STATE OF ILLINOIS
ILLINOIS COMMERCE COMMISSION

North Shore Gas Company	)	
	)	Docket No. 23-0068
	)	
Proposed General Increase in Rates and Revisions to Other Terms and Conditions of Service	)	
	)	
	)	
The Peoples Gas Light and Coke Company	)	Docket No. 23-0069 (cons.)
	)	
Proposed General Increase in Rates and Revisions to Other Terms and Conditions of Service	)	

DIRECT TESTIMONY OF

CHRIS NEME

ON BEHALF OF
ENVIRONMENTAL LAW & POLICY CENTER
ENVIRONMENTAL DEFENSE FUND
NATURAL RESOURCES DEFENSE COUNCIL
ILLINOIS STATE PUBLIC INTEREST RESEARCH GROUP, INC.

(PUBLIC INTEREST ORGANIZATIONS)

May 9, 2023

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I. WITNESS IDENTIFICATION

Q. Please state your name, employer and business address.

A. My name is Chris Neme. I am a co-founder and Principal of Energy Futures Group, a consulting firm that provides specialized expertise on energy efficiency, demand response, renewable energy, strategic electrification, and other clean energy markets, programs and policies. My business address is P.O. Box 587, Hinesburg, VT 05461.

Q. On whose behalf is this testimony being offered?

A. I am submitting testimony on behalf of the Environmental Law and Policy Center (ELPC), Environmental Defense Fund (EDF), The Natural Resources Defense Council (NRDC), and Illinois State Public Interest Research Group, Inc. (ILPIRG), collectively the Public Interest Organizations (PIO).

Q. Please describe your educational background.

A. I received a Master of Public Policy degree from the University of Michigan (Ann Arbor) in 1986. That is a two-year, multi-disciplinary degree focused on applied economics, statistics and policy development. I also received a Bachelor's degree in Political Science from the University of Michigan (Ann Arbor) in 1985. My first year of graduate school counted towards both my Masters' and Bachelor's degrees.

Q. Please summarize your business and professional experience.

A. I have worked in the energy industry for more than thirty years for clients in more than 30 different states, half a dozen Canadian provinces and several European countries. My work has focused on electric and gas utility system planning, with particular focus on markets, programs and policies regarding energy efficiency, demand response, and strategic electrification. That has included development and analysis of policies and pathways for decarbonizing the energy sector. Much of my work includes economic analysis, including benefit-cost analyses of various distributed energy resources and electrification measures. A copy of my curriculum vitae is attached as Exhibit 2.1.

Q. Can you provide examples of projects on which you have worked since co-founding Energy Futures Group (EFG)?

A. I co-founded Energy Futures Group in 2010. Since then, I have played lead roles in a variety of energy consulting projects. Recent examples include:

- Representing NRDC in informal consultations and contested regulatory proceedings in Illinois, Michigan and Ohio on energy efficiency, demand response and electrification program designs, cost-effectiveness, and shareholder incentives; distribution system planning; and integrated resource planning;
- Testifying on behalf of the Green Energy Coalition in an Enbridge Gas rate case in Ontario on the impacts of decarbonization policy on the future of the gas utility system and implications for regulatory policies on capital investments in the system;
- Assisting the Sierra Club in providing technical input on gas utility decarbonization pathways and policies as part of the Massachusetts Future of Gas utility-stakeholder collaborative process and subsequent regulatory process;
- Co-leading a multi-stakeholder Vermont working group, co-authoring a white paper and providing legislative testimony and technical support on the policy concept of a

Clean Heat Standard – a performance standard that would impose increasing annual obligations on Vermont Gas as well as the state's wholesale suppliers of fuel oil and propane to reduce greenhouse gas emissions;

- Serving as an appointed expert representative on both the Ontario Energy Board's Gas Integrated Resource Planning (IRP) Technical Working Group and its Evaluation and Audit Committee for gas demand-side management; and
- Co-authoring the 2020 *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources* (NSPM for DERs) and its 2017 predecessor *National Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources* (NSPM for EE), as well as providing technical support to numerous state regulators, utilities and other stakeholders in applying the guidance from these manuals.

Q. Have you previously filed expert witness testimony in other proceedings before the Commission?

A. Yes. I filed testimony in the six different Illinois Service Commission (ICC) dockets (20-0477, 18-0211, 17-0311, 13-0499, 13-0495 and 10-0570), all related to electric and gas utility energy efficiency program plans and reported savings. I have also been actively involved since 2010 in the development of multi-party settlements on numerous energy efficiency program plans submitted to the ICC by all of the major Illinois gas and electric utilities, including Peoples Gas.

Q. Have you been an expert witness on energy efficiency matters before other regulatory commissions?

A. Yes, I have filed expert witness testimony more than 60 dockets before similar regulatory bodies in twelve other states and provinces.

Q. Are you sponsoring any exhibits?

A. Yes, I am sponsoring the following exhibit:

- Exhibit 2.1: Christopher Neme CV

II. PURPOSE OF TESTIMONY

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to present an analysis on the economics of electrification for many of Peoples Gas' residential customers. I also identify important regulatory policies that merit consideration given the potential for significant future electrification.

III. CONCERNS WITH PEOPLES GAS

Q. What are the results of your analysis of the current economics of electrification in Peoples Gas' service territory?

A. As Table 1 shows, electrification is a cost-effective alternative for many residential buildings in Chicago. In particular, electrification of residential single-family homes with gas forced air heating systems will lower total energy bills substantially in the very first year (last row of the table). It will also provide thousands of dollars of total cost savings over the next twenty years (the first three rows), particularly when homes fully electrify (the first two columns) and particularly for low-income households for which financial incentives from

Commonwealth Edison and the federal government (through the Inflation Reduction Act, or IRA) will cover 100% of capital costs of electrification. IRA tax credits and ComEd heat pump rebates also improve the economics for higher income households. However, even without those incentives, electrification would be cost-effective in all cases, particularly for complete electrification that enables customers to eliminate fixed monthly gas charges as well as variable costs.

Table 1: Cost Savings from Electrification of Single-Family Homes (2024 $)

	All Electric New Construction	Existing Home Full Electrification	Existing Home Heating Electrification Only	Existing Home Water Heating Electrification Only
20-Year NPVs of Total Cost Savings from Electrification (Capital + Energy)				
Low Income Households	**$24,196**	**$19,528**	**$13,276**	**$2,263**
Moderate Income Households	**$19,546**	**$12,400**	**$8,708**	**$1,388**
Higher Income Households	**$16,231**	**$9,085**	**$5,708**	**$1,248**
1st Year Energy Bill Savings from Electrification				
	$703	**$703**	**$344**	**$71**

This analysis is based on Peoples' proposed rate increase for 2024, as well as Commonwealth Edison's proposed rate increases for 2024 through 2027. However, because I did not develop my own estimates of their likely impacts, the analysis excludes future increases in gas rates that will result from Peoples' post-2024 investments in its System Modernization Plan (SMP). I would expect inclusion of future base rate increases from further SMP investments to significantly improve the cost-effectiveness of electrification.

Q: Have you conducted a similar analysis for multi-family apartments?

No, not for this proceeding using Peoples' and ComEd's proposed new rates. However, the fundamental drivers of the results of the analysis – differences in gas and electric rates, differences in gas and electric equipment efficiency, the ability to realize electricity bill savings by switching to ComEd's lower all electric rate, the ability to reduce (with space heating electrification) or to completely eliminate (with full electrification) high fixed monthly gas charges, and the availability of federal and ComEd financial incentives – are largely the same for individually-metered multi-family apartments as for single family homes. Thus, I would expect the results for apartments with their own forced air gas heating systems to be very similar – i.e., that electrification will be very cost-effective.

Q: Will electrification also reduce greenhouse gas emissions?

A. Yes, electrification will reduce greenhouse gas emissions by 35% or more in the first year, and by 50% or more as the Illinois electric grid becomes increasingly clean over the 20-year time horizon of our analysis.

Q: How is the cost-effectiveness of electrification to residential customers likely to change in the future with the adoption of additional state and/or federal decarbonization policies?

A: To the extent that Peoples and/or other gas utilities are required to bear the costs of decarbonizing their industry – e.g., through a clean heat standard, clean fuel standard, emissions cap, carbon tax and/or other policies – the customer economics of electrification will improve significantly.

Q: What are the implications of the results of your analysis?

A: The cost-effectiveness of residential electrification in Peoples' service territory – and the likelihood that customer economics will significantly improve in the future – suggests that there is potential for current and any new gas capital assets to become under-utilized, if not stranded. That, in turn, suggests that a number of changes are likely necessary to reduce risks to gas customers, including changes to the way gas assets are depreciated, subsidies for new gas connections, requirements for assessing non-pipe solutions, gas planning requirements, and other regulatory policies. Public Interest Organizations (PIO) witness Cebulko discuss some of these regulatory policies in his direct testimony.

Q: What is your recommendation to the Commission in this proceeding?

A: Consistent with Cebulko's testimony, I recommend that the Commission initiate a "future of gas" process to identify the most likely pathways to decarbonizing the current Illinois fossil gas system and the impacts that those pathways will have on gas and electric rates and bills. The Commission should fund an independent decarbonization pathways study, with significant stakeholder (including gas utility) input, as part of that process. It is important that the Commission, rather than gas utilities, fund and oversee the study, as Peoples and other gas utilities have inherent conflicts of interest. A second component of a future of gas process should be an in-depth exploration of regulatory policy changes that may be appropriate to mitigate financial risks to gas customers.

IV. ANALYSIS OF ELECTRIFICATION ECONOMICS

1. Analytical Approach and Assumptions

Q. What is the nature of the electrification analysis that you performed?

A: I analyzed the customer economics of electrifying single-family homes that currently have forced air gas heating systems in Peoples Gas service territory. By "customer economics" I mean the financial impact on the average homeowner. That includes initial and long-term changes in energy bills as well as differences between the capital costs for new electric heating equipment and appliances and the capital costs the customer would incur instead if it did not electrify and continued to use gas. The analysis assumes the electric conversions take place in 2024 and considers the net present value (NPV) of costs over the ensuing twenty years, in order to capture impacts over the life of new heating equipment and other appliances. It also computes the impacts of electrification on greenhouse gas emissions.

Q. Do most single-family homes served by Peoples Gas have forced air heating systems?

A: Yes, in 2016, Peoples had more than 330,000 customers living in single family homes. More than three-quarters of those customers had forced air heating systems.[1] I would expect the percentage to have grown since then as new homes added to the system are more likely to have central duct work, and as some existing homes add central air conditioning.

Q. What residential gas end uses did you consider for electrification?

A: The analysis focuses most heavily on space heating electrification, but also addresses water heating, cooking and drying in some circumstances. The economics and environmental impacts are addressed across four potential electrification investment decision points:

- **New construction** – all end uses are assumed to be met with electricity.
- **Existing buildings, full electrification at the time of HVAC equipment replacement** – the purchase and installation of an electric heat pump, electric heat pump water heater, electric induction stove and electric dryer at the time that an existing

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[1] Seventhwave, "Peoples Gas Light & Coke Energy Efficiency Potential Study, Program years 7, 8 and 9, March 2016 (https://www.ilsag.info/wp-content/uploads/Peoples_Gas_Potential-Study_March-2016.pdf), Appendix A.

gas furnace and central air conditioner would have otherwise been replaced (I assume that gas furnace and central air conditioner would be replaced at the same time).[2]

- **Existing buildings, space heating electrification at the time of HVAC equipment replacement** – the purchase and installation of just an electric heat pump at the time an existing gas furnace and central air conditioner would otherwise have been replaced (I assume both are replaced together); other gas appliances remain.
- **Existing buildings, water heating electrification at the time of domestic water heater (DHW) replacement** – purchase and installation of just an electric heat pump water heater at the time that an existing gas water heater would otherwise have been replaced.

These decision points are depicted in Table 2 below.

Table 2: Electrification Decision Points Analyzed

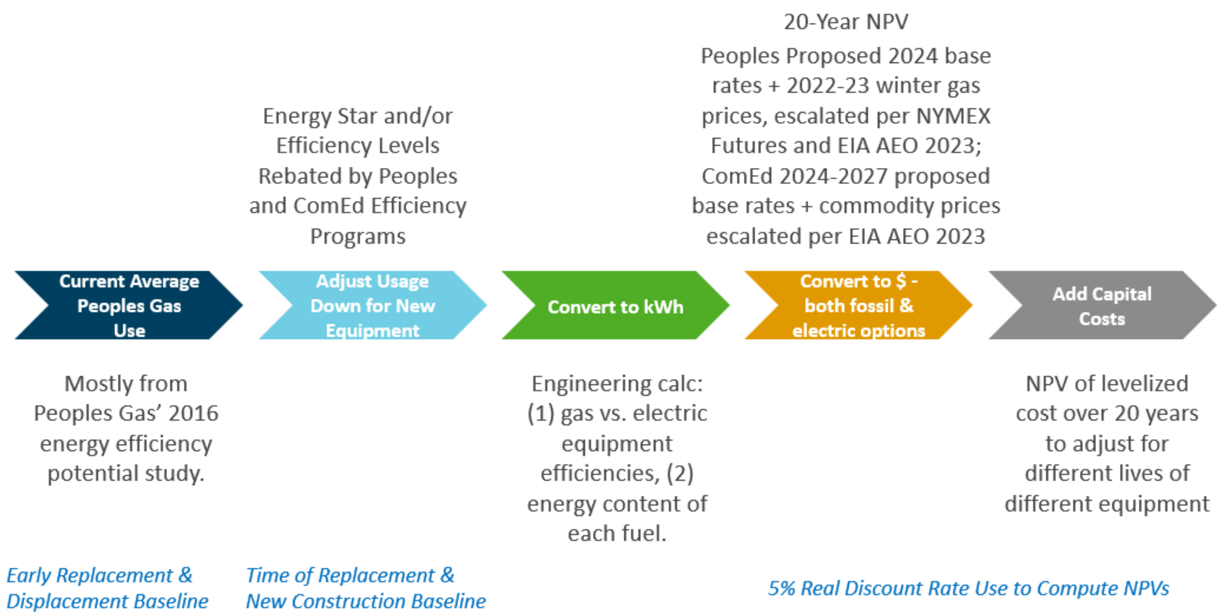
Vintage	Full or Partial Electrification	Decision Point	End Uses Addressed			
			Heating & Cooling	Hot Water	Drying	Cooking
New	Full	Design/Construction	X	X	X	X
Existing	Full	Time of Replacement - HVAC	X	X	X	X
Existing	Partial	Time of Replacement - HVAC	X			
Existing	Partial	Time of Replacement - DHW		X		

Q. How did you assess the customer economics of electrification for these decision points?

A: *Figure 1* summarizes five key analytical steps for my analysis.

[2] Not all gas heating customers also use gas for water heating, cooking and drying. Thus, not all gas heating customers would need to switch all those additional end uses in order to fully electrify and get off the gas system. However, to simplify the analysis, I assumed all three of these additional end uses are currently gas and would need to be electrified.

Figure 1: Overview of Analytical Steps for Assessment of Electrification Economics



In Step 1, I start by estimating current average annual energy consumption for heating (985 therms, plus 906 kWh for fans), water heating (233 therms), cooking (56 therms), drying (23 therms, plus 135 kWh for the dryer motor) and central air conditioning (1754 kWh) for the customers that have each of those end uses. The gas components of the estimates are based on a 2016 Peoples Gas efficiency potential study, which provides the most recently available data that breaks down Peoples' residential consumption by building and heating system type.[3] The electric components are derived primarily from engineering calculations in the Technical Reference Manual (TRM) that Peoples Gas and the other gas and electric utilities in the state use to assess the impacts of their energy efficiency programs.[4]

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[3] Seventhwave, "Peoples Gas Light & Coke Energy Efficiency Potential Study, Program years 7, 8 and 9, March 2016 (https://www.ilsag.info/wp-content/uploads/Peoples_Gas_Potential-Study_March-2016.pdf), Appendix A.
[4] 2023 Illinois Technical Reference Manual for Energy Efficiency, Version 11.0, Volume 3: Residential Measures, Final, September 22, 2022 (https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010123_v11.0_Vol_3_Res_09222022_FINAL.pdf).

In Step 2, I adjust those estimates down, as appropriate, to account for efficiency improvements that would result if a customer replaced an existing gas furnace, water heater, range/stove or dryer with a new one. I generally assume that they would buy an efficient Energy Star labeled product. For example, I assume that a new gas furnace would have an AFUE of 95% (reducing estimated annual gas consumption to 829 therms)[5] and that a new gas water heater would have an Energy Factor of 0.83 – essentially the efficiency levels Peoples is currently promoting through its efficiency programs.

In Step 3, I estimate the change in electricity consumption that would result from a customer buying an efficient new electric appliance instead of an efficient new gas one. Those estimates are based on engineering calculations that reflect both the energy content of gas and electricity, and differences in assumed efficiency ratings of new electric and new gas equipment. For example, an efficient new cold climate air source heat pump with an average annual heating coefficient of performance (COP) of 2.51 was estimated to consume 9198 kWh per year for heating when installed instead of a 95% efficient gas furnace that would have consumed 829 therms and 497 kWh.[6] I also account for reductions in electricity consumption for cooling, as cold climate air source heat pumps tend to be more efficient in cooling mode than even Energy Star rated central air conditioners.

In Step 4, I convert the estimated gas consumption (without electrification) and electricity consumption (with electrification) into energy bill impacts. The analysis accounts for both the variable volumetric component (per therm and per kWh) and fixed cost component (e.g.,

[5] We assume the average efficiency of all gas furnaces currently in use in Peoples' territory is 80%. 985 therms * 0.80 / 0.95 = 829 therms. Note that new efficient gas furnaces also have fans that consume about 40% less electricity than older furnaces. I have accounted for that improvement in my analysis as well.

[6] 829 therms * 100,000 Btu/therm * (0.95 / 2.51) / 3412 Btu/kWh = 9196 (I estimate 9198 when less rounded values are used).

monthly gas and electric charges) of a household's energy bills. Households that electrify space heating but continue to use gas for cooking or other end uses are able to switch to a lower fixed monthly gas charge; those that fully electrify can eliminate their fixed monthly gas charge altogether. For any case in which space heating is electrified, my analysis also accounts for the benefits of being able to apply ComEd's electric heating rate, which will be about 2.7 cents per kWh (including taxes) lower than its standard rate for single-family homes in 2024, to all electricity consumption in the home.[7]

In Step 5, differences between capital costs for each piece of equipment are added.[8] To account for varying lifetimes, I estimate the levelized annual cost for each piece of capital equipment, apply that annual cost to the full 20-year analysis period, and then compute the NPV of the 20-year stream of annualized capital costs. This ensures an "apples to apples" comparison of the costs of equipment with different lives. For example, when comparing a gas furnace with an assumed average measure life of 21.5 years to an electric air source heat pump with an assumed average life of 15.3 years, one needs to account for the fact that the furnace will last a little longer than my 20 year analysis period, and that the electric heat pump will need to be replaced before the end of the 20-year analysis period.

I also consider the impacts of federal rebate and/or tax incentives available for electrification investments through the recently enacted Inflation Reduction Act. I also include the efficiency program rebates offered by ComEd for all electric new construction, for low-income retrofits and for heat pumps installed in existing homes through traditional market

[7] The electric heat rate also has fixed charges that are about $2 per month higher than the standard rate. I also account for that higher fixed charge rate in my analysis.

[8] Note that for new construction, I conservatively assume that the entire cost of connecting to the Peoples Gas system is subsidized by existing gas customers.

channels (i.e., HVAC contractor sales),[9] as well as the Peoples' efficiency program rebates for 95% gas furnaces and efficient gas water heaters.[10]

Finally, I assume that existing homes will require upgrades to their electric panel. While that will certainly be true for some homes, there are many for which such upgrades will not be needed, so this is a conservative assumption.

The key inputs used in our analysis are provided in Appendix A to my testimony.

Q: What do you assume about how gas and electricity prices will change over time (in Step 4 of your analysis)?

A: For gas commodity costs, I start with the average cost over the past winter,[11] adjust those costs through 2027 based on current NYMEX monthly futures prices[12] and then use the U.S. Energy Information Administration's (EIA's) 2023 Annual Energy Outlook (AEO) forecasts of real annual price changes for the East North Central region to adjust prices for 2028 and subsequent years.[13]

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[9] ComEd's rebate for a new all electric home ranges from $3000 for homes less than 800 square feet to $5000 for homes greater than 1500 square feet (https://www.comed.com/SiteCollectionDocuments/WaysToSave/Business/ComEdEHNCBuilderBrochure.pdf). I assume the average home is on the higher end of that spectrum. ComEd also currently pays 100% of the cost of all whole building weatherization and electrification measures in low-income homes. ComEd's rebate for the most efficient centrally-ducted air source heat pumps (SEER of 18 or higher) is $2000 (https://www.comed.com/WaysToSave/ForYourHome/Pages/HeatingCoolingRebates.aspx).

[10] Peoples' rebate for a 95% efficient gas furnace is $200 (https://www.peoplesgasdelivery.com/savings/rebates-residential); its rebate for a tankless gas water heater with an Energy Factor of at least 0.82 is $150.

[11] I used the average of the monthly rates for November 2022 through March 2023 from https://www.icc.illinois.gov/natural-gas-choice/purchased-gas-adjustment-rates?refresh.

[12] Henry Hub monthly futures prices as of April 21, 2023 from https://www.teletrader.com/quickbar/nymex-futures/henry-hub?ts=1682083077260. I used the ratio of November through March Futures prices (adjusted for inflation) to Henry Hub prices for November 2022 through March 2023 from the U.S. EIA used to forecast changes in Peoples' commodity charge rates through 2027.

[13] https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2023&region=1-3&cases=ref2023&start=2021&end=2050&f=A&linechart=~ref2023-d020623a.5-3-AEO2023.1-3~ref2023-d020623a.6-3-AEO2023.1-3&map=ref2023-d020623a.4-3-AEO2023.1-3&ctype=linechart&chartindexed=0&sourcekey=0.

For gas base rates, I use Peoples' proposed rates for 2024[14] and assume that those rates do not change (in inflation-adjusted terms). It should be noted that Peoples has been investing $280 to $300 million per year in its System Modernization Plan (SMP).[15] The SMP has already added hundreds of dollars to the average residential gas heating customers[16] and is only about 35% complete.[17] Thus, completion of the SMP will likely add substantially more cost to the average bill. However, I have not attempted to quantify the annual magnitude of those additional bill impacts. Thus, my analysis excludes them. But, including future gas base rate increases resulting from further future SMP investments would likely increase the cost-effectiveness of electrification significantly.

For electric commodity costs, I start with the most recent winter and summer costs per kWh[18] and assume annual changes consistent with the 2023 EIA AEO forecast for the East North Central region. In addition, I assume that the current "carbon free energy resource adjustment", which currently reduces electricity prices by about 4.3 cents/kWh in summer months and 2.4 cents/kWh in winter months, will sunset at the end of 2027.[19]

For electric base rates, I use ComEd's proposed rates for 2024 through 2027,[20] plus current riders such as those for efficiency programs, the renewable portfolio standard, environmental

[14] PGL Ex. 7.4.
[15] Direct testimony of Theodore Eidukas, p. 8, line 168.
[16] The Peoples Gas Light and Coke Company, Safety Modernization Program, ICC 2022 4th Quarter Report, published February 14, 2023, Table 8c shows added costs from just the QIP rider of over $177; there are additional costs from the early years of the program that are not reflect in the QIP rider.
[17] Direct testimony of Theodore Eidukas, p. 8, line 170.
[18] https://www.comed.com/SiteCollectionDocuments/MyAccount/MyBillUsage/TypicalChargesSummaryResidential.pdf.
[19] https://www.comed.com/MyAccount/MyBillUsage/Pages/CFRAFAQs.aspx
[20] Docket Nos. 22-0486/23-0055, ComEd Ex 17.02.

recovery and energy transition assistance. I assume base rates grow at the rate of inflation after 2027; I also assume current riders grow at the rate of inflation.

Q: How did you assess the Greenhouse Gas (GHG) emission impacts of electrification?

A: My analysis focuses on lifecycle GHG emissions expressed in carbon dioxide equivalents (CO2e). Lifecycle emissions includes both emissions resulting from the combustion of fossil fuels and upstream (or pre-combustion) emissions associated with the extraction, processing and transportation of all fuels (fossil fuels, uranium and biomass), including fugitive emissions. The CO2e value of different greenhouse gases is computed on a 100-year global warming potential basis.[21] My estimates of both gas and electric GHG emissions is based on estimates developed by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) for the development of its Cambium model of the national, regional and state electric grids.

For fossil gas delivered directly to residential customers for space heating, water heating and other end uses, I estimate CO2e from combustion to be 117.1 lbs/MMBtu and upstream CO2e emissions of 32.1 lbs/MMBtu, for a total of 149.3 lbs/MMBtu.[22] I assume that those emissions levels remain constant over time. While it is possible that a modest portion of current fossil gas could be replaced with lower emitting gases (e.g., so-called renewable gas

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[21] Historically, many analyses have used the GWP of methane and nitrogen dioxide assessed over a 100-year period (GWP100). However, this approach underestimates the warming effects of methane in the near term. While I have used GWP100 in this analysis, it would be reasonable to also compare the 20-year global warming potential of electrification versus continued gas appliance use.

[22] Gagnon, Pieter et al (NREL), Cambium 2022 Scenario Descriptions and Documentation, Technical Report NREL/TP-6A4084916, January 2023, Table 8 on pp. 40-41 (https://www.nrel.gov/docs/fy23osti/84916.pdf). Note that the upstream or "pre-combustion" emissions rates are for natural gas burned in an electric power plant. It is my understanding that those emissions are expected to be higher for gas delivered through utility distribution systems to homes and/or businesses because of additional methane leaks through those systems and/or on the customer side of the gas meter (personal communication with Pieter Gagnon of NREL, April 24, 2023). Thus, my lifecycle emissions estimates for residential gas consumption are conservatively low.

or RNG) in the future, I am not aware of any firm commitments to do so at any significant volume. It should also be noted that if such fuel substitution were to occur at any significant scale, the costs per MMBtu of methane energy delivered to customers would increase substantially because – as discussed further below – the cost of RNG at scale will be an order of magnitude greater than the current cost of fossil gas. I have been consistent in not adjusting either emissions or cost assumptions to reflect potential changes in the type of gas delivered to Peoples' customers.

For emissions associated with electricity, I rely on NREL's forecast of long-run marginal emissions rates for the state of Illinois.[23,24] NREL provides a range of future scenarios to consider. I use their default "mid-case" scenario. The result is a lifecycle emissions rate of 965 lbs./MWh in 2024 which declines to 621 lbs./MWh by 2030 and 567 lbs./MWh by 2040.[25]

2. Economic Results

Q: What did your analysis find regarding the customer economics of electrification in Peoples service territory?

A: I have separately estimated the impacts of electrification for low-income households (those with incomes at or below 80% of Area Median Income, or AMI), for moderate-income

[23] See the NREL Cambium scenario viewer at https://scenarioviewer.nrel.gov/?project=82460f06-548c-4954-b2d9-b84ba92d63e2&mode=view.

[24] NREL provides an extensive discussion of the reasons why long-run marginal emissions rates are the appropriate rates to consider when contemplating policies or programs or long-term investments that affect electrical loads (https://www.cell.com/iscience/fulltext/S2589-0042(22)00185-7?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS2589004222001857%3Fshowall%3Dtrue).

[25] Note that NREL's forecast electric emissions rates for Illinois do not get appreciably higher in other scenarios than in the mid-case scenario forecast that I used over the 2024 to 2043 period of my analysis. For example, for the year 2030, NREL's forecast Illinois electric emissions rate in the nine other scenarios range between 43% and 113% of the "mid-case" forecast emissions rate; for the year 2035, they range between 0% and 103% of the mid-case forecast.

households (those with incomes between 80 and 150% of AMI) and for higher income households. While the magnitude of the energy bill savings from electrification are the same regardless of income level, the availability of financial incentives to defray or eliminate the capital cost of heat pumps and other electrification measures varies considerably by income. For example, the federal IRA authorized a rebate of up to $8000 for heat pumps for low-income households and up to $4000 for moderate-income households. There will be no federal rebates available for higher income households. However, IRA tax credits of up to $2000 are currently available for any household whose federal income tax liability allows them to take advantage of it. While some moderate-income households could potentially get both an IRA rebate and tax credit, I have conservatively assumed that only higher income households can utilize the tax credit. Similarly, ComEd's efficiency programs will fund the full cost of electrification for low-income households.[26] For all other households, I assume that ComEd's $2000 market rebate applies. I assume that Peoples' $200 rebate for a 95% efficient furnace and $150 rebate for efficient gas water heaters apply to all customers, regardless of income.

As

Table 3 shows, electrification of single-family homes with forced-air heating systems (i.e., with gas furnaces) is cost-effective for all four scenarios analyzed. As the bottom row of the table shows, energy bills are hundreds of dollars lower in the very first year for space heating or full electrification in either existing or new homes. And as the first three rows show, electrification can save customers literally thousands of dollars over the

[26] For low-income households I assume that the combination of federal IRA rebates and ComEd low-income program rebates would cover 100% of the capitol cost of electrification.

next twenty years even after accounting for the capital costs (as well as the energy cost savings) of electrifying. Cost reductions are most dramatic for full electrification (first two columns), and/or for low-income customers for whom the combination of federal IRA rebates and ComEd efficiency and electrification program rebates is enough to cover 100% of the capital cost of electrification measures.

Table 3: Cost Savings from Electrification of Single-Family Homes (2024 $)

	All Electric New Construction	Existing Home Full Electrification	Existing Home Heating Electrification Only	Existing Home Water Heating Electrification Only
20-Year NPVs of Total Cost Savings from Electrification (Capital + Energy)				
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1st Year Energy Bill Savings from Electrification				
	$703	**$703**	**$344**	**$71**

Q: Have you conducted a similar analysis for multi-family apartments?

No, not for this proceeding using Peoples' and ComEd's proposed new rates. However, the fundamental drivers of the results of my single-family analysis would be largely the same for individually-metered, multi-family apartments.[27] Thus, I would expect the results for apartments with their own forced air gas heating systems to be very similar – i.e., that electrification will be very cost-effective.

Q: What are the key factors driving the results for single family homes?

A: Several key factors influence these results. The following are some of the more important factors:

[27] Note that in 2016 there were more than 292,000 individually-metered, multi-family apartments served by Peoples Gas. That represented 34% of all multi-family housing units served by Peoples [Seventhwave, "Peoples Gas Light & Coke Energy Efficiency Potential Study, Program years 7, 8 and 9, March 2016 (https://www.ilsag.info/wp-content/uploads/Peoples_Gas_Potential-Study_March-2016.pdf), Appendix A.]

- **Full electrification allows customers to not only avoid volumetric gas charges, but to also avoid fixed monthly gas charges**. That is a substantial added benefit – over $580 per year under Peoples proposed 2024 rates. Even customers who electrify just space heating can realize a $265 annual reduction in fixed monthly gas charges.
- **Electric equipment is much more efficient than gas equipment for key end uses**. For example, efficient cold climate air source heat pumps are on the order of two and one-half times more efficient than even the most efficient gas furnace. Efficient heat pump water heaters are four and a half times more efficient than the most efficient new gas water heaters. These efficiency advantages offset or more than offset the fact that gas has a lower cost per unit of fuel *input*.
- **Space heating electrification enables customers to switch to ComEd's lower electric heating rate**. That electric heat rate will be approximately 2.6 cents per kWh less expensive than its standard rate in 2024 and 3.1 cents per kWh lower by 2027. Switching to the electric heat rate not only means lower costs for heating, but also for all their other uses of electricity (e.g., lighting, refrigeration, computers, TVs, etc.).
- **Efficient electric heating and water heating equipment provide other ancillary energy savings.** For example, electric cold climate air source heat pumps are typically much more efficient in cooling mode than even efficient new central air conditioners. Heat pump water heaters reduce cooling and dehumidification needs.[28]

[28] They also cause small increases in space heating needs, but those increases are smaller than the cooling savings.

- **Federal incentives from the IRA substantially reduce the cost of electric heat pumps, heat pump water heaters and other electrification investments.** This is true for all households, but particularly true for low- or moderate-income households.
- **ComEd's efficiency programs offer substantial rebates for heat pumps and other electrification measures.** While Peoples' efficiency programs offer rebates for efficient gas furnaces and efficient gas water heaters, those rebate levels are much lower than ComEd's rebates for heat pumps.

Q: Are there any important caveats about your analysis?

A: Yes. Key caveats are as follows:

- **No increases in Peoples' base rates after 2024 assumed**. As stated above, it is reasonable to expect People's base rates to continue to grow as it continues making major capital investments each year through its System Modernization Plan (SMP). My analysis does not capture those increases, or the cost savings would be greater than I have estimated.
- **Results are for the average home**. My analysis is based on the average single-family home served by Peoples Gas. However, sensitivity analyses suggest that electrification will save households money even if they consume 50% less or more than average, for space heating.
- **No building efficiency improvements assumed.** To the extent that there are cost-effective opportunities to reduce air leakage, increase insulation and/or make other efficiency improvements to a home, such investments will lower energy bills while also providing comfort and other non-energy benefits. Of course, this would be true

whether a gas-heated home continued to burn gas or whether it is electrified. However, while electrification reduces cost across a range of heating energy usage levels, cost reductions are greater for homes with lower heating loads.[29]

- **Electric panel upgrades assumed to be necessary**. My analysis is for homes for which electric panel upgrades are necessary to enable electrification. While many homes will require such upgrades, many others will not. For those that do not, the cost savings from electrification will be greater than my analysis shows.[30]
- **HVAC time-of-replacement scenario assumes both furnace and central air conditioner would otherwise be replaced together**. However, even if only the furnace or central air conditioner was going to be replaced, electrification would still be very cost-effective for all of the scenarios I analyzed.
- **5% real discount rate used for NPV calculations.**[31] Sensitivity analyses suggest that electrification is cost-effective under any reasonable assumption about the real discount rate. For example, the $5708 total cost savings for full electrification of higher income homes increases to over $6885 with a 1% real discount rate (comparable to the societal discount rate ComEd, Peoples Gas and other Illinois utilities use to assess the cost-effectiveness of their efficiency programs) and declines to about $4897 with a 10% real discount rate.

[29] More efficient homes would also enable the purchase of smaller heat pumps. However, they would also enable the purchase of smaller gas furnaces and central air conditioners for homes that do not electrify.

[30] I assume a typical electric panel upgrade cost of $2000 per the Illinois TRM. Note that federal IRA rebates will cover all of the cost of such electric panel upgrades for low-income households and half of the cost for moderate income households.

[31] Discount rates are used to assign a time preference for money. The higher the discount rate, the higher the implied preference for money this year instead of next year or any subsequent year. Real discount rates are already adjusted to remove the impacts of inflation. For example, a 5% real discount rate is equivalent to 7.1% discount rate if long-term inflation is projected to average 2% per year. Thus, a real discount rate reflects a time preference for money even if there was no inflation.

Q: How will the future adoption of policies to decarbonize the gas industry affect the economics of electrification?

A: GHG emissions caps, clean heat standards, carbon taxes and other policies commonly considered for decarbonizing the gas industry will generally make the economics of electrification much more compelling.

Q: Why is that?

A: While the gas industry sometimes touts biomethane (sometimes referred to as "renewable natural gas," or RNG) as an alternative to electrification, the reality is that the amount of RNG forecast to be available is a small fraction of current fossil gas use. For example, a recent American Gas Foundation (AGF) study found that the amount of RNG available nationally by 2040 was about 1500 to 3800 tBtu per year.[32] That represents about 5-12% of the average annual U.S. gas consumption between 2018 and 2021 and 8-19% of the portion of that average annual gas consumption that was for residential, commercial and industrial customers.[33] Similarly, a recent study for the Michigan Public Service Commission found that the amount of RNG potentially available in the state was equal to 8.5% to 22.0% of current average fossil gas use in the state's residential, commercial, industrial and vehicular

[32] ICF, *Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment*, an American Gas Foundation Study, 2019. Note that this excludes the study estimates of "power to gas" (P2G), in which electricity is used to split water into hydrogen and oxygen, with the hydrogen then being combined with a source of carbon dioxide to synthetically produce methane gas. However, even when the study estimates of P2G are included, the amount of RNG is only about 1900 to 4500 tBtu/year in 2040, or 6-15% of average annual U.S. natural gas consumption between 2018 and 2021.

[33] U.S Energy Information Administration data suggest annual average gas consumption in the U.S. averaged 30.8 thousand tBtu between 2018 and 2021, with 19.5 thousand tBtu of that being consumed in the residential, commercial and industrial sectors (https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm).

sectors.[34] Moreover, both of those estimates have been criticized by a number of parties as unreasonably optimistic.[35]

Perhaps more importantly, much of the available RNG that the studies identified as available is extremely expensive. For example, the AGF study found that the costs of some of the potential they identified would be $45/MMBtu – or about seven times the average Henry Hub price for fossil gas in 2022, and more than twenty times the average price in 2021.[36] It is important to recognize that, in a competitive market, the most expensive unit of RNG will set the market clearing price for all RNG. Put simply, in part because it is a very constrained resource, any significant commitment to RNG as part of a gas decarbonization strategy will dramatically increase the price of gas.

The alternative investment in RNG will be substantial additional forms of financial support for electrification measures. Indeed, some North American gas utilities are already offering financial incentives or financing for some forms of electrification.[37] That too would improve the customer economics and/or customer adoption of electrification.

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[34] ICF, Michigan Renewable Natural Gas Study, Final Report, submitted to the Michigan Public Service Commission, September 23, 2022 (https://www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/workgroups/RenewableNaturalGas/MI-RNG-Study-Final-Report-9-23-22.pdf?rev=213e31ab46c24ce1b799eeb8a42f0824&hash=5B8C2CEB98C8F8F20C7D65F4C4153CE1).

[35] Borgeson, M. (June 2020). A Pipe Dream or Climate Solution? The Opportunities and Limits of Biogas and Synthetic Gas to Replace Fossil Gas. Natural Resources Defense Council. https://www.nrdc.org/sites/default/files/pipe-dream-climate-solution-bio-synthetic-gas-ib.pdf

[36] https://www.eia.gov/dnav/ng/hist/rngwhhdA.htm.

[37] For example, Enbridge Gas in the Canadian province of Ontario is currently providing rebates for electric air source and ground source heat pumps (https://www.enbridgegas.com/residential/rebates-energy-conservation/home-efficiency-rebate-plus). Vermont Gas is currently promoting electric air source heat pumps and electric heat pump water heaters, in part by offering customers monthly leasing options (https://vermontbiz.com/news/2022/october/20/donnelly-vgs-embracing-heat-pump-technology and https://vgsvt.com/heatpumps/?gclid=Cj0KCQjw0tKiBhC6ARIsAAOXutkRQ4NWNMykvKaE7PLg5_wSSDMSeFDgqnqf1nlUZIPYvXOG9uCydIQaAr6MEALw_wcB).

3. Greenhouse Gas Emission Results

Q: What are the greenhouse gas emissions impacts of residential electrification?

A: As shown in Table 4, depending on the end uses electrified, residential electrification in Peoples' service territory will reduce lifecycle GHG emissions by 35% to 67% in the first year and by 52% to 76% over the next twenty years. If one were to focus on only combustion emissions (rather than lifecycle emissions), the percentage reductions are only slightly smaller. This analysis suggests electrification can play a particularly important role in decarbonizing Chicago, where buildings account for nearly 70% of citywide greenhouse gas emissions.[38]

Table 4: Lifecycle Greenhouse Gas Emission Reductions from Electrification

	All Electric New Construction	Existing Home Full Electrification	Existing Home Heating Electrification Only	Existing Home Water Heating Electrification Only
CO2e Emission Reductions				
1st Year % Reduction	38%	38%	35%	67%
20-Year % Reduction	55%	55%	52%	76%
20-Year Tons of Reduction per Hom	90	90	68	18

V. RECOMMENDATIONS

Q: What are the implications of the results of your analysis?

A: The cost-effectiveness of residential electrification in Peoples' service territory – and the likelihood that customer economics are likely to significantly improve in the future – suggests that it is likely that existing customers will begin to leave the Peoples Gas system – or at least significantly reduce gas consumption through partial electrification – and that

[38] https://www.chicago.gov/city/en/sites/climate-action-plan/home/2022-planning.html.

fewer new customers will join the system. That, in turn, would mean lower gas sales over which to spread fixed (including previously capitalized) costs, further increasing gas rates. It also means that there is potential for current and any new gas capital assets to become under-utilized, if not stranded, particularly if current economics become even more compelling as a result of future policies aimed at decarbonizing the gas system. That would create risk and exacerbate existing financial challenges for gas customers remaining on the gas system.

Q: Are there ways to mitigate that risk?

A: Yes. There are several regulatory policies that could potentially be modified to address that risk, including policies governing the way and time horizon over which gas assets are depreciated, subsidies for line extensions and new gas connections, requirements for assessing non-pipe alternatives, gas system planning and performance-based ratemaking.

Q: Do you have specific recommendations with regard to such regulatory policies?

A: No. However, Brad Cebulko of Strategen Consulting addresses several of these policies in his direct testimony.

Q: What is your recommendation to the Commission in this proceeding?

A: I recommend that the Commission initiate a "future of gas" process to identify the optimal pathways to decarbonizing the current Illinois fossil gas system and the impacts that those pathways will have on future gas and electric rates and bills. Mr. Cebulko also recommends such a process in his direct testimony.

I further recommend that the Commission fund an independent decarbonization pathways study, with significant stakeholder (including gas utility) input, as part of its future of gas process. Another component of that process should be an in-depth exploration of regulatory policy changes that may be appropriate to mitigate risk to gas customers.

Q: Do you have personal experience with statewide "future of gas" processes?

A: Yes. I was an active participant, on behalf of the Sierra Club, in the recent Massachusetts Future of Gas process.

Q: How did that process unfold?

A: That process was initiated by the Massachusetts Department of Public Utilities in a 2020 order in which it instructed the state's gas utilities to initiate "an investigation into the role of natural gas distribution companies (LDCs) in the Commonwealth's goal to achieve net zero greenhouse gas emissions by 2050."[39] As part of that effort, the gas utilities hired Energy and Environmental Economics (E3) to conduct a detailed assessment of a number of different pathways for decarbonizing fossil gas use in the state. The utilities also hired E3 and ScottMadden Management Consultants to develop a set of regulatory policy recommendations to support the energy transition. Per direction from their regulators, the gas utilities convened an extensive group of stakeholders to provide input on both studies. Literally dozens of individuals representing at least 15 different stakeholder groups participated in 14 different meetings between May 2021 and February 2022 to provide input and feedback on a draft list of decarbonization pathways/scenarios to be analyzed, and draft and final reports on both the pathways analyses and regulatory policy recommendations. The gas utilities ultimately filed both reports, along with their plans for beginning to address the

[39] https://thefutureofgas.com/overview

energy transition in March 2022. Numerous parties subsequently filed extensive comments critiquing the gas utilities' filings.

Q: Have other states also initiated "future of gas" processes?

A: Yes. A number of other states have also launched such processes. Brad Cebulko of Strategen Consulting identifies and discusses other state processes in his direct testimony.

Q: What do you consider to be the key lessons from your involvement in the Massachusetts Future of Gas process?

A: There are several key lessons from the process. First, the work that is produced from this kind of process provides the context necessary for regulators to consider the reasonableness of specific utility decarbonization proposals, such as RNG pilots or hydrogen blending pilots. It also provides the context necessary to consider the risks associated with proposed capital investments by gas utilities and a range of regulatory policies governing gas utility investments (e.g., depreciation approaches, new connection subsidies, consideration of non-pipe solutions, etc.). Put simply, regulators need to understand how proposed gas utility investments will fit into – or conflict with – the least cost, least risk pathway for decarbonizing the gas industry.

The significant involvement of stakeholders in the Massachusetts process also meant that there was significant scrutiny of key assumptions that went into the statewide decarbonization pathways study. A number of assumptions were corrected as a result. There is also more and better documentation of key assumptions – i.e., greater transparency – than I have seen in many other studies.

That said, one downside to the Massachusetts process is that the gas utilities hired, managed and oversaw the work of the study consultants and ultimately controlled final decisions on study design, assumptions, recommendations and presentation. The end result – even though the E3 study made clear that significant reductions in annual gas sales was inevitable – was a biased final work product. That is why I strongly recommend that the ICC fund and manage all consultant studies that are completed as part of an Illinois Future of Gas process. Scenarios and assumptions need to be transparent. Both gas utilities and other stakeholders should have the opportunity to review them, critique them and recommend changes. However, an independent party such as the Commission – and not the gas utilities – should have final say over how to address that input.

VI. CONCLUSION

Q: Does that conclude your testimony?

A: Yes, it does.

APPENDIX A: KEY ASSUMPTIONS FOR ELECTRIFICATION ANALYSIS

Table 5: Gas and Electric Consumption and Equipment Efficiency Assumptions[40]

End Use	Units	Existing Stock	Time of Replacement (TOR)	New Construction (NC)	Efficiency Stock-TOR/NC
Not Electrified					
Heating	therms	985	829	829	0.80 to 0.95
Cooling	kWh	1754	1500	1500	13.0 to 15.2
Hot Water	therms	233	169	169	0.60 to 0.83
Cooking	therms	56	50	50	40% to 45%
Drying	therms	23	19	19	2.84 to 3.49
Electrified					
Heating	kWh	9198	9198	9198	2.51
Cooling	kWh	1060	1060	1060	21.50
Hot Water	kWh	934	934	934	3.73
Cooking	kWh	452	452	452	n.a.
Drying	kWh	591	591	591	3.93

Note: Gas consumption also includes 110-135 kWh for dryers and 497-906 kWh for furnace fans

[40] Gas therm consumption for existing stock from Seventhwave, "Peoples Gas Light & Coke Energy Efficiency Potential Study, Program years 7, 8 and 9, March 2016 (https://www.ilsag.info/wp-content/uploads/Peoples_Gas_Potential-Study_March-2016.pdf), Appendix A. Adjustments for higher efficiency equipment upon equipment replacement based on standard engineering calculations. Electricity consumption estimates also based on standard engineering calculations from the Illinois TRM.

Table 6: Peoples Gas and ComEd Electric Charges for Residential Customers (2024 $)[41]

	Units	2024	2025	2026	2027	2028	2029	2030	2035	2040	2043
Variable Fuel Cost											
Peoples	therm	$1.057	$1.160	$1.194	$1.178	$1.167	$1.171	$1.177	$1.222	$1.249	$1.255
ComEd Elec Heat Summer	kWh	$0.111	$0.113	$0.116	$0.114	$0.153	$0.152	$0.152	$0.153	$0.155	$0.156
ComEd Elec Heat Winter	kWh	$0.117	$0.119	$0.121	$0.119	$0.141	$0.140	$0.140	$0.141	$0.143	$0.143
ComEd Non Heat Summer	kWh	$0.138	$0.143	$0.149	$0.145	$0.184	$0.184	$0.184	$0.184	$0.186	$0.187
ComEd Non Heat Winter	kWh	$0.144	$0.148	$0.154	$0.150	$0.172	$0.171	$0.171	$0.172	$0.174	$0.175
ComEd Non Heat Avg	kWh	$0.142	$0.146	$0.152	$0.149	$0.176	$0.176	$0.175	$0.176	$0.178	$0.179
Fixed Charge											
Peoples Heat	Month	$48.53	$48.53	$48.53	$48.53	$48.53	$48.53	$48.53	$48.53	$48.53	$48.53
Peoples Non-Heat	Month	$26.45	$26.45	$26.45	$26.45	$26.45	$26.45	$26.45	$26.45	$26.45	$26.45
ComEd Electric Heat	Month	$18.39	$19.95	$21.58	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00	$20.00
ComEd Non-Electric Heat	Month	$16.48	$17.91	$19.42	$18.11	$18.11	$18.11	$18.11	$18.11	$18.11	$18.11

Table 7: Initial Installed Costs, Measure Lives and Levelized Costs[42]

Fuel	Equipment Type	Notes	Initial Cost	Measure Life	Levelized Annual Cost
Natural Gas	Furnace	95% AFUE	$4,150	21.5	$304
Natural Gas	Central A/C	40 kBtuh 15.2 SEER2	$5,880	18.0	$479
Natural Gas	Water Heater	0.83 EF (2023 Energy Star)	$2,145	14.5	$201
Natural Gas	Range	"high efficiency"	$1,000	15.0	$92
Natural Gas	Dryer	3.48 CEF	$870	13.0	$88
Electricity	Heat Pump	40 kBtuh, SEER2: 21.5, HSPF2: 10.6	$9,568	15.3	$866
Electricity	Water Heater	heat pump water heater 3.73 UEF	$2,450	15.1	$224
Electricity	Range	"high efficiency"	$1,050	17.0	$89
Electricity	Dryer	3.93 CEF	$710	13.0	$72
Electricity	Electric Panel		$2,000	30.0	$124

[41] For gas base rates, I started with Peoples proposed rates for 2024 and assumed they would stay constant in inflation-adjusted terms. For gas commodity costs, I started with the average Peoples monthly gas charges for the past winter (November 2022 through March 2023), adjusted them through 2027 based on NYMEX Henry Hub monthly futures and adjusted them for 2028 and subsequent years using the U.S. EIA's Annual Energy Outlook 2023 forecast changes in gas prices for the East North Central region. For electric base rates, I used ComEd's recently proposed 2024 through 2027 rates and assumed the 2027 values would stay constant in inflation adjusted terms for 2028 and subsequent years. For electric commodity costs, I used the most recent winter and summer costs and adjusted them based on the U.S. EIA's Annual Energy Outlook 2023 forecast for the East North Central Region.

[42] Costs and measure lives for all equipment are from Leidos, EIA – Technology Forecast Updates – Residential and Commercial Building Technologies – Reference Case, presented to U.S. Energy Information Administration, March 23, 2023 (https://www.eia.gov/analysis/studies/buildings/equipcosts/pdf/appendix-a.pdf). Electric panel upgrade cost is from the Illinois Technical Reference Manual used by Peoples and other utilities in the state to estimate efficiency program savings, costs and cost-effectiveness.

Table 8: Greenhouse Gas Lifecycle Emissions Rates (lbs. of CO2e)[43]

Utility/Fuel	Units	2024	2025	2026	2027	2028	2029	2030	2035	2040	2043
Peoples Gas	per MMBtu	149	149	149	149	149	149	149	149	149	149
ComEd Electric	per MWh	965	896	828	745	661	641	621	665	567	437

[43] For gas: Gagnon, Pieter et al. (NREL), Cambium 2022 Scenario Descriptions and Documentation, Technical Report NREL/TP-6A4084916, January 2023, Table 8 on pp. 40-41 (https://www.nrel.gov/docs/fy23osti/84916.pdf). Note that the upstream or "pre-combustion" emissions rates are for natural gas burned in an electric power plant. It is my understanding that those emissions are expected to be higher for gas delivered through utility distribution systems to homes and/or businesses because of additional methane leaks through those systems and/or on the customer side of the gas meter (personal communication with Pieter Gagnon of NREL, April 24, 2023). Thus, my lifecycle emissions estimates for residential gas consumption are conservatively low. For electricity: Mid-Case scenario, LRMER CO2e (combustion + pre-combustion) metric, for Illinois from NREL Cambium scenario viewer at https://scenarioviewer.nrel.gov/?project=82460f06-548c-4954-b2d9-b84ba92d63e2&mode=view.