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August 12, 2022

VIA ELECTRONIC FILING

Public Utility Commission of Oregon
Attn: Filing Center
201 High Street SE, Suite 100
Post Office Box 1088
Salem, Oregon 97308-1088

Re: UM 2251 - NW Natural's Application for Approval of Eugene Hydrogen Project

Northwest Natural Gas Company, dba NW Natural ("NW Natural" or the "Company"), files herewith an application for approval of an emission reduction program located in Eugene, Oregon ("Eugene Hydrogen Project"). In support of this application, the Company also submits the filed testimony of Chris Kroeker (NW Natural/100-106), Ryan Weber (NW Natural/200), and Robert Wyman (NW Natural/300-304).

This filing contains confidential information that represents business-sensitive, non-public information and will be provided under General Protective Order No. 22-289.

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Respectfully submitted,

NW Natural

/s/ Ryan Sigurdson
Ryan Sigurdson
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BEFORE THE PUBLIC UTILITY COMMISSION
OF OREGON

UM 2251

In the Matter of NORTHWEST NATURAL GAS COMPANY, dba NW Natural, Application for Approval of Eugene Hydrogen Project.	APPLICATION

I. INTRODUCTION

Northwest Natural Gas Company, dba NW Natural ("NW Natural" or the "Company"), hereby files with the Public Utility Commission of Oregon (the "Commission") this application ("Application") seeking authorization to establish a voluntary emission reduction project pursuant to ORS 757.539. Specifically, the Company is seeking authorization to construct the Eugene Hydrogen Pilot Project ("Project"), which is a power-to-gas project that will produce low-carbon intensity hydrogen gas that will be blended into NW Natural's distribution system to serve its customers. As discussed herein, such blending reduces the use of conventional natural gas, thereby also reducing greenhouse gas ("GHG") emissions. This Application and accompanying testimony and exhibits demonstrate that the Project meets the project eligibility criteria and application requirements set out in ORS 757.539 and Commission Rules 860-085-0500 through 860-085-0750. For the reasons set forth below, NW Natural respectfully requests the Commission approve this Application.

A. ORS 757.539

Subject to Commission approval, ORS 757.539 permits a natural gas utility to pursue GHG emission reduction projects that it would not otherwise invest in the ordinary

course of business.[1] A project must meet the minimum eligibility and application requirements contained in OAR 860-085-0600 through 860-085-0750. Upon approval of an emission reduction project, the natural gas utility is permitted to recover the costs of the project.[2] The projected costs to ratepayers of a natural gas utility's portfolio of emission reduction projects must not exceed four percent of the utility's last approved retail revenue requirement, inclusive of all revenue collected under adjustment schedules.[3]

B. Tier 2 Project.

ORS 757.539 establishes a two-tier process for submitting project proposals under the emission reduction program.[4] The Commission's rules define Tier 1 and Tier 2 projects as follows:

> A Tier-1 Project is one that has projected costs that would be borne by the ratepayers of the utility proposing the Project that are equal to or less than $1 million and has an overall project cost of less than $85 per metric ton of reduced emissions.
>
> A Tier-2 Project is one that has projected costs that would be borne by the ratepayers of the utility proposing the Project that are greater than $1 million or has an overall project cost of equal to or greater than $85 per metric ton of reduced emissions.[5]

As described in the Direct Testimony of Chris Kroeker, NW Natural/100, this is a Tier-2 project because the projected cost is greater than $1 million and it has an overall project

[1] ORS 757.539(3)(d).

[2] ORS 757.539(8).

[3] OAR 860-085-0700.

[4] ORS 757.539(5).

[5] OAR 860-085-0650(1), (2).

cost of greater than $85 per metric ton of reduced emissions.[6] Since it is a Tier 2 project, ORS 757.539(7) provides for: (a) a process giving interested parties an opportunity to submit testimony in response; and (b) specifies that a final Commission order on the Project be issued within 180 days of receiving this Application, or at a later time as authorized by the public utility.[7]

C. Project Background

The Project is a 1 MW power-to-gas project that will produce hydrogen that NW Natural will use to serve its customers in the west Eugene area.[8] Power-to-gas projects produce hydrogen by passing an electric current through water (H2O), which splits the molecule into its elements: hydrogen and oxygen. The hydrogen gas is then collected and can be used directly as a fuel.[9] NW Natural will deliver an initial blend of five percent hydrogen gas to 95 percent natural gas by volume to west Eugene customers. The Project will have the capacity to increase the hydrogen blend in this area to 10 percent.

The combustion of hydrogen gas is 100 percent carbon-free, so any GHG emissions attributable to the power-to-gas process depends on the fuel used to generate the necessary power to operate the Project. NW Natural will acquire the Project's power from the Eugene Water & Electric Board ("EWEB"). EWEB's electric generation resource portfolio is approximately 90 percent non-emitting, using hydroelectric, nuclear, and wind generation.[10] Since the carbon intensity of EWEB's power is lower than the conventional

[6] NW Natural/100, Kroeker/28.

[7] ORS 757.539(7).

[8] *See* NW Natural/100, Kroeker/20 (map showing the area that will receive a blend of hydrogen and natural gas).

[9] This process is further explained in NW Natural/100, Kroeker/4-14 and NW Natural 200, Weber/2-10.

[10] EWEB, *Where Your Power Comes From*, https://www.eweb.org/about-us/power-supply (last visited Aug. 8, 2022).

natural gas that would otherwise serve customers, the Project reduces GHG emissions. Mounting data show that blends up to 20 percent hydrogen are compatible with existing natural gas infrastructure and downstream appliances and the gas industry worldwide is gathering data through pilot projects and lab work to mitigate operational risks.[11] NW Natural has been monitoring and contributing towards these efforts, and based on its learnings and work with hydrogen blends, believes that its system can integrate the hydrogen produced by this Project, starting with a blend of five percent by volume.[12]

D. Why the Company is Pursuing the Project.

The Company is pursuing this Project for both its immediate and long-term benefits. The immediate benefit is that the Project will produce hydrogen gas that will reduce the Company's GHG emissions. This reduction in GHG emissions will help the Company meet its own decarbonization goals and comply with the Climate Protection Program ("CPP"). The CPP sets a declining limit, or cap, on greenhouse gas emissions from fossil fuels used in Oregon, including the direct use of natural gas, resulting in GHG reductions of 50 percent by 2035 and 90 percent by 2050.[13]

The long-term benefit is that it will help the Company develop the operational experience necessary to introduce large-scale hydrogen gas blending into NW Natural's distribution system. Hydrogen gas will likely play a major role in achieving economy-wide decarbonization for not only those that currently use conventional natural gas, but also to decarbonize the electric sector and other industries, such as heavy-duty transportation, aviation, and maritime shipping. Already some of the Company's customers are inquiring

[11] NW Natural/100, Kroeker/6-8. NW Natural/101, Kroeker.

[12] NW Natural/100, Kroeker/15-17. NW Natural/200, Weber/7-9.

[13] OAR 340-271-0010 – 9000.

about the possibility of being served with hydrogen gas. In its recent draft Integrated Resource Plan Oregon base case, the Company projects large amounts of hydrogen gas on its system in the early 2030s as hydrogen gas becomes the lowest cost incremental resource and GHG emissions permitted under the CPP are reduced.[14] Gaining the operational experience with hydrogen gas now will better prepare NW Natural for increasing amounts of hydrogen gas in the future.

The combination of immediate and long-term benefits is why the Company is pursuing this Project. There are cheaper sources of renewable natural gas ("RNG") currently available and these sources would also provide an immediate CPP compliance benefit,[15] but NW Natural and its customers would lose the long-term benefit of better positioning the Company's distribution system to accept more hydrogen as it becomes the lowest cost incremental resource. Similarly, NW Natural could have chosen to introduce a more GHG-emissions intensive form of hydrogen gas that likely would have been less costly and that would have resulted in at least some of the long-term benefits as the Project, such as experience with hydrogen blending. But it would have offered little to no immediate GHG reduction benefits and it would not have prepared the Company to operate power-to-gas facilities. Rather the Company is pursuing the Project because of its unique combination of immediate and long-term benefits to all customer classes.

In sum, the Company anticipates using this Project as a stepping stone to further increase the amount of hydrogen gas on its distribution system as part of its

[14] NW Natural Draft 2022 Integrated Resource Plan, at Figure 7.7and 7.16 (https://www.nwnatural.com/about-us/rates-and-regulations/resource-planning).

[15] NW Natural/100, Kroeker/28-29.

decarbonization efforts. The Project will ultimately help prepare NW Natural to accept hydrogen gas injected from third-party developers and potential Company-owned resources as economy-wide decarbonization accelerates.

II. PROJECT APPLICATION REQUIREMENTS

ORS 757.539 establishes the minimum eligibility criteria and application requirements for emission reduction projects.[16] In its rulemaking process, the Commission adopted a single set of "Project Application Requirements" in OAR 860-085-0600, which includes both the statutory minimum requirements provided for by the legislature, plus the additional requirements adopted by the Commission. These criteria are set forth and discussed below and in supporting testimony.[17]

A. General Information OAR 860-085-0600(1)(a)-(f).

1. OAR 860-085-0600(1)(a): Minimum Eligibility Criteria.

Under OAR 860-085-0600(1)(a), the applicant must demonstrate that it satisfies the minimum eligibility criteria set out in 757.539(3)(a) – (f). The Project satisfies these criteria as follows:

(a) The public utility requesting the Project be a public utility that furnishes natural gas and that the project involve the provision of natural gas. ORS 757.539(3)(a).

NW Natural is a public utility that furnishes natural gas, as required by ORS 757.005(1). The Project involves the provision of natural gas because it involves blending hydrogen with natural gas.

[16] ORS 757.539(3),(4).

[17] *See* NW Natural/100-106, Kroeker; NW Natural/200, Weber; NW Natural/300-304, Wyman.

(b) The Project directly or indirectly reduces emissions. ORS 757.539(3)(b).

The Project will directly reduce emissions because it produces low carbon intensity hydrogen gas that will replace the use of conventional natural gas. The Project is estimated to reduce emissions by approximately 194 $MTCO_2(e)$ each year through the annual production of 4,300 MMBtu (32,000 kg) of low carbon intensity hydrogen gas.[18]

(c) The Project benefits customers of the public utility as identified by the commission by rule or order. ORS 757.539(3)(c)

The Project benefits NW Natural's customers because it directly reduces GHG emissions and better prepares the Company to introduce increasing amounts of hydrogen gas into its system in the future.[19] This Project will provide learnings on best practices for the blending of hydrogen gas into the Company's distribution system, as well as the construction and operation of power-to-gas plants. These learnings benefit customers by likely leading to efficiencies and lower costs when applied to introducing increased amounts of hydrogen into NW Natural's system and larger scale plants.

The Project also benefits customers and the state of Oregon more broadly because the hydrogen gas will be produced within Oregon using power sourced from EWEB. These types of initiatives contribute to economic development in Oregon by increasing renewable energy development. More specifically, as stated above, this Project can help facilitate future hydrogen infrastructure that can contribute to not only the decarbonization of the direct use natural gas system, but also the electric sector and other industries, such as heavy-duty transportation, aviation, and maritime shipping.

[18] *See* NW Natural/100, Kroeker/34-37; NW Natural/106, Kroeker.

[19] *See* NW Natural/100, Kroeker/17-19.

(d) The public utility, without the emission reduction program, would not invest in the Project in the ordinary course of business. ORS 757.539(3)(d).

Without the Commission's authorizing cost recovery under ORS 757.539, the Company would not propose this Project in the ordinary course of business. In its most recent request-for-proposals ("RFP") for renewable natural gas ("RNG") in April 2022, NW Natural received bids ranging from **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**.[20] The estimated price of hydrogen gas from this Project is $30-40/MMBtu, including capital costs over a 20-year life. In its most recent RFP, **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL].**[21] The Eugene Hydrogen Pilot Project, however, is much further along in development and has a fixed on-system location that will allow NW Natural to begin blending hydrogen gas into a portion of its distribution system. Developing the Project will allow the Company to take full advantage of falling hydrogen prices by ensuring that it has the "real-world" experience to blend hydrogen into its system on a large scale. It will also help ensure that NW Natural has the expertise to integrate these resources onto its system and not solely rely on off-system hydrogen acquisitions. Nonetheless, the Company would not pursue the Project in the ordinary course of business due to less expensive sources of RNG.

[20] NW Natural/100, Kroeker/28-29.

[21] *Id.*

(e) The public utility, prior to filing an application, involved stakeholders as required by the Commission by rule or order. ORS 757.539(3)(e).

As explained in the Direct Testimony of Chris Kroeker, NW Natural/100,[22] NW Natural first coordinated with EWEB, the Renewable Hydrogen Alliance ("RHA") and the Bonneville Environmental Foundation ("BEF"). The RHA is a Pacific Northwest regional non-profit trade association whose mission is to promote the use of renewable energy to produce hydrogen and help reduce carbon emissions in multiple sectors like transportation, energy and industry.[23] The BEF is a non-profit working on society's most pressing energy, carbon, and water issues, and has focused on integrating renewable hydrogen into the electricity system with the goal of maximizing systemic benefits of renewable energy production and utilization across all sectors of the economy.[24]

EWEB, RHA and BEF provided their expertise throughout the project development process. These organizations, along with NW Natural, explained the benefits of hydrogen, and this Project in particular, from their own perspectives at two stakeholder workshops. The first workshop was held on May 24, 2022, and focused on giving the community of Eugene an opportunity to learn more about the Project.[25] Specifically, the focus of this meeting was on local concerns, such as whether the hydrogen would be odorized and the heat content of the gas, and to provide the community an opportunity to ask questions. Approximately 22 people attended the virtual meeting.[26]

[22] NW Natural/100, Kroeker/31-34.

[23] *See* NW Natural/102, Kroeker; NW Natural/103, Kroeker.

[24] *Id.*

[25] NW Natural/102, Kroeker; NW Natural/104, Kroeker.

[26] *Id.*

The second stakeholder meeting was held on July 8, 2022. NW Natural invited parties in its ongoing rate case, stakeholders participating in the Company's Integrated Resource Plan process, and stakeholders involved in the Commission's Natural Gas Fact-Finding, docket UM 2178.[27] Approximately 47 people attended the virtual meeting.[28] Several stakeholders, including the NW Alliance for Clean Transportation, Oregon Hearth Patio Barbecue Association, and six representatives of different labor unions all explicitly supported the Project in the chat function of the meeting.[29]

(f) The rate impact of the aggregate of all projects undertaken by a public utility under this section not exceed an amount established by the Commission by rule or order. ORS 757.539(3)(f).

The amount established by the Commission under OAR 860-600-0700 is "4 percent of the utility's last approved retail revenue requirement, inclusive of all revenue collected under adjustment schedules." A cap of four percent of NW Natural's last approved retail revenue requirement, inclusive of all revenue collected under adjustment schedules, is $30.9 million.[30] The Company currently has no other authorized projects under ORS 757.539 and the Project's estimated initial annual revenue requirement of $1.75 million is well under $30.9 million project cap.[31] The proposed ratemaking treatment of the Project is further described in the Direct Testimony of Robert Wyman, NW Natural/300.

[27] NW Natural/103, Kroeker; NW Natural/105, Kroeker.

[28] NW Natural/105, Kroeker.

[29] *Id.*

[30] NW Natural/300, Wyman/8.

[31] *See* NW Natural/100, Kroeker/22 for a map of the Project's location.

B. OAR 860-085-0600(b): Discussion of all Project Measures Being Employed to Reduce Emissions.

As described above and in supporting testimony, the Project replaces conventional natural gas with low-carbon hydrogen gas, which reduces GHG emissions.

C. OAR 860-085-0600(c): Estimated Project Measure Life.

The estimated life of a power-to-gas plant is approximately 20 years; however, this life can be extended indefinitely with component replacement and upgrades.

D. OAR 860-085-0600(d): Description of the Project Boundary and Scope.

The Project will be located adjacent to EWEB's Roosevelt Operations Center on land leased from EWEB.[32] This location minimizes the Project's interconnection costs to EWEB's electrical and water systems and is also adjacent to large diameter NW Natural distribution lines, which can receive the hydrogen gas the Project produces. The Project's boundary is the area that will be served with the 5 percent hydrogen/95 percent natural gas blend in west Eugene, as shown on the map in NW Natural/100, Kroeker/20.

The scope of Project is two-fold. First, using low-carbon intensity hydrogen gas in lieu of conventional natural gas to meet a portion of customers' energy needs provides immediate GHG reductions. Second, the Project gives the Company "real-world" blending experience in blending hydrogen into its system and operating a power-to-gas project that are necessary to expand the delivery of hydrogen on a larger—and more economical—basis.

[32] *See* NW Natural/100, Kroeker/21-22.

E. OAR 860-085-0600(e): A discussion of the emission reduction strategy used, and why the approach is appropriate, timely, and merits approval.

The Project is appropriate, timely, and merits approval because it prepares NW Natural for future hydrogen blending projects throughout its system, which may include hydrogen projects owned and operated by third parties, as well as projects owned and operated by the Company.[33] Although small in size, the Project is a step towards large-scale hydrogen gas production and blending that will provide a viable substitution for natural gas with an almost emissions-free fuel and, as explained above, will help prepare NW Natural (and other industries and natural gas utilities) for its wider introduction into the natural gas distribution system. By obtaining first-hand experience in developing this infrastructure now, NW Natural will be in a much better position to utilize hydrogen gas at a larger scale as the cost of hydrogen decreases. If NW Natural were to wait to pursue hydrogen gas until it was cost competitive with other sources of RNG, the introduction of hydrogen gas into its system would likely be delayed, as NW Natural would first seek to develop its hydrogen gas expertise with a relatively limited hydrogen blend (e.g., five percent hydrogen blend by volume) over a limited geographic area.

In short, the Project will allow NW Natural to introduce more hydrogen gas to its system faster, thereby further helping both the state and the Company achieve its decarbonization goals.

[33] *See* NW Natural/100, Kroeker/38-40.

F. OAR 860-085-0600(f): Whether the Project is able to generate environmental credits or certificates and any potential revenues associated with their sale or use.

The Project may be eligible for tax credits if Congress passes the Inflation Reduction Act.[34] Based on the Company's understanding of the current language in the bill, the Project would be eligible for a tax credit of $1.49/MMBtu based on the Project's carbon intensity of 1.1 CO2e per kg of hydrogen. NW Natural is also working towards understanding what the prevailing wages requirements within the bill would be for the Project. If those requirements are met, the tax credit would be increased by a factor of five to $7.44/MMBtu. Value from tax credits produced from the production of hydrogen would be delivered back to all customers to reduce costs.

The Project may also produce credits associated with the environmental attributes of the hydrogen gas. The Company would not seek to monetize any such credits by separating or "unbundling" them from the energy content of the hydrogen gas.[35] By not unbundling and monetizing these credits, the Company ensures that all environmental attributes, including GHG reductions, are appropriately credited to the Company and its customers.

G. Cost Recovery Information OAR 860-085-0600(2).

1. OAR 860-085-0600(2)(a): A requested method for cost recovery.

The Company proposes Schedule 184, which will allow the Company to include the cost of service for the Project in customer rates at the time that the project is placed in-service, which is currently anticipated to be March 31, 2024.[36] Following the initial rate

[34] *See* NW Natural/100, Kroeker/37.

[35] NW Natural/100, Kroeker/38.

[36] NW Natural/300, Wyman/8; NW Natural/304, Wyman (Schedule 184).

change, the Company will update the cost of service for the Project in subsequent rate cases.

The Company proposes to allocate the annual Project costs across all Oregon rate schedules on an equal percent of margin basis.[37] The equal percent of margin calculation allocates incremental revenue by calculating a percent of margin (margin by rate schedule divided by total margin) 'scalar' and multiplying the margin scalar by the total incremental revenue. The Company believes that this is the appropriate rate treatment because all rate classes benefit equally from the operational experience gained from the Project.

2. OAR 860-085-0600(2)(b): A showing of the Project benefits received and the allocation of benefits for each type of ratepayer.

Residential, commercial, and industrial customer classes will all benefit from the hydrogen-blending expertise that the Company will gain from the Project because, as explained above, it provides immediate emissions reductions and prepares NW Natural to introduce larger amounts of hydrogen onto its system in the future.[38]

3. OAR 860-085-0600(2)(c): A description of any requested incentive payments, and requested recovery of the incentive.

The Company will not be seeking an incentive payment for the Project.

4. OAR 860-085-0600(2)(d): Any required tariffs for the Program.

Please see NW Natural/304, Wyman.

H. Emissions Reduction Verification Plan – OAR 860-085-0600(3).

NW Natural developed an Emissions Reduction Verification Plan ("Plan")[39] that includes the following required components:

[37] *See* NW Natural/300, Wyman/8-12.

[38] *See* Section I.D above & NW Natural/300, Wyman/4-7.

[39] *See* NW Natural/106, Kroeker.

1. OAR 860-085-0600(3)(a): The methodology used to calculate the projected emission reductions.

(A) The Project Baseline

The baseline of emissions is the emissions that would occur under the normal course of business if the Project was not built. If the Project was not built and, therefore, did not produce an estimated 4,300 MMBtu of hydrogen annually, then NW Natural would acquire the same amount of conventional natural gas to serve its load. Using the Oregon Department of Environmental Quality ("ODEQ") GHG emissions estimate of 0.053 MTCO2(e)/MMBtu for conventional natural gas, the baseline emissions for this volume of natural gas is approximately 228 MTCO2(e) per year.[40]

(B) Emission Leakage and Project Emissions

The methodology accounts for and deducts any estimated emission leakage and project emissions. Emission leakage means "a reduction in greenhouse gas emissions within the Project that is offset by an increase in greenhouse gas emissions outside the Project."[41] There will be no emissions leakage associated with the Project because the hydrogen gas is able to replace the natural gas with no additional fuel resources outside of the Project or additional processes that would generate or increase emissions.

Project emissions means "any emissions attributable to the implementation of an Emission Reduction Project."[42] The Project will rely on EWEB for power, and, while EWEB's system is overwhelmingly emissions-free, it still relies on a small percentage of fossil fuel for power. Due to this minimal reliance on fossil fuel, EWEB's carbon intensity

[40] NW Natural/100, Kroeker/34-35; NW Natural/106, Kroeker.

[41] OAR 860-085-0600(3)(a)(B).

[42] *Id*.

is not zero, but rather 0.02 MTCO2(e)/MWh. This results in the Project's emissions being approximately 34 MTCO2(e)/year.[43]

Subtracting the Project's emissions (34 MTCO2(e)/year) from the Project's baseline above (228 MTCO2(e)/year) results in a total emissions savings from the Project of approximately 194 MTCO2(e)/year.

(C) Development of the Emission Reduction Verification Methodology

The Emission Reduction Verification Methodology ("Methodology") is largely adopted from the OAR 860-085-0600 requirements, which requires calculating the difference between baseline emissions and the emissions that would occur after the Project is completed. As explained above, the methodology takes into account the small amount of emissions produced by the Project and also explicitly addresses leakage. The methodology also relies on ODEQ's GHG emissions estimate of 0.053 MTCO2(e)/MMBtu for conventional natural gas. The Methodology is presented in further detail in the Plan.[44]

I. Additional Application Requirements - ORS 757.539(4)(a)–(k).

1. ORS 757.539(4)(a): The description of the Project.

The description of the Project is outlined above in Sections I.C and I.D, as well as the Direct Testimonies of Chris Kroeker, NW Natural/100, and Ryan Weber, NW Natural/200.

[43] NW Natural/100, Kroeker/35-36; NW Natural/106, Kroeker.

[44] *See* NW Natural/106, Kroeker.

2. ORS 757.539(4)(b): The projected amount of capital and operating costs necessary to complete the Project.

As described in the Direct Testimony of Ryan Weber, the projected amount of capital to build the Project is approximately $9.8 million.[45] Annual operating costs are approximately $140,000.[46]

3. ORS 757.539(4)(c): The projected amount of reduced emissions created by the Project.

As explained above, the total emissions savings from the Project is approximately 194 MTCO2(e)/year.[47]

4. ORS 757.539(4)(d): The potential of the Project to reduce emissions not identified in response to ORS 757.539(4)(c).

NW Natural is not aware of further emission reductions beyond those reductions considered and addressed in this Application. In the event NW Natural becomes aware of additional emission reduction potential through the Project, NW Natural will timely notify the Commission of such change.

5. ORS 757.539(4)(e): The projected date on which the Project will become operational.

The Project is projected to become operational in March 31, 2024.

6. ORS 757.539(4)(f): A requested method, as described in subsection (8) of this section, for recovery of costs incurred and investments made.

Pursuant to ORS 757.539(8), "[a] public utility may recover costs incurred and investments made from a type of ratepayer . . . only if the commission makes a finding that the type of ratepayer receives a benefit from the project. If the commission makes a

[45] NW Natural/200, Weber/15-16.

[46] *Id.* at 16-17.

[47] NW Natural/100, Kroeker/34-37; NW Natural/106, Kroeker.

finding that more than one type of ratepayer receives a benefit from the project, the commission shall allow recovery from each type of ratepayer in an amount that is proportionate to the proportion of the benefit received, as determined by the commission, by the type of ratepayer."

As explained in Section I.D above, the Program offers benefits to all customer classes because it not only reduces GHG emissions immediately, but also paves the way for increasing the amount of hydrogen gas on NW Natural's distribution system. Please see Section II.G.1 describing NW Natural's proposed method of cost recovery.[48]

7. ORS 757.539(4)(g): An explanation of why the public utility, without the emission reduction program, would not invest in the project in the ordinary course of business.

See Section II.(A)(1)(d) above.

8. ORS 757.539(4)(h): Proof of stakeholder involvement.

Please see NW Natural/102 and NW Natural/103 which provide the presentations given at the stakeholder meetings, and NW Natural/104 and 105, which describes the stakeholder meetings and provides a link to their recordings.

9. ORS 757.539(4)(i): The projected rate impact of the Project.

Table 1 below shows the impacts of the $1.75 million Year 1 revenue requirement and average bill increase for firm customers. NW Natural/302, Wyman shows the rate impact in detail. Due to depreciation on the capital assets associated with the Project, the Company forecasts that the Year 1 revenue requirement will represent the peak of the Project costs on an annual basis.

[48] *See also* NW Natural/300, Wyman/4-8.

Table 1
Incremental Revenue Requirement and Average Bill Increase,
Firm Customers Only

Rate Schedule	Revenue Req. Increase	Pct. Increase to Avg. Cust. Bill*
02R	$ 1,189,729	0.2%
03C	$ 363,661	0.2%
03I	$ 9,056	0.2%
27R	$ 1,853	0.2%
31CSF	$ 32,834	0.2%
31CTF	$ 3,849	0.4%
31ISF	$ 13,324	0.2%
31ITF	$ 573	0.4%
32CSF	$ 45,163	0.2%
32CTF	$ 4,027	0.4%
32ISF	$ 10,128	0.1%
32ITF	$ 27,088	0.5%
Total All Schedules**	$ 1,750,205	

* The average customer bill impact figure calculation excludes pipeline capacity charges for RS 31 and RS 32 rate classes, and thus the rate impacts for these schedules are overstated.
** The proposed margin revenue increase is based on volumetric billing rates rounded to the fifth decimal as necessitated by the Company's tariff. Therefore, there may be a small discrepancy with the indicated revenue requirement.

10. ORS 757.539(4)(j): The projected aggregate rate impact of all projects proposed by the public utility under this section and approved by the commission for the public utility under this section.

This Project is currently the only project that NW Natural is seeking approval of or operating under ORS 757.539. *See* Section II.A.1(f) above.

11. ORS 757.539(4)(k): An explanation of how the public utility will provide the commission with progress updates during the life of the project, including updates on costs and reduced emissions associated with the project.

NW Natural proposes to submit an annual report that will calculate the Project's emissions savings as an appendix to its RNG Compliance Report required in OAR 860-

150-0600.[49] The report will use the actual amount of hydrogen gas produced in the previous calendar year, as well as any updates to the carbon intensity of EWEB's power supply to calculate an annual emissions reduction value.

III. CONCLUSION.

For the foregoing reasons, NW Natural respectfully requests that the Commission approve its Application for this Project.

Dated this 12th day of August 2022.

Respectfully Submitted,

NW NATURAL

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[49] NW Natural/100, Kroeker/37; NW Natural/106, Kroeker. This report is also intended to fulfill the ongoing monitoring requirement in OAR 860-085-0600(3)(b). NW Natural expects to incur de minimis costs to monitor and verify emissions reductions.

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Direct Testimony of Chris Kroeker

EUGENE HYDROGEN PILOT PROJECT
EXHIBIT 100

REDACTED

August 12, 2022

EXHIBIT 100 – DIRECT TESTIMONY– EUGENE HYDROGEN PILOT PROJECT

Table of Contents

I. INTRODUCTION AND SUMMARY

Q. Please state your name and position at Northwest Natural Gas Company ("NW Natural" or "the Company").

A. My name is Chris Kroeker. I am a Business Development Segment Manager at NW Natural. I have worked for the Company since 2017. My responsibilities include origination of hydrogen projects and evaluation of emerging technologies.

Q. Please describe your education and employment background.

A. I received my Bachelor of Science and Master of Science degrees in Mechanical Engineering from the University of Manitoba and a Master of Business Administration degree from the University of British Columbia. Prior to my work at NW Natural, I worked extensively in the automotive industry in Engineering and Marketing, as well as in energy efficiency market transformation.

Q. What is the purpose of your testimony?

A. The primary purpose of my testimony is to describe the Eugene Hydrogen Pilot Project ("the Project"). The Company is seeking the Public Utility Commission of Oregon ("Commission") approval of the Project under Senate Bill ("SB") 844 (ORS 757.539). I will explain how the Project complies with the requirements for SB 844 projects, focusing on the general eligibility requirements under ORS 757.539(3) and OAR 860-085-0550, and requirements for an Emissions Reduction Verification Plan under OAR 860-085-0600(3). Finally, I will explain why the emissions reduction strategy that will be achieved through the project is appropriate, timely and merits approval, as required by OAR 860-085-0600(1)(e).

Q. Please summarize why NW Natural is pursuing the Project.

A. NW Natural is pursuing the Project as part of its ongoing efforts to decarbonize. The Company has long pursued meaningful decarbonization efforts. In 2003, NW Natural became one of the first gas utilities to establish a decoupling mechanism to align the Company's and its customers' incentives to reduce usage and, consequently, emissions. In 2007, NW Natural launched its Smart Energy program, becoming the first stand-alone gas utility to offer our customers a voluntary carbon offset program. In 2015, the Company was among the first to replace all cast iron and bare steel pipes, increasing the integrity of NW Natural's distribution system and reducing the risk of leaks. In 2019, the Company was instrumental in the passage of SB 98 (ORS 757.390-398), which permits the Company to acquire renewable natural gas ("RNG").

In 2020, Executive Order 20-04 ("EO 20-04") directed the Oregon Environmental Quality Commission ("EQC") and the Oregon Department of Environmental Quality ("ODEQ") to take actions necessary to cap and reduce greenhouse gas ("GHG") emissions from a variety of industries, including natural gas utilities. The regulations subsequently adopted by the EQC and ODEQ as OAR 340-271 *et seq.,* the Climate Protection Program ("CPP"), will require NW Natural to reduce GHG emissions associated with its customers' gas use by 90 percent by 2050. Given the Company's own decarbonization goals and the CPP requirements, the Company must significantly reduce the carbon intensity of its product as soon as reasonably possible, while also continuing to provide safe, reliable, and affordable service to its customers.

For these reasons, the Company has been exploring a variety of approaches, including energy efficiency, as well as RNG and hydrogen gas as substitutes for conventional natural gas. Specific to this filing, over the past two years, the Company has been actively engaged in research and testing of hydrogen gas blends in laboratory and training environments. NW Natural is now prepared to test the production and delivery of low-carbon intensity hydrogen gas, blended with conventional natural gas, to a limited subset of its customers and is therefore seeking Commission approval of the Project under SB 844.

The goal of the Project is to gain the experience the Company will require to expand the delivery of hydrogen gas on a larger-scale—and ultimately on a more economical basis. NW Natural believes that the delivery of hydrogen gas will play a major role in achieving economy-wide decarbonization and will be important not only for those customers that currently use natural gas as a direct end use, but also to help in the decarbonization efforts of the electric sector, and other industries, such as heavy-duty transportation, aviation, and maritime shipping. NW Natural needs to be prepared to inject increasing amounts of hydrogen gas into its system, both to respond to customer demand, some of which are already inquiring about the possibility of being served with hydrogen, and to be able to transport hydrogen produced by third-party developers, as well as potential Company-owned hydrogen projects.

Q. Please summarize your testimony.

A. My testimony begins with a general background discussion of hydrogen gas, how it is produced, how it can be utilized in existing natural gas infrastructure, and the

environmental benefits of using hydrogen gas in lieu of conventional natural gas. I discuss how other gas distribution companies have developed hydrogen gas generation projects that are now successfully blending hydrogen gas into the natural gas supply. I also discuss the Company's own experience testing hydrogen gas under laboratory and training conditions. Finally, I will provide a detailed description of the Project itself, including its design and environmental benefits, and will explain how the Project complies with the requirements of SB 844 and the Commission's implementing regulations.

II. BACKGROUND

A. How Hydrogen Gas is Produced

Q. What is hydrogen gas?

A. The term "hydrogen gas" refers to the hydrogen molecule (H2) in a gaseous state. Hydrogen gas has an approximate heating value of 325 British thermal units per cubic foot (Btu/cf) and it can be blended with natural gas to produce heat for homes and businesses and for certain industrial applications. Hydrogen gas can also be used to generate electricity through fuel cells or gas turbines.

Q. How is hydrogen, in its elemental form, found in nature?

A. Hydrogen molecules, together with oxygen, comprise the compound of water and are found in nearly all living things. However, it is not commonly found as a gas in nature. Hydrogen gas must be produced by separating hydrogen from other molecules.

Q. Please briefly describe the common methods by which hydrogen gas is produced for use in the natural gas supply system.

A. There are two common methods for producing hydrogen gas for use in the natural gas system. The first method is a "power-to-gas" technology that uses electricity to create hydrogen gas from water. Specifically, through a process called "electrolysis", an electric current is passed through water, which splits the water molecule into its elements: hydrogen and oxygen. The hydrogen gas is collected and can be used on demand to meet customers' energy needs or stored for later use. As described in greater detail below, NW Natural will use power-to-gas technology to produce hydrogen gas for this Project.

The second method for producing hydrogen gas is by reforming natural gas. The most common reforming method is called Steam Methane Reforming ("SMR"), which requires water, air, and heat to convert methane into carbon dioxide ("CO2") and hydrogen. Another reforming method is autothermal reforming ("ATR"), which uses oxygen instead of air to eliminate the flue gas and enable much higher carbon capture efficiencies. When carbon dioxide is captured and sequestered in either of these processes, the hydrogen is commonly referred to as "blue hydrogen."

Q. What are the relative environmental merits of these technologies?

A. With respect to the electrolysis approach, the environmental benefits depend upon the fuel that powers the electricity used in the process. The hydrogen gas itself is 100 percent carbon-free, so any greenhouse gas emissions attributable to the hydrogen gas as a combustion fuel depends on the fuel used to generate the electricity. If the electricity used in the electrolysis process is non-emitting, then

both the process and hydrogen gas product are entirely carbon free. Thus, when blended with conventional gas, use of hydrogen gas will reduce overall emissions. The environmental merits of the reforming process, which relies on natural gas and produces CO2 as a byproduct, depends on whether or not the CO2 released in the process is being captured or released into the atmosphere.

B. Utilization of Hydrogen Gas

Q. Have natural gas utilities successfully delivered hydrogen gas blended with natural gas over existing natural gas infrastructure?

A. Yes. In fact, hydrogen gas has been successfully delivered to customers through gas distribution systems for over half a century. The first hydrogen gas product was referred to as "town gas", which is a manufactured gas containing approximately 50 percent hydrogen, with the remaining percentage being mainly carbon monoxide. Town gas was widely used in the United States for heating and lighting purposes from the early 1800s until the mid-20th century. Moreover, since the 1970's Hawai'i Gas has been delivering a blend of gas manufactured from naphtha that contains approximately 12-15 percent hydrogen by volume for use in standard natural gas appliances and distribution infrastructure.

More recently there has been significant interest in introducing hydrogen gas onto natural gas distribution systems as a means to reduce the carbon intensity of gas heating. For instance, the British natural gas distributor, Cadent, recently completed a pilot program in which it utilized an electrolyzer to generate hydrogen gas that was injected to produce a 20 percent hydrogen gas/80 percent natural gas blend that served 130 mixed-use buildings from 2019-2021.

Addressing concerns about the safety and reliability of the use of hydrogen gas in natural gas distribution systems, the study found the following:

- No increase in leakage frequency from system piping, fittings, or end use appliances, relative to historical levels when the system operated with only natural gas.
- No perceivable dilution in odor intensity observed (i.e., no impacts on the ability of the public to detect and report gas leakage), as the Sulphur-based odorants combine with hydrogen gas similarly as they do with methane.
- Standard appliances designed to operate on natural gas continued to operate within the recommended limits of typical operation and no increase in failure frequency was observed, again, relative to historical trends.[1]

A second phase of the Cadent study is currently underway in an area of northeast England, where the 20 percent hydrogen gas blend will help meet the energy needs of approximately 668 homes, a church, primary school, and several small businesses.

The UK is also pursuing 100 percent hydrogen networks to first serve specific neighborhoods and then expanding to cover larger areas as part of its H21 program. This program would reuse the existing gas network to transport 100 percent hydrogen to residential and commercial customers.[2]

[1] *See* NW Natural/101, Kroeker.

[2] *About H21*, https://h21.green/about/ (last visited Aug. 8, 2022).

Q. Have there been any hydrogen pilot projects in North America?

A. Yes. There are currently several pilot projects:

- Enbridge Gas is currently conducting a pilot project in Markham, Ontario, using an electrolyzer to produce hydrogen gas to test a two percent hydrogen gas blend. The project serves the hydrogen/natural gas blend to 3,600 customers and is estimated to reduce the utility's natural gas related emissions by 117 metric tons of carbon dioxide equivalent ("MTCO2e") every year. As this project is fairly recent, NW Natural is following its progress.[3]
- New Jersey Natural Gas is currently conducting a pilot project located in Howell, New Jersey, which tests a five percent hydrogen gas blend delivered to an isolated subsidiary within the utility's service territory. The project uses a 175 kW electrolyzer to generate hydrogen gas, reducing natural gas associated emissions by 180 MTCO2(e) per year.[4]
- CenterPoint has launched a pilot project in Minneapolis, Minnesota, using an electrolyzer to generate a five percent hydrogen gas blend for injection into limited, low-pressure sections of the utility's distribution pipeline

[3] Enbridge, *Clean hydrogen enters the Markham energy mix* (Jan. 13, 2022), https://www.enbridge.com/stories/2022/january/hydrogen-blending-project-enbridge-gas-cummins-operational-markham-ontario.

[4] New Jersey Natural Gas, *NJNG's Green Hydrogen Project*, https://www.njrsustainability.com/environmental/NJR_HydrogenProject_Factsheet_01d1.pdf (last visited Aug. 8, 2022).

system. The project is expected to avoid 1,200 tons of CO2 emissions annually.[5]

Q. Is NW Natural aware of any safety or reliability issues that have arisen during operation of these pilot projects?

A. No. NW Natural has reviewed and is continuing to follow each of these projects and is in close communication with each of these utilities, and there have been no safety or reliability issues reported. All of the current research indicates that any safety or reliability issues associated with hydrogen gas blends can be mitigated through reasonable and effective measures.

C. Environmental Benefits of Hydrogen Gas as a Substitute for Natural Gas

Q. What are the environmental benefits of utilizing hydrogen gas generated by power-to-gas projects that use an electrolyzer as a substitute for natural gas?

A. As discussed above, the primary environmental benefit of hydrogen gas is that it is an efficient and effective approach to decreasing the overall carbon intensity of the gas supply. Conventional natural gas has estimated CO2 combustion emissions of 0.053 MTCO2(e)/MMBtu, as compared to hydrogen gas produced by electrolysis, which is 0. Moreover, if the electricity used in the electrolyzer process is produced using a low or no emissions fuel, such as wind or solar, the

[5] Cision PR Newswire, *CenterPoint Energy launches green hydrogen project in Minnesota* (June 3, 2022), https://www.prnewswire.com/news-releases/centerpoint-energy-launches-green-hydrogen-project-in-minnesota-301560709.html.

greenhouse gas emissions associated with the overall production and combustion are correspondingly low or zero.

Q. Is it efficient to use electric generation from renewable energy to produce hydrogen gas?

A. Yes, the efficiency of hydrogen gas production lies in its ability to leverage the variable nature of renewable generation technologies, using excess generation capacity that would otherwise be wasted.

Renewables, such as solar and wind, are variable and peak production does not always correlate with times of peak demand. Therefore, in order to meet peak demand with variable resources, there may be excess supply in periods of lower demand. Similarly, electric demand may be high on a cold and dark winter mornings, but renewable electric energy production may be low due to a lack of wind, sun, and poor hydroelectric conditions. Conversely, demand for electricity is much lower on a mild and sunny spring day, where renewable electric energy production is typically high due to spring runoff and potential abundance of wind and sun. This scenario of low demand/high generation may result in the need to curtail renewable resources, thus wasting the potential production of valuable energy and requiring generation assets to sit idle.

The production of hydrogen gas with electrolyzers is a particularly efficient approach to store such “excess” electric generation; electrolyzers are able to ramp up and down in sync with electricity usage and supply, and during periods of low demand/high generation, the electrolyzers will allow for the storage of energy for future use through the generation of hydrogen gas. The ability to integrate natural

gas system with the electric grid has the potential to facilitate both the decarbonization of the gas system through the blending of hydrogen in the natural gas supply, and the electric grid by facilitating the integration of wind and other variable resources.

Q. Does NW Natural believe there will be enough renewable or non-emitting electric energy in the region that can be used to produce hydrogen gas on a large-scale using power-to-gas technology to provide significant energy storage capabilities?

A. Yes. Policies in Oregon and surrounding states require that all electric demand must eventually be met by renewable or non-emitting generation. To meet these goals, a significant amount of variable renewable generation must be developed.

Additionally, the ability to efficiently store energy plays a key role in achieving these goals because renewable electric energy production is variable and, as stated above, such production is not necessarily correlated to periods of high demand.

Q. Can hydrogen gas technology deliver other benefits to the energy industry and the public more generally?

A. Yes. As more renewable generation is developed and as fossil-fueled electric generation is retired, the challenges associated with variable electric generation will become more pronounced. NW Natural envisions that the incorporation of power-to-gas generation and ultimately hydrogen gas into the energy system can help address these challenges by ensuring that: 1) any excess renewable electric energy that would otherwise be curtailed during periods of low demand can instead

be converted to hydrogen, and 2) the hydrogen can be stored for later use during periods of high demand when renewable energy production is low (e.g., a cold and dark winter morning) when the stored hydrogen gas can be deployed to direct end use natural gas appliances or electrical generation equipment, such as a fuel cell or gas turbine. Thus, production, storage and use of hydrogen gas can make the most efficient use of clean electric generation and facilitate the growth of renewables on the electric grid by providing a tool for grid planners to align supply and demand.

In addition, electrolyzers, which are the heart of power-to-gas systems, can help stabilize the power grid by ramping up and down in seconds in response to changes in variable electric generation (i.e., wind and solar), as well as changes in load. Hydrogen gas production facilities can also provide demand response by quickly ramping up when renewable generation is high or shutting off completely during times of peak demand. Electrolyzers can therefore be used to help balance electric generation and load.

Finally, there is a potential for gas utilities to be financially compensated both for generating hydrogen gas during periods when the price of electricity is low (by increasing demand on the electric system) and for demand response (reducing demand on the electric system). The natural gas industry has historically not participated in providing these grid services, which is why projects such as this one provide an excellent opportunity to better align electric and natural gas industries on the shared objective of reducing GHG emissions for both industries at the lowest overall cost.

Q. Would it be more efficient to store excess energy in batteries rather than using excess energy to produce hydrogen gas?

A. Generally, no. Lithium-ion batteries and flow batteries can keep an energy supply flowing for approximately 4 to 10 hours, but cannot produce at their full capacity for any extended period of time. For this reason, batteries are useful for daily load-shifting purposes, but are not cost-effective for longer duration output.

On the other hand, hydrogen gas can be stored indefinitely in existing underground storage facilities and, if blended with natural gas, can readily be made available within the existing gas storage system. Alternatively, hydrogen gas can be stored alone for specific uses, such as fuel-cell backup power and vehicle fueling, with high-pressure aboveground tanks. The stored hydrogen gas can then be released at a steady state to provide a consistent level of output over an extended period of time.

Moreover, the use of hydrogen gas to store excess electricity is significantly more cost-effective than the use of batteries, which have a much higher cost of capital per kilowatt-hour. Although the power-to-gas-to-power ("PGP") round-trip efficiency is lower than batteries—PGP is approximately 40 percent efficient, and battery round-trip efficiencies peak at approximately 95 percent and decrease over time, the stored energy in both instances is typically curtailed power that would otherwise be wasted. Therefore, the total cost of stored energy for customers is a better indicator of the value of long-term storage capabilities. In fact, the total capital cost per kWh of hydrogen gas generation and long-term storage is orders of magnitude lower than batteries. Additionally, PGP will ultimately establish lower

costs for wind and solar buildouts, as PGP can provide backup power during extended periods (days or even weeks) of low sun and wind resources on the coldest days of the year, allowing these facilities to recoup their power costs that would otherwise be wasted.

Q. Can hydrogen gas create pathways to decarbonize other markets as well?

A. Yes. The development of power-to-gas pilot projects, such as this proposed Project, will help facilitate the development of hydrogen gas infrastructure in Oregon that can contribute to decarbonizing other sectors, such as heavy-duty transportation, aviation, and maritime shipping. These sectors are currently exploring the utilization of hydrogen gas in the operation of their equipment. Projects like this one will lead to progress towards the development of the infrastructure to generate and deliver a reliable source of hydrogen gas to these sectors.

D. NW Natural's Experience with Hydrogen Gas

Q. When did NW Natural first become interested in blending hydrogen gas into conventional natural gas?

A. NW Natural initially became interested in hydrogen gas in 2015 when the Company began to consider alternatives to conventional natural gas that could contribute to a reduction in GHG emissions.

Q. Has NW Natural conducted research and testing that has confirmed that a five percent blend of hydrogen gas can safely be introduced into its system?

A. Yes. Before proposing this Project, the Company completed several laboratory and field tests that confirmed that a five percent hydrogen gas blend will be

compatible with its distribution system and downstream appliances and can be safely introduced onto its system.

First, NW Natural procured five percent blended hydrogen gas/natural gas in cylinders to test its leak detection devices to ensure that they are compatible with the gas blend. Second, NW Natural introduced this blended gas into its "Training Town" at our Sherwood, Oregon Operations and Training Center. Training Town is a "model neighborhood" consisting of small buildings, streets, distribution system equipment, and various natural gas appliances, where numerous scenarios can be introduced therein for field employees and emergency response personnel training.[6] The Training Town exercise allowed the Company to evaluate the impact of the gas blend on existing system piping fittings and end-use appliances, and that operating procedures and leak detection equipment for conventional natural gas are applicable to blended gas. Third, NW Natural introduced the blended gas into the NW Natural "Light-up Lab," where the Company tests natural gas appliances, to ensure a wide variety of household and industrial natural gas appliances will operate without issue with blended gas.

Additionally, NW Natural is also a member of several industry groups that promote the advancement of hydrogen gas generation and demonstration projects and systems, such as the HyReady consortium, the Low Carbon Resource Initiative (LCRI), the Gas Technology Institute, and the Center for Hydrogen Safety. These industry groups share testing data of hydrogen gas and its effect

[6] *See* NW Natural Gas, *NW Natural Training Town* (May 14, 2014), https://www.youtube.com/watch?v=oLTjtu9ZpJo .

on existing natural gas system components and appliances, and experiential insight on the safe handling and distribution of hydrogen gas. NW Natural's participation in these groups allows the Company to contribute its gained experience and learn from industry experts in the field of hydrogen gas generation, distribution, and utilization.

Q. Is NW Natural going to test a higher percentage of a hydrogen gas blend?

A. Yes. The Company intends to begin testing a 20 percent hydrogen gas blend at the Sherwood Operations and Testing Center by the end of the year. That project will be conducted at the Sherwood Service Center Building "A", for a period of 12 months. The natural gas equipment at Building "A", including rooftop HVAC units, water heaters, and a domestic oven, will be monitored for leaks and operational performance with the blended gas at increasing amounts of hydrogen.

Q. Based on its research and testing of hydrogen gas, does NW Natural believe that a five percent hydrogen blend (by volume) can safely be introduced into its distribution system?

A. Yes. The research and testing performed to-date shows that a five percent of hydrogen gas (by volume) can safely be introduced into the existing natural gas distribution system. Furthermore, the Company's testing results are consistent with the results of the pilot projects conducted by others. As we learn more from the previously mentioned 20 percent Sherwood project, and other similar projects throughout the country, the Company will continue to increase the blended amount of hydrogen gas to an estimated maximum of 10 percent for this Project.

III. EUGENE HYDROGEN PILOT PROJECT

A. Background and Objectives of Project

Q. Please briefly describe the Project.

A. The Project is a 1 MW electrolyzer plant that will generate hydrogen gas to be blended with NW Natural's existing natural gas supply and delivered to the immediate area of the Eugene Water & Electric Board ("EWEB") facility. The Project will be constructed on EWEB property, with NW Natural purchasing the water and electricity necessary to produce the hydrogen gas from EWEB. Importantly, EWEB's electric generation resource portfolio is approximately 90 percent non-emitting, using hydroelectric, nuclear, and wind generation.[7] For this reason, the production of hydrogen gas from the Project will produce minimal amounts of GHG emissions.

Q. What are the main objectives for this Project?

A. The main objectives of the Project are to provide NW Natural with knowledge and experience about: 1) constructing, operating, and maintaining an electrolyzer facility designed to produce hydrogen gas; and 2) introducing hydrogen gas into the Company's distribution lines to serve customers under "real world" conditions. This Project will provide the Company with the experience and knowledge required for a more extensive hydrogen roll out over time, with additional power-to-gas projects in other areas of its service territory.

[7] EWEB, Where Your Power Comes From (Aug. 1, 2022), https://www.eweb.org/about-us/power-supply.

Q. What is the value of such "real world" experience, given the work that the Company has already performed to study the feasibility of introducing hydrogen gas onto its system?

A. NW Natural's laboratory and training tests of hydrogen gas all indicate that hydrogen gas blends provide a safe and reliable approach to reducing GHG emissions associated with its product. However, before introducing hydrogen gas on a large scale—as the Company is planning to do—NW Natural believes it must observe first-hand how the hydrogen gas blends impact the Company's pipeline infrastructure and customer appliances in a more limited pilot. Thus, the Project will provide the Company with an opportunity to confirm its laboratory findings, and thereby ensure customers and the public are protected. Specifically, the Project will demonstrate that the leak detection instrumentation, distribution system piping and fittings, and end-use appliances operate safely and reliably with the introduction of the hydrogen gas blend. Importantly, if any operational issues arise, NW Natural will gain experience in reacting quickly to address and mitigate such issues, just as it does today when issues arise with conventional natural gas. The Company will gain practical experience in best practices for gas blend leak detection, gas energy density for billing purposes, and which standard operating procedures may need to be changed to accommodate hydrogen gas.

In addition, NW Natural will develop experience with electrolyzers, and permitting, constructing, operating, and maintaining a hydrogen gas generation and distribution project. On the construction side, the Company will gain knowledge and experience applying building codes that are specific to hydrogen

facilities. The Company will also gain knowledge regarding the operations and maintenance of hydrogen gas equipment. The Company believes that this experience and knowledge will inform and streamline future construction and operation of large-scale hydrogen facilities. All of this information will ultimately benefit customers as hydrogen gas is deployed more widely across NW Natural's system.

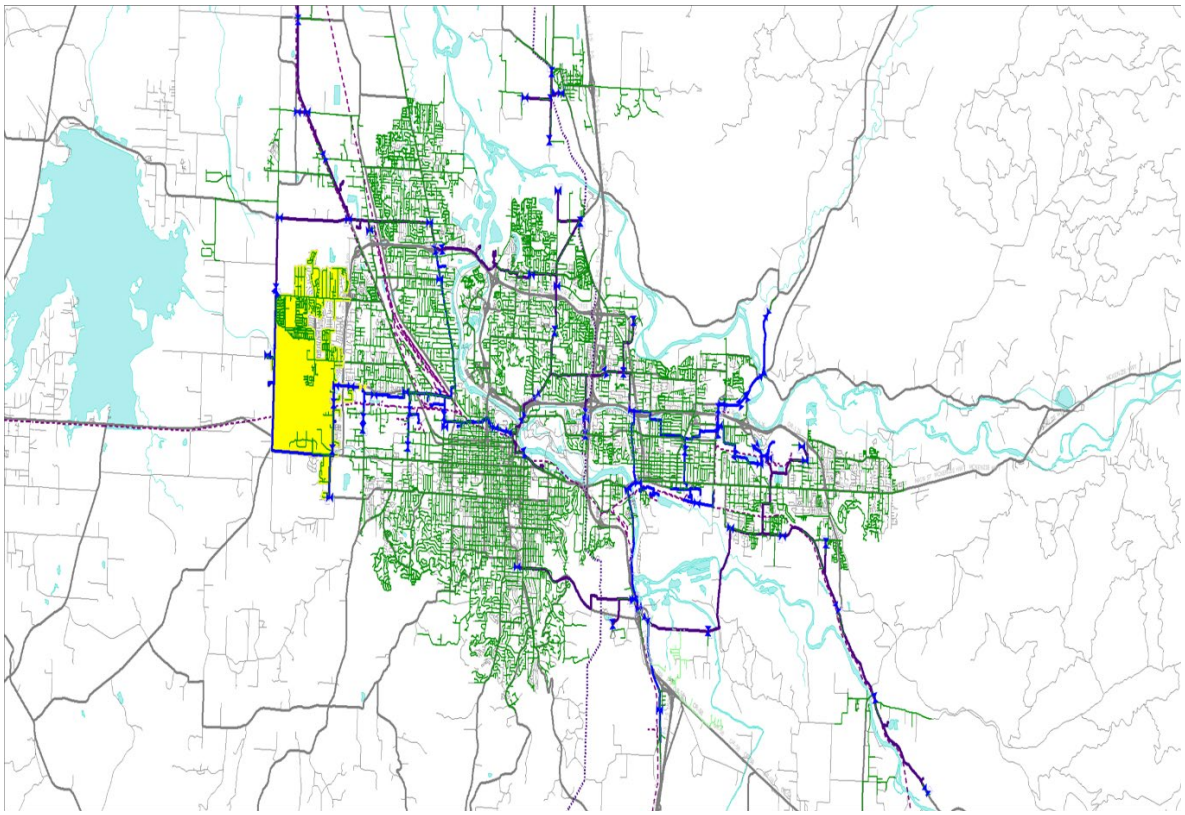
B. Details of Project Operations

Q. What ratio of hydrogen gas to natural gas will be used?

A. NW Natural will deliver an initial blend of five percent hydrogen gas to 95 percent natural gas (by volume). The installed 1 MW electrolyzer capacity will enable an approximate 10 percent by volume blend in the future, based on the Project's operational data. NW Natural believes that this higher percentage of hydrogen gas will be both technically feasible and safe. The Company will ensure the heating value of the gas remains within the current tariff, which requires that the product delivered to customers has a minimum heating value of 985 Btu/cf.

Q. To whom will the blended gas be distributed?

A. NW Natural will use its existing gas pipeline distribution system to deliver the blended gas to approximately 2,439 customers in the West Eugene area. The service area includes a mix of residential, commercial, and industrial customers, which is representative of NW Natural's broader customer base. The map below shows the extents of the project boundary in yellow.



Q. Please provide some detail on the design and construction of the Project.

A. Initially, NW Natural will install water and electrical supply interconnections and a 1 MW electrolyzer, with the infrastructure in place to install an additional 1 MW electrolyzer in the future.[8] The electrolyzer was sized at 1 MW to ensure that the Project will meet hourly, peak, and seasonal demands, and is expected to operate at full capacity, up to 1 MW, during peak winter load/throughput to provide up to a 10 percent blend of hydrogen by volume (initial blend will be five percent). NW Natural will install piping from the electrolyzer to the nearest NW Natural

[8] NW Natural is not seeking approval of such an expansion in this filing. If the Company decides to expand the pilot project, it will seek cost recovery in a subsequent filing.

distribution line, with instrumentation and slip-stream piping for controlled blending of the hydrogen gas prior to injection into the natural gas system.

Q. How will NW Natural contain the area to which the blended gas is delivered?

A. NW Natural will utilize existing control valves that have been installed throughout its distribution system to isolate the area and ensure that the distribution of hydrogen gas is controlled.

Q. What equipment, in addition to the electrolyzer, is needed for operation of the Project?

A. Other equipment needed for operation of the Project will include: on-site and remote control systems, water purification, gas blending equipment, chromatographs, various gas meters, building HVAC, and safety systems.

Q. Where will the Project be located?

A. The Project will be located adjacent to EWEB's Roosevelt Operations Center on land leased from EWEB, as shown below.

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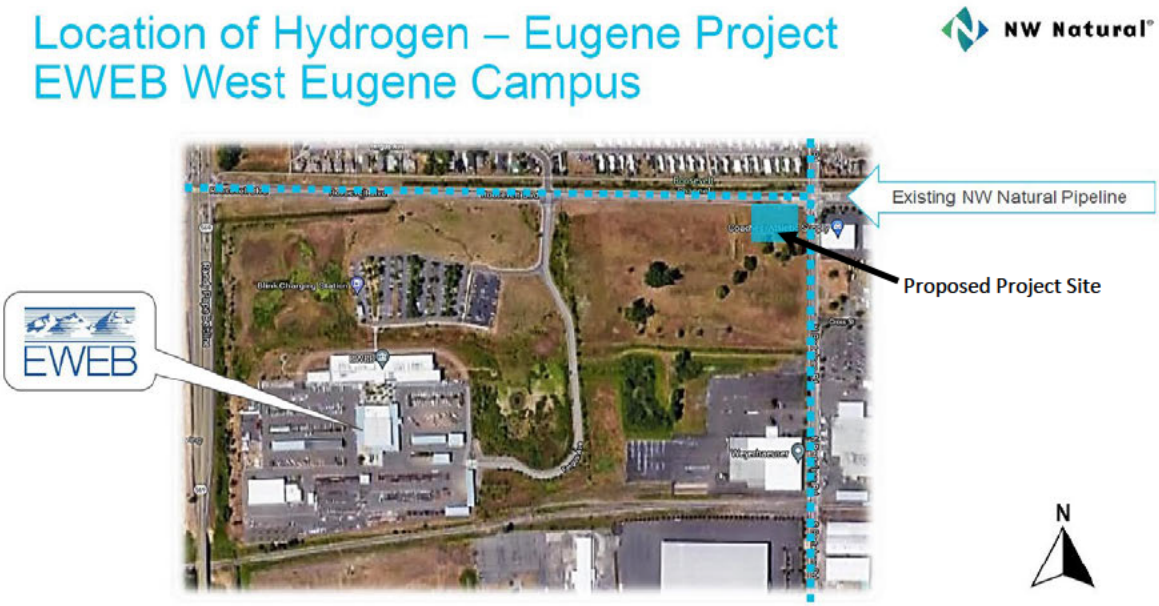

This location minimizes the Project's interconnection costs to EWEB's electrical and water systems and is also adjacent to large diameter NW Natural distribution lines, which can receive the hydrogen gas the Project produces.

Q. What price will NW Natural pay for the electric energy needed to power the electrolyzer and how much electricity does the Company expect to purchase?

A. NW Natural will purchase firm power from EWEB at its standard industrial rate, which is approximately $65 per megawatt hour (MWh). For the Project, NW Natural needs a relatively small—1 MW—dedicated source of power to produce the amount of hydrogen that is necessary for a maximum 10 percent blend by volume in the West Eugene area. The project is anticipated to use less than 2,000 MWh per year at the initial hydrogen production level.

Q. How much water will NW Natural be required to purchase from EWEB to produce the hydrogen gas?

A. The Company plans to purchase water from EWEB at its standard rate. The Company estimates that the Project will use approximately 1,000,000 gallons per year, which is equal to approximately 0.1 percent of the water that EWEB provides to its customers each year and is equivalent to a light industrial load. The total annual water cost is less than $5,000.

Q. Will NW Natural operate the electrolyzer consistent with the approach previously discussed—ramping up and down to accommodate fluctuations in renewable energy demand and supply?

A. NW Natural intends to operate the Project to accommodate fluctuations in demand and supply. NW Natural is coordinating with EWEB on how to operate the project in order to demonstrate in real world conditions how an electrolyzer project can provide demand response to the electric grid.

If the Project is successful, NW Natural expects that larger power-to-gas projects would source their power from renewable sources that may otherwise be curtailed, as previously discussed in Section II.C and these projects would ramp up and down to accommodate fluctuations in renewable energy demand and supply.

Q. Is NW Natural foreclosing other means of producing hydrogen by focusing on power-to-gas technology for this Project?

A. No. While NW Natural is using power-to-gas technology for this Project, the Company is also pursuing another pilot that will reform natural gas into hydrogen

gas and solid carbon.[9] The resulting hydrogen gas will be blended into NW Natural's system in a very small amount (estimated 0.16 percent in summer and 0.03 percent in winter, as opposed to five percent for this Project). Since the carbon from the natural gas is not emitted into the atmosphere, but rather is solidified using methane pyrolysis technology from Modern Electron, GHG emissions will be reduced.

Although NW Natural is very excited about this new pilot project, it does not diminish the need for the Eugene Hydrogen Pilot Project. The new pilot project is largely to help advance methane pyrolysis technology, learn how the technology can be integrated into utility operations, and how the solid carbon can be monetized and/or safely disposed of.

As stated above, NW Natural still needs to pursue the Eugene Hydrogen Pilot Project to gain real world experience in blending larger amounts of hydrogen gas into its system, and the limited amount of hydrogen gas produced by this new pilot project is insufficient for such blending. NW Natural selected power-to-gas technology for this Project because it is an economical way to produce the steady stream of hydrogen gas that it needs to provide reliable service to the customers that will be serviced by this Project, while ensuring emissions reductions in the natural gas supply and exploring grid benefits that could lead to lower power costs in the future, as was previously discussed.

[9] BusinessWire, *NW Natural to Partner with Modern Electron on Exciting Pilot Project to Turn Methane into Clean Hydrogen and Solid Carbon* (July 27, 2022), 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.

IV. COMPLIANCE WITH SB 844 REQUIREMENTS

A. Eligibility Requirements

Q. Does the Project comply with the eligibility requirements applicable to SB 844 programs?

A. Yes. The Project satisfies all eligibility requirements of SB 844 (ORS 757.539(3)). The Commission incorporated these eligibility requirements into its own implementing regulations, which are found at OAR 860-085-0500 through OAR 860-085-0750. Please note that the regulatory requirements specific to costs and cost recovery (OAR 860-085-0600(2) and OAR 860-085-0700) will be addressed in the Direct Testimony of Robert Wyman, and the requirements for the Project Application (OAR 860-085-0600) are addressed in the Application that the Company is filing contemporaneously with the testimony.

Q. What are the general eligibility requirements contained in SB 844, as well as the Commission's regulations?

A. ORS 757.539(3) requires (in summary) that:

(a) The project be proposed by a natural gas utility and involve natural gas;

(b) The project directly or indirectly reduce emissions;

(c) The project benefit customers of the utility;

(d) The utility would not have invested in the project in the ordinary course of business;

(e) The utility engage stakeholders; and

(f) The rate impact of all SB 844 projects undertaken by NW Natural not exceed the amount established by the Commission.

Q. Does the Project satisfy each of these requirements?

A. Yes. The Project is proposed by NW Natural, a natural gas utility, and involves natural gas as required by ORS 757.539(3)(a). Additionally, the rate impact of all SB 844 projects undertaken by NW Natural—currently only this proposed Project—does not exceed the project cap established by the Commission. The Project satisfies each of the remaining requirements as well.

1. Emissions Reductions

Q. Please explain how the Project will reduce GHG emissions as required by ORS 757.539(3)(b).

A. As a general matter, the Project will reduce GHG emissions because 1) the hydrogen gas that will be produced by the Project will be created from electricity that is largely associated with non-emitting resources: hydroelectric, wind, and nuclear; and 2) the carbon intensity of the blended gas is lower than conventional natural gas.[10]

First, the hydrogen gas production process has lower associated GHG emissions than the conventional natural gas process because of the energy resource utilized to produce the hydrogen gas. EWEB estimates that 90 percent of its portfolio is from carbon-free resources[11] and that the carbon intensity of its overall resource portfolio is approximately 0.02 MTCO2(e)/MWh. As a result, the

[10] See Section IV. B for further discussion of associated emissions reductions.

[11] EWEB, Where Your Power Comes From (Aug. 1, 2022), https://www.eweb.org/about-us/power-supply.

carbon intensity of the blended hydrogen gas that will be delivered to NW Natural's pilot customers will be lower than that associated with conventional natural gas.

Second, the blended gas will have a lower carbon intensity than 100 percent conventional natural gas because hydrogen gas does not emit carbon dioxide upon combustion. Later in my testimony I discuss in further detail the specific values associated with the reduction in emissions between the two gas blends.

NW Natural also believes that the Project will indirectly reduce emissions by contributing significantly to the Company's knowledge and expertise in producing, blending, and delivering hydrogen gas safely to its customers. This knowledge and expertise will allow the Company to deliver hydrogen gas on a larger scale, further decreasing the carbon intensity of its gas supply beyond the service area of this Project.

2. Customer Benefits

Q. How will the Project benefit NW Natural's customers, as required by ORS 757.539(3)(c)?

A. At its core, reducing emissions and decarbonizing the gas system is a benefit to our customers. Moreover, as discussed above, the CPP *requires* the Company to reduce its GHG emissions significantly—90 percent by 2050. The Company believes that, along with RNG and energy efficiency, production of hydrogen gas is one of the key strategies that will assist NW Natural to meet its emissions-reduction goals. In this context, the Project will help the Company develop the operational experience necessary to introduce a hydrogen gas blend to NW Natural's distribution system on a large-scale—a step that the Company believes

is crucial to its plans to reduce emissions associated with its gas supply as quickly as possible.

3. The Company Would Not Pursue the Project in the Ordinary Course of Business

Q. Please explain, as required under ORS 757.539(3)(d), why the Company would not pursue this Project in the ordinary course of business, even though emissions reductions are now required by the CPP.

A. The Company would not pursue the Project in the ordinary course of business because it is more expensive than other RNG resources.[12] In its most recent request-for-proposals for RNG in April 2022, NW Natural received bids ranging from **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**. The estimated price of hydrogen gas from this Project is $30-40/MMBtu,[13] including capital costs over a 20-year life, resulting in a cost of approximately $3,000 per metric ton of reduced emissions.[14]

Q. Did NW Natural receive bids for hydrogen resources in its 2022 RFP?

A. Yes. **[BEGIN CONFIDENTIAL]** [redacted]

[redacted]

[12] NW Natural is permitted to acquire RNG under ORS 757.390-398, even if it is more expensive than conventional natural gas.

[13] This price does not reflect the incremental cost of the Project. The incremental cost is the difference between the total (or "all-in") levelized cost of the Project and the all-in levelized cost of the same quantity of conventional natural gas. Although not required in an ORS 757.539 application, NW Natural will supplement its filing with the Project's incremental cost later in this proceeding.

[14] Per OAR 860-085-0650, this amount classifies the Project as Tier 2. Under ORS 757.539(7), the Tier 2 process provides interested parties with an opportunity to submit testimony in response to the proposed project and specifies that a final Commission order on the Project be issued within 180 days of receiving the ORS 757.539 application or at a later time as authorized by the public utility.

[redacted] **[END CONFIDENTIAL].** The Project, however, is much further along in development and has a fixed on-system location that will allow NW Natural to begin blending hydrogen into a portion of its distribution system, as explained above. Developing the Project will allow the Company to take full advantage of falling hydrogen gas prices by ensuring that it has the "real-world" experience to blend hydrogen gas into its system on a large scale. It will also help ensure that NW Natural has the expertise to integrate these resources onto its system and not solely rely on off-system hydrogen acquisitions.

Q. Given these benefits, why would NW Natural not pursue the Project in the ordinary course of business?

A. Simply put, other sources of RNG are less expensive and, therefore, absent SB 844, the Project would not be pursued by the Company. However, as stated above, the Project better positions the Company to inject hydrogen gas into its system as the cost of hydrogen falls.

Q. You stated that the estimated price of hydrogen gas from this Project is $30-40/MMBtu and costs approximately $3,000 per metric ton of reduced emissions. Would these per-unit costs decrease if NW Natural pursued a larger power-to-gas pilot project?

A. Potentially, yes. Although NW Natural could have pursued a larger hydrogen gas project to lower per-unit capital costs and possibly obtain a lower electricity price from EWEB or another provider, a larger project would have increased the overall costs and, for that reason, NW Natural decided to pursue this smaller scale pilot

project. Furthermore, pursuing a larger hydrogen pilot project would produce more hydrogen gas than is needed for this Project, which will serve a relatively small area of the Company's service territory. Ultimately, this Project is sized such that it is large enough to gain real-world experience from, yet small enough to minimize the Project's overall costs.

Q. Are there other factors that will decrease the cost of hydrogen over time?

A. Yes. As more and more renewable generation comes online to meet the region's decarbonization goals and is produced at times in excess of demand (see Section II.C. above), costs will decrease, making hydrogen gas from power-to-gas facilities on par or less expensive than other sources of RNG. Therefore, the Company expects that hydrogen gas produced from power-to-gas and other technologies will be a key part of its decarbonization efforts in the future through hydrogen/natural gas blends, as well as 100 percent hydrogen systems that will produce minimal, if any, GHG emissions. Both hydrogen/natural gas blends and 100 percent hydrogen systems are currently being pursued elsewhere and the Company strongly believes it must gain expertise with hydrogen now to take full advantage of this emerging technology in the future.

4. Stakeholder Outreach and Involvement

Q. As part of the program eligibility requirements, ORS 757.539(3) mandates that an applicant involve stakeholders prior to filing an application. Did NW Natural initiate stakeholder outreach and involvement prior to filing this application?

A. Yes. NW Natural involved stakeholders in the development and scope of this Project prior to filing its Application. The Company is aware that the Commission favors designs that have broad support from Staff, customer groups, and other intervenors, as was noted in NW Natural's prior SB 844 filing, and NW Natural acknowledges the Commission's direction to work more closely with stakeholders on future program designs.

Q. In developing this Project, what stakeholders did NW Natural coordinate with first?

A. As explained above, NW Natural first coordinated with EWEB. EWEB is providing the power and water for the Project, as well as the Project site and has been instrumental in developing the Project to date. NW Natural also coordinated with the Renewable Hydrogen Alliance ("RHA") and the Bonneville Environmental Foundation ("BEF"). The RHA is a Pacific Northwest regional non-profit trade association whose mission is to promote the use of renewable energy to produce hydrogen and help reduce carbon emissions in multiple sectors like transportation, energy and industry.[15] The BEF is a non-profit working on society's most pressing

[15] *See* NW Natural/102, Kroeker (presentation from NW Natural's first stakeholder meeting).

energy, carbon, and water issues, and has focused on integrating renewable hydrogen into the electricity system with the goal of maximizing systemic benefits of renewable energy production and utilization across all sectors of the economy.[16]

Along with EWEB, RHA and BEF provided their support and expertise throughout the Project development process, including participating in meetings with other stakeholders where they each explained the benefits of hydrogen, and this Project in particular, from their own perspectives. EWEB, for instance, explained how hydrogen can benefit the power system by facilitating the build out of large amount of variable renewable generation, as well as providing storage, local gird support, and resiliency.[17] RHA and BEF explained the systemic and regional benefits of hydrogen, including how hydrogen helps reduce carbon emissions in multiple sectors, including transportation, energy and industry.[18]

NW Natural greatly appreciates the effort and time that EWEB, RHA, and BEF have put into the Project, including their willingness to share their expertise and perspective with other stakeholders. By ensuring that the Project was presented from multiple perspectives during stakeholder workshops, NW Natural attempted to make the stakeholder process more inclusive, engaging, and informative than a process solely dependent on NW Natural to present information and answer questions.

[16] *Id.*

[17] *See* NW Natural/102, Kroeker; NW Natural/103, Kroeker.

[18] *Id*.

Q. How many stakeholder workshops did NW Natural have?

A. NW Natural held two stakeholder workshops. The first workshop was held on May 24, 2022, and was focused on giving the community of Eugene an opportunity to learn more about the Project, as well as ask questions. The second workshop was held on July 8, 2022, with a wider group of stakeholders, many involved in the Company's dockets at the Commission.

Q. Who did NW Natural invite to the first stakeholder meeting on May 24, 2022?

A. NW Natural invited local government officials, neighborhood and community organizations, organized labor, and local schools. In addition, as explained above, EWEB, RHA, and BEF were involved in presenting the information and in answering questions. Approximately 22 people attended the virtual meeting.[19]

Q. Who did NW Natural invite to the second stakeholder meeting?

A. NW Natural invited parties involved in its ongoing rate case, stakeholders participating in the Company's Integrated Resource Plan process, and stakeholders involved in the Commission's Natural Gas Fact-Finding, docket UM 2178. EWEB also publicized the meeting on its website.[20] EWEB, RHA, and BEF were again involved in presenting the information and in answering questions. Approximately 47 people attended the virtual meeting.[21]

[19] *See* NW Natural/102, Kroeker; NW Natural/104, Kroeker.

[20] EWEB, NW Natural Hydrogen-Eugene Project Meeting, https://www.eweb.org/about-us/calendar/nw-natural-hydrogen-eugene-project-meeting.

[21] *See* NW Natural/103, Kroeker; NW Natural/105, Kroeker.

Q. Has NW Natural conducted additional stakeholder outreach to neighborhood associations in Eugene?

A. Yes. NW Natural shared information and established a line of communication with Eugene neighborhood associations as part of its stakeholder outreach.

Q. Is NW Natural planning on additional stakeholder outreach?

A. Yes. During construction and operation of the Project, NW Natural will continue to remain engaged with these parties and inform them on construction progress, experienced gained from construction and initial operation, and continue to receive and address questions and concerns.

B. Emissions Reduction Verification Plan

Q. Aside from ORS 757.539(3), are there any other requirements that you would like to address?

A. Yes. OAR 860-085-0600(3) requires NW Natural to develop an Emissions Reduction Verification Plan ("Plan") to calculate the emission reductions provided by the Project over the course of the Project's life (20 years). NW Natural also must explain how the Plan was developed and its proposal for monitoring and verifying the estimated emissions reductions.

Q. Please explain the Emissions Reduction Verification Plan methodology used to calculate the projected emissions reductions.

A. First, NW Natural calculates the baseline of emissions that would occur under the normal course of business where conventional natural gas is used to meet the demand in the Project service area that will now be provided by hydrogen gas. Over the course of one year, the Project will replace approximately 4,300 MMBtu

of thermal energy currently provided by natural gas. The Project will provide that heating value in the form of the hydrogen gas. Using the Oregon Department of Environmental Quality ("ODEQ") GHG emissions estimate of 0.053 MTCO2(e)/MMBtu for conventional natural gas,[22] the baseline emissions for the volume of natural gas displaced by hydrogen gas are equal to approximately 228 MTCO2(e) per year.

Second, the methodology accounts for and deducts any estimated emission leakage and project emissions. Emission leakage means "a reduction in greenhouse gas emissions within the Project that is offset by an increase in greenhouse gas emissions outside the Project."[23] There will be no emissions leakage associated with the Project because the hydrogen gas is able to replace the natural gas with no additional fuel resources outside of the Project needed or additional processes that would generate or increase emissions. Therefore, there are zero emissions related to leakage to be deducted from the emission reduction estimate.

In the next step of the methodology, the Project emissions are calculated. Project emissions means "any emissions attributable to the implementation of an Emission Reduction Project."[24] The Project will rely on EWEB for power, and, while EWEB's system is currently overwhelmingly emissions-free (and EWEB

[22] ODEQ utilizes the Environmental Protection Agency's GHG Reporting Values. 40 CFR Part 98, subpart NN.

[23] OAR 860-085-0600(3)(a)(B).

[24] *Id*.

expects to continue to phase out fossil fuel generated power) EWEB still relies on a small-percentage of fossil fuels for power. Due to this minimal reliance on fossil fuel, EWEB's carbon intensity is not zero, but rather 0.02 MTCO2(e)/MWh. This results in an estimate of the Project's emissions being 34 MTCO2(e)/year. Therefore, the total emissions savings from the Project is approximately 194 MTCO2(e)/year. This estimate is based on the emission reduction estimate of 228 MTCO2(e)/year, deducting leakage (0 MTCO2(e)/year) and Project emissions (34 MTCO2(e)/year).

Q. How was this methodology developed?

A. The methodology is largely adopted from the OAR 860-085-0600 requirements, which requires calculating the difference between baseline emissions[25] and the emissions that would occur after the Project is completed. As explained above, the methodology takes into account the negligible amount of emissions produced by the Project and also explicitly addresses leakage, as required by OAR 860-065-0600, although, as stated above, there will be no leakage as a result of the Project. The methodology also relies on ODEQ's GHG emissions estimate of 0.053 MTCO2(e)/MMBtu for conventional natural gas.

Q. Will the baseline emissions change over the 20-year life of the Project due to SB 98 and the CPP?

A. No. The Company only intends to displace conventional natural gas with hydrogen gas produced from the Project. In other words, the Company will not use the

[25] That is, the emissions that would otherwise occur in the normal course of business without the Project.

hydrogen gas the Project produces to reduce its use or procurement of RNG. Using hydrogen gas to displace RNG would be counterproductive in complying with CPP and in meeting SB 98 volumetric sales targets.

Q. What is NW Natural's plan for monitoring emissions reductions as required under ORS 757.539(4)(k) and OAR 860-085-0600(3)(b)?

A. NW Natural proposes to submit an annual report that will calculate the Project's emissions savings as an addition to its RNG Compliance Report required in OAR 860-150-0600. The report will use the actual amount of hydrogen gas produced in the previous calendar year, as well as any updates to the carbon intensity of EWEB's power supply to calculate an annual emissions reduction value.

C. Environmental Credits

Q. In addition to the requirements of ORS 757.539, OAR 860-085-0600 requires applications for SB 844 projects to describe whether the Project is able to generate environmental credits or certificates and any potential revenues associated with their sale or use. Is the Project eligible for any credits?

A. If the federal Inflation Reduction Act is passed, the hydrogen gas produced is eligible for tax credits. Based on the carbon intensity of the electricity supplied by EWEB, the Project should produce 1.1 CO2e per kg of hydrogen, and therefore produce a tax credit of $1.49/MMBtu. NW Natural is working towards understanding what the prevailing wage and apprenticeship requirements would be for this Project. If the requirements are met, the tax credit would be increased by a factor of five to $7.44/MMBtu. Value from tax credits produced from the production of hydrogen would be delivered back to all customers to reduce costs.

If the Project is eligible for any other credits based on the environmental attributes of the Project, the Company would not seek to monetize them by separating or "unbundling" them from the energy content of the hydrogen gas. By not unbundling and monetizing these credits, the Company ensures that all environmental attributes, including GHG reductions, are appropriately credited to the Company and its customers.

D. Why the Project is Appropriate, Timely, and Merits Approval

Q. OAR 860-085-0600 also requires applications for SB 844 projects to explain why the proposed project is appropriate, timely, and merits approval. Given that the per-unit costs of hydrogen gas are projected to fall substantially over the coming years, why is the Project timely?

A. The Project is timely because it prepares NW Natural for future hydrogen blending projects throughout its system, which may include hydrogen projects owned and operated by third parties, as well as projects owned and operated the Company. Already customers are inquiring as to whether NW Natural can serve them with hydrogen. While, as explained above, NW Natural expects that both larger projects and the increasing amounts of renewable power will decrease the per-unit costs of hydrogen gas production, this Project will be invaluable in decreasing these costs even further by giving NW Natural both construction and operational experience. This experience will further enhance NW Natural's ability to build and operate these projects efficiently.

Further, the Project will provide first-hand experience for utilizing a hydrogen gas blend in its distribution system. By pursuing the Project now, NW

Natural will gain real world experience in operating its distribution system with a hydrogen gas blend and will be able to quickly pivot to introducing hydrogen gas over larger areas of its system as hydrogen gas production costs decrease. This experience will, for example, allow NW Natural to respond more quickly to a third-party project developer seeking to inject hydrogen into NW Natural's system and to better respond to customers seeking to meet their energy needs, in whole or in part, with hydrogen gas. If NW Natural were to wait to pursue hydrogen gas until it was cost competitive with RNG, the introduction of hydrogen gas into its system would likely be delayed, as NW Natural would first seek to develop its hydrogen gas expertise with a relatively limited hydrogen blend (e.g., five percent hydrogen blend by volume) over a limited geographic area. In short, the Project will allow NW Natural to introduce more hydrogen gas to its system faster in the future, thereby further helping both the state and the Company achieve its decarbonization goals.

Q. Why is the Project appropriate and merits approval?

A. The Project is appropriate and merits approval because it is a crucial step in meeting both NW Natural's and the state's decarbonization goals. Although small in size, the Project is a step towards large-scale hydrogen gas production that will provide a viable substitution for natural gas with an essentially emissions free fuel and, as explained above, will help prepare NW Natural (and other industries and natural gas utilities) for its wider introduction into the natural gas distribution system. By starting to develop this infrastructure now, NW Natural will be in a much better position to utilize hydrogen gas at a larger scale.

In addition, the Project is appropriate and merits approval because it is aligned with the Commission Staff's recommendations in its recent docket UM 2178 Natural Gas Fact Finding (draft) Report ("the Report"). In the Report, the Commission recommends that SB 844 pilot projects, generally, should be encouraged as the natural gas industry explores all available GHG reduction pathways.[26] Furthermore, as an existing regulatory tool, SB 844 will provide incentives for the development of pilot projects that will lead to large-scale implementation and contribute knowledge and experience to other ventures, such as the joint pilot for Green Hydrogen by 2025.[27] Therefore, approval of this Project is aligned with Commission Staff recommendations and the decarbonization goals of the state and NW Natural.

Q. Does this conclude your testimony?

A. Yes.

[26] *Natural Gas Fact-Finding Report*, Docket UM 2178 at 27 (Apr. 15, 2022), https://edocs.puc.state.or.us/efdocs/HAH/um2178hah155046.pdf.

[27] *Id.* at 28 (describing such a pilot as an "urgent action").

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibits of Chris Kroeker

EUGENE HYDROGEN PILOT PROJECT
EXHIBITS 101-106

August 12, 2022

EXHIBITS 101-106 – EUGENE HYDRON PILOR PROJECT

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EUGENE HYDROGEN PILOT PROJECT
EXHIBIT 101

August 12, 2022

THE OXFORD INSTITUTE FOR ENERGY STUDIES

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A QUARTERLY JOURNAL FOR DEBATING ENERGY ISSUES AND POLICIES

THE ROLE OF HYDROGEN IN THE ENERGY TRANSITION

Fuel mix to comply with IMO emissions strategy by 2050

Projected overall fuel mix by 2050	Energy requirement (EJ/year)	Fuel mix (million t oil equivalent)
Carbon-neutral fuels[a]	4.3	102
LNG	2.5	60
Electricity	0.6	13
HFO / marine gas oil	3.7	89
Total	11.1	264

[a] These include biofuels and carbon-free fuels (H_2, NH_3).Source: DNV (2019, June), *Assessment of Selected Alternative Fuels and Technologies*

Conclusion

The best technological pathways to achieving decarbonization of shipping are right now highly uncertain. It is likely that in the near term the greatest potential for GHG reduction will be in operational efficiencies, most obviously in slow speeds and port congestion management. In the short to medium term, batteries, and later on hydrogen-based electrification, will become more common, at least for short-sea shipping. The use of biofuels will significantly expand, limited ultimately by the sustainability of their production and the relative price of alternatives. LNG and to a lesser extent LPG will play a significant, but ultimately time-limited role, as they offer significant GHG reductions now but not the prospect of full decarbonization.

In the much longer term, ammonia currently looks like the most likely route to total decarbonization in deep-sea shipping, although a whole new world fleet and bunkering infrastructure would need to be developed, which will take time. Much depends on future pricing of renewably generated electricity. Carbon capture and nuclear power could well remain enticing but undelivered silver bullets.

The cost of decarbonization may seem high; but in the long run, it will have only a modest effect on the cost of goods transported. If the pace of regulatory change in the shipping industry going forward is slow, then regulators may well be overtaken by the pace of markets, as all stakeholders demand further change. Investors and businesses, and increasingly governments, are making commitments and starting to act. The shipping industry is fragmented geographically and between sectors; its immediate priorities must be on ways to more quickly bring about a mix of commercial incentives and regulatory change that results in tangible emissions reductions.

HYDROGEN BLENDING—LESSONS FROM HYDEPLOY

Tommy Isaac and Andy Lewis

The HyDeploy project[35] is the first programme in the UK to supply hydrogen, in the form of a blend, to a live gas network since the conversion from towns gas in the mid-1970s. The project is delivered by Cadent, Northern Gas Networks, Progressive Energy, the Health and Safety Executive (HSE) Science and Research Centre, Keele University, and ITM Power. The programme is funded via the Ofgem Network Innovation Competition and commenced in 2017.

The objective of the HyDeploy programme is to demonstrate that a blend of hydrogen, up to 20 per cent by volume (vol%), can be safely distributed and utilized within the Great Britain (GB) gas distribution network. The current limit for hydrogen distribution is 0.1 per cent by moles (mol%) as per Schedule 3 of the Gas Safety (Management) Regulations (GS(M)R), 1996.[36] Derogation, or exemption, to elements within the regulations can be applied for via Schedule 11 of GS(M)R. Such exemption cases must be presented to the regulator, the HSE. The exemption cases must demonstrate that 'those affected by the proposed change are not prejudiced in consequence of it'. To achieve this, a safety case must be presented that evidences that a blend of 20 vol% hydrogen is 'as safe as' natural gas. The purpose of the HyDeploy programme is therefore to generate and demonstrate this evidence base on a GB scale to facilitate the deployment of hydrogen blending across the GB gas distribution network.

[35] Isaac, T. (2019), 'HyDeploy: The UK's first hydrogen blending deployment project', Clean Energy Journal, 3:2, 114–125.
[36] UK Gas Safety (Management) Regulations 1996, UK Statutory Instruments 1996, No. 551.

The overall HyDeploy project is structured into two separately funded programmes, HyDeploy and HyDeploy$_2$. The first HyDeploy programme has delivered the first private trial of hydrogen blends at Keele University; it started in 2017 and will end in 2021. The HyDeploy$_2$ programme continues on, to deliver the first public trial of hydrogen blends in Winlaton, Gateshead, and will seek to deliver a final exemption to act as a template for national hydrogen blending. HyDeploy$_2$ started in 2019 and will continue to 2023.

The purpose of this article is to detail the lessons learnt from the core technical programmes of the overall project to date and from the operation of the first trial at Keele University. The evidence base in support of the Keele University trial exemption has been assessed and approved by the HSE. At the time of writing, the evidence base for the Winlaton safety case is still under review by the HSE.

Technical programmes

The technical programmes of the overall HyDeploy programme are the basis on which the safety case is developed to apply for exemption to the hydrogen limit within GS(M)R. Each technical area seeks to investigate any marginal impacts that relate to the introduction of a hydrogen blend, relative to business-as-usual operations with natural gas. Any impacts are then quantified and assessed though an overarching quantitative risk assessment (QRA) to understand the total risk profile and structure of the hydrogen blend relative to natural gas.

Gas characteristics

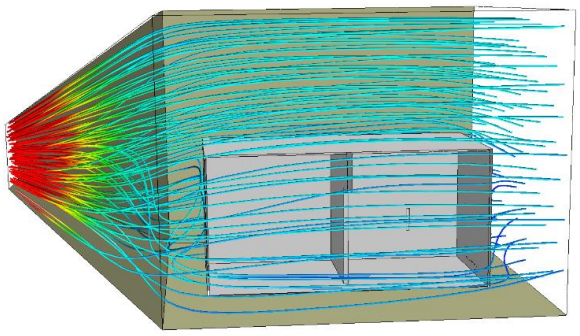
Gas characteristics research is central to the understanding of any marginal differences between a hydrogen blend and natural gas. For the purposes of the research undertaken, natural gas has been explored via a proxy of 100 per cent methane, as is standard practice in gas research. The gas characteristics work streams have primarily explored the chain of causality that leads to fire/explosion, to understand at each stage whether a hydrogen blend affects the current elements. For clarity, the chain of independent events of concern is as follows: a gas leak occurs; the gas leak accumulates to a flammable concentration; an ignition source of sufficient energy is present and activated within the flammable cloud; and a fire or explosion occurs, leading to building impacts and injury.

Gas leakage characteristics are determined by the flow regime of the moving fluid; lower velocity and therefore lower volumetric leaks are laminar, and larger leaks are turbulent. In the laminar flow regime, viscosity is the dominant gas characteristic. In turbulent flow, density is the dominant factor. The viscosity of a hydrogen blend is 99 per cent that of methane; therefore, no practical difference in leak rate occurs for smaller leaks. For larger leaks, an increase of up to 10 vol% would be expected due to the reduced density of the hydrogen blend relative to natural gas.

Extensive experimental and modelling analysis has been undertaken to explore if any changes in leak dynamics result in a greater propensity to generate flammable environments. Both the experimental and analytical results have shown that no meaningful changes in gas concentration result from the potential increase in volumetric leak rate for turbulent leaks. This is due to the self-correcting nature of the induced ventilation flow. Following a leak of a buoyant gas, the fluid will naturally accumulate at the highest point of a room, and from there the gas will start to escape the room through windows, doors, ceilings, or cracks. The outflow of gas from the room induces ventilation into the room. Over time, the flow of air into the room equilibrates with the outflow of the gas, and a steady-state concentration is established. Given that both the volumetric leak rate and induced ventilation flow are driven by the buoyancy of the gas, both increase with reducing gas density. The net effect created is a self-correcting mechanism where the ultimate gas concentration is not affected. This conclusion was analytically predicted and then experimentally confirmed.

The potential risk of a fire or explosion primarily relates to the impact on the building structure in which the incident occurs. The direct impact of a pressure wave on a human is a secondary factor given the order of magnitude difference between the impact pressure required to cause structural damage, such as window or wall blowing out, relative to the impact pressure required to cause direct damage to humans. The impact of pressure waves on building structures is nuanced, with complex stoichiometric and geometric factors heavily influencing the resulting pressure–time curve. Peak pressure and impulse are the two characteristics that determine structural damage, where the impulse accounts for the time duration of the pressure wave as well the magnitude of the pressure wave itself. As pressure waves relate to structural damage, the impulse metric is a more appropriate parameter, as it accounts for a greater number of characteristic variables than just the peak overpressure.

Gas leakage research facility



Ignition research facility

These dynamics have been extensively studied, both using established theoretical models and through dedicated experimentation where nearly 60 gas-air-geometries were studied. In general, peak pressures change with laminar burning velocities, where a hydrogen blend has an approximately 20 per cent increase in laminar burning velocity. However, due to the higher laminar burning velocity, the duration of the pressure wave was found to reduce, and hence changes to the impulse metric were significantly less.

Appliances

Demonstrating the safe operation of appliances without the need for disruption or change is a fundamental objective of the HyDeploy programme. Extensive experimentation and field testing have taken place to study the impact of a hydrogen blend on the operation of both well-operating and malfunctioning appliances. Since 1993 all domestic gas appliances sold into the UK have been tested for operability with 23 vol% hydrogen, which has been part of the certification testing required to achieve their CE marking (designating compliance with European standards).

The laboratory analysis was supported by a review of appliance design and certification standards from the present back to 1976, when the first natural gas standards came into effect following the conversion from towns gas. A carefully defined sample set of 13 appliances, primarily determined by their burner and flue design, were selected to provide a GB-representative test set. Safety and performance testing was then undertaken to evaluate the impact of a hydrogen blend on operational parameters such as flue gas emissions, nitrogen oxides production, combustion efficiency, delayed ignition, component temperatures, and appliance commissioning and set-up. The evidence generated showed that UK appliances are capable of operating with a 20 vol% hydrogen blend safely and with good performance and without the need for adjustment.

Methane flame (left); methane and 28.4 vol% hydrogen flame (right)

The work demonstrated an important beneficial safety impact of operating malfunctioning appliances on a hydrogen blend. When the appliances were put into fault conditions to generate high levels of carbon monoxide (CO), changing the gas supply to a hydrogen blend reduced CO production by around 70 per cent; in many cases the level of CO reduced back to acceptable limits.

Materials and assets

Materials and assets research has assessed a wide array of materials to understand whether exposure to a hydrogen blend could be expected to have any potential impact. The programme has encompassed many common materials, including stainless steels, brass, copper, rubbers, polyethene, and aluminium. A rigorous asset register was developed for the whole network and downstream equipment that would be exposed to the hydrogen blend; then the components and materials of construction were identified. A literature review was then undertaken to inform the physical testing programme. Samples of materials were produced and then exposed to hydrogen blends for varying durations, followed by tensile and mechanical testing.

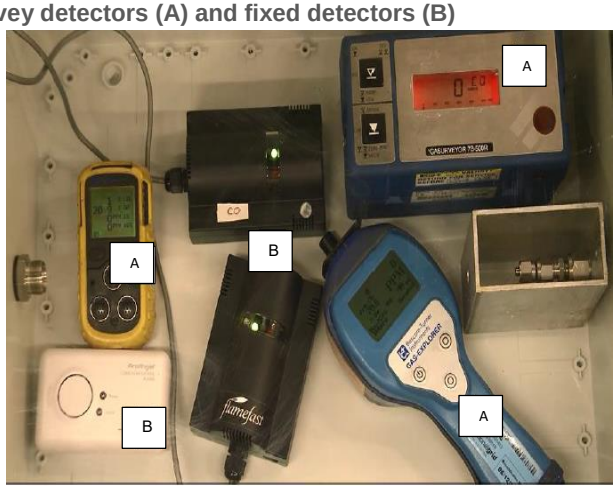
Materials soaking facility

This process of materials testing has enabled a body of evidence to be generated on the expected impacts on material properties following exposure to a 20 vol% hydrogen blend. Testing to date has focused on that which is required to justify the safety cases in support of the trials, and therefore has been bounded to representative conditions of the low- and medium-pressure distribution tiers. These tiers are up to 2 barg. Further testing is under way at higher pressures which are representative of the full pressure boundary of the gas distribution network. The results of these tests will allow a complete picture of material suitability to be established.

Procedures and gas detection

Procedures, both upstream (gas network) and downstream (within premises), and their supporting gas detection equipment, are critical to ensuring the safe use of gas within the UK. Using the outputs of the scientific programmes, an understanding was reached of whether procedures would need to change to accommodate the impacts of a hydrogen blend. Much like the materials work streams, the network procedures were bounded to the low- and medium-pressure procedures. Higher-pressure tier procedures will be reviewed in due course by the project.

Gas detection instruments—survey detectors (A) and fixed detectors (B)



Almost all low- and medium-pressure tier procedures were demonstrated to be adequate in their current form. Importantly, the emergency response procedures used by network engineers to respond to public reports of gas escapes were demonstrated to be suitable, provided they were paired with the appropriate gas detection equipment. Only a handful of procedures, such as network purging, required a minor update, such as specifying a slightly higher minimum purge velocity.

The review of the downstream procedures took the form of assessing all procedures that a Gas Safe certified engineer could use to install, commission, repair, and maintain appliances and their supporting installation such as the pipework and ventilation. A process of review and challenge was undertaken and the findings shared with the standard-setting bodies, the British Standard Institution and the Institute of Gas Engineers and Managers. It was concluded, and agreed to by the standard-setting bodies, that no domestic procedure would require modification to accommodate the impacts of a hydrogen blend.

Quantitative risk assessment

A QRA was developed to understand the causality of risk that results from the use of natural gas within the GB gas distribution network. The QRA encompassed both the gas network and appliance operations, assessing the risk to life due to both CO exposure and fire/explosion. The QRA was ‘baselined’ by first assessing the whole of the GB network, for which independent historical figures were available to calibrate and validate the model. From this a regional model of risk was developed using characteristic values of the regions under consideration. This allowed a baseline of the regional risk with natural gas to be understood. Finally, the outputs of the scientific programmes were converted to inputs into the QRA to understand the risk profile that resulted from introducing the hydrogen blend. Through this step-wise approach, a comparative analysis could be presented to numerically demonstrate that the total impact of a hydrogen blend did not result in an increase in risk.

Keele University trial

The evidence base generated in support of the Keele University trial set the expectations of the trial. Over the course of the trial, a continuous monitoring programme was enacted to collate evidence to confirm the pretrial expectations. As the purpose of the HyDeploy programme is to demonstrate the safe transportation and utilization of a 20 vol% hydrogen blend, the lessons learnt from the trial are structured in that order.

Network findings

The findings from the network surveys and monitoring confirmed the pretrial expectation of the impacts on the network:

- Gas composition: A consistent composition of gas was observed throughout the trial, utilizing a permanently installed gas chromatograph as well as six sample points for manual samples.
- Network pressures: The pressure profile of the network remained within the normal operating bounds. At the six sample points, permanent remote pressure indication was installed to gather data.
- Odour intensity: No perceivable dilution in odour intensity was observed; therefore, no impacts on the ability of the public to detect and report gas escapes would be expected. The six sample points contained test stations to assess the odour intensity (rhinology testing).
- Network leakage: No increase in leakage frequency was identified, relative to historical trends.

Overall, the network findings have provided strong confirmatory evidence that the introduction of a hydrogen blend does not result in the generation of operational constraints or risks that would require separate processes to mitigate and manage.

Appliance findings

The trial findings as they relate to appliances were generated by active monitoring and testing. A dedicated facility was constructed to operate typical appliances in an accelerated fashion (continuous operation), where half were supplied with natural gas and the other half with a hydrogen blend; this allowed a direct comparison of the two fuels. Alongside this facility monitoring of the existing customer and University appliances was undertaken as well as annual services and Gas Safe checks. The findings were as follows:

- Safe operation: The appliances continued to operate safely and within the recommended limits of typical operation.
- Failure frequency: No increase in failure frequency was observed, relative to historical trends.
- Installation tightness: Nearly 100 installations were tested for their tightness with both natural gas and a hydrogen blend, all installations found to be acceptably tight on natural gas were also compliant with the hydrogen blend.

Conclusion

The scientific programmes developed through the HyDeploy project and the evidence they have produced have helped to develop a robust understanding of the risk profile of a 20 vol% hydrogen blend relative to natural gas, within the context of the proposed trials. The technical evidence base collected so far, as well as the supporting field evidence, have shown that for the purpose of the trials a hydrogen blend is as safe as natural gas. The remainder of the programme will be focused on making this case beyond the constraints of individual trials to underpin and facilitate national blending.

HYDROGEN AND THE DECARBONIZATION OF STEELMAKING

Markus Schöffel

Traditional blast furnace steelmaking

Global crude steel (CS) production totalled about 1.88 billion metric tonnes in 2019, of which 72 per cent or 1.34 billion metric tonnes were primary steel produced via the blast furnace and basic oxygen furnace (BF-BOF) route.[37] This carbon-based pathway, as implemented in integrated steel mills, comprises coking plant, sinter plant, and BF-BOF plant. First, coking coal is transformed into coke in the coking plant, and iron ore fines are agglomerated to lumps in the sinter plant, generating emissions of about 300 kg CO_2/t coke and about 270 kg CO_2/t sinter.[38]

In a second step, coke is fed in alternating layers together with sinter and lump ore as well as pellets into the blast furnace. During descent of the burden in the BF, iron ore gets reduced to metallic iron by coke as well as by pulverized coal being injected together with the hot blast as reducing agents. As temperature rises above the melting point in the lower part of the BF, liquid hot metal, a eutectic iron carbon phase, containing about 4.5 per cent carbon by mass, is formed and leaves the tap hole.

The third step consists in refining of hot metal to CS in the BOF, where dissolved carbon is oxidized and removed. Based on

[37] *Steel Statistical Yearbook 2020*, concise version, Brussels: World Steel Association, https://www.worldsteel.org/steel-by-topic/statistics/steel-statistical-yearbook.html.
[38] Climate Change Committee, Eurofer (2020), *Benchmarking Study among 20 European Sites*.

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

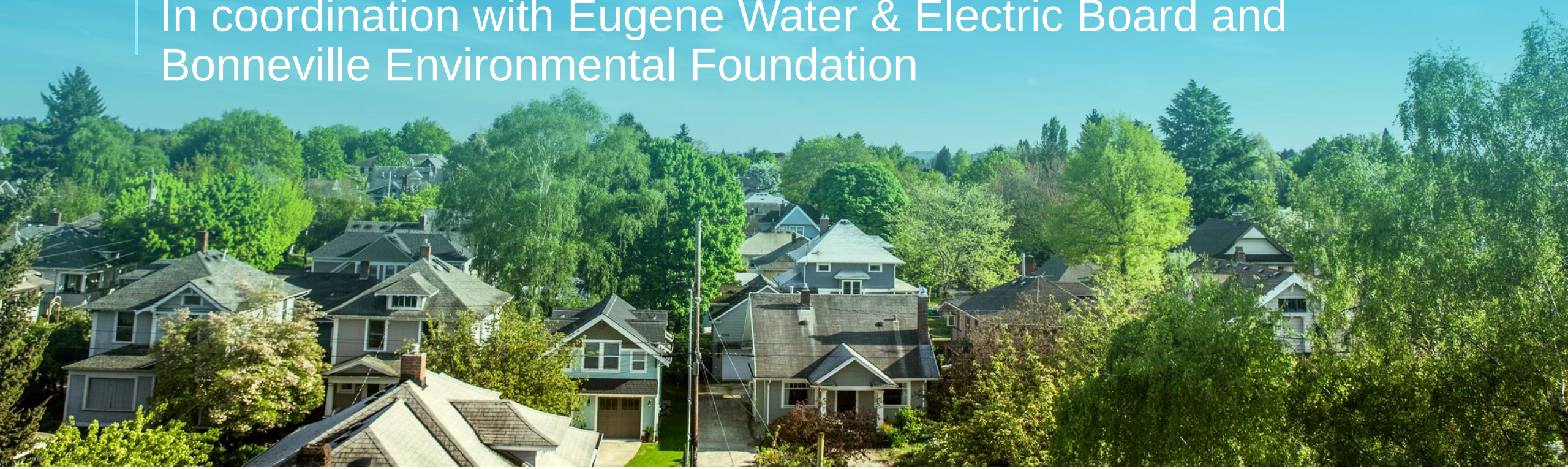
Exhibit of Chris Kroeker

EUGENE HYDROGEN PILOT PROJECT
EXHIBIT 102

August 12, 2022

Hydrogen – Eugene

An innovative clean energy development
In coordination with Eugene Water & Electric Board and Bonneville Environmental Foundation



May 24, 2022

NW Natural®

Agenda

- Welcome and Speaker Introductions
- Clean Hydrogen: Benefits, Opportunities and Global Context
- Northwest Perspectives – Renewable Hydrogen Alliance
- Systemic and Regional Benefits of Renewable Hydrogen – Bonneville Environmental Foundation
- Leveraging Today's Gas Infrastructure – NW Natural
- Hydrogen – Eugene: An Innovative Clean Energy Development
- Eugene Water & Electric Board: Role and Benefits
- Timelines and Next Steps
- Questions

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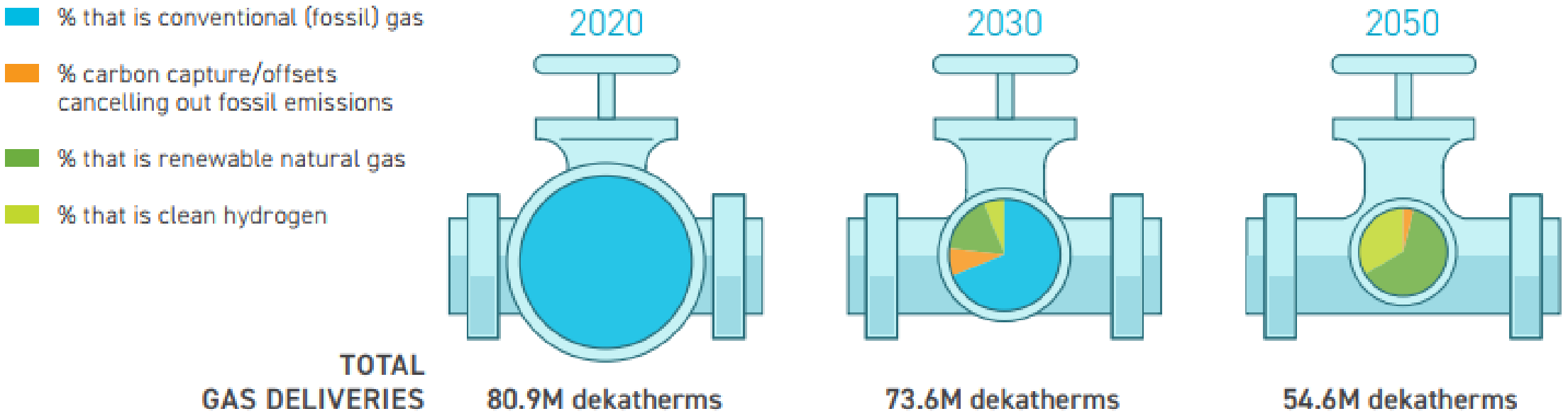
Additional Team Members

- **Chris Kroeker**
  Business Development Segment Manager, NW Natural
- **Tony Ramos**
  Community & Government Affairs Manager for Lane, Benton and Linn Counties, NW Natural
- **Clif Hazen**
  Major Accounts Manager, NW Natural
- **Jennifer Yocom**
  Local Government Affairs Manager, NW Natural
- **Nels Johnson**
  Federal & State Government Affairs Manager, NW Natural
- **Ryan Sigurdson**
  Regulatory Attorney, NW Natural

Vision 2050: Destination Zero

Reducing overall consumption, increasing renewable supplies

Balanced Approach Scenario, Vision 2050: Destination Zero



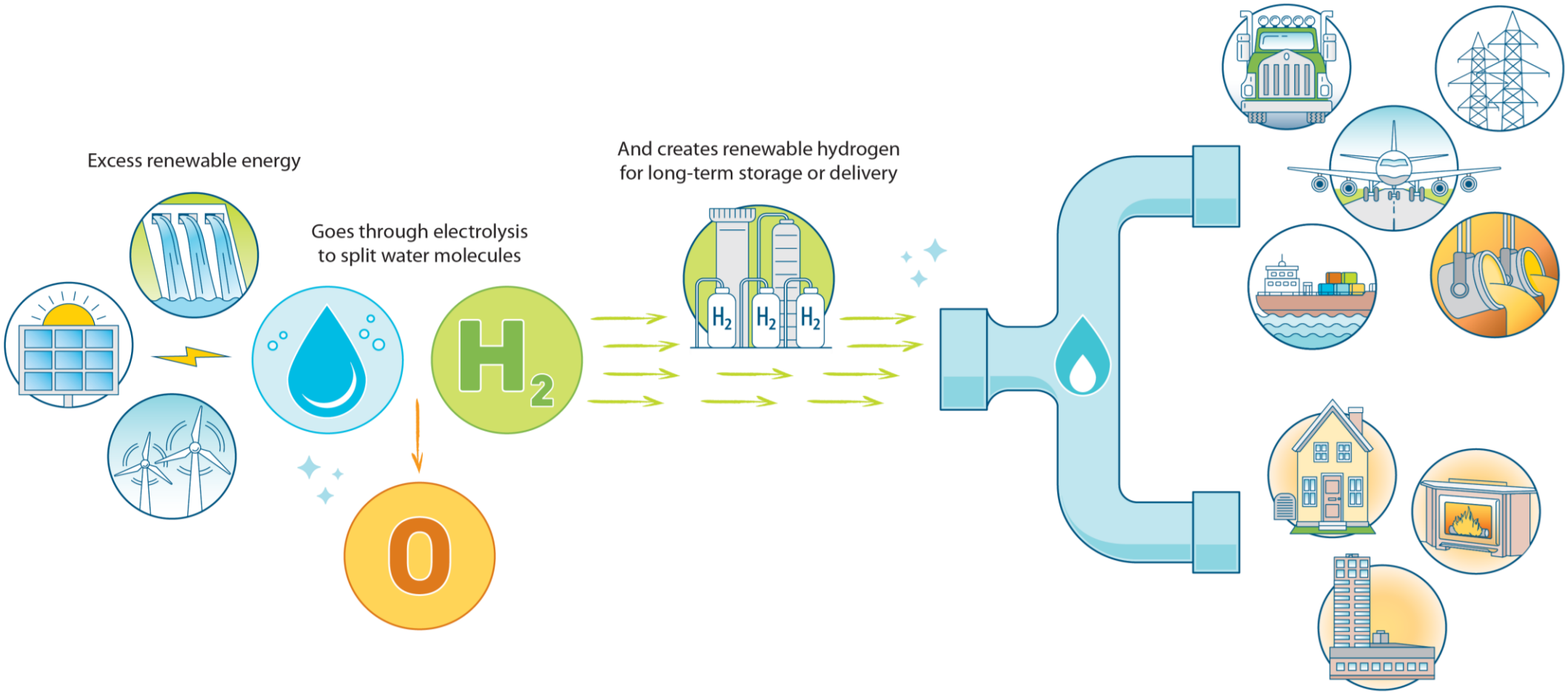
Benefits of Clean / Renewable Hydrogen

- The term “hydrogen gas” refers to the molecule (H2) in a gaseous state
- Hydrogen provides a unique energy storage and delivery solution, with potential applications across practically every sector and industry
- When combusted in equipment, hydrogen releases water vapor
- Most hydrogen in use today is produced using fossil fuels
- However, there are many low-carbon production pathways that make hydrogen a compelling renewable energy option
- Declining costs for hydrogen and the renewable electricity used to make it will be key to hydrogen’s success

Source: 2022 Gas for Climate, European Hydrogen Backbone Initiative; https://ehb.eu/

Hydrogen Production and End-Uses

Low-Carbon Energy Solutions for Multiple Industries



Global Context

- **Global Estimates**
  - Clean hydrogen could supply 20-30% of all energy needs worldwide by 2050
  - 228 large-scale hydrogen projects announced across the value chain, with 85% located in Europe, Asia, and Australia (Source: Hydrogen Council)
  - 30+ countries have hydrogen roadmaps
- **European Union**
  - 31 energy companies across 28 European countries have created a hydrogen roadmap that re-uses approximately 60% of existing, repurposed natural gas infrastructure and 40% of new hydrogen pipelines by 2040 to help Europe achieve its decarbonization goals
- **United States**
  - Infrastructure bill signed into law by President Biden in November dedicated $9.5 billion to support the hydrogen industry
  - 14 states and hundreds of private companies competing for regional hydrogen hubs

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- RHA works with legislators, regulators, industry, tribes, national labs, environmental groups and others to educate and raise awareness of renewable hydrogen as a versatile tool to help meet state GHG reduction goals
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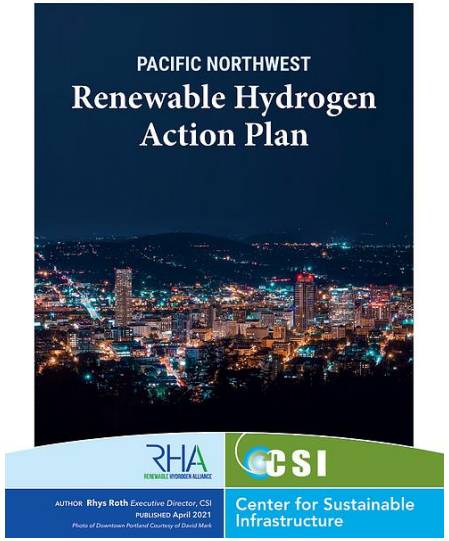

Systemic and Regional Benefits of Renewable Hydrogen

Bonneville Environmental Foundation (BEF):

- 501(c)3 non-profit working on society's most pressing energy, carbon, and water issues
- Past five years: Focused on integrating renewable hydrogen into our electricity system
- Goal is to maximize systemic benefits of renewable energy production and utilization across all sectors of our economy
- Supported a convening of stakeholders to expand understanding and awareness of the renewable hydrogen opportunity

Early Wins:

- Pacific Northwest Renewable Hydrogen Action Plan identifying multi sectoral priorities to advance clean fuels production and consumption regionally
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Hydrogen Blending Is Not New

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- Town gas (approximately 50% hydrogen) was developed in the 19th century
  - NW Natural used town gas in Oregon up until the 1950's
  - Still used today in other areas of the world (e.g., Singapore)
- 1,600 miles of dedicated hydrogen piping exists in the US today
- Natural gas utilities leading new efforts to utilize existing infrastructure to decarbonize with low-carbon hydrogen to reduce emissions faster and more cost-effectively

Natural Gas + Hydrogen Blending Projects

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1 MW electrolyzer, 5% blend, construction nearly completed

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<1 MW electrolyzer, 5% blend, gas flowing

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20% blending complete, serves 350 mixed-use buildings

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100% hydrogen network underway

The gas blending building in Mainz, Germany, home to a 6 MW electrolyzer and direct hydrogen blending into the natural gas system

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- Increased leakage surveys in Eugene once hydrogen is introduced
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- Added chromatography to the Eugene area so that the hydrogen blend can accurately be assessed

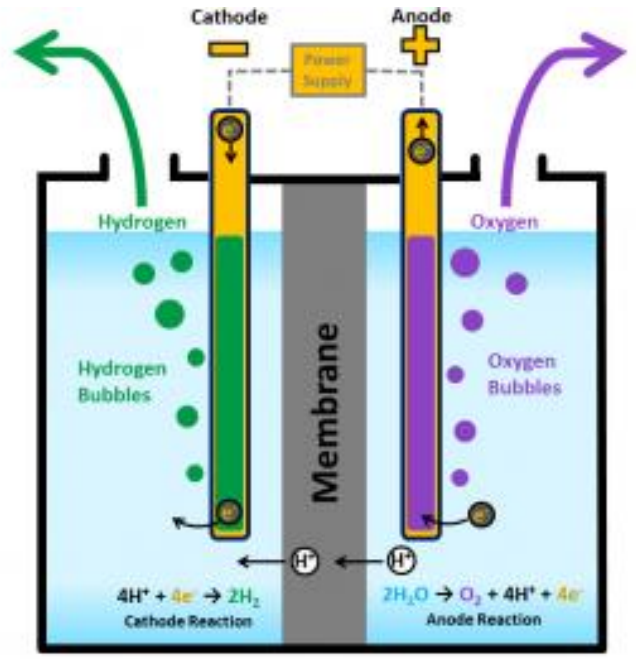
NW Natural®

HYDROGEN – EUGENE

An innovative clean energy development, in coordination with Eugene Water & Electric Board and Bonneville Environmental Foundation.

Eugene Project Capacity and Specs

- Capacity: 1 MW (provisions for 2 MW)
- Electrolyzer type: Proton Exchange Membrane
- Estimated utilization: 90%
- Electricity: Low-carbon mix (EWEB)
- Production: 4,300MMBtu of renewable hydrogen annually for 20 years
- Estimated CO2 emissions reduction: ~228 MTCO2(e) annually



Source: U.S DOE

Location of Hydrogen – Eugene Project

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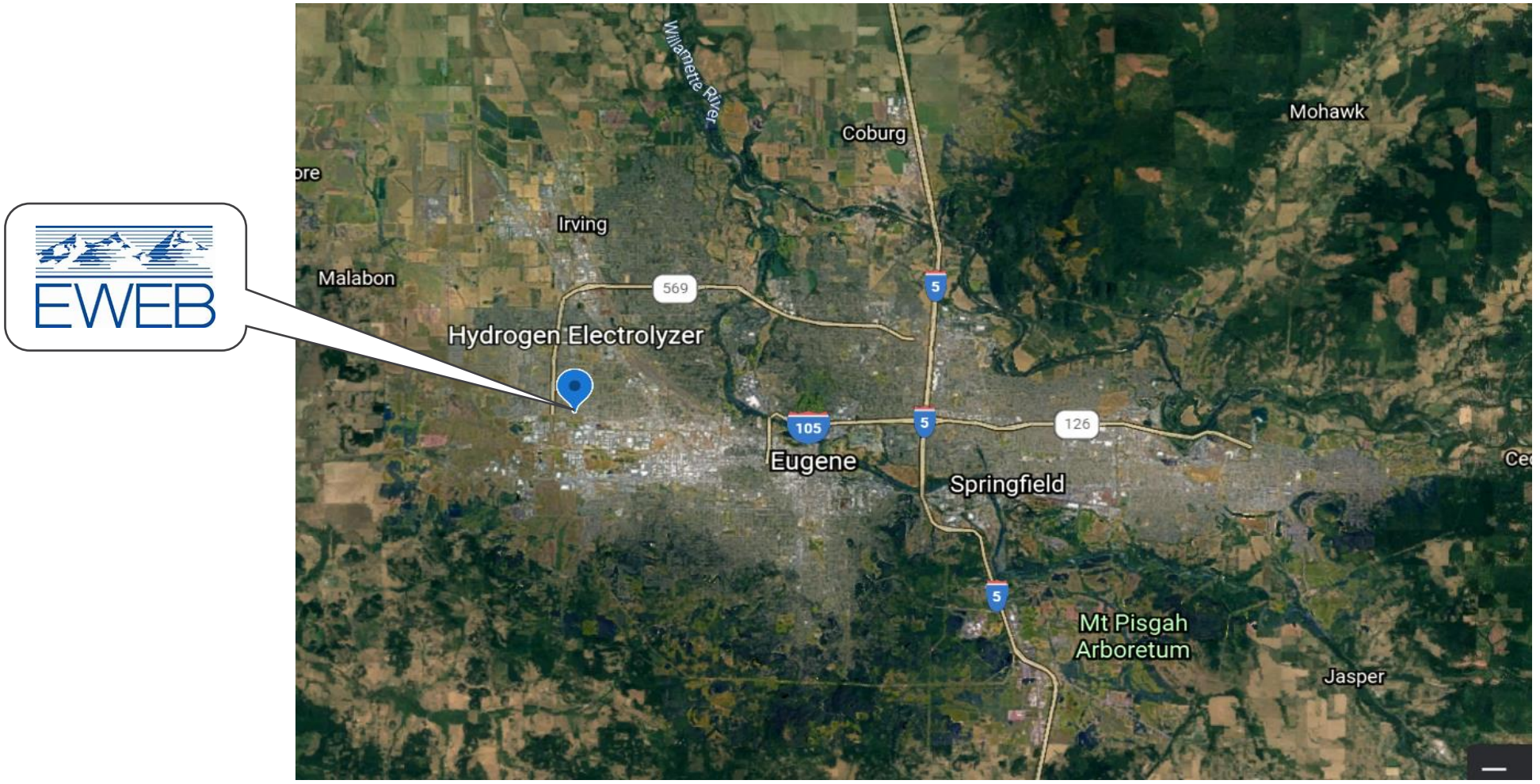
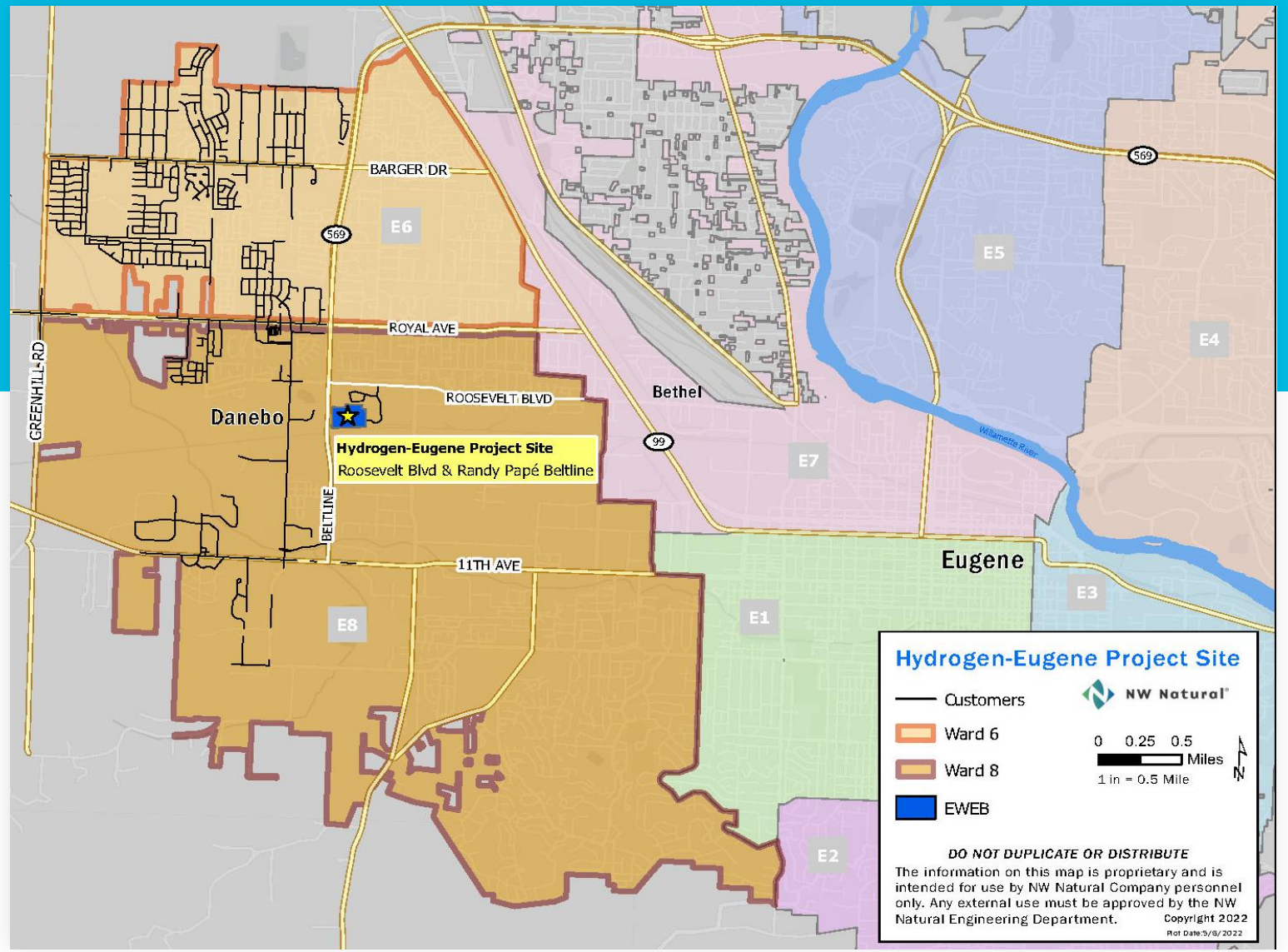


Location of Hydrogen – Eugene Project
EWEB West Eugene Campus



Planned Area for Hydrogen Blending

NW Natural customers served in area

- 2,273 Residential
- 160 Commercial
- 6 Industrial

Eugene Water & Electric Board (EWEB)

NW Natural®

EWEB Role & Interests: NW Natural Hydrogen Pilot Project

Role of "Supplier" (Water, Electricity, Property)

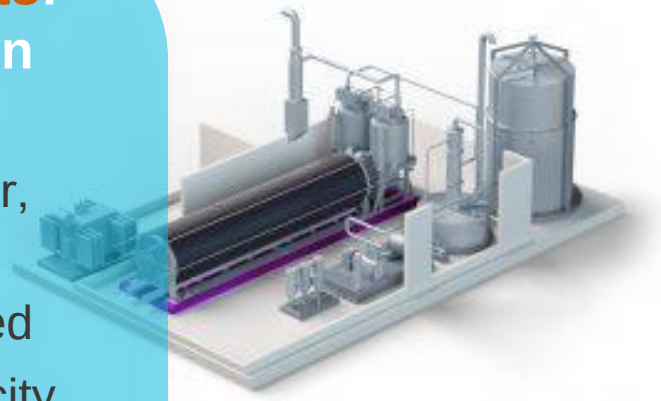
Retail/Market-Rate Based

Clean Market-Mix Electricity

Understand Operational Impacts of Hydrogen Production:

Synchronization with Resources and/or Grid Characteristics

"Alternative Fuels" Rate Development
(Surplus Conditions, TOU, Interruptible)



Long-Term Electric Utility Hydrogen Benefits

1. Secondary Market
   (Facilitates/Leverages Renewables Buildout)
2. Bridge to Decarbonization
3. Local Grid Support: Intermediate-Term Storage
   (Demand Response, Load Shifting/Peak Shaving, Pricing Arbitrage)
4. Resiliency
   (Distributed, carbon free, backup fuel)

Key Project Workstreams

NW Natural and our project partners have taken several key steps as we prepare our system for clean hydrogen

Commissioned outside experts to conduct a pre-feasibility system study and address other potential needs

Secured a location with EWEB that provides ideal electric grid and pipeline access

Assigned dedicated hydrogen engineer and support resources to project development

Project Details

CUSTOMER FACING

- Hydrogen-blended gas will perform like 100% natural gas
- Same appliances and equipment as with 100% natural gas

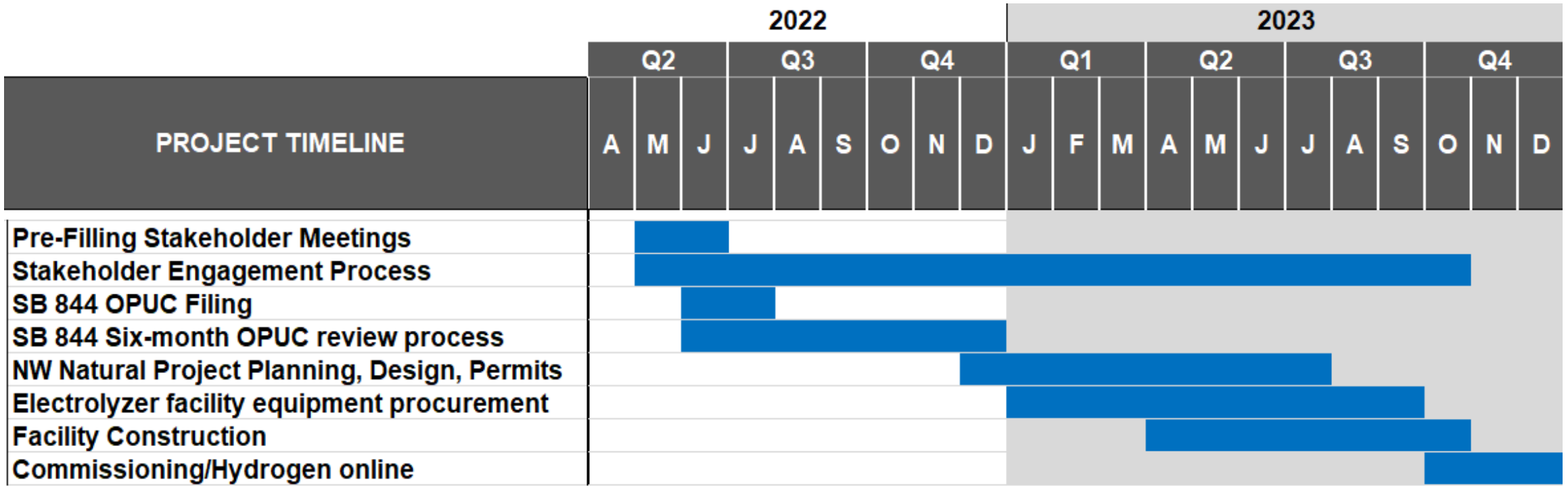
COMMUNITY FACING

- No significant changes in noise, traffic, air quality
- Small footprint facility co-located on EWEB campus in commercial area

Estimated Costs

- Long-term, clean hydrogen could be the lowest-cost option for low-carbon gas supplies
- This project puts the region on the path to a clean hydrogen economy
- Estimated project construction costs: $6.4M – $8.8 M (estimated)
- NW Natural plans to submit a request to the Oregon PUC under S.B. 844
- Costs would be distributed across all Oregon customers – not just those in Eugene

Tentative Project Timeline



Stakeholder Engagement

NW Natural plans ongoing engagement and updates to key stakeholder groups:

- West Eugene project residential and commercial neighbors
- Hydrogen-blend customers in Eugene
- NW Natural customers
- Regulators and staff
- Local and state elected officials
- Industry partners

Key Project Benefits

- Enhanced understandings about integrating hydrogen into the gas system
  - Real-world data on costs, performance, and operations
  - Experience with engineering, procurement, and construction of equipment and site permitting
- Project is large enough to learn from, but small enough to avoid excess costs
  - Demonstrate technology viability as we consider blending elsewhere
  - Enables third-party H_2 injection and industrial decarbonization projects
- Electric system benefits and hydrogen-related learnings for EWEB

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Questions?

Project Contact:
hydrogen-eugene@nwnatural.com

Thank you.

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibit of Chris Kroeker

EUGENE HYDROGEN PILOT PROJECT
EXHIBIT 103

August 12, 2022

Hydrogen – Eugene

An innovative clean energy development
In coordination with Eugene Water & Electric Board and Bonneville Environmental Foundation

July 8, 2022

NW Natural®

Agenda

- Welcome, Procedures and Speaker Introductions
- Clean Hydrogen: Benefits, Opportunities and Global Context
  - Northwest Perspectives – Renewable Hydrogen Alliance
  - Systemic and Regional Benefits – Bonneville Environmental Foundation
  - Leveraging Today's Gas Infrastructure
- Hydrogen – Eugene: An Innovative Clean Energy Development
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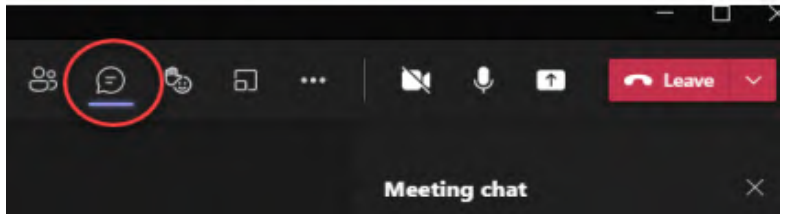
Meeting Procedures

- Meeting is being recorded
- Please mute your microphones during the presentation and be respectful
- Add a question at any time using the chat box
- To ask a question verbally during the Q&A session use the raised hand function
- Microsoft Teams has a live caption function for any participant to use

Chat box will open when you click on the conversation bubble



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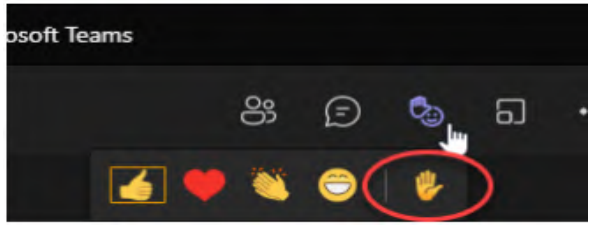

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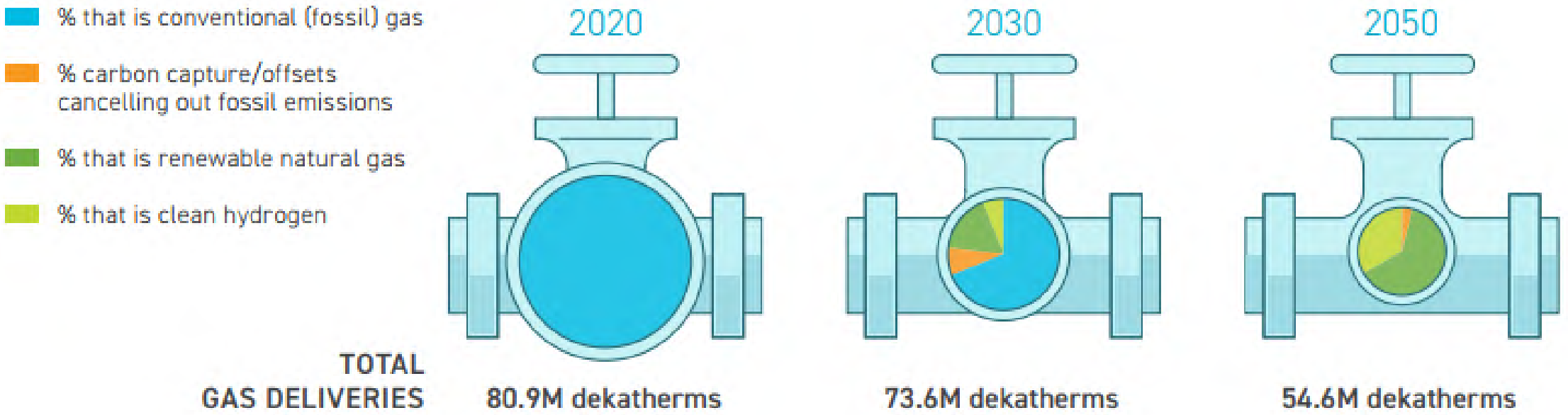
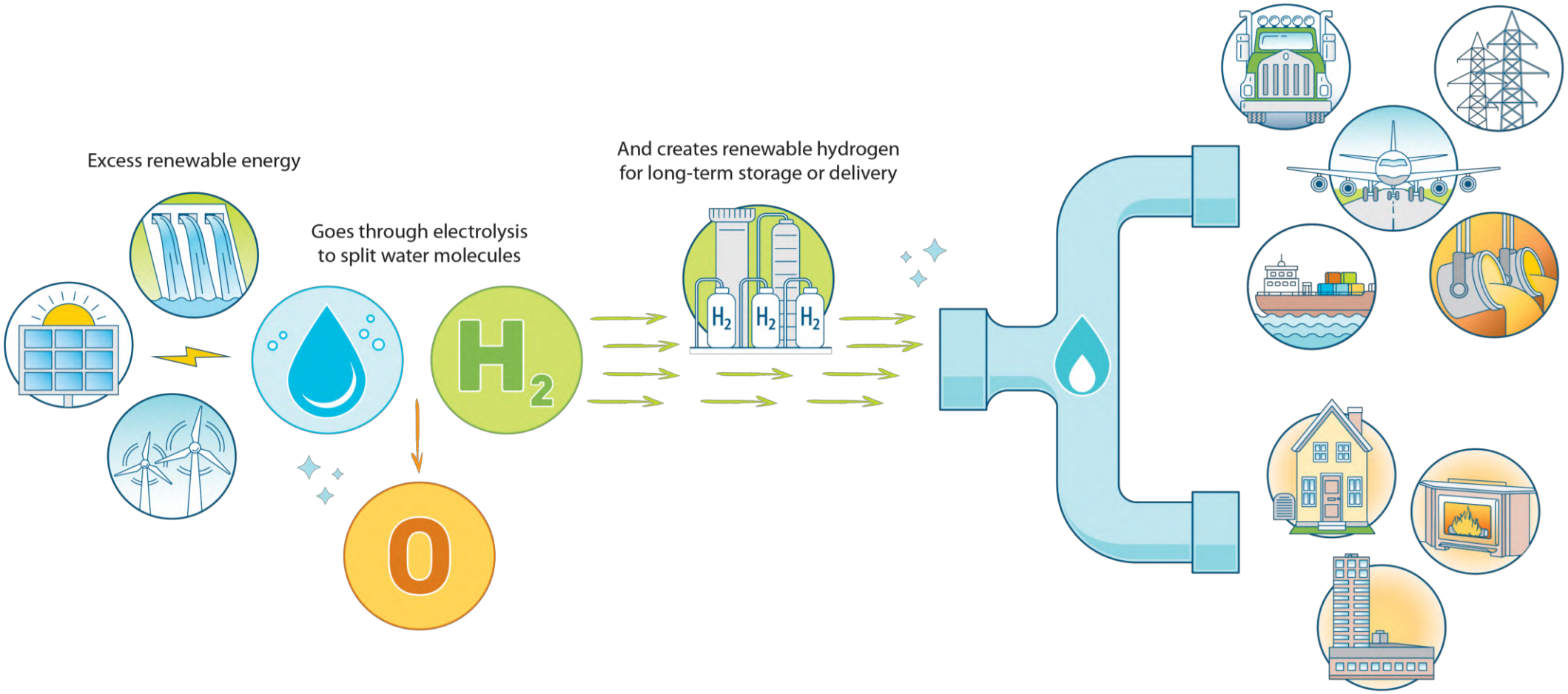


Hydrogen Production and End-Uses

Low-carbon energy solutions for multiple industries



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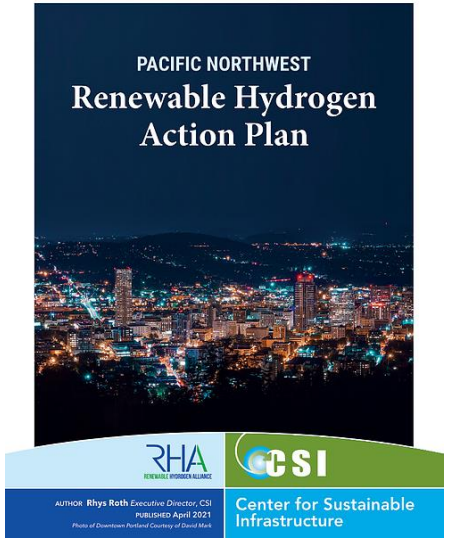

RHA
RENEWABLE HYDROGEN ALLIANCE

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NW Natural®

HYDROGEN – EUGENE

An innovative clean energy development, in coordination with Eugene Water & Electric Board and Bonneville Environmental Foundation.

EWEB Interests – NW Natural Green Hydrogen Pilot Project

NW Natural Hydrogen Pilot Project

EWEB Role & Interests:

Role of "Supplier" (Water, Electricity, Property)

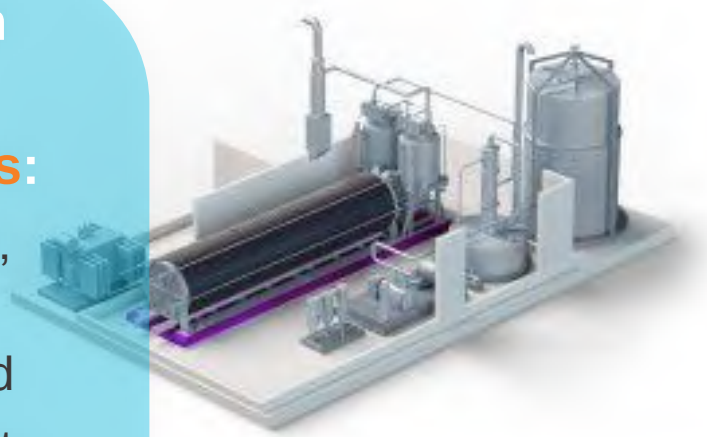
Retail/Market-Rate Based

Clean Market-Mix Electricity

Understand Operational Impacts of Hydrogen Production:

Synchronization with Resources and/or Grid Characteristics

"Alternative Fuels" Rate Development
(Surplus Conditions, TOU, Interruptible)

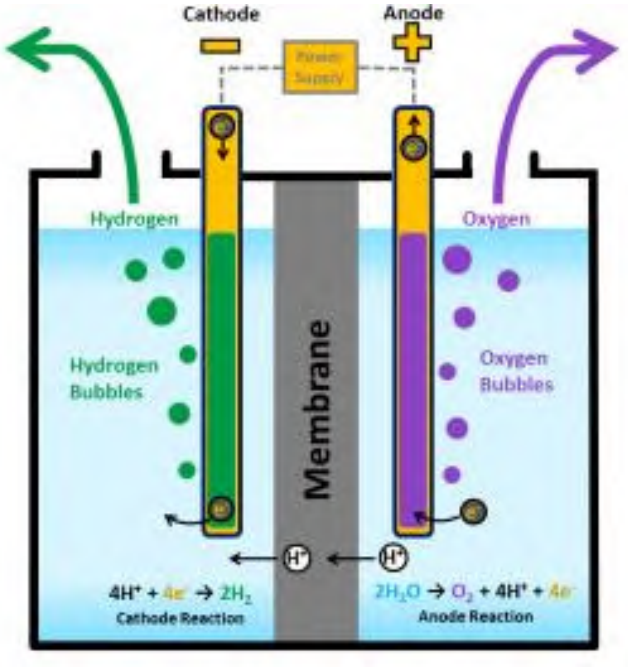


Long-Term Electric Utility Hydrogen Benefits

1. Secondary Market
   (Facilitates/Leverages Renewables Buildout)
2. Bridge to Decarbonization
3. Local Grid Support: Intermediate-Term Storage
   (Demand Response, Load Shifting/Peak Shaving, Pricing Arbitrage)
4. Resiliency
   (Distributed, carbon free, backup fuel)

Project Capacity and Specs

- Capacity: 1 MW (provisions for 2 MW)
- Electrolyzer type: Proton Exchange Membrane (PEM)
- Estimated utilization: 90%
- Electricity: Low-carbon mix (EWEB)
- Production: 4,300MMBtu of renewable hydrogen annually for 20 years
- Estimated emissions reduction: ~228 MTCO2(e) annually



Source: U.S DOE

Location of Hydrogen – Eugene Project

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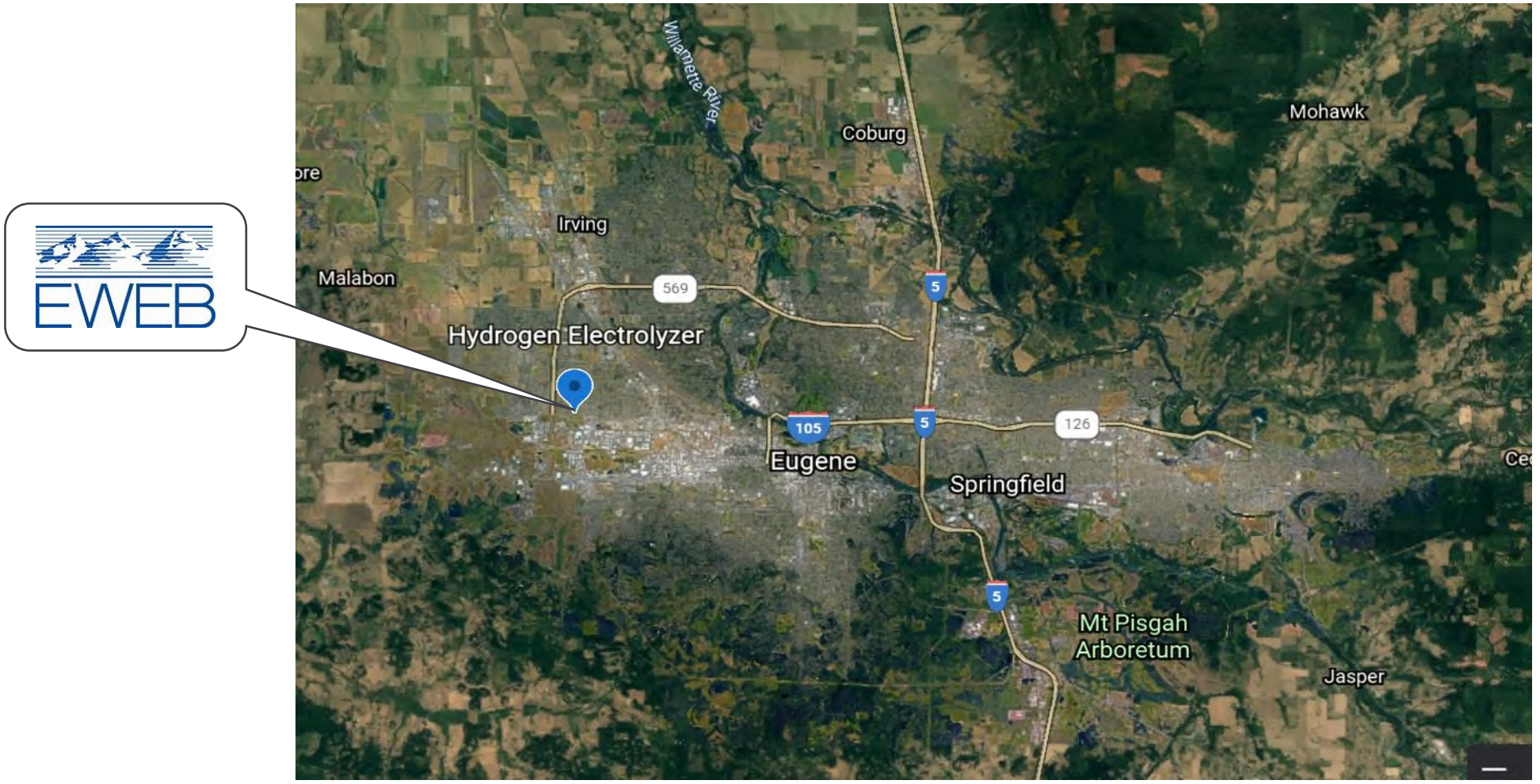
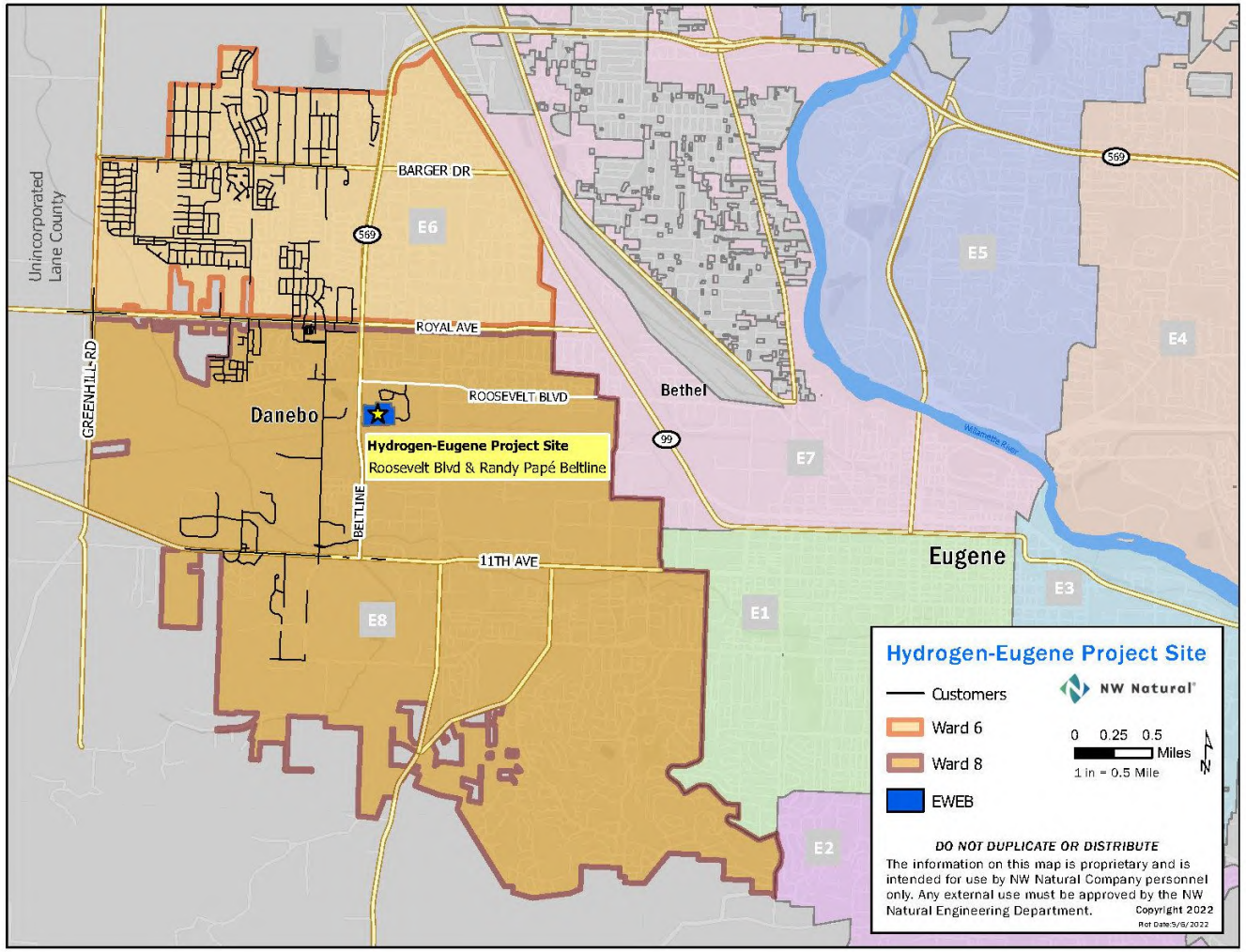


Location of Hydrogen – Eugene Project
EWEB West Eugene Campus

Planned Area for Hydrogen Blending

NW Natural customers served in area:

- 2,273 Residential
- 160 Commercial
- 6 Industrial



Project Details

COMMUNITY

- No significant changes in noise, traffic, air quality
- Small footprint facility co-located on EWEB campus in commercial area

CUSTOMERS

- Hydrogen-blended gas will perform like 100% natural gas
- Same appliances and equipment as with 100% natural gas

Key Project Benefits

Enhanced understanding of hydrogen integrating into gas system

- Real-world data on costs, performance, operations
- Experience with site engineering, procurement, construction permitting

Project scale is large enough to learn from, but small enough to avoid excess costs

- Demonstrates technology viability as we consider blending elsewhere
- Enables third-party H_2 injection and industrial decarbonization projects

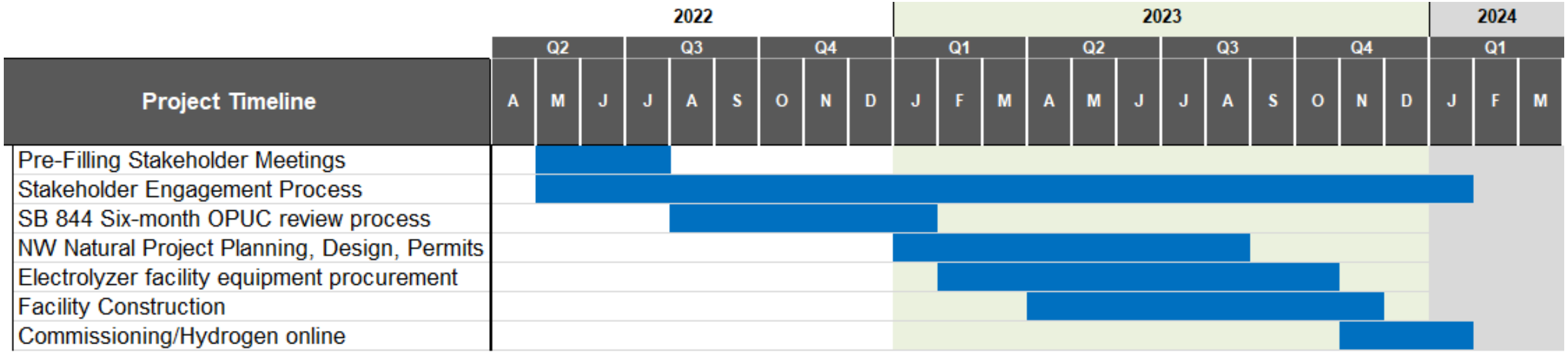
Electric system benefits and hydrogen-related learnings for EWEB

- Operational impacts
- Potential for grid support, intermediate storage, and increased resiliency

Estimated Costs

- Estimated project construction costs: $7.1M – $9.8M
- Estimated residential rate impacts: about $0.15 per month (about 0.2% of an average bill)
- Costs would be distributed across all Oregon customers – not just those in Eugene

Tentative Project Timeline



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Questions?

Project Contact:
hydrogen-eugene@nwnatural.com

Thank you.

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibit of Chris Kroeker

EUGENE HYDROGEN PILOT PROJECT
EXHIBIT 104

August 12, 2022

Hydrogen-Eugene Project
Eugene Community Stakeholder Meeting Summary

Overview

NW Natural hosted a public, informational meeting on May 24, 2022, 12:00-1:00pm, on the Zoom virtual platform to provide stakeholders within the community of Eugene the opportunity to learn more and ask questions about the role and benefit of hydrogen, including work done throughout the country and within the company's own system, and the proposed hydrogen Project in Eugene. It was designed and held to achieve the objectives outlined below.

- Demonstrate commitment to proactive and meaningful community outreach
- Introduce the Project team
- Inform, educate, and engage the community about hydrogen's role in the gas system, including within NW Natural's system, and the project concept and general timing
- Gather input and address questions

Meeting Panelists, Invitees and Attendees
Panelists

- Kim Heiting, Senior Vice President of Operations, NW Natural
- Anna Chittum, Director of Renewable Resources, NW Natural
- Ryan Weber, Hydrogen Engineer, NW Natural
- David Roy, Senior Director of Communications, NW Natural, meeting facilitator
- Frank Lawson, General Manager, EWEB
- Evan Ramsey, Senior Director, Renewables Program, BEF
- Michelle Detwiler, Executive Director, Renewable Hydrogen Alliance

Attendee Summary

The invitation was sent to a broad distribution list of local stakeholders. The following list identifies those that participated. The entire invite list is available upon request.

Total Attendees: 22
Government Officials/Staff and Agencies/Organizations
• Councilor Randy Groves, City of Eugene • Cody Kleinsmith, Lane County • EWEB- Rod Price, Kelly Hoell, Aaron Orlowksi, Eli Volem
Businesses/Organizations
• Weyerhaeuser- Bruce Wittman and Yvonne Couts • Scientific Developments-Michael Fitzgerald • Big Laundry Service – Dennis Cooley • Columbia Hyfuel-David White • Renewable Hydrogen Alliance-Martina Steinkusz • Home Builders Association of Lane County- Pete Barrell • Oregon Hearth Patio and Barbecue Association- Harvey Gail

• Oregon Restaurant and Lodging – Terry Hopkins, Greg Astley
Unions
• Nate Stokes • Matt Jensen • Jeff McGillivray
Schools
• University of Oregon-Matt Roberts • Lane County Community College- Luis Maggiori
Individuals
Jere Rosemeyer

Key Questions and Comments

- "Will the hydrogen gas be odorized with Mercaptan like natural gas to help with leak detection or unintended releases?"

  Answer: Yes. Gas will be odorized. Based on work NW Natural has done, it anticipates no issues with odorization.

- "With all the other renewable projects being built at this time and are able to leverage workforce development and apprenticeship opportunities, my question is could this or any other project like this be able create the same opportunities."

  Answer: Presents opportunities for workforce development concerning hydrogen.

- "Have connected with the UO and Prof. Shannon Boettcher Department of Chemistry and the Materials Science Institute Director, Oregon Center for Electrochemistry. Professor Boettcher's work seems to match this project perfectly. http://boettcher.uoregon.edu"

  Answer: NW Natural spoke with Professor Boettcher about potential opportunities and leveraging research.

- "Regarding the blended hydrogen/natural gas stream, what will the heat content of that blended stream be compared to the current heat content per Mcf."

  Answer: Energy content of the blend will be within applicable tariff requirements.

- "So, all customers will pay for the project, but which customers, if any, will own the associated environmental attributes?"

  Answer: Environmental attributes will be retired on behalf of all customers paying for the project.

Meeting Follow-up

A follow-up email was sent to all meeting attendees with a link to the meeting recording. In addition, the recording link was shared with those that requested it and could not attend.

Meeting Recording – https://nwnatural.zoom.us/rec/share/coo3VWe4CSU-AjYoF18FSJd0NngBJ44f2v7YGRQ-ZNnR2ZqQqEPSofJMOz52Dz9e.X9usKlwfvhdeWr97

One meeting attendee reached out to the project email address after the meeting with the following questions,

- "I would like to know the purpose of the submission to OR PUC. Is it for permits or for a rate increase?
- I would also like to know what permits from city, county or state governments will be required before the plant goes online."

NW Natural responded with the following,
"The Oregon Public Utility Commission approval is necessary for NW Natural to recover the costs of the project. NW Natural will seek OPUC approval under Senate Bill 844 (ORS 757.539). Senate Bill 844 is a voluntary program that enables Oregon natural gas utilities to pursue projects that reduce greenhouse gas emissions. Based on current project estimates, we would expect a small impact to most rate classes – around half a percent increase.

We are in the early stages of the project design and the work to determine necessary permits is ongoing. We are committed to coordinating with all applicable regulatory agencies."

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Exhibit of Chris Kroeker

EUGENE HYDROGEN PILOT PROJECT
EXHIBIT 105

August 12, 2022

Hydrogen-Eugene Project
PUC Stakeholder Meeting Summary

Overview

NW Natural hosted a public stakeholder meeting on July 8, 2022, 12:00-1:00pm, on the Microsoft Teams virtual platform to provide the Public Utility Commission of Oregon (PUC) stakeholders the opportunity to learn more and ask questions about the proposed hydrogen project in Eugene. It was designed and held to achieve the objectives outlined below.

- Inform, educate, and engage the PUC and current rate case and IRP stakeholders
- Gather input and address questions in advance of applying for the PUC approval under SB 844 (ORS 757.539)

Meeting Panelists, Invitees and Attendees

Panelists

- Zach Kravitz, Senior Director of Rates & Regulatory Affairs, NW Natural
- Kim Heiting, Senior Vice President of Operations, NW Natural
- Anna Chittum, Director of Renewable Resources, NW Natural
- Chris Kroeker, Business Development Segment Manager, NW Natural
- Ryan Weber, Hydrogen Engineer, NW Natural
- David Roy, Senior Director of Communications, NW Natural, meeting facilitator
- Frank Lawson, General Manager, Eugene Water & Electric Board
- Evan Ramsey, Senior Director, Renewables Program, Bonneville Environmental Foundation
- Michelle Detwiler, Executive Director, Renewable Hydrogen Alliance

Invitees

Email invitations were sent on June 28, 2022, to the following organizations and individuals.

- PUC
- Oregon Citizens' Utility Board
- Alliance of Western Energy Consumers
- Climate Solutions
- Verde
- Columbia Riverkeeper
- Oregon Environmental Council
- Community Energy Project
- Sierra Club
- Coalition of Communities of Color
- Avista
- Cascade Natural Gas
- Puget Sound Energy
- Decisionware Group
- Earth Advantage
- Enbridge

- Energy Trust of Oregon
- Fortis BC
- Green Energy Institute, Lewis & Clark Law School
- Lake Oswego Sustainability Network
- Multnomah County Office of Sustainability
- The Nature Conservancy in Oregon
- Natural Resources Defense Council
- NW Energy Coalition
- Oregon Department of Environmental Quality
- NWGA
- Portland Energy Conservation Inc
- Washington Utilities and Transportation Commission
- Pilot Strategies
- The Energy Project
- WA Public Counsel
- Melanie Plaut
- Kathy Moyd
- Bill Harris
- OPEIU Local 11
- UA Local 290 Plumbers & Fitters
- Columbia Pacific Building and Construction Trades Council
- Focus Point

Attendee Summary

Total External Attendees: 47

First Name	Last Name	Organization
Alex	Schay	NW Alliance for Clean Transportation
Ashton	Davis	Cascade Natural Gas
Chris	Carpenter	Focus Point
Kim	Herb	PUC
Ed	Finklea	AWEC
Kathy	Moyd	
Kyle	Morrill	Energy Trust of Oregon
Nate	Stokes	Operating Engineers Local 701
William	Gehrke	CUB
Scott	Strickland	SMART Local 16
Andrew	Rector	WUTC

Peter	Ullrey	Operating Engineers Local 701
Garrett	Martin	PUC
Lorne	Bulling	Ironworkers Local 29
Paul	Hopfauf	MDU Resources
Dan	Kirschner	NWGA
Bryan	Conway	PUC
Kate	Ayres	CUB
Lisa	Rackner	McDowell Rackner Gibson
Brian	Robertson	Cascade Natural Gas
Alexandra	Guillot	Lewis & Clark Law School
Drew	Lindsey	IBEW 280
Harvey	Gail	Oregon Hearth Patio and Barbecue Association
Matt	Muldoon	PUC
Carra	Sahler	Lewis & Clark Law School
Sudeshna	Pal	CUB
Melanie	Plaut	
Pat	DeLaquil	
Aaron	Tam	Office of the Attorney General, Washington
Willy	Myers	Columbia Pacific Building and Construction Trades Council
Matt	Steele	Oregon Department of Environmental Quality
David	Burger	The Central Oregon Building and Construction Trades Council
John	Kimberling	UA Local 290
Devin	McGreal	Cascade Natural Gas

Ken	Ross	Fortis BC
Natasha	Jackson	NWGA
Rose	Anderson	PUC
Mark	Sellers-Vaughn	Cascade Natural Gas
Jeff	McGillivray	UA Local 290 Plumbers & Steamfitters
Karyn	Morrison	OPEIU Local 11
Diane	Henkels	Small Business Utility Advocates
Angus	Duncan	
Greg	Astley	Oregon Restaurant and Lodging Association
1503539XXX	Unidentified caller	
1503893XXX	Unidentified caller	
1503312XXX	Unidentified caller	

The following individuals registered for the meeting but did appear not attend—however, please note, we do not have conclusive information on some of the phone numbers above.

Tom	Pardee	Avista
JP	Batmale	PUC
Nick	Sayen	PUC
Heide	Caswell	PUC
Zachariah	Baker	PUC
Mike	Goetz	CUB
Tim	Miller	PECI
Cecilia	Bremner	Lewis & Clark Law School

Key Questions and Comments

Question	**Answer**
How does Hydrogen Hub Funding impact NW Natural?	We are looking at a potential hub application in the next few months. It could provide an additional source of funding for us to expedite our hydrogen efforts.

Are these charts going to be distributed?	The slide deck and meeting recording will be distributed after the meeting
What kind (e.g. color) of hydrogen are you using at the Sherwood facility?	For the Sherwood blending project, we're using grey hydrogen as this is the least cost resource to give us the data we need. We will not be relying on grey hydrogen for system-wide blending.
Do you have customers for the oxygen?	We do not have a customer for the oxygen, as this is a relatively low-cost commodity and would not be cost effective for oxygen customers. The oxygen will be vented on-site.
As stationary engineers, we work in hospitals running both the gas and electric systems. Redundancy and backup systems are very important. How does hydrogen help with resilience and backup systems?	Hydrogen blends will provide the same resilience as the natural gas system does today. From a stationary engineering perspective, hydrogen provides new opportunities for back-up power using fuel cells.
What is the estimated cost to small commercial ratepayers?	The estimated small commercial rate impact associated with this project is roughly a 0.2% increase in an average bill, or about $0.49 per month.
Do we anticipate hydrogen being used in power plants for electricity generation? Are there existing examples? What retrofitting will need to be done?	Yes, we do anticipate hydrogen being used in power plants for electricity generation. Gas turbines are great ways to produce power to back up lulls in renewable energy production. This can continue with hydrogen, and we can leverage underground storage to supply them as well just like we do today. From what we understand from the electric utilities in Oregon, existing gas turbines are compatible with up to 30% hydrogen (depending on the facility) already. Manufacturers, such as Mitsubishi and GE are working towards 100% hydrogen turbines. Here are a few links if you're interested: • ACES project • Mitsubishi • GE

What's the avg blending ratio, how much blending can NWN's current pipeline system support?	This specific project will blend 5-10% H2 on our west Eugene system
Members are building wind projects but there isn't enough east-west transmission. Heard from some wind developers that the repowering of existing wind farms isn't penciling out because of transmission challenges. Is NW Natural looking at underground transmission of hydrogen from renewable projects at the site of generation because building underground pipes may be more affordable than burying power lines through wildfire territory?	We are looking at the economics around using pipelines to deliver hydrogen from solar and wind assets that are in the region but hundreds of miles away. Hydrogen pipelines are about a tenth of the cost of electric transmission and they provide a low-cost option for bringing in hydrogen and storing it for later use.
Much of what we do is work with steel and cement when we build buildings and bridges so how does hydrogen work with the heat processes that we need to create these materials. Where does hydrogen fit in long term?	Hydrogen has a lower btu content per cubic foot than natural gas so when you blend it in, you need to use a little bit more of it. Existing equipment will work just fine with blends up to 10%, 15%, 20%. As we go to 100% hydrogen systems, we will have to upsize pipes and burners, etc to accommodate the extra gas flow needed to heat things. The hydrogen flame burns slightly hotter so that needs to be taken into account.
I'm hopeful, grateful and excited about the vision represented by this project. I remember back in 2007 when our region launched efforts for more renewable electricity and now 15 years later we are up to about 10%. It takes time and I'm glad to see this project getting started. This offers hope of what can be done and a contradiction to some of the things we have been hearing about what shouldn't be done	
We represent service techs and clerical staff and our members will likely be getting questions from the public. How is project information going to be provided to NW Natural employees so they can best explain how the project will be impact customers?	We have started stakeholder engagement through a number of channels. We have previously reached out to neighborhood associations and will work more directly with folks to give them information. Kim Heiting has been out meeting with employees to talk about hydrogen blending at Sherwood and the project at a high level so employees are aware and

	excited. We have made a commitment that we will provide proper training and bring everyone along in the transition.
The presentation was pretty good about describing the promise of hydrogen and the level of enthusiasm for developing it as a fuel and it's an enthusiasm, I generally share. What are the hurdles that need to be overcome in order for hydrogen to become a significant part of decarbonizing the Pacific Northwest. Can you touch on the most significant unresolved hurdle?	The gas and electric system undertake their own long-term system planning. Are there policies that can we look across the entire energy system for opportunities, identify present day investments that are needed to have an impact in the long term. Frank Lawson- From marketing analysis, we identified two hurdles. From a capitol perspective, the equipment is still in its infancy and hasn't been developed to scale yet. The way to get scale is to look at cross industry applications as we have seen with wind and solar and subsidies. From an operations and maintenance perspective, the largest cost to production of electrolytic hydrogen is the cost of electricity. Looking for opportunities to leverage surplus conditions, where you would be comparing it a low wholesale market condition and develop the rate structure to leverage it is a hurdle to overcome
Follow-up: Question was specific to NW Natural's distribution system and if there are hurdles in order for the system to deliver zero carbon gas.	We see a number of solutions to displace conventional gas, including renewable natural gas and three applications of clean and renewable hydrogen. One is blended hydrogen up to 20%, another is synthetic hydrogen, and finally dedicated hydrogen systems (industrial sites and even new neighborhoods). All of the resources combined with the demand side, including energy efficiencies. Technically we are not seeing any large hurdles based on the testing others have conducted. As we get more hydrogen into the system we are seeing we may need to look at storage facilities.

Statements of Support

The following eight statements were provided in the chat box during the meeting:

- NW Alliance for Clean Transportation
  - "Good afternoon, We are writing to express the NW Alliance for Clean Transportation's support for NW Natural's / EWEB's 1 MWe Renewable Hydrogen project in Eugene. We believe that Renewable Hydrogen offers tremendous opportunities to: 1. Utilize excess electricity to generate Hydrogen, 2. Decarbonize the natural gas fuel mix, and 3. Decarbonize medium- and heavy-duty transportation sectors. With that backdrop in mind, please let us know when & how we may support your good work. We will welcome your call or e-mail, any time. Warm regards, Alex Schay - NW Alliance for Clean Transportation - aschay@nwalliance.net"
- Oregon Hearth Patio Barbecue Association
  - "Hello, The Oregon Hearth Patio Barbecue Association supports the renewable hydrogen project. It's essential that we have this technology available for home heating, which is what our members provide to the community. To do this we must retain the gas network and advocate that homes remain connected to it. Our industry is still in development of technology to use this resource, but we support it. All forms of renewable energy will be needed in the future to offer an option to electric energy."
- UA Local 290 Plumbers & Steamfitters
  - "UA Local 290 Plumbers & Steamfitters support the renewable Hydrogen project. This will be a great affordable addition to other Green energy options while adding redundancy to our energy grid."
- Ironworkers Local 29
  - "The Ironworkers Local 29 supports the renewable Hydrogen project. We need to continue working towards 100% clean energy, and hydrogen is a great way to add redundancy and storage capacity to the energy grid."
- Operating Engineers Local 701
  - The Operating Engineers Local 701 fully support this Project and any moving forward.
- The Central Oregon Building and Construction Trades Council
  - "The Central Oregon Building and Construction Trades Council representing 31 Construction Unions support the transition into Clean Hydrogen into existing pipelines, new pipelines and projects like this one in Eugene and many more to come!"
- Columbia Pacific Building and Construction Trades Council
  - "Columbia Pacific Building and Construction Trades Council supports this needed clean energy project and expanding the use of Clean Hydrogen."
- SMART Local 16
  - "SMART Local 16 supports the opportunities provided by renewable fuels and the transition to a climate resilient infrastructure and economy. Oregon has committed to 100% renewable energy, and hydrogen distribution will be an invaluable technology to achieve that goal while providing family wage jobs and career opportunities to communities across our state and region. Projects like this one will provide resilient jobs in manufacturing, construction, and maintenance. Thank you!"

Meeting Follow-up

A follow-up email was sent to all meeting attendees with a link to the meeting recording and a copy of the slide deck.

Meeting Recording –https://www.nwnatural.com/about-us/environment/hydrogen-projects

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibit of Chris Kroeker

EUGENE HYDROGEN PILOT PROJECT
EXHIBIT 106

August 12, 2022

Emissions Reduction Verification Plan – Eugene Hydrogen Pilot Project

The Emissions Reduction Verification Plan (the "Plan") for the Eugene Hydrogen Pilot Project (the "Project), was prepared in accordance with the requirements of OAR 860-085-0600(3). Specifically, the Plan includes the following elements:

a) Emissions Verification Methodology

1) A baseline of emissions that would occur in the ordinary course of business, in the absence of the Project, within the defined Project boundary;

2) Any potential emission leakage and Project emissions[1]; and

3) Details of how the emission reduction verification methodology was developed, such as calculations and data sources.

b) Monitoring and Data Collection - A plan for monitoring emission reductions, including the ongoing collection and retention of data for determining the Project baseline, Project emissions, and emissions reductions that are attributable to the Project.

A. Emissions Verification Methodology

The following presents the Emissions Verification Methodology (the "Methodology") used to calculate the projected emission reductions.

1. Baseline Emissions

The Project Baseline is an estimate of emissions that would occur "under the ordinary course of business or set of conditions reasonably expected to occur within the defined boundary."[2] The Project baseline is providing conventional natural gas to meet customer demand.

To calculate the baseline emissions associated with the amount of conventional natural gas that would be replace by the hydrogen gas provided by the Project, the Methodology uses the Oregon Department of Environmental Quality ("ODEQ") emissions estimate of 0.053 MTCO2(e)/MMBtu for conventional

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[1] OAR 860-085-0600(3)(a)(B) "'Emission leakage' means a reduction in greenhouse gas emissions within the Project that is offset by an increase in greenhouse gas emissions outside the Project. 'Project emissions' means any emissions attributable to the implementation of an Emission Reduction Project".

[2] OAR 860-085-0600(3)(a).

natural gas. The Eugene Hydrogen Pilot Project will only displace conventional natural gas and not other low or zero carbon fuel sources.

NW Natural estimates that the Project will displace approximately 4,300 MMBtu of conventional natural gas per year. Multiplying that number by 0.053 MTCO2(e)/MMBtu results in a projected baseline of approximately 228 MTCO2(e) per year.

2. Emissions Leakage and Project Emissions

Per OAR 860-085-0600(3)(a)(B), "emissions leakage" means "a reduction in greenhouse gas emissions within the Project that is offset by an increase in greenhouse gas emissions outside the Project." There will be no emissions leakage associated with the Project. The hydrogen gas that the project produces replaces conventional natural gas with no additional fuel resources outside of the Project needed or additional processes that would generate or increase emissions. Therefore, there are zero emissions associated with leakage.

The Project emissions means "any emissions attributable to the implementation of an Emission Reduction Project."[3] The Project creates hydrogen gas from power purchased from the Eugene Water & Electric Board ("EWEB"). Due to EWEB's minimal reliance on fossil fuel, the carbon intensity of its electricity supply is 0.02 MTCO2(e)/MWh. Since NW Natural estimates purchasing approximately 1,700 MWh from EWEB, the Project's emissions are estimated at 34 MTCO2(e)/year.

The total Project emissions are a reduction of the baseline emissions (that are reduced to zero by the Project's generated hydrogen gas) by the Project's operational emissions. Therefore, subtracting the Project's estimated emissions of 34 MTCO2(e)/year from baseline emissions—228 MTCO2(e)/year—results in an estimated 194 MTCO2(e)/year of emissions savings.

3. Developing the Emissions Reduction Verification Methodology

NW Natural developed the Methodology based on the requirements found in OAR 860-085-0600(3). The Methodology calculates the difference between baseline emissions prior to the Project and the emissions that would occur after commencement of the Project. As explained above, the Methodology takes into account the negligible amount of emissions produced by the operation of the Project and also explicitly addresses leakage, as required by OAR 860-065-0600, although there will be no leakage as a result of the project.

[3] OAR 860-085-0600(3)(a)(B).

The sources of information used include:

- The ODEQ emissions for conventional natural gas. ODEQ utilizes the Environmental Protection Agency's GHG Reporting Values, 40 CFR Part 98, subpart NN.
- EWEB's provided carbon intensity of its electricity supply.

B. Plan for Monitoring Emissions Reductions

NW Natural proposes to submit an annual report that will present the Project's emissions savings calculated by the Methodology as an additional appendix to its RNG Compliance Report required in OAR 860-150-0600.

The annual report will have the amount of hydrogen produced in the past year. If necessary, the carbon intensity of conventional natural gas or EWEB's power supply will be updated as needed to ensure accurate of remission reduction calculations, as changes to these inputs will affect the amount of annual emissions savings.

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Direct Testimony of Ryan Weber

EUGENE HYDROGEN PILOT PROJECT
Hydrogen Gas and Project Technology
EXHIBIT 200

REDACTED

August 12, 2022

EXHIBIT 200 – DIRECT TESTIMONY– HYDROGEN GAS AND PROJECT TECHNOLOGY

Table of Contents

I. INTRODUCTION AND SUMMARY

Q. Please state your name and position at Northwest Natural Gas Company ("NW Natural" or the "Company").

A. My name is Ryan Weber. I am an engineer at NW Natural. I have worked for the Company since 2019. My responsibilities include technical engineering for all hydrogen related projects.

Q. Please describe your education and employment background.

A. I received my Bachelor of Science degree in Biology from University of Oregon and a Master of Science degree in Chemical Engineering from Oregon State University. From 2008 to 2010, I worked as a process engineer at the Hanford Nuclear Reservation, remediating nuclear waste. From 2010 to 2019, I worked as a process engineer and program manager at Intel Corporation. Since 2019, I have worked at NW Natural, both as a project engineer, and now the technical engineer for hydrogen related projects.

Q. What is the purpose of your testimony?

A. The primary purpose of my testimony is to expand on the Direct Testimony of Chris Kroeker, NW Natural/100, by providing additional technical details regarding the Eugene Hydrogen Pilot Project (the "Project"). My testimony includes a more granular explanation of the power-to-gas technology that will be used to convert electric energy to hydrogen gas, as well as the closed loop gas distribution system that NW Natural will utilize to serve its customers in the West Eugene area with a five percent hydrogen gas/95 percent natural gas blend. I will also further discuss

why this hydrogen gas blend can be safely and reliably used to serve NW Natural's customers.

II. OVERVIEW OF HYDROGEN GAS TECHNOLOGY

A. Electrolyzer Technology

Q. Please briefly describe what an electrolyzer does and the different types of electrolyzers available on the market.

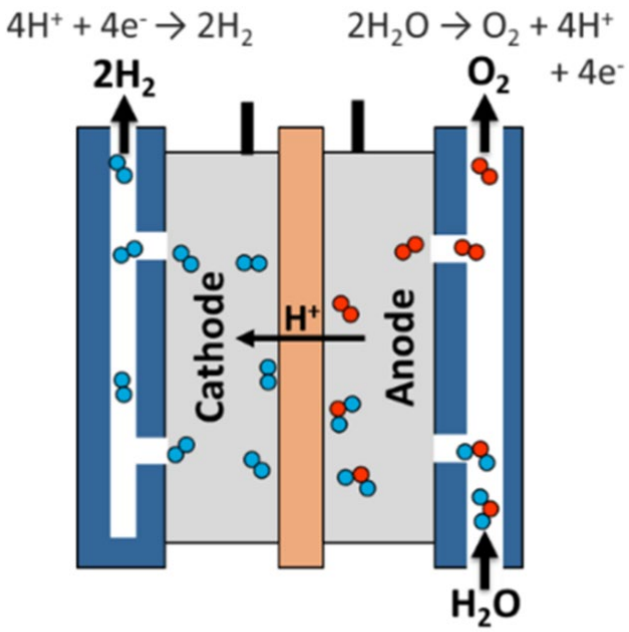
A. Electrolyzers use electricity to create hydrogen gas from water. There are three types of electrolyzers used to generate hydrogen: Proton Electrolyte Membrane ("PEM"), Alkaline Electrolyzers, and Solid Oxide Electrolyzers. PEM uses a solid polymer electrolyte, Alkaline Electrolyzers use a liquid electrolyte, and Solid Oxide Electrolyzers use a ceramic material as the electrolyte. Each type has different characteristics that may be favored depending on the end use application.

Q. Which of the types of electrolyzers is most efficient?

A. Solid Oxide electrolyzers are the most efficient, although they operate at very high temperatures (between 500-800°C) and are not yet commercially available. PEM electrolyzers—which have been commercially available for decades—are the most responsive of all three types of electrolyzers and can ramp up production of gas to meet demand within seconds.

Q. How do PEM electrolyzers create hydrogen gas?

A. All electrolyzers consist of an anode and a cathode separated by an electrolyte. In a PEM electrolyzer, the electrolyte is a solid specialty plastic material, shown as the light brown rectangle in the figure below.



Source:DOE

Water is sourced at 2 gallons per minute, treated on-site to remove ions, and then injected into the PEM membrane stack, which is like a sandwich of polymer materials. An electric voltage is applied to the anode and cathode of the PEM, which causes the water molecule to split into hydrogen and oxygen. The hydrogen ions then selectively move across the polymer to the cathode. At the cathode, hydrogen ions combine with electrons to form hydrogen gas.

Q. Are PEM electrolyzers a proven technology?

A. Yes. PEM electrolyzers are a proven technology with a long production history and excellent safety record. The PEM electrolyzer was pioneered by General Electric in the 1960's. During the 1980's and 1990's, PEM electrolyzer hydrogen gas facilities were developed in Switzerland, Germany, and Japan. However, production at these facilities was relatively limited because it was more economical

to create hydrogen gas from fossil fuels, through a process called Steam Reforming of Methane ("SMR"), which was briefly discussed in the Direct Testimony of Chris Kroeker, NW Natural/100. In the past 20 years, PEM electrolyzers have seen a resurgence as the industry works to reduce fossil fuel use and carbon dioxide emissions.

Q. Are PEM electrolyzers the most common electrolyzer used in utility blending applications?

A. Yes, most power-to-gas facilities constructed in the last few years utilize PEM electrolyzers.

B. Safety and Reliability

Q. As a general matter, are there safety concerns specifically associated with the use of hydrogen gas in the natural gas distribution system?

A. Yes. When introducing hydrogen gas into a natural gas system, there are two commonly held safety and reliability concerns: leakage and embrittlement.

Q. Please explain the concern regarding leakage.

A. A commonly held misconception among the general public is that because H2 is a smaller molecule than methane or natural gas it must preferentially leak. The science behind gas leaks shows that this is not the case and the accepted view among industry experts is that hydrogen will not preferentially leak within the natural gas system.

In low pressure configurations, for example on the residential customer side of the natural gas distribution system, hydrogen/conventional natural gas blends leak at the same rate as conventional natural gas alone. In higher pressure

systems, like transmissions systems, hydrogen/conventional natural gas blends appear to leak marginally more and at a higher rate than conventional natural gas alone. However, the operating pressures within our Eugene closed loop system are below the higher transmission pressures, and therefore the risk of leakage is substantially lower.

Concerns about leakage are also significantly mitigated in the context of the Eugene Hydrogen Project, for two reasons. First, as explained in the Direct Testimony of Chris Kroeker, NW Natural/100, the Company has already removed all of its cast iron and bare steel pipes, reducing the risk of leaks. Second, at low blend levels the rate of leakage is not anticipated to be any greater than pure natural gas.

It is important to point out that adding hydrogen to natural gas only marginally impacts the Upper and Lower Flammability Limit ("UFL", "LFL") as shown in the table below. The UFL and LFL do not change significantly until much higher blends, higher than anything NW Natural is trying to achieve with this Project:

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Table 1– Upper (UFL) and Lower (LFL) flammability limit for natural gas, hydrogen, and their blends at different levels[1]

CH_4 (mole%)	H_2 (mole%)	LFL, vol.%	UFL, vol %
100	0	4.99	14.73
98	2	4.97	14.97
95	5	4.93	15.35
90	10	4.88	16.01
80	20	4.77	17.54
70	30	4.67	19.39
0	100	4.07	74.24

[1] G. Hankinson, H. Mathurkar, B.J. Lowesmith, *Ignition Energy and Ignition Probability of Methane Hydrogen Air Mixtures*, International Conference on Hydrogen Safety, (Sept. 16-18, 2009).

Q. Please explain the concern regarding hydrogen metal embrittlement.

A. Hydrogen embrittlement ("HE") occurs when hydrogen ions are absorbed into the steel pipe surface. The ions interrupt the crystal lattice structure of the metal, thereby weakening the material. This mechanism occurs most rapidly at high tension locations (e.g., cracks) and weakens the metal, making it more susceptible to cracking. HE is typically seen in high pressure, high SMYS (specified minimum yield stress) pipelines because HE is directly related to pipe pressure, stress, geometry, and crack size, so with increasing pressure there is an increase in hydrogen induced embrittlement.

Q. Please explain why the Project characteristics mitigate concerns regarding HE.

A. HE concerns are typically associated with transmissions systems that operate at a SMYS above 20 percent, as opposed to distribution systems like this Project.

Also, HE is more pronounced in certain materials, for example cast iron, or higher-grade bare steel. As stated above, NW Natural has none of these piping materials of concern in our system. The two most important factors for HE—high stress and pipe material—are not factors in the Eugene closed loop.

Q. Can NW Natural's piping system safely accommodate the introduction of the hydrogen gas?

A. Yes, NW Natural has one of the most modern and tight natural gas distribution systems in the United States, with no bare steel and no carbon steel piping. Therefore, there is little concern about potential leakage of hydrogen gas. Moreover, as noted above, HE tends to be a problem on high pressure transmission pipelines as opposed to lower pressure distribution lines such as those present in NW Natural's Eugene service territory. Therefore, these safety concerns are not present in the areas to be served by the Project.

Q. What steps have NW Natural taken to ensure the safe and reliable operation of its system with hydrogen/natural gas blends?

A. NW Natural has taken several important steps to ensure the safe operation of our system with the hydrogen/natural gas blend through both prior testing and safety measures to be taken during operations.

First, as explained in the Direct Testimony of Chris Kroeker, NW Natural/100, the Company conducted several tests to confirm that the hydrogen gas blend would be safe in our existing system. Specifically, NW Natural tested the introduction of the hydrogen/natural gas blend at its Training Town Sherwood testing facility. The facility replicates current distribution piping and system fittings

to test the compatibility of hydrogen gas in the existing system. Additionally, NW Natural tested hydrogen gas in a wide variety of customer appliances and ensured that NW Natural's leak detection equipment is compatible with the hydrogen gas blend.

In addition to these tests, NW Natural designed a three-phase study specifically to evaluate safety and reliability of service, before and during Project deployment. During Phase One, NW Natural reviewed gas volumes, flows, and pressure on the natural gas system within the area that will be served by the five percent hydrogen gas blend[1] to ensure that it will meet the energy content requirements in the NW Natural tariff (minimum of 985 Btu/cf). NW Natural also determined the appropriate size electrolyzer to ensure that the Project will meet hourly and seasonal demands, i.e., the five percent hydrogen gas blend can be maintained throughout the year to meet the needs for the natural gas flow that is being replaced by the hydrogen gas.

In Phase Two of the study, NW Natural worked with an outside consultant, DNV. DNV summarized how hydrogen blends can impact a utility's system, and how to approach updating our procedures and emergency responses to include hydrogen blends. DNV also performed a high-level review of NW Natural's existing system and found that the Eugene location is a favorable candidate for introducing hydrogen.

[1] *See* NW Natural/100, Kroeker/20 for a map of this area.

Finally, in Phase Three, DNV will conduct a more detailed assessment of NW Natural's distribution system based on its Phase Two work and develop any mitigation plans for certain components, as necessary.

Q. Are NW Natural's staff trained to address specific issues that may arise from working with hydrogen gas?

A. Yes. NW Natural has conducted additional training with our technicians to ensure that they are aware of issues specific to working with hydrogen gas. We have provided hands-on training and have tested hydrogen gas leak detection equipment; we are confident that our technicians have successfully learned to detect hydrogen gas leaks. Additionally, we have educated our technicians on the slightly increased Upper and Lower Flammability Limits of our hydrogen blends (see table above). Finally, we are working with third-party experts (DNV) to update our emergency response procedures to incorporate hydrogen blends.

Q. Will hydrogen gas affect how the Company measures its customers' energy consumption?

A. No. The Company's measuring equipment will measure the energy content of the hydrogen gas blend delivered to the customers within the Project just as we do elsewhere in our service territory. The hydrogen gas blend that NW Natural will deliver to customers will continue to satisfy all energy content delivery requirements and meet the minimum BTU content specified in our tariff.

III. THE EUGENE HYDROGEN PILOT PROJECT TECHNOLOGY

A. Pilot Project Technology and Equipment

Q. Please briefly explain the technology used in the Eugene Hydrogen Pilot Project.

A. The Project will produce hydrogen gas using power-to-gas technology. As explained in the Direct Testimony of Chris Kroeker, NW Natural/100, hydrogen gas can be used in place of natural gas, either directly (e.g., space heating, industrial applications, etc.) or for power generation. While hydrogen is abundant in nature, it is not commonly found as a gas. Therefore, the Project will use power-to-gas technology to create hydrogen gas from water through electrolysis, which is when electric current is passed through water and splits the molecule into hydrogen and oxygen.

Q. What type of electrolyzer technology does NW Natural intend to use for the Eugene Hydrogen Pilot Project?

A. NW Natural intends to use a PEM electrolyzer, the benefits of which I discussed earlier in my testimony. The Company chose to use this technology because it can ramp up and down within seconds. This technology makes it ideal to help stabilize the power grid, which is integrating more and more variable renewable generation. The use of electrolyzers for power grid stabilization was discussed in detail in the Mr. Kroeker's testimony.[2]

[2] NW Natural/100, Kroeker/12.

Q. In turning power into hydrogen gas, will NW Natural need to utilize any other equipment besides PEM electrolyzers?

A. Yes. While PEM electrolyzers are the heart of this power-to-gas project, other equipment is also required to complete the system. NW Natural will construct a facility that will include a control center, water handling equipment, cooling equipment, and hydrogen gas handling equipment at the Project site.

Q. Where will all of this equipment be housed?

A. All of this equipment will be housed in an approximately 900 square foot building located on the Eugene Water & Electric Board's ("EWEB") West Eugene campus. This location was selected because of its proximity to existing NW Natural pipeline infrastructure, allowing the hydrogen gas to be injected onto NW Natural's existing gas distribution piping located on Roosevelt Blvd. This location minimizes the cost of interconnecting the Project to both EWEB's and NW Natural's systems. A map of the Project's location is included in the Direct Testimony of Chris Kroeker, NW Natural/100.

Q. Please describe the control center for the project.

A. The control center consists of a programmable logic controller ("PLC"), that is wired to the various pieces of equipment in the facility and provides control and communication to the equipment. The PLC receives real-time readings from temperature and pressure transducers, as well as gas and water flow meters, and calculates the volume of hydrogen gas to generate and inject into the main gas distribution system. The control center will also monitor and adjust critical parameters within the facility, such as temperature and water quality and quantity.

The control center will also be responsible for alarms and communication from the facility to the NW Natural communications network. This communication on our existing network enables our gas control team to remotely monitor, control, and even shutdown the facility if required.

Q. Please describe the water handling equipment.

A. The water handling equipment consists of water purification equipment, analytical equipment, and flow control to ensure that the water feeding the electrolyzer meets the required water quality and quantity specifications.

Q. Please describe the cooling equipment.

A. PEM electrolyzers produce heat as part of the operating process, the heat is removed from the equipment via a water/glycol cooling system. The hot water/glycol coming from the equipment is transferred through a heat exchanger, which releases the heat to the atmosphere.

Q. Please describe the hydrogen gas handling equipment.

A. Once the electrolyzer generates the hydrogen gas, that gas is then transferred through steel piping equipped with a flow control valve, which controls the volume of hydrogen gas injected into the natural gas system. The volume of hydrogen gas injected into the system is pre-determined by the project engineer and entered into the PLC. The PLC then uses the flow control valve and natural gas flow data to ensure the correct amount of hydrogen gas is injected onto the natural gas system. The oxygen that is generated from the electrolyzer is released to the atmosphere. There are no other direct emissions from the facility equipment.

B. Pipeline Injection and Quality Control

Q. Where will NW Natural inject the hydrogen gas that the Project produces?

A. As stated above, NW Natural will inject the hydrogen gas into its existing pipeline distribution system that is adjacent to the Project. The hydrogen gas will be blended with NW Natural's existing natural gas supply and then injected into the distribution system that serves the area shaded in yellow as shown in the Direct Testimony of Chris Kroeker.[3] This area will be served with a blend of five percent hydrogen gas and 95 percent natural gas—with the potential to increase the hydrogen percentage up to 10 percent.

Q. How does the facility determine the quantity of hydrogen gas to inject into the system?

A. First, NW Natural will establish a closed loop system for the area referenced above; this area will be the only section of NW Natural's distribution system that will receive the blended gas. As part of the closed loop system, NW Natural will close the valves of any gas piping that would allow the hydrogen/natural gas blend outside of this area. The project will also install a new regulator on the northwest side of the system to ensure that the hydrogen gas blend is confined to the closed loop. This closed loop system will be used to establish the operational parameters for the system. The baseline pressure and flow for this configuration will inform the PLC of the quantity of hydrogen gas to generate.

[3] NW Natural/100, Kroeker/20.

The electrolyzer facility will use a flow meter to measure the incoming amount of conventional gas entering the closed loop system. The PLC then calculates how much hydrogen gas to inject based on the flow meter data and the percent hydrogen setpoint. The flow of total gas is dictated by downstream consumer consumption; as consumption goes up, the flow goes up, as consumption goes down, the flow goes down.

Upstream of the electrolyzer facility is a gas regulator (valve) that correctly matches the consumption of gas downstream. If the electrolyzer goes offline the regulator is designed to ensure enough conventional natural gas is available for downstream customers; the regulator will further open to increase injection of conventional gas to accommodate the loss of hydrogen gas production.

Q. How will NW Natural ensure that there is a consistent five percent hydrogen and 95 percent natural gas blend?

A. NW Natural's PLC and flow meters that were mentioned earlier ensure that five percent hydrogen gas is blended on the closed loop system. Additionally, the Company will use chromatographs to check the percentage of H2 on the system. Chromographs are ubiquitous to the natural gas industry and are used to measure the gas constituents within the pipeline.

Q. Are there any reliability impacts if the project stops producing hydrogen?

A. No. If the electrolyzer stops producing hydrogen gas, a regulator, which is upstream of the Project, will compensate by increasing the flow of conventional natural gas to meet NW Natural's customer demand. Our system is designed for

just such a scenario, the additional gas needed will be provided by gas line pack and increased flow at our gate stations.

C. Operational Monitoring

Q. What system wide safety procedures is NW Natural planning to implement during the operation of the pilot program?

A. Although NW Natural does not anticipate increased leakage as a result of the hydrogen blend, as explained above, the Company will nonetheless increase leak surveys and work with DNV to develop any necessary revisions to its emergency response protocols.

Q. How will NW Natural ensure that the hydrogen blend it provides to customers is safe?

A. NW Natural will be continuously monitoring the gas composition in our system ensuring that the blend percentages are safe. A five percent hydrogen gas blended with natural gas is safe for use with customer equipment and has no impact to odorant and odor detection.

D. Costs of Eugene Hydrogen Pilot Project

Q. Please describe the estimated capital costs for the Project.

A. The capital costs of the Project are currently estimated to be approximately $9.8 million. **[BEGIN CONFIDENTIAL]** [redacted] [**END CONFIDENTIAL].** These costs include: 1) the PEM electrolyzer, which is the heart of the power-to-gas system; 2) constructing the facility that will house the equipment to convert the power into hydrogen gas,

including structural foundations and electrical work; and 3) ancillary equipment, such as the PLC, cooling pumps, water treatment skid, and piping to the main distribution line, and instrumentation.

Q. Has NW Natural contracted with a supplier for the electrolyzer yet?

A. No. NW Natural has not yet selected a supplier for the electrolyzer. However, NW Natural will send out a request-for-proposal to qualified electrolyzer vendors and contractors for purchase of the electrolyzer and auxiliary equipment.

Q. Will NW Natural issue a request-for-proposal to construct the facility that will house the equipment to convert the power into hydrogen gas?

A. Yes. NW Natural will issue request-for-proposals to select contractors for construction of the building and site improvements. The contractor selected to construct the approximately 900 square foot building to house the project's equipment would also install the site's underground utility services and coordinate installation and commissioning of the electrolyzer and water handling systems.

Q. How will NW Natural source the ancillary equipment, such as the PLC and pumps, and piping to the main distribution line, and instrumentation?

A. NW Natural will include this equipment in the RFP for the electrolyzer. NW Natural will then evaluate the most prudent way to proceed with this equipment, either source it through the contractor or purchase directly.

Q. Please describe the operating costs of the Project.

A. The operating costs of the Eugene Hydrogen Pilot project are projected to be approximately $140,000 per year. These operating costs include: 1) the lease of the project site from EWEB, and 2) power and water provided by EWEB. The cost

of the lease reflects market rates and allows NW Natural to select a site that is located close to both NW Natural's and EWEB's distribution systems, minimizing project interconnection costs to the power and natural gas grids. Power and water costs reflect EWEB's standard rates and ensure a relatively cost effective source of low carbon power, especially given the relatively small amount that NW Natural is purchasing annually (less than 2,000 MWh).

Q. Does this conclude your testimony?

A. Yes.

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Direct Testimony of Robert Wyman

EUGENE HYDROGEN PILOT PROJECT
Cost Recovery and Rate Spread
EXHIBIT 300

August 12, 2022

EXHIBIT 300 – DIRECT TESTIMONY– COST RECOVERY AND RATE SPREAD

Table of Contents

I. INTRODUCTION

Q. Please state your name and position with Northwest Natural Gas Company ("NW Natural" or the "Company").

A. My name is Robert Wyman. I am currently employed as a Rates and Regulatory Consultant for NW Natural. I am responsible for economic analysis, cost of service, and rate spread and rate design. I have been a witness, supported witnesses, and created technical work papers on multiple rate and advice filings with the Oregon and Washington utility commissions.

Q. Please summarize your educational background and business experience.

A. I hold a Bachelor of Science in Economics from the Robert D. Clark Honors College at the University of Oregon and a Master of Arts in Applied Economics from the University of Michigan. Prior to attending graduate school, I was employed by ECONorthwest, an economic consultancy, and worked in the firm's development and transportation practice area. I was responsible for the technical analysis and consultation for dozens of projects, largely in the Pacific Northwest and Western states. When I joined NW Natural in 2016 as a Rates and Regulatory Analyst, I had a cumulative eight years of professional consulting experience with a focus on public finance and policy, urban economics, and financial feasibility (benefit-cost) analysis.

Q. What is the purpose of your testimony?

A. My testimony is responsive to the regulatory requirements specific to Senate Bill ("SB") 844 project costs and cost recovery per OAR 860-085-0600(2) and OAR

860-085-0700 for the development of the Eugene Hydrogen Pilot Project ("the Project"). These requirements are:

OAR 860-085-0600(2)

- Present the requested method for cost recovery;
- Show the project benefits received that can be attributed to the Project, and the allocation of benefits for each type of ratepayer;
- Describe any incentive payments or a proposed incentive structure associated with the Project, and the recovery thereof;
- Present any required tariffs that would be associated with the Project.

OAR 860-085-0700

- Determine that the projected costs to ratepayers of all of the Company's SB 844 projects do not exceed four percent of the utility's last approved retail revenue requirement, inclusive of all revenue collected under adjustment schedules.

Q. How does your testimony address these regulatory requirements?

A. First, I describe how the Project benefits all of the Company's rate classes. Next, I discuss the Company's cost of service analysis and the forecasted annual revenue requirement needed for cost recovery of its capital investment and on-going operations and maintenance expense associated with the Project. Then, I present the Company's rate spread allocation proposal and show how the rate spread proposal will allocate the Project cost recovery on a per rate schedule basis. I estimate the average bill impacts associated with the proposed rate

allocation. My testimony also presents the rate schedule tariffs and proposed tariff rates associated with the Project.

Finally, my testimony determines that the rate impact amount associated with the Project, which would be the first SB 844 project developed by the Company, is well under the cap established by the Commission.[1] The cap is four percent of NW Natural's last approved retail revenue requirement, inclusive of all revenue collected under adjustment schedules, or $30.9 million.[2]

Q. Are you introducing any exhibits with your testimony?

A. Yes. I am sponsoring Exhibits 301, 302, 303, and 304. Exhibit NW Natural/301, Wyman is results of the cost of service analysis, which derives the Project's annual revenue requirement that the Company is proposing for cost recovery. Exhibit NW Natural/302, Wyman is the proposed incremental allocation by rate schedule. Exhibit NW Natural/303, Wyman is the proposed base and total billing rates by rate schedule and block. Exhibit NW Natural/304, Wyman presents the proposed Project tariff sheets with tariff rates.

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[1] OAR 860-085-0700.

[2] The $30.9 million is the total approved revenue from UG 388 (most recent approved general rate case), UG 402-410 (2020-21 PGA), and UG 434 (2021-22 PGA) multiplied by four percent.

II. EUGENE HYDROGEN PILOT PROJECT BENEFITS AND COST TREATMENT

Q. Does the Project have both immediate and long-term benefits to all customer classes (residential, commercial, and industrial)?

A. Yes. As described in the Direct Testimony of Chris Kroeker (NW Natural/100, Kroeker), the Project benefits all customers classes (residential, commercial, and industrial) as soon as the Project enters service by reducing emissions immediately. The Project also has long-term benefits because it prepares NW Natural to integrate increasing amounts of hydrogen in the future.

Q. Please describe the Project's immediate GHG reduction benefit to customers.

A. When the Project enters service, it will immediately benefit customers by producing hydrogen gas that will reduce the Company's greenhouse gas ("GHG") emissions. NW Natural must reduce its emissions to meet its own emissions-reduction goals and the requirements established in the Climate Protection Program ("CPP").[3] The CPP sets a declining limit, or cap, on GHG emissions from fossil fuels used throughout the state of Oregon, including diesel, gasoline, natural gas and propane, used in transportation, residential, commercial and industrial settings (the program is not inclusive of fossil fuel used in electric generation).[4] The CPP also regulates site-specific GHG emissions at large stationary sources, such as

[3] OAR 340-271-0010 – 9000.

[4] OAR 340-271-0110.

emissions from industrial processes.[5] The program baseline is set at average GHG emissions from covered entities from years 2017-2019.[6] Reductions from this baseline are set at 50 percent by 2035 and 90 percent by 2050.[7]

As a natural gas local distribution company, NW Natural is a "covered fuel supplier"[8] under the CPP and is the point of regulation for the emissions associated with gas used by its sales and transport customers.[9] Transport schedule customers purchase the commodity they use directly from marketers and suppliers and have historically only paid NW Natural for delivery via the distribution system.

While this project is small in scale, all customer classes, including transport customers, immediately benefit from the Project as a source of low GHG-emitting fuel that will help the Company comply with the CPP.

Q. Please describe the Project's long-term benefit.

A. The Project's long-term benefit is that it will help the Company develop the operational expertise necessary to introduce a hydrogen gas blend into NW Natural's distribution system on a large-scale. As explained in the Direct Testimony of Chris Kroeker, increasing the amount of hydrogen on NW Natural's system is a crucial part of NW Natural's decarbonization strategy, along with energy efficiency and acquiring biogenic renewable natural gas ("RNG"). In its

[5] OAR 340-271-0310.

[6] Rulemaking, Action Item A, Greenhouse Gas Emissions Program 2021 Rulemaking Climate Protection Program, at 8 (Dec. 16, 2021), available at: https://www.oregon.gov/deq/EQCdocs/121621_ItemA.pdf.

[7] *Id*.

[8] OAR 340-271-0020(15).

[9] OAR 340-271-0110(4). There is an exclusion for natural gas not used for combustion, as well as several other exclusions per OAR 340-271-0110(4)(b)(B).

recent draft Integrated Resource Plan Oregon base case, the Company projects large amounts of hydrogen gas on its system in the early 2030s as hydrogen becomes the lowest cost incremental resource and the GHG emissions permitted under the CPP are reduced.[10] By pursuing this Project, the Company is better positioned to introduce more hydrogen gas to its system, which benefits all customers by helping the Company meet its CPP compliance obligations in the future, as well as its own decarbonization goals.

Q. Why is it important that there are both immediate and long-term benefits to the Project?

A. The combination of immediate and long-term benefits is why the Company is pursuing this Project. As explained in the Direct Testimony of Chris Kroeker, there are cheaper sources of RNG currently available and these sources would also provide an immediate CPP compliance benefit, but NW Natural and its customers would lose the long-term benefit of better positioning the Company's distribution system to accept more hydrogen as it becomes the incremental resource to both meet customer demand and decarbonize. Similarly, NW Natural could have chosen to introduce a more GHG-emissions intensive form of hydrogen that likely would have been less costly. However, although that choice would have resulted in at least some of the long-term benefits as the Project, such as experience with hydrogen blending, it would have offered little to no immediate GHG reduction benefits and it would not have prepared the Company to operate power-to-gas

[10] NW Natural Draft 2022 Integrated Resource Plan, at 7.16 and Figure 7.7 (available at: https://www.nwnatural.com/about-us/rates-and-regulations/resource-planning).

facilities. Rather the Company is pursuing the Project because of its unique combination of immediate and long-term benefits to all residential, commercial, and industrial customer classes.

Q. What are the Project capital and on-going operating costs?

A. The Direct Testimony of Ryan Weber (NW Natural/200, Weber) explains the Project capital and operations costs in detail. The Company forecasts capital costs of roughly $9.8 million. Project operating costs are projected to be approximately $140,000 per year.[11]

Q. How does the Company propose to treat Project costs for ratemaking purposes?

A. The Company seeks cost recovery of the cost of service for the Project at the authorized rate of return set in its last general rate case through a base rate adjustment in Schedule 184 (*see* NW Natural/304, Wyman).

Q. Is the Company proposing an incentive structure or incentive payments associated with the Project as described in OAR 860-085-0600(2)(c)?

A. No, the Company is not proposing an incentive structure or any incentive payments as described in OAR 860-085-0600(2)(c) associated with the Project.

Q. What is the anticipated Project in-service and rate effective dates?

A. The Company currently anticipates that the Project will be complete and in-service by March 31, 2024. The anticipated rate effective date is April 1, 2024.

[11] NW Natural/200, Weber/16.

Q. How does the Company propose to recover expenses of the Project in rates?

A. The Company proposes Schedule 184, which will allow the Company to include the cost of service for the Project in customer rates at the time that it is placed in service. Following the initial rate change, the Company will update the cost of service for the Project in subsequent rate cases.

Q. What is the estimated revenue requirement associated with the Project?

A. Exhibit NW Natural/301, Wyman presents the results of the Company's cost of service analysis which derives the Project's annual revenue requirement. The Company currently estimates a Year 1 revenue requirement of approximately $1.75 million.

Q. Given this revenue requirement, is the Company below the cap established by the Commission for SB 844 projects?

A. Yes, the Company is well under the cap established by the Commission in OAR 860-085-0700, equal to four percent of NW Natural's last approved retail revenue requirement, inclusive of all revenue collected under adjustment schedules, or $30.9 million.

III. RATE SPREAD AND IMPACT

Q. How does the Company propose to allocate the Project revenue requirement?

A. Since all rate classes will benefit from the Project, as discussed earlier in my testimony and in the Direct Testimony of Chris Kroeker, NW Natural/100, the Company proposes to allocate the Project costs to all Oregon rate schedules and customer classes.

Q. How does the Company propose to spread the Project revenue requirement to the rate schedules?

A. The Company proposes to allocate the annual Project costs across all Oregon rate schedules on an equal percent of margin basis. The equal percent of margin calculation allocates incremental revenue by calculating a percent of margin (margin by rate schedule divided by total margin) 'scalar' and multiplying the margin scalar by the total incremental revenue.

Q. Why does the Company propose an equal percent of margin rate allocation for the Project costs to all customers?

A. As explained earlier in my testimony, the Project will provide the Company with the experience and knowledge required for a more extensive hydrogen roll out over time. The Company believes that during this developmental stage, all rate classes benefit equally from the operational experience gained from the Project, and therefore allocating out the costs on an equal percent of margin to all customer classes/rate schedules is appropriate.

Q. The Company recently proposed to spread the costs of an RNG project on an equal cent per therm basis to all customers based on the Company's emission reduction requirements and status as the point of regulation for all customers. How is this different?

A. In the Company's current general rate case, docket UG 435, NW Natural proposed recovering the costs of an RNG qualified investment from all sales and transport customers on an equal cent per therm basis. The basis of that request was that the CPP requires NW Natural to reduce the number of therms of natural gas its

sales and transport customers use. Because CPP compliance is based on therms of natural gas used, it was reasonable to allocate the costs in a similar manner (i.e., equal cents per therm).

While the hydrogen blending Project provides CPP compliance benefits, as stated above, these benefits are limited both by the size of the Project and by the fact that there are less expensive forms of RNG available.[12] Instead, the Company is pursuing this small, initial Project not just for its immediate CPP compliance benefits, but also to maximize its experience blending hydrogen into its system and operating power-to-gas technology without investing at scale. This benefit of experience of day-to-day operations of the system is equally shared among customers, and the Company anticipates it being a launching point for larger projects with significantly more emissions reductions. As the Company develops more hydrogen projects and increases the amount of hydrogen blending on its system, thereby reducing carbon dioxide emissions associated with therms of natural gas consumed, there will be a stronger causal link between the cost of these new projects and the cost of complying with the CPP emissions reduction targets. The Company anticipates proposing an equal cent per therm allocation at the time it seeks regulatory approval for these future projects.

[12] NW Natural/100, Kroeker/28-29.

Q. What is the rate impact to firm customers under the Company's proposed rate spread allocation?

A. Table 1 below shows the impacts of the $1.75 million Year 1 revenue requirement and average bill increase for firm customers. These impacts are also presented in Exhibit NW Natural/302, Wyman. Note that due to depreciation in the capital assets associated with the Project, the Company forecasts that the Year 1 revenue requirement will represent the peak of the Project costs on an annual basis.

Table 1
Incremental Revenue Requirement and Average Bill Increase,
Firm Customers Only

Rate Schedule	Revenue Req. Increase	Pct. Increase to Avg. Cust. Bill*
02R	$ 1,189,729	0.2%
03C	$ 363,661	0.2%
03I	$ 9,056	0.2%
27R	$ 1,853	0.2%
31CSF	$ 32,834	0.2%
31CTF	$ 3,849	0.4%
31ISF	$ 13,324	0.2%
31ITF	$ 573	0.4%
32CSF	$ 45,163	0.2%
32CTF	$ 4,027	0.4%
32ISF	$ 10,128	0.1%
32ITF	$ 27,088	0.5%
Total All Schedules**	$ 1,750,205	

* The average customer bill impact figure calculation excludes pipeline capacity charges for RS 31 and RS 32 rate classes, and thus the rate impacts for these schedules are overstated.
** The proposed margin revenue increase is based on volumetric billing rates rounded to the fifth decimal as necessitated by the Company's tariff. Therefore, there may be a small discrepancy with the indicated revenue requirement.

Q. What is the estimated monthly bill impact for residential and small commercial customers?

A. The estimated Year 1 bill impact for a residential customer using 53 therms is 15 cents per month (roughly 0.2 percent). The estimated bill impact for a small commercial customer using 237 therms is 51 cents per month (roughly 0.2 percent).

Q. Does your testimony present the revenue and rate changes applicable to all other rate schedules, including transportation schedules, as well?

A. Yes. Exhibit NW Natural/302, Wyman presents the revenue increases and average bill impacts by rate schedule for the revenue requirement effects shown in Table 1 above. Exhibit NW Natural/304, Wyman contains the volumetric rate increases by rate schedule and block for all Oregon rate schedules.

Q. In the event that the Project qualifies for a tax credit under the proposed federal Inflation Reduction Act, will NW Natural update the Project to reflect the lower cost?

A. Yes, the Company will ensure that the benefit is passed through to customers.

Q. Does this conclude your testimony?

A. Yes.

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibits of Robert Wyman

EUGENE HYDROGREN PILOT PROJECT
Cost Recovery and Rate Spread
EXHIBITS 301-304

August 12, 2022

EXHIBITS 301-304 – COST RECOVERY AND RATE SPREAD

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BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibit of Robert Wyman

EUGENE HYDROGEN PILOT PROJECT
Cost Recovery and Rate Spread
EXHIBIT 301

August 12, 2022

NW Natural
Determination of Cost of Service
UM 2251 - SB 844 Eugene Hydrogen Pilot Project Year 1 Cost of Service

NW Natural/Exhibit 301
Wyman / Page 1

	Year 1
Depreciation	601,941
O&M	136,889
Property Taxes	141,770
Taxes on Equity Return	
State and Federal Income Taxes	171,151
Total Taxes	171,151
Return on Rate Base	
Debt and Equity Return	649,939
Total Return	649,939
Subtotal Cost of Service	1,701,689
Revenue Sensitive Items	48,294
Total Cost of Service - Annual	**$1,749,983**

Combined Overall Tax Rate (OR & Fed)		27.004%		
Property Tax Rate		1.500%		
Franchise Taxes		2.311%		
Commission Fee		0.430%	2.838%	*'--> (rev sens rate)*
Uncollectible Rate		0.097%		
		Capital Structure	**Rates**	**Post-Tax**
Long-Term Debt		50.000%	4.271%	2.136%
Common Equity		50.000%	9.400%	4.700%
ROR				6.836%
Bonus Depreciation?	**NO**	0%	*--> At 0%, no bonus depreciation.*	
Non-Bonus		100%		

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibit of Robert Wyman

EUGENE HYDROGEN PILOT PROJECT
Cost Recovery and Rate Spread
EXHIBIT 302

August 12, 2022

NW Natural
Rates & Regulatory Affairs
SB 844 Eugene Hydrogen Pilot Project Rate Spread - UM 2251
Proposed Incremental Allocation by Rate Schedule - Eugene Hydrogen Pilot Project Effects
UM 2251 Exhibit NW Natural/302, Wyman

Proposed UM 2251 Revenue Requirement Impacts

				Eugene Hydrogen	Total: Rev. Req. Items			Revenue Requirement Effects		
Line No.	Rate Schedule	Margin Revenue at Present Rates	Total Revenue at Present Rates	Margin Increase ($) (1)	Margin Increase ($)	Margin Revenue at Proposed Rates	Total Revenue at Proposed Rates	Margin Revenue Increase (%)	Total Revenue Increase (%)	Average Bill Increase (%)
		A	B	C	E	F = A+E	G = B+E	H	I	J
1	02R	$ 302,743,546	$ 468,913,370	$ 1,189,729	$ 1,189,729	$ 303,933,276	$ 470,103,100	0.4%	0.3%	0.2%
2	03C	$ 92,803,627	$ 162,351,317	$ 363,661	$ 363,661	$ 93,167,289	$ 162,714,979	0.4%	0.2%	0.2%
3	03I	$ 2,141,772	$ 4,226,612	$ 9,056	$ 9,056	$ 2,150,828	$ 4,235,668	0.4%	0.2%	0.2%
4	27R	$ 471,508	$ 796,163	$ 1,853	$ 1,853	$ 473,361	$ 798,016	0.4%	0.2%	0.2%
5	31CSF	$ 8,261,800	$ 17,117,489	$ 32,834	$ 32,834	$ 8,294,634	$ 17,150,323	0.4%	0.2%	0.2%
6	31CTF	$ 981,292	$ 981,292	$ 3,849	$ 3,849	$ 985,142	$ 985,142	0.4%	0.4%	0.4%
7	31ISF	$ 3,237,130	$ 8,236,625	$ 13,324	$ 13,324	$ 3,250,454	$ 8,249,949	0.4%	0.2%	0.2%
8	31ITF	$ 143,836	$ 143,836	$ 573	$ 573	$ 144,408	$ 144,408	0.4%	0.4%	0.4%
9	32CSF	$ 11,882,484	$ 30,465,691	$ 45,163	$ 45,163	$ 11,927,648	$ 30,510,855	0.4%	0.1%	0.2%
10	32ISF	$ 2,462,192	$ 8,156,582	$ 10,128	$ 10,128	$ 2,472,320	$ 8,166,710	0.4%	0.1%	0.1%
11	32CTF	$ 1,024,698	$ 1,024,698	$ 4,027	$ 4,027	$ 1,028,725	$ 1,028,725	0.4%	0.4%	0.4%
12	32ITF	$ 6,584,741	$ 6,584,741	$ 27,088	$ 27,088	$ 6,611,828	$ 6,611,828	0.4%	0.4%	0.5%
13	32CSI	$ 2,232,839	$ 10,222,297	$ 9,209	$ 9,209	$ 2,242,048	$ 10,231,506	0.4%	0.1%	0.1%
14	32ISI	$ 3,307,718	$ 14,833,805	$ 11,912	$ 11,912	$ 3,319,631	$ 14,845,718	0.4%	0.1%	0.1%
15	32CTI	$ 525,889	$ 525,889	$ 2,334	$ 2,334	$ 528,223	$ 528,223	0.4%	0.4%	0.4%
16	32ITI	$ 6,064,679	$ 6,064,679	$ 25,464	$ 25,464	$ 6,090,143	$ 6,090,143	0.4%	0.4%	0.4%
17	33T	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	0.0%	0.0%	0.0%
	Total	**$ 444,869,752**	**$ 740,645,087**	**$ 1,750,205** (2)	**$ 1,750,205** (2)	**$ 446,619,957**	**$ 742,395,292**	**0.4%**	**0.2%**	(3)

NOTE **(1):** Revenue Requirement spread based on the Company's proposal described in UM 2251 Testimony NW Natural 300/Wyman.
NOTE **(2):** The proposed margin revenue increase is based on volumetric billing rates rounded to the fifth decimal as necessitated by the Company's tariff. Therefore, there may be a small discrepancy with the indicated revenue requirement presented in Testimony NW Natural 1300/Walker.
NOTE **(3)**: The average customer bill percentage impact figure calculation excludes pipeline capacity charges for RS 31 and RS 32 rate classes, and thus the bill rate impacts for these schedules are overstated.

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibit of Robert Wyman

EUGENE HYDROGEN PILOT PROJECT
Cost Recovery and Rate Spread
EXHIBIT 303

August 12, 2022

NW Natural
Rates & Regulatory Affairs
SB 844 Eugene Hydrogen Pilot Project Rate Spread - UM 2251
Proposed Base and Total Billing Rates by Rate Schedule and Block
UM 2251 Exhibit NW Natural/303, Wyman

						Current Tariff	Current Tariff Rate						$1,750.0 Eugene Hydrogen Proposed Increase: Base Rate Adjustment			BILLING RATE
							11/01/2021	11/01/2021	11/01/2021	11/01/2021	11/01/2021					
Line No.	Schedule	Block	Block Volumes	Volumes	Customers	Current Monthly Base Charge	Current Rates: Base Rate	Current Rates: Pipeline Capacity	Current Rates: Commodity	Current Rates: Temporary Adjustment	Current Billing Rates	Proposed Base Rate		Proposed Base Rate Adjustment	Proposed Temporary Rate	Proposed Rate
	A	B	C	D	E	F	H	I	J	K	L = H...K	M=H	N	O=N	P=K	Q=I+J+M+O+P
1	2R		N/A	407,441,557	643,080	$ 8.00	$0.57799	$0.10569	$0.31601	$0.04668	$ 1.04637	**$0.57799**	$0.00292	**$0.00292**	**$0.04668**	**$1.04929**
2	3C Firm Sales		N/A	169,935,174	59,720	$ 15.00	$0.46794	$0.10569	$0.31601	$0.06216	$ 0.95180	**$0.46794**	$0.00214	**$0.00214**	**$0.06216**	**$0.95394**
3	3I Firm Sales		N/A	5,555,882	339	$ 15.00	$0.39243	$0.10569	$0.31601	$0.07021	$ 0.88434	**$0.39243**	$0.00163	**$0.00163**	**$0.07021**	**$0.88597**
4	27 Dry Out		N/A	798,862	1,493	$ 8.00	$0.39846	$0.10569	$0.31601	$0.05061	$ 0.87077	**$0.39846**	$0.00232	**$0.00232**	**$0.05061**	**$0.87309**
5	31C Firm Sales	Block 1	2,000	12,240,292	644	$ 325.00	$0.25989	$0.00000	$0.31601	$0.05240	$ 0.62830	**$0.25989**	$0.00153	**$0.00153**	**$0.05240**	**$0.62983**
6		Block 2	all additional	10,075,855			$0.23713	$0.00000	$0.31601	$0.05241	$ 0.60555	**$0.23713**	$0.00140	**$0.00140**	**$0.05241**	**$0.60695**
7	31C Firm Transpt	Block 1	2,000	1,200,912	59	$ 575.00	$0.22948	$0.00000	$0.00000	$0.00061	$ 0.23009	**$0.22948**	$0.00155	**$0.00155**	**$0.00061**	**$0.23164**
8		Block 2	all additional	1,399,993			$0.20980	$0.00000	$0.00000	$0.00057	$ 0.21037	**$0.20980**	$0.00142	**$0.00142**	**$0.00057**	**$0.21179**
9	31I Firm Sales	Block 1	2,000	4,375,718	196	$ 325.00	$0.20042	$0.00000	$0.31601	$0.07022	$ 0.58665	**$0.20042**	$0.00108	**$0.00108**	**$0.07022**	**$0.58773**
10		Block 2	all additional	8,864,215			$0.18068	$0.00000	$0.31601	$0.07022	$ 0.56691	**$0.18068**	$0.00097	**$0.00097**	**$0.07022**	**$0.56788**
11	31I Firm Transpt	Block 1	2,000	157,673	7	$ 575.00	$0.20139	$0.00000	$0.00000	$0.00069	$ 0.20208	**$0.20139**	$0.00119	**$0.00119**	**$0.00069**	**$0.20327**
12		Block 2	all additional	359,813			$0.18202	$0.00000	$0.00000	$0.00068	$ 0.18270	**$0.18202**	$0.00107	**$0.00107**	**$0.00068**	**$0.18377**
13	32C Firm Sales	Block 1	10,000	33,270,116	541	$ 675.00	$0.12925	$0.00000	$0.31601	$0.06999	$ 0.51525	**$0.12925**	$0.00109	**$0.00109**	**$0.06999**	**$0.51634**
14		Block 2	20,000	8,591,128			$0.10911	$0.00000	$0.31601	$0.07001	$ 0.49513	**$0.10911**	$0.00092	**$0.00092**	**$0.07001**	**$0.49605**
15		Block 3	20,000	1,344,529			$0.07565	$0.00000	$0.31601	$0.07002	$ 0.46168	**$0.07565**	$0.00064	**$0.00064**	**$0.07002**	**$0.46232**
16		Block 4	100,000	374,028			$0.04208	$0.00000	$0.31601	$0.07003	$ 0.42812	**$0.04208**	$0.00036	**$0.00036**	**$0.07003**	**$0.42848**
17		Block 5	600,000	-			$0.01796	$0.00000	$0.31601	$0.06962	$ 0.40359	**$0.01796**	$0.00015	**$0.00015**	**$0.06962**	**$0.40374**
18		Block 6	all additional	-			$0.00652	$0.00000	$0.31601	$0.06964	$ 0.39217	**$0.00652**	$0.00006	**$0.00006**	**$0.06964**	**$0.39223**
19	32I Firm Sales	Block 1	10,000	6,782,853	62	$ 675.00	$0.11887	$0.00000	$0.31601	$0.07017	$ 0.50505	**$0.11887**	$0.00076	**$0.00076**	**$0.07017**	**$0.50581**
20		Block 2	20,000	6,150,884			$0.10035	$0.00000	$0.31601	$0.07018	$ 0.48654	**$0.10035**	$0.00064	**$0.00064**	**$0.07018**	**$0.48718**
21		Block 3	20,000	2,109,522			$0.06942	$0.00000	$0.31601	$0.07019	$ 0.45562	**$0.06942**	$0.00044	**$0.00044**	**$0.07019**	**$0.45606**
22		Block 4	100,000	432,851			$0.03858	$0.00000	$0.31601	$0.07021	$ 0.42480	**$0.03858**	$0.00025	**$0.00025**	**$0.07021**	**$0.42505**
23		Block 5	600,000	-			$0.01706	$0.00000	$0.31601	$0.06988	$ 0.40295	**$0.01706**	$0.00011	**$0.00011**	**$0.06988**	**$0.40306**
24		Block 6	all additional	-			$0.00623	$0.00000	$0.31601	$0.06989	$ 0.39213	**$0.00623**	$0.00004	**$0.00004**	**$0.06989**	**$0.39217**
25	32C Firm Transpt	Block 1	10,000	2,727,494	28	$ 925.00	$0.12059	$0.00000	$0.00000	$0.00026	$ 0.12085	**$0.12059**	$0.00077	**$0.00077**	**$0.00026**	**$0.12162**
26		Block 2	20,000	2,018,013			$0.10247	$0.00000	$0.00000	$0.00024	$ 0.10271	**$0.10247**	$0.00065	**$0.00065**	**$0.00024**	**$0.10336**
27		Block 3	20,000	813,126			$0.07236	$0.00000	$0.00000	$0.00020	$ 0.07256	**$0.07236**	$0.00046	**$0.00046**	**$0.00020**	**$0.07302**
28		Block 4	100,000	881,623			$0.04222	$0.00000	$0.00000	$0.00016	$ 0.04238	**$0.04222**	$0.00027	**$0.00027**	**$0.00016**	**$0.04265**
29		Block 5	600,000	17,547			$0.02409	$0.00000	$0.00000	$0.00015	$ 0.02424	**$0.02409**	$0.00015	**$0.00015**	**$0.00015**	**$0.02439**
30		Block 6	all additional	-			$0.01210	$0.00000	$0.00000	$0.00001	$ 0.01211	**$0.01210**	$0.00008	**$0.00008**	**$0.00001**	**$0.01219**
31	32I Firm Transpt	Block 1	10,000	10,979,432	104	$ 925.00	$0.11903	$0.00000	$0.00000	$0.00044	$ 0.11947	**$0.11903**	$0.00065	**$0.00065**	**$0.00044**	**$0.12012**
32		Block 2	20,000	15,838,003			$0.10116	$0.00000	$0.00000	$0.00042	$ 0.10158	**$0.10116**	$0.00055	**$0.00055**	**$0.00042**	**$0.10213**
33		Block 3	20,000	10,218,330			$0.07142	$0.00000	$0.00000	$0.00038	$ 0.07180	**$0.07142**	$0.00039	**$0.00039**	**$0.00038**	**$0.07219**
34		Block 4	100,000	20,114,491			$0.04168	$0.00000	$0.00000	$0.00035	$ 0.04203	**$0.04168**	$0.00023	**$0.00023**	**$0.00035**	**$0.04226**
35		Block 5	600,000	17,579,409			$0.02379	$0.00000	$0.00000	$0.00034	$ 0.02413	**$0.02379**	$0.00013	**$0.00013**	**$0.00034**	**$0.02426**
36		Block 6	all additional	5,722,185			$0.01194	$0.00000	$0.00000	$0.00033	$ 0.01227	**$0.01194**	$0.00006	**$0.00006**	**$0.00033**	**$0.01233**
37	32C Interr Sales	Block 1	10,000	4,831,958	39	$ 675.00	$0.11743	$0.00000	$0.31601	$0.06615	$ 0.49959	**$0.11743**	$0.00060	**$0.00060**	**$0.06615**	**$0.50019**
38		Block 2	20,000	7,061,623			$0.09914	$0.00000	$0.31601	$0.06612	$ 0.48127	**$0.09914**	$0.00051	**$0.00051**	**$0.06612**	**$0.48178**
39		Block 3	20,000	3,862,838			$0.06862	$0.00000	$0.31601	$0.06609	$ 0.45072	**$0.06862**	$0.00035	**$0.00035**	**$0.06609**	**$0.45107**
40		Block 4	100,000	5,558,708			$0.03810	$0.00000	$0.31601	$0.06606	$ 0.42017	**$0.03810**	$0.00020	**$0.00020**	**$0.06606**	**$0.42037**
41		Block 5	600,000	2,444,511			$0.01978	$0.00000	$0.31601	$0.06603	$ 0.40182	**$0.01978**	$0.00010	**$0.00010**	**$0.06603**	**$0.40192**
42		Block 6	all additional	-			$0.00638	$0.00000	$0.31601	$0.06579	$ 0.38818	**$0.00638**	$0.00003	**$0.00003**	**$0.06579**	**$0.38821**
43	32I Interr Sales	Block 1	10,000	6,057,349	69	$ 675.00	$0.11691	$0.00000	$0.31601	$0.06642	$ 0.49934	**$0.11691**	$0.00065	**$0.00065**	**$0.06642**	**$0.49999**
44		Block 2	20,000	7,673,149			$0.09869	$0.00000	$0.31601	$0.06640	$ 0.48110	**$0.09869**	$0.00055	**$0.00055**	**$0.06640**	**$0.48165**
45		Block 3	20,000	4,025,675			$0.06831	$0.00000	$0.31601	$0.06636	$ 0.45068	**$0.06831**	$0.00038	**$0.00038**	**$0.06636**	**$0.45106**
46		Block 4	100,000	9,365,410			$0.03792	$0.00000	$0.31601	$0.06634	$ 0.42027	**$0.03792**	$0.00021	**$0.00021**	**$0.06634**	**$0.42048**
47		Block 5	600,000	2,348,854			$0.01968	$0.00000	$0.31601	$0.06632	$ 0.40201	**$0.01968**	$0.00011	**$0.00011**	**$0.06632**	**$0.40212**
48		Block 6	all additional	-			$0.00634	$0.00000	$0.31601	$0.06604	$ 0.38839	**$0.00634**	$0.00004	**$0.00004**	**$0.06604**	**$0.38843**
49	32C Interr Transpt	Block 1	10,000	944,323	6	$ 925.00	$0.11522	$0.00000	$0.00000	$0.00018	$ 0.11540	**$0.11522**	$0.00051	**$0.00051**	**$0.00018**	**$0.11591**
50		Block 2	20,000	1,795,370			$0.09794	$0.00000	$0.00000	$0.00016	$ 0.09810	**$0.09794**	$0.00043	**$0.00043**	**$0.00016**	**$0.09853**
51		Block 3	20,000	1,051,398			$0.06915	$0.00000	$0.00000	$0.00013	$ 0.06928	**$0.06915**	$0.00031	**$0.00031**	**$0.00013**	**$0.06959**
52		Block 4	100,000	3,494,819			$0.04033	$0.00000	$0.00000	$0.00011	$ 0.04044	**$0.04033**	$0.00018	**$0.00018**	**$0.00011**	**$0.04062**
53		Block 5	600,000	1,258,826			$0.02306	$0.00000	$0.00000	$0.00009	$ 0.02315	**$0.02306**	$0.00010	**$0.00010**	**$0.00009**	**$0.02325**
54		Block 6	all additional	-			$0.01156	$0.00000	$0.00000	$0.00001	$ 0.01157	**$0.01156**	$0.00005	**$0.00005**	**$0.00001**	**$0.01162**
55	32I Interr Transpt	Block 1	10,000	7,218,210	77	$ 925.00	$0.11522	$0.00000	$0.00000	$0.00018	$ 0.11540	**$0.11522**	$0.00052	**$0.00052**	**$0.00018**	**$0.11592**
56		Block 2	20,000	12,888,268			$0.09794	$0.00000	$0.00000	$0.00016	$ 0.09810	**$0.09794**	$0.00044	**$0.00044**	**$0.00016**	**$0.09854**
57		Block 3	20,000	8,993,557			$0.06915	$0.00000	$0.00000	$0.00013	$ 0.06928	**$0.06915**	$0.00031	**$0.00031**	**$0.00013**	**$0.06959**
58		Block 4	100,000	21,708,722			$0.04033	$0.00000	$0.00000	$0.00011	$ 0.04044	**$0.04033**	$0.00018	**$0.00018**	**$0.00011**	**$0.04062**
59		Block 5	600,000	44,259,590			$0.02306	$0.00000	$0.00000	$0.00009	$ 0.02315	**$0.02306**	$0.00010	**$0.00010**	**$0.00009**	**$0.02325**
60		Block 6	all additional	98,363,488			$0.01156	$0.00000	$0.00000	$0.00001	$ 0.01157	**$0.01156**	$0.00005	**$0.00005**	**$0.00001**	**$0.01162**
61	33		N/A	-	-	$ 38,000.00	$0.00574	$0.00000	$0.00000	$0.00011	$ 0.00585	**$0.00574**	$0.00000	**$0.00000**	**$0.00011**	**$0.00585**

BEFORE THE

PUBLIC UTILITY COMMISSION OF OREGON

UM 2251

NW Natural

Exhibit of Robert Wyman

EUGENE HYDROGEN PILOT PROJECT
Cost Recovery and Rate Spread
EXHIBIT 304

August 12, 2022

NORTHWEST NATURAL GAS COMPANY
P.U.C. Or. 25

Fifth Revision of Sheet 184-1
Cancels Fourth Revision of Sheet 184-1

SCHEDULE 184
SB 844 CARBON EMISSION REDUCTION PROGRAMS - EUGENE HYDROGEN PROJECT

(N)

PURPOSE:
To recover costs associated with NW Natural's SB 844 Carbon Emission Reduction Programs approved by the Commission in accordance with ORS 757.539 and OAR 860-085-0500 through 860-085-0750.

APPLICABLE:
To all Customers on the Rate Schedules of this Tariff listed below:

Rate Schedule 2	Rate Schedule 27	Rate Schedule 32
Rate Schedule 3	Rate Schedule 31	Rate Schedule 33

GENERAL:
This Schedule is governed by the terms of this Schedule, the General Rules and Regulations contained in this Tariff, any other schedules that by their terms or by the terms of this Schedule apply to service under this Schedule and by all rules and regulations prescribed by regulatory authorities, as amended from time to time.

APPLICATION TO RATE SCHEDULES: Effective: TBD

The Base Rate Adjustment applies to all customer classes (Sales and Transportation Service) and is calculated on an equal percent of margin by Rate Schedule and Customer class. The effect of this adjustment is reflected in the Base Rate Adjustment shown in the respective Rate Schedules. NO ADDITIONAL ADJUSTMENT TO RATES IS REQUIRED.

(continue to Sheet 184-2)

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Issued TBD
NWN OPUC Advice No. TBD

Effective with service on
and after TBD

NORTHWEST NATURAL GAS COMPANY
P.U.C. Or. 25

Fourth Revision of Sheet 184-2
Cancels Third Revision of Sheet 184-2

SCHEDULE 184
SB 844 CARBON EMISSION REDUCTION PROGRAMS - EUGENE HYDROGEN PROJECT

(N)

RATE ADJUSTMENTS (continued):
The volumetric adjustment applicable to each Rate Schedule is shown in the table below:

Rate Schedule	Block	Base Adjustment (per therm)		Rate Schedule	Block	Base Adjustment (per therm)
2		$0.00292		32 ITF	Block 1	$0.00065
03 CSF		$0.00214			Block 2	$0.00055
03 ISF		$0.00163			Block 3	$0.00039
27		$0.00232			Block 4	$0.00023
31 CSF	Block 1	$0.00153			Block 5	$0.00013
	Block 2	$0.00140			Block 6	$0.00006
31 CTF	Block 1	$0.00155		32 CSI	Block 1	$0.00060
	Block 2	$0.00142			Block 2	$0.00051
31 ISF	Block 1	$0.00108			Block 3	$0.00035
	Block 2	$0.00097			Block 4	$0.00020
31 ITF	Block 1	$0.00119			Block 5	$0.00010
	Block 2	$0.00107			Block 6	$0.00003
32 CSF	Block 1	$0.00109		32 ISI	Block 1	$0.00065
	Block 2	$0.00092			Block 2	$0.00055
	Block 3	$0.00064			Block 3	$0.00038
	Block 4	$0.00036			Block 4	$0.00021
	Block 5	$0.00015			Block 5	$0.00011
	Block 6	$0.00006			Block 6	$0.00004
32 ISF	Block 1	$0.00076		32 CTI	Block 1	$0.00051
	Block 2	$0.00064			Block 2	$0.00043
	Block 3	$0.00044			Block 3	$0.00031
	Block 4	$0.00025			Block 4	$0.00018
	Block 5	$0.00011			Block 5	$0.00010
	Block 6	$0.00004			Block 6	$0.00005
32 CTF	Block 1	$0.00077		32 ITI	Block 1	$0.00052
	Block 2	$0.00065			Block 2	$0.00044
	Block 3	$0.00046			Block 3	$0.00031
	Block 4	$0.00027			Block 4	$0.00018
	Block 5	$0.00015			Block 5	$0.00010
	Block 6	$0.00008			Block 6	$0.00005
				33 (all)		$0.00000

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