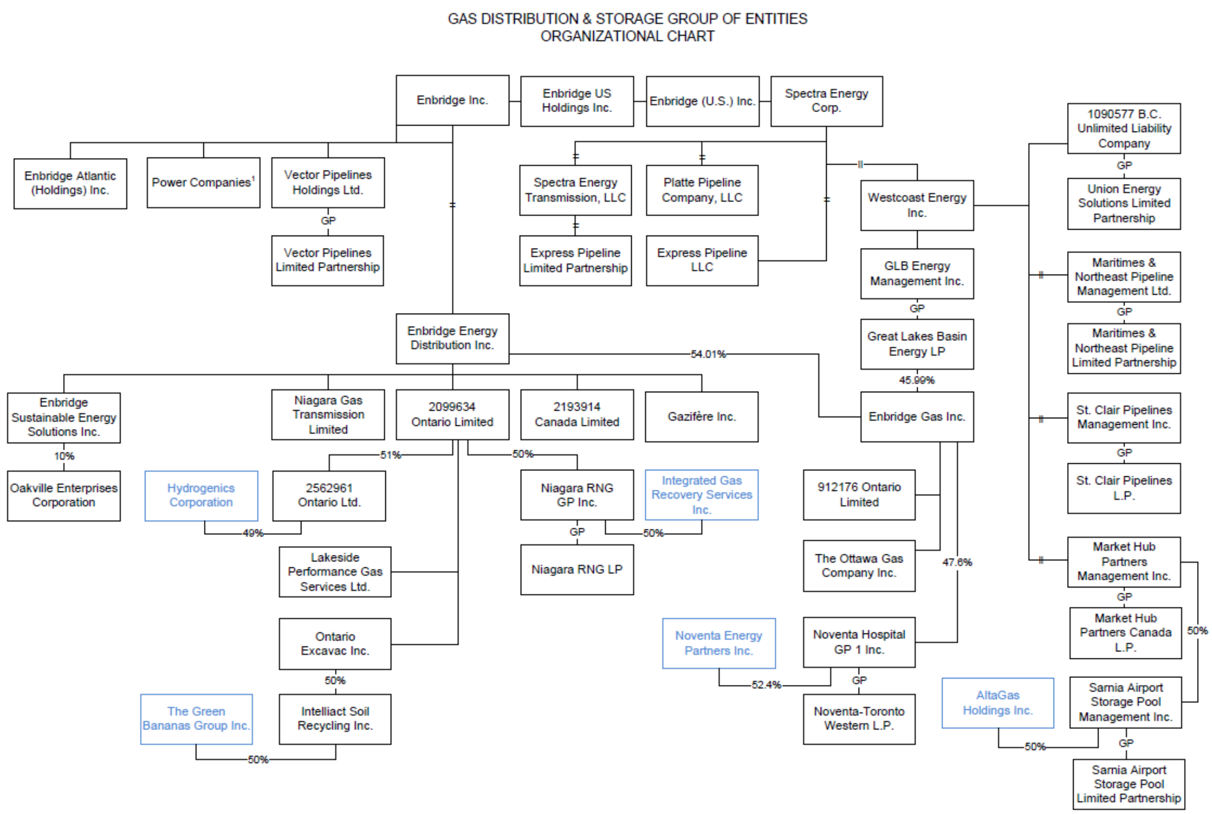
# EB-2022-0200
# Enbridge Gas Inc. 2024 to 2028 Rates Application

# Interrogatories of Environmental Defence – Part 1

**Interrogatory # 1.2-ED-1**

Reference: Exhibit 1, Tab 3, Schedule 1, Attachment 1, Page 1

Preamble: The following org chart is found at the above reference




Question(s):

(a) Please indicate how much profit Enbridge has earned from its regulated gas business in the past 5 years and how much it forecasts earning each year 2024 to 2028.
(b) Please indicate how much profit Enbridge's parent and sister companies have earned from with respect to the gas pipelines that feed into Ontario. This is meant in part to explore the incentive facing the Enbridge families of companies to maintain gas volumes flowing into Ontario, and whether that may impact the relief sought by Enbridge.

**Interrogatory # 1.4-ED-2**

Reference: Exhibit 1, Tab 4, Schedule 1

Preamble: "1. Enbridge Gas has over $14 billion in regulated assets…"

Question(s):

(a) Please provide the exact figure quantifying Enbridge's regulated assets in Ontario.
(b) With respect to its current assets, by what year would they be fully depreciated based on the proposed depreciation policies/periods proposed by Enbridge in this application?
(c) With respect to its current assets, how much ($) would remain undepreciated in 2050 under the proposed depreciation policies/periods proposed by Enbridge?

**Interrogatory # 1.10-ED-3**

Reference: Exhibit 1, Tab 10, Schedule 2, Page 2

Preamble:

> "On a peak basis, the natural gas system provides three to five times as much energy as the electricity system. For example, the most recent winter peak (highest hourly flow measured during the winter) occurred at 9 am on January 22, 2022 and was 8,507 103m3/hr or approximately 92 GW. In comparison, the amount of electricity generated in Ontario at the same time was approximately 21 GW, and of this around 20 GW was to serve demand within the province. The amount of electricity generated was close to 70% of the 30.2 GW effective winter capacity."

Question(s):

(a) Please provide the temperature at 9 am on January 22, 2022 (i) in Toronto, and (ii) as an average for Enbridge customers that is population-weighted (i.e. reflecting the fact that most customers are in Southern Ontario). An approximation may be used for the population-weighting. Please provide the calculations.
(b) Please provide the temperature, date, time, and GW Ontario electricity demand at the coincident winter peak hour on the *electricity* system in Ontario in the winter of 2021-2022.
(c) Please provide the approximate co-efficient of performance ("COP") of 3-ton centrally ducted Mitsubishi-Zuba system and Moovair Central system at the temperatures in the answers to (a) and (b). Please indicate the tool or method used to estimate the COP and indicate if the tools found at neep.org would generate a different result, and if yes, please explain. If necessary, please contact the manufacturers to access the information.
(d) What temperature does the IESO use to model electricity demand from heating at the time of the coincident electricity system peak for the purposes of determining the electricity resource adequacy.

**Interrogatory # 1.10-ED-4**

Reference: Exhibit 1, Tab 10, Schedule 2, Page 13

Preamble:

> "Ontario's natural gas system provides reliable, resilient, and secure energy in a cost-effective manner. According to the OEB's 2020 Yearbook of Natural Gas Distributors, Ontario's natural gas distributors received $5.1 billion in total revenue for services related to natural gas supply, transport and distribution in 2019. During the same period, the 2020 Yearbook of Electricity Distributors lists power and distribution revenues of $21.7B for Ontario's electricity distributors. Even if the differential between these revenues is adjusted for energy payments to other parties (natural gas marketers who provide natural gas supply to large users, for example), the conclusion that natural gas is very cost effective is inescapable, given that natural gas energy accounted for 30% of total energy demand of Ontario while electricity accounted for 16% of total energy demand in 2019, as shown in Figure 1."

Question(s):

(a) The above passage states: "[e]ven if the differential between these revenues is adjusted for energy payments to other parties…" Please calculate the adjustment and provide the adjusted differential. Please include the calculations.
(b) Please provide the ratio of T&D costs to commodity costs in Ontario for (i) gas and (ii) electricity.
(c) Please provide an estimate of the total costs incurred by Ontario customers in 2020 including commodity (incl. upstream transportation), transmission, distribution, and carbon costs. For volumes of gas not purchased from Enbridge, please either use Enbridge's best estimate of the price paid for the gas or provide the average gas cost for the gas that Enbridge sells to its own customers.
(d) Please provide an estimate of the total electricity costs incurred by Ontario customers in 2020 including commodity, transmission, distribution, and carbon costs.
(e) Please provide the figures calculated in (c), (d), for the latest year possible (i.e. 2022 if possible).
(f) If the figures cannot be calculated for 2022, please recalculate the figure in (c) with the commodity costs increased by the percentage difference in the average commodity costs for 2020 versus 2022.
(g) Please recalculate the figure in (c) as if the 2030 carbon prices applied.

**Interrogatory # 1.10-ED-5**

Reference: Exhibit 1, Tab 10, Schedule 2, Page 13

Preamble:

"According to the OEB's 2020 Yearbook of Natural Gas Distributors, Ontario's natural gas distributors received $5.1 billion in total revenue for services related to natural gas supply, transport and distribution in 2019. During the same period, the 2020 Yearbook of Electricity Distributors lists power and distribution revenues of $21.7B for Ontario's electricity distributors"

Question(s):

(a) Approximately percent of gas consumed in Ontario is imported from out-of-province?
(b) Approximately percent of electricity consumed in Ontario is imported from out-of-province?
(c) Approximately how much did Ontario's gas consumers pay in 2020 for gas transmission costs (i.e. the cost to transport the gas to Ontario)? Please provide an estimate on a best-efforts basis and with any necessary caveats. If you do not have the upstream transmission costs for direct purchase customer volumes, please indicate that volume (m3), the average cost for upstream transmission for volumes purchased by Enbridge for its customers ($/m3), and the cost for direct purchase customers extrapolated therefrom.

**Interrogatory # 1.10-ED-6**

Reference: Exhibit 1, Tab 10, Schedule 2, Page 14

Preamble:

"Enbridge Gas's residential customers will pay approximately $45/month in distribution revenues based on Enbridge Gas's proposal, which reflects the value of resiliency, reliability and security provided by Enbridge Gas's rate base."

Question(s):

(a) Please provide the approximate monthly average residential distribution costs for (i) Ontario electricity customers on average and (ii) customers of Toronto Hydro.

**Interrogatory # 1.10-ED-7**

Reference: Exhibit 1, Tab 10, Schedule 2, Page 14

Question(s):

(a) Please confirm that gas heating usually also requires electricity (e.g. for furnace electronics and for the blower).
(b) Approximately what percent of Enbridge residential customers have backup power?

**Interrogatory # 1.10-ED-8**

Reference: Exhibit 1, Tab 10, Schedule 2, Page 14

Dunsky, *Ontario's Distributed Energy Resources (DER) Potential Study*, Prepared for the IESO, September 28, 2022 (link)

Preamble:

> "48. The IESO forecasts incremental capacity needs of 1,796 MW with the continued availability of existing resources in 2025; by 2032 these incremental needs are expected to grow to 3,443 MW."

Question(s):

(a) Please confirm that the above-reference DER potential study found that the achievable potential for distributed energy resource by 2032 is between 1.3 and 4.3 GW.[1] Please indicate if Enbridge disagrees with this figure, and if yes, please provide Enbridge's estimate. [2]

(b) Please confirm that the above-reference DER potential study found as follows:

> The economic potential results indicate there is ample cost-effective DER capacity to meet or exceed all incremental system needs under all scenarios.
> …

*Table E-1: System Incremental Seasonal Capacity Needs vs Economic and Achievable Potential Results*

| Seasonal Capacity | Potential | BAU | BAU+ | Accelerated |
|---|---|---|---|---|
| Summer 2032 | **Incremental System Needs** | **2.6 GW** | **5.6 GW** | **6.9 GW** |
| | **Economic Potential** | 4.1 GW *(15% of peak demand)* | 8.2 GW *(27% of peak demand)* | 18.9 GW *(61% of peak demand)* |
| | **Achievable Potential** | 1.3 GW *(5% of peak demand)* | 2.2 GW *(7% of peak demand)* | 4.3 GW *(14% of peak demand)* |
| Winter 2032 | **Incremental System Needs** | **0.9 GW** | **6.4 GW** | **13.3 GW** |
| | **Economic Potential** | 2.8 GW *(11% of peak demand)* | 6.8 GW *(22% of peak demand)* | 15.0 GW *(40% of peak demand)* |
| | **Achievable Potential** | 1.0 GW *(4% of peak demand)* | 1.8 GW *(6% of peak demand)* | 3.6 GW *(9% of peak demand)* |

> The gap between achievable and economic potentials relates to a range of factors, including DER adoption and diffusion, market barriers, DR program participation limits and the limited financial attractiveness of some DERs to specific customers. This gap can be narrowed through actions such as improving DER compensation for services like capacity and T&D benefits, securing DERs more directly through programs or procurements, and by enhancing opportunities for DERs to participate in wholesale markets.

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[1] Dunsky, *Ontario's Distributed Energy Resources (DER) Potential Study*, Prepared for the IESO, September 28, 2022 (link), p. ES-2

[2] Dunsky, *Ontario's Distributed Energy Resources (DER) Potential Study*, Prepared for the IESO, September 28, 2022 (link), p. ES-2

Please indicate if Enbridge disagrees with these conclusions, and if yes, please provide Enbridge's alternative conclusions.

**Interrogatory # 1.10-ED-9**

Reference: Exhibit 1, Tab 10, Schedule 2, Page 24

Preamble:

> "the proposed federal Clean Electricity Regulations, which would require the electricity sector to have net-zero emissions by 2035, create uncertainties regarding the future of gas-fired generation."

Question(s):

(a) Please file on the record the latest information about the Clean Electricity Regulations available at the time that interrogatory responses are provided.
(b) Based on the latest information available to Enbridge, what is Enbridge's best estimate of the impact of the clean electricity regulations for gas demand (annual and peak) in Ontario by 2035?
(c) Please provide a table showing the annual demand and design day demand attributable to gas powered power generation in Ontario from 2020 (historical) to 2035 (forecast).
(d) Please provide a table showing the annual demand and design day demand attributable to gas powered power generation in Ontario from 2020 (historical) to 2035 (forecast) focusing only on the demand served by the Dawn-Parkway system.
(e) Has Enbridge made comments to the federal government regarding the content of the Clean Electricity Regulations? If yes, please provide a list of those comments, including both those provided publicly and privately.
(f) Please file a copy of all comments made by Enbridge to the federal government regarding the content of the Clean Electricity Regulations.

**Interrogatory # 1.10-ED-10**

Reference: Exhibit 1, Tab 10, Schedule 3, Page 2

Preamble:

> "6. Ontario's GHG emissions in 2020, the last year for which data are publicly available, were 150 million tCO2e. Enbridge Gas's scope 1 and 2 emissions are less than 1% of Ontario's GHG emissions and the scope 3 GHG emissions from combustion of natural gas by Enbridge Gas's end-use customers are approximately 32% of Ontario's emissions.2 Enbridge Gas's scope 3 GHG emissions by sector are provided in Figure 1."

Question(s):

(a) Please confirm that the emissions referred to above do not include the upstream emissions from the extraction of gas at its source and transportation to Ontario.
(b) Please provide Enbridge's best estimate of the upstream carbon emissions (tCO2e/m3) attributable to Ontario's gas consumption. As Ontario's gas comes from a variety of sources, please provide a best estimate with any necessary caveats. Please also provide the underlying calculations, such as the upstream emission intensity. Please also provide a high and low range estimate of this figure representing the differing scientific views on the upstream carbon emissions.

    This is relevant, among other things, to the probability that the lifecycle carbon emissions from gas will result in policies and market forces that significant reduce or eliminate gas consumption before the end of the life of assets to be built during the rate period.
(c) Please also provide the gross upstream carbon emissions associated with Ontario's total gas consumption (tCO2e).
(d) Please provide the total non-rounded Ontario 2020 GHG emissions (tCO2e) and the combined Enbridge scope 1, 2, and 3 emissions.

**Interrogatory # 1.10-ED-11**

Reference: Exhibit 1, Tab 10, Schedule 3, Page 2

Preamble:

Table 1
Enbridge Gas GHG Emissions (1)

| Line No. | Emissions Category (2) | Description | 2021 Emissions (Million $tCO_2e$) |
|---|---|---|---|
| 1 | Scope 1 | Emissions from Enbridge Gas's operations: combustion, flaring, venting and fugitives | 0.9 |
| 2 | Scope 2 | Emissions from off-site generation of electricity, which Enbridge Gas buys and consumes | 0.001 |
| 3 | Scope 3 | Emissions from combustion of natural gas by the Company's end-use customers. | 48.3 |
| 4 | Total | | 49.2 |

Question(s):

(a) Please confirm that scope 3 emissions also include emissions from unburned methane gas emitted by end-use customers. If not, please explain why not.
(b) What definition of scope 1, 2, and 3 emissions does Enbridge use?
(c) Please provide a table comparing the definition of scope 1, 2, and 3 emissions per (i) Enbridge's practices/policies, (ii) the GHG Protocol, (iii) ICO 14064, and (iv) the United Nations Framework Convention on Climate Change.

**Interrogatory # 1.10-ED-12**

Reference: Exhibit 1, Tab 10, Schedule 3, Page 2

Preamble:

> "6. Ontario's GHG emissions in 2020, the last year for which data are publicly available, were 150 million $tCO_2e$. Enbridge Gas's scope 1 and 2 emissions are less than 1% of Ontario's GHG emissions and the scope 3 GHG emissions from combustion of natural gas by Enbridge Gas's end-use customers are approximately 32% of Ontario's emissions.2 Enbridge Gas's scope 3 GHG emissions by sector are provided in Figure 1."

Question(s):

(a) Please confirm that the emissions noted above do not include unburned methane emissions from residential natural gas appliances. If they do, please provide a breakdown.
(b) Please provide Enbridge's best estimate of the unburned methane emissions from residential natural gas appliances (Ontario total, $CO_2e$). Please make and state assumptions as necessary and include caveats as necessary.
(c) If it differs from the answer to (b), please provide Enbridge's best estimate of the unburned methane emissions from residential natural gas appliances (Ontario total, $CO_2e$) based on Zachary Merrin and Paul W. Francisco*, Unburned Methane Emissions from Residential Natural Gas Appliances* (link). Please make and state assumptions as necessary and include caveats as necessary.
(d) If it differs significantly from the answer to (c), please provide Enbridge's best estimate of the unburned methane emissions from residential natural gas appliances (Ontario total, $CO_2e$) based on Patricia M. B. Saint-Vincent and Natalie J. Pekney, *Beyond-the-Meter: Unaccounted Sources of Methane Emissions in the Natural Gas Distribution Sector* (link). Please make and state assumptions as necessary and include caveats as necessary.
(e) With reference to these academic studies:
    - Quantifying Methane Emissions from Natural Gas Water Heaters (link)
    - Unburned Methane Emissions from Residential Natural Gas Appliances (link)
    - An Estimate of Natural Gas Methane Emissions from California Homes (link)
    - Beyond-the-Meter: Unaccounted Sources of Methane Emissions in the Natural Gas Distribution Sector (link)
    - Methane and NOx Emissions from Natural Gas Stoves, Cooktops, and Ovens in Residential Homes (link)

    Please provide a summary table of the results indicating, where available, for each equipment type: (i) the estimated unburned methane emissions ($tCO_2e/m^3$); (ii) the estimated unburned methane emissions per year on average ($t/CO_2e/yr$); and (iii) the estimated unburned methane emissions as a percent of gas consumption ($m^3/m^3$).
(f) What is the impact of 1 $m^3$ of methane gas combusted in Ontario ($tCO_2e$) versus 1 $m^3$ of methane gas emitted to the atmosphere without combustion ($tCO_2e$).
(g) Based on Enbridge's residential gas equipment survey results, please provide a table showing the number of customers with a gas: furnace, stove, tank water heater, tankless water heater, and fireplace.
(h) Please file the latest copy of Enbridge's residential gas equipment survey results.

**Interrogatory # 1.10-ED-13**

Reference: Exhibit 1, Tab 10, Schedule 3, Page 3

Preamble:

> "in November 2020, Enbridge announced corporate ESG targets, which included targets related to reducing GHG emissions from operations. This includes achieving net-zero emissions by 2050 and an interim target of a 35% reduction in GHG emission intensity by 2030 relative to a 2018 base year."

Question(s):

(a) Do Enbridge's GHG emissions reductions targets include: (i) direct emissions, (ii) indirect emissions, and (iii) customer emissions? Please explain.
(b) Please provide a table showing the Enbridge's GHG emissions from 2018 (historical) through to 2030 (targeted).
(c) How many gas-fired compressors does Enbridge own in Ontario?
(d) Approximately how many gas-fired compressors will Enbridge replace between now and 2028? Of those, approximately how many will be replaced with an electric compressor versus a gas compressor?
(e) Please provide complete the following table:

| **Activities to Achieve 35% GHG Reduction by 2030** | | | |
|---|---|---|---|
| Activity | GHG reduction (tCO2e) | Forecast net incremental cost | Start and end date |
| Activity 1 | | | |
| … | | | |
| Activity n | | | |
| | | | |
| Total of activities | | | |
| Total GHG reductions needed to meet 35% goal | | | |

**Interrogatory # 1.10-ED-14**

Reference: Exhibit 1, Tab 10, Schedule 4, Page 17

Preamble:

> "There is potential that climate change legislation, such as municipal or provincial plans to phase out the use of natural gas, could have a life-shortening effect on Enbridge Gas's system. However, there is also the possibility that service lives could be lengthened or

maintained if low-carbon fuels, such as hydrogen and **RNG**, are determined to be viable sustainable alternatives to natural gas."

Question(s):

(a) Please file a copy of all studies estimating the RNG potential in Ontario that Enbridge is aware of.
(b) Please summarize the conclusions of RNG potential studies referred to in (a) regarding Ontario's RNG potential in the following table:

| **Ontario's RNG Potential (m3) – Comparison of Report Conclusions** | | | | | |
|---|---|---|---|---|---|
| **Feedstock** | **Report 1 (potential year)[3]** | **Report 3 (potential year)** | **Report 3 (potential year)** | **…** | **Report n (potential year)** |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

(c) Please file a copy of all studies estimating the RNG cost that would be applicable to Ontario that Enbridge is aware of.
(d) Please summarize the conclusions of RNG potential studies referred to in (c) regarding Ontario's RNG potential in the following table:

| **RNG Cost in Ontario ($/m3) – Comparison of Report Conclusions** | | | | | |
|---|---|---|---|---|---|
| **Feedstock** | **Report 1 (year)[4]** | **Report 3 (year)** | **Report 3 (year)** | **…** | **Report n (year)** |
| Feedstock 1 | | | | | |
| … | | | | | |
| Feedstock n | | | | | |
| Weighted average | | | | | |

**Interrogatory # 1.10-ED-15**

Reference: Exhibit 1, Tab 10, Schedule 5, p. 14

Preamble:

[3] i.e. the year in which the stated potential is described in the report as being available.
[4] i.e. The year that the cost estimate relates to if it is not a current-year estimate.

"41. Regardless of the pathway chosen to achieve net-zero, the study found that energy efficiency, RNG, hydrogen and natural gas with CCUS are required, and net-zero cannot be achieved without these actions."

Question(s):

These questions are for Guidehouse:

(a) Does the Guidehouse report study find that CCUS is required for Ontario to reach net-zero by 2050? If yes, please justify that conclusion and explain how it was reached in light of the fact that Guidehouse did not study a scenario that excludes CCUS.
(b) Does the Guidehouse report find that significant use of RNG and hydrogen for residential heating is required for Ontario to reach net-zero by 2050? If yes, please justify that conclusion and explain how it was reached in light of the fact that Guidehouse did not study a scenario that is specific to this.
(c) Does the Guidehouse report find that transportation of RNG and hydrogen through major pipelines required for Ontario to reach net-zero by 2050 (versus on-site electrolysis/storage or local pipelines)? If yes, please justify that conclusion and explain how it was reached in light of the fact that Guidehouse did not explicitly study this.

## All of the questions on Exhibit 1, Tab 10, Schedule 5, Attachment 1 are directed to the Posterity Group, unless otherwise noted.

**Interrogatory # 1.10-ED-16**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 1, p. 21

Preamble:

Exhibit 13 – Emission Factors

| Fuel | Emission Factor (gramsCO2e/m3) | Notes/Assumptions |
|---|---|---|
| Natural Gas | 1,899 | • Calculated using a 100-year AR4 GWP values of 25 and 298 for CH4 and NO2 respectively.[8] |
| Natural Gas with Carbon Capture | 389 | • PG Analysis, using the 2020 NIR emission factors for CH4 and NO2 and assuming an 80% capture rate of CO2. |
| Renewable Natural Gas | 11 | • Enbridge Gas analysis, using the 2020 NIR emissions factors for CH4 and NO2 and assuming 100% of CO2 is biogenic. |
| Hydrogen | 0 | • Hydrogen does not produce combustion emissions. |

Question(s):

(a) Please provide the basis for the 80% capture rate for CCS. Please provide any underlying studies or reports.
(b) Please explain the emissions factor for RNG. What portion of those emissions are fugitive emissions.
    (i)

**Interrogatory # 1.10-ED-17**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 1, p. 29

Preamble:

| Critical Driver | Setting that deviates the most from the Reference Case assumption | Impact on Annual Volume by 2038 | Impact on Peak | Impact on GHG Emissions by 2038 |
|---|---|---|---|---|
| Carbon price | Max: $282/tonne. | 22% decline | 22% decline in hourly and daily peak | 22% decline |
| Natural Gas Price | Max: 400% higher than current natural gas prices. | 30% decline | ~27% decline in hourly and daily peak | 30% decline |

Question(s):

(a) Are the above two drivers considered to be additive? For instance, if both occur, would annual demand decline by 52%?
(b) Please provide all calculations and assumptions underlying the assumption of a 30% decline in annual demand resulting from a 400% increase in gas prices. What does this amount to in terms of the differential between the price of home heating by gas versus electric heat pumps (lifetime $ difference and % difference)? At the time of the report, what was considered the "baseline" current price ($/m3)?

**Interrogatory # 1.10-ED-18**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 1, p. 29

Question(s):

(a) What would the impact be on annual and peak gas demand if, starting in 2022, the cost-effectiveness of fully electrified heating/cooling with a heat pump was $11,071 cheaper than traditional gas heating (gas furnace, gas water heater, and AC) over the 15-year equipment lifetime? Please assume that the cost-effectiveness differential increases as the carbon price increases according to announced federal prices. Please provide a response on a best efforts basis. In answering the question, Posterity Group need not agree with any of the premises.

**Interrogatory # 1.10-ED-19**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 1, p. 40

Preamble:

Exhibit 26 – Scenario Narratives

| *Scenario Title:* | Reference Case | Steady Progress | Diversified Portfolio | Electricity Centric |
|---|---|---|---|---|

Question(s):

(a) For each scenario, please provide relative cost-effectiveness of residential space conditioning and cooling from a customer perspective as between (i) gas equipment and a traditional air conditioner, (ii) hybrid heating, and (iii) a house fully electrified with heat pumps (and not required to pay for gas distribution charges).
(b) Please confirm that the relative cost-effectiveness of the above options will impact gas demand.
(c) Page 40 states: "The ETSA project team built off the scenario narratives envisioned by Enbridge Gas prior to beginning the project to draft scenario narratives." Please provide a copy of what Enbridge provided.
(d) This question is for Enbridge: How did Enbridge develop the scenario narratives provided to Posterity Group? Please provide any reports or memos in relation the development of those narratives.
(e) Please assess the relative probability of the future being more similar to the reference case, study progress, diversified portfolio, or electricity centric scenarios.

**Interrogatory # 1.10-ED-20**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 1, 40

Preamble:

Exhibit 15 – Sensitivity of Annual Volumes, Peak and GHG Emissions by Critical Driver

| Critical Driver | Setting that deviates the most from the Reference Case assumption | Impact on Annual Volume by 2038 | Impact on Peak | Impact on GHG Emissions by 2038 |
|---|---|---|---|---|
| Carbon price | Max: $282/tonne. | 22% decline | 22% decline in hourly and daily peak | 22% decline |
| Natural Gas Price | Max: 400% higher than current natural gas prices. | 30% decline | ~27% decline in hourly and daily peak | 30% decline |
| … | | | | |
| Non-Price Driven fuel-switching (gas to electricity) | Max: Beginning in 2025, no new gas connections, and space and water heating equipment at existing accounts must be replaced with electric alternatives at the equipment's natural end of life. | 42% decline | Hourly peak: 50% decline<br>Daily peak: 55% decline | 42% decline |

Question(s):

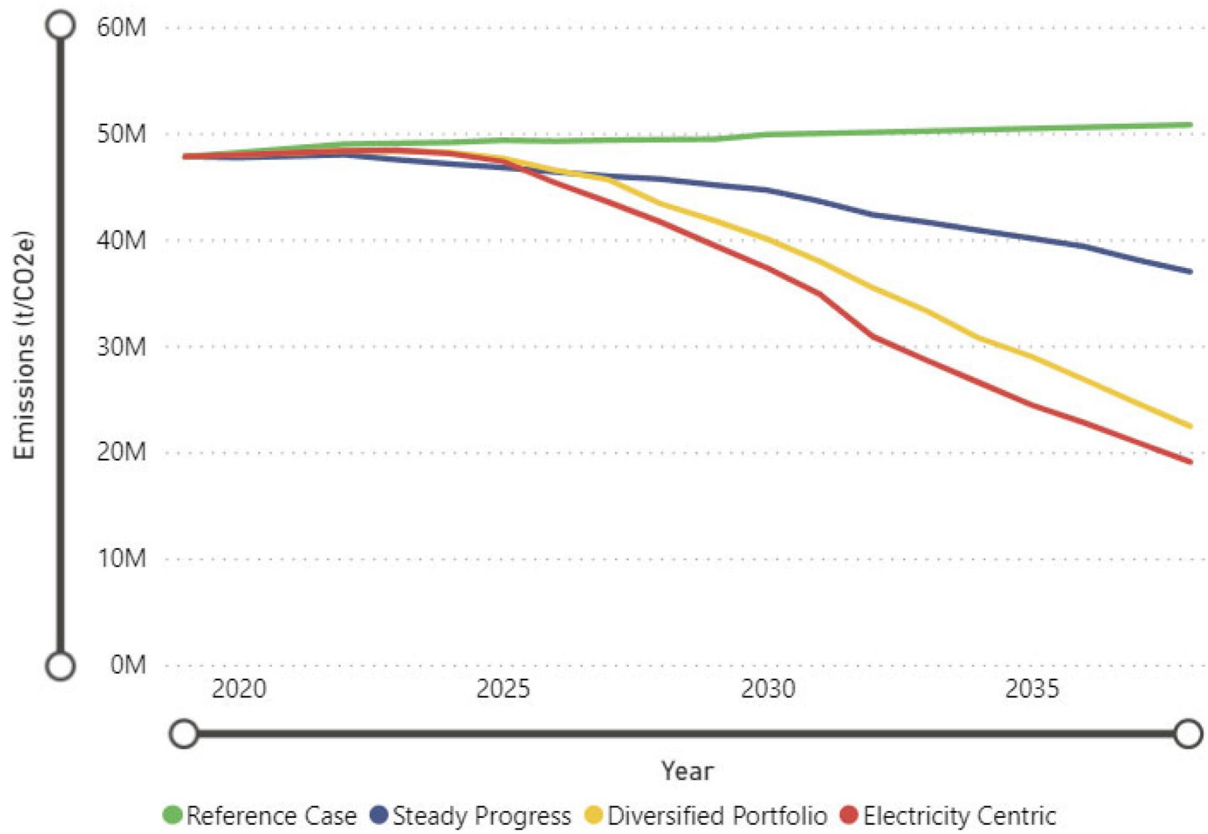
(a) Please confirm whether any of the scenarios studied include any of the three drivers noted above. If not, why not. Please explain in detail.
(b) What is the likelihood that one of the three "settings" above would come to pass? Please provide the likelihood for each individually, and the likelihood that any one of them would come to pass. Please justify the answer answer with specific details.

**Interrogatory # 1.10-ED-21**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 1, p. 79

Preamble:

Exhibit 71 – Scenarios Comparison: GHG Emissions




Question(s):

(a) Please reproduce the above figure including full lifecycle emissions, including upstream emissions (e.g. from fossil-fuel-based hydrogen, transmission methane leaks, etc.) and methane leaks from customer equipment. Please make and state your assumptions for those.

For upstream emissions from fossil-fuel-based hydrogen, please use the figures found in the following peer-reviewed report or justify a decision to use different figures: Robert W. Howarth and Mark Z. Jackson, "How green is blue hydrogen?" *Energy Science & Engineering*, 26 July 2021 (link).

For the emissions of unburned methane from customer equipment, please use the figures found in the following peer-reviewed report or justify a decision to use different figures: Zachary Merrin and Paul W. Francisco*, Unburned Methane Emissions from Residential Natural Gas Appliances* (link).

**Interrogatory # 1.10-ED-22**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 1

Preamble:

- *Electricity Centric Scenario:* The fuel shares for residential and commercial space heating is 27% and 24% respectively by 2038 (approximately 800,000 customers). As the natural gas system is contracting, investment into adding new hydrogen loops (additional customers) is not made. Blend percent is increased from 2% to 10% in 2035 for customers on existing hydrogen loop (21,000 customers).

Exhibit 101 – Hydrogen Blend in the Steady Progress and All Electric Scenarios

| | Steady Progress Scenario (# customers receiving 10% H2) | All Electric Scenario (#customers receiving 10% H2) |
|---|---|---|
| 2035 | 200,000 customers | 18,760 customers |
| 2038 | 800,000 customers | 20,770 customers |

Question(s):

(a) Why does Posterity Group assume that customers were use 10% hydrogen? Does Posterity believe this would be cheaper than customers converting to electric heating? If yes, why?
(b) What is the "existing hydrogen loop" referred to above?
(c) What are the RNG assumptions for the steady state and all electric scenarios?

**Interrogatory # 1.10-ED-23**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 1, p. 113

Preamble:

Question(s):

(a) According to Posterity Group, what is the feasible RNG potential in Ontario (PJ/d)? Please justify the answer with reference to RNG potential studies. Please compare the answer to the RNG potential found by the OEB in its Marginal Abatement Cost Curve study.
(b) Please reproduce the above, inserting amounts in terms of PJ/d.
(c) If RNG potential in Ontario is 40 PJ/d, how would that impact the peak gas volume results of the various scenarios.

## All of the questions on Exhibit 1, Tab 10, Schedule 5, Attachment 2 are directed to Guidehouse, unless otherwise noted.

**Interrogatory # 1.10-ED-24**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2

Question(s):

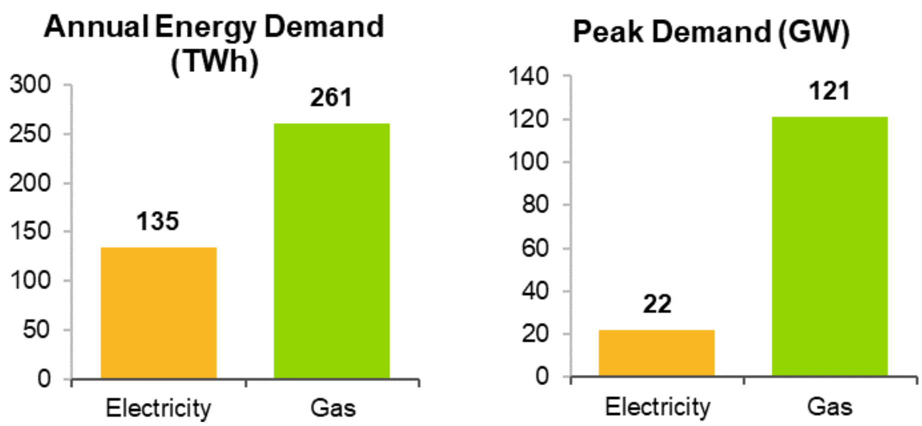
(a) Please provide a list of the authors of the Guidehouse report and copies of their CVs.
(b) Please provide a table showing the decarbonization pathways studies that the report authors have worked on, a description of their role(s) in said studies, and links to (or copies of) those studies.

**Interrogatory # 1.10-ED-25**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2

Preamble:

**Figure 4. Comparison of Ontario's Electricity and Natural Gas Demand (2019)**




Question(s):

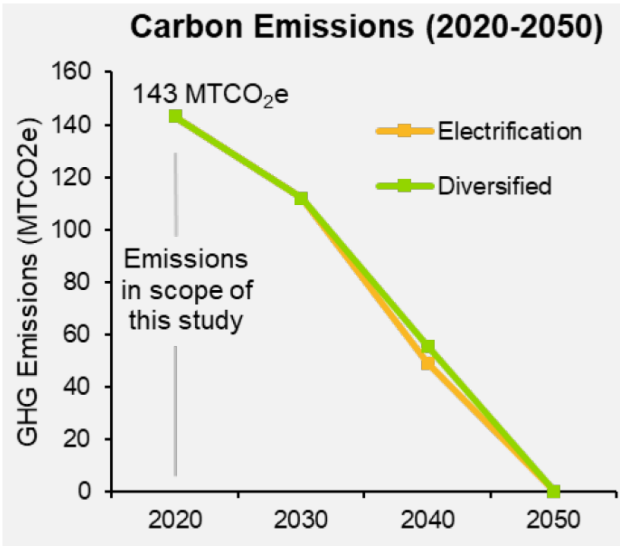
(a) Please provide an excel spreadsheet showing the total Ontario gas demand for each hour in 2019 and 2020. We wish to use the data to assess the "peakiness" of gas demand.
(b) Please provide an excel spreadsheet showing the total Ontario electricity demand for each hour in 2019 and 2020. We wish to use the data to assess the "peakiness" of elect.

Note – We wish to use the above information to assess the "peakiness" of Ontario's gas demand and electricity demand; to compare the two; and assess the reports characterization of each.

**Interrogatory # 1.10-ED-26**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 3

Preamble:




Question(s):

(a) Please provide an updated version of the above figure that accounts for the full lifecycle emissions associated with gaseous fuels (including as many of those listed in (b) as possible). Please provide all calculations and assumptions. Please make assumptions and state caveats as necessary.

For upstream emissions from fossil-fuel-based hydrogen, please use the figures found in the following peer-reviewed report or justify a decision to use different figures: Robert W. Howarth and Mark Z. Jackson, "How green is blue hydrogen?" *Energy Science & Engineering*, 26 July 2021 (link).

For the emissions of unburned methane from customer equipment, please use the figures found in the following peer-reviewed report or justify a decision to use different figures: Zachary Merrin and Paul W. Francisco*, Unburned Methane Emissions from Residential Natural Gas Appliances* (link).

(b) Please indicate whether the following emissions are accounted for in Guidehouse's study and the above figure:

(i) Upstream emissions for fossil gas consumed in Ontario (e.g. emissions from extraction, transportation leaks, etc.);

(ii) Upstream emissions for hydrogen produced out-of-province and consumed in Ontario, including:

(A) Uncaptured GHG emissions from the production of hydrogen from methane and the carbon capture process;

(B) Fugitive methane emissions;

(C) Fugitive hydrogen emissions (H2 is an indirect greenhouse gas, which reacts with other greenhouse gases in the atmosphere to increase their global warming potential);[5]

(iii) Fugitive methane emissions in Ontario from pipelines;
(iv) Fugitive hydrogen emissions in Ontario from pipelines;
(v) Fugitive methane emissions in Ontario from behind-the-meter equipment or pipes;
(vi) Fugitive hydrogen emissions in Ontario from behind-the-meter equipment or pipes; and
(vii) Emissions unsuccessfully captured in CCUS projects in Ontario.

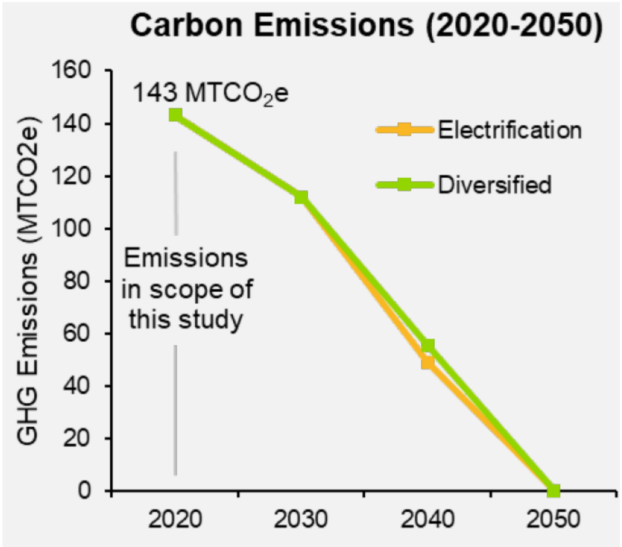
(c) Please provide a list of emissions related to RNG or hydrogen that are not accounted for in Guidehouse's study aside from those listed in (b), if any.
(d) Please express the impact in terms of tCO2e of (i) 1 m3 of fugitive methane; (ii) 1 m3 of combusted methane; and (iii) 1 m3 of fugitive hydrogen.
(e) What is Guidehouse's best estimate of the the global warming potential (GWP) of carbon dioxide, methane, and hydrogen? With respect to hydrogen, is the GWP 11[6] as per more recent research or 5.8 as per older studies[7]?
(f) Please provide a copy of the above table in the units of MW/yr.
(g) Please provide a best estimate of the GHG emissions (tCO2e/m3) from:
    (i) Upstream emissions (extraction and fugitive) for fossil gas consumed in Ontario, on average;
    (ii) Upstream emissions for hydrogen produced out-of-province and consumed in Ontario, on average, with and without CCUS;
    (iii) Fugitive emissions from leaks in Enbridge's gas infrastructure, on average;
    (iv) Fugitive emissions from behind-the-meter gas equipment and pipes, on average.
(h) Please discuss the likely impact of hydrogen being a smaller molecule on the impact on the percentage of leakage from gas pipelines in comparison to methane. Please provide any studies that can be efficiency located on this topic.

**Interrogatory # 1.10-ED-27**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 3

Preamble:

[5] Nicola Warwick et al, *Atmospheric implications of increased Hydrogen use*, April 2022 (link); Ilissa Ocko, *Climate consequences of hydrogen emissions*, July 20, 2022 (link).
[6] Nicola Warwick et al, *Atmospheric implications of increased Hydrogen use*, April 2022 (link)
[7] E.g. Richard Derwent, *Global environmental impacts of the hydrogen economy*, January 2006 (link)




Question(s):

(a) Please provide an updated version of the above figure that does not factor-in negative emissions (e.g. direct air capture).
(b) Please complete the following table indicating the volume and cost of the negative emissions (e.g. direct air capture) in each of the scenarios:

| Negative Emissions by Scenario | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| *Diversified scenario* | | | | |
| Negative emissions (tCOe2/yr) | | | | |
| Breakdown of negative emission sources | | | | |
| Cost to achieve negative emissions ($/yr) | | | | |
| *Electrification scenario* | | | | |
| Negative emissions (tCOe2/yr) | | | | |
| Breakdown of negative emission sources | | | | |
| Cost to achieve negative emissions ($/yr) | | | | |

(c) Please provide a breakdown of the origin of the remaining emissions sources from gaseous fuels (e.g. industrial, power generation, etc.) by scenario:

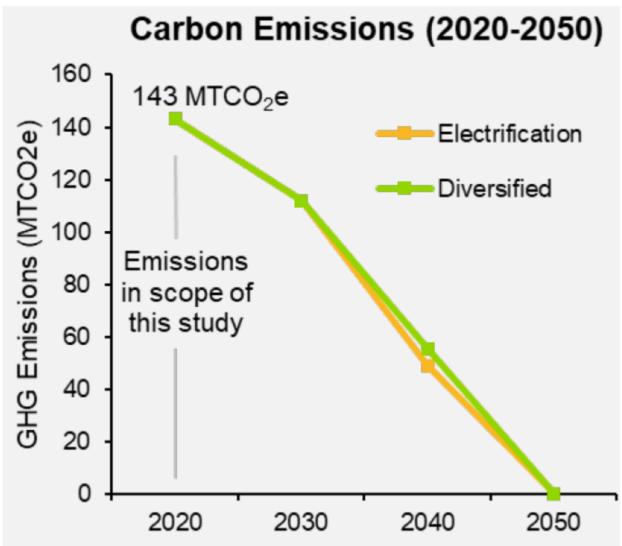
| GHG Emission Sources by Scenario | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| *Diversified scenario* | | | | |
| Source 1 (tCO2e/yr) | | | | |
| … | | | | |

| | | | | |
|---|---|---|---|---|
| Source n (tCO2e/yr) | | | | |
| *Electrification scenario* | | | | |
| Source 1 (tCO2e/yr) | | | | |
| … | | | | |
| Source n (tCO2e/yr) | | | | |

**Interrogatory # 1.10-ED-28**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 3

Preamble:




Question(s):

(a) Please add a line to the above figure to reflect the emissions reductions buildings per Canada's 2030 Emissions Reductions Plan (22% by 2026 and by 41% by 2030), which can be found in this footnote[8] and are shown in the following chart. Please provide a response on a best-efforts basis, making assumptions and stating caveats as necessary. Please provide all underlying sources, calculations, and assumptions. To translate the national emissions reductions for buildings to provincial fossil gas emissions reductions, we recommend the following assumptions: (i) Ontario's share of reductions is proportional to Ontario's share of national emissions and (ii) all or almost all the reductions from buildings are achieved with respect to fossil gas consumption (as it constitutes almost all the GHGs from buildings). However, please use whatever assumptions Guidehouse believes are appropriate.

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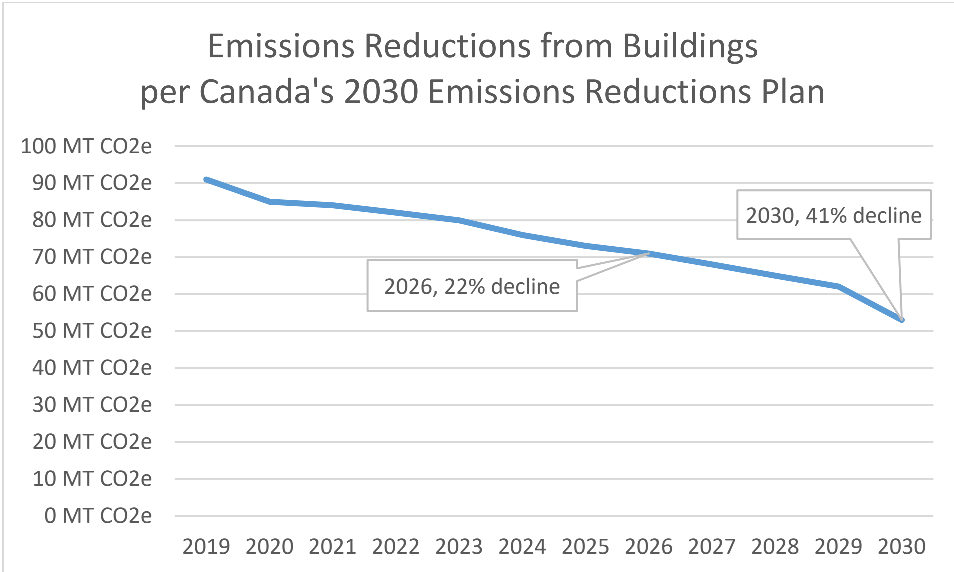
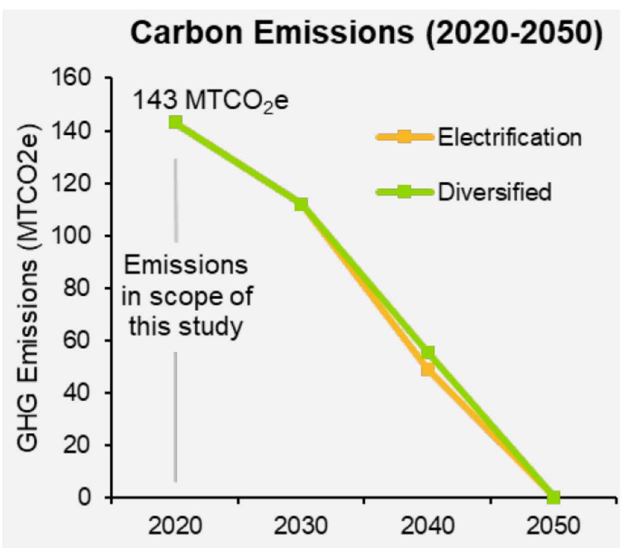
[8] Exhibit I.ED.3(a), (f), & (g); see also: *2030 Emissions Reduction Plan – Canada's Next Steps for Clean Air and a Strong Economy* (link); for the full plan see https://publications.gc.ca/collections/collection_2022/eccc/En4-460-2022-eng.pdf.




**Interrogatory # 1.10-ED-29**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 3

Preamble:



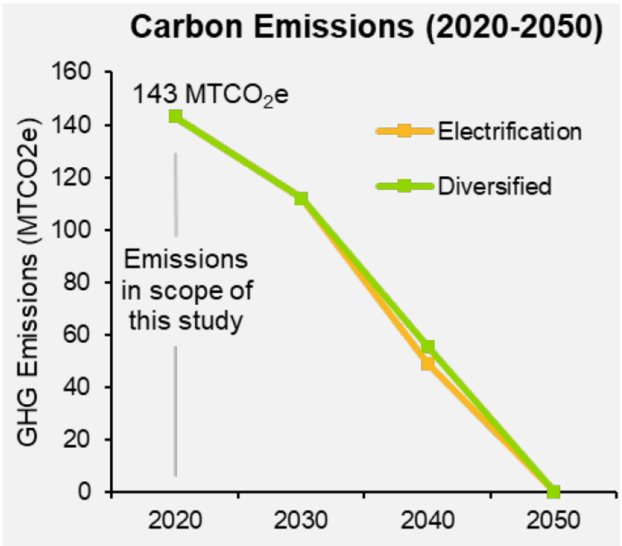

Question(s):

(a) Please provide a table with a breakdown of the emissions by sector by year (or by decade, if by year is not possible) corresponding to the above table for each of the two scenarios.
(b) Please provide a table with a breakdown of the emissions by (i) gaseous fuels and (ii) other sources by year (or by decade, if by year is not possible) corresponding to the above table for each of the two scenarios.

**Interrogatory # 1.10-ED-30**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 3

Preamble:




Question(s):

(a) Please provide a list of measures based on the Guidehouse study that would be attributable to the emissions reductions shown above for each scenario and the emissions reductions from each up to 2028. Please provide an answer on a best-efforts basis, making assumptions and stating caveats as necessary. Please provide all underlying calculations and assumptions. Please use the following format for the figures:

| **Emissions Reductions Sources by Scenario in 2028** | | |
|---|---|---|
| | Description | Expected reductions by 2028 (tCO2e) |
| *Diversified scenario* | | |
| Measure 1 | | |
| … | | |
| Measure n | | |
| *Electrification scenario* | | |
| Measure 1 | | |
| … | | |
| Measure n | | |

(b) This response will require both Guidehouse and Enbridge staff. Please complete the following tables comparing the scenarios with the emissions reductions forecast based on the current policies in place and Enbridge's application. Where there is a variance, please explain the variance and describe how it could be closed through additional relief from the OEB over the 2024-2028 period.

| **Emissions Reductions – Diversified Scenario vs. Enbridge Application** |
|---|

| | Scenario reductions by 2028 (tCO2e) | Forecast reductions by 2028 (tCO2e) | Variance explanation | Possible ways to eliminate variance |
|---|---|---|---|---|
| *Diversified scenario* | | | | |
| Measure 1 | | | | |
| … | | | | |
| Measure n | | | | |

| **Emissions Reductions – Electrified Scenario vs. Enbridge Application** | | | | |
|---|---|---|---|---|
| | Scenario reductions by 2028 (tCO2e) | Forecast reductions by 2028 (tCO2e) | Variance explanation | Possible ways to eliminate variance |
| *Electrified scenario* | | | | |
| Measure 1 | | | | |
| … | | | | |
| Measure n | | | | |

**Interrogatory # 1.10-ED-31**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 19

Preamble:

> "While the supply of RNG in Ontario is currently small and more costly that importing natural gas, the province has significant RNG production potential. Torchlight Bioresources estimated Ontario's RNG potential via conventional RNG production technologies like anaerobic digestion and landfill gas.[9] Torchlight's report estimated that Ontario has the potential to produce around 40 PJ per year of RNG supply from wet organic wastes and up to around 240 PJ per year if agricultural residues are included. These agricultural residues reflect waste products such as corn stover and corn silage, and not new crop production that would need to be redirected to RNG production. This RNG potential represents roughly 4%-26% of Ontario's annual natural gas demand.[10]"

Question(s):

(a) The following figure from page 56 of the Torchlight Bioresources report relied on by Guidehouse study states that the "feasible RNG potential" is 155 PJ/yr **for all of Canada**. In contrast, Guidehouse states that Ontario's RNG potential is 240 PJ/yr and includes 171 PJ/yr of RNG in its diversified scenario by 2050 (p. 40). Please provide the **"feasible"** RNG potential for Ontario. If necessary, please contact Torchlight Bioresources to

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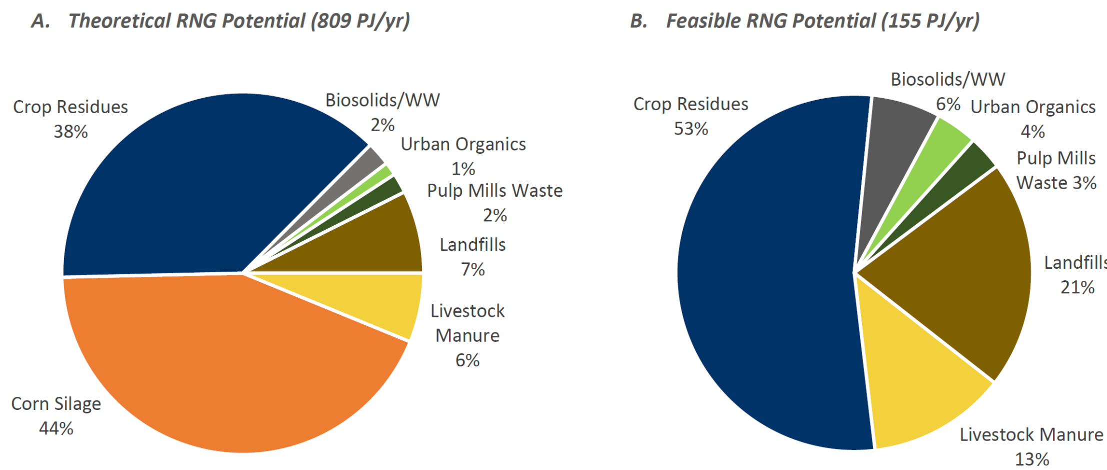
[9] Torchlight Bioresources (2020). Renewable Natural Gas (Biomethane) Feedstock Potential in Canada. Available: https://www.enbridge.com/~/media/Enb/Documents/Media%20Center/RNG-Canadian-Feedstock-Potential-2020%20(1).pdf?la=en

[10] Torchlight's 240 PJ estimate is based on anaerobic digestion and landfill potential and does not reflect more advanced RNG production technologies like biomass gasification or power-to-gas, which are not yet commercially available. Of the 240 PJ estimate, landfill gas accounts for approximately 21 PJ, equivalent to 9%.

determined the specific figure for Ontario. Please indicate in the response if they have been contacted.




**Interrogatory # 1.10-ED-32**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 19

Preamble:

> "While the supply of RNG in Ontario is currently small and more costly that importing natural gas, the province has significant RNG production potential. Torchlight Bioresources estimated Ontario's RNG potential via conventional RNG production technologies like anaerobic digestion and landfill gas.[11] Torchlight's report estimated that Ontario has the potential to produce around 40 PJ per year of RNG supply from wet organic wastes and up to around 240 PJ per year if agricultural residues are included. These agricultural residues reflect waste products such as corn stover and corn silage, and not new crop production that would need to be redirected to RNG production. This RNG potential represents roughly 4%-26% of Ontario's annual natural gas demand.[12]"

Question(s):

(a) Is the 40 PJ to 240 PJ of Ontario RNG potential that Guidehouse references from the Torchlight Bioresources report the "feasible potential" or the "theoretical conventional RNG potential" (per p. 27 of the Torchlight report)? If neither, please explain.
(b) Please describe the difference between the "feasible" and "theoretical" RNG potential as described in the Torchlight Bioresources report.

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[11] Torchlight Bioresources (2020). Renewable Natural Gas (Biomethane) Feedstock Potential in Canada. Available: https://www.enbridge.com/~/media/Enb/Documents/Media%20Center/RNG-Canadian-Feedstock-Potential-2020%20(1).pdf?la=en
[12] Torchlight's 240 PJ estimate is based on anaerobic digestion and landfill potential and does not reflect more advanced RNG production technologies like biomass gasification or power-to-gas, which are not yet commercially available. Of the 240 PJ estimate, landfill gas accounts for approximately 21 PJ, equivalent to 9%.

(c) Please confirm that Torchlight Bioresources estimates that there is "660 PJ of theoretical conventional RNG potential" in Canada (per p. 54) and 155 PJ/yr of "feasible RNG potential" in Canada (p. 56). If not, please explain.
(d) Please confirm that, according to Torchlight Bioresources, the theoretical conventional RNG potential in Canada is over 4.2 times the feasible RNG potential.
(e) Please provide the Ontario RNG consumption assumed in the Guidehouse report for each scenario annually between 2020 and 2050. Please express the answer in a table showing both m3 and PJ.

**Interrogatory # 1.10-ED-33**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 19 & 40

Preamble:

> Per p. 40: "The increase in supply capacity for RNG production will be primarily via anaerobic digestion, reaching 171 PJ by 2050 in the Diversified scenario and 139 PJ in the Electrification scenario. These figures represent a significant share of Ontario's RNG potential, estimated to be 240 PJ.[13]"
>
> Per p. 19: "Torchlight's report estimated that Ontario has the potential to produce around 40 PJ per year of RNG supply from wet organic wastes and up to around 240 PJ per year if agricultural residues are included. These agricultural residues reflect waste products such as corn stover and corn silage, and not new crop production that would need to be redirected to RNG production. This RNG potential represents roughly 4%-26% of Ontario's annual natural gas demand.[14]"

Question(s):

(a) The only reference we can find in the Torchlight Bioresources report that provides a breakdown for the Ontario potential is the "Theoretical Conventional RNG Potential" at page 27 of the report (excepted below). That lists the "theoretical" potential as being 224 PJ (including herbaceous) and 41 PJ (excluding herbaceous). Is Guidehouse's reference to Ontario's RNG potential being 240 PJ a typo? If not, please explain how Guidehoue can assume an RNG potential based on the Torchlight Bioresources report that is higher than even the "theoretical potential" in the Torchlight Bioresources report, let alone the feasible potential in that report.

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[13] Torchlight Bioresources (2020). Renewable Natural Gas (Biomethane) Feedstock Potential in Canada. Available: https://www.enbridge.com/~/media/Enb/Documents/Media%20Center/RNG-Canadian-Feedstock-Potential-2020%20(1).pdf?la=en

[14] Torchlight's 240 PJ estimate is based on anaerobic digestion and landfill potential and does not reflect more advanced RNG production technologies like biomass gasification or power-to-gas, which are not yet commercially available. Of the 240 PJ estimate, landfill gas accounts for approximately 21 PJ, equivalent to 9%.

Figure 19. Annual Theoretical Conventional RNG Potential, by Province

| Province/Territory | RNG Potential (Including Herbaceous) | RNG Potential (Excluding Herbaceous) | Feedstocks Exceeding 2.5 PJ/yr Potential |
|---|---|---|---|
| British Columbia | 20 | 16 | Corn silage, hog manure, landfills, pulp mills |
| Alberta | 105 | 15 | Crop residues, corn silage, landfills, cattle feedlot manure |
| Saskatchewan | 112 | 3 | Crop residues, corn silage |
| Manitoba | 70 | 4 | Crop residues, corn silage |
| Ontario | 224 | 41 | Corn silage, landfills, crop residues, biosolids/wastewater, hog manure, poultry manure, urban organics |
| Quebec | 116 | 38 | Corn silage, landfills, hog manure, crop residues, pulp mills, biosolids/wastewater, dairy manure |
| New Brunswick | 5 | 4 | - |
| Nova Scotia | 4 | 2 | - |
| Prince Edward Island | 2 | 0 | - |
| Newfoundland and Labrador | 1 | 1 | - |
| **Canada** | **660** | **123** | **All** |

(b) Why does Torchlight Bioresources differentiate between the potential including and excluding herbaceous? Is that because herbaceous feedstocks have competing uses and therefore may not be available for RNG?
(c) Please provide a breakdown of the herbaceous feedstocks available in Ontario (PJ), indicating which are currently used for other purposes.
(d) How much of Ontario's RNG potential (JP) is from corn silage/stover?
(e) Please confirm that corn silage/stover can be used as fodder, bedding, or a soil amendment.
(f) Approximately how much (PJ) of Ontario's available corn silage/stover is already being used as fodder, bedding, or a soil amendment.

**Interrogatory # 1.10-ED-34**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 19 & 40

Preamble:

> Per p. 19 of the Guidehouse report: "Torchlight's 240 PJ estimate is based on anaerobic digestion and landfill potential and does not reflect more advanced RNG production technologies like biomass gasification or power-to-gas, which are not yet commercially available."
>
> Per p. 40 of the Guidehouse report: "Other RNG production technologies such as biomass gasification do not play major roles in RNG supply today; however, local conditions and the availability of low-cost biomass feedstock (such as in Northern Ontario) may encourage the development of gasification plants in the future."
>
> Per p. 54 of the Torchlight Bioresources report: "This bottom-up resource analysis has shown the theoretical potential for RNG production in Canada is approximately 809 PJ

per year … Of this 809 PJ, 660 PJ is the theoretical potential for conventional RNG. This excludes precommercial wood-to-gas pathways of gasification and methanation, and pyrocatalytic hydrogenation (150 PJ). As identified in Section 4.3 and as stated by stakeholders in a recent national survey, these technologies face major scale-up hurdles.[47,59] In addition, if RNG from wood is used for building or process heat, the production pathway will be notably lower efficiency and higher capital cost than direct combustion of solid wood fuel.

Question(s):

(a) Does Guidehouse agree that RNG from the gasification of wood is "notably lower efficiency and higher capital cost than direct combustion of solid wood fuel" if the RNG is to be used to generate heat?
(b) Does Guidehouse believe it is likely that RNG from biomass gasification will become cost-effective?
(c) Approximately how much does it cost ($/m3) to produce RNG from biomass gasification?

**Interrogatory # 1.10-ED-35**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 19 & 40

Preamble:

Per p. 40 of the Guidehouse report: "The increase in supply capacity for RNG production will be primarily via anaerobic digestion, reaching 171 PJ by 2050 in the Diversified scenario and 139 PJ in the Electrification scenario. These figures represent a significant share of Ontario's RNG potential, estimated to be 240 PJ.[15]"

Per page 54 of the 2017 MACC report for the OEB:[16]

[15] Torchlight Bioresources (2020). Renewable Natural Gas (Biomethane) Feedstock Potential in Canada. Available: https://www.enbridge.com/~/media/Enb/Documents/Media%20Center/RNG-Canadian-Feedstock-Potential-2020%20(1).pdf?la=en
[16] EB-2016-0359, ICF, *Marginal Abatement Cost Curve*, July 20, 2017, prepared for the OEB, p. 14 (link);

Table 22 Summary of the National and Ontario Provincial RNG Potential in 2028 by Feedstock

| Feedstock | National Potential by 2028 (million $m^3$/yr) | National Potential by 2028 ($tCO_2$/yr) | Ontario Potential by 2028 (million $m^3$/yr) | Ontario Potential by 2028 ($tCO_2$/yr) | LCOE (\$/$m^3$) | Notes |
|---|---|---|---|---|---|---|
| **Landfill gas** | 290 | 540,000 | 113 | 210,000 | \$0.33-\$0.82 | Evaluated 5 different sized facilities based on survey referenced in Canadian Biogas Study; linked to study for Environment Canada |
| **WWT gas** | 180 | 340,000 | 71 | 135,000 | \$0.48-\$3.73 | Evaluated 4 different sized facilities – ICF analysis |
| **Animal manure** | 874 | 1,640,000 | 191 | 360,000 | \$0.87-\$1.66 | Considered 3 different farms (Electrigaz study): baseline, large, and co-op |
| **SSO residential & commercial** | 300 | 560,000 | 110 | 210,000 | \$2.90 | Assumed a single facility capable of processing 60,000 tonnes/yr per Canadian biogas study. Larger/smaller facilities conceivable |

Question(s):

(a) What is Guidehouse's best estimate of Ontario's RNG potential by 2028? Please provide a breakdown by feedstock, including the price for each (\$/m3).
(b) What are the conversion factors between (i) \$/m3 and \$/PJ of RNG, and (ii) m3 to PJ of RNG?
(c) Please fill out the following table comparing the Ontario RNG potential and cost per the above-referenced OEB report with Guidehouse figures.

| **Comparison of 2028 RNG Potential, Consumption & Cost Figures OEB MACC vs Guidehouse** | | | | | | |
|---|---|---|---|---|---|---|
| **Feedstock** | **Potential per OEB Study (M m3/yr)** | **Potential per Guidehouse estimate (M m3/yr)** | **Consumption per diversified scenario (M m3/yr)** | **Consumption per electrified scenario (M m3/yr)** | **Cost per OEB Study (\$/m3)** | **Cost per Guidehouse estimate (\$/m3)** |
| [E.g. landfill gas, WWT gas, | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| manure, etc.] | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

(d) Please file a copy of all studies estimating the RNG potential in Ontario that Guidehouse is aware of.
(e) Please summarize the conclusions of RNG potential studies referred to in (d) regarding Ontario's RNG potential in the following table:

| **Ontario's RNG Potential – Comparison of Report Conclusions** | | | | | |
|---|---|---|---|---|---|
| **Feedstock** | **OEB MACC (potential year)[17]** | **Torchlight Bioresources (potential year)** | **Report 3 (potential year)** | **…** | **Report n (potential year)** |
| [E.g. landfill gas, WWT gas, manure, etc.] | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

**Interrogatory # 1.10-ED-36**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 19, 40, & A-5

Preamble:

The following questions focus on the cost of RNG. Responses are needed to test and analyze (i) the Guidehouse report; (ii) the Application's reliance on the Guidehouse report; and (iii) Enbridge's assertion that its proposed capital spending likely will not be stranded because it can be used in the future for a large quantity of cost-effective renewable natural gas.

Question(s):

[17] i.e. the year in which the stated potential is described in the report as being available.

(a) Please provide all assumptions in the Guidehouse report regarding the cost of RNG ($/m3). Please explain the basis of those assumptions, including the assumed feedstocks and assumed prices for each feedstock. Please provide all sources.
(b) Please complete the following tables:

| RNG Volumes and Cost by Feedstock – Diversified Scenario | | | | |
|---|---|---|---|---|
| | **2020** | **2030** | **2040** | **2050** |
| Feedstock 1 | | | | |
| Volume (m3) | | | | |
| Unit cost ($/m3) | | | | |
| … | | | | |
| Feedstock n | | | | |
| Volume (m3) | | | | |
| Unit cost ($/m3) | | | | |
| Total of all feedstocks | | | | |
| Volume (m3) | | | | |
| Unit cost – weighted average ($/m3 | | | | |

| RNG Volumes and Cost by Feedstock – Electrified Scenario | | | | |
|---|---|---|---|---|
| | **2020** | **2030** | **2040** | **2050** |
| Feedstock 1 | | | | |
| Volume (m3) | | | | |
| Unit cost ($/m3) | | | | |
| … | | | | |
| Feedstock n | | | | |
| Volume (m3) | | | | |
| Unit cost ($/m3) | | | | |
| Total of all feedstocks | | | | |
| Volume (m3) | | | | |

| | | | | |
|---|---|---|---|---|
| Unit cost – weighted average ($/m3) | | | | |

(c) If Guidehouse has data to complete the tables in (b) on an annual basis, please provide those tables on an annual basis.
(d) Please file a copy of all studies estimating the RNG cost that would be applicable to Ontario that Guidehouse is aware of. Please include the studies that Guidehouse relied on, as well as the studies that Guidehouse decided not to rely on (indicating why it chose not to rely on them).
(e) Please summarize the conclusions of the RNG cost studies referred to in (m) regarding in the following table:

| **RNG Cost in Ontario ($/m3) – Comparison of Report Conclusions** | | | | | |
|---|---|---|---|---|---|
| **Feedstock** | **Report 1 (year)**[18] | **Report 3 (year)** | **Report 3 (year)** | **…** | **Report n (year)** |
| Feedstock 1 | | | | | |
| … | | | | | |
| Feedstock n | | | | | |
| Weighted average | | | | | |

**Interrogatory # 1.10-ED-37**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 20

Preamble:

> "Prior studies have assessed CCS options in Ontario and have determined that the only sequestration option is geological sequestration in saline aquifers. Carbon dioxide is expected to be stored in these aquifers for long periods, from one hundred years to several thousand years depending on the size, properties, and location of the reservoir. Prior studies identified two different major reservoirs appropriate for CCS in southwestern Ontario: one located in the southern part of Lake Huron and the other located inside Lake Erie. These sites have approximate storage capacities of 289 million and 442 million tonnes of CO2 emissions.[19]"

Question(s):

[18] i.e. The year that the cost estimate relates to if it is not a current-year estimate.
[19] Shafeen, Ahmed & Croiset, Eric & Douglas, Peter & Chatzis, Ioannis. (2004). CO2 sequestration in Ontario, Canada. Part I: Storage evaluation of potential reservoirs. Energy Conversion and Management. 45. 2645-2659. Available: http://dx.doi.org/10.1016/j.enconman.2003.12.003

(a) What is the average lifetime of the equipment needed for a CCS facility?
(b) For economic assessments of CCS facilities, what are the typical assumed economic lifetimes? In other words, approximately how many years of operating revenue would be required to recoup the upfront capital investment?
(c) Please complete the following table indicating the annual and cumulative quantity of CO2 to be sequestered in Ontario under the two scenarios. For years beyond 2050, please extrapolate the annual CO2 to be sequestered based on the previous 5-year trend (or make, state, and explain a different assumption if Guidehouse believes a different assumption is warranted for future years). If annual figures are not possible, please provide the figures by decade. This question is meant, in part, to explore how long it would take for the aquifers to be full.

| **Ontario-Based Carbon Sequestration Volumes by Scenario Annual and Cumulative** | | | | |
|---|---|---|---|---|
| | 2020 | 2021 | …. | Year in which cumulative total is 731 M t CO2e |
| *Diversified* | | | | |
| Annual (MtCO2) | | | | |
| Cumulative (MtCO2) | | | | |
| *Electrified* | | | | |
| Annual (MtCO2) | | | | |
| Cumulative (MtCO2) | | | | |
| Estimated reservoir capacity | 731 | 731 | 731 | 731 |

(d) Please complete the following table indicating the annual and cumulative quantity of CO2 to be sequestered in Ontario under the scenarios with a breakdown between CCS for blue hydrogen occurring in Ontario (SMR & CCS) and combustion of fossil gas. For years beyond 2050, please extrapolate the annual CO2 to be sequestered based on the previous 5-year trend (or make, state, and explain a different assumption if Guidehouse believes a different assumption is warranted for future years). This question is meant, in part, to explore how long it would take for the aquifers to be full.

| **Ontario-Based Carbon Sequestration Volumes by Scenario Annual and Cumulative** | | | | |
|---|---|---|---|---|
| | 2020 | 2021 | …. | 2050 |
| *Diversified* | | | | |

| | | | | |
|---|---|---|---|---|
| Blue hydrogen consumption (PJ/yr) | | | | |
| Blue hydrogen CO2 capture (MtCO2e/yr) | | | | |
| Fossil gas combustion (PJ/yr) | | | | |
| Fossil gas combustion capture (MtCO2e/yr) | | | | |
| Total capture (MtCO2e/yr) | | | | |
| *Electrified* | | | | |
| Blue hydrogen consumption (PJ/yr) | | | | |
| Blue hydrogen CO2 capture (MtCO2e/yr) | | | | |
| Fossil gas combustion (PJ/yr) | | | | |
| Fossil gas combustion capture (MtCO2e/yr) | | | | |
| Total capture (MtCO2e/yr) | | | | |

**Interrogatory # 1.10-ED-38**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 20

Preamble:

> "Prior studies have assessed CCS options in Ontario and have determined that the only sequestration option is geological sequestration in saline aquifers. Carbon dioxide is expected to be stored in these aquifers for long periods, from one hundred years to several thousand years depending on the size, properties, and location of the reservoir. Prior studies identified two different major reservoirs appropriate for CCS in southwestern Ontario: one located in the southern part of Lake Huron and the other

located inside Lake Erie. These sites have approximate storage capacities of 289 million and 442 million tonnes of $CO_2$ emissions.[20]"

Question(s):

(a) Please provide a map showing the location and size of the potential CCS locations in Ontario.
(b) Please confirm that the two potential CCS locations in Ontario fall along the Canada-US border.
(c) Would use of the CCS locations in Ontario require an agreement or permit(s) from the United States federal government or a state government in light of the fact that the reservoir crosses the international border?
(d) Please provide the cost of CCS in Ontario ($/tCO2e) assumed in the Guidehouse report, the basis for that estimate, identify the CCS projects that serve as the basis for that cost estimate, and describe those CCS projects (e.g. the geologic formation they are in). Please break down the cost into the cost of capturing the $CO_2$ and sequestering it.
(e) Do the two potential CCS locations in Ontario raise additional challenges (e.g. being under lakes) that may raise costs in comparison to the CCS projects that served as the basis for Guidehoues' estimate of the costs of CCS in Ontario?

**Interrogatory # 1.10-ED-39**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 20

Preamble:

> "Prior studies have assessed CCS options in Ontario and have determined that the only sequestration option is geological sequestration in saline aquifers. Carbon dioxide is expected to be stored in these aquifers for long periods, from one hundred years to several thousand years depending on the size, properties, and location of the reservoir. Prior studies identified two different major reservoirs appropriate for CCS in southwestern Ontario: one located in the southern part of Lake Huron and the other located inside Lake Erie. These sites have approximate storage capacities of 289 million and 442 million tonnes of $CO_2$ emissions.[21]"

Question(s):

(a) Please confirm that "[s]ignificant uncertainties are associated with the reservoir capacity calculation" underlying the approximate storage capacities of 289 million and 442

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[20] Shafeen, Ahmed & Croiset, Eric & Douglas, Peter & Chatzis, Ioannis. (2004). CO2 sequestration in Ontario, Canada. Part I: Storage evaluation of potential reservoirs. Energy Conversion and Management. 45. 2645-2659. Available: http://dx.doi.org/10.1016/j.enconman.2003.12.003

[21] Shafeen, Ahmed & Croiset, Eric & Douglas, Peter & Chatzis, Ioannis. (2004). CO2 sequestration in Ontario, Canada. Part I: Storage evaluation of potential reservoirs. Energy Conversion and Management. 45. 2645-2659. Available: http://dx.doi.org/10.1016/j.enconman.2003.12.003

million tonnes of $CO_2$ emissions cited in the Guidehouse report.[22]

(b) Please confirm that there is a "lack of scientifically sound data to predict a true porosity and permeability" for the formation containing the two potential CSS cites in Ontario."[23]

(c) Please confirm that "one of the major concerns for sequestration is leakage to the atmosphere" and that "occur through abandoned wells" and that:

> "A large number of abandoned and unknown oil wells are present in southwestern Ontario whose status is not well documented. These have been abandoned for the past 20–90 years. There are no updated reports available about the status of cement plugging and its strength. Moreover, the quality and quantity of cement used in the early years might have severely degraded by this time. The reactivity of the injected $CO_2$ (or mixture of gas) with this cement and its consequences needs to be evaluated. Many of these wells ( 2500) have no plug end date, which raises questions about their present situation."[24]

(d) Please confirm that "[a] detailed investigation is necessary to determine the real status of these wells, their ability to withstand the sequestration pressure and impact on the environment in case of a failure."[25] Please confirm whether Guidehouse included the cost of this investigation in its report.

(e) Please confirm that "[u]ncertainties in the reservoir condition during the injection process could lead to an unexpected work load associated with huge cost involvement."[26]

(f) Please estimate the "huge cost involvement" described in the above passage from the report cited by Guidehouse. Is this possibility accounted for in the Guidehouse report.

(g) Please file a copy of the report in the footnote to the above passage from the Guidehouse report so it can be referred to with an exhibit number.[27] If it is proprietary, please file a copy on a confidential basis.

(h) The quote from the Guidehouse report refers to sequestration for "one hundred years to several thousand years." What are the factors that would determine whether the actual amount would be nearer to the top or the bottom of that scale.

**Interrogatory # 1.10-ED-40**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 26

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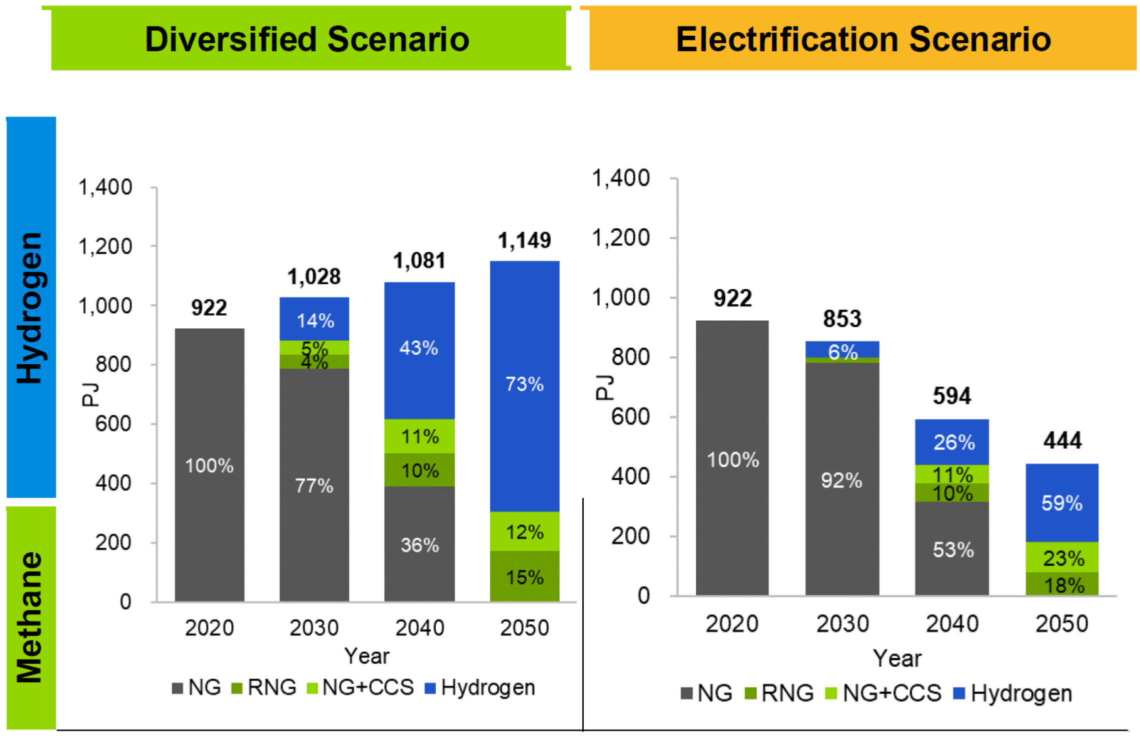
[22] *Ibid*. p. 2655.
[23] *Ibid*., p. 2649
[24] *Ibid*., p 2653.
[25] *Ibid*., p. 2654.
[26] *Ibid*. p. 2655
[27] *Ibid*.

Preamble:




Question(s):

(a) Please complete the following table. Please provide a response on a best-efforts basis, making assumptions and stating caveats as necessary. Please provide all underlying sources, calculations, and assumptions. Please provide two copies – one in m3/yr and one in PJ/yr.

| **Consumption of Gaseous Fuels by Scenario and Year** | | | | | |
|---|---|---|---|---|---|
| | 2024 | 2025 | 2026 | 2027 | 2028 |
| *Diversified scenario* | | | | | |
| Fossil gas | | | | | |
| Renewable natural gas | | | | | |
| Fossil gas with CCS | | | | | |
| Hydrogen derived from fossil gas (i.e. blue) | | | | | |
| Hydrogen derived from electrolysis (i.e. green) | | | | | |
| *Electrification scenario* | | | | | |
| Fossil gas | | | | | |
| Renewable natural gas | | | | | |
| Fossil gas with CCS | | | | | |
| Hydrogen derived from fossil gas (i.e. blue) | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Hydrogen derived from electrolysis (i.e. green) | | | | | |

(b) Please complete the following table. Please provide a response on a best-efforts basis, making assumptions and stating caveats as necessary. Please provide all underlying sources, calculations, and assumptions. Please provide two copies – one in m3/yr and one in PJ/yr.

| **Consumption of Gaseous Fuels by Scenario and Decade** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| *Diversified scenario* | | | | |
| Fossil gas | | | | |
| Renewable natural gas | | | | |
| Fossil gas with CCS | | | | |
| Hydrogen derived from fossil gas (i.e. blue) | | | | |
| Hydrogen derived from electrolysis (i.e. green) | | | | |
| *Electrification scenario* | | | | |
| Fossil gas | | | | |
| Renewable natural gas | | | | |
| Fossil gas with CCS | | | | |
| Hydrogen derived from fossil gas (i.e. blue) | | | | |
| Hydrogen derived from electrolysis (i.e. green) | | | | |

(c) This question is for Enbridge: Please complete the following table. Please provide a response on a best-efforts basis, making assumptions and stating caveats as necessary. Please provide all underlying sources, calculations, and assumptions. Please provide two copies – one in m3/yr and one in PJ/y.

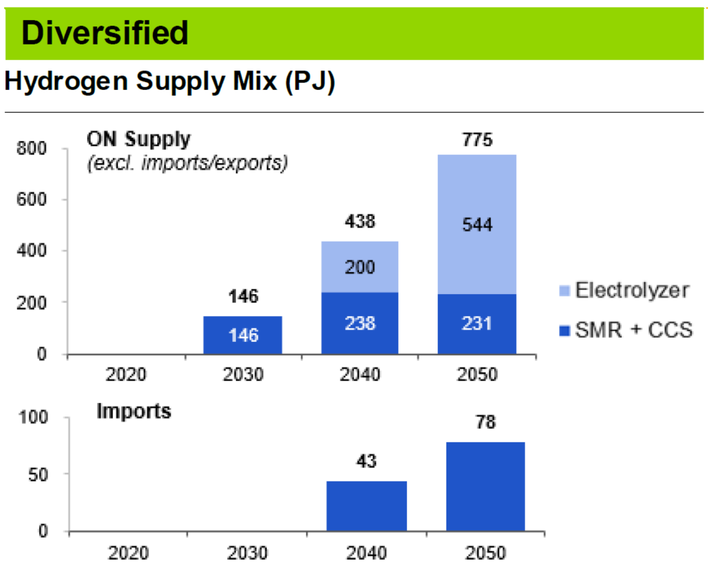
| **Forecast Consumption of Gaseous Fuels per Enbridge Application** | | | | | |
|---|---|---|---|---|---|
| | 2024 | 2025 | 2026 | 2027 | 2028 |
| Fossil gas | | | | | |
| Renewable natural gas | | | | | |
| Fossil gas with CCS | | | | | |
| Hydrogen derived from fossil gas (i.e. blue) | | | | | |
| Hydrogen derived from electrolysis (i.e. green) | | | | | |

**Interrogatory # 1.10-ED-41**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 40; CSA Statement on Hydrogen Blending

Preamble:

The following figure appears at page 40 of the Guidehouse report.




The Canadian Standards Organization Statement on Hydrogen Blending reads as follows:

> Use of hydrogen and natural gas mixtures in products certified for natural gas in Canada and the US
>
> It has come to our attention that some natural gas utilities in North America have begun to blend, or are planning to blend, hydrogen with natural gas for residential and industrial applications. In the interest of public safety, we are compelled to remind our customers and other stakeholders of the following:
>
> - At present, there are no accepted standards in Canada or the US for fuel burning products using mixtures of natural gas and hydrogen, for either residential or industrial applications
> - In the absence of accepted standards, CSA Group does not currently offer certification programs for products and appliances that burn a mixture of natural gas and hydrogen
> - CSA Group's current certification programs only apply to products that burn natural gas in accordance with existing accepted standards
> - CSA certification of a product is void when it is used outside the parameters of the applicable standards – which would include the use of fuels other than natural gas, such as a mixture of natural gas and hydrogen

> CSA Group has been following developments related to the potential use of hydrogen and hydrogen fuel blends in fuel-burning products for many years, and we are currently involved in several research initiatives to study these alternative fuels and their implications. Technical committees within our standards development organization are evaluating potential amendments of the current fuel burning standards to include hydrogen and natural gas mixtures. This evaluation is ongoing and involves a thorough review of supporting evidence.
>
> Research and testing are vital to ensuring that any modifications to the current standards for fuel-burning appliances achieve their core purpose – enabling the safe deployment of products in society. While we are excited by the potential role hydrogen could play in reducing carbon emissions, we feel it is vital that the necessary research and standards development take place before hydrogen-blended fuels are used in products certified solely for natural gas.
>
> It is our hope that, until appropriate standards and certification programs are in place, gas utilities and other suppliers of natural gas will abstain from blending hydrogen with natural gas for use with products only certified for natural gas. We urge utilities, regulatory authorities, certification bodies, and manufacturers of gas appliances to work together to ensure that the use of any mixture of hydrogen and natural gas in natural gas products take place *only after the ongoing research is complete, the standards are amended, and products can be certified to the amended standards.*[28]

Question(s):

(a) The CSA states as follows: "CSA certification of a product is void when it is used outside the parameters of the applicable standards – which would include the use of fuels other than natural gas, such as a mixture of natural gas and hydrogen." Does Enbridge agree? If not, please explain.
(b) In light of the above, please confirm that the CSA certification of the gas equipment in all homes served by Enbridge's hydrogen blending project is void. If not, please explain.
(c) Is Enbridge offering compensation to customers whose gas equipment no longer has valid CSA certification due to Enbridge's hydrogen blending pilot? If not, why not?
(d) The CSA states as follows: "We urge utilities, regulatory authorities, certification bodies, and manufacturers of gas appliances to work together to ensure that the use of any mixture of hydrogen and natural gas in natural gas products take place *only after the ongoing research is complete, the standards are amended, and products can be certified to the amended standards.*" Will Enbridge abide by this request from the CSA? If not, why not?
(e) When did Enbridge first become aware of this CSA statement?
(f) When Enbridge first became aware of this CSA statement, did it consider halting its hydrogen blending pilot, for example, on the basis that it would be voiding the CSA certification of its customers' gas equipment?

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[28] https://www.csagroup.org/article/use-of-hydrogen-and-natural-gas-mixtures-in-products-certified-for-natural-gas-in-canada-and-the-us/

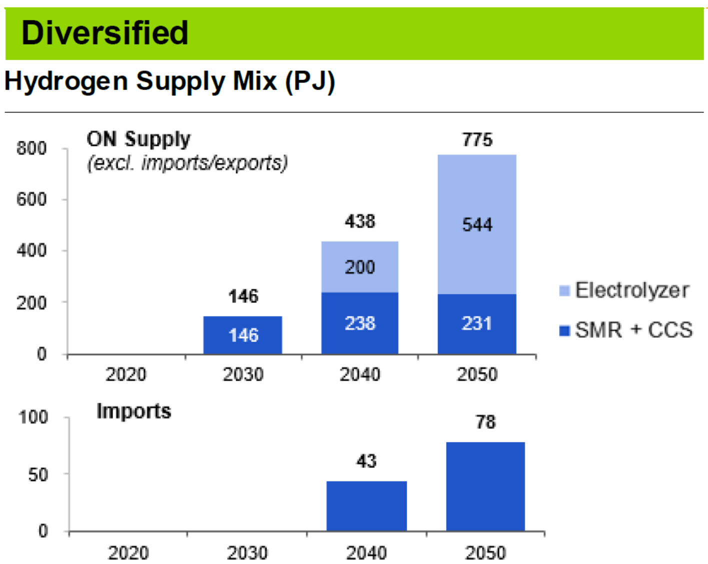
(g) What are the consequences for a consumer with gas equipment that without valid CSA certification?

**Interrogatory # 1.10-ED-42**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 40

Preamble:

The following figure appears at page 40 of the Guidehouse report.




Question(s):

(a) Please complete the following table with details regarding the use of hydrogen under the two scenarios:

| **Hydrogen Consumption by Scenario** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| *Diversified scenario* | | | | |
| Hydrogen consumption (m3/yr) | | | | |
| Hydrogen consumption at 100% H2 concentration (m3/yr) | | | | |
| Hydrogen consumption in a hydrogen/methane blend (m3/yr) | | | | |
| Maximum hydrogen concentration (%, by volume) | | | | |
| Maximum hydrogen concentration (%, by energy value) | | | | |
| *Electrification scenario* | | | | |

| | | | | |
|---|---|---|---|---|
| Hydrogen consumption (m3/yr) | | | | |
| Hydrogen consumption at 100% H2 concentration (m3/yr) | | | | |
| Hydrogen consumption in a hydrogen/methane blend (m3/yr) | | | | |
| Maximum hydrogen concentration (%, by volume) | | | | |
| Maximum hydrogen concentration (%, by energy value) | | | | |

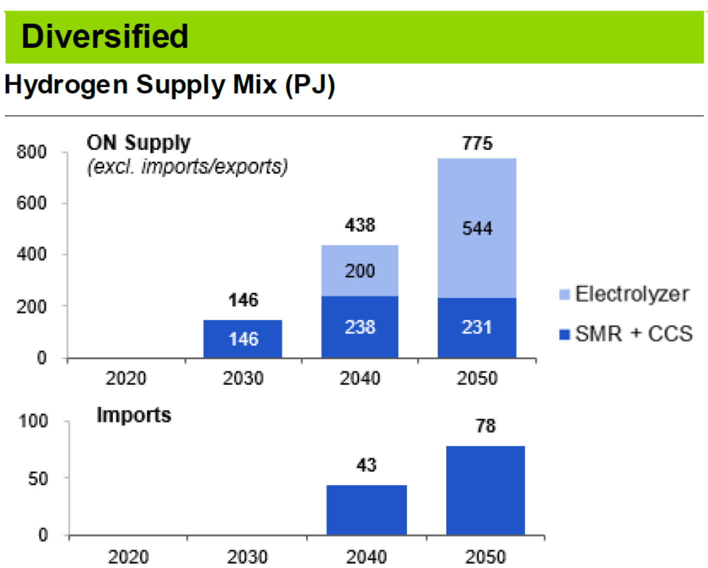
(b) Please provide a copy of the above table with the m3/yr figures replaced by PJ/yr.

**Interrogatory # 1.10-ED-43**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 40

Preamble:

The following figure appears at page 40 of the Guidehouse report.




Question(s):

(a) What percentage of hydrogen blending has been confirmed to be safe? Please explain and provide references. Please provide the response both in terms of percent by volume and percent by energy value.
(b) The California Public Utilities Commission concluded as follows:

"Relative to injecting and blending hydrogen into the natural gas pipeline, leaks and losses of hydrogen gas are two important considerations. Leaks are of high importance for safety reasons particularly in confined spaces, while losses are more relevant to storage and economics. Leaks in the distribution natural gas system, comprised of plastic pipelines are expected to occur primarily by hydrogen permeation, while the majority of leaks in the transmission system and distribution system comprised of metal pipelines are expected to occur through cracks, joints, seals, or threads [2]. The findings of the experimental work conducted by this project on controlled leaks through orifices, suggest that volumetric gas blend leak flow rate increases with increase in concentration of hydrogen gas in the blend …

Based on a recently published report, there is literature available for the lower blending percentage (1-2% per volume). Beyond 2%, the literature starts to show gaps in areas such as 'inspection and maintenance' and 'underground gas storage'."[29]

Does Guidehouse agree that the safety of hydrogen blending at percentages beyond 2% has not yet been conclusively established due to remaining gaps in the literature?

(c) The California Public Utilities Commission concluded as follows:

> Under the assumption of viscous turbulent flow for gas leaks in the natural gas pipeline system, originating from joints, threads, cracks, and pinhole defects, gas blends of hydrogen and methane would leak at a higher volumetric flow rates compared to pure methane, under the same conditions. The increase of flow rate is inversely proportional to the square root of the specific gravity of the hydrogen/methane gas blend. Thus for a gas blend containing 10% hydrogen the expected increase in flow rate is 5% compared to pure methane, while for 20% hydrogen gas blend the increase in leak flow rate is 10%.[30]

Does Guidehouse or Enbridge have any reason to disagree with that conclusion?

(d) The California Public Utilities Commission concluded as follows:

> The lower energy content of hydrogen gas compared to methane, means that a volume of hydrogen more than three times that of methane is necessary to deliver the same amount of energy. Therefore, without any changes in the natural gas transmission and distribution pipeline system, larger operating pressures may be required with hydrogen- methane gas blends to deliver the same amount of energy comparable to pure methane. Increasing operating pressure would result in increased leak flow rates. Thus any changes to operating gas pressure should consider gas leak rates, among other factors, such as integrity of the system.[31]

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[29] The California Public Utilities Commission, Final Report, *Hydrogen Blending Impacts Study*, Prepared by: University of California, Riverside, July 18, 2022, p. 107 (link).
[30] The California Public Utilities Commission, Final Report, *Hydrogen Blending Impacts Study*, Prepared by: University of California, Riverside, July 18, 2022, p. 37 (link).
[31] The California Public Utilities Commission, Final Report, *Hydrogen Blending Impacts Study*, Prepared by: University of California, Riverside, July 18, 2022, p. 37 (link).

Does Guidehouse or Enbridge have any reason to disagree with that conclusion?

(e) The California Public Utilities Commission concluded as follows:

> Hydrogen gas has significantly broader flammability range, much lower ignition energy, and higher flame velocity compared to natural gas.[32]

Do Guidehouse and Enbridge agree? If not, why not.

(f) Please provide a table comparing the flammability range, ignition energy, and flame velocity of hydrogen and methane.

**Interrogatory # 1.10-ED-44**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 43

Preamble:

These questions relate to the costing of the scenarios.

Question(s):

(a) Please complete the following tables with the average and marginal cost assumptions underlying Guidehouse's analysis of the two scenarios:

| **Commodity, Transmission, and Distribution Cost Assumptions – Diversified Scenario** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| Electricity – Average Cost | | | | |
| Energy cost ($/MWh) | | | | |
| Capacity cost ($/MW) | | | | |
| Transmission & distribution ($/MW) | | | | |
| Electricity – Marginal Cost | | | | |
| Energy ($/MWh) | | | | |
| Capacity ($/MW) | | | | |
| Transmission & distribution ($/MW) | | | | |
| Fossil gas – Average Cost | | | | |
| Commodity ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Fossil gas – Marginal Cost | | | | |
| Commodity ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Fossil gas with CCS – Average Cost | | | | |
| Commodity ($/PJ) | | | | |

[32] The California Public Utilities Commission, Final Report, *Hydrogen Blending Impacts Study*, Prepared by: University of California, Riverside, July 18, 2022, p. 37 (link).

| | | | | |
|---|---|---|---|---|
| CCS process ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Fossil gas with CCS – Marginal Cost | | | | |
| Commodity ($/PJ) | | | | |
| CCS process ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| RNG – Average Cost | | | | |
| Commodity ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| RNG – Marginal Cost | | | | |
| Commodity ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Green Hydrogen – Average Cost | | | | |
| Commodity ($/PJ)[33] | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Green Hydrogen – Marginal Cost | | | | |
| Commodity ($/PJ) [34] | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Blue Hydrogen – Average Cost | | | | |
| Commodity ($/PJ)[35] | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Blue Hydrogen – Marginal Cost | | | | |
| Commodity ($/PJ) [36] | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |

| **Commodity, Transmission, and Distribution Cost Assumptions – Electrified Scenario** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| Electricity – Average Cost | | | | |
| Energy cost ($/MWh) | | | | |
| Capacity cost ($/MW) | | | | |
| Transmission & distribution ($/MW) | | | | |
| Electricity – Marginal Cost | | | | |
| Energy ($/MWh) | | | | |
| Capacity ($/MW) | | | | |
| Transmission & distribution ($/MW) | | | | |
| Fossil gas – Average Cost | | | | |

[33] Including the electrolysis process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.
[34] Including the electrolysis process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.
[35] Including the SMR process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.
[36] Including the SMR process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.

| | | | | |
|---|---|---|---|---|
| Commodity ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Fossil gas – Marginal Cost | | | | |
| Commodity ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Fossil gas with CCS – Average Cost | | | | |
| Commodity ($/PJ) | | | | |
| CCS process ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Fossil gas with CCS – Marginal Cost | | | | |
| Commodity ($/PJ) | | | | |
| CCS process ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| RNG – Average Cost | | | | |
| Commodity ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| RNG – Marginal Cost | | | | |
| Commodity ($/PJ) | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Green Hydrogen – Average Cost | | | | |
| Commodity ($/PJ)[37] | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Green Hydrogen – Marginal Cost | | | | |
| Commodity ($/PJ) [38] | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Blue Hydrogen – Average Cost | | | | |
| Commodity ($/PJ)[39] | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |
| Blue Hydrogen – Marginal Cost | | | | |
| Commodity ($/PJ) [40] | | | | |
| Transmission & distribution ($/PJ/hr) | | | | |

(b) Please complete the following tables with the annualized costs in the two scenarios and provide the response in a live excel spreadsheet. If we have missed any energy-related cost categories, please add those. If a cost is not included in the scenarios (or is only partially included), please indicate so and provide a best estimate of the value.

| **Annualized Cost Figures – Diversified Scenario** |
|---|

[37] Including the electrolysis process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.
[38] Including the electrolysis process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.
[39] Including the SMR process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.
[40] Including the SMR process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.

| | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|
| Electricity | | | | |
| Annual energy demand (MWh) | | | | |
| Annual avg. energy price ($/MWh) | | | | |
| Annual energy cost ($) | | | | |
| Annual capacity demand (MW) | | | | |
| Capacity cost ($/MW, annualized) | | | | |
| Annual capacity cost ($) | | | | |
| Transmission & distribution cost ($/MW, annualized) | | | | |
| Annual transmission and distribution cost ($, annualized) | | | | |
| Annual electricity costs ($) | | | | |
| Fossil gas | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ) | | | | |
| Annual commodity cost ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual fossil gas costs ($) | | | | |
| Fossil gas with CCS | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ) | | | | |
| Annual commodity cost ($) | | | | |
| Annual avg. CCS costs ($/PJ) | | | | |
| Annual CCS costs ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual fossil gas with CCS costs ($) | | | | |
| RNG | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ) | | | | |
| Annual commodity cost ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual RNG costs ($) | | | | |

| | | | | |
|---|---|---|---|---|
| Green Hydrogen | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ) [41] | | | | |
| Annual commodity cost ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual green hydrogen costs ($) | | | | |
| Blue Hydrogen | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ)[42] | | | | |
| Annual commodity cost ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual blue hydrogen costs ($) | | | | |

| **Annualized Cost Figures – Electrified Scenario** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| Electricity | | | | |
| Annual energy demand (MWh) | | | | |
| Annual avg. energy price ($/MWh) | | | | |
| Annual energy cost ($) | | | | |
| Annual capacity demand (MW) | | | | |
| Capacity cost ($/MW, annualized) | | | | |
| Annual capacity cost ($) | | | | |
| Transmission & distribution cost ($/MW, annualized) | | | | |
| Annual transmission and distribution cost ($, annualized) | | | | |
| Annual electricity costs ($) | | | | |
| Fossil gas | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ) | | | | |
| Annual commodity cost ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |

41 Including the electrolysis process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.

42 Including the SMR process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.

| | | | | |
|---|---|---|---|---|
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual fossil gas costs ($) | | | | |
| Fossil gas with CCS | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ) | | | | |
| Annual commodity cost ($) | | | | |
| Annual avg. CCS costs ($/PJ) | | | | |
| Annual CCS costs ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual fossil gas with CCS costs ($) | | | | |
| RNG | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ) | | | | |
| Annual commodity cost ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual RNG costs ($) | | | | |
| Green Hydrogen | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ) [43] | | | | |
| Annual commodity cost ($) | | | | |
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual green hydrogen costs ($) | | | | |
| Blue Hydrogen | | | | |
| Annual demand (PJ) | | | | |
| Annual avg. commodity price ($/PJ)[44] | | | | |
| Annual commodity cost ($) | | | | |

[43] Including the electrolysis process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.
[44] Including the SMR process, CCS process, and transportation to Ontario if that is applicable and not included in the transmission and distribution row below.

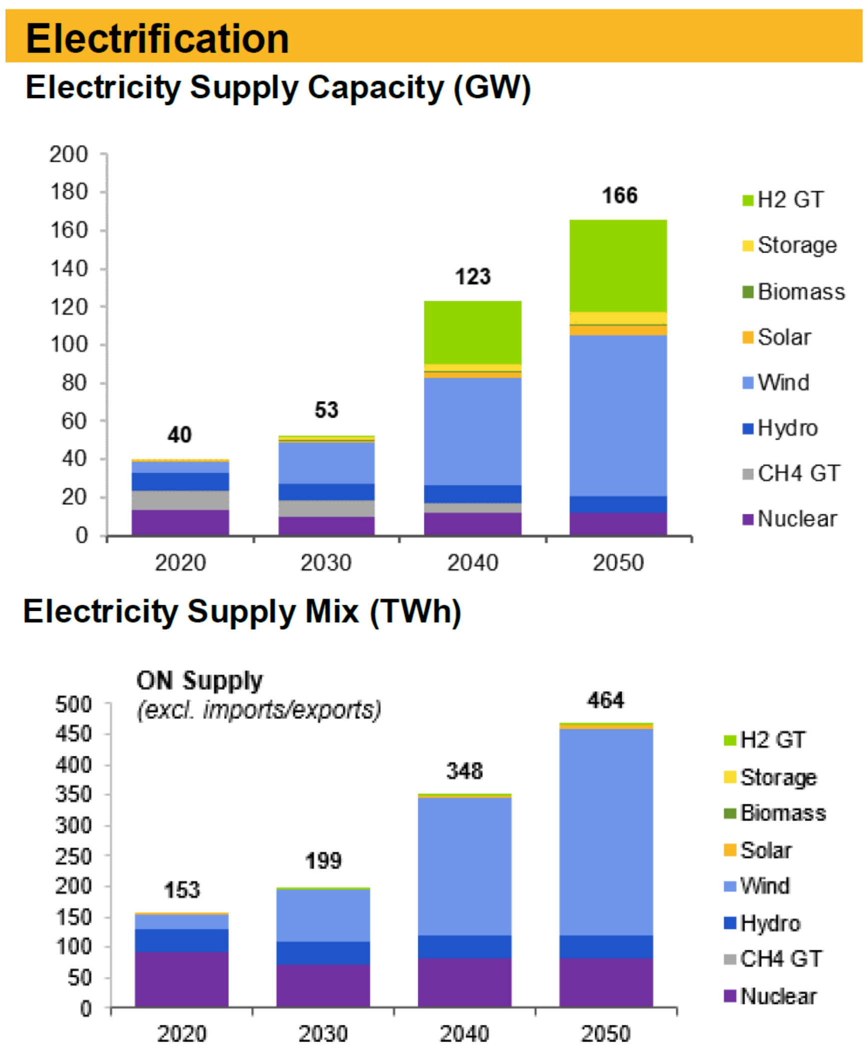
| | | | | |
|---|---|---|---|---|
| Annual capacity demand (PJ/hr) | | | | |
| Transmission & distribution cost ($/PJ/hr, annualized) | | | | |
| Annual transmission and distribution costs ($, annualized) | | | | |
| Annual blue hydrogen costs ($) | | | | |

(c) Please describe how each of the figures in (b) was derived, including any relevant sources.

**Interrogatory # 1.10-ED-45**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

Preamble:




Question(s):

(a) Please complete the following table detailing the cost of the electricity supply resources listed above. If they differ between each, please complete one table per scenario.

| Cost of Electricity Supply Resources | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| Resource 1 … n | | | | |
| LUEC ($/MWh) | | | | |
| Energy ($/MWh) | | | | |
| Capacity ($/MW, levelized) | | | | |
| … | | | | |

(b) Guidehouse includes a large amount of hydrogen generation capacity starting in 2040. Please explain this? Is that because Guidehouse assumes hydrogen generation to be cheaper than all other alternatives? If yes, please explain, including via a comparison with the cost of storage.

(c) Why did Guidehouse not include demand response as a resource?

**Interrogatory # 1.10-ED-46**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

Question:

(a) Please provide a table showing the potential energy and capacity from the following incremental non-emitting resources.

| Electricity Resource Potential – Energy and Capacity | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| Wind | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Solar (excl. rooftop) | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Solar (rooftop) | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Hydro | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Geothermal | | | | |

| | | | | |
|---|---|---|---|---|
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Grid-Scale Storage | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Storage – V2G/B | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Hydro imports from Quebec | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Energy efficiency | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |
| Demand response | | | | |
| Energy (MWh) | | | | |
| Capacity (MW) | | | | |

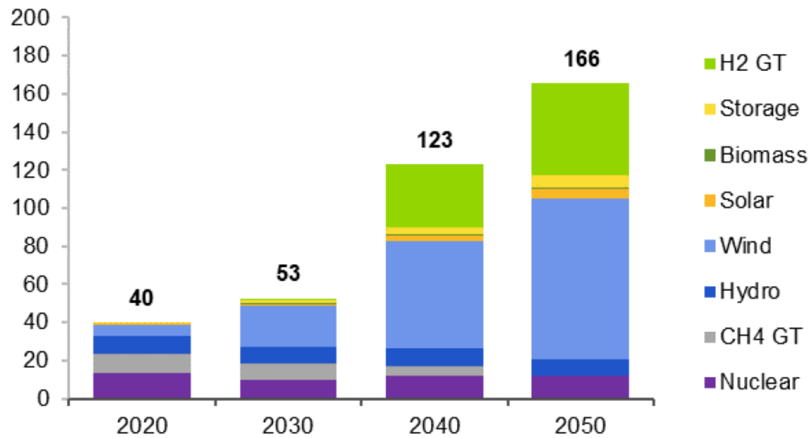
**Interrogatory # 1.10-ED-47**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

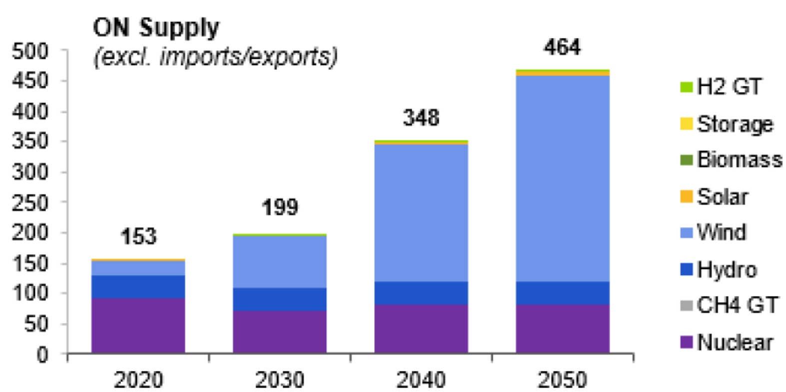
Preamble:

## Electrification

### Electricity Supply Capacity (GW)




### Electricity Supply Mix (TWh)




Question(s):

(a) How did Guidehouse determine the load factor for (i) all electricity consumption, (ii) EVs, and (iii) space heating, and (iv) water heating.

(b) Please complete the following table showing the forecast load factor for all electricity consumption:

| Electricity Load Factor | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| *Diversified* | | | | |
| Energy demand (MWh) | | | | |
| Capacity demand (MW) | | | | |
| Load factor | | | | |
| *Electrified* | | | | |
| Energy demand (MWh) | | | | |

| | | | | |
|---|---|---|---|---|
| Capacity demand (MW) | | | | |
| Load factor | | | | |

(c) Please complete the following table showing the load factor for EVs.

| **Electric Vehicle Load Factor** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| *Diversified* | | | | |
| Energy demand (MWh) | | | | |
| Demand at system peak (MW) | | | | |
| Load factor | | | | |
| *Electrified* | | | | |
| Energy demand (MWh) | | | | |
| Demand at system peak (MW) | | | | |
| Load factor | | | | |

(d) Please complete the following table showing the electric load factor for space and water heating.

| **Electric Load Factor for Space and Water Heating** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| *Diversified* | | | | |
| Energy demand (MWh) | | | | |
| Demand at system peak (MW) | | | | |
| Load factor | | | | |
| *Electrified* | | | | |
| Energy demand (MWh) | | | | |
| Demand at system peak (MW) | | | | |
| Load factor | | | | |

(e) If possible, please reproduce (g) with a breakdown between space and water heating. If that is not possible, please provide a rough estimate of the contribution of each (%) to the overall space and water heating load.

**Interrogatory # 1.10-ED-48**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

Preamble:

> These questions relate to Guidehouse's calcualtion of annual and peak electricity demand arising from space conditioning and water cooling in different scenarios.

Question(s):

(a) Please complete the following table regarding residential space and water heating equipment in each scenario. If we are missing different kinds of systems, please add those.

| Residential Space and Water Heating Equipment | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| **Number of customers** | | | | |
| *Diversified* | | | | |
| Fully electrified | | | | |
| Resistance | | | | |
| Heat pump | | | | |
| Hybrid | | | | |
| Gaseous only | | | | |
| Gas furnace | | | | |
| Gas heat pump | | | | |
| Other | | | | |
| *Electrified* | | | | |
| Fully electrified | | | | |
| Resistance | | | | |
| Heat pump | | | | |
| Hybrid | | | | |
| Gaseous only | | | | |
| Gas furnace | | | | |
| Gas heat pump | | | | |
| Other | | | | |
| **Percent of customers** | | | | |
| *Diversified* | | | | |
| Fully electrified | | | | |
| Resistance | | | | |
| Heat pump | | | | |
| Hybrid | | | | |
| Gaseous only | | | | |
| Gas furnace | | | | |

| | | | | |
|---|---|---|---|---|
| Gas heat pump | | | | |
| Other | | | | |
| *Electrified* | | | | |
| Fully electrified | | | | |
| Resistance | | | | |
| Heat pump | | | | |
| Hybrid | | | | |
| Gaseous only | | | | |
| Gas furnace | | | | |
| Gas heat pump | | | | |
| Other | | | | |
| Fully electrified | | | | |

(b) Please provide the following assumptions as used in Guidehouse's estimate of the impact of residential space and water heating options on electricity demand (both energy (kWh) and peak demand (kW)). Where no assumption was explicitly made, please provide the implied value based on the analysis inputs and outputs. If the numbers change over time, please provide those (at least with the granularity of each decade).

(i) Average home demand for space heating at the time of the electricity system peak hour (BTU or kW of heat);

(ii) Average home hot water demand at the time of the electricity system peak (BTU or kW);

(iii) Average or design day outdoor temperature at the time of the electricity system peak hour;

(iv) For the average home with fully electric heat pump space and water heating:

(A) Size of ASHP (BTU);

(B) Size of resistance backup (kW);

(C) Seasonal COP of ASHP (region 5):

(D) COP of ASHP at time of electricity system winter peak hour;

(E) HWHP COP;

(F) Contribution to electricity system winter peak hour for space/water heating without accounting for diversity / coincidence (kW);

(G) Coincidence factor for heating;

(H) Contribution to electricity system winter peak hour for space/water heating after accounting for diversity / coincidence (kW);

(I) Breakdown of contribution to winter peak hour by space and water heating, with and without accounting for coincidence/diversity;

(J) Annual electricity demand for heating (kWh);

(K) SEER of the ASHP for <u>cooling;</u>

(L) COP of ASHP cooling at time of electricity system <u>summer</u> peak hour;

(M) Coincidence factor for cooling;

(N) Contribution to electricity system summer peak hour with and without accounting for coincidence / diversity(kW);

(O) Annual electricity demand for cooling (kWh);

(v) For the average home with a hybrid system;
   (A) Size of ASHP (BTU);
   (B) Seasonal COP of ASHP (region 5):
   (C) COP of ASHP at time of electricity system winter peak hour;
   (D) HWHP COP;
   (E) Contribution to electricity system winter peak hour for space/water heating without accounting for diversity / coincidence (kW);
   (F) Coincidence factor for heating;
   (G) Contribution to electricity system winter peak hour for space/water heating after accounting for diversity / coincidence (kW);
   (H) Breakdown of contribution to winter peak hour by space and water heating, with and without accounting for coincidence/diversity;
   (I) Annual electricity demand for heating (kWh);
   (J) SEER of the ASHP for cooling;
   (K) COP of ASHP cooling at time of electricity system summer peak hour;
   (L) Coincidence factor for cooling;
   (M) Contribution to electricity system summer peak hour with and without accounting for coincidence / diversity(kW);
   (N) Annual electricity demand for cooling (kWh);

(vi)For the average home with gaseous only heating:
   (A) Size of GHP (BTU);
   (B) Seasonal COP of GHP (region 5):
   (C) COP of GHP at time of electricity system winter peak hour;
   (D) Contribution to electricity system winter peak hour for space/water heating without accounting for diversity / coincidence (kW);
   (E) Coincidence factor for heating;
   (F) Contribution to electricity system winter peak hour for space/water heating after accounting for diversity / coincidence (kW);
   (G) Annual electricity demand for heating (kWh);
   (H) SEER of the air conditioner for cooling;
   (I) Coincidence factor for cooling;
   (J) Contribution to electricity system summer peak hour with and without accounting for coincidence / diversity(kW);
   (K) Annual electricity demand for cooling (kWh);

(c) Please provide all details, calculations, assumptions, and spreadsheets used by Guidehouse to calculate the annual and peak annual electricity demand from residential space and water heating.

(d) To calculate the peak hour electricity demand from ASHPs, what temperature(s) did Guidehouse assume for planning/design purposes? Please provide all details and explain the choices made.

(e) What temperature(s) at the time of the electricity system peak hour does the IESO use when planning for electricity capacity adequacy?

(f) When Guidehouse calculated the impact of ASHPs on the peak and annual electricity demand, did it net out the existing electricity demand from the blower and control systems for a conventional gas heating system? Please explain the choices made.

(g) When Guidehouse calculated the impact of ASHPs on the peak and annual electricity demand, did it account for the fact that ASHPs typically reduce a building's summer peak electricity draw through more efficient cooling than traditional air conditioning systems?
(h) Please provide a table with a breakdown between air and ground source heat pumps in each scenario for each decade.

**Interrogatory # 1.10-ED-49**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

Preamble:

> These questions relate to Guidehouse's calcualtion of annual and peak electricity demand arising from space conditioning and water cooling in different scenarios.

Question(s):

(a) Please provide a table comparing Guidehouse's inputs and outputs regarding the annual and peak electricity demand arising from a switch to ASHPs with the inputs in the New England ISO's 2022 Analysis found here: https://www.iso-ne.com/static-assets/documents/2022/04/final_2022_heat_elec_forecast.pdf. Note in particular page 26, which suggests a net contribution of approximately 5 kW, not accounting for diversity / coincidence factors.
(b) With respect to the regions used for calculating heat pump performance (HSPF & seasonal COP, sCOP), does Guidehouse agree with NRCan that "region 5 would cover most of the southern half of the provinces in Canada" and that "region 5 HSPF is most reflective of heat pump performance in the Ottawa region."[45]

**Interrogatory # 1.10-ED-50**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

Preamble:

> These questions relate to Guidehouse's calcualtion of annual and peak electricity demand arising from space conditioning and water cooling in different scenarios and the assuming efficiencies and forecast future efficiencies of heating equipment.

Question(s):

(a) Please complete the following table containing assumptions in Guidehouse's analysis (explicit or implied) regarding technology improvements relating to home heating and cooling. If these assumptions differ between the scenarios, please provide a copy of this table for each scenario.

[45] Heating and Cooling With a Heat Pump, https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817

| Guidehouse Forecasts re Heating Technology Improvements | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| ***Air source heat pump*** | | | | |
| Seasonal COP (#) | | | | |
| COP at time electricity system coincident winter peak (#) | | | | |
| Electricity demand at time of electricity system coincident winter peak (kW)[46] | | | | |
| SEER at the time of electricity system coincident peak (kW) | | | | |
| Equipment cost | | | | |
| ***Electric heat pump water heater*** | | | | |
| Seasonal COP (#) | | | | |
| COP at time electricity system coincident winter peak (#) | | | | |
| Electricity demand at time of electricity system coincident winter peak (kW)[47] | | | | |
| SEER at the time of electricity system coincident peak (kW) | | | | |
| Equipment Cost | | | | |
| ***Gas heat pump*** | | | | |
| Seasonal COP (#) | | | | |
| COP at time electricity system coincident winter peak (#) | | | | |
| Electricity demand at time of electricity system coincident winter peak (kW)[48] | | | | |
| SEER at the time of electricity system coincident peak (kW) | | | | |
| Equipment Cost | | | | |
| ***CCS for blue hydrogen*** | | | | |
| Capture rate (%) | | | | |
| CCS cost ($/PJ) | | | | |
| ***Electrolyser for green hydrogen*** | | | | |
| Cost ($/PJ) | | | | |

[46] Please account for diversity / coincidence and include the total load, including the resistance heating.
[47] Please account for diversity / coincidence and include the total load, including the resistance heating.
[48] This would include the circulation fans, outdoor unit, controls, etc. Please account for diversity / coincidence and include the total load, including the resistance heating.

(b) With respect to the regions used for calculating heat pump performance (HSPF & seasonal COP, sCOP), does Guidehouse agree with NRCan that "region 5 would cover most of the southern half of the provinces in Canada" and that "region 5 HSPF is most reflective of heat pump performance in the Ottawa region."[49]
(c) What are the three most efficient centrally-ducted cold climate air source heat pumps currently available in the North American market with 3-ton capacity? Please complete the following table. (We are seeking this, in part, to compare the best current units with Guidehouse's forecast of future standard efficiency levels.) If Guidehouse uses a source other than NEEP, please explain why.

| **Most Efficient Cold Climate Air Source Heat Pumps (Three Ton, Centrally Ducted, North American Market Available)** | | | | | |
|---|---|---|---|---|---|
| | HSPF (IV) | HSPF (V) | sCOP (V) | COP (-25 °C)[50] | Capacity (BTU, -25 °C)[51] |
| Unit 1 | | | | | |
| Unit 2 | | | | | |
| Unit 3 | | | | | |

(d) What are the three most efficient centrally-ducted gas heat pumps currently available in the North American market with 3-ton capacity? Please complete the following table. (We are seeking this, in part, to compare the best current units with Guidehouse's forecast of future standard efficiency levels.

| **Most Efficient Gas Heat Pumps (Three Ton, Centrally Ducted, North American Market Available)** | | | | | |
|---|---|---|---|---|---|
| | HSPF (IV) | HSPF (V) | sCOP (V) | COP (-25 °C)[52] | Capacity (BTU, -25 °C)[53] |
| Unit 1 | | | | | |
| Unit 2 | | | | | |
| Unit 3 | | | | | |

(e) Please provide a table detailing the improvements in overall efficiency (sCOP), cold climate efficiency, and cold climate capacity of heat pumps since 2000.
(i) ISO New England believes that "ASHP technologies deployed in the coming years are expected to improve in terms of their overall coefficient of performance (COP)."[54] Does Guidehouse agree?
(j) What is the maximum theoretical COP for an ASHP?

**Interrogatory # 1.10-ED-51**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

[49] Heating and Cooling With a Heat Pump, https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817
[50] If this precise figure is not available, please provide the COP at the lowest rated temperature.
[51]
[52] If this precise figure is not available, please provide the COP at the lowest rated temperature.
[53]
[54]

Question(s):

Please provide the following figures:

(a) Did Guidehouse analyze the capacity of electric thermal storage units to cost-effectively reduce the coincident peak demand of fully-electrified heating systems? If not, why not? If yes, please provide that analysis.
(b) Please confirm that there are electric thermal storage units available in Ontario (e.g. those from SSi Energy, Stash, and Steffes).[55]
(c) If all heating in homes were to be fully electrified through heat pumps, what would the aggregate co-incident winter peak demand from the heat pumps be (i) without electric thermal storage and (ii) with electric thermal storage?
(d) Why did Guidehouse model a 55% penetration rate for gas heat pumps by 2050 but zero penetration for electric thermal storage, even though gas heat pumps are not currently available in the Ontario market (according to Enbridge in its recent DSM proceeding) whereas electric thermal storage units are?

**Interrogatory # 1.10-ED-52**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

Question(s):

Please provide the following figures:

(a) Annual energy consumption (kWh) from the IESO-controlled grid of an air-source heat pump;
(b) An air-source heat pump's kW demand from the IESO-controlled at the time of the IESO-controlled grid's peak winter demand hour;
(c) Annual energy consumption (kWh) from the IESO-controlled grid of a ground-source heat pump;
(d) A ground-source heat pump's kW demand from the IESO-controlled at the time of the IESO-controlled grid's peak winter demand hour;
(e) Time of day of IESO-controlled grid's peak winter demand hour;
(f) Outside temperature at time of the IESO-controlled grid's peak winter demand hour;
(g) Coincidence demand factor of air-source heat pumps at time of IESO-controlled grid's peak winter demand hour; and
(h) Coincidence demand factor of ground-source heat pumps at time of IESO-controlled grid's peak winter demand hour.

**Interrogatory # 1.10-ED-53**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

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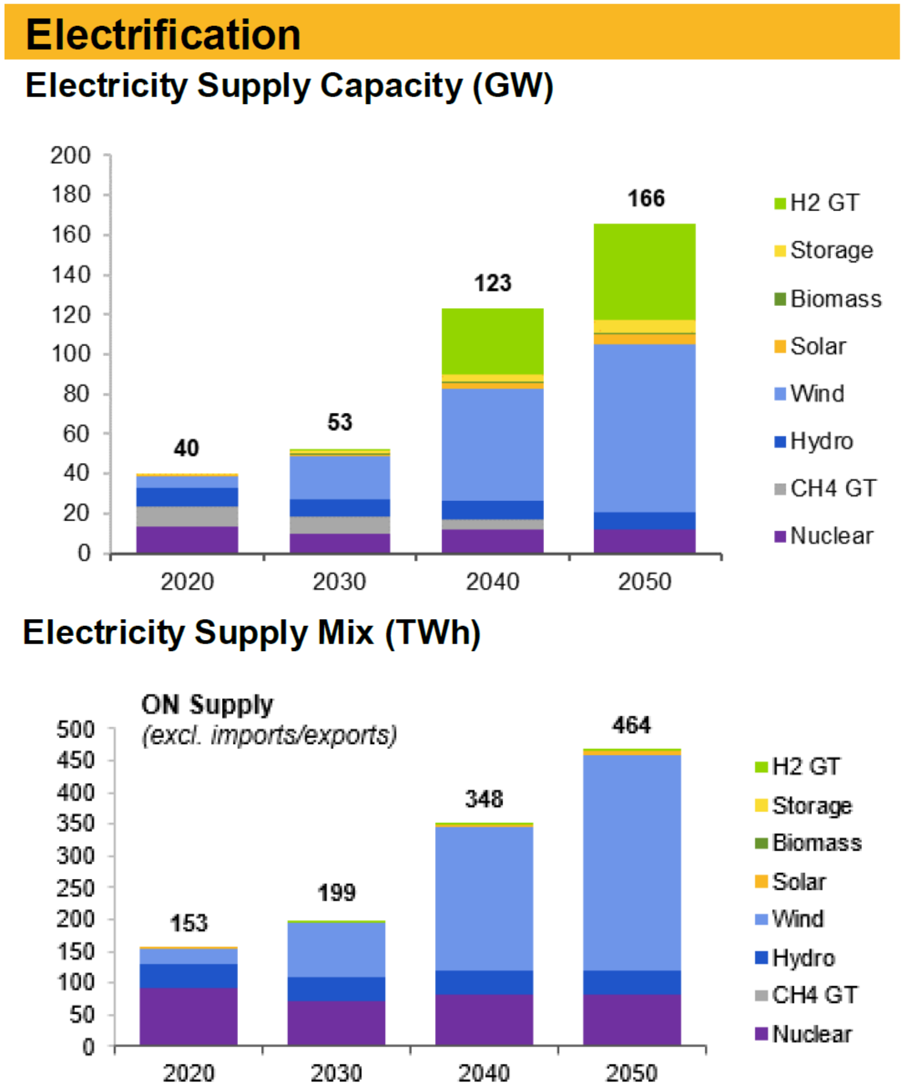
[55] See https://www.ssie.ca/products/, https://stash.energy/en/product/, and https://www.steffes.com/ets/comfort-plus-forced-air/.

Preamble:




Question(s):

(a) Please provide a table comparing Guidehouse's estimates of the cost of storage capacity with the cost of capacity from vehicle-to-grid/building technology based on the IESO's DER Potential Study:
(b) Please provide the cost-effective potential from vehicle-to-grid/building technology in 2020, 2030, 2040, and 2050 based on extrapolation from the IESO's DER Potential Study.
(c) Approximately many vehicles are there in Ontario?[56] What is the *technical* potential for vehicle-to-grid/building technology by 2040 based on the number of vehicles in Ontario,

[56] We suggest this source: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310006701&pickMembers%5B0%5D=1.7&cubeTimeFrame.startYear=2015&cubeTimeFrame.endYear=2019&referencePeriods=20150101,20190101

an appropriate average battery size (e.g. 75 kWhs), and an estimate of the percent of vehicles that are electrified by 2040 (e.g. 90%)?

(d) Please provide a table comparing Guidehouse's estimate of the average and marginal cost of zero-emitting resources with the average and marginal cost of the zero-emitting resources outlined in the IESO's DER Potential Study:

(e) Please provide the cost-effective potential from DERs in 2020, 2030, 2040, and 2050 based on extrapolation from the IESO's DER Potential Study.

**Interrogatory # 1.10-ED-54**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 36

Preamble:

Question(s):

(a) Please complete the following table comparing the Guidehouse forecasts for the price of hydrogen power generation versus storage:

| **Guidehouse Cost Forecasts Regarding Peak Power Resources – Storage vs. Hydrogen** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| ***Hydrogen power generation – blue hydrogen*** | | | | |
| Capacity ($/MW, levelized) | | | | |
| Energy ($/MWh) | | | | |
| ***Hydrogen power generation – green hydrogen*** | | | | |
| Capacity ($/MW, levelized) | | | | |
| Energy ($/MWh) | | | | |
| Efficiency (%)[57] | | | | |
| ***Grid-scale battery storage*** | | | | |
| Capacity ($/MW, levelized) | | | | |
| Energy ($/MWh) | | | | |
| Efficiency (%)[58] | | | | |

**Interrogatory # 1.10-ED-55**

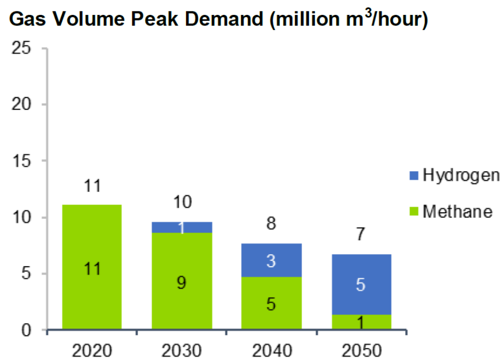
Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 38

Preamble:

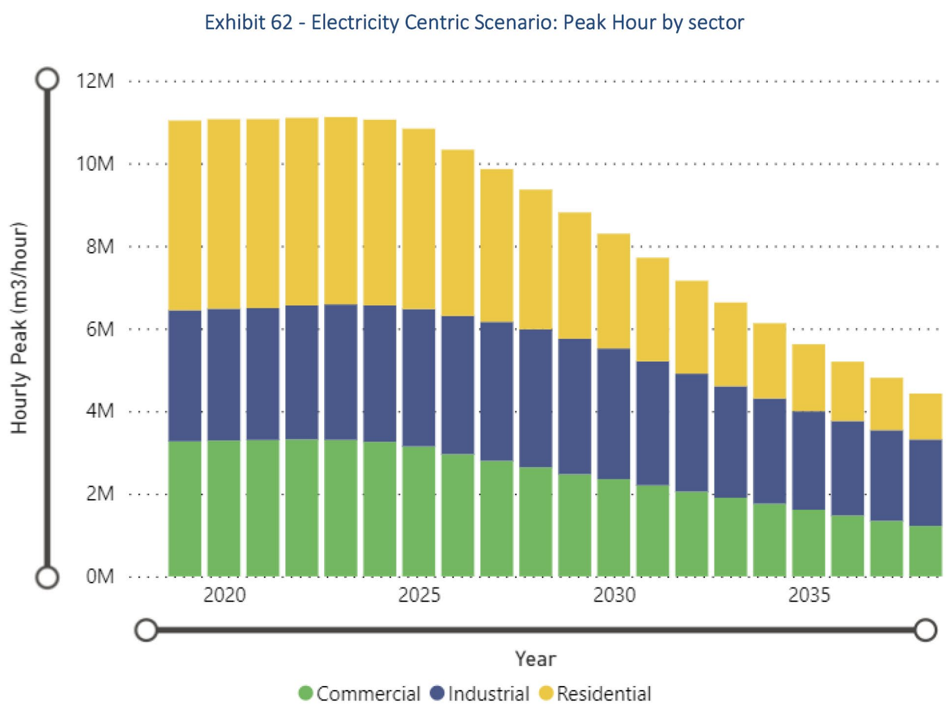
[57] Efficiency is [power input into the electrolyser]/[power generated from the resulting hydrogen], accounting for all losses involved in the electrolysis, storage, transportation, and power generation steps.

[58] Efficiency is [power input into the battery]/[power drawn from the battery], accounting for all losses involved therein.

Electrification scenario peak demand per page 38 of the Guidehouse report:




Electrification scenario peak demand per the Posterity Group report at Exhibit 1, Tab 10, Schedule 5, Attachment 1, Page 72:




Question(s):

(a) Please provide a table reconciling the above figures. If necessary, please communicate with the Posterity Group to obtain the underlying data. Please explain any differenes.

**Interrogatory # 1.10-ED-56**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. B-1

Preamble:

> "This study expands on previous energy transition scenario analysis (ETSA) done by Enbridge Gas that forecasts gas demand from 2020 to 2038. More specifically, this study expands the Enbridge Gas forecasts from 2038 to 2050 and develops electricity demand scenarios that are internally aligned with the underlying assumptions of Enbridge Gas's gas forecasts. This section describes the forecasting methodology and presents the gas and electricity demand forecasts for the Diversified and Electrification scenarios. The Diversified and Electrification scenarios are intended to represent plausible, potential future visions of the Ontario energy system by 2050. They are not intended to represent the most optimal or perfect scenarios."

Question(s):

(b) It is unclear from the Guidehouse report which aspects of the scenarios were determined by Enbridge as part of its energy transition scenario analysis and which aspects were determined by Guidehouse through its own optimization. Please provide a table for each scenario listing all of the assumptions (including the values for assumptions) that were exogenous to Guidehouse's work.

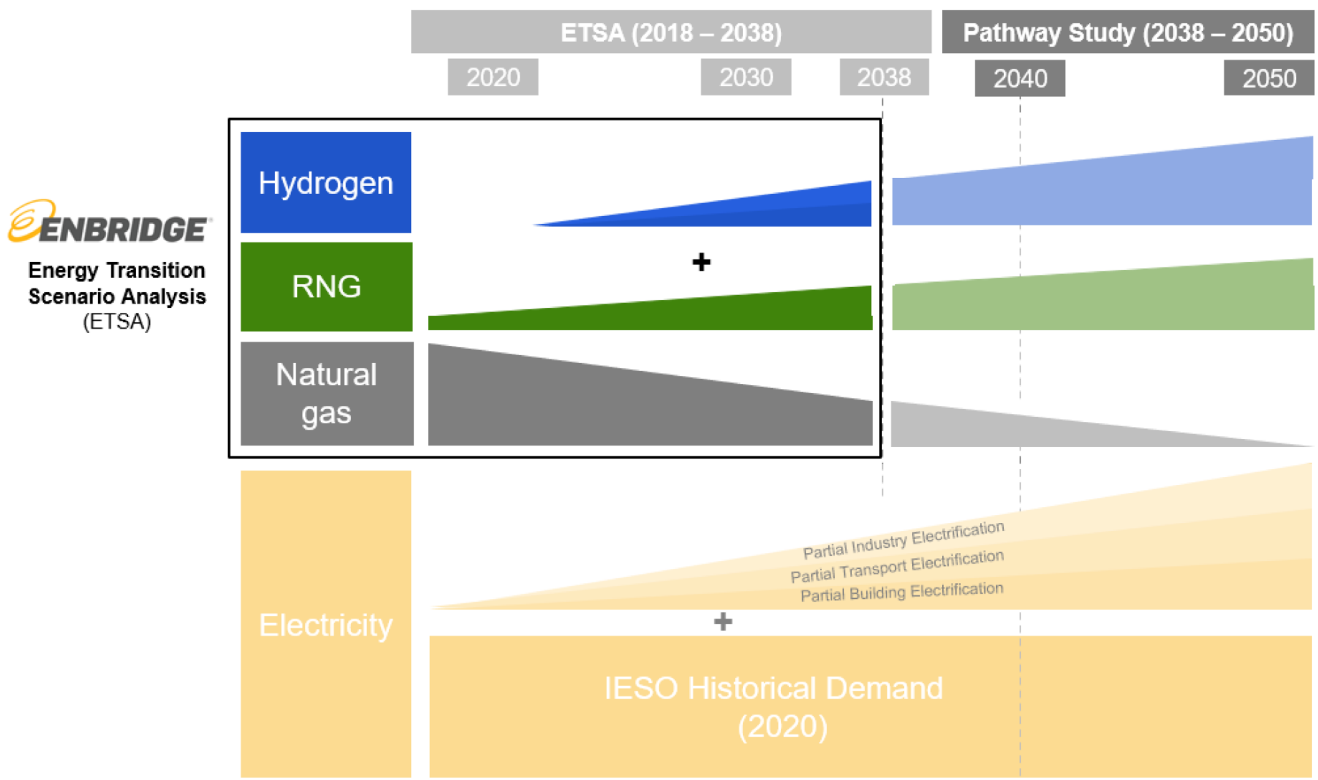
(c) Why did Guidehouse not explore a scenario that did not rely on gaseous fuels delivered by pipelines, such as electrification where possible supplemented by hydrogen created onsite?

**Interrogatory # 1.10-ED-57**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. B-1

Preamble:

**Figure B-1. Graphical Representation of the Extrapolation Used to Develop the Demand Scenarios**




Question(s):

(a) Figure B-1 is a "Graphical Representation of the Extrapolation Used to Develop the Demand Scenarios." Please explain how this graphic can represent both scenarios.
(b) When Guidehouse extrapolated the scenarios from the Enbridge ETSA, did it do so by maintaining the rate of increase or decrease in each fuel type constant as suggested by this graphic.? If not, please explain.

**Interrogatory # 1.10-ED-58**

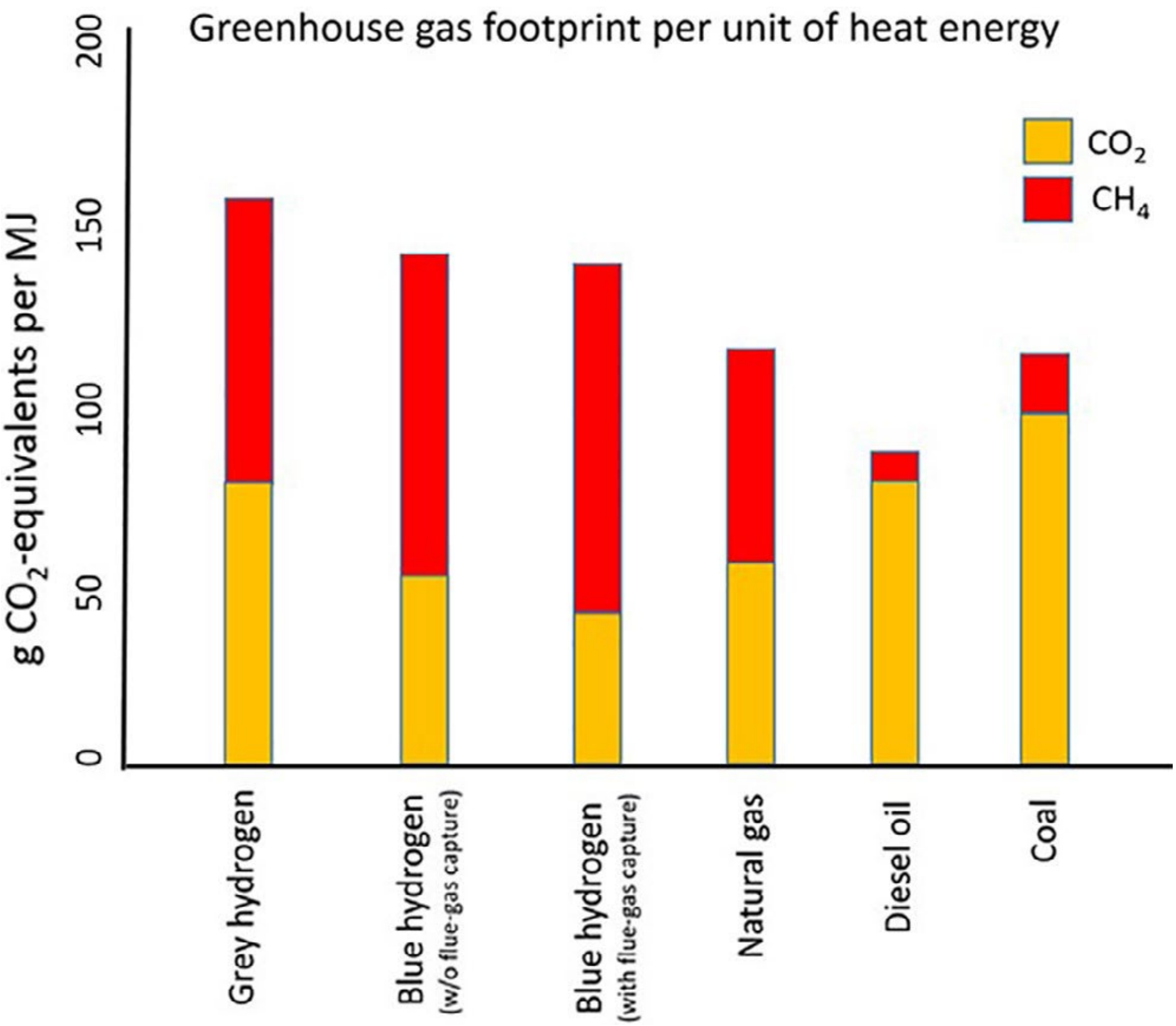
Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 35

Preamble:

> "Both scenarios require a large scale-up in wind capacity and hydrogen-fired gas turbines"

Question(s):

(a) As detailed in the below figure from a peer-reviewed study published in an academic journal, electricity generated from blue hydrogen actually results in more carbon emissions than standard methane gas-fired generation.[59] Please produce a table comparing Guidehouse's assumptions to the assumptions in that peer-reviewed study. In doing do, please separately address each of the figures Table 1 from the study, listing the figure from the study and Guidehouse's different assumptions.




(b) Wherever Guidehouse's assumptions in response to (a) are materially different, please describe the basis of Guidehouse's assumption versus the basis in the paper.

(f) Please comment on the following conclusion from the report: "As we have demonstrated, far from being low emissions, blue hydrogen has emissions as large as or larger than those of natural gas used for heat (Figure 1; Table 1; Table 2). The small reduction in carbon dioxide emissions for blue hydrogen compared wit natural ga are more than made up for by the larger emissions of fugitive methane."

---

[59] Robert W. Howarth and Mark Z. Jackson, "How green is blue hydrogen?" *Energy Science & Engineering*, 26 July 2021; https://onlinelibrary.wiley.com/doi/epdf/10.1002/ese3.956

**Interrogatory # 1.10-ED-59**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 43

Preamble:

> "Finally, end-user costs are $56 billion higher compared to the Diversified scenario. End-user costs are higher because of the high penetration of electric heat pumps which require significant upfront investment in equipment for geothermal heat pumps and costly building retrofits to maintain the same level of comfort for air-source heat pumps.88"

Question(s):

(a) Are the above-noted building retrofits cost-effective?
(b) Please provide the aggregate energy costs savings arising from the above-noted retrofits from 2020 to 2050. Where are these energy cost savings accounted for in the Guidehouse analysis, if anywhere?
(c) Please provide the aggregate energy costs savings arising from the above-noted retrofits over the lifetime of those measures that accrue beyond 2050.

**Interrogatory # 1.10-ED-60**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 43

Preamble:

> "In the middle decade from 2030 to 2040, however, emissions costs are $49 billion higher in the Electrification scenario than in the Diversified scenario. This is because in that decade, carbon emissions will still be significant, and the price of carbon will have risen significantly. The Electrification scenario uses a higher projected price of carbon compared to the Diversified scenario, resulting in higher emissions costs in that decade."

Question(s):

(a) Carbon pricing is a transfer, not a cost. The funds are returned to Ontarians. Should it not be excluded from the analysis?
(b) Please describe the methodology used by Guidehouse in its analysis in terms of the traditional tests (TRC, SCT, etc.).
(c) Please provide a table with a breakdown of the carbon cost included in figure 18 on page 44 for each scenario per decade and total.

**Interrogatory # 1.10-ED-61**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, 44

Preamble:

| Diversified | | | | |
|---|---|---|---|---|
| *Billion CAD, real 2020$* | | | | |
| | **2020-30** | **2030-40** | **2040-50** | **Total** |
| Gas System | 48 | 58 | 71 | **177** |
| Elec. System | 132 | 108 | 114 | **354** |
| Emissions | 23 | 66 | 31 | **120** |
| End Users | 19 | 54 | 41 | **114** |
| **Total** | **221** | **286** | **258** | **765** |

| Electrification | | | | |
|---|---|---|---|---|
| *Billion CAD, real 2020$* | | | | |
| | **2020-30** | **2030-40** | **2040-50** | **Total** |
| Gas System | 35 | 40 | 44 | **119** |
| Elec. System | 170 | 147 | 149 | **466** |
| Emissions | 30 | 115 | 46 | **191** |
| End Users | 15 | 89 | 66 | **170** |
| **Total** | **250** | **391** | **305** | **946** |

Question(s):

(a) Where are RNG and fossil gas costs included in the above?
(b) Please provide a live excel spreadsheet with as detailed of a breakdown of the above figures into their constituent parts as possible.
(c) Where are the costs of the new hydrogen transmission and distribution costs included in the above? How much are the costs of the new hydrogen transmission and distribution infrastructure by decade and total by 2050?

**Interrogatory # 1.10-ED-62**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, 44

Preamble:

Figure 18:

| Diversified | | | | |
|---|---|---|---|---|
| *Billion CAD, real 2020$* | | | | |
| | **2020-30** | **2030-40** | **2040-50** | **Total** |
| Gas System | 48 | 58 | 71 | **177** |
| Elec. System | 132 | 108 | 114 | **354** |
| Emissions | 23 | 66 | 31 | **120** |
| End Users | 19 | 54 | 41 | **114** |
| **Total** | **221** | **286** | **258** | **765** |

| Electrification | | | | |
|---|---|---|---|---|
| *Billion CAD, real 2020$* | | | | |
| | **2020-30** | **2030-40** | **2040-50** | **Total** |
| Gas System | 35 | 40 | 44 | **119** |
| Elec. System | 170 | 147 | 149 | **466** |
| Emissions | 30 | 115 | 46 | **191** |
| End Users | 15 | 89 | 66 | **170** |
| **Total** | **250** | **391** | **305** | **946** |

Question(s):

(a) Please reproduce the above figure with cost of carbon pricing removed from the figures.
(b) Please reproduce the above figure adding 2050-2070. Please do so on a best-efforts basis, making any simplifying assumptions as necessary. The purpose, in part, is to explore whether one scenario has longer-lived assets that may become more cost-effective over a

longer time horizon (e.g. wind power and building retrofits, which have substantial up-front costs but produce benefits for many years).

(c) Please reproduce the above figure on the assumption that fully electrified homes heating with heat pumps contribute 5 kW to the system peak from 2020 to 2040 and 4 kW from 2040 to 2050 (net of their existing, baseline contribution). Please do so on a best-efforts basis, making any simplifying assumptions as necessary. Please provide all calculations and assumptions.

(d) Please reproduce the above figure on the assumption that the RNG potential in Ontario is 41 PJ and that the difference is made up by the most cost-effective alternative,

**Interrogatory # 1.10-ED-63**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 45

Preamble:

> "Electricity system costs include … new or reinforced T&D infrastructure."
>
> "Costs for expanding and upgrading gas and electricity distribution systems (last-mile delivery) are out of scope."

Question(s):

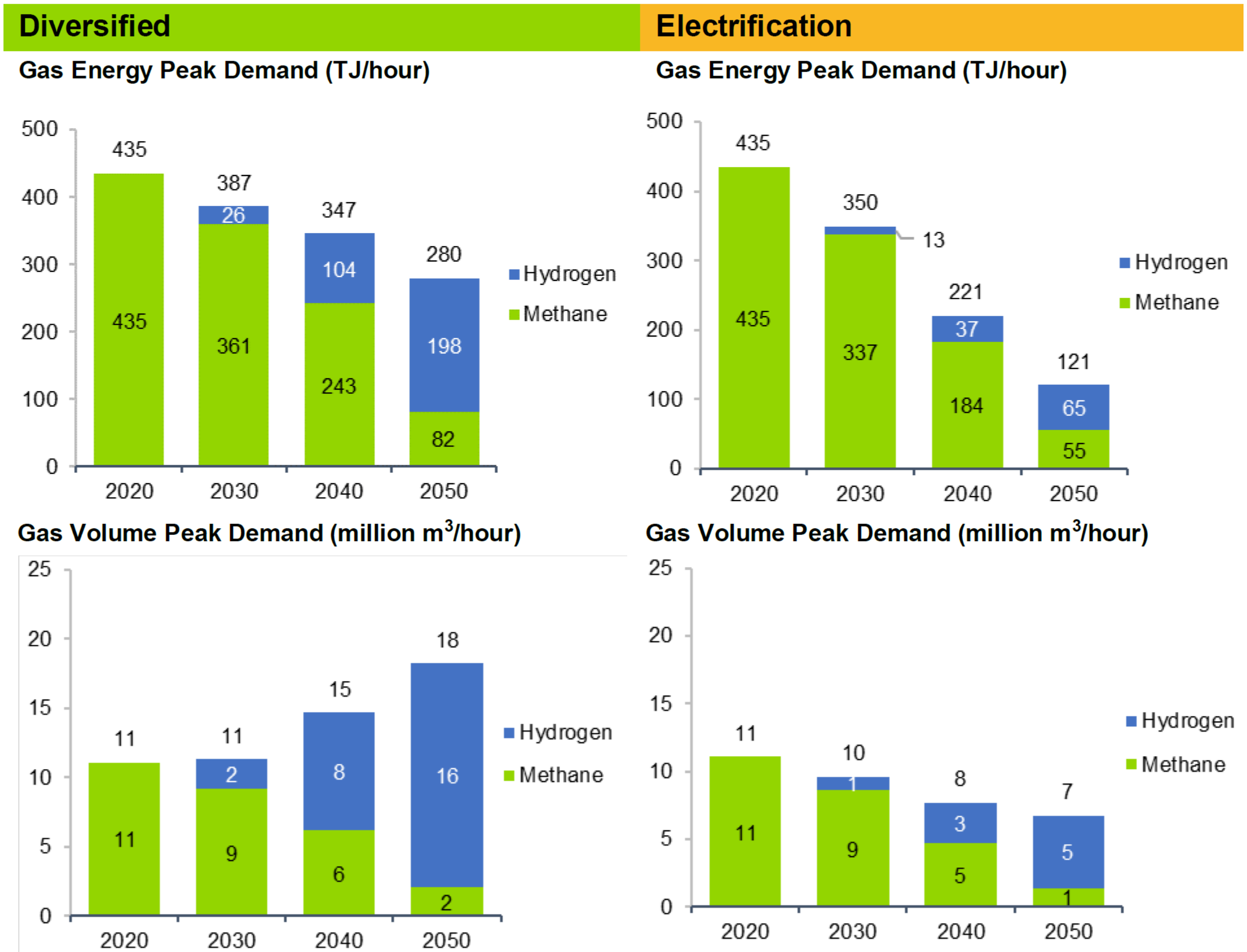
(a) Please reconcile the above two sentences as they relate to electricity distribution.

(b) Please assess the cost of developing the hydrogen-only transmission and distribution pipelines required in Ontario for the scenarios.

**Interrogatory # 1.10-ED-64**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 38 & 44-45

Preamble:




Question(s):

This question will require assistance from Enbridge in relation to the categorization of its pipelines as between transmission and distribution pipelines.

(a) Please complete the below table detailing the methane and hydrogen gas pipeline capacity requirements in each scenario, expressed in TJ/hour.

| **Ontario Methane and Hydrogen Pipeline Capacity Requirements (TJ/hour)** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| Gas transmission pipelines – methane only | | | | |
| Gas distribution pipelines – methane only | | | | |
| Gas transmission pipelines – methane & hydrogen blend | | | | |
| Gas distribution pipelines – methane & hydrogen blend | | | | |

| | | | | |
|---|---|---|---|---|
| Gas transmission pipelines – dedicated hydrogen | | | | |
| Gas distribution pipelines – dedicated hydrogen | | | | |

(b) Please complete the below table detailing the methane and hydrogen gas pipeline capacity requirements in each scenario, expressed in million/hour.

| **Ontario Methane and Hydrogen Pipeline Capacity Requirements (million m3/hour)** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| Gas transmission pipelines – methane only | | | | |
| Gas distribution pipelines – methane only | | | | |
| Gas transmission pipelines – methane & hydrogen blend | | | | |
| Gas distribution pipelines – methane & hydrogen blend | | | | |
| Gas transmission pipelines – dedicated hydrogen | | | | |
| Gas distribution pipelines – dedicated hydrogen | | | | |

(c) Please reproduce the table in (b), indicating in brackets in each cell which pipelines are included in the Guidehouse cost estimates and which are not.
(d) Please make best efforts to estimate the gas pipeline costs that are not already included in the Guidehouse analysis, including, if applicable, the cost to build a new hydrogen distribution system.
(e) Please complete the below table detailing the methane and hydrogen gas pipeline requirements in each scenario, expressed in kms.

| **Ontario Methane and Hydrogen Pipeline Length Requirements (km)** | | | | |
|---|---|---|---|---|
| | 2020 | 2030 | 2040 | 2050 |
| Gas transmission pipelines – methane only | | | | |
| Gas distribution pipelines – methane only | | | | |
| Gas transmission pipelines – methane & hydrogen blend | | | | |
| Gas distribution pipelines – methane & hydrogen blend | | | | |
| Gas transmission pipelines – dedicated hydrogen | | | | |
| Gas distribution pipelines – dedicated hydrogen | | | | |

**Interrogatory # 1.10-ED-65**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 38 & 44-45

Question(s):

These questions are primarily for Enbridge:

(a) Enbridge describes its gas peak demand as 11 million m3/hour. What is the peak capacity of Enbridge's gas system, expressed in million m3/hour?
(b) What is the total capital cost of Enbridge's pipeline system in Ontario expressed as $ per million m3/hour of capacity?
(c) What is the levelized cost of Enbridge's pipeline system in Ontario, including capital and operating costs, expressed as $ per million m3/hour of capacity?

**Interrogatory # 1.10-ED-66**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, p. 38 & 44-45

Question(s):

(a) This question is for Guidehouse: Please provide a table showing the annual cost for Ontario gas transmission and distribution in each scenario from 2020 to 2050.
(b) This question is for Enbridge: Please provide the response to (a) and derive the implied annual revenue requirement.

**Interrogatory # 1.10-ED-67**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2

Preamble:

> Per the Ontario Association of Fire Chiefs: "More than 50 people die each year from carbon monoxide poisoning in Canada, including 11 on average in Ontario."[60]

Question(s):

(a) Does Guidehouse agree that a decarbonization pathway that involves fully electrifying homes in Ontario could save approximately 11 lives each year by preventing carbon monoxide poisoning from homes? If not, please provide the estimated lives saved in a decarbonization pathway that involves full electrification of space and water heating through avoided carbon monoxide poisoning.

**Interrogatory # 1.10-ED-68**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2, A-10

[60] https://www.oafc.on.ca/carbon-monoxide

Preamble:

> "Gas Heat Pump with A/C Unit [CAD$/unit] $12,200"

Question(s):

(a) Guidehouse's estimate for a gas heat pump originates from Enbridge. Please independently estimate the cost of a gas heat pump and provide the results.
(b) Please provide a list of Gas Heat Pumps available on the market in Ontario, the price (equipment and install), the seasonal COP, and the COP at -20°C.
(c) Please provide a list of Gas Heat Pumps available on the market in the United States, the price (equipment and install, converted to CAD), and seasonal COP, and the COP at °C

**Interrogatory # 1.10-ED-69**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2

Question(s):

(a) Please provide a map of Ontario showing the location of industrial facilities that require a high-grade heat that cannot be electrified.
(b) Please provide any reports or analysis comparing the cost-effectiveness of on-site or local electrolysers versus green hydrogen delivered by a dedicated pipeline system for that purpose.

**Interrogatory # 1.10-ED-70**

Reference: Exhibit 1, Tab 10, Schedule 5, Attachment 2

Question(s):

Please respond to the following comments on the Guidehouse report:

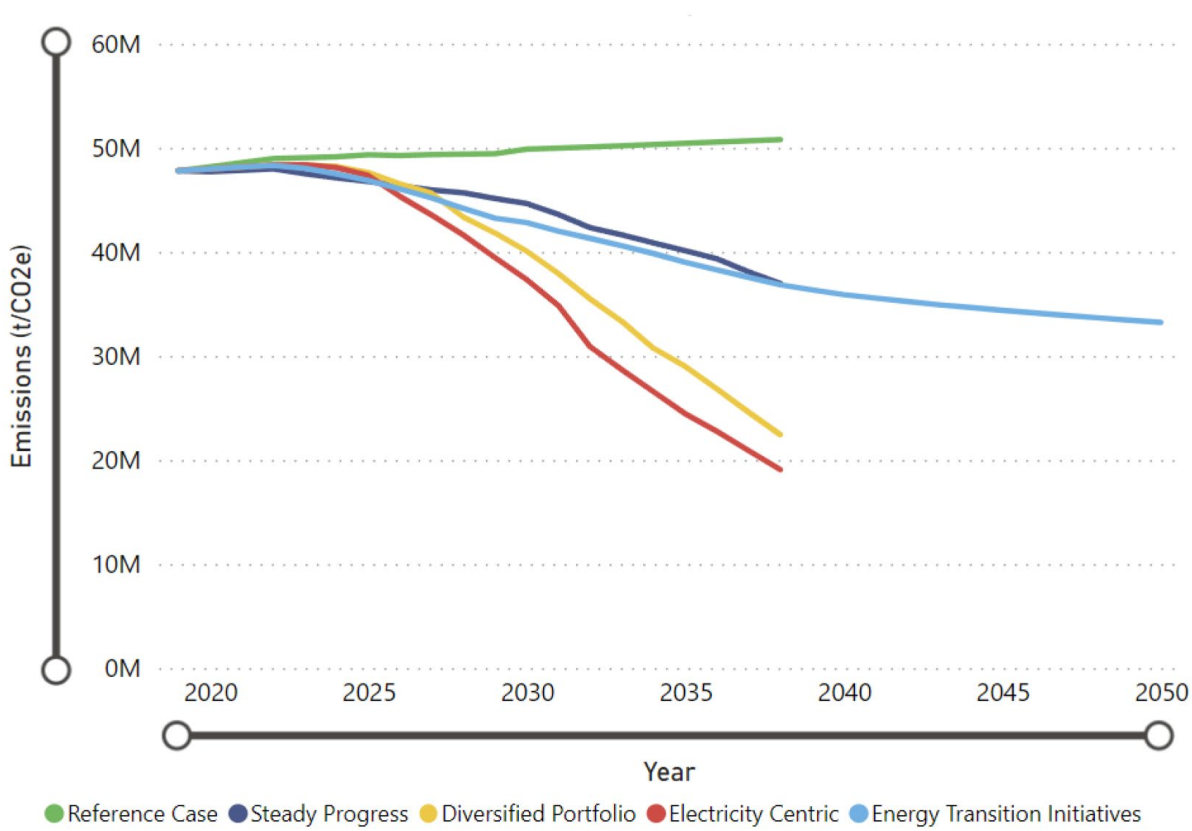
(a) The Guidehouse report does not study or assess the cost for a full electrification scenario wherein (i) investment in province-wide pipeline infrastructure is reduced over time to zero, (ii) hard-to-electrify sectors convert to hydrogen via as on-site electrolyser, a nearby electrolyser (e.g. with short-distance distribution), storage, and/or trucked fuel, (iii) the remaining sectors electrify, and (iv) cost-effective methods are adopted to decrease peak and annual electricity resource requirements (e.g. thermal storage, V2G/B, etc.).
(b) The Guidehouse analysis does not extend beyond 2050 to account for the benefits of investments with long-lived benefit streams. It therefore is biased against investments with significant up-front costs that have a stream of future benefits with low or no ongoing costs. Those include, for example: building envelope energy efficiency, wind power, solar power, investments in electricity transmission and distribution infrastructure.

**Interrogatory # 1.10-ED-71**

Reference: Exhibit 1, Tab 10, Schedule 6, Attachment 1, p. 23

Preamble:

Exhibit 17 – All Scenarios GHG Emissions (t/$CO_2$e)




Question(s):

(a) This question is for the Posterity Group: Please reproduce the above figure including full lifecycle emissions, including upstream emissions (e.g. from fossil-fuel-based hydrogen, transmission methane leaks, etc.) and methane leaks from customer equipment. Please make and state your assumptions for those.

For upstream emissions from fossil-fuel-based hydrogen, please use the figures found in the following peer-reviewed report or justify a decision to use different figures: Robert W. Howarth and Mark Z. Jackson, "How green is blue hydrogen?" *Energy Science & Engineering*, 26 July 2021 (link).

For the emissions of unburned methane from customer equipment, please use the figures found in the following peer-reviewed report or justify a decision to use different figures:

Zachary Merrin and Paul W. Francisco, *Unburned Methane Emissions from Residential Natural Gas Appliances* (link).

**Interrogatory # 1.10-ED-72**

Reference: Exhibit 1, Tab 10, Schedule 5

Question(s):

(a) Please provide the cost for the (i) Guidehouse report; (ii) Posterity Group, June 23, 2022 report, and (iii) Posterity Group, September 22, 2022 report.
(b) Please confirm if the above costs are covered by ratepayers and what account they are attributed to.

**Interrogatory # 1.10-ED-73**

Reference: Exhibit 1, Tab 10, Schedule 5

Question(s):

(a) Natural Resources Canada provides the following Natural Gas Conversions:

**Approximate Natural Gas Conversions**

| | **‹- Multiply by -›** | | | |
|---|---|---|---|---|
| | **m³** | **cf** | **MMBtu** | **GJ** |
| **Cubic Metres (m³)** | | 35.301 | 0.0353 | 0.0373 |
| **Cubic Feet (cf)** | 0.0283 | | 0.001 | 0.001055 |
| **Million British thermal units (MMBtu)** | 28.3278 | 1000 | | 1.0551 |
| **Gigajoules (GJ)** | 26.853 | 947.817 | 0.9478 | |

For example, to convert from 1 MMBtu to Gigajoules, multiply by 1.055.[61]

Please confirm whether Enbridge believes those conversion rates are (i) accurate and (ii) the same as the conversion rates used in its application. If not, please (i) reproduce the table with the rates that Enbridge used for its application and (ii) provide the rates that Enbridge believes are accurate.

[61] https://www.nrcan.gc.ca/energy/energy-sources-distribution/natural-gas/natural-gas-primer/5641

(b) Please provide the following figures and conversion factors:
   (i) tCO2e/m3 methane gas (combustion, Ontario)
   (ii) m3 of hydrogen with the equivalent energy of 1 m3 of methane gas
   (iii) $/m3 hydrogen to equivalent of $/m3 methane gas (i.e. equivalent energy content)
   (iv) 1 kg hydrogen to 1 m3 hydrogen
   (v) 1 kg hydrogen to 1 J hydrogen
   (vi) $/kg hydrogen to $/m3 hydrogen

(c) Please complete the following conversion tables.

| **Watt and Joules** | | | | |
|---|---|---|---|---|
| | **‹- Multiply by -›** | | | |
| | **J** | **PJ** | **GJ** | **TJ** |
| **kW** | | | | |
| **MW** | | | | |
| **GW** | | | | |

| **Watt and Joules - Hourly** | | | | |
|---|---|---|---|---|
| | **‹- Multiply by -›** | | | |
| | **J/hr** | **PJ/hr** | **GJ/hr** | **TJ/hr** |
| **kWh** | | | | |
| **MWh** | | | | |
| **GWh** | | | | |

| **Watts and Joules - Price** | | | | |
|---|---|---|---|---|
| | **‹- Multiply by -›** | | | |
| | **$/J** | **$/PJ** | **$/GJ** | **$/TJ** |
| **$/kWh** | | | | |
| **$/MWh** | | | | |

| | | | | |
|---|---|---|---|---|
| $/GWh | | | | |

| Methane Gas – Energy and Volume | | | | |
|---|---|---|---|---|
| | ‹- Multiply by -› | | | |
| | J | PJ | GJ | TJ |
| m3 | | | | |
| million m3 | | | | |

| Methane Gas Peak Demand Conversion Factors | | | | |
|---|---|---|---|---|
| | ‹- Multiply by -› | | | |
| | J/hr | PJ/hr | GJ/hr | TJ/hr |
| m3/hour | | | | |
| million m3/hour | | | | |

| Methane Gas - Price | | | | |
|---|---|---|---|---|
| | ‹- Multiply by -› | | | |
| | $/J | $/PJ | $/GJ | $/TJ |
| $/m3 | | | | |
| $/million m3 | | | | |

| Hydrogen Gas – Energy and Volume | | | | |
|---|---|---|---|---|
| | ‹- Multiply by -› | | | |
| | J | PJ | GJ | TJ |
| m3 | | | | |

| | | | | |
|---|---|---|---|---|
| **million m3** | | | | |

| **Hydrogen Gas Peak Demand Conversion Factors** | | | | |
|---|---|---|---|---|
| | **‹- Multiply by -›** | | | |
| | **J/hr** | **PJ/hr** | **GJ/hr** | **TJ/hr** |
| **m3/hour** | | | | |
| **million m3/hour** | | | | |

| **Hydrogen Gas - Price** | | | | |
|---|---|---|---|---|
| | **‹- Multiply by -›** | | | |
| | **$/J** | **$/PJ** | **$/GJ** | **$/TJ** |
| **$/m3** | | | | |
| **$/million m3** | | | | |