BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

LC 79

In the Matter of	)
	)
NORTHWEST NATURAL GAS COMPANY, dba NW NATURAL,	)
	)
2022 Integrated Resource Plan.	)
	)

REDACTED OPENING COMMENTS

OF THE

OREGON CITIZENS' UTILITY BOARD

December 30, 2022

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I. INTRODUCTION

The Oregon Citizens' Utility Board (CUB) appreciates the opportunity to comment on NW Natural's (NWN or the Company) 2022 Integrated Resource Plan (IRP) filing. This IRP comes amid a period of considerable regulatory and policy change. These changes are not only impacting the Company in the near-term, but have far-reaching implications for NWN's future operations. The IRP—with its twenty-year planning horizon—is therefore to an important document with which to asses the reasonableness of the Company's future plans. IRPs have always been important, but this one, for Oregon's largest local distribution company (LDC), is perhaps more so.

As explained below, CUB will focus much of its analysis on NW Natural's Climate Protection Program (CPP) compliance plan. CUB is concerned that the Company's CPP compliance plan is based on assumptions that are not reasonable. It is important to address and assess the assumptions baked into NWN's CPP compliance plan because the Company has indicated this proceeding will form a basis for its future planning and operations.

In these comments, CUB discusses the following:

A. The Need to Look Beyond the Action Plan
B. Emerging Technology
C. Synthetic Gas
D. Hydrogen
E. Electrification
F. Compliance Scenarios
G. Pilot Programs
H. CUB Recommendations

II. DISCUSSION

A. The Need to Look Beyond the Action Plan

CUB has participated in a large number of gas utility IRPs. Normally, our focus is primarily on the items in the action plan, which address investments over the next 2-4 years. These are generally the projects and actions that the utility asks the Public Utility Commission of Oregon (Commission) to acknowledge. Most investments beyond the action plan will be revisited in future IRPs, so they can largely be considered placeholders. In this IRP, however, CUB believes it is necessary to spend a significant amount of effort looking at the context beyond the action plan, particularly the plan and assumptions that relate to complying with the CPP over the long term. There are a two principal reasons for this:

1. To review the near-term action plan requires an understanding of the Company's plans to comply with the CPP and a critical look at how the economy will decarbonize. As Commission Staff stated in its October 7, 2022 Staff Report on the Cascade IRP update, in order to understand whether the "IRP action plan represents the least-cost, least-risk plan now requires analysis encompassing a wider range of costs, risks and benefits that are associated with a company's near- and long- term greenhouse gas (GHG) emissions and CPP compliance in general."[1] CUB supports this notion and understands the analysis in Staff's Cascade IRP report will be revisited and potentially utilized in this and other gas utility IRPs going forward.

   NWN's action plan includes replacing its Portland LNG Plant Cold Box and upgrading its Forest Grove Feeder. Both will have long useful lives, extending beyond the time that the CPP will require a 90% reduction in emissions. If the Company's plan to comply with the CPP is flawed and based on unlikely assumptions, then these long-term investments are being built on an unstable and unreliable base. This would add significant risk to customers in addition to the cost of the resources. Therefore, a review of the Company's CPP compliance pathway at this time is reasonable.

   NWN's CPP compliance plan may represent NWN's preferred path for CPP compliance, but decarbonizing the economy will necessarily encompass many decision makers and entities, many of who may have different preferred strategies. NWN's compliance plan relies significantly on new and yet-unproven technology, such as gas heat pumps and synthetic gas. This allows NWN to project lower usage without electrification and a low-cost alternative to renewable natural gas (RNG). However, if these new technologies are not available and NWN does not have an identified affordable compliance path, it is difficult to justify acknowledgement of investments that rely on assumptions and speculation about future adoption rates. In addition, NWN does not control how the economy decarbonizes. Thousands of

[1] Docket No. LC 76, Staff Final Report, October 7, 2022, page 4-5.

Oregon households who make individual energy decisions for their homes and businesses have significant control – as do municipalities, who control local development; the State Legislature that controls building codes; and the federal government, which issues appliance standards, awards tax credits, and is committed to decarbonization.

The biggest issue in all of this is electrification. If NWN's decarbonization assumptions are incorrect and it is harder and more expensive to decarbonize with natural gas, this will encourage decarbonization through electrification. Or if other decision-makers decide that electrification is the preferable strategy for decarbonization, there is the risk that there will not be the load on the system to pay for amortization of the action plan investments over the next 40 to 50 years. A review of the Company's CPP compliance pathway before these investments are acknowledged and made is therefore appropriate.

2. Decision-makers in the State need to know whether NWN's compliance plan is reasonable. CUB served on the REBuilding Task Force with NWN. NWN criticized the Task Force for not assuming its compliance with the CPP. To justify this argument, the Company asserted it NWN is required to comply with the CPP and has filed an IRP with the Commission showing that it is able to comply. However, this IRP has not yet been thoroughly vetted by stakeholders and the Commission. The Company's wants decision-makers to assume that NWN's compliance plan is reasonable and that no additional supportive policies are needed to support it.

   Essentially, NW Natural is using this IRP to conclude that efforts to decarbonize buildings and communities do not need to worry about the gas system. If the Commission believes there are doubts about NWN's compliance plan, it needs to say so. If the Commission believes that the plan represents a credible and entirely reasonable approach to compliance and that there is nothing more that needs to be done relative to decarbonizing the gas system, then the Commission should say so. The fact that the IRP has been filed with the Commission is used to give the CPP compliance plans credibility. The Commission needs to state whether the plans are credible.

   The key is to recognize that this IRP filing has become a political document that is being used by NWN. NWN has a business interest in opposing efforts to electrify buildings, whether that pertains to a local government ban on new gas hook ups or a state building code that encourages heat pumps. But decision-makers—including homeowners replacing an end of life space heating system, municipal leaders trying to achieve local climate action plans, or state legislators trying to meet Oregon GHG goals—need to know whether there are risks to relying on IRP compliance scenarios.

B. Emerging Technology

Reducing load is one of the lower cost methods to reducing emissions. If load is reduced, there are fewer emissions to reduce. If NWN's load reduction forecasts are unrealistic, it will have a much higher CPP compliance obligation in the future. CUB believes NWN is making unrealistic assumptions related to energy efficiency deployment, particularly the deployment of new technologies.

The IRP Guidelines state that a utility should "ensure that a conservation potential study is conducted periodically for its entire service territory."[2] The Energy Trust of Oregon (ETO) conducted such a study. NWN, however, believes the study under-forecasts emerging technology, so the Company dismissed the ETO study and developed its own forecast of emerging technologies. The difference between the two forecasts is not a small difference in rate of installation of the new technology, instead the difference is a fundamental disagreement about the potential for new gas technologies to reduce demand and therefore reduce emissions.[3]

1. The Role of Emerging Technology within Energy Efficiency Programs

Emerging technology has long been a significant contributor to conservation potential studies and has been a major element of energy efficiency. In the 1990's, electric utilities, working with stakeholders across the region, formed the Northwest Energy Efficiency Alliance (NEEA). NEEA is the region's vehicle for market transformation, the process of identifying emerging technologies and accelerating its adoption. NEEA looks forward at potential technologies that might fit the region, works with product manufacturers to create a supply chain for the new technologies and works with the region's utilities to create programs to support adoption of the new technologies, from the earliest adopters to adding the technology to state or national codes and standards.[4]

As NEEA's name implies, the market transformation it engages in is viewed as energy efficiency. NEEA's funding comes from utility energy efficiency budgets – in Oregon this means that utility energy efficiency programs support the Energy Trust of Oregon (ETO), which in turn provides funding to NEEA. The energy savings derived from NEEA's market transformation work is included in ETO's study results.

In this IRP, NWN treats the energy efficiency benefits from some emerging technologies as a separate element from energy efficiency programs in the ETO potential study and conducted its own projection of these emerging technologies. NWN admits that one reason it created this alternative forecast is that the level of adoption that ETO forecasts is "somewhat small."[5]

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[2] OPUC Order No 07-047, Appendix A, page 6.
[3] LC 79, NW Natural, 2022 Integrate Resource Plan, p 147 compared to page 172.
[4] We note that CUB Executive Director Bob Jenks served on the NEEA Board of Directors for three years, beginning in 2013. While this gave him a more intimate understanding of the scope and impact of NEEA's work, we do not believe it represents any conflict of interest.
[5] LC 79 CUB Opening Comments, Attachment 1.

2. Forecasting Emerging Technology

Utilities in the Pacific Northwest have had energy efficiency programs for the last 40 years and have developed methodologies to forecast energy efficiency. In this process, the first step is to identify what is technically feasible. The second step is to recognize that there are market barriers which prevent utilities from acquiring all of the resource that is included in the technical potential. An example of a market barrier is rental housing, which often separates the utility ratepayer from the equipment purchaser. The third step is to evaluate how much of the achievable potential is cost effective. The final step is to design a program to acquire the potential. This involves calculating ramp rates reflecting things like the fact that most appliances are replaced at the end of their useful life. Finally, there is recognition that once the measure becomes commonplace, it can be incorporated into codes and standards.
Here is a graphic example:[6]

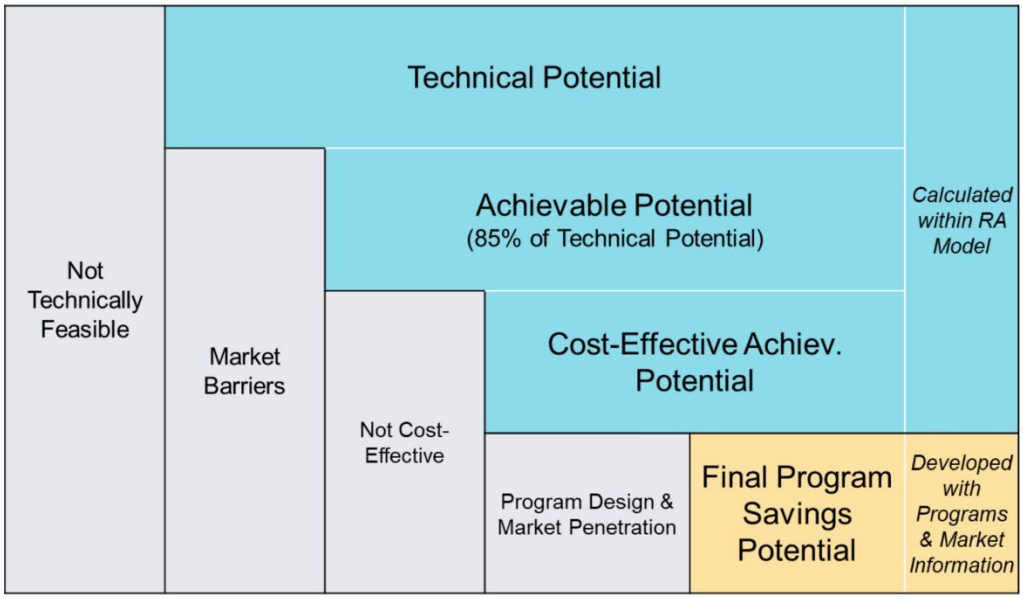


Figure 4: Types of Energy Savings Potential to Come out of Resource Assessment Modeling Process

Emerging technologies are typically subject to an additional risk factor that reduces the forecast savings based on market risk, technical risk, and data source risk. Bringing a new technology to market is complicated, requires significant investment, and often does not happen in the manner that is predicted. While energy industry insiders will look at the potential of new technologies to reduce energy demand, the market considers them based on their potential for profitability. While energy benefits might be a selling point, profitability also includes concerns about cost, quality, consumer acceptance, alternative products, branding, and marketing.

[6] Energy Trust of Oregon, Long Term Energy Efficiency Forecasting, Board Learning Paper, May 2028, Page 10, Figure 4.

In NWN's 2018 IRP, the ETO found that emerging technology was 21% of the technical potential for energy efficiency, but was just 10% of the cost-effective achievable energy efficiency forecast:[7]

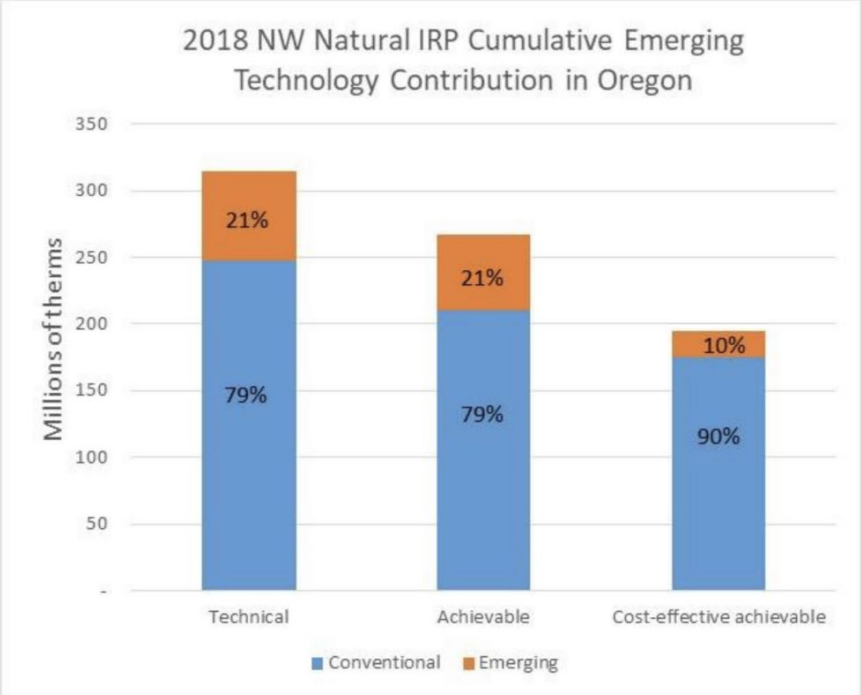


Figure 2: 2018 NW Natural IRP Cumulative Emerging Technology Contribution in Oregon

3. ETO's Emerging Technology Forecast

ETO's forecast of potential energy efficiency has increased significantly from the 2018 IRP to the current IRP, with a large part of that increase due to efficiencies gained from emerging technologies. The ETO forecasts the ***potential*** for gas heat pump water heaters as 13.11 million therms, however this is subject to a high degree of uncertainty and the ETO appropriately applies a risk factor to that potential:

> Gas heat pump water heaters constitute 13.11 million therms of the emerging technology potential. Energy Trust applies a risk adjustment factor to emerging technologies based on market risk, technical risk and data risk ranging from 10% to 90%. Gas heat pump water heaters are assigned an adjustment of 70% to account for market uncertainty. Furthermore, while the total Cost-Effective potential is 13.11 million therms, the Energy Trust deployment process allows emerging technology measures to gradually enter the marketplace and gain market share over

[7] Energy Trust of Oregon, Long Term Energy Efficiency Forecasting, Board Learning Paper, May 2028, Page 8, Figure 2.

conventional measures. The final deployed savings projection for Gas fired heat pump water heaters is 2.5 million therms over the 20-year forecast period.[8]

Meanwhile, the potential for gas heat pumps is significantly smaller, 0.45 million therms before applying a discount rate.[9] However, after applying a 75% discount rate[10] to this, it becomes a negligible energy efficiency resource.

i. Why the steep discount?

The steep discount from the cost-effective potential is not surprising. Nor is it surprising that there is a higher forecast for gas heat pump water heaters. NEEA has been actively working on acceleration of gas heat pump water heaters but has limited work with gas heat pumps.[11] NEEA has been looking at gas heat pump water heaters since 2017.[12] These are included in NEEAs 2020-2024 Business Plan and Advanced Water Heater Specification report.[13]

ETO applies a 70% discount rate to gas heat pump water heaters and a 75% discount rate to gas heat pumps. While the IRP does not provide an explanation for this, it is easy to understand. There are a variety of reasons to doubt the potential for gas heat pump technology. Currently, these products are not manufactured for mass market installation in North America. A company considering mass market production of gas heat pumps has a number of barriers to overcome:

- Rarely is there a reference to "electric heat pumps" because the term "heat pump" has come to mean electric heat pump.
- Heat pumps fueled by electricity have been on the market since the 1970s and are taking an increasing share of the market.
- The Inflation Reduction Act created $2000 tax credits and funding for state programs to provide additional support for low- and moderate-income customers to purchase and install heat pumps starting in 2023. This will increase the market share of electric heat pumps long before gas heat pumps are readily available in the marketplace.
- It will take several years before mass market gas heat pumps can fully enter the market. The NEEA approach typically begins with market research. If a product looks promising, NEEA will test the product. If it passes testing, then a pilot program can be developed, targeting early adopters. Only after finding ready acceptance for early adopters, does it really hit the mass market and it typically grows slowly over the first few years.[14]

[8] LC 79, Northwest Natural Draft IRP, page 147.
[9] LC 79, Northwest Natural Draft IRP, page 147.
[10] LC 79 CUB Opening Comments, Attachment 1.
[11] This month, NEEA announced that it is developing a market research study on gas heat pumps to determine if there should be a further investigation into gas heat pumps and the potential for a market transformation program.
[12] https://neea.org/news/emerging-natural-gas-water-heating-technology-comes-to-the-u-s
[13] https://neea.org/our-work/natural-gas
[14] See electric heat pump water heater discussion in Section 5(i) below.

- Electrification of gas products is increasingly being promoted as a solution to climate change, with the idea that gas should be used for technologies that cannot be replaced by electricity. This will influence the decision-making of customers who are purchasing space heating equipment.
- The electric system is moving to non-emitting energy at a faster rate than the gas system. By 2030, Oregon electric utilities will have to reduce emissions by 80% from a baseline that already included a fair amount of non-emitting hydroelectric generation.[15] The gas system will have to reduce emissions by 50% by 2035 from a baseline that was entirely fossil fuel.[16] From a climate perspective, gas heat pumps are likely to be viewed as a higher emitting alternative to electric heat pumps which may reduce the incentive to invest in production of this new technology.
- Cities and states are adopting electrification of buildings as a strategy to respond to climate change reducing the potential market.
- On the West Coast, California and Washington have moved significantly in the direction of electrification. With communities adopting bans on expansion of the gas network, Washington now includes heat pumps in building codes[17]. California has eliminated Line Extension Allowances (LEA) for expansion of gas networks[18]. Puget Sound Energy, the largest gas utility in Washington, has committed to eliminate its LEA[19]. The Oregon Commission has cut NWN's LEA in half over for at least the next three years in a recent general rate case decision.[20] Even if a product was manufactured, it is not clear that the West Coast market would be targeted.

These market barriers will affect investors' willingness to commit to developing gas heat pump technology in the US and could limit their focus on the West Coast as a potential market. The market barriers are large and the ETO is wise to recognize the need to apply a discount rate.

4. NWN's Emerging Technology Forecast

NWN does not accept the ETO forecast of emerging technology and proposes a different set of assumptions related to emerging technology.[21] NWN's draft IRP says little about how this was developed or why it is developing its own assumptions and forecast for emerging technologies. It also says little about the methodology that the company used. CUB asked NWN about how this was developed and NWN responded:

[15] ORS 469A.410(1)(a).
[16] OAR 340-271-8100(3)(b).
[17] https://www.thecentersquare.com/washington/washington-building-code-council-mandates-heat-pumps-in-all-new-homes/article_da78a11a-5ef8-11ed-9293-2386c56f6fbf.html
[18] https://www.utilitydive.com/news/california-puc-gas-subsidies-electrification/632006/
[19] Washington UTC, Dockets UE-220066/UG-220067 and UG-210918 (consolidated)
Settlement Stipulation and Agreement on Revenue Requirement and All Other Issues Except Tacoma LNG and PSE's Green Direct Program
[20] OPUC Order No 22-388
[21] LC 79, NW Natural's 2022 Draft IRP, p 172.

> In 2020, NW Natural surveyed 6 internal experts and the Northwest Energy Efficiency Alliance (NEEA) about expected adoption of gas heat pumps and gas heat pump water heaters. These responses were weighted to ascertain the adoption curves that were initially used in NW Natural's Carbon Neutral analysis published in 2021 and the figures used in the modeling in Docket No UM 2178.[22] Based upon stakeholder feedback in UM 2178 and feedback received during and following Technical Working Group #2 in this IRP process, these deployment figures were reduced substantially to the figure seen in the Workpapers_2022 IRP Emerging Technology.xlsx….[23]

NWN also supplied workpapers. The workpapers focus on the initial survey and how they created the initial forecast. The workpapers are revealing.

i. Initial Survey

The workpapers show that each of the six NWN internal experts and NEEA identify two cases, the less aggressive case and the more aggressive case. NEEA's less aggressive is also identified as the NEEA Current Forecast. CUB Attachments 3 and 4 shows the response from the six NWN staff and NEEA. What is strikingly obvious is there are two outliers with one being extremely outside of the forecasts of any of the others.[24] NWN had six of its own staff provide forecasts, in the chart below we label two of the NWN employees, as NWN 1, and NWN 2. Below is a comparison of the forecast in 5, 10 and 15 years.[25]

	Less Aggressive Case (NEEA Current Forecast)				More Aggressive Case			
year	NEEA	NWN 1	NWN 2	average of all 7	NEEA	NWN 1	NWN 2	average of all 7
2027	1%	33%	8%	7%	2%	70%	12%	13%
2032	4%	70%	20%	16%	11%	70%	49%	24%
2037	13%	100%	72%	33%	35%	70%	100%	44%

Today, gas heat pumps are not available in the North American market for residential homes, with the possible exception of large multi-family dwellings. One of the NWN employee's ***less aggressive*** forecasts is that in 5 years, 33% of gas installs (furnace replacements and new gas homes) will be gas heat pumps, and up to 70 % in 10 years. Based on CUB's knowledge of market transformation efforts, this is not a reasonable forecast.

NWN 1 and NWN 2 are outliers when compared to the other five forecasters. The predictions from these two employees are not reasonable, but they go a long way toward increasing the average of all seven forecasts.

[22] UM 2178 is the Commission's open Natural Gas Fact-Finding investigation.
[23] LC 79 CUB Opening Comments, Attachment 2.
[24] LC 79 CUB Opening Comments Attachments 3 and 4. While these attachments contain yellow highlighted material, CUB has confirmed with NWN that they do not contain confidential information.
[25] LC 79 CUB Opening Comments Attachments 3 and 4.

The rapid deployment proposed in NWN modeling is not consistent with market transformation. Consider electric heat pump water heaters (HPWHs), which NEEA considers a success story. NEEA had a HPWH market transformation program when Bob Jenks joined the NEEA Board in 2013.[26] Today, nearly 10 years later, 60,000 HPWHs have been sold in the region (Oregon, Washington, Idaho and Montana). The goal is to attain a market share of 30% by 2030.[27] It is expected that it will take 17 years of active programs to achieve 30% of the market.

Yet one of NWN's employees believes gas heat pumps can beat this in five years when no regional active market transformation program for gas heat pumps currently exists. Again, NWN 1 forecasts a 70% gas heat pump market share within 10 years. On December 15, 2022, NEEA announced:

> **Dual Fuel and Gas Heat Pump Market Research**.
>
> NEEA is planning a market research study for its Natural Gas efforts to gather actionable information about four emerging HVAC technologies. The objective of this study is to gather buyer and HVAC contractor perceptions and (when possible) feedback about each of the technologies. Findings from the study will complement ongoing NEEA product research to assess product performance and readiness for Northwest markets. The study will help NEEA determine which, if any, of these technologies to further investigate for market transformation or other types of energy efficiency programs in the Northwest.[28]

This shows the current state of market transformation programs for gas heat pumps. First, NEEA needs to do a market research study. This will help NEEA determine ***if*** it will further investigate gas heat pumps and then consider the possibility of a market transformation program. It is not clear how long the new market research will take or the length of time necessary for further investigation, but in CUB's experience this means an ongoing regional market transformation program is, at best, a few years away.

Consider our experience with electric vehicles (EVs). Tesla began selling new modern EVs in 2008.[29] In 2022, nationally, EVs had 6% of the market. It took EVs 14 years to achieve 6% of the vehicle market.[30] And remember, gas heat pumps are not currently available on the retail market for residential single-family homes.

Ultimately, NWN dismisses the forecast from ETO and overwhelms the forecast of NEEA, two independent sources that have a large degree of expertise in energy efficiency, emerging technology, and market transformation. It is appropriate to be skeptical of NWN's gas and dual

[26] NEEA's Market Research and Evaluation Newsletter, Quarter 4, 2022
[27] https://neea.org/img/uploads/HPWH-Success-Story.pdf
[28] NEEA's Market Research and Evaluation Newsletter, Quarter 4, 2022
[29] https://en.wikipedia.org/wiki/Tesla_Roadster_(first_generation)
[30] https://electrek.co/2022/10/18/us-electric-vehicle-sales-by-maker-and-ev-model-through-q3-2022/

fuel heat pump projections.

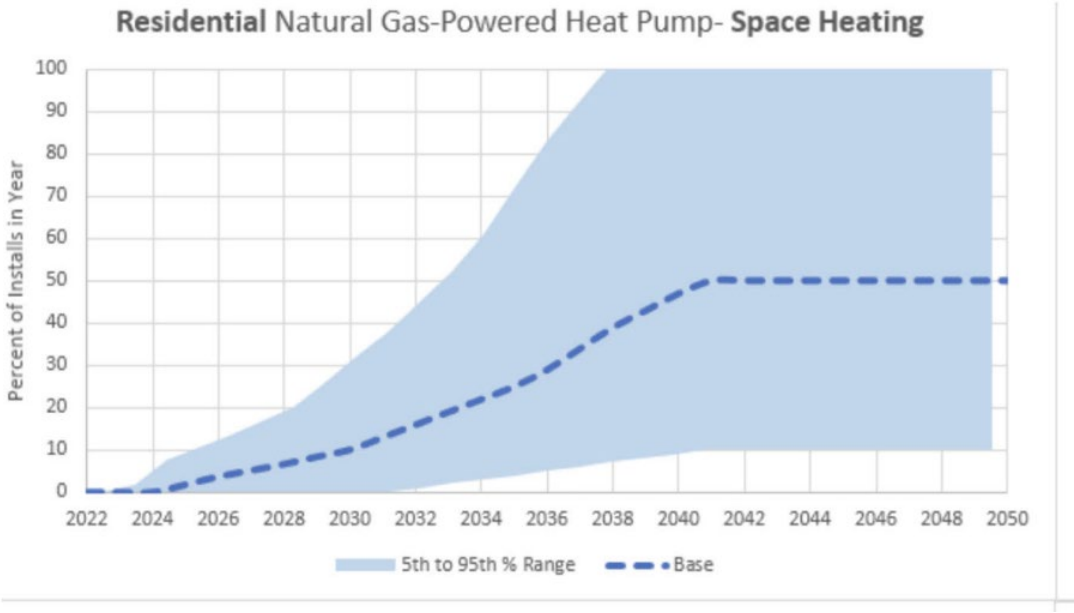
ii. IRP Forecast.

Because the forecast NWN created for gas heat pumps was criticized in the UM 2178 proceeding, NWN "substantially reduced" it to create the parameters used in the IRP.[31] NWN provides no methodology or basis other than they were responding to criticism. As a result, the IRP forecast is now below the average of the seven Less Aggressive Case forecasts, but is still substantially above the NEEA forecast:

Year	NEEA	Less Aggressive average	IRP Base
2027	1%	7%	5%
2032	4%	16%	15%
2037	13%	33%	25%

NWN's forecasts are still significantly above the forecasts of NEEA and the ETO, the entities that Oregon, the Commission, and utilities routinely rely on for energy efficiency and market transformation forecasts.

For residential space heating, the end result was this forecast from NWN:[32]



This graph shows the base and the 5th and 95th percentile. These elements are used to define the possibilities and probable distribution for the Monte Carlo methodology used by NWN.

[31] LC 79 CUB Opening Comments Attachment 2.
[32] LC 79 NWN Integrated Resource Plan, p. 172.

By ignoring the ETO forecast and creating its own, NWN is able to project a significant market transformation for gas heat pump space heating and gas heat pump water heaters. Because this analysis represents a significant reduction in load, it also represents a significant reduction in emissions and CPP compliance costs.

iii. Building Codes and Standards.

In the REBuilding Task Force, NWN has argued that because the CPP requires a reduction in gas emissions, that the Task Force should assume compliance[33]—there is therefore no need for the Task Force to consider changes to building codes and standards that would reduce building emissions from natural gas. NWN's workpapers for the emerging technology forecast include a set of assumptions, including "Code cycles will move toward Reach for GHP then mandate." Therefore, while arguing in the REBuidling Task Force that changes to codes and standards are not necessary to reducing natural gas emissions in buildings because of the CPP, embedded in NWN's CPP compliance modeling are new codes and standards designed to reduce natural gas emissions from buildings.

5. ***Emerging Technology Conclusion.***

NWN points out that:

> As can be seen in the graph, both the Median and Average installations in year 2025 are essentially zero, such that there is no meaningful assumption that any heat pumps will be deployed before the next IRP.[34]

While NWN's forecasts for gas heat pumps don't affect the Action Plan, these flawed forecasts cannot be ignored. Gas heat pumps and gas HPWH have a huge effect on load and, therefore, CPP compliance. The Commission, the Company, and stakeholders need to be realistic about how soon these technologies can be implemented.

CUB Recommendation:

The Commission should explicitly reject or not acknowledge NWN's forecast for emerging technology. In addition, the Commission should direct NWN to base its future modeling on ETO forecasts of emerging technology. To the degree that NWN does not believe ETO forecasts are accurate, it should be required to support that conclusion with more than they thought the forecast was low.

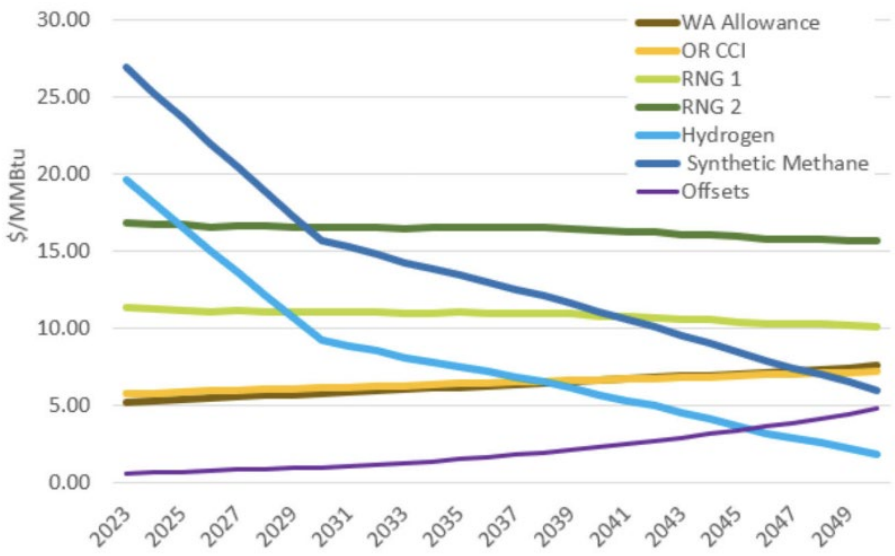
C. Synthetic Methane

The energy efficiency forecast discussed above allows NWN to forecast growing its customer count while simultaneously reducing load. But there is still a problem with the cost of compliance. RNG is expensive, and relying on it to reduce emissions will, if we assume it is

[33] https://olis.oregonlegislature.gov/liz/2021I1/Downloads/CommitteeMeetingDocument/258275
[34] LC 79 CUB Opening Comments Attachment 2, p. 2.

available, raise rates significantly. Synthetic gas allows NWN to forecast RNG as a bridge to something similar to current gas in terms of price but without the level of emissions:

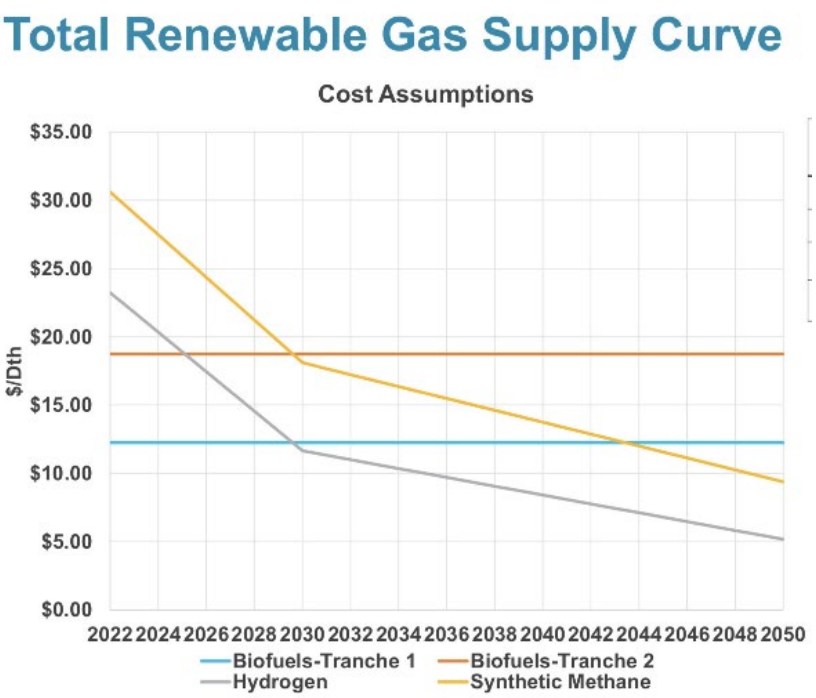
Figure 1.10: Emissions Compliance Option Cost Trajectories



Above is Figure 1.10 from NWN's IRP. We can see that the cost of the cheapest RNG (digester) is around 10.00/MMBtu, while additional RNG (thermal gasification) is above $15. After a decade of gas in the $2 to $4 range, this suggests that an RNG system for NWN will be quite expensive relative to the current gas market. Synthetic methane is forecast with a sharply falling price that ends up around $5/MMBtu. With the CPP's greenhouse gas (GHG) emissions reduction requirements phasing in between now and 2050, this allows NWN to project that it can fully comply with the CPP at a low cost.

We note that the cost of synthetic methane, hydrogen, RNG 1, and RNG 2 have all fallen as compared to what NWN was projecting during the UM 2178 process.[35] At that time, NWN was projecting synthetic methane would see its costs fall to about $10/dekatherm.[36] The cost projections utilized in UM 2178 can be seen in the figure below:[37]

[35] UM 2178 OPUC Natural Gas Fact-Finding Workshop #3 – Modeling, NWN Slide deck page 31
[36] One dekatherm is equal to 1 million Btu (MMBtu).
[37] UM 2178 OPUC Natural Gas Fact-Finding Workshop #3 – Modeling, NWN Slide deck page 31.



Synthetic Gas is made by combining hydrogen with CO_2. Hydrogen can be produced from electricity by electrolysis. Since hydrogen is not methane and can only replace a fraction of the natural gas in a pipeline (20% is often cited in literature, but a study by the California Public Utilities Commission (CPUC) suggests it is lower),[38] methanation (adding CO_2) can be used to convert that hydrogen into methane that is similar to natural gas. The price of synthetic methane will largely depend on the price of renewable electricity for electrolysis, the price of CO_2, and the operating characteristics of the electrolysis facility and the methanation facility (what capacity do they operate at, for example).

1. Is synthetic methane "clean"?

How "clean" synthetic methane is depends in part on the source of electricity for electrolysis, the source of the CO_2, and the definitions in the carbon accounting rules that are in place.[39] For example, in the UM 2178 proceeding, NWN indicated it would consider a product "clean" if it was manufactured with waste CO_2 and renewable electricity.

Much of the literature that CUB has reviewed suggests that the sources of waste CO_2 for synthetic methane would be things like electric generating plants and large industrial facilities that produce CO_2 emissions. However, just because the CO_2 would otherwise be released into

[38] https://www.cpuc.ca/gov/news-and-updates/all-news/cpuc-issues-independent-study-on-injecting-hydrogen-into-natural-gas-systems

[39] CUB remains confident that carbon accounting rules, in some form, are here to stay in Oregon.

the atmosphere if it wasn't captured, doesn't guarantee that it would be considered clean by prevailing carbon accounting rules.

Unlike carbon capture and sequestration, the carbon that is captured to be converted into synthetic methane is then released into the atmosphere when combusted at someone's home or business. A power plant that had its CO_2 captured and sequestered would be considered clean. But capturing the carbon, reusing it once and, releasing it, as contemplated in synthetic methane deployment in this IRP, has different emissions implications. There are carbon emissions associated with synthetic methane and they must be accounted for.

The original source of the carbon used for synthetic methane is the fossil fuel that powered the generating plant or the industrial customer. The question from an emissions accounting perspective is where to assign the carbon: to the generator who burned the fossil fuel but had its carbon emissions captured; or to the natural gas system that converted it to synthetic gas and sent to customers who combusted it in their homes and businesses and released it into the atmosphere? Will it be as simple as whoever pays for the cost of the CO_2 capture gets to claim the non-emitting value? These questions largely remain unanswered in the Company's long-term plan for synthetic methane deployment, which creates risk for customers.

NWN proposes to solve some of this problem by identifying RNG production as a source of captured CO_2. Presumably, if the source of the captured CO_2 is from production of renewables rather than from fossil fuels, it would be perceived as clean. This creates issues concerning the availability and price of synthetic methane, but does not fully solve the issue of whether synthetic methane is clean.

Because synthetic methane relies on carbon that is captured, it is competing against sequestration, which would keep the carbon out of the atmosphere. There is a clear benefit to sequestering carbon that has been captured from a power plant or from RNG production. It would be surprising that carbon accounting rules, government regulations or subsidies would attempt to direct captured carbon away from sequestration and that emitting captured carbon as an alternative to sequestration will be considered non-emitting. In short, NWN's reliance on synthetic methane raises outstanding questions regarding how it will be accounted from a carbon perspective. Until these questions are resolved, CUB recommends that the reliance on synthetic methane as a means to comply with the CPP should be subject to a discount rate, like ETO does to other new technology.

3. Availability and Cost.

During the fact-finding investigation, NWN stated that it believed that, in addition to being low-cost, it expects that the availability of synthetic methane from green hydrogen – hydrogen produced using non-emitting electricity – will be unlimited.[40] There are several problems with the Company's assertion:

[40] UM 2178 OPUC Natural Gas Fact-Finding Workshop #3 – Modeling, NWN Slidedeck page 31.

1. The availability of synthetic methane requires a low-cost source of waste CO_2. To the degree that is from sources like natural gas-fired power plants, as the economy decarbonizes, the amount of power generated from natural gas will decline and the available waste CO_2 will therefore also decline. This will be the case in Oregon as the electric sector undergoes changes to meet the emissions reduction mandates found in HB 2021.
2. If the source of low-cost waste CO_2 is RNG production, and the cost of synthetic methane is significantly less than RNG, as NWN forecasts, then why would anyone be using RNG? RNG and synthetic methane are both methane. They are 1-to-1 substitutes for each other. If RNG costs $10 and synthetic methane costs $5, and there is an unlimited supply of the synthetic methane, then there will no longer be a market for RNG, the production of RNG will fall and the amount of waste CO_2 from RNG will decline.
3. There will not be separate markets for RNG from digesters, RNG from thermal gasification, and synthetic methane. They are all the same thing—forms of methane that are cleaner than natural gas. Ultimately, the cost/value of these will be determined by which element is on the margin and competitive from a cost perspective. If there is enough synthetic methane to serve the market, then it will be the marginal resource and the market price/value will reflect the cost of synthetic methane. This means entities will not be purchasing digester RNG or thermal gasification RNG. If there is not enough synthetic methane and higher priced digester RNG, or thermal gasification, RNG become the marginal resource and will determine the market price/value of all three. There is no reason to believe that synthetic methane will generally be available for a low price in the market if it is not the marginal resource.
4. NWN may well assume that these are all utility-owned resources developed by NWN and sold to customers at cost, but these plants must still operate economically. If there is enough synthetic methane in Spring and Fall to generally meet demand, then the market price will reflect the cost of synthetic methane. NWN may have a choice of displacing its RNG production and buying cheaper synthetic gas on the market (economic displacement of a resource). Economic displacement of RNG will reduce production levels and increase the cost because the fixed costs of production will be spread among a lower number of units. The potential for this economic displacement of RNG increases the risk of the Company-owned production of RNG resources as part of its decarbonization pathway.
5. Waste CO_2 may not be very low cost. There may be a future price on carbon that is high enough to support carbon sequestration. NWN will then have to compete with carbon sequestration for captured CO_2. Reusing it and releasing it into the atmosphere will have an economic cost because it removes the possibility of sequestration and the CO_2 is released into the atmosphere. Let's assume that there is a future $100 carbon tax and that is enough to support carbon capture and sequestration. If the source of waste CO_2 is a power plant that uses fossil gas, then then emitting carbon costs $100/ton. Removing that CO_2 would save $100/ton and allow the carbon to be sequestered. But if the $100

value is attached to carbon removal, reusing the carbon and then releasing it again will likely cost $100 because that is the price associated with releasing carbon emissions.

6. The price of captured waste CO_2 and the cost of green hydrogen are both speculative and should be subject to wide bands of uncertainty. Because these are the two major inputs to synthetic methane, the future price of synthetic methane should have a very large band of uncertainty. NWN's IRP's base assumption that this technology will be developed and will be low-cost is highly problematic considering how little is known about its future cost.
7. Because this is a new, emerging technology, it should be subject to a discount rate to recognize that it may not be commercialized, and, if it is, it might not be at a reasonable enough price to utilize for purposes like space heating, which already have alternatives such as heat pumps. Much like emerging technology analyzed in a conservation potential study like ETO's, this technology should be subject to a discount to recognize that there are market and technological risks associated with the technology.

Synthetic methane serves a clear purpose in the IRP. It allows the Company to project a low-cost end game – a resource that is similar in cost to current natural gas and will be available in unlimited quantities. Any concerns about growing the system -- decarbonization and costs -- will be solved eventually. The Company can reduce its emissions by 90% in 2050 and still provide an affordable product to customers. The Weighted Average Cost of Gas (WACOG) in the Company's Scenario Results workpaper show that with synthetic gas having unlimited availability, the WACOG which is $4.50/MMBtu in 2022, never rises above $5.00.

CUB makes the following recommendations related to synthetic methane:

- NWN should subject its synthetic methane availability forecasts to an emerging technology discount.
- NWN should use wide bands which reflect uncertainty in creating price and quantity forecasts.

Synthetic methane should only be included in a limited number of scenarios that reflect speculative future technology and should not be included in the majority of scenarios.

D. Hydrogen

In the IRP, the Company detailed trends around the cost of expected Oregon CPP compliance resources. The Company expects that, around 2030, renewable hydrogen is expected to be the incremental resource.

NWN used third-party estimates from Lazard and Bloomberg NEF as estimates of the costs of renewable hydrogen resources. These third parties expect that the cost of hydrogen resources is expected to decline over the next decade. The economics of power to gas projects rely on the cost of associated capital costs (electrolyzer and methanation capital equipment costs), feedstock costs (renewable electricity), and the capacity factor of the power to gas facility. **(Begin**

Confidential) **(End Confidential)**[41]

NWN's Oregon service territory is served by a mixture of two large investor-owned electric utilities (Portland General Electric and Pacific Power). These two utilities serve a majority of the Company's customers. Portland General Electric and Pacific Power are vertically integrated. These electric utilities are responsible for operating and maintaining the generation, distribution, and transmission functions for electricity customers in their service territory. A smaller portion of NWN's service territory is served by publicly-owned electric utilities. The largest of these is Eugene Water and Electric Bureau, but other public power organizations, PUDs, and electric co-ops provide electricity to NWN's customers.

CUB is concerned about the risk (cost and its impact on the capacity factor of hydrogen) of procuring power for use in hydrogen production. This is a huge risk for customers since the third-party analysis demonstrates **(Begin Confidential)** **End Confidential).**[42]

There are several ways to procure electricity in the Northwest for hydrogen production. The first way is through the electric utility. Most of the communities that NWN serves are within in the service territory of Portland General Electric or Pacific Power. These investor-owned utilities have a monopoly on electricity service in their service territory. These utilities serve a variety of customers classes (residential, commercial, industrial, agricultural). If NWN were to acquire electricity for hydrogen facilities from the incumbent utilities, the hydrogen utilities would likely be subject to service under the industrial rate tariff. These tariffs are regulated, and are subject to regulated prices, with rate of return pricing.

In the IRP, NWN stated:

> [a]s the penetration of renewable generation resources increases in the region as a result of both market and policy forces, periods of curtailment (excess generation) are expected to increase in duration and frequency, and both power-to-hydrogen and power-to-methane technologies are recognized as well positioned for large scale and extended-duration storage. For NW Natural, the utilization rates of our power-to-gas facilities used for direct-use energy will likewise depend on this growing availability of low-cost electricity.[43]

If NWN were to obtain service through an investor utility, its hydrogen facility would be subject to cost-based retail rates (regulated retail generation charges), not wholesale bilateral energy costs at Mid-Columbia or Palo Verde. Under the current ratemaking framework, low wholesale energy costs are baked into the retail net variable power costs of all retail customers. If NW Natural were to acquire electricity for renewable hydrogen from the investor-owned utilities, CUB fails to see how hydrogen assets would be able to opportunistically dispatch based on

[41] LC 79 Advocate DR 7 NWN Response Confidential.
[42] *Id.*
[43] NW Natural IRP Page 203.

wholesale prices. Further, as regional utilities enter into resource-sharing and market-based programs such as the Western Resource Adequacy Program and the Extended Day Ahead Market of the California Independent System Operator, periods of curtailment are likely to be mitigated. The Company offers no citation to further its bald assertion that "periods of curtailment . . . are expected to increase in duration and frequency."[44]

The second way acquire electricity for hydrogen production is through Electricity Service Suppliers that serve the direct access market. Rather than procuring electricity through an investor-owned utility, third party power marketers can acquire electricity for a hydrogen producer in Oregon. There are several barriers to NWN participating in the direct access market for hydrogen, including transition costs adjustments, direct access caps, and program availability. NWN may also be attempting to build dedicated renewable resources to provide electricity for hydrogen projects.

The electric utility industry is going through a large renewable procurement process of renewable generating facilities. Oregon energy providers are subject to HB 2021, which requires reductions in the emissions of electricity to be non-emitting by 2040. Washington utilities are subject to the Clean Energy Transformation Act (CETA), which requires electricity by 2045 to be non-emitting. If NW Natural were to seek to acquire dedicated renewable generation facilities, NW Natural will have to compete for new renewable projects and associated transmission rights to their load with other utilities. CUB asks NW Natural to detail how it expects to procure electricity for renewable hydrogen projects.

In addition, there are concerns with how much hydrogen can be blended into the natural gas supply. The California PUC recently issued an independent study on blending hydrogen into pipelines of natural gas. The study was done to assess the feasibility and safety implications of injecting hydro into the natural gas system. The study was conducted by the University of California at Riverside and reached the following findings:[45]

- Hydrogen blends of up to 5 percent in the natural gas stream are generally safe. However, blending more hydrogen in gas pipelines overall results in a greater chance of pipeline leaks and the embrittlement of steel pipelines.
- Hydrogen blends above 5 percent could require modifications of appliances such as stoves and water heaters to avoid leaks and equipment malfunction.
- Hydrogen blends of more than 20 percent present a higher likelihood of permeating plastic pipes, which can increase the risk of gas ignition outside the pipeline.
- Due to the lower energy content of hydrogen gas, more hydrogen-blended natural gas will be needed to deliver the same amount of energy to users compared to pure natural gas.

[44] *Id*.

[45] https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-issues-independent-study-on-injecting-hydrogen-into-natural-gas-systems#:~:text=The%20Study's%20findings%20include%3A,the%20embrittlement%20of%20steel%20pipelines.

NWN's IRP generally assumes that 20% hydrogen can be blended into the pipeline without issues. However, the CPUC reports that this could create problems with customers appliances. CUB urges the Commission to be skeptical of NWN's long-term plans to utilize hydrogen on its system and looks forward to the Company addressing some of these concerns in its reply comments.

E. Electrification.

While NWN has some compliance scenarios that assume that there will be some level of electrification, isolating electrification into specific scenarios is problematic. Electrification is being heavily promoted by climate activists. The federal government has announced a federal policy of promoting electrification of homes as part of its climate agenda:[46]

> By building a clean power grid and electrifying our homes, businesses, industry, and transportation, the United States can get more than halfway to our goal of a net-zero emissions economy by 2050.

Cities, including Eugene[47] and Milwaukie[48] are looking to electrify most new residential buildings. And many of us know people who are electrifying their own homes, which suggests that early adopters are already engaged in electrification. Electrification is not a resource option that can be chosen or rejected by a gas utility as part of an IRP. It is a government policy, and a choice by builders and homeowners that impacts the gas utility.

NWN's load forecast uses historic results to project future growth in customer counts. With the exception of the scenarios that model electrification, all other scenarios assume that there will 200,000 new customers added to the system.[49] CUB believes that because the historic data comes from a period before electrification, this is not a reasonable assumption.

F. Compliance Scenarios

NWN's CPP compliance scenarios are filled with assumptions that CUB believes are unrealistic. This IRP builds its modeling on questionable assumptions about emerging technology, synthetic methane, hydrogen blending and growth in customer counts. Below we list each scenario, NWN's description, and CUB's concerns with that scenario.

1. Scenario 1 – Balanced Decarbonization

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[46] https://www.whitehouse.gov/ostp/news-updates/2022/12/14/fact-sheet-new-innovation-agenda-will-electrify-homes-businesses-and-transportation-to-lower-energy-bills-and-achieve-climate-goals/#:~:text=Supporting%20Building%20Decarbonization%20through%20Tax,for%20America's%20homes%20and%20businesses

[47] https://cleantechnica.com/2022/07/30/eugene-becomes-first-city-in-oregon-to-ban-natural-gas/

[48] https://www.kgw.com/article/tech/science/climate-change/milwaukie-to-ban-natural-gas-new-construction/283-c46fa9c6-6aaa-427f-901f-ba2f56ce7c4e

[49] LC 79, NWN Workpaper, Scenario Results

NWN describes scenario 1 as:

> Scenario 1 represents what NW Natural considers to be a balanced approach to meeting the emissions compliance obligation of Oregon's Climate Protection Program (CPP) and Washington's Cap-and-Invest program. Customer growth is based upon historical trends. It uses the energy efficiency forecasts provided by Energy Trust of Oregon for sales customers and AEG for transport customers. It also deploys a moderate amount of both natural gas heat pump technology for space and water heating and dual-fuel heating systems (electric heat pump with natural gas supplemental/backup heat). It uses our best estimate of the availability and cost of biofuel RNG and a conservative estimate of the amount of renewable hydrogen that is either blended into our system or deployed in pure hydrogen to some customers (20% of deliveries in energy terms). Key assumptions in the other scenarios are varied to be able to compare against Scenario 1.[50]

CUB comments on Scenario 1:

There are several problems with this scenario which can be seen by looking at the workpaper Scenario Results. These results include the emerging technology assumptions that we discussed above for heat pumps, and heat pump hot water heaters. NWN calls these assumptions "moderate" but they are well in excess of the forecast from the ETO. In the scenario, gas heat pumps represent 10% of installs by 2026. It projects a "conservative estimate" of hydrogen, which is four times the level that the CPUC says is generally safe. It assumes that historical growth continues with 120,000 new residential customers by 2035, in spite of the increasing expectation that there will be some electrification regardless of government policies (indeed, electrification is the policy of the federal government which is offering incentives promoting electric heat pumps). It assumes that synthetic gas is available in the later years in unlimited supply allowing for a low-cost supply. This allows a projection that the gas supply can reduce its emissions by 90% by 2050 and while the WACOG increases from $4.50/MMBtu to 4.99/MMBtu. The problematic assumptions about energy efficiency (emerging technology), supply (synthetic methane and hydrogen), and customer growth, combine to make this scenario highly unlikely.

2. Scenario 2 — Carbon Neutral

NWN describes scenario 2 as:

> Scenario 2 is the scenario meant to help answer the question "What if NW Natural reduced emissions faster and further than is required by the OR CPP and WA CCA programs?" As such, it is the only scenario that does not use NW Natural's emissions cap in Oregon's CPP program or expected activity to comply with

[50] LC 79, NW Natural Draft IRP, p 264.

> Washington's Cap-and-Invest program as the constraint for emissions. It deploys a requirement that NW Natural's emissions are zero in 2050 without the use of offsets or compliance instruments (like CCIs in OR or emissions allowances in WA). It assumes customer growth based upon historical trends. In order to meet this more aggressive emissions target it deploys a more aggressive deployment of existing Energy Trust EE programs and expected transport schedule EE programs than Scenario 1. It also assumes a more aggressive penetration of natural gas heat pump technology for space and water heating. While the cost and availability of the modeled renewable supply options is the same as Scenario 1 it allows for more pure hydrogen to be blended or dedicated to some customers.[51]

CUB comments on Scenario 2:

This scenario does nothing to correct the problematic assumptions in Scenario 1, in fact it makes some of them worse. It continues to look to the past to project customer growth, in spite of increasing policies to support electrification. It is more reliant on gas heat pumps, though they ramp up a little slower in the early years than in Scenario 1. It allows hydrogen up to 40% when the CPUC says blends above 20% present a "higher likelihood of permeating plastic pipes which can increase the risk of gas ignition."[52] With the unlimited availability of synthetic methane, this scenario purports to achieve zero emissions with the WACOG going from 4.50 to 4.98.

3. Scenario 3 — Dual-Fuel Heating

NWN describes scenario 3 as:

> Scenario 3 helps to answer the question "What could it mean for gas utility customers if dual-fuel heating (an electric heat pump supplemented by a gas furnace during cold events) becomes the primary equipment to meet heating need in NW Natural's service territory?" It utilizes the same customer growth and supply-side assumptions as Scenario 1 but assumes that by 2028 all heating equipment installations (replacement of existing equipment reaching the end of its life as well as installations in newly constructed buildings) that would be natural gas heating in the reference case become dual-fuel systems, such that by 2050 dual-fuel heating systems predominate in NW Natural's service territory.[53]

CUB Comment on Scenario 3:

This scenario assumes that dual-fuel space heating becomes the norm. CUB finds this scenario to be interesting, but it includes many of the same assumptions. Dual fuel systems combine a gas furnace with an electric heat pump. It is not emerging technology, but an application of existing technology. Scenario 3 assumes that nearly all space heating needs can be achieved

[51] LC 79, NW Natural Draft IRP, p 262.
[52] [52] https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-issues-independent-study-on-injecting-hydrogen-into-natural-gas-systems#:~:text=The%20Study's%20findings%20include%3A,the%20embrittlement%20of%20steel%20pipelines.
[53] LC 79, NW Natural Draft IRP, p 280.

through this level of electrification without this push towards electrification leading some customers to use an electric heat pump without a gas furnace. It assumes that NWN customers who live on the coast with milder winters will continue to desire gas furnaces even with a heat pump. It assumes dual fuel system for all new buildings in addition to existing buildings which means home builders will be interested in installing two space heating appliances, rather than reducing their costs by just installing a heat pump.

While CUB notes that this scenario does a good job of reducing loads and compliance obligation at a reasonable cost, there is little evidence that the utility is interested in pursuing it. There is current no mechanism in place or proposed to place dual fuel system in new homes. NWN's line extension allowance penalizes builders who put these in new buildings. Not only would builders have to pay for the cost of two space heating appliances, which increases the cost of the building by about $4000, but they lose the line extension allowance, which adds more than another $2000 to the cost of the building. For existing buildings, when the ETO's budget was approved in November, ETO discussed launching a pilot program to test dual fuel systems, but NWN had not agreed to participate. Such a pilot program will help provide data that will allow the ETO to understand the implications and costs of such a program on both the gas and the electric side. Although Cascade Natural Gas and Avista are participating, these utilities operate in colder parts of the state than NWN. Therefore, without NWN's participation, the ETO will not develop good data on how dual fuel systems impact NWN.

CUB admits that we find dual fuel systems intriguing. While we don't think they are likely to be placed in new buildings due to the cost of installing two HVAC systems, they make a lot of sense in existing buildings where someone can add a heat pump which will provide efficient cooling and heating, but use the gas furnace as back up on the coldest days. Installing these would extend the life of the gas furnace which would help NWN maintain that customer. With tax credits and government programs to help offset the cost of heat pumps, it seems like there is an opportunity to reduce natural gas heating load, reduce gas emissions, and retain the customer. But NWN has no programs to incent this and the current rules against fuel switching disincentivize it. A customer with a gas furnace who wants whole house cooling is offered a central air conditioning incentive from the ETO rather than a more efficient heat pump. This steers the customer away from the heat pump as an efficient option. With the federal government's tax credits for heat pumps, and the Inflation Reduction Act's state funding for heat pumps programs for low- and moderate- income households, we are missing an opportunity to align the ETO programs with broader energy policy. To the extent that this scenario offers some promise, NWN should be proposing programs that would build on the Inflation Reduction Act and encourage heat pumps being added to homes with natural gas furnaces. Now is the time to eliminate the fuel switching prohibition and allow energy efficiency programs that promote heat pumps for efficient cooling and to develop natural gas incentives to incent using heat pumps to reduce space heating emissions.

4. Scenario 4 — New Gas Customer Moratorium

NWN describes scenario 4 as:

> Scenario 4 helps to answer the question "What would be the implications if policy prohibited new customers from connecting to the natural gas grid?" It deploys the same demand and supply-side resource option assumptions as Scenario 1, but assumes that no new customers connect to the gas system starting in 2025. This reduces much of the energy efficiency deployed via Energy Trust programs given that much of the expected savings over the planning horizon come from new construction and conversions.[54]

CUB Comments on Scenario 4:

This scenario also contains a number of assumptions that CUB finds problematic. In this scenario, gas heat pumps represent 10% of the new installs in 2026 pushing down the load in existing building and lowering the Company's compliance obligation. Synthetic methane is cheap and plentiful in the later years, allowing the WACOG to go from $4.50 in 2022 to $4.96 in 2050. Because the Company must reduce emissions from the historic baseline associated with the CPP, NWN must reduce existing customer emissions by 50% by 2035 and 90% by 2050 and NWN must reduce emissions from new customers by 100% since they were not included in the historic baseline.

If there is no cost to reducing emissions—if emissions-free synthetic gas is essentially priced at the same price as fossil gas—then the new customer compliance obligation does not harm the system. The cheap synthetic methane would allow additional load from new customers to be met without increasing costs for existing customers, so removing new customer growth does little to reduce compliance costs on the remaining customers. However, losing the revenue from customer will reduces their contribution to joint and common costs. This produces modeling results that show that a ban on new customers raises costs on existing customers. However, if we were to remove the synthetic methane assumption and instead assume that RNG was the primary option for clean gas, then WACOG would reflect this much higher cost, and this scenario would be much different.

5. Scenario 5 – Aggressive Building Electrification and Scenario 6 – Full Building Electrification

NWN describes Scenario 5 as:

> Scenario 5 helps to answer the question "What would it mean if policy prohibited new customers from connecting to the natural gas grid and many existing customers also left the gas system to electrify?" Scenario 5 assumes the same cost and availability of renewable supply as Scenario 1 but assumes no new customers are added to the system starting in 2025, and that half of the customers who

[54] LC 79, NW Natural Draft IRP, p 287.

> replace their existing gas heating equipment in a given year choose to electrify their homes upon that decision and leave the gas system.[55]

NWN describes Scenario 6 as:

> Scenario 6 helps to answer the question "What would it mean if a policy were implemented that required homes and businesses to leave the gas system when they replaced their heating equipment?" This scenario represents the bookend of what the implications could be if the most extreme electrification policy were implemented. While rendered largely moot by the electrification assumption, this scenario assumes the same availability and cost of renewable resources as Scenario 1.[56]

CUB Comments on Scenario 5 and Scenario 6:

Scenarios 5 and 6 are designed to show what a transition to electrification of buildings would look like. They are among the costliest of all scenarios for gas customers who remain connected to the gas system, though they may be cost effective for the customers who leave the system. Again, as in Scenario 4, some of this comes from the assumption that complying with the CPP is inexpensive due to synthetic gas and hydrogen, so the benefits of reducing compliance through the load reduction associated with electrification is minimal. The modeling does show one very real issue. As electrification increases, much of the cost on remaining customers is not associated with compliance, but instead is the cost of the existing –and growing – system of pipelines. In scenario 6, 90% of the customers leave the NWN system, and the remaining 10% have to pay for the full costs of the system. CUB is very concerned about how the stranded costs of the gas system will fall on existing gas customers. This risk needs to be examined when considering new capital investments in the gas system.

In addition, to the degree that, as customer electrify, some part of the gas system becomes fully stranded (no longer used and useful) then there are ratemaking issues associated with the stranded equipment. This also implicates the useful life and depreciation curves for capital investments. For example, it may be beneficial for more of the capital investment to be recovered earlier when the customer base is larger.

Finally, there are also some questionable assumptions embedded in this scenario. This scenario eliminates energy efficiency programs. While it makes sense to eliminate programs aimed at new buildings, if the scenario does not have new buildings connected to the gas system, energy efficiency programs aimed at making existing buildings more efficient are still helpful to the customers who live in those buildings. This scenario also eliminates dual fuel systems, but if there is electrification happening in existing buildings, then heat pumps (electric) are likely being added. Some customers will likely retain their existing gas furnace for the coldest days of the year.

[55] LC 79, NW Natural Draft IRP, p 316.
[56] LC 79, NW Natural Draft IRP, p 323.

6. Scenario 7 — RNG and H2 Policy Support

NWN describes Scenario 7 as:

> Scenario 7 answers the question "What would it mean if there were federal policy support for renewable natural gas and renewable hydrogen that reduced the cost of these resources to gas utility customers?" This scenario assumes a federal production tax credit of 30% for RNG and H2 similar to policies to support renewable electricity generation. It is assumed that this reduction in the price of these resources also results in a moderate increase in the availability of biofuel RNG. The customer growth demand-side resource assumptions in this scenario are the same as Scenario 1.[57]

CUB Comments on Scenario 7:

Scenario 7 has the same assumptions that CUB has criticized concerning load growth and emerging technology. The reductions in the price of green hydrogen embedded in this scenario push hydrogen costs even lower. Because the costs on the supply side are lower, this scenario purchases more supply-side resources and fewer demand side resources. And this scenario brings in 30% hydrogen which lowers costs but is well above what the CPUC says is safe.

7. Scenario 8 — Limited RNG

NW Natural describes Scenario 8 as:

> Scenario 8 helps to answer the question "What are the implications if biofuel RNG is less plentiful and more expensive than expected?" This scenario assumes a low resource potential for biofuel RNG (roughly half of the resource assumed in Scenario 1) at a higher cost than can be seen in current markets, and that less hydrogen can be delivered to customers via a combination of blending and dedicated delivery to some customers. Customer growth and demand-side resource assumptions in this Scenario Care the same as Scenario 1.[58]

CUB comments on Scenario 8:

Scenario 8 uses the same questionable assumptions about load growth continuing historic patterns. However, by limiting hydrogen blending to 12%, rather than assuming 20% to 40%, this scenario may have more realistic assumptions about hydrogen. Yet, this scenario still has questionable assumptions about synthetic methane, which NWN presumes is relatively cheap with unlimited availability and this keeps the 2050 WACOG below $5/MMBtu.

8. Scenario 9 – Supply Focused Decarbonization

[57] LC 79, NW Natural Draft IRP, p 331.
[58] LC 79, NW Natural Draft IRP, p 339.

NWN describes Scenario 9 as:

> Scenario 9 helps to answer the question "What would it mean if less load can be reduced than is expected?" This scenario assumes less energy efficiency can be achieved than Scenario 1 and assumes that natural gas heat pump technology never becomes available in NW Natural's service territory. This assumption results in a great need for renewable supply to meet the emissions requirements of the OR-CPP and WA-CCA programs. It assumes the same customer growth and price and availability of renewable supply sources (RNG, H2) as Scenario 1.[59]

CUB Comments on Scenario 9:

While CUB agrees that scenarios which do not assume gas heat pumps are useful, this scenario contains many of the same questionable assumption that customer growth will continue as it historically had in spite of a great deal of support for electrification, including federal tax incentives and policies. This scenario also assumes that 35% of the system can run off hydrogen which conflicts with the study for the California PUC mentioned above. It assumes synthetic methane is cheap and plentiful allowing the WACOG to increase from 4.50 to 5.00 between 2022 and 2050. Less energy efficiency is not a problem if hydrogen is really cheap, and a utility can blend at 35% and synthetic methane is cheap and unlimited. However, the assumptions used to demonstrate the availability and level of inexpensive hydrogen contain varying degrees of uncertainty.

Ultimately, CUB found that all of the scenarios had unrealistic assumptions about demand, supply, and/or energy efficiency.

9. Scenario Recommendations:

CUB makes the following recommendations that the Commission should require NWN to adopt before next year's IRP Update:

- The ETO forecast for emerging technology should be the base for NWN projections and should be included in most scenarios. NWN can include higher levels in some scenarios to establish what may happen if these technologies overcome their market barriers. In addition, NWN should ensure that it is using reasonable ramp rates for emerging technologies.
- NWN should be required to hire an independent third-party to supply electrification projections – maybe a high, medium and low projections. Just as utilities have used independent third-parties to project conservation potential, carbon regulation/prices, and EV penetration, there can be a benefit from independent source of information. This should be used to create a new forecast (or set of forecasts) for new customer growth and existing customer retention.

[59] LC 79, NW Natural Draft IRP, p 347.

- NWN should subject its synthetic methane availability forecasts to an emerging technology discount. It should use wide bands which reflect uncertainty in creating price and quantity forecasts and it should include more scenarios that do not include synthetic methane as a cost effective, non-emitting resource.
- NWN should limit methane to 5% in some of its scenarios and should provide for wider bands of uncertainty on the cost and availability of green methane.

G. Pilot Projects

Recently, NWN proposed two public pilot projects.

The first project is the Carbin-X program. In this project, Canadian Company CleanO2's Carbin-X unit directly captures carbon dioxide (CO_2) emissions at the point of combustion and converts the CO_2 to the raw material potassium carbonate.[60] The second project is the Modern Electron program that would convert methane into hydrogen and solid carbon. NWN and Modern Electron signed an agreement that would allow the technology to be tested on NW Natural's system.[61] It is CUB's understanding that hydrogen facility will be built at the Company's Central Portland facility.[62]

Earlier this year, NWN created a subsidiary called NW Natural Renewables. NW Natural Renewables operates separately from NWN's own procurement of RNG and hydrogen. NW Natural Renewables' business is developing new RNG projects, which does not occur within the regulated utility. Unlike other developers in the RNG space, NWN appears to be targeting small to medium sized development projects.

In NWN's Quarter 3 2022 earnings call, the Company's executives talked with equity analysts about these pilot programs. During the earnings call, NWN's executives were asked if these pilot programs would lead to investment opportunities inside the regulated utility or outside the regulated utility. NW Natural indicated that while the focus was one decarbonizing their core utility business, CEO David Anderson said "[t]he more we learn about [these pilot programs], just like we learned about RNG in the utility business, I think it will provide opportunities outside the utility."[63] CUB is concerned that ratepayer resources may be used as venture capital to develop NW Natural Renewable's business. Since NW Natural Renewables is an unregulated subsidiary, this is troubling.

While NW Natural is the largest LDC in Oregon, CUB does not agree that it is NW Natural's role to prove the effectiveness of new technology. NW Natural is not a research institute, a

[60] https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/nw-natural-tees-up-carbon-capture-pilot-advances-renewable-gas-initiatives-72931608
[61] https://www.businesswire.com/news/home/20220727006176/en/NW-Natural-to-Partner-with-Modern-Electron-on-Exciting-Pilot-Project-to-Turn-Methane-into-Clean-Hydrogen-and-Solid-Carbon
[62] *Id*.
[63] NW Natural Holdings Reports Third Quarter 2022 Results November 8, 2022.

national energy laboratory, or an extremely large natural gas utility with a huge customer base. New technology comes with inherent risks, and NWN's core customer base should not be exposed to risks taken by an unregulated subsidiary. Under the CPP, NWN is required to comply with state carbon emissions. New emerging technology such as carbon capture technology and hydrogen projects discussed above have significant fixed costs. The cost curve for these new technologies are expected to decline over time. It is not NW Natural's role to "prove" emerging technologies for the natural gas system. The Company should be focusing on low regret, low risk, and least risk options for complying with CPP, when evaluating supply side resources spending. Indeed, that is a core goal of the IRP. Other, larger utilities and research organizations are testing these facilities and technologies.

CUB specifically asks NW Natural to justify spending ratepayer funds on these pilot projects, which are conspicuously absent from this IRP. CUB also recommends that NW Natural include details about expected pilot programs in the action plan of IRP's or IRP updates prior to signing up for new pilot programs.

CUB's Recommendation:
CUB recommends that the Commission require NW Natural to justify future pilot programs in future IRP's around RNG, hydrogen, and carbon storage projects.

III. CONCLUSION

CUB appreciates the opportunity to comment on NWN's IRP. CUB recognizes that this is the first IRP since the DEQ established the Climate Protection Plan. We know that NWN has put a lot of work into developing this plan. However, the plan is built on assumptions that are not credible.

CUB recommends that the Commission find that this IRP does not show a plausible pathway to complying with the CPP. We believe that the Commission should order NWN to make the following changes to its modeling before the IRP Update:

- The ETO forecast for emerging technology should be the base for NWN projections and should be included in most scenarios.
- NWN should be required to hire an independent third-party to supply electrification projections.
- NWN should subject its synthetic methane availability forecasts to an emerging technology discount. It should use wide bands which reflect uncertainty in creating price and quantity forecasts.
- NWN should limit synthetic methane to 5% in some of its scenarios and should provide for wider bands of uncertainty on the cost and availability of green methane.

With regards to pilot programs, CUB makes the following recommendation:

- CUB recommends that the Commission require NW Natural to justify future pilot programs in future IRP's around RNG, hydrogen, and carbon storage.

Finally, with regards to the actions in the Action Plan:

- CUB is unable to recommend acknowledgement at this time. This is due to the fact that making significant investments without having a credible plan to comply with the CPP creates risk on customers. Many of the elements in the action plan seem sensible to CUB: recalling Mist storage, replacing the cold box, scoping demand response programs, and initiating energy efficiency programs for transportation customers. But our hesitancy comes from our discomfort with acknowledging millions in new investment without a full understanding of how that investment fits with a credible plan to comply with Oregon GHG rules.

Dated this 30th day of December, 2022.

Respectfully submitted,

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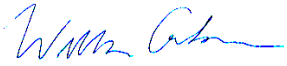

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LC 79– CERTIFICATE OF SERVICE

I hereby certify that, on this 30th day of December, 2022, I served the **Confidential Opening Comments of the Oregon Citizens' Utility Board** in docket LC 79 upon the Commission and each party designated to receive confidential information pursuant to Order 22-444 through a secure, encrypted attachment to an e-mail.

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Dated this 30th day of December, 2022.

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LC 79
Integrated Resource Planning
Data Request Response

Request No.: LC 79 CUB IR 4

4. Refer to Page 172, Figure 5.26 of the IRP, Assumptions on Emerging Technology Adoption Over Time. P. 172 says that this is an assumption used in its "both its reference case and scenarios"

a. Please confirm that this forecast of natural gas heat pumps and natural gas heat pump hot water heaters is included in the reference case.

b. Is this assumption used in all scenarios? If not, please identify which scenarios include this assumption and which do not include this assumption.

c. Provide all analysis that the ETO has provided NWN on emerging technologies in the last 5 years.

d. Footnote 98 discusses emerging technology and the risk adjustment factor the ETO applies to emerging technology such as natural gas fired heat pump hot water heaters: "while the total Cost-Effective potential is 13.11 million therms, the Energy Trust deployment process allows emerging technology measures to gradually enter the marketplace and gain market share over conventional measures. The final deployed savings projection for Gas fired heat pump water heaters is 2.5 million therms over the 20-year forecast period." Are the graphs in Figure 5.26 consistent with:

i) the ETO forecast of 13.11 million therms over 20 years,
ii) the risk adjusted 2.5 million therms over 20 years, or
iii) neither of the two?

e. If neither of the two, please explain how the forecast of gas fired heat pump water heater was developed.

f. The ETO cost-effective potential over 20 years for natural gas fired heat pumps is 0.45 million therms, before applying a risk adjustment factor. What is the risk adjustment factor that the ETO applies to natural gas heat pumps?

Response:

a. No, the statement quoted is incorrect. The reference case does not include an assumption of an *incremental* deployment of any of the emerging technologies shown in Figure 5.26 beyond what is included in the reference case, which includes the forecast provided for the IRP by the Energy Trust of Oregon (ETO). Given that the ETO forecast for (i) gas heat pump technology is focused on water heating and at levels that are somewhat small, and (ii) dual-fuel/hybrid heating

systems are not evaluated in the ETO forecast, adoption of these technologies is assumed to be incremental to the ETO forecast.

b. Figure 5.26 includes a range of installations for each shown emerging technology, so NW Natural interprets “this assumption” to ask “do the non-reference scenarios fall within the ranges in Figure 5.26?” The answer is yes. The penetration of equipment in each scenario is described at a high level in Table 7.3 (page 255 of the errata 2022 IRP), where more detailed information about installations and what that means for stock in the customer base in the scenario are found in the key inputs and results booklets of each Scenario found in section 7.4 (pages 258-345). Exact figures for each scenario and draw can be found in the Workpapers_2022 IRP Monte Carlo Customer Counts, Equipment Penetration, and Usage Coefficients.xlsx and Workpapers_2022 IRP Emerging Technology.xlsx workbooks found on NW Natural’s workpapers provided to stakeholders on the FTP site.

c.&d. All long-term planning analysis provided to NW Natural by ETO prior to the filing of the its 2022 IRP is included in its IRPs or IRP updates. From stakeholder review of NW Natural’s draft IRP distributed prior to filing the IRP a question similar to (d) was asked by a stakeholder in Washington. In response to that request ETO developed a workpaper that addresses this issue that was provided to NW Natural shortly after filing of the 2022 IRP. It is included as Attachment 1 to this response. Per the answer to (a) above, the answer is that ETO’s forecast is consistent with the reference case in NW Natural’s IRP, and that any incremental adoption, which is detailed in Figure 5.26 is above and beyond the ETO forecasted figures. Between residential and commercial gas heat pump technology and hybrid systems ETO’s forecast in the reference case, ETO projects savings from only gas heat pump water technology, with a risk-adjusted forecast of 2.5 million therms over a 20-year planning horizon. For framing, NW Natural’s deliveries are roughly 1,200 million therms per year.

e. For the forecast provided by ETO used in the reference case ETO provided the following:

a) The 13.11 million therms of gas heat pump water heater savings are the 20-year risk adjusted cost-effective achievable total and not the Energy Trust 20-year savings forecast. Energy Trust decrements the cost-effective achievable potential in the deployment process by applying emerging technology ramp rates described in the supporting excel workbook “NWN 2022 IRP_measure level detail and ramp rates_upper bound”, resulting in a forecast of 2.5 million therms over the 20-year forecast period. The deployment process allows conventional efficient equipment to satisfy market share left vacant by the emerging technology ramp rate such that the annual number of efficient equipment installs remains constant. The emerging technology ramp rate sets the market share assumption for emerging technologies over time. The gas fired heat pump

technology ramp rate in year one (2022) is 0.1% and increases to 15.5% by the end of the forecast period (2041).

The potential for gas heat pump adoption beyond the forecast provided by ETO was discussed at NW Natural's 4th Technical Working Group (TWG) stakeholder workshop from via two third party presenters- The Northwest Energy Efficiency Alliance (NEEA) and the Gas Technology Institute (GTI). The presentation is posted on NW Natural's website and can be found here, where NEEA's and GTI slides are from slides 127-159. Additionally, the TWG was recorded and the presentations can be found on the recording on NW Natural's website. The presentations run from the 1:01-1:54 mark of the afternoon session of the TWG found here. Using the information from these 3rd parties NW Natural developed the adoption potential curves shown in Figure 5.26. It is of note that the original adoption curves presented by NW Natural at TWG 4 were scaled back in response to stakeholder feedback.

f. From ETO: *"The ETO risk adjustment factor for residential gas fired heat pumps is 75% and 60% for commercial gas fired heat pumps."*

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LC 79
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Data Request Response

Request No.: LC 79 CUB IR 6

6. Refer to Figure 5.26 on Page 176 of the IRP.
a. Please describe the methodology that NWN used to create these adoption forecasts for Gas Heat Pumps and Gas Heat Pump Hot Water Heaters.
b. Please provide all workpapers associated with this forecast.
c. The shaded areas in the 5.26 graphs are labeled, the "5th to 95th % range. Please explain how NWN identified this range.
d. The graphs' dotted lines are identified as "the base." Please describe how the base is used in the IRP load forecast.
e. To the degree that these forecasts are based on forecasts supplied by a third-party (or third-parties), please provide those third-party forecasts, including any potential ranges or alternative forecasts provided by those third-parties.
f. To the degree that these forecasts are based on forecasts supplied by a third-party (or third-parties), please provide the credentials of that third-party.
g. Please provide all correspondence with these third-parties associated with these forecasts.

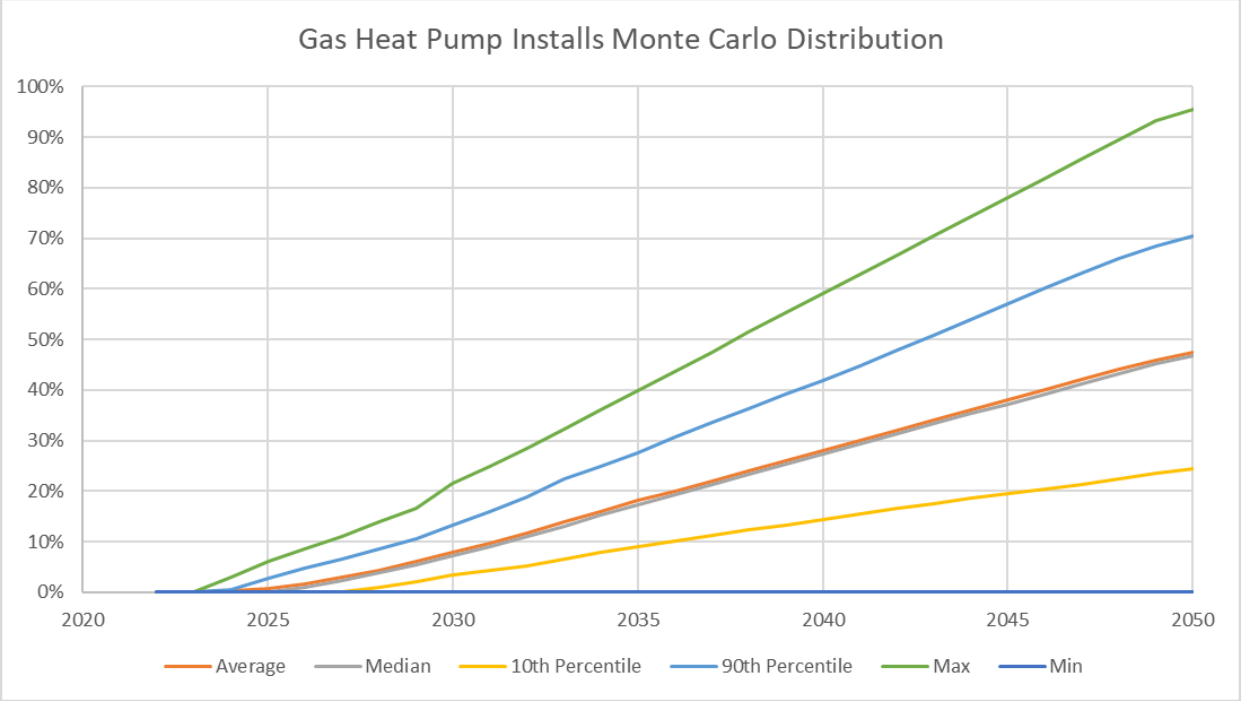
Response:

a. In 2020, NW Natural surveyed 6 internal experts and the Northwest Energy Efficiency Alliance (NEEA) about expected adoption of gas heat pumps and gas heat pump water heaters. These responses were weighted to ascertain the adoption curves that were initially used in NW Natural's Carbon Neutral analysis published in 2021 (see https://www.nwnatural.com/about-us/the-company/carbon-neutral-future) and the figures used in the modeling in Docket No. UM 2178. Based upon stakeholder feedback in UM 2178 and feedback received during and following Technical Working Group #2 in this IRP process, these deployment figures were reduced substantially to the figures seen in the Workpapers_2022 IRP Emerging Technology.xlsx and Workpapers_2022 IRP Monte Carlo Customer Counts, Equipment Penetration, and Usage Coefficients.xlsx workbooks found in NW Natural's workpapers provided to stakeholders on the FTP site.

b. Please see Confidential LC 79 CUB IR 6 Confidential Attachment 1.

c. NW Natural looked at the range of responses in the survey process detailed in (a) to assess the uncertainty around incremental deployment of these technologies to develop the ranges seen in Figure 5.26.

d. "Base" assumptions are those developed from the survey process detailed in (a) that are used to help define deployments across scenarios and stochastic draws. The deployment of each technology in each scenario and in each stochastic draw can be found in the Workpapers_2022 IRP Emerging Technology Workbook. As the Action Plan is based upon the distribution across the stochastic draws in the Monte Carlo Simulation process they are most important to understanding the implication of the deployment of these technologies in the IRP analysis. The gas heat pump installation distribution across the 500 Monte Carlo draws included in the workbook provides the following result:



As can be seen in the graph, both the Median and Average installations in year 2025 are essentially zero, such that there is no meaningful assumption that any heat pumps will be deployed before the next IRP.

e. Third-party forecasts are included in Confidential LC 79 CUB IR 6 Attachment 1.

f. Information about NEEA and GTI can be found on their websites at www.neea.org and www.gti.energy. Both NEEA and GTI presented information on these technologies at Technical Working Group #3.

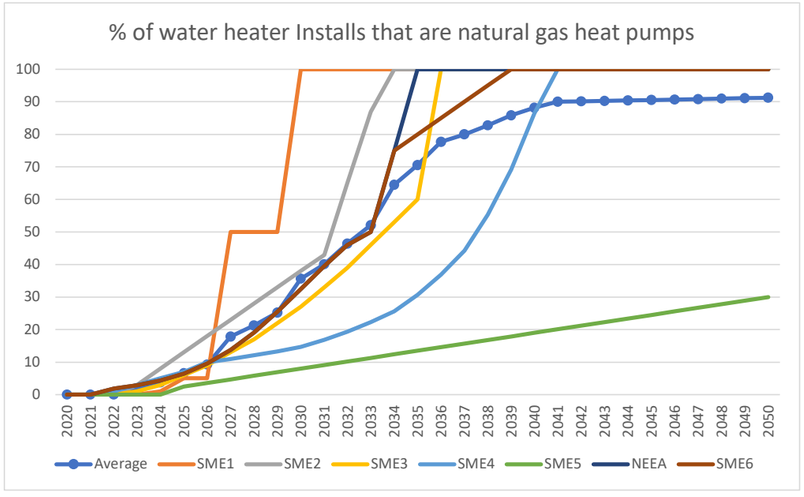
g. While the actual correspondence is no longer accessible to the Company, NW Natural asked NEEA to populate the blank workbook in LC 79 CUB IR 6 Attachment

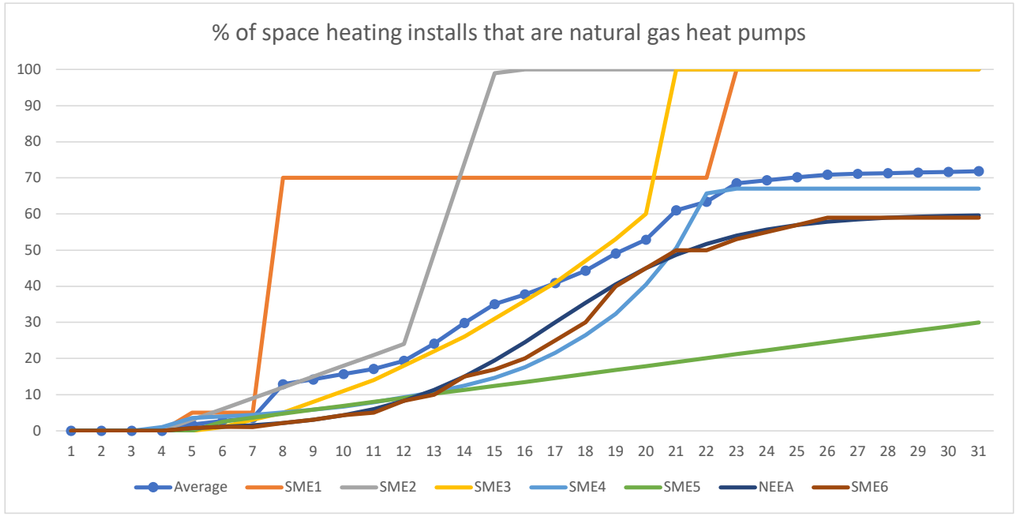
2. NEEA provided the tab labeled “NEEA work” in Confidential LC 79 CUB IR 6 Attachment 1 in response, and this is what was used to help define the forecasts in the analysis in the 2022 IRP.

Supplemental Response:

b. NW Natural is supplementing this response to add a non confidential version of CUB DR 6 Attachment 1.

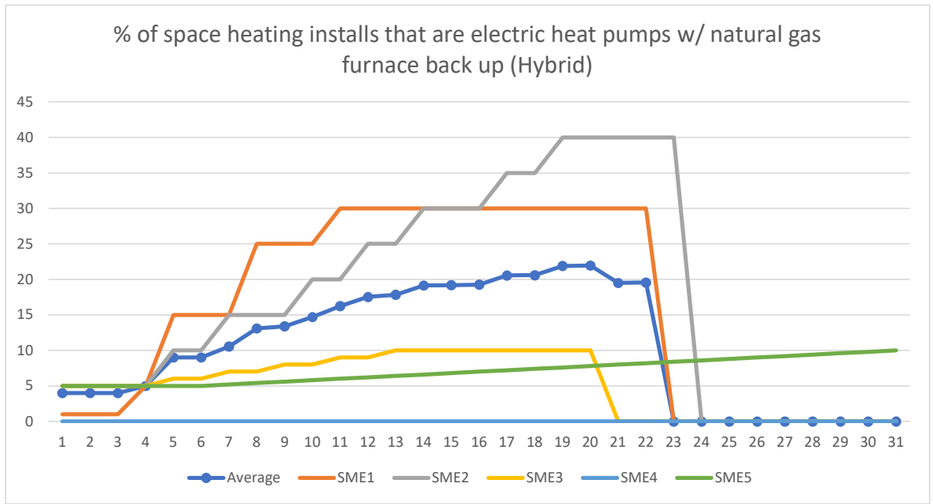
Year	% of water heater Installs that are natural gas heat pumps									% of space heating installs that are natural gas heat pumps				
	Average	SME1	SME2	SME3	SME4	SME5	SME6	NEEA		Average	SME1	SME2	SME3	SME4
2020	0	0	0	0	0	0	0	0		0	0	0	0	0
2021	0	0	0	0	0	0	0	0		0	0	0	0	0
2022	0	0	0	0	1	0	2	2		0	0	0	0	0
2023	2	0	3	1	3	0	3	3		0	0	0	0	1
2024	4	1	8	3	5	0	4	4		2	5	3	0	4
2025	7	5	13	6	7	3	7	7		3	5	6	1	4
2026	9	5	18	9	10	4	10	10		4	5	9	3	4
2027	18	50	23	13	11	5	14	14		13	70	12	5	5
2028	21	50	28	17	12	6	19	19		14	70	15	8	6
2029	25	50	33	22	13	7	25	25		16	70	18	11	7
2030	36	100	38	27	15	8	33	33		17	70	21	14	8
2031	40	100	43	33	17	9	40	40		19	70	24	18	9
2032	46	100	65	39	19	10	46	46		24	70	49	22	11
2033	52	100	87	46	22	11	50	50		30	70	74	26	12
2034	65	100	100	53	26	12	75	75		35	70	99	31	15
2035	71	100	100	60	31	14	80	100		38	70	100	36	18
2036	78	100	100	100	37	15	85	100		41	70	100	41	22
2037	80	100	100	100	44	16	90	100		44	70	100	47	26
2038	83	100	100	100	55	17	95	100		49	70	100	53	32
2039	86	100	100	100	69	18	100	100		53	70	100	60	40
2040	88	100	100	100	86	19	100	100		61	70	100	100	51
2041	90	100	100	100	100	20	100	100		63	70	100	100	66
2042	90	100	100	100	100	21	100	100		69	100	100	100	67
2043	90	100	100	100	100	22	100	100		69	100	100	100	67
2044	90	100	100	100	100	23	100	100		70	100	100	100	67
2045	91	100	100	100	100	25	100	100		71	100	100	100	67
2046	91	100	100	100	100	26	100	100		71	100	100	100	67
2047	91	100	100	100	100	27	100	100		71	100	100	100	67
2048	91	100	100	100	100	28	100	100		72	100	100	100	67
2049	91	100	100	100	100	29	100	100		72	100	100	100	67
2050	91	100	100	100	100	30	100	100		72	100	100	100	67





% of space heating installs that are electric heat pumps w/ natural gas furnace back up (Hybrid)

SME5	SME6	NEEA	Average	SME1	SME2	SME3	SME4	SME5	NEEA
0	0	0	4	1	5	5	0	5	NA
0	0	0	4	1	5	5	0	5	
0	0	0	4	1	5	5	0	5	
0	0	0	5	5	5	5	0	5	
0	1	1	9	15	10	6	0	5	
3	1	1	9	15	10	6	0	5	
4	1	2	11	15	15	7	0	5	
5	2	2	13	25	15	7	0	5	
6	3	3	13	25	15	8	0	6	
7	4	4	15	25	20	8	0	6	
8	5	6	16	30	20	9	0	6	
9	8	8	18	30	25	9	0	6	
10	10	11	18	30	25	10	0	6	
11	15	15	19	30	30	10	0	7	
12	17	19	19	30	30	10	0	7	
14	20	25	19	30	30	10	0	7	
15	25	30	21	30	35	10	0	7	
16	30	35	21	30	35	10	0	7	
17	40	41	22	30	40	10	0	8	
18	45	45	22	30	40	10	0	8	
19	50	49	20	30	40	0	0	8	
20	50	52	20	30	40	0	0	8	
21	53	54	0	0	40	0	0	8	
22	55	56	0	0	0	0	0	9	
23	57	57	0	0	0	0	0	9	
25	59	58	0	0	0	0	0	9	
26	59	58	0	0	0	0	0	9	
27	59	59	0	0	0	0	0	9	
28	59	59	0	0	0	0	0	10	
29	59	59	0	0	0	0	0	10	
30	59	60	0	0	0	0	0	10	

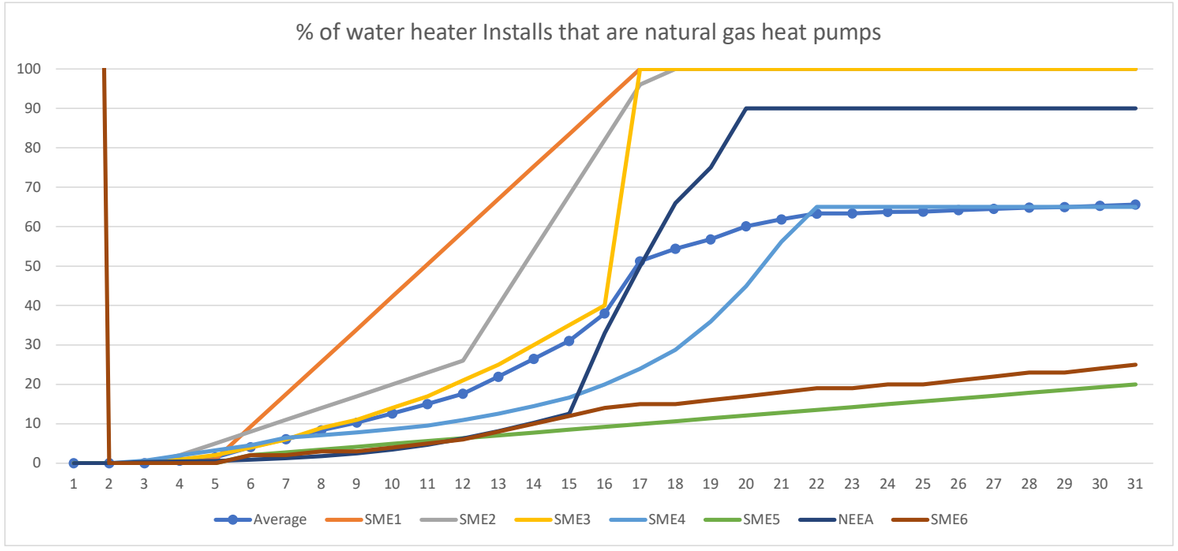


Assumed Improvement in Industrial Usage Efficiency Above and Beyond Energy Trust	22.5	30% Max
Assumed Reduction in Building Space Heating Needs from Improved Building Shells Above and Beyond Energy Trust Expectations in 2050	21.25	30% Max

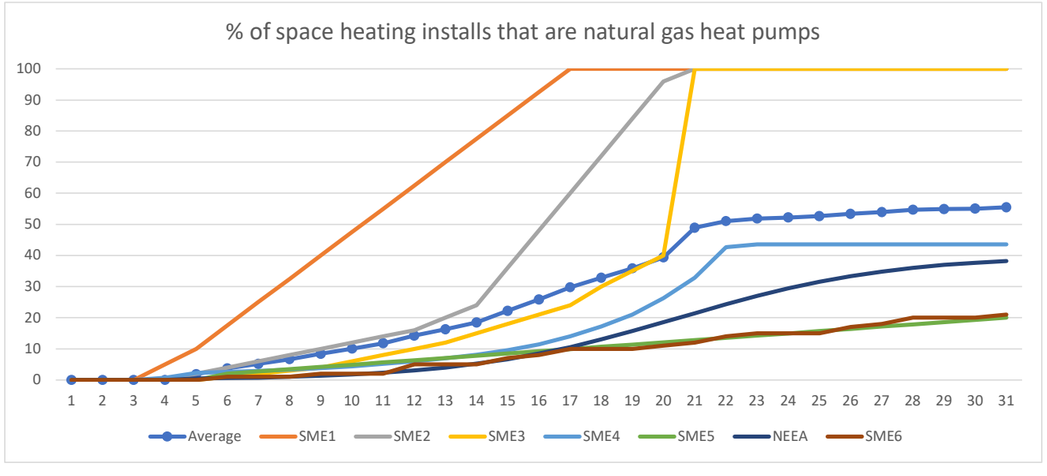
Notes

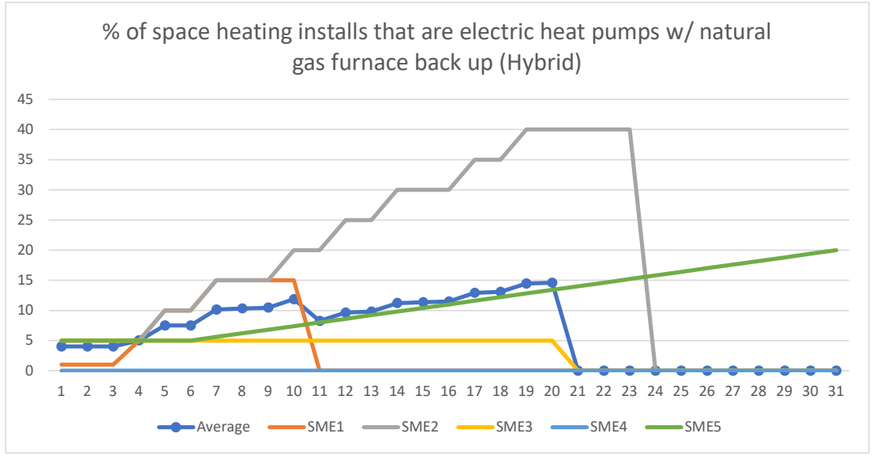
1. Installs includes both installations in new buildings (homes and businesses) as well as replacement of existing equipment that is at the end of its life (in a given year replacements are usually about double the installations in new buildings). Roughly 1 out of 25 existing customers will replace their space heating equipment in a given year and roughly 1 out of 15 of our existing water heating customers will replace their water
2. Water heating units that are not natural gas heat pumps will be an assumed mix of tank and tankless water heaters, efficiencies based on current market trends
3. Space heating units that are not assumed to be natural gas heat pumps or gas systems backing up
4 electic heat pumps will be assumed to be 95% efficient units
4. If you fill in any column with all zeros it indicates you feel we should not include assume any of these systems are installed at all. If the majority of respondants fill in a column with zeros in each year the scenario will not assume any of those systems (i.e it will be zero rather

	% of water heater Installs that are natural gas heat pumps									% of space heating installs that are natural gas heat pumps				
	Average	SME1	SME2	SME3	SME4	SME5	SME6	NEEA		Average	SME1	SME2	SME3	SME4
2020	0	0	0	0	0	0	700	0		0	0	0	0	0
2021	0	0	0	0	0	0	0	0		0	0	0	0	0
2022	0	0	0	0	1	0	0	0		0	0	0	0	0
2023	1	0	2	1	2	0	0	0		0	5	0	0	1
2024	1	1	5	2	3	0	0	1		2	10	2	0	2
2025	4	9	8	4	5	2	2	1		4	18	4	1	3
2026	6	18	11	6	7	3	2	1		5	25	6	2	3
2027	8	26	14	9	7	3	3	2		7	33	8	3	3
2028	10	34	17	11	8	4	3	3		8	40	10	4	4
2029	13	42	20	14	9	5	4	3		10	48	12	6	4
2030	15	51	23	17	10	6	5	5		12	55	14	8	5
2031	18	59	26	21	11	6	6	6		14	63	16	10	6
2032	22	67	40	25	13	7	8	8		16	70	20	12	7
2033	26	75	54	30	14	8	10	10		18	78	24	15	8
2034	31	84	68	35	17	8	12	13		22	85	36	18	10
2035	38	92	82	40	20	9	14	33		26	93	48	21	11
2036	51	100	96	100	24	10	15	50		30	100	60	24	14
2037	54	100	100	100	29	11	15	66		33	100	72	30	17
2038	57	100	100	100	36	11	16	75		36	100	84	35	21
2039	60	100	100	100	45	12	17	90		39	100	96	40	26
2040	62	100	100	100	56	13	18	90		49	100	100	100	33
2041	63	100	100	100	65	14	19	90		51	100	100	100	43
2042	63	100	100	100	65	14	19	90		52	100	100	100	44
2043	64	100	100	100	65	15	20	90		52	100	100	100	44
2044	64	100	100	100	65	16	20	90		53	100	100	100	44
2045	64	100	100	100	65	16	21	90		53	100	100	100	44
2046	65	100	100	100	65	17	22	90		54	100	100	100	44
2047	65	100	100	100	65	18	23	90		55	100	100	100	44
2048	65	100	100	100	65	19	23	90		55	100	100	100	44
2049	65	100	100	100	65	19	24	90		55	100	100	100	44
2050	66	100	100	100	65	20	25	90		55	100	100	100	44



				% of space heating installs that are electric heat pumps w/ natural gas furnace back up (Hybrid)						
SME5	SME6	NEEA		Average	SME1	SME2	SME3	SME4	SME5	NEEA
0	0	0		4	1	5	5	0	5	NA
0	0	0		4	1	5	5	0	5	
0	0	0		4	1	5	5	0	5	
0	0	0		5	5	5	5	0	5	
0	0	0		8	10	10	5	0	5	
2	1	1		8	10	10	5	0	5	
3	1	1		10	15	15	5	0	6	
3	1	1		10	15	15	5	0	6	
4	2	1		10	15	15	5	0	7	
5	2	2		12	15	20	5	0	7	
6	2	2		8	0	20	5	0	8	
6	5	3		10	0	25	5	0	9	
7	5	4		10	0	25	5	0	9	
8	5	5		11	0	30	5	0	10	
8	7	7		11	0	30	5	0	10	
9	8	8		12	0	30	5	0	11	
10	10	11		13	0	35	5	0	12	
11	10	13		13	0	35	5	0	12	
11	10	16		14	0	40	5	0	13	
12	11	19		15	0	40	5	0	13	
13	12	21		0	0	40	0	0	14	
14	14	24		0	0	40	0	0	15	
14	15	27		0	0	40	0	0	15	
15	15	29		0	0	0	0	0	16	
16	15	32		0	0	0	0	0	16	
16	17	33		0	0	0	0	0	17	
17	18	35		0	0	0	0	0	18	
18	20	36		0	0	0	0	0	18	
19	20	37		0	0	0	0	0	19	
19	20	38		0	0	0	0	0	19	
20	21	38		0	0	0	0	0	20	





WITH FORMULAS

Assumed Improvement in Industrial Usage Efficiency Above and Beyond Energy Trust Expectations in 2050	13.125	30% Max
Assumed Reduction in Building Space Heating Needs from Improved Building Shells Above and Beyond Energy Trust Expectations in 2050	12.5	30% Max

Notes

1. Installs includes both installations in new buildings (homes and businesses) as well as replacement of existing equipment that is at the end of its life (in a given year replacements are usually about double the installations in new buildings). Roughly 1 out of 25 existing customers will replace their space heating equipment in a given year and roughly 1 out of 15 of our existing water heating customers will replace their water heater in a given year

2. Water heating units that are not natural gas heat pumps will be an assumed mix of tank and tankless water heaters, efficiencies based on current market trends

3. Space heating units that are not assumed to be natural gas heat pumps or gas systems backing up electic heat pumps will be assumed to be 95% efficient units

4. If you fill in any column with all zeros it indicates you feel we should not include assume any of these systems are installed at all. If the majority of respondants fill in a column with zeros in each year the scenario will not assume any of those systems (i.e it will be zero rather than an average of all responses).