Northwest **Power** and
**Conservation** Council



January 7, 2025

**MEMORANDUM**

**TO:** **Council Members**

**FROM:** **Tomás Morrissey, Senior Analyst, Annika Roberts, Resource Policy Analyst**

**SUBJECT:** **Approach to Modeling Hydrogen into the Ninth Power Plan**

## BACKGROUND:

Presenters: Tomás Morrissey and Annika Roberts

Summary: As many states and utilities in the Northwest push to decarbonize, clean hydrogen is being discussed to reduce emissions in the power sector, industrial sector, and for transportation. Creating clean hydrogen requires energy inputs and could create load for the electric power sector. It can also be used as fuel to power future power generation.

Council staff will discuss the two lenses the Ninth Plan will examine hydrogen through. First, Tomás will discuss the high-level approach to estimate industrial and transportation sector hydrogen load. Second, Annika will discuss how the Plan will include proxy resources that represent hydrogen power generation assets.

On our current timeline, staff are planning to bring new generating resource options to the Council in February for consideration. Over the following two meetings, March and April, staff will be bringing forward the approach to the demand forecast. This is an opportunity for members to ask questions and provide insights before staff finalize the analysis

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approach and assumptions for modeling loads and resources. Please come prepared with questions.

Relevance: Clean hydrogen assumptions impact both the development of loads and resources for the Ninth Power Plan.

Workplan: A.3.1: Track emerging technologies, both supply and demand side, providing periodic updates to the Council.
A.2.2: Create an updated in region hourly load forecast and updates to WECC-wide loads to inform the Adequacy Assessment.

# Hydrogen and the Ninth plan

*initial overview , draft work*

January 2025

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## Agenda

- Why hydrogen
  - Benefits
  - Challenges
- Hydrogen in the Ninth Plan workflow
- Hydrogen for non-power generation
- Hydrogen for power generation


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Image from: https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf 2

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# Why hydrogen?

- Depending on the production process, *and jurisdictional definition*, hydrogen fuel ($H_2$) can be made with a low/zero carbon footprint
- Hydrogen can be used for decarbonization of the power system and other end-uses (like industrial uses, or transportation)
- The Northwest, among other areas, was recently awarded up to ~1 billion dollars to develop a hydrogen hub



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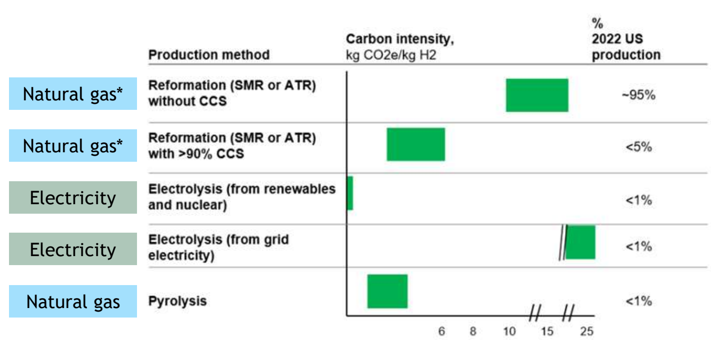
# Hydrogen creation carbon intensities and fuels

- Hydrogen (as $H_2$) is not commonly found in nature
- As a result, hydrogen is made using other energy sources
- State and federal rules have different definitions of what counts as clean hydrogen





Graphic (not including gas/electric labels) from: https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf?sfvrsn=c425b44f_5
*Reformation could use other feedstock fuels as well, natural gas is commonly used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# Hydrogen in the US today

- Around 10 million metric tons (MMT) of hydrogen usage per year
  - Mostly produced via natural gas reforming (without CCS)
  - Mostly used in refineries and for ammonia production




https://www.energy.gov/eere/fuelcells/fact-month-may-2018-10-million-metric-tons-hydrogen-produced-annually-united states#:~:text=Contact%20Us,Fact%20of%20the%20Month%20May%202018%3A%2010%20Million%20Metric%20Tons,Annually%20in%20the%20United%20States&text=Most%20of%20the%20hydrogen%20produced,process%20called%20steam%20methane%20reforming.



# Clean hydrogen challenges

- Clean hydrogen does not exist in the Northwest today at scale *(although the 5 MW Douglas PUD project is nearly done)*
- The Northwest does not have hydrogen infrastructure
  - Pipelines or underground storage facilities are needed to store and transport large quantities of hydrogen
  - Hydrogen is challenging to store from a volumetric perspective
- The Northwest is somewhat energy constrained, hydrogen is a net energy load
  - Demand today is high on both the electric and gas system

# Hydrogen in the 9th Power Plan

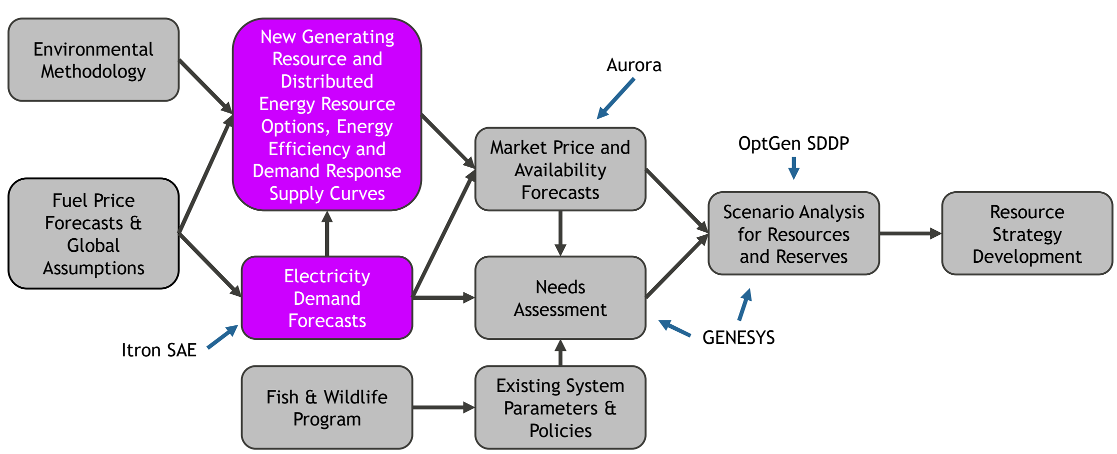
Breaking our hydrogen work into two pathways:

1. Hydrogen for non-electric generation *(via the Fuels Advisory Committee )*
   - For example, hydrogen for industrial uses and transportation
   - This will be a model input (as a load), not an output
     - Estimates will be rough and general, we are not doing a hydrogen or economy wide study
2. Hydrogen for electric generation *(via the Generating Resources Advisory Committee )*
   - For example, a turbine that burns hydrogen
   - This will be generally represented by a proxy resource that the model can select
     - This will be a model output (the model will choose, or choose not to, build the proxy resource)
     - Could also represent natural gas to hydrogen conversions





# Ninth Plan Workflow



# Non-power generation hydrogen

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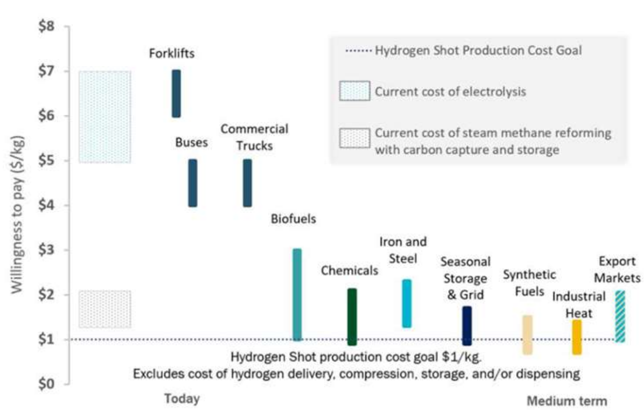
## Hydrogen for non-power uses

- Transportation
- Liquid fuels (drop in fuels, biofuels, synthetic fuels, etc.)
- Industrial applications (refining, high-heat applications, etc.)
- This will be a model input (not an output)

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From: https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf?sfvrsn=c425b44f_5

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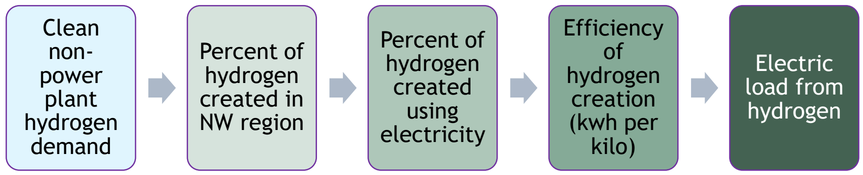
# High level approach




We will likely have two hydrogen forecasts for the Plan. The goal is to represent different future pathways for the economy. Given the nascent state of the industry we will downplay the assumptions and focus on the final load value.



# Where are we getting our assumptions

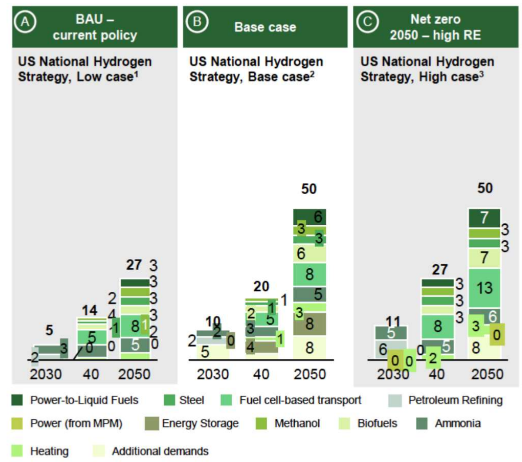
- For total hydrogen consumption we are planning to use the 2023 DOE US Clean Hydrogen Strategy and Roadmap for long term, and data from the PNW Hydrogen Hub for near term
- For electrolyzer efficiencies we are looking at DOE targets for 1$ per kilo efficiency (a current US DOE goal)
- Using analyst judgment on how much hydrogen is produced in-region with electricity

We are bringing these assumptions to the Fuels Advisory Committee in late January for additional review

DRAFT & subject to change

# DOE clean hydrogen cases

- The DOE report focuses on national hydrogen demand – we scaled that down to regional demand using industrial and transportation energy usage ratios
  - Weighting this by energy usage in those sectors, the NW gets a 3.5% share (*this may change*).
  - For 2030, this results in 0.2 to 0.4 MMT of hydrogen consumed in the Northwest
  - For 2040, this results in 0.5 to 1.0 MMT of hydrogen consumed in the Northwest
  - **For 2050, this results in 1.0 to 1.8 MMT of hydrogen consumed in the Northwest**

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https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf?sfvrsn=c425b44f_5





# PNW Hydrogen Hub

- Eight potential project nodes, up to $1 billion in Federal funding
- Node 1's original developer, Fortescue, paused their involvement in 2024, citing energy costs [a]
- Node 4, Atlas Agro, is planning to make its final investment decision in early 2025 (~300 MW) [b]
- Mitsubishi is partnering with PGE and Williams for Node 6 (with plans to include power generation) [c]
- **Total hub production estimated at 300-400 tons/day** [d] ~(0.1-0.15 MMT/year with steady production)


map: https://pnwh2.com/projects/

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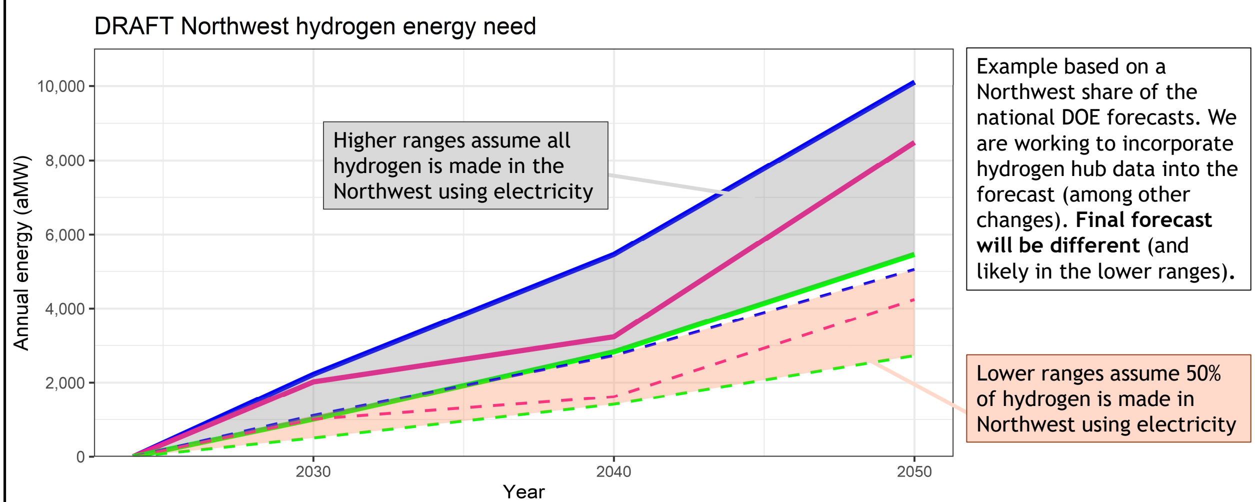
a: https://www.opb.org/article/2024/08/15/high-energy-costs-pacific-northwest-hydrogen-hub/
b: https://www.atlasagro.ag/atlas-agro-and-international-raw-materials-ltd-irm-announce-strategic-offtake-and-marketing-agreement/
c: Energy News Data, "Clearing Up", No. 2190, Dec 2024
d: https://www.energy.gov/nepa/doeeis-0571-pacific-northwest-hydrogen-hub

DRAFT examples & subject to change

# DRAFT hydrogen energy need examples

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Ranges based on DOE national level projections and a 50 kwh/kilo electrolyzer efficiency
https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf?sfvrsn=c425b44f_5
https://pnwh2.com/projects





# Work still to come

- We are still vetting and improving our assumptions with the Fuels Advisory Committee
  - Next meeting is January 27, will be discussing hydrogen
- Aiming to have a final value in late Q1 / early Q2 this year
- There is a lot of potential with hydrogen, but also many unknows about how large or small a role it will play in the future Northwest energy landscape

# Hydrogen for power generation

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## Two New Hydrogen Resource Options

- Hydrogen Only New Resource
  - Emerging technology proxy reference plant
    - One of three emerging tech options that fill different grid needs
    - An all hydrogen burning resource would fulfill the niche of a clean, mid duration storage, peaker-style plant
    - Not available at the start of the action plan period, but at a realistic future date
- Natural Gas Plant Upgrade
  - An additional natural gas reference plant that will be converted to hydrogen at a set date (likely in line with clean policies that would make a gas plant otherwise inoperable beyond that date)
    - The conversion would include all emissions & cost implications at that upgrade year

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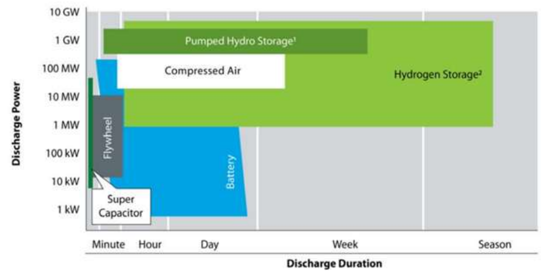
# Resource Considerations




- There *is* a hydrogen hub in the PNW with 8 potential project nodes which will likely drive development
  - And hydrogen is showing up in regional IRPs
- However, there is no existing $H_2$ infrastructure and most forecasts don't show significant $H_2$ for power until the 2040s
  - Therefore hydrogen would have to be produced and stored on site
- After a literature review, the following costs were presented to the GRAC for approval
  - Component parts:
    - Electrolyzer (PEM)—$1500
    - Storage 24hr (Tank/Pipe)—$800
    - Turbine (SCCT)—$1000
    - Other infrastructure (Compressor/Rectifier)—$200

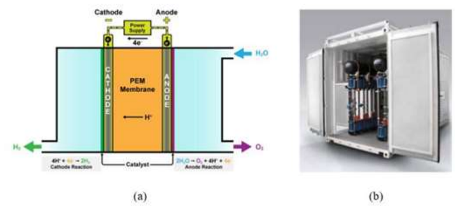



Figure 3. PEM Electrolyzers – a) schematic [12] and b) Proton on-site electrolyzer

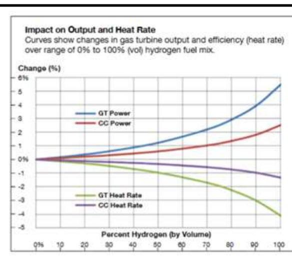


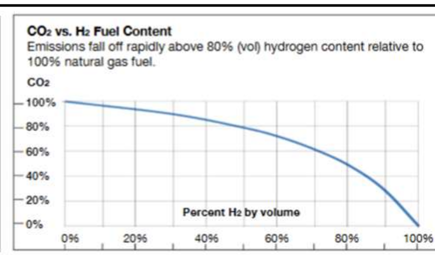
DOE Energy Storage Handbook Chapter 11: Hydrogen





# Hydrogen Conversion




- Why include this resource?:
  - Many regional IRPs are assuming some conversion capability to utilize their existing gas fleet & still hit clean goals
  - Therefore, it's worth testing: are the costs and the emissions and the resource characteristics filling a gap in the region's system need
- Is it possible?:
  - Gas plants are theoretically able to burn 100% hydrogen with some modifications with similar efficiency/heat rates
  - Gas pipes are incompatible with transporting hydrogen gas which creates infrastructural barriers (couldn't accomplish a direct gas → hydrogen transition)

- What's the proposal?:
  - Additional simple cycle gas turbine reference plant that after a certain year will convert to burning hydrogen
  - At that point, the additional costs of having onsite hydrogen production and storage will be incorporated, as well as the change in plant emissions
  - This remains a proposal and will need to be tested in the models as well with the GRAC, but we are interested in your initial feedback



Gas Turbine World 2024 Handbook

## Questions and feedback

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## Additional Slide

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## *Reminder:* Emerging Tech Methodology for the 9th Plan

**1. Multiple Proxies**

- Build multiple proxy ref. plants that each fill a system need
  - Baseload
  - Clean Peaker
  - Long Duration Storage

**+ Pros**

- Speaks to a system need we believe technology will fill
- More representative

**- Cons**

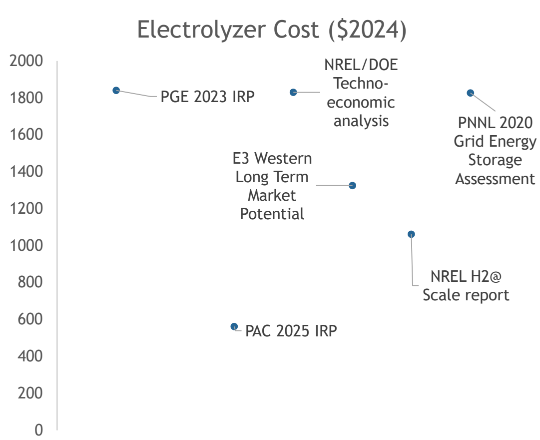
- We cannot know the future, the need might not get filled, or it might get filled a different way

- The intention of the proxy approach is to avoid picking favorite resources or being overly prescriptive of a future technology that we just don't know
- By identifying these emerging technology resources as proxies, that are representative of a set of characteristics rather than a particular technology the hope is we have more space to test within those characteristics
  - Even if these technologies or these exact characteristics don't come to bear, these proxies will still tell us something about regional needs
- Available far enough out that we will have time to revisit any assumptions by the next Plan





## Hydrogen Cost Details




IRA tax credit 45V—As yet unfinalized, and difficult to achieve

| Pillar | Three pillars |
|---|---|
| Additionality | Incremental electrolyzer loads must be met with an equivalent amount of incremental annual renewable energy. |
| Hourly Matching | Resources must be supplied with a resource portfolio of wind/solar/batteries time-matched to electrolyzer production. Electrolyzers are allowed to sell excess energy from the dedicated resource portfolio back to the grid. |
| Deliverability | Renewables must be deliverable within the zone the electrolyzer is located in. |

| Reference Plant | SCCT-Frame | Clean Medium Duration Storage/Peaker |
|---|---|---|
| Configuration | | SCCT w/ onsite hydrogen production (via PEM) and storage (tank/pipe)-24hr |
| Technology Vintage | 2024 | 2024 |
| Development Period (Years) | 2 | 1 |
| Construction Period (Years) | 1 | 1 |
| Capacity (MW) | 250 | 250 |
| Heat Rate (Btu/kWh) | 9500 | 9500 |
| Round trip Efficiency | n/a | 40% |
| Overnight Capital Cost ($/kW) | 1000 | 3500 |
| Fixed O&M Cost ($/kW-yr) | 16.00 | 16.00 |
| Variable O&M ($/MWh) | 3.50 | 3.50 |
| Economic Life (years) | 30 | 30 |
| Financial Sponsor | IOU | IOU |