7.a Please further explain which frequencies blackbody radiation emits.

Response:

The following response is provided by Exponent.

All frequencies. To reiterate, the fundamental physics of blackbody radiation, which was discussed in both the Exponent RF Technology report (pp. 4-5) and Exponent's Rebuttal Evidence (Ex. B-26, Appendix B) at response A25, blackbody radiation emits at all frequencies. The amount of energy emitted at each frequency, including the RF/microwave range of 3 kHz-300 GHz, can be readily described and calculated by Planck's law. Figure 4 of Exponent's Rebuttal Evidence at response A27 illustrates the spectral radiance of blackbody radiation over the frequency range covering the ultraviolet, visible, infrared, and RF/microwave frequencies. The frequency range chosen is for illustrating the broadband nature of blackbody radiation, and it should not be misconstrued as the frequency limits of the blackbody radiation.

CORE-FEI-2022JULY14-008

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 64, Section 5.1 (Comparisons to Blackbody Radiation), Q 25.

Issue: On PDF page 64 (lines 13-21), Exponent provides the following response to Q25:

> Figure 2 below, from a peer-reviewed engineering journal, compares power from 3K and 310 K sources as a function of wavelength on a logarithmic scale. The figure clearly shows the power density of black body radiation of the human body, although less than from a light bulb, is nevertheless still quite evident. The energy from a human or earth (i.e., the electromagnetic energy only in the 3 kHz–300 GHz RF/microwave range) is so small as to be negligible to any potential exposure assessment, but as shown in the Exponent RF Technology Report (Figure 5), this comparison provides valuable context—even this extremely small amount of energy is approximately 4,200 times greater than the average exposure 1 meter away (indoors) from a Sonix IQ gas meter.

8.a Please confirm whether the wavelength referred to in Figure 2 relate to infrared radiation or radio frequency radiation.

Response:

The following response is provided by Exponent.

The wavelengths referred to in Figure 2 of Exponent's Rebuttal Evidence (Ex. B-26, Appendix B) encompass the ultraviolet, visible, and infrared range of the blackbody radiation of several sources. As described in Exponent's Rebuttal Evidence, at A25 (pp. 27-28), the portion of blackbody radiation in the microwave/RF frequency range was not included in Figure 2, but that does not mean it is absent. Figure 2 should not be misconstrued as suggesting that blackbody radiation only emits at wavelengths shorter than 100 µm (i.e., frequencies higher than 3,000 GHz). To demonstrate the magnitude of blackbody radiation in the microwave/RF range, Figure 4 of Exponent's Rebuttal Evidence (Exhibit B-26, Appendix B, A27, p. 32) shows the spectral radiance of blackbody radiation that extends beyond the infrared range into the microwave/ RF range of 3 kHz to 300 GHz (or equivalently wavelengths of 100 km to 1 mm).

CORE-FEI-2022JULY14-009

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 65-66, Section 5.1 (Comparisons to Blackbody Radiation), Q 25, Figure 3.

Issue: On PDF pages 65-66 (lines 1-5), Exponent provides the following response to Q25 and commentary regarding Figure 3:

> Although extremely small, the blackbody energy from humans can be measured with the use of proper instrumentation. For example, the RF/microwave energy of a human is shown below in Figure 3. The image is an example of the RF energy from a human in the RF/microwave portion of the electromagnetic spectrum and is proposed to be used in security applications.

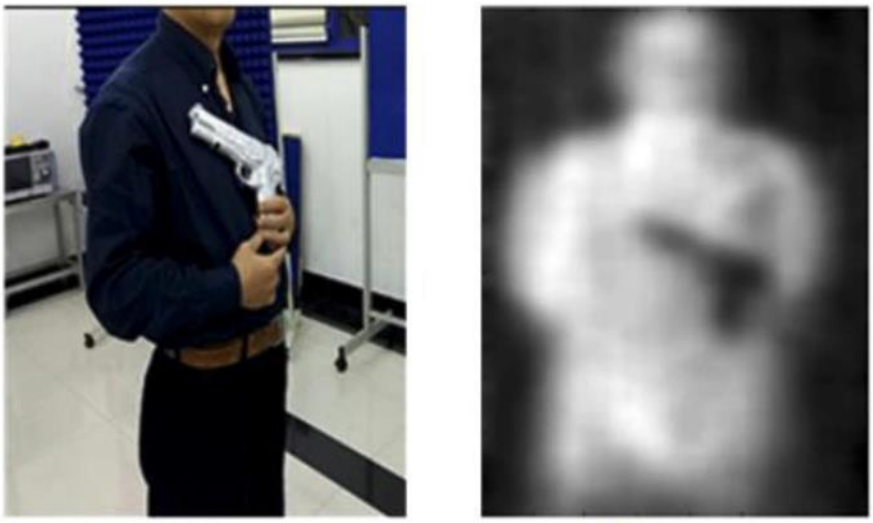

Figure 3. Blackbody image of a human holding a toy metal gun (a) photograph, (b) image in the RF/microwave portion of the electromagnetic spectrum. (Meng et al., 2018).

9.a Please confirm that the caption provided with Figure 3 is its original caption. If not, please provide the original caption.

Response:

The following response is provided by Exponent.

The caption for Figure 3 was added by Exponent to assist the lay reader in understanding the context. The original caption read *"Figure 12. A Volunteer Holding a Metal Toy Gun. (a) Photo of Real Scenario, (b) Imaging Result."*

CORE-FEI-2022JULY14-010

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 65-66, Section 5.1 (Comparisons to Blackbody Radiation), Q 25, Figure 3.

Issue: On PDF pages 65-66 (lines 1-5), Exponent provides the following response to Q25 and commentary regarding Figure 3:

> Although extremely small, the blackbody energy from humans can be measured with the use of proper instrumentation. For example, the RF/microwave energy of a human is shown below in Figure 3. The image is an example of the RF energy from a human in the RF/microwave portion of the electromagnetic spectrum and is proposed to be used in security applications.

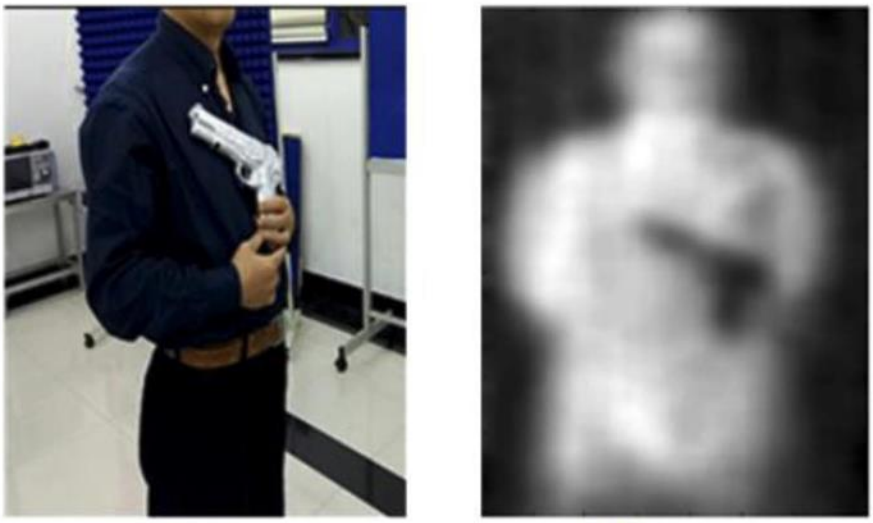

Figure 3. Blackbody image of a human holding a toy metal gun (a) photograph, (b) image in the RF/microwave portion of the electromagnetic spectrum. (Meng et al., 2018).

10.a What evidence does FEI rely upon to support its contention that Figure 3 shows the measurements of RF/microwave radiation rather than thermal effects from passive millimeter wave (PMMW)?

Response:

The following response is provided by Exponent.

Exponent disagrees with the implication that Figure 3 in the Exponent Rebuttal Evidence (Exhibit B-26, Appendix B, A25, p. 30) does not show *"measurements of RF/microwave radiation."* Figure

3 shows the measurements of the passive millimeter wave (PMMW), which originates from the blackbody radiation in the millimeter wave range. For reference, the frequency corresponding to wavelengths of 100 mm and 1 mm is 3 GHz and 300 GHz, respectively, so by definition millimeter-wave signals fall primarily in the RF/microwave portion of the electromagnetic spectrum of 3 kHz to 300 GHz. This is further supported by the following from Meng et al. (2018) cited in Exponent's Rebuttal Evidence:

> Millimeter wave (MMW) has emerged as a promising innovative approach for security check due to its penetration capability and high resolution. More importantly, according to the principle of blackbody radiation, each and every object with temperature above absolute zero emits characteristic MMW carrying intrinsic information about itself. The object could be non-invasively identified by receiving the autonomous MMW radiation from the object only. In principle, there is no artificial MMW source in a PMMW imaging system to illuminate objects of interest (p. 1, emphasis added).

10.b Where in the Meng et al. (2018) report are the terms "radio frequency radiation" and "microwave radiation" used?

Response:

The following response is provided by Exponent.

Please refer to the response to CORE IR3 10.a.

The description added to Figure 3 in the FEI Rebuttal Evidence was made to assist a lay reader not familiar with the definitions and terms in the highly technical paper by Meng et al. (2018) published in *Nature Scientific Reports*. Nevertheless, it is clear from the paper that the energy measured and described in the paper falls within the RF/microwave portion of the electromagnetic spectrum (i.e., 3 kHz to 300 GHz).

Meng et al. (2018) states:

> … [A]ccording to the principle of blackbody radiation, each and every object with temperature above absolute zero emits characteristic MMW carrying intrinsic information about itself. The object could be non-invasively identified by receiving the autonomous MMW radiation from the object only …
>
> It is well known that all natural objects with absolute temperature above zero emit electromagnetic radiation including millimeter wave. […] Passive millimeter wave (PMMW) imaging systems measure the distribution of effective radiation temperatures of concerned objects. In laboratory experiment, the received MMW

presents the integrated effect of the tested objects of interest, volunteer's body, clothes, and the test environment (p. 1, emphasis added).

10.c Why was the caption in Figure 3 changed to include RF/microwave portion of the electromagnetic spectrum when neither term is used in this report except to refer to a microwave absorbing wall?

Response:

The following response is provided by Exponent.

The description added to Figure 3 in the FEI Rebuttal Evidence was made to assist a lay reader not familiar with the definitions and terms in a highly technical Nature Scientific Reports paper. Please also refer to the response to CORE IR3 10.b, above.

CORE-FEI-2022JULY14-011

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 66-67, Section 5.1 (Comparisons to Blackbody Radiation), Q 26.

Issue: On PDF pages 66 – 67 (p. 66 lines 16-19; p. 67, lines 1-3), Exponent states the following, in part, in response to Q26:

> When making measurements, it is important to carefully evaluate the capabilities of the instrumentation selected. In this case Dr. Havas is using the wrong tool for the job. The manual for the measurement device used by Dr. Havas specifies that the device is not capable of measuring the vast majority of RF/microwave energy (3 kHz–300 GHz) from either a human or from the Earth. Other instrumentation, such as that cited by Meng et al. (2017) [*sic*], is required to measure the extremely low levels of RF/microwave energy from humans or the Earth.

11.a: Is there technology available to measure such low levels of power density at 900 MHz (smart meters)?

Response:

The following response is provided by Exponent.

Exponent's Rebuttal Evidence (Exhibit B-26, Appendix B, A27, pp. 32-33) cited technology described by Meng et al (2018) and other technical papers:

> For example, Momenroodaki and Popovic (2014) measured RF fields at a frequency of 1.4 GHz to estimate temperatures within a human phantom containing water at 30° C and 40 C, corresponding to temperatures of 303.2 and 313 degrees K. Measurements of electromagnetic energy emitted from persons at 3.7 GHz have been used to detect and locate humans as a passive surveillance tool (Jacob et al., 2018).

These papers describe examples of devices capable of measuring power densities at frequencies near to 900 MHz.

CORE-FEI-2022JULY14-012

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 67, Section 5.1 (Comparisons to Blackbody Radiation), Q 27.

Issue: On PDF page 67 (lines 17-20), Exponent provides the following Figure in response to Q27:

> No, as stated above, her claims are incorrect and deny the existence of the entire scientific field of passive microwave sensing which uses satellites to measure and visualize temperature-related microwave energy from the Earth to assess water, weather, and soil conditions.

12.a Please define "passive microwave sensing".

Response:

The following response is provided by Exponent.

The National Snow and Ice Data Center, (Remote Sensing: Passive Microwave | National Snow and Ice Data Center [nsidc.org]) describes passive microwave sensing as follows:

> Objects at the Earth's surface emit not only infrared radiation; they also emit microwaves at relatively low energy levels. When a sensor detects microwave radiation naturally emitted by the Earth, that radiation is called passive microwave.[4]

The detection of such passive microwave energy, which falls within the RF/microwave frequency range, (3 kHz to 300 GHz) is also known as *"passive microwave sensing."* No microwave energy is sent toward the object during the detection/sensing process, and hence it is regarded as *"passive."* This is in contrast with *"active microwave sensing,"* which is described by the National Snow and Ice Data Center as follows:

> In addition to passively sensing emissions coming from objects on Earth, satellite sensors can also actively emit microwaves toward the Earth's surface. These microwaves reflect off the surface and return to the sensors. This type of remote sensing is called active microwave, or radar. This same technology is used to track aircraft, ships, and speeding automobiles.[5]

In active microwave sensing, microwave energy is sent toward the object and that energy is reflected back to the sensor during the detection/sensing process.

[4] https://nsidc.org/cryosphere/seaice/study/passive_remote_sensing.html. Accessed, July 26, 2022.
[5] https://nsidc.org/cryosphere/seaice/study/active_remote_sensing.html. Accessed July 26, 2022.

CORE-FEI-2022JULY14-013

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 45, Section 2.2 (Characteristics of Radiofrequency Signals), Q7.

Issue: At PDF page 45 (lines 10-11), FEI states, in part, the following in response to Q7:

> The RF signal from the Sonix IQ gas meter turns on and transmits a continuous frequency shift-keying (FSK) signal for 55 milliseconds and then turns off for approximately 4 hours.

13.a Is FEI suggesting in the above statement that a signal lasting 55 msec, but is quiet at other times, does not constitute a pulse?

Response:

The following response is provided by Exponent.

Please refer to the response to CORE IR3 5.a. The turning *"on"* of a signal for a very brief time and *"off"* for a much greater time is not the same as a signal (such as radar) where switching within the signal waveform is part of its modulation.

13.b Does FEI agree with the proposition that the signal from the AMI smart meter is continuous for 55 msec, but is discontinuous (pulse-like) for practically all the time outside this 55 msec? If not, why not?

Response:

The following response is provided by Exponent.

No. When the Sonix IQ gas meter is not transmitting it is not "pulse-like," it is off. Further, the system is not transmitting for the vast majority of the time and then transmits a continuous signal for the brief periods (55 milliseconds) of transmission. Please also refer to the responses to CORE IR3 5.a and 13.a, above.

13.c If one pulse was transmitted per month (to relay monthly gas consumption), does FEI agree that the signal would be "continuous" for 55 msec and "discontinuous" (pulse-like) for 2,592,000,000 / 55 or 47,127,273 longer than 55 msec. (2,592,000,000= 30 days x 24 hours x 60 min x 60 sec x 1000)? If not, why not?

Response:

The following response is provided by Exponent.

Please refer to the response to CORE IR3 13.a and 13.b, above.

CORE-FEI-2022JULY14-014

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 50, Section 3.1 (RF Safety Limits), Q9

Issue: On PDF page 50 at lines 1-13, FEI states the following, in part, in response to Q9:

> b. IGNIR (2021) states, "IGNIR guidelines are designed to prevent all adverse effects 2 from wireless radiation and EMFs for all people without any exceptions, at the relevant level of Day, Night or Sensitive."
>
> No evidence is presented to support the claim that exposure to RF during the day produce different effects from those at night or that there are "sensitive" populations for whom the weight of the evidence identifies RF exposure as the cause of self reported symptoms. Neither IGNIR (2018) nor the current edition, IGNIR (2021), provide their own scientific rationale or documentation for the IGNIR guideline. Rather, IGNIR states that, *"IGNIR has developed a set of Guidelines for electromagnetic exposure based on the peer-reviewed EUROPAEM EMF Guidelines 2016."* The frequency ranges to which the limits of the EUROPAEM, AMA, and Bau guidelines are meant to apply are not specified, except for IGNIR, which states a range from 30 MHz to 300 GHz.

14.a Does FEI agree that in terms of its safety standards, IEEE sought to introduce blanket permissions to devise systems within a wide range of frequencies, such that it would have a broad coverage of its standard? If not, why not?

Response:

The following response is provided by Exponent.

Exponent has no knowledge that IEEE had any such intent.

14.b Does FEI agree that the health derived standards are actually derived from actual risks from the use of actual devices in populations, and that these are not necessarily stated in terms of frequency ranges? If not, why not?

Response:

The following response is provided by Exponent.

The meaning of the question is not clear. Frequency ranges are used to describe exposures, not specific adverse effects.

14.c Does FEI agree, for example, that EUROPAEM refers to transmission protocols, because they include both modulation protocols and frequency ranges within one designation, and can often correspond to specific devices such as: TETRA, GSM 900/1800 MHz, DECT (cordless phone, UMTS, LTE, GPRS, PTCCH, DAB+, Wi-Fi 2.4/5.6 GHz? If not, why not?

Response:

The following response is provided by Exponent.

Exponent is not aware that EUROPAEM (2016) (also known as Belyaev et al., 2016) cited in CORE's filings includes any such explanation as suggested. In addition, the use of protocols does not uniquely identify frequencies of transmission because there are RF sources that emit electromagnetic energy unrelated to a communication protocol.

CORE-FEI-2022JULY14-015

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 50, Section 3.1 (RF Safety Limits), Q9

Issue: On PDF page 50 at lines 14-31, FEI states the following, in part, in response to Q9:

> c. The EUROPAEM guidelines (Belyaev et al., 2016) are a little more than a recitation of "... more than 20 position papers and resolutions regarding EMF and health [that] have been adopted by EMF researchers and physicians" (p. 4). The EUROPAEM guidelines are based on an earlier document, "EUROPAEM EMF guideline 2015 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses," that was also published in the journal *Reviews on Environmental Health*, and was later retracted by the authors (Belyaev et al., 2015). Like the 2015 paper, EUROPAEM (2016) paper is titled "*EUROPAEM EMF Guideline for the prevention, diagnosis and treatment of EMF-related health problems and illnesses*" so the question of whether scientific evidence supports the premise of adverse effects or disease caused by RF is not one examined by EUROPAEM. Despite the many references cited, the text devoted to EMF at RF frequencies is scant, and no health assessment or research upon which the guidelines should be based is provided; the focus is merely on guidance for avoiding exposure. There is no explanation for the 1,000- fold difference between exposure limits for different sources. EUROPAEM (Belyaev et al., 2016) also notes "These recommendations are preliminary and in large parts, although related to the whole body of evidence rooted in the experience of the team, cannot in every detail be strictly considered evidence-based" (p. 13).

15.a Does FEI agree that the above noted retraction was due to editorial errors in which the authors published the following statement:

> "The authors regret to announce the following: The EUROPAEM EMF Guideline 2015 has been retracted by the authors. During the preparation of the EUROPAEM EMF Guideline 2015 several citations were lost and other errors were detected. This was completely unintentional and the authors are very sorry for this. However, the content and conclusions of the Guideline are not altered by this. A revised version will be published as soon as possible." (see:https://www.degruyter.com/document/doi/10.1515/reveh-2015-0033/html?lang=en

Response:

The following response is provided by Exponent.

Exponent is aware of this retraction but is not aware of *"what other errors"* may have been corrected.

15.b Does FEI agree that heat-induced behavioral modification can be used to represent all of human reactions to EMR, particularly considering that every aspect of living systems physiology is full of electrical processes? If not, why not?

Response:

The following response is provided by Exponent.

Exponent is not aware of a scientific or regulatory organization making such a claim.

Exposure to RF fields above reference levels may increase energy deposition and so increase the temperature of tissues in part or most of the body. The detection of this energy deposition by electrical or other systems in the body and normal thermoregulatory mechanism can stimulate adaptive behavioral and physiological responses locally or throughout the body similar to those produced by other source (e.g., a heat lamp or elevated environmental temperature).

CORE-FEI-2022JULY14-016

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 53, Section 3.2 (Comparisons of RF to Other Frequencies of Electronmagnetic [*sic*] Fields), Q11

Issue: At PDF page 53, lines 17-19, FEI states, in part, in response to Q11 the following:

> More important, as noted in the Exponent RF Health Report, there are serious criticisms of some methods and interpretation of the NTP study regarding the role of thermal effects.

16.a Please confirm the source of the "serious criticisms" referenced in the Exponent RF Health Report.

Response:

The following response is provided by Exponent.

The sources that criticized the NTP study cited in Exponent's RF Health Report, Exhibit B-1, Appendix F-2, include:

- The Federal Office for Radiation Protection in Germany (BIS, 2019; Kuhne et al., 2020),
- U.S. Food and Drug Administration (FDA, 2018; 2020).
- ICNIRP (2019, 2020b, 2020c)
- The Swiss Federal Office for the Environment (BERENIS, 2018).
- The Swedish Radiation Safety Authority (2019)

The bibliographic references to the reports of these agency agencies were provided in Exponent's RF Health Report.

Other agencies that have criticized the NTP study that were not cited by Exponent in its initial RF Health Report include:

- The French Agency for Food, Environmental and Occupational Health & Safety (ANSES)

  Opinion of the National Agency for Food, Environment and Labour Safety on an Analysis of Interim Reports of the U.S. National Toxicology Program Study on Animal Exposure to Radiofrequency, 28 Sept. 2018. https://www.anses.fr/fr/system/files/AP2016SA0176.pdf

- FDA Scientific Evidence for Cell Phone Safety 02/10/2020.

  https://www.fda.gov/radiation-emitting-products/cell-phones/scientific-evidence-cell-phone-safety#frequency

CORE-FEI-2022JULY14-017

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 54, Section 3.3 (Cumulative Effects of RF), Q13

Issue: On PDF page 54 at lines 8-15), FEI states, in part, the following in response to Q13:

> Q13: In section 4 of his report (Appendix B to Exhibit C7-12-1), on page 38, Dr. Héroux comments on the "densification of the RF Environment" (i.e., the proposed increase in the number and distribution of RF sources associated with the AMI Project). Does he present a scientific basis for these comments?
>
> A13: No. Dr. Héroux's complaint conflates the number of sources with the extent of exposure to RF fields. The very small areas around the Sonic [sic] IQ gas meters where RF signals are greatest in aggregate are very much smaller than the area exposed to RF fields by even a single radio station in British Columbia.
>
> […]

17.a Does FEI agree that the comparison to a "single radio station" in the above answer strikes an incorrect comparison between AM modulation (continuous signals) and pulse modulation (brief packets of energy)? If not, why not?

Response:

The following response is provided by Exponent.

Exponent does not agree. The comparison between a radio station and Sonix IQ gas meters clearly relates to areas of signal coverage, not modulation. The comparison between a radio station and Sonix IQ gas meters in the cited response from Exponent's Rebuttal Evidence (Exhibit B-26, Appendix B, A13) clearly relates to areas of signal coverage, not modulation.

CORE-FEI-2022JULY14-018

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 55, Section 3.4, (Rebuttal to Specific Statements), Q15

Issue: At PDF page 55 at lines 21-24, FEI states in part in response to Q15 the following:

> Second, even if there were a bank of 100 meters, the total daily transmission time from the combined 100 meters would be approximately 34 seconds, which would result in a tiny fraction of the SC 6 limit (see the Exponent RF Technology Report, Table B-2).

18.a Although it is true that according to the present scheme the meters would not be synchronized, would FEI agree that the exposure would still be 100 times more? If not, why not?

Response:

The following response is provided by Exponent.

No. The practical physical limitation to the placement of 100 meters in a bank means that the exposure from the furthest Sonix IQ gas meter will necessarily be much less than the nearest meter. The result is that exposure at any one location would be at varying distances from all adjacent meters and thus varying levels of RF exposure from each one. Thus, even in this hypothetical example, the exposures would not be 100 times greater than that from a single meter, even if all 100 meters were synchronized (which they are not). At a location so far from the meters that the distances from each meter to that location were very similar and with the exposure from each meter synchronized to precisely the same time, the hypothetical total exposure from the 100 meters would approach 100 times that of a single meter but would be of negligible magnitude.

CORE-FEI-2022JULY14-019

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 55-6, Section 3.4 (Rebuttal to Specific Statements), Q16

Issue: On PDF page 55, lines 35 to 38; page 56, lines 1 to 8), FEI states the following, in part, in response to Q16:

> Q16: On pages 14-15 of Appendix B to Exhibit C7-12-1, Dr. Héroux suggests that "health criteria to establish these much lower levels [of RF exposure recommended by EUROPAEM, AMA, IGNIR, Baubiologie]" include "(1) sleep disruption; (2) headaches; (3) ringing or buzzing in the ears; (4) fatigue; (5) loss of concentration, memory, and learning ability; and (6) disorientation, dizziness, and loss of balance. Dr. Héroux identifies to two public opinion surveys of self-reported symptoms in which sleep disruption symptoms were the most common of these or other symptoms reported in both surveys
>
> Are these the type of surveys that can scientifically link self-reported Health symptoms to RF exposure from smart meters?
>
> A6: No, these public opinion surveys cannot assess the relationship between self-reported symptoms and RF exposure from smart meters. […]

19.a Does FEI agree that the surveys referred to in the above statement were not of public "opinion" but of actual symptoms surveys experienced by actual people in the field? If not, why not?

Response:

The following response is provided by Exponent.

The surveys cited by Dr. Héroux, in which respondents reported on subjective, non-specific symptoms (e.g., "sleep problems", stress, headaches), but for which no RF exposure levels were measured or calculated, cannot be used to assess the relationship between self-reported symptoms and RF exposure. The current scientific consensus of scientific and health organizations is that exposure to RF signals from mobile phones or other sources has not been found to cause symptoms or disturbances to well-being; this is consistent with the conclusions of the World Health Organization following a 2004 workshop on electromagnetic hypersensitivity, which noted, *"[idiopathic environmental tolerance] patients have real symptoms, but […] there is no scientific evidence of causal link with EMF exposure"* (p. 4).

CORE-FEI-2022JULY14-020

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 39, Section 2.1 (Status of the Research), Q3

Issue: At PDF page 39, (lines 19-23), Exponent states in part in response to Q3 the following:

> As stated in the Exponent RF Health report, the objective of the report was to provide a summary of primary, peer-reviewed epidemiologic and experimental research (i.e. published articles that present the author's original research and findings) published after the most recent comprehensive review – SCENIHR (2015) … on such outcomes as cancer and non-specific symptoms (p. 32).

20.a Is FEI aware that the SCENHIR (2015) article has been the subject of critique (see articles cited below). If so, does that modify in any way FEI's evidence on this issue?

- Sage, Cindy, David Carpenter, and Lennart Hardell. "Comment on SCENIHR: Opinion on Potential Health Effects of Exposure to Electromagnetic Fields, Bioelectromagnetics 36:480-484 (2015)." Bioelectromagnetics, December 20, 2015. https://doi.org/10.1002/bem.21949
- Nordhagen, Else K., and Einar Flydal. "Self-Referencing Authorships behind the ICNIRP 2020 Radiation Protection Guidelines." Reviews on Environmental Health, June 27, 2022. https://doi.org/10.1515/reveh-2022-0037

Response:

The following response is provided by Exponent.

Exponent is aware of both cited studies. The comments made by Sage et al. (2016) were authored by Cindy Sage, who has no scientific degree, and her colleague David Carpenter, both of whom are co-editors and contributors to the Bio-initiative report. The third author, Lennart Hardell, is also a contributor to the Bio-initiative report.[6] They commented on *"problems with the SCENIHR review process and faulty derivation of many of the Committee's overall conclusions"* (Sage et al.,

[6] The Bio-initiative report was prepared on extremely low frequency and RF fields by a self-selected group of researchers and activists, and includes many claims about electric- and magnetic-field research that differ substantially from the findings of national and international public health organizations that have examined the biological and health research on these exposures in detail. These organizations include the WHO, the International Agency for Research on Cancer, and public health authorities in the United States, Canada, United Kingdom, Ireland, Sweden, and Australia, among others. Recent critics of the interpretation of scientific research by this group include the RSC (RSC, 2014) and the New Zealand Ministry of Health, Interagency Committee on the Health Effects of Non-ionising Fields (2022). https://www.health.govt.nz/publication/interagency-committee-health-effects-non-ionising-fields-report-ministers-2022.

2016, p. 190). These criticisms were rebutted in a subsequent response by SCENIHR (Leitgeib, 2016), who pointed out that *"[c]riticizing SCENIHR for not having made conclusions on 'evidence for the possibility of an effect' is a somewhat puzzling result of a misunderstanding" (p. 193)* and who noted that*, "[b]y alleging SCENIHR gave too little weight to some studies, Sage et al. have just demonstrated the difference between their weighting criteria and those adhered to by SCENIHR and other national and international risk assessment bodies" (p. 194).* Leitgeib (2016) also points out that the SCENIHR review was preceded by a public consultation process and SCENIHR added additional studies to the review and made revisions as a result.

The article by Nordhagen et al. (2022) complains that there is a lack of diversity of the members of ICNIRP and that it lacks "a broad scientific base." It stands to reason that experts in the field of bioelectromagnetics are needed to evaluate such a specialized area of research and so it is not surprising that some members of ICNIRP's review committee, like those assembled by the International Agency for Research on Cancer, also have published research on RF fields.

The scope of the Nordhagen et al. (2022) review was limited and did not include major assessments of RF research cited in Exponent's RF Health Report that were performed by U.S. Food and Drug Administration (FDA) scientists (FDA, 2020) and scientists assembled by the Royal Society of Canada (RSC) that has reviewed RF studies for Health Canada (RSC, 1999, 2001, 2007, 20099, 2013). The scientists at FDA who authored their 2020 report were not identified, but the authors of expert reviews of RF research performed for the RSC at the request of Health Canada are published.[7] Exponent has not identified the members of the panels that reviewed RF research for the RSC as members of ICNIRP, and their assessments of the RF research are similar to those prepared by scientists for ICNIRP and IARC. Hence, the criticism of ICNIRP or its members does not explain the similar assessments by wholly independent groups of Canadian scientists.

20.b Why did Exponent limit outcomes to cancer and non-specific symptoms rather than consider the many health effects shown to be related to exposure to RF radiation that have been reported by many independent scientists in peer-reviewed studies?

[7] A Review of the Potential Health Risks of Radiofrequency Fields from Wireless Telecommunication Devices, Expert Panel Report. Ottawa, Ontario: Royal Society of Canada, 1999. https://rsc-src.ca/sites/default/files/RFreport-en.pdf. Accessed April 27, 2021. Royal Society of Canada (RSC). Update 1 to 1999 Report. Krewski D, Byus CV, Glickman BW, Lotz WG, Mandeville R, McBride ML, Prato FS, Weaver DF. Recent advances in research on radiofrequency fields and health. J Toxicol Environ Health B Crit Rev. 4:145-59, 2001. Royal Society of Canada (RSC). Update 2 to 1999 Report. Krewski D, Glickman BW, Habash RW, Habbick B, Lotz WG, Mandeville R, Prato FS, Salem T, Weaver DF. Recent advances in research on radiofrequency fields and health: 2001-2003. J Toxicol Environ Health B Crit Rev. 10:287-318, 2007. Royal Society of Canada (RSC). Update 3 to 1999 Report. Habash RW, Elwood JM, Krewski D, Lotz WG, McNamee JP, Prato FS. Recent advances in research on radiofrequency fields and health: 2004-2007. J Toxicol Environ Health B Crit Rev. 12:250-88, 2009. Demers P, Findlay R, Foster K, Kolb B, Moulder J, Nicol A-M, Prato F, Stam R. Royal Society of Canada Expert Panel. Report on A Review of Safety Code 6 (2013): Health Canada's Safety Limits for Exposure to Radiofrequency Fields. Ottawa, Ontario: Royal Society of Canada, 2014.

Response:

The following response is provided by Exponent.

Please refer to the response to CEC IR3 7.1.

CORE-FEI-2022JULY14-021

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 39, Section 2.1 (Status of the Research), Q3

Issue: At PDF page 39 (lines 23-26), Exponent states in part in response to Q3 the following:

> The documents listed by Ms. Friesen as not included in the Exponent RF Health Report were not included because they did not fit this objective inclusion criteria. Specific reasons for exclusion from the Exponent RF Health Report are listed below in Table 1.

21.a What specifically were Exponent's "objective inclusion criteria"? Please explain how Exponent determined and restricted such inclusion criteria.

Response:

The following response is provided by Exponent.

As described in Section 6 of the Exponent RF Health report, Exponent included in its review primary, peer-reviewed epidemiologic and experimental studies (i.e., articles published in the peer-reviewed literature that present the authors' original research and findings) on cancer and non-specific symptoms that were published between June 2014 (the cut-off date for the SCENIHR 2015 review) and March 2021. Please refer to the responses to CORE IR3 20.b a and CEC IR3 7.1 for the explanation as to why the RF Health report focused on the health outcomes of cancer and non-specific symptoms. The selection criterion to include only peer-reviewed, published studies in the Exponent RF Health report is consistent with the methodology used by scientific and health organizations; for example, in their 2011 monograph on RF, IARC notes, *"[w]ith regard to epidemiological studies, cancer bioassays, and mechanistic and other relevant data, only reports that have been published or accepted for publication in the openly available scientific literature are reviewed"* (p. 12).

CORE-FEI-2022JULY14-022

Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 39, Section 2.1 (Status of the Research), Q3

Issue: At PDF page 39 (lines 27-36) and page 40 (lines 1-3), Exponent states in part in response to Q3 the following:

> Many of the published articles listed by Ms. Friesen are outside the scope of the Exponent RF Health Report, in that they are in vivo studies of biological and health outcomes other than cancer. In vivo studies of non-cancer outcomes were not covered in the report, which notes that all studies relevant to such outcomes have been reviewed by scientific and health organizations and that the overall conclusions of these organizations remain consistent. Specifically, the scientific evidence does not confirm that exposure to RF fields below scientifically based exposure guidelines cause or contribute to the development of any adverse health effects, including chronic diseases and other health conditions. In addition, several of the documents listed by Ms. Friesen are review articles, not primary research articles. Review articles were intentionally excluded from the Exponent RF Health Report, as is common in systematic literature reviews, because they do not report on new, original data, and are subject to gaps in the literature and the biases of the author or authors.

22.a Is FEI aware that in vivo studies on non-cancer outcomes being omitted from the report is a substantial gap in evidence for non-cancer outcomes (see, for example, Adams, J. A., Galloway, T. S., Mondal, D., Esteves, S. C., & Mathews, F. (2014) Effect of mobile telephones on sperm quality: A systematic review and meta-analysis. *Environment International*, 70, 106–112. https://doi.org/10.1016/j.envint.2014.04.015 ; and Houston, B. J., Nixon, B., King, B. V., De Iuliis, G. N., & Aitken, R. J. (2016))

Response:

The following response is provided by Exponent.

Exponent does not agree that this is a *"substantial gap in evidence."* As discussed in the response to CORE IR3 20.b, the results of recent studies on non-cancer outcomes (including those identified in Exponent's response to CEC IR3 7.1) are consistent with previous research over many years in that they do not provide sufficient evidence for a causal association with RF exposure. This is consistent with the conclusions of SCENIHR (2015) and other recent reviews, as summarized in the section on *"Other health conditions studied"* in the Exponent RF Health report.

Of note, one of the studies CORE cites in IR3 22.a (Adam et al., 2014) was noted by SCENIHR in its 2015 report to have included studies with low quality exposure assessments in the analysis.

Per SCENIHR (2015), *"all except two of the studies in the pooled analysis [conducted in Adams et al.] had used a commercial phone as an exposure source with little or no dosimetry to calculate the absorbed energy in the samples. As explained elsewhere, a mobile phone is not acceptable as an exposure source without detailed dosimetry, and studies with such methodological shortcomings should not have been included in the pooled analysis"* (p. 146). This is a limitation of the Adam et al. (2014) study, which does not provide sufficient evidence for an association between RF exposure and reproductive/developmental outcomes.

Please also refer to the response to CORE IR3 22.b, below, for commentary on the Houston et al. (2016) article cited in CORE IR3 22.a, above. Altogether, Houston et al. conclude:

> Collectively, the uncertainty surrounding the effects of RF-EMF on the male germline presents a challenge for interpretation, which is further exacerbated by the lack of any consolidated, mechanistic explanation for the effects of such low-energy radiation on biological systems. (p. R269)

> To date, contradictory studies surrounding the impacts of RF-EMR on biological systems maintain controversy over this subject ... Although this subject remains a topic of active debate, this review has considered the growing body of evidence suggesting a <u>possible</u> role for RF-EMR-induced damage of the male germline (p. R273, emphasis added).

22.b Is FEI aware of the effects of radiofrequency electromagnetic radiation on sperm function? (see, for example, *Reproduction (Cambridge, England*), 152(6), R263–R276. https://doi.org/10.1530/REP-16-0126).

Response:

The following response is provided by Exponent.

Yes, the authors of the paper cited in CORE IR3 22.b are Houston et al. (2016) and this paper is referenced in response to CORE IR3 22.a.

The paper presents the authors' hypothesis regarding the effects of exposure to RF fields on sperm function as recorded in some studies in which rodents or humans were exposed (*in vivo*) and the sperm examined, or most of the studies in which isolated sperm were exposed (*in vitro*). Aspects of the study results were rated, and the main outcomes of each study summarized in a sentence, but the paper did not provide a systematic review of the topic. No evaluation of the strengths or weaknesses of the individual studies was presented. Eight studies cited in the paper included no estimates of exposure (SAR). No analysis of the data from the studies by intensity of the field (SAR), duration of exposure (that ranged from 5 minutes to 2 years), or frequency (850-1,800 MHz) was included.

The role of "RF-EMR" (i.e., electromagnetic radiation) heating as a possible contributor to reported effects is dismissed—*"the effects of bulk heat stress are likely to be negligible"*—and therefore the authors did not explore the differences between *in vivo* and *in vitro* exposures or evaluate the methods in each study to maintain and control temperature from any source. Indeed, sperm are *"uniquely susceptible of oxidative stress"* in part because of their temperature sensitivity, which is mitigated *in vivo* by the testes residing outside the body and good circulation, thus providing a cooler environment for tissue and sperm within. This is why temperature control is such an important factor in these experiments as reviewed in this paper.

Houston et al. (2016) adopt a summary from the Adams et al. (2014) study (criticized by SCENIHR, 2015, as noted in the response to CORE IR3 22.a above) as to evidence that support RF-EMR contributing to "*reductions in motility and loss of viability" (p. R268).* Yet, Houston et al. themselves suggest otherwise:

> A possible explanation for such inconsistencies in the effects of RF-EMR on sperm motility rests with the use of different exposure conditions. Indeed, in a majority of studies reporting negative impacts of RF-EMR on sperm motility (64%), the study design featured the use of isolated human spermatozoa that were exposed to RF-EMR via a mobile phone device [for which battery discharge is known to be an independent source of heating apart from RF-EMF].

Following a long discussion of eight studies with discordant results, Houston et al. (2016) concludes:

> Notwithstanding the conflicting nature of the data documented above, … [and the discussion of two meta-analyses published in 2014] this analysis confirmed that sperm concentration is not significantly influenced by RF-EMR treatment. Although these data suggest that RF-EMR is not capable of causing major disruptions to the spermatogenic cycle, in line with Sommer and coworkers (2009), they do nonetheless highlight an effect on the functional attributes of spermatozoa" (pp. R268-269, emphasis added).

Regarding effects of RF-EMR on DNA discussed in the review, only 5 of 27 studies report on this parameter and all were *in vitro* studies, a type of study excluded from the Exponent RF Health report. But the Exponent RF Health report did evaluate the more relevant *in vivo* studies of RF fields on DNA damage in 23 separate experiments described in 16 studies. Although some studies reported DNA damage at low levels, the apparently most reliable of these studies conducted for the U.S. National Toxicology Program reported comet assay results that "were only statistically different *at SAR levels of 5 W/kg in mice and 6 W/kg in rats, which are well above the permitted whole body exposures of the general public of 0.08 W/kg in Canada, the United States, and Europe"* (NTP, pp. 101-102).

The scientific evidence to date does not confirm that exposure to RF fields below scientifically based exposure guidelines causes or contributes to the development of any adverse health

effects, including reproductive and developmental outcomes. This is consistent with the conclusions of recent reviews of the scientific research conducted by health and scientific agencies:

- SCENIHR (2015): "*Studies on male fertility are of poor quality and provide little evidence*" (p.6).5
- SSM (2018): "*Several studies observed decreased semen quality of mobile phone users. Exposure to electromagnetic fields from mobile phones produces heating, and heating can affect sperm quality. However, at levels below standard limits and as encountered under real-life conditions, the extent of heating is too low for such effects and thus the potential underlying biological mechanism remains unclear*" (p. 9).
- Several studies observed decreased semen quality of mobile phone users. However, at levels below standard limits and as encountered under real-life conditions, the extent of heating is too low for such effects and thus the potential underlying biological mechanism remains unclear.
- ICNIRP (2020): "*no adverse effects of radiofrequency EMF exposure on fertility, reproduction, or development relevant to human health have been substantiated*" (p. 522).
- SSM (2021): "*No new established causal relationships between EMF exposure and health risks have been identified*" (p. 3).

22.c Does FEI agree that a proper systematic review following best international practices would reduce the possibility of gaps or bias in the scientific evidence? If not, why not?

Response:

The following response is provided by Exponent.

Exponent is not aware of a standard definition of *"best international practices"* for systematic reviews.

The goal of a "*proper*" systematic review is to draw conclusions based on a comprehensive evaluation of the research without preferential selection of studies. Reviewing agencies (SCENIHR, SSM, etc.) do conduct and publish systematic reviews and often include as part of these reviews an assessment of the potential for data gaps and biases.

22.d Does FEI agree that gaps in evidence can occur if the exclusion data are too restrictive? (see Rooney, A. A., Boyles, A. L., Wolfe, M. S., Bucher, J. R., & Thayer, K. A. (2014). Systematic Review and Evidence Integration for Literature-Based Environmental Health Science Assessments. *Environmental Health Perspectives*. https://doi.org/10.1289/ehp.1307972) If not, why not?

Response:

The following response is provided by Exponent.

Exponent supports health risk assessments that are thorough and of high quality. The methodology described by Rooney et al. (2014) as applied by the NTP's Office of Health Assessment and Translation (OHAT) (NTP, 2019) is representative of the "*weight-of-evidence evaluation and health risk assessment[s]*" cited in Exponent's RF Health report (p. 17). Nowhere does the word "*gap*" appear in the text of this report. CORE appears to incorrectly believe that *"gaps in evidence"* occur because of the review and assessment process, which is in fact designed to avoid gaps of this type, as described by OHAT.[8] The *"gaps in evidence"* that impede the risk assessment process instead refer to the total absence of studies on a relevant topic or the insufficiency of studies of adequate quality to be considered in the assessment process.

As discussed in response to CORE IR3 22.c, above, scientific and health agencies that conduct systematic reviews of the literature frequently include an assessment of the potential for gaps in the literature, which is available for assessment. These reviews will also often include recommendations for future research in topic areas for which the agency felt that additional information would assist in the evaluation of the topic.

[8] The OHAT process includes steps to ensure that all relevant studies are included: *"**Search for studies**. A comprehensive search of the primary scientific literature is performed. . . . The protocol establishes requirements for consideration of data from meeting abstracts or other unpublished sources. If a study that may be critical to the evaluation has not been peer reviewed and the authors agree to make all study materials available, the NTP will have it peer reviewed by independent scientists with relevant expertise. The peer-review requirement assures that studies considered in the evaluation have been reviewed by subject-matter experts and the information from this review would be available . . . . **Select studies for inclusion**. All references identified in the search are screened for relevance to the key question(s) of the evaluation . . . . The protocol establishes criteria for including or excluding references based on, for example, applicable outcomes, relevant exposures, and types of studies. These criteria contain sufficient detail to develop an inclusion and exclusion checklist in order to limit the use of scientific judgment during the literature-selection process. If major limitations in a specific study type or design for addressing the question are known in advance (e.g., unreliable methods to assess exposure or health outcome), the basis for excluding those studies must be described **a priori** in the protocol* (pp. 712-713).

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Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 39, Section 2.1 (Status of the Research), Q3

Issue: At PDF page 40 (lines 4-10), Exponent states in part in response to Q3 the following:

> Some of the other articles listed by Ms. Friesen would never be included in a report that summarizes research on RF exposure and human health because they either did not study the association between RF fields and a health outcome or they were not at all relevant to humans (e.g., a study on RF exposure to ticks; a separate study on RF exposure to onions). Additional documents listed by Ms. Friesen are not peer-reviewed articles published in a reputable journal and instead are simply articles pulled from the internet.

23.a Is FEI aware that the World Health Organization's International Agency for Research on Cancer (WHO/IARC), which assesses for carcinogenicity various agents, including RF radiation, includes studies from diverse taxa including bacteria, earthworms, frogs, fruit flies and yeast in its assessments?

Response:

The following response is provided by Exponent.

Exponent is aware that IARC may include studies of non-mammalian species in its assessments. IARC noted in its preamble to its review of RF exposures that non-mammalian species may be considered in its evaluation of genotoxic endpoints:

> Positive results in tests using prokaryotes, lower eukaryotes, insects, plants and cultured mammalian cells suggest that genetic and related effects could occur in mammals (IARC, 2013, p. 24).

A few studies of fruit flies (*Drosophila melanogaster*, a standard *in vivo* model for biological genetic studies), were reviewed in IARC (2013) and dismissed as described in response to CORE IR 23.c. IARC clearly states in this report that *"[g]enetic or other activity manifest in humans and experimental mammals is regarded to be of greater relevance than that in other organisms"* (pp. 24-25). The studies in Ms. Friesen's list (the Frątczak et al., study on ticks; the Kumar et al., study on onions) were therefore of lesser relevance than the *in vivo* studies of mammals included in the Exponent RF Health report.

23.b Is FEI aware that WHO/IARC has classified RF radiation as a Group 2B possible human carcinogen, and that the evidence on which the Group 2B classification is based includes [*sic*] the aforementioned organisms?

Response:

The following response is provided by Exponent.

Exponent is aware that WHO/IARC has classified RF radiation as a Group 2B possibly human carcinogen. The IARC Monograph could have included studies of nonmammalian species as described in response to CORE, but did not cite studies of bacteria, earthworms, frogs, fruit flies, and yeast as the basis for its classification of RF radiation as Group 2B.

23.c Would FEI agree that studies on onions and other non-human organisms are relevant because they add to the weight of evidence that there are adverse biological effects resulting from RF radiation exposure? (See Panagopoulos, Dimitris J. Comparing DNA Damage Induced by Mobile Telephony and Other Types of Man- Made Electromagnetic Fields. *Mutation Research/Reviews in Mutation Research* 781 (July 1, 2019): 53–62. https://doi.org/10.1016/j.mrrev.2019.03.003). If not, why not?

Response:

The following response is provided by Exponent.

The weight of scientific evidence should be assessed for each species of interest and relevant similar species. For human health risk assessment, the most relevant species are humans and mammals. Extrapolations of the results from *"studies on onions and other non-human [non-mammalian]"* in theory might be relevant if the mechanism of action were to be confirmed as the same as in humans and the results were reliable and persuasive. The review of relevant species is a standard part of human health risk assessment, (refer to e.g., SCENIHR, 2012), cited in Exponent's RF Health report.

CORE IR3 23.c cites a single general review that summarizes the results of *in vitro* studies of the ovaries of common fruit flies, *Drosophila melanogaster,* obtained by one researcher (Panagopoulos, 2019). While fruit flies are commonly used as a simple and inexpensive model test system, the review does not cite a body of evidence that demonstrates that the mechanism of action underlying the responses reported is the same as in mammalian cells or that the comet assays for DNA damage were performed according to the Organization for Economic Cooperation and Development (OECD) Guidance Document 116 on the Conduct and Design of Chronic Toxicity and Carcinogenicity Studies, Supporting Test Guidelines 451, 452 and 453 (Second

Edition. Paris: OECD, 2012). One of the criteria that Exponent used in its evaluation of new *in vivo* human and mammalian studies for the Exponent RF Health report was this OECD standard.

Regarding studies of fruit flies, the IARC review reported no evidence of gene mutations caused by RF exposure and dismissed claims for DNA fragmentation by Panagopoulos and colleagues as follows:

> [In reviewing these studies with Drosophila [(Panagopoulos, 2011; Panagopoulos & Margaritis, 2008, 2010a, b; Panagopoulos et al., 2004, 2007, 2010).], the Working Group noted several shortcomings related to the methods of exposure assessment and temperature control, which could have influenced the results (IARC, 2013 p. 291)

The IARC conclusion regarding DNA and other genotoxic indicators was that "[o]verall, the Working Group concluded that there was weak evidence that RF radiation is genotoxic, and no evidence for the mutagenicity of RF radiation" (p. 415).

23.d Would FEI agree that demonstrating DNA damage at low RF radiation levels in a variety of organisms adds to the weight-of-evidence that DNA damage occurs in humans? (see Appendix C to CORE's Intervener Evidence (Exhibit C7-12-1) the included article: Miller, Anthony B., Margaret E. Sears, L. Lloyd Morgan, Devra L. Davis, Lennart Hardell, Mark Oremus, and Colin L. Soskolne. Risks to Health and Well-Being From Radio-Frequency Radiation Emitted by Cell Phones and Other Wireless Devices. *Frontiers in Public Health 7* (2019). https://doi.org/10.3389/fpubh.2019.00223)

Response:

The following response is provided by Exponent.

Please refer to the response to CORE IR3 23.c. Furthermore, the limitations of the paper by Miller et al. (2019) have been identified in Exponent's Rebuttal Evidence. The brief mention of the NTP studies and a study from the Ramazzini Institute by Miller et al. (2019) and some other scattered references (not to onions or non-mammalian organisms) adds little weight to offset the severe limitations of the NTP and Ramazzini studies reviewed in Exponent's RF Health report.

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Reference: FEI Rebuttal Evidence, Exhibit B-26

PDF page 39, Section 2.1 (Status of the Research), Q3

Issue: At PDF page 40, Exponent provides in part in response to Q3 the following Table 1:

Table 1. Reasons for exclusion from the Exponent RF Health Report

Reason for exclusion in Exponent RF Health Report	Friesen Group 1. Primary Research specifically on 900 MHz exposures (n=21)	Friesen Group 2. Primary/original – RF radiation but not specifically on 900 MHz (n=2)	Friesen Group 3. Comments and articles about the NTP animal studies (n=1)	Friesen Group 4. Reviews and comments – except on NTP studies (n=25)
Not primary, peer-reviewed epidemiologic or experimental research			1	20
Outside the scope of the report (*in vivo* studies of non-cancer outcomes; *in vitro* studies; studies not relevant to human exposures)	19	1		1
Did not study the association between RF fields and a health outcome	1			1
Not isolated RF exposure	1	1		1

24.a Please provide the citations for the specific journal articles FEI is referencing in each column of Table 1.

Response:

The following response is provided by Exponent.

The citations to the specific journal articles are provided in Exponent's response to CEC IR3 7.1.