Answer to Undertaking J3.4

Undertaking:

J3.4: EFG to catalogue the list of impacts, if any, provided its report based on the updated program details filed by Enbridge

Response:

There are no substantive changes to the Environmental Defense submitted testimony based on our review and cataloging of the changes made to the Enbridge submission for the LCEP.
In our review we noted the following changes in the revised LCEP submission:

1) Title changed from Low Carbon to Lower Carbon[1] (p. 1)
2) Addition to witnesses of Lauren Whitwham listed as Manager Community & Indigenous Engagement (p.1)
3) Change of item 53) to item 17). (p.1)
4) Change in the percent targets. New target up to 0.25 percent RNG in 2026, increasing to up to 2% RNG in 2029. Language that RNG will play an important role in energy transition moved to item 6. (p.1)
5) New paragraph stating the reduction in target percentages acknowledges nascent supply and demand markets for RNG. (p.2)
6) Change in language to indicate biogas, can be upgraded to pipeline quality methane, modification to language to indicate processing of organic waste material into biogas. (p.3)
7) Lower Carbon Energy Program Proposal (change in name from low to lower) modified percent targets. (p.4)
8) Maximum bill impacts for average residential customer estimated at $0.50 per month for 2026, and $4 per month in 2029. (p.5)
9) Minor language change to cost recovery certainty on long-term basis. (p.7)
10) Under item 20 update to reflect the downward revisions in procurement targets. (p.8)
11) Item 21 change from time of purchase to time of procurement. (p.8)
12) Modified footnote 4 to reflect lower procurement target. (p.8)
13) Item 22 modified to reflect lower procurement targets. (p.9)
14) Change in the Federal Carbon Charge values and dates. (p.9)
15) Item 26, change to lower carbon energy procurement activities. (p.11)
16) Item 29, added language to indicate LCVP will be made available, "*upon the implementation of planned changes to internal and customer-facing business applications and processes to support participation in the program*". Additional modification of the language in this section indicating "intends to offer the LCVP…(p 12)
17) Item 35 changes to reflect lower RNG procurement targets of up to 0.25% in 2026 and up to 2% in 2029. (p.13)

[1] All references are to Phase 2 Exhibit 4 Tab 2, Schedule 7 Plus attachments. Updated 2024-11-15.

18) Item 36 – change to reflect lower maximum estimated bill impact for average residential customer. (p.14)
19) Item 38 – added language – "*Additionally, the FCC benefit associated with RNG purchases on behalf of sales service customers will be recorded in the CCCVA until planned changes to reduce the FCC for sales service customers are implemented in internal and customer-facing business applications*." (p.15)
20) Item 44 – modifies estimated emissions reduction impacts to reflect lower levels of RNG procurement targets. (p.17)
21) Item 46 – reflects lower procurement target of up to 2% lower carbon energy in gas supply by 2029. (p.18)

EB-2024-0111
Exhibit J3.5
Plus Attachment

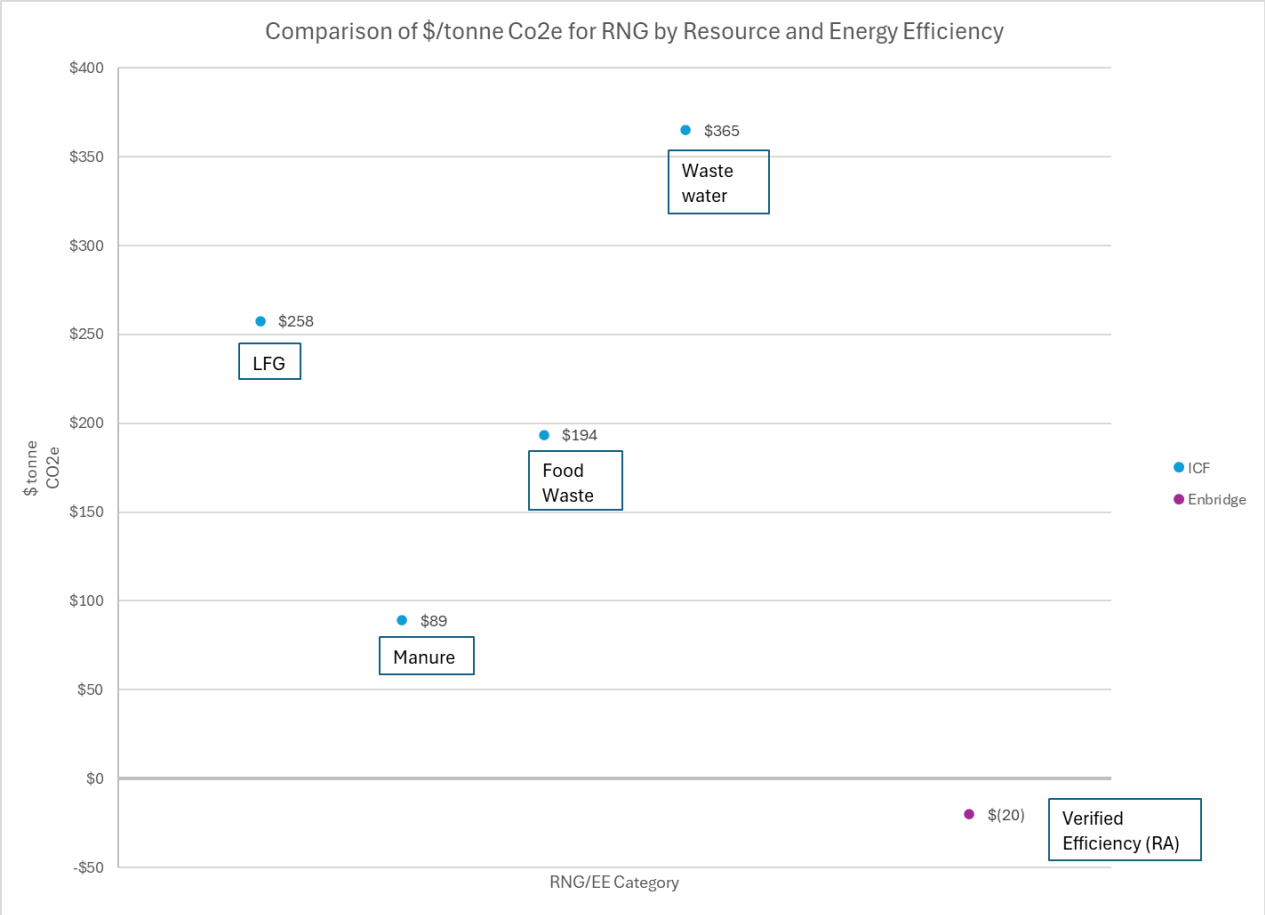
Answer to Undertaking J3.5

Undertaking:

J3.5: ED panel to provide a ranking for cost-effective alternatives to RNG to reduce emissions, showing cost per tonne at different price points for RNG purchases; to include evidence citations as available.

Response:

The following chart compares the lifecycle cost per tonne of CO2e reductions for RNG from various sources based on a study conducted by ICF for the American Gas Association in 2019[2] and for resource acquisition (RA) energy efficiency based on the verified 2022 DSM Evaluation for Enbridge.



[2] American Gas Foundation, 2019. Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, prepared by ICF.

The findings from the ICF study confirm that RNG sources with a higher cost per unit of energy or volume, including Manure and Food Wastes, have a lower cost per unit of CO2e emissions due to variation in lifecycle carbon intensity, and the ability for manure and food waste to more than fully offset the emissions from fossil gas.

The following table illustrates how the higher cost pe unit energy resources have a lower cost per unit of emission reduction.

		g/co2e/MJ	delta emiss g/co2e/MJ	% Emissions Reduction from Fossil Gas	CAD$/MMBtu	CAD$/GJ	delta cost $/GJ	2024 $/tonne CO2e
ICF, 2019	Fossil Gas	85	NA	NA	$ 5.48	$ 5.19	NA	NA
	LFG	31	54	64%	$ 17.81	$ 16.88	$ 11.69	$ 258
	Manure (dairy)	-289	374	439%	$ 34.94	$ 33.11	$ 27.92	$ 89
	Waste Rec	31	54	64%	$ 22.95	$ 21.75	$ 16.56	$ 365
	Food Waste	-74	159	186%	$ 32.67	$ 30.97	$ 25.78	$ 194

The attached workbook contains further details along with references to RNG studies by Torchlight Bioresources[3], and McKinsey[4], both of which are consistent with the findings of the ICF study related to relative costs and lifecycle emissions reductions.

For contrast, in response to ED-48, the company estimates that based on their generic assumption of all sources of RNG having an equal emission reduction of 0.05 tCO2/GJ of RNG, Enbridge estimates a cost per tonne of $511.60.

The estimated levelized cost per tonne of CO2e emissions reductions from efficiency of ***negative $20*** is based on verified costs and savings from the Resource Acquisition Programs in the 2022 Enbridge Efficiency Program portfolio.[5] See attached J.5 workbook for calculation details.

The undertaking analysis and results above confirm the cost for emission reductions varies significantly depending upon the RNG source. The proposed approach from Enbridge to treat the carbon intensity of all RNG as similar is not supported by these findings and overlooks the importance of accounting for lifecycle emissions from RNG and the RNG source. The summary chart also supports the ED testimony that energy efficiency has substantially lower costs per tonne of emission reductions than RNG.
The undertaking also asked ED for citations in the record to the cost per tonne of emission reductions in the record. A review of materials identified the following, though this may not be an exhaustive list of the relevant citations.

[3] Torchlight Bioresources, 2020. Renewable Natural Gas (Biomethane) Feedstock Potential in Canada.
[4] McKinsey & Company, 2023. Renewable Natural Gas: A Swiss Army Knife for US Decarbonization?
[5] DNV, 2024: 2022 Natural Gas Demand-Side Management Annual Verification Report, prepared for Ontario Energy Board.

- ED M1 Evidence on Page 16 first full bullet. Cross reference to the Company's estimates for cost per tonne reduction for energy efficiency and RNG at $25.58/GJ. Exhibit I.4.2-ED-48 p. 3.

- Page 19 reference to variation in carbon intensities and resulting variation in cost per tonne, cross reference to Appendix A.

- Appendix A Table 2 presents ranges of lifecycle intensities for various RNG sources based on GREET model for CA.

- Appendix A Table 3 is Enbridge response to GEC-22, table showing variation.

Further Citations to related interrogatory responses on cost per tonne reductions from ED:

- M1-CBA-3
- M1-CCC9 d)
- M1-EGI- 11 b)
- M1. Staff-2 b)
- M1. Staff – 3 a)
- M1. PP-2 b)
- M1. PP-3

EB-2024-0111
Exhibit J3.6
Plus Attachment

Answer to Undertaking J3.6

Undertaking:

J3.6: ED/EFG to provide an update to the analysis that led to the results shown, reflecting any changes in assumptions that are appropriate given changes in the market, whether that is on gas prices or on equipment rebates that are available today relative to when the analysis was initially done.

Response:

In the report filed in Phase 1 of Enbridge's rebasing proceeding in May of 2023 (EB-2022-0200 Exhibit M9), Energy Futures Group (EFG) included two comparisons of the cost of residential electric heating to gas heating. One of Mr. Neme's analyses focused on a decarbonized future. That is the most important comparison for understanding the impact of the energy transition on the gas system and that comparison continues to show that the cost of heating exclusively with decarbonized gas would likely be on the order of five times the cost of heating with carbon neutral electricity.

That analysis compared (A) the energy cost of heating with renewable natural gas (RNG) when it is being acquired a scale envisioned in a decarbonization pathway that emphasizes reliance on lower-carbon gases; to (B) the cost of heating with a cold climate air source heat pump drawing power from a decarbonized electric grid in a highly electrified future (i.e., with significant energy loads from the residential, commercial, industrial and transportation sectors having been electrified). As Table 1 shows, that analysis suggested the annual cost of heating exclusively with RNG in the future would be on the order of five times the cost of heating with electricity, even though electricity prices are assumed to be about 25% higher because of investments needed to accommodate significant new electrified loads.

As Mr. Neme noted during cross-examination by Enbridge in the current Phase 2 proceeding, this comparison of costs in a decarbonized future is the most important in terms of understanding the extent to which gas demand will likely change as a result of an energy transition necessary to meet net zero greenhouse gas emissions.

Mr. Neme is unaware of any information that would require updating his May 2023 analysis of such future decarbonized heating costs.

Table1: Volumetric Cost of RNG Heat vs. High Electrification Heat

	Full Decarbonization	
	Biogas vs. Electric Heat	
	$62/GJ RNG	
	IESO 25% Rate Increase w/Hi Electrification	
	RNG Furnace	Electric Heat Pump
$/m3 or $/kWh *input*		
Commodity	$2.41	
Transportation	$0.05	
Distribution	$0.12	
Carbon Tax	$0.00	
HST	$0.34	
Total	$2.91	$0.17
$/GJ of Energy *Input*	$78.25	$46.31
Heating Efficiency	95%	293%
$/GJ of Heat *Output*	**$82.37**	**$15.81**
Gas Price as % of Electric	521%	

The second comparison of electric and gas costs that Mr. Neme presented in his May 2023 report was of the annual energy costs and total lifecycle costs (energy plus capital) based on then current electric and gas rates. Per the requested undertaking, Mr. Neme has reviewed all of the assumptions he used in that analysis and updated a number of them to reflect better and/or more up-to-date information. The updated results continue to show substantial savings of electric over gas options – roughly $10,000 in lifetime energy bill savings and roughly $6,800 lifetime total cost savings. The results of his updated analysis are presented below in Table 2 and Table 3. This analysis is conservatively based on the current $3,000 rebate for heat pumps provided by Enbridge Gas to gas customers. However, a new provincial program with rebates of up to $7,500 has recently been announced. Also, certain homeowners are eligible for greater savings through other existing programs, such as a no-cost heat pump for low-income customers and $10,000 rebate for median-income families with oil heating. The rebate amount assumed in the analysis has a direct impact on the NPV of total costs. For instance, a $7,500 rebate would bring the lifetime cost savings to $14,351. A summary of the assumptions that were updated is provided at the end of this undertaking.

Table 2: Change in Energy Bills from Electrification of Single-Family Toronto Home Today

	without Electrification	with Electrification	$ Change	% Change
2025 Electrification				
1st Year (2023) Energy Bills	$1,855	$1,268	($587)	-32%
18-Year NPV of Energy Bills	$27,276	$16,700	($10,576)	-39%

Table 3: Change in Total Cost from Electrification of Single-Family Toronto Home Today

	without Electrification	with Electrification	$ Change	% Change
2025 Electrification				
18-Year NPV of Energy Bills	$27,276	$16,700	($10,576)	-39%
18-Year NPV of Equipment Costs	$13,532	$17,257	$3,725	28%
18-Year NPV of Total Costs	$40,808	$33,957	($6,851)	-17%

A number of points are worth making about these updated results:

- As with Mr. Neme's 2023 analysis, the results are estimated for the average, existing, single-family detached home in Toronto that fully electrifies at the time it would otherwise be replacing its gas furnace and central air conditioner.
- The energy cost savings of a cold climate heat pump relative to a gas furnace plus central air conditioner remain substantial. Mr. Neme's 2023 analysis estimated first year bill savings as $683 and the 18-year net present value (NPV) of bill savings to be $13,018 for a home that electrified in 2023. Though the updated values for a home that electrifies in 2025 are a little lower, they are still nearly $600 in the first year and over $10,000 over eighteen years.
- Energy bill savings remain substantial despite very low current gas commodity prices. Though commodity prices can and have historically fluctuated up and down considerably, this updated analysis assumes that current very low prices remain constant (in inflation adjusted terms) over the next eighteen years.
- With changes in assumptions about equipment costs, particularly rebates available for heat pumps and heat pump water heaters, EFG now estimates that customers will incur $3725 higher capital costs over the 18-year analysis period to electrify than if they simply replaced their gas equipment. For comparison, Mr. Neme's 2023 analysis estimated that lifecycle equipment costs would be about $3900 lower for customers who electrified.
- Even with higher capital cost estimates, total costs to customers who electrify are nearly $7000 lower than if they did not electrify (Mr. Neme previously estimated this net benefit to be nearly $19,000). Put simply, the value of the lifetime energy bill savings for customers who electrify outweighs higher capital costs.
- The magnitude of the net cost savings to customers is sensitive to assumptions about available rebates for electric equipment. For this updated analysis, Mr. Neme has assumed that customers could receive a $3000 rebate for a cold climate heat pump sized to meet all the full heating load of a home and a $500 rebate for a heat pump water heater. The $3000 heat pump rebate is consistent with both current Enbridge advertising[6] and its proposed 2026 to 2030 DSM plan.[7] However, even if such rebates were not available, the total costs of electrification would be lower than staying on gas. On the other hand, it is possible that rebates for at least some customers will be higher than assumed in EFG's

[6] https://www.enbridgegas.com/ontario/rebates-energy-conservation/home-efficiency-rebate.
[7] EB-2024-0198 Exhibit E, Tab 2, Schedule 3, p. 5.

updated analysis. For example, Enbridge and the Government of Ontario appear to have recently announced a new Home Renovation Savings Program that will offer "up to $7500" for a cold climate air source heat pump.[8] And just last month the IESO announced that low-income households could receive free cold climate air source heat pumps.[9] Also, the federal government is offering up to $10,000 in heat pump rebates for median-income households that heat with fuel oil.[10]

- EFG has not included an electric panel upgrade cost in its analysis (consistent with its 2023 analysis). First, we would expect a significant portion of homes to already have 200-amp service. While we are unaware of any Ontario-specific data on this issue, a recent U.S. analysis concluded that 62% of homes currently have 200 Amp service.[11] Second, 100-amp service will often (though not always) be more than adequate to accommodate the operation of a heat pump, even in cold climates. This is partly because the actual amperage required by many modern appliances is often much lower than they are assumed to need as well as the fact that homes never have all of their loads on at once. Finally, we are aware of several anecdotal examples of homes in the Toronto area which have installed and are operating heat pumps with only 100-amp service.

As previously noted, the EFG analysis is of the costs for an existing home. EFG did not conduct a similar comparison for new homes because we could not gather the data necessary to do so without significant additional research. There are several reasons we would expect the relative economics of all-electric new homes compared to gas-heated homes to be better than for electrifying existing gas-heated homes.

- First, builders would avoid the need to run gas pipe from the gas meter to different appliances inside the home.
- Second, builders would avoid any potential costs of connecting to the gas distribution system. Although there is one preliminary analysis which suggests that electricity system connection costs may be greater for all-electric homes, as discussed at the hearing, the data available is not sufficient to draw that conclusion and no evidence to suggests that any changes to electric connection costs for all-electric homes is imminent or even likely in the future.
- Third, at least volume builders would have the ability to purchase HVAC equipment and appliances at bulk purchase discounts. While that would be true of gas equipment as well as electric equipment, if electric equipment is more expensive, the absolute value of the difference in cost would shrink.

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[8] https://www.enbridgegas.com/homerenovationsavings.
[9] https://www.ieso.ca/Corporate-IESO/Media/News-Releases/2023/12/Energy-Affordability-Program-Free-Heat-Pumps.
[10] https://natural-resources.canada.ca/energy-efficiency/homes/canada-greener-homes-initiative/oil-heat-pump-affordability-program/24775
[11] Meier, Alan and Sadia Gul, "A Comprehensive Survey of Electrical Panel Capacities in U.S. Single Family Homes and Implications for Nationwide Electrification", Proceedings from the 2024 ACEEE Summer Study on Energy Efficiency in Buildings (www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/A%20Comprehensive%20Survey%20of%20Electrical%20Panel%20Capacities%20in%20U.S.%20Single-Family%20Homes%20and%20Implications%20for%20Nationwide%20Electrification.pdf).

In addition, a homebuyer in an electrified development could avoid future costs to swap out a gas furnace with a heat pump to achieve decarbonized heating in the future.
I have not been able to quantify the costs to a builder nor estimate the percentage of those costs that would passed along to a homebuyer. However, it is clear from the figures in table 2 above that a homebuyer in an all-electric development would likely experience significant energy bill savings over the gas alternative.

Changes in Assumptions

The following table identifies each change in assumption that EFG made to update Mr. Neme's 2023 analysis, along with an explanation of the reason and source of the updated assumptions. An electronic copy of EFG's analysis tool is also provided as part of this undertaking.

	Current Assumption 2025	Previous Assumption 2023	Nature/Basis of Changes
Gas Rates			
Fixed Charges (annual)	$363	$310	Updated based on rates applicable starting 1/1/25 with two exceptions: (1) since new carbon tax rates go into effect April 1st, a weighted annual average rate is used; (2) the current gas supply cost adjustment of -$0.021/m3 is excluded as such very short-term adjustments exist only to correct for previous over- or under-collections from previous periods, are highly variable (positive and negative) and are therefore not appropriate to include in an analysis that is forecasting/estimating expected impacts over the next 18 years.
Variable Charges ($/m3)			
Commodity	$0.092	$0.221	
Transportation	$0.058	$0.050	
Distribution	$0.124	$0.118	
Carbon Tax	$0.176	$0.126	
HST	$0.059	$0.067	
Total	$0.509	$0.582	
Electric Rates			
Commodity	$0.100	$0.093	Based average commodity cost on 1/1/25 Toronto Hydro TOU rates, using Enbridge assumptions on allocation of kWh by costing period. Previously used IESO forecast energy price. Updated all values based on rates effective 1/1/25. Note that previous analysis mistakenly did not include Ontario Energy Rebate.
Rider for disposition of capacity based recovery acct	$0.000	$0.000	
Rider for disposition of deferral/variance accounts	$0.002	$0.003	
Rider for disposition of global adjustment account	$0.001	-$0.003	
Transmission charge	$0.024	$0.019	
Regulatory charge - wholesale market service	$0.006	$0.005	
Total	$0.133	$0.118	
HST	13.0%	13.0%	
Ontario Energy Rebate (OER)	-13.1%		
Total w/HST and OER	$0.133	$0.133	
Baseline annual m3 Consumption per Single-Family Home			
Heating	2101	2117	Referencing same Posterity forecast developed for Enbridge, but using 2025 instead of 2023 values
Water Heating	440	441	
Equipment Efficiency Ratings			
cold climate Air Source Heat Pump (ccASHP)	2.87	2.84	Same reference (Guidehouse decarb study for Enbridge), but newer model (study assumed slight increase in average efficiency each year).
Efficient Gas Water Heater	0.69	0.83	Based on actual model referenced in costs from Home Depot Canada. For reasons discussed in the cost section below, this change makes the gas option more cost-effective.
Heat Pump Water Heater	3.75	3.73	Based on actual model referenced in costs from Home Depot Canada
Electric Dryer	3.94	3.93	Based on actual model referenced in costs from Home Depot Canada
Equipment Cost Assumptions			
Furnace + Central A/C	$9,120	$8,000	Same reference (Guidehouse decarb study for Enbridge and Enbridge estimates in DSM plan case), but adjusted for inflation.
cold climate Air Source Heat Pump (ccASHP)	$12,654	$11,100	
Efficient Gas Water Heater	$3,500	$3,016	Changed references from Guidehouse/Leidos study for U.S. EIA to (A) equipment cost from Home Depot Canada plus (B) installation cost from Guidehouse study. Used lower efficiency gas model (EF 0.69) than previous assumed because higher efficiency models (EF 0.88) are several thousand dollars more for a modest incremental energy savings. Thus, using the lower efficiency gas model improves the economics of gas relative to EFG's previous analysis.
Heat Pump Water Heater (HPWH)	$4,150	$2,411	
Gas Dryer	$1,139	$1,223	
Electric Dryer	$887	$998	
Gas Range	$1,515	$1,195	
Electric Induction Range	$1,613	$1,476	
ccASHP Rebate	$3,000	$6,500	Updated assumption based on current Enbridge advertising
HPWH Rebate	$500	$1,300	Updated assumption based on Enbridge/Ontario government announcement
Other			
US Dollar to Canadian Dollar exchange rate	1.37	1.34	Updated based on Bank of Canada average of the past 12 months. Note that this affects cost references that are expresed in USD (e.g., equipment installation costs from the Guidehouse/Leidos study for US EIA).
2024 to 2025 inflation rate	2.5%	n.a.	Based on Bank of Canada forecast