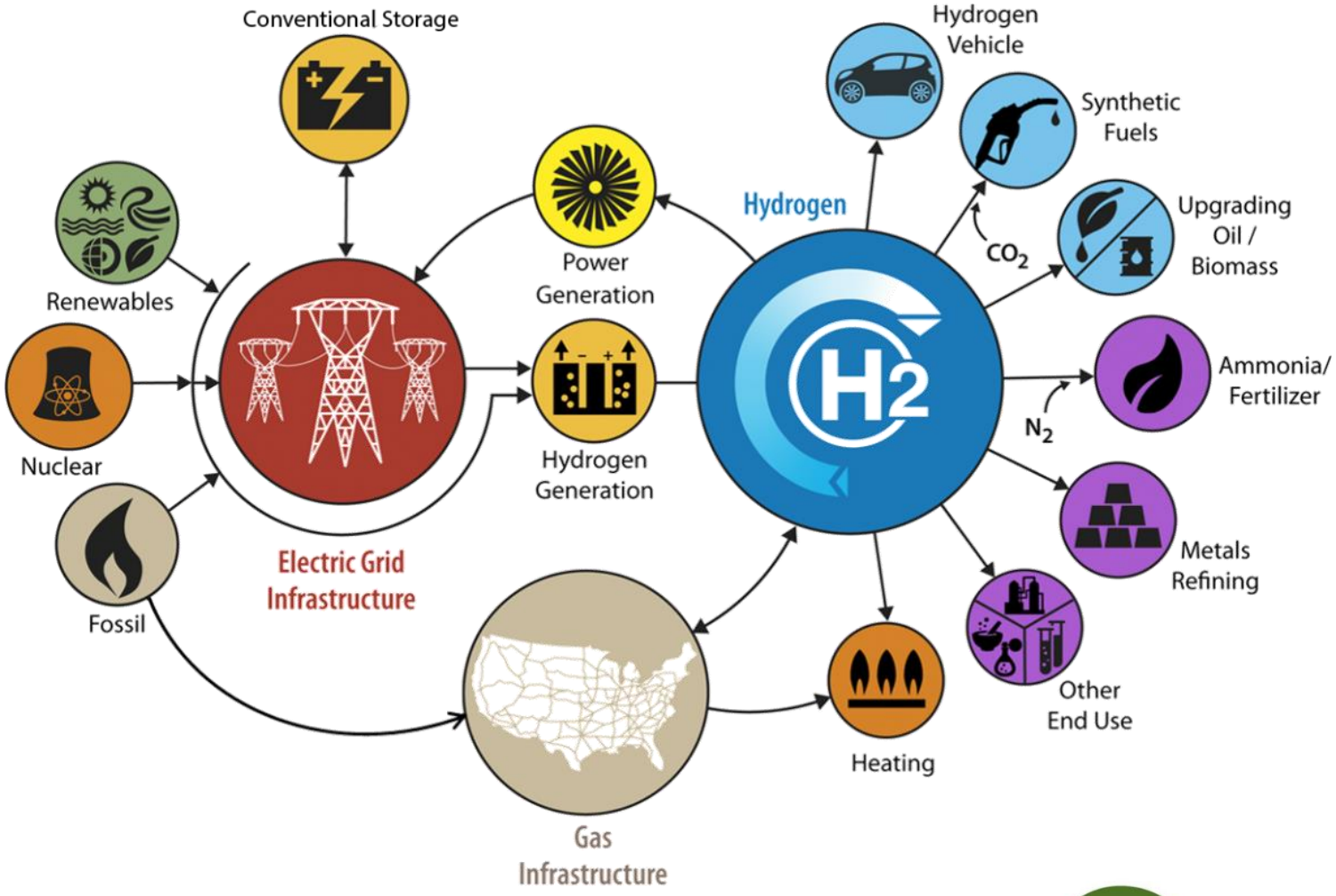
Oregon Department of **ENERGY**

ODOE RH2 Study
Stakeholder Workshop #2

Rebecca Smith
July 6, 2022



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WORKSHOP AGENDA

- Welcome & Logistics
- Presentation on Initial Findings of Renewable Hydrogen Study

  ~ 10:30 a.m. Break (10 min)
- Discussion / Q&A on Initial Findings
- Next Steps

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OREGON DEPARTMENT OF ENERGY

Leading Oregon to a safe, equitable, clean, and sustainable energy future.

Our Mission

The Oregon Department of Energy helps Oregonians make informed decisions and maintain a resilient and affordable energy system. We advance solutions to shape an equitable clean energy transition, protect the environment and public health, and responsibly balance energy needs and impacts for current and future generations.

What We Do

On behalf of Oregonians across the state, the Oregon Department of Energy achieves its mission by providing:

- A Central Repository of Energy Data, Information, and Analysis
- A Venue for Problem-Solving Oregon's Energy Challenges
- Energy Education and Technical Assistance
- Regulation and Oversight
- Energy Programs and Activities

HOW THIS MEETING WILL BE FACILITATED

Panelists and Attendees

- **Panelists** – ODOE Staff sharing initial findings, facilitating Q&A ,and moderating the discussion.
- **Attendees** – Time is reserved for attendee feedback & discussion after the presentation on initial findings. During the presentation, attendees may ask clarifying questions.

Community Agreements:

- Be present and ready to learn.
- Be respectful to others.
- Learning happens outside of our comfort zones.
- Listen to learn first, and to supply information or perspectives second.
- Thank you for being flexible and patient around any technology needs or changes.
- If you need something at this meeting, please ask for it!
- Technical issues or questions: Contact **"Host"** in the chat or send an email to Linda.Ross@Energy.Oregon.Gov

OPTIONS TO ASK QUESTIONS AND PROVIDE FEEDBACK

Objective of Today's Workshop: Share initial findings with the public, provide opportunity for the public to ask clarifying questions, and provide an opportunity for discussion with ODOE, the Technical Advisory Committee, and among stakeholders and the public.

During Today's Workshop

- During the presentation, please use the chat to ask any clarifying questions. We will continually pause to see if there are any questions or to address those that have been entered into the chat.
- We have set aside the second half of the workshop for discussion. You may enter questions or comments for discussion in the chat during the presentation, but we will wait to address them until the discussion period. During the discussion, you can indicate a question in the chat or use the "raise hand" function. When the moderator calls on you, please unmute yourself to speak.

After the Workshop

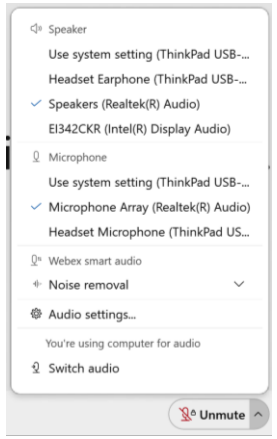
- Please submit additional written feedback after today's meeting to Rebecca Smith by July 20, 2022 to Rebecca.Smith@energy.oregon.gov

USING WEBEX

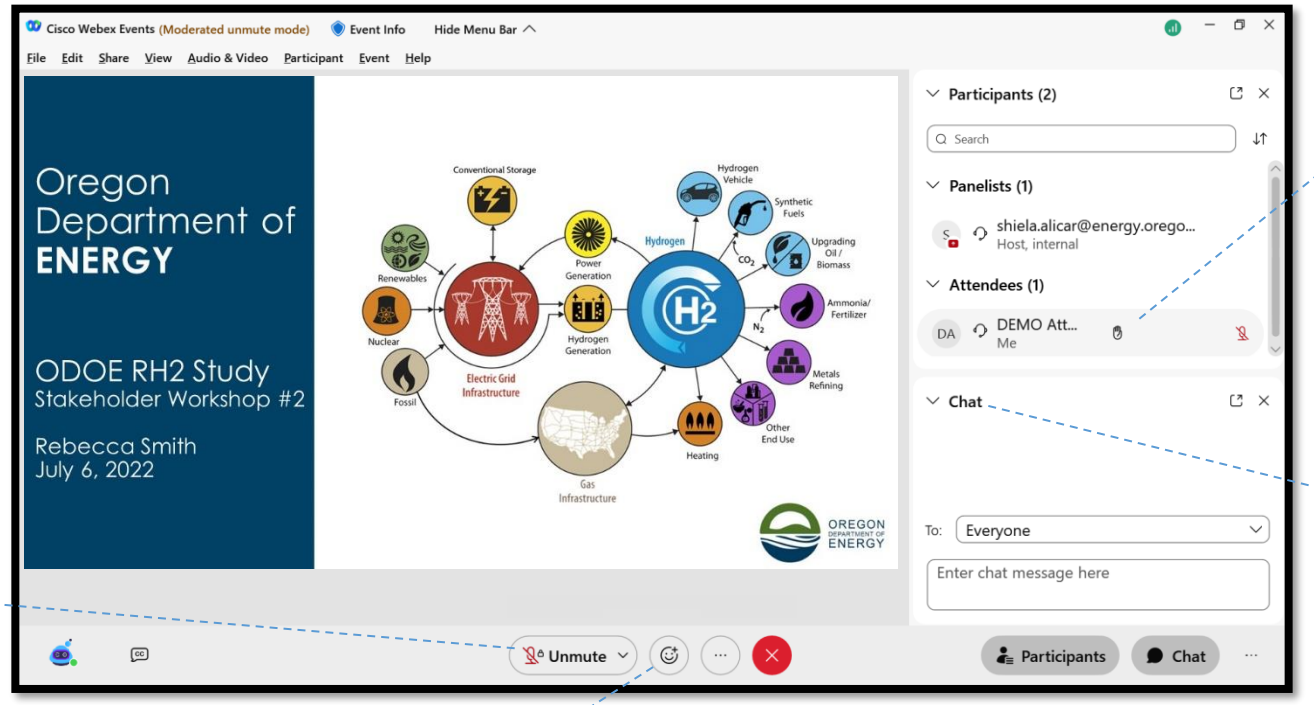
Audio Options

Mute — *Microphone On*

Unmute — *Microphone Off*



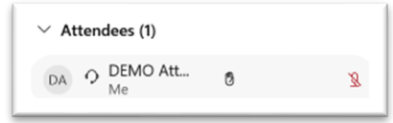
You can check Speaker and Microphone settings by clicking the arrow next to Mute/Unmute.



Second Raise Hand Option

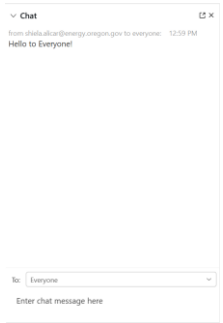
You can also click on the hand next to your name in the Participant list to raise your hand.

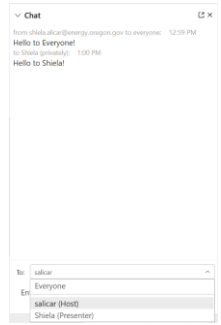
Click on Lower hand when you are done.



Chat

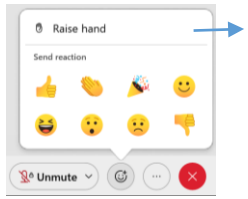
You can chat to Everyone in the meeting.





You can send a private message to the Host or Presenter (or all Panelists when there is a Panel).

Reactions



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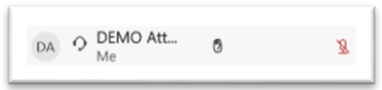

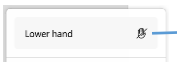

Click on Lower hand when you are done.

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The SB 333 Renewable Hydrogen Study

SB 333

Study Goal: Provide legislators and stakeholders with a better understanding of the benefits of and barriers to production and consumption of RH2 in Oregon, including trade offs.

For the purposes of the study, **“renewable hydrogen”** means hydrogen gas derived from energy sources that do not emit greenhouse gases.

Study meant to provide “high-level analysis” and draw upon “existing data, studies, or other publicly available information.”

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STUDY REQUIREMENTS PER SB 333 (2021)

- High-level analysis of how RH2 may support existing renewable energy and greenhouse gas reduction policies and goals in Oregon.
- Identification of the total H2 volume currently used annually in Oregon.
- Identification of potential applications of RH2 in Oregon by 2030.
- Assessment of potential for coupling renewable electricity generation and RH2 production to increase resiliency or provide flexible loads.
- Discussion of forecasted costs of RH2 and how they might affect adoption of RH2 in Oregon.
- Identification of technological, policy, commercial, and economic barriers to adoption of RH2 in Oregon.

TECHNICAL ADVISORY COMMITTEE (TAC)

Comprised of technical experts from the public and non-profit sectors to provide feedback on data sources, assumptions for analysis and findings.

- Pacific Northwest National Lab
- Oregon Department of Transportation
- Oregon State University
- Portland State University
- NW Power and Conservation Council

Experts on call:

- National Renewable Energy Lab
- JCDREAM

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STUDY TIMELINE

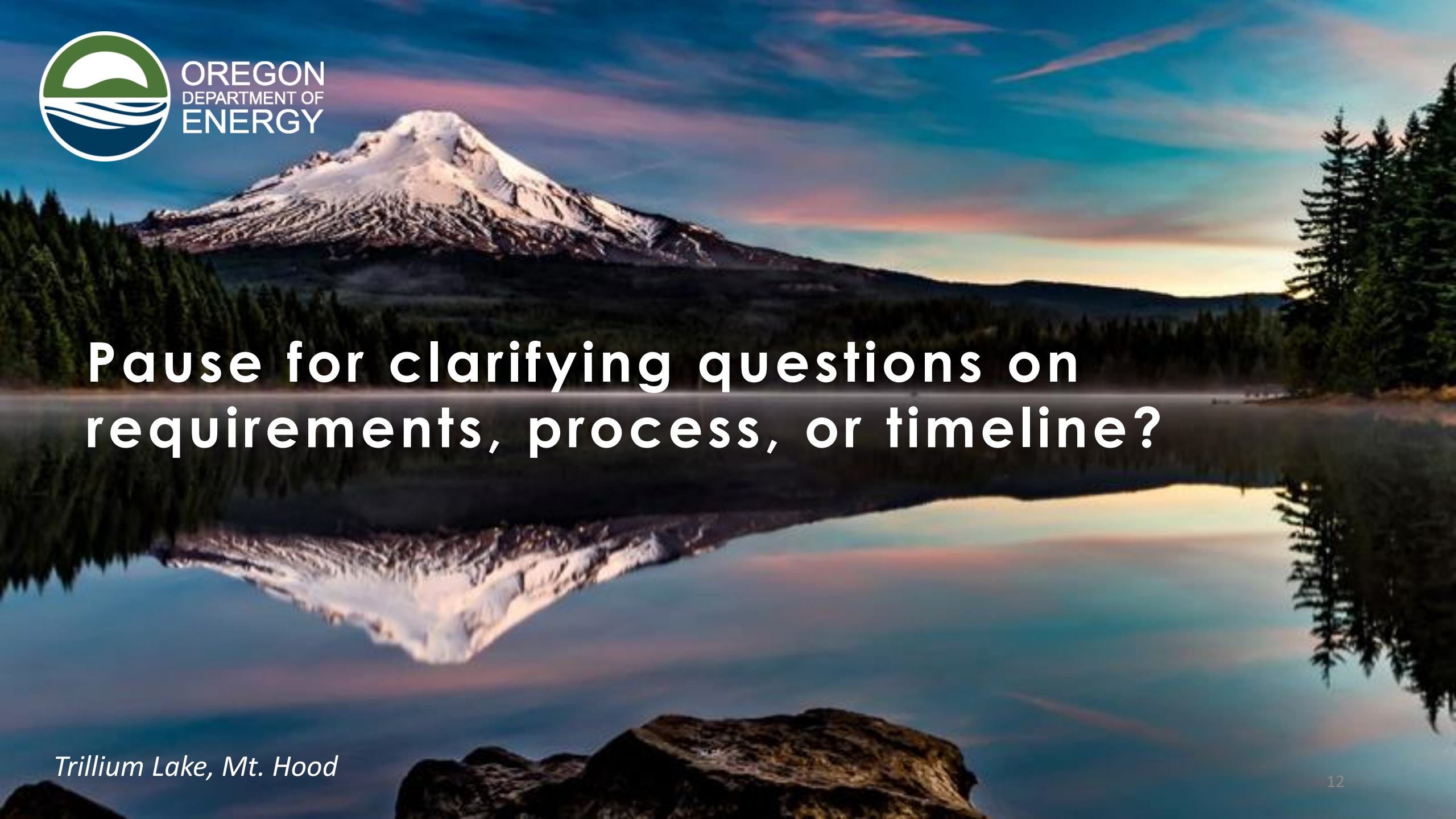
	2021	2022		
TASKS	**Q4**	**Q1**	**Q2**	**Q3**
Research and analysis				
Stakeholder Engagement	Workshop #1 (Nov 16)			Workshop #2 (July 6) Workshop #3 (Aug) TAC mtgs
Report drafting				
Report to Legislature				Sept 15

TAC Meetings

- Individual outreach
- Initial findings
- Final findings

Stakeholder Workshops

- Introduction to study, H2 101, study feedback
- Initial findings
- Final findings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Pause for clarifying questions on requirements, process, or timeline?
Trillium Lake, Mt. Hood

RH2 Study: Initial Findings

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INTERPRETING THE SB 333 DEFINITION OF RENEWABLE HYDROGEN

- Bill defines RH2 as:

> "…hydrogen gas derived from energy sources that do not emit greenhouse gases."

- Interpreting this definition:
  - Does this mean energy sources that *inherently* do not emit GHGs only?
  - Could it include energy sources that emit GHGs but are considered "carbon neutral," like biomass?
  - Could it include energy sources where GHG emissions associated with hydrogen production are captured and stored?
- Legislative intent re: definition? Direction of the industry?

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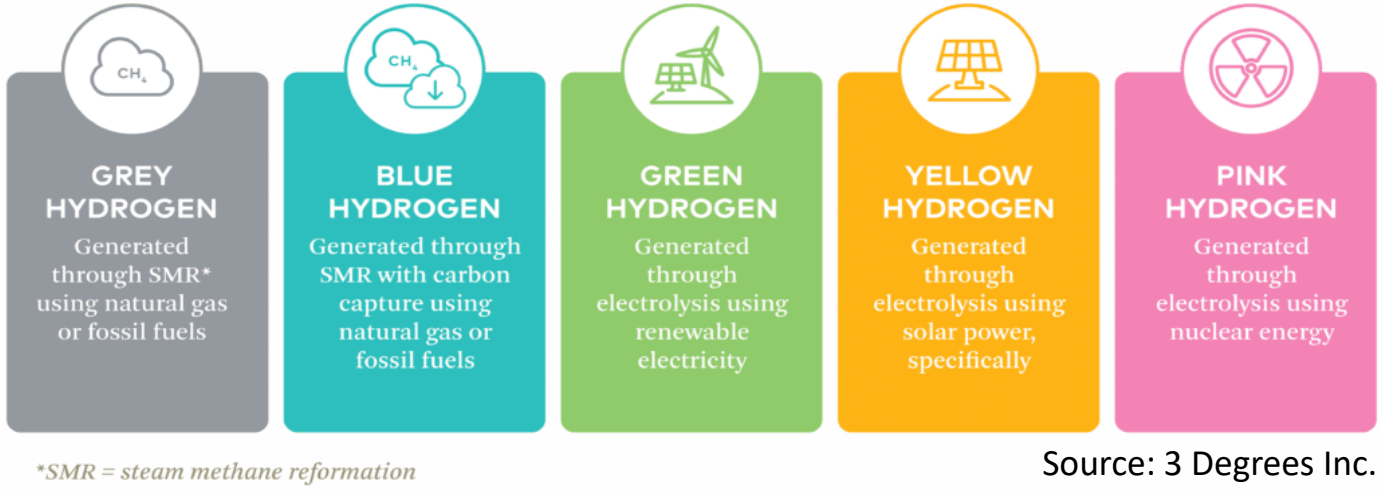
CATEGORIZING HYDROGEN



Source: 3 Degrees Inc.

- Industry moving away from color categorization of hydrogen.
- IIJA defines "**clean** hydrogen" as hydrogen "produced with a carbon intensity equal to or less than 2 kilograms of carbon-dioxide equivalent produced at the site of production per kilogram of hydrogen produced."
- Clean fuel standards use lifecycle emissions, not just those from production.
- Bottom line – industry moving toward measure of "clean" based on CI, not on whether feedstock is considered "renewable."

INTERPRETING THE SB 333 DEFINITION OF RENEWABLE HYDROGEN

Initial Study Findings

- Numerous ways to define hydrogen – renewable, clean, by color, etc. – but industry is moving toward use of carbon intensity measure and study report emphasizes this.
- Spirit of legislation is to focus on “renewable” pathways, so study analysis focuses on feedstocks that are considered renewable for the purpose of the Renewable Portfolio Standard.
- Based on Oregon’s statute that considers biomass to be carbon neutral, hydrogen production pathways that use biomass and have carbon emissions associated with the combustion or decomposition of biomass are considered to meet the definition of renewable hydrogen for the purposes of the study.

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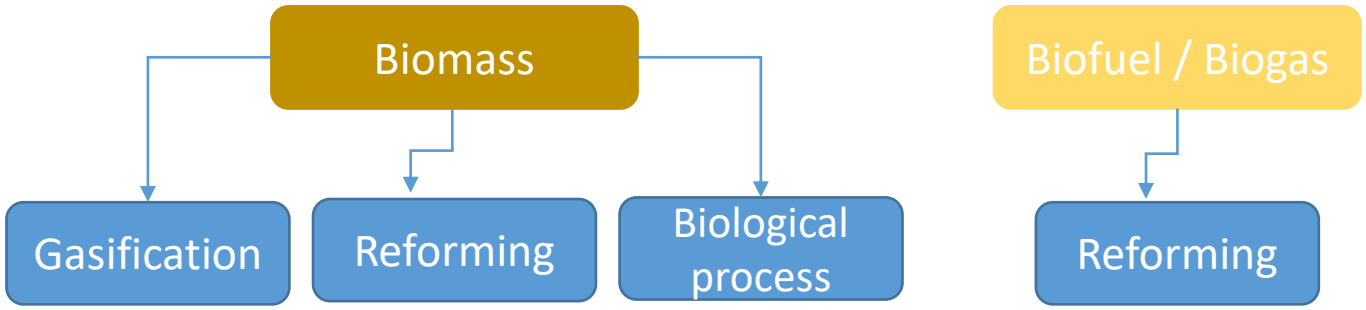
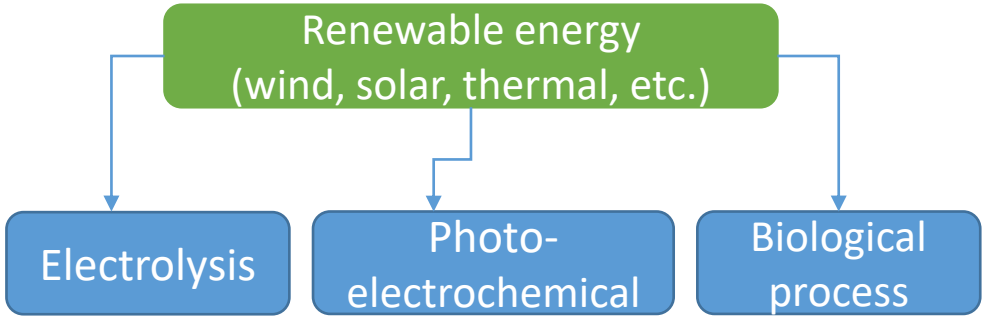
RENEWABLE PATHWAYS FOR RH2





Reforming: Steam reformation uses high-temperature steam with a catalyst to produce hydrogen from a source of methane, such as natural gas, biogas, ethanol, etc. Very established process.

Gasification: Process involving heat, steam, and oxygen to convert biomass to hydrogen and other products. Very established process.

Biological processes: These can include fermentation of biomass to produce RH2 as a byproduct. Emerging process.

Photo-electrochemical: Using sunlight to directly split water into hydrogen and oxygen. Emerging process.

Electrolysis: Renewable electricity is used to split water into hydrogen and oxygen using an electrolyzer. Very established process.

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HOW RH2 MAY SUPPORT EXISTING RENEWABLE ENERGY AND GREENHOUSE GAS REDUCTION POLICIES AND GOALS IN OREGON

- Key policies analyzed:
  - Renewable Portfolio Standard (RPS)
  - 100% Clean Standard
  - Climate Protection Program (CPP)
  - Clean Fuels Program
  - ZEV Adoption Targets and Advanced Clean Trucks Rule
- Consideration of how RH2 can support these policies in the near term (2030) as well as longer-term time horizon (2050)

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HOW RH2 MAY SUPPORT EXISTING POLICIES – RPS AND 100% CLEAN

Renewable Portfolio Standard

- Investor-owned utilities (IOUs) must meet retail electricity load with 50% eligible renewables by 2040. Hydrogen is an eligible resource.
- Compliance cost cap of 4% of utility's annual revenue requirement.

100% Clean Standard

- Requires emissions-free electricity by 2040 from IOUs.
- Compliance exemptions for reliability or excessive rate increases.
- Restricts EFSC from issuing new/amended site certificates for fossil-fueled energy facilities that emit GHGs.

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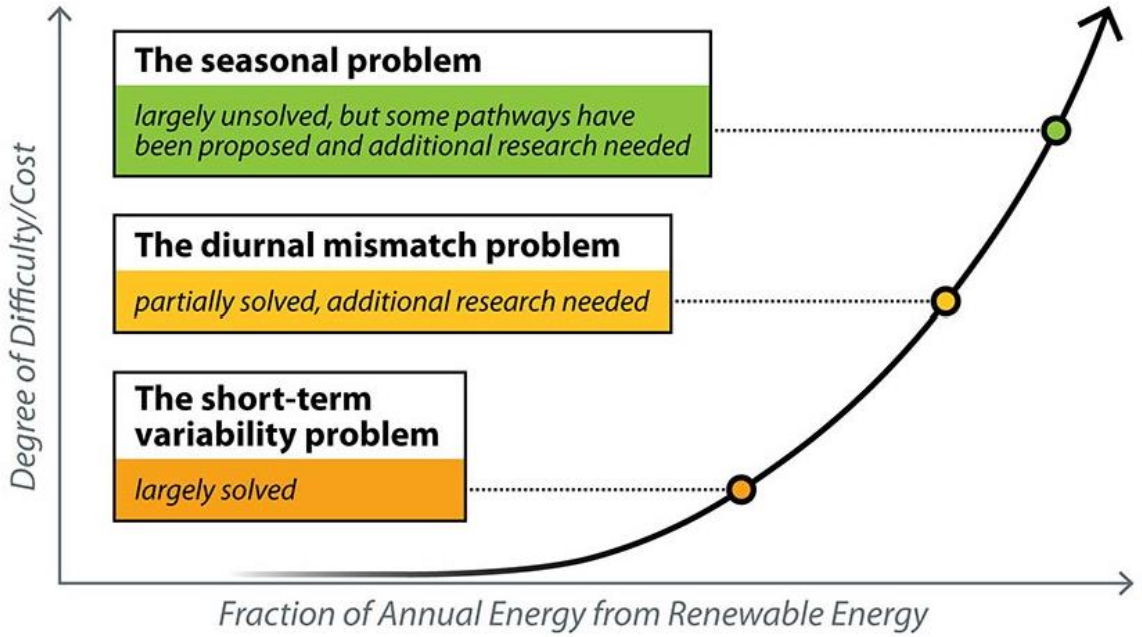
HOW RH2 MAY SUPPORT EXISTING POLICIES – RPS AND 100% CLEAN

- Grid balancing more challenging with high penetration of intermittent renewables.
  - Need flexible zero-carbon resources.
  - Need energy storage.
- Likely overbuild resources to meet resource adequacy requirements, which leads to periods of curtailment.
  - Increased need for variable loads. Pg 52
- With economy-wide decarbonization, expected to see big increases in future load, which increases scale of new resources required.
  - Competition for best project sites and access to transmission, etc.

Grid Balancing Challenge with Increasing Deployment of Renewables



NREL Transforming ENERGY 45th anniversary

Source

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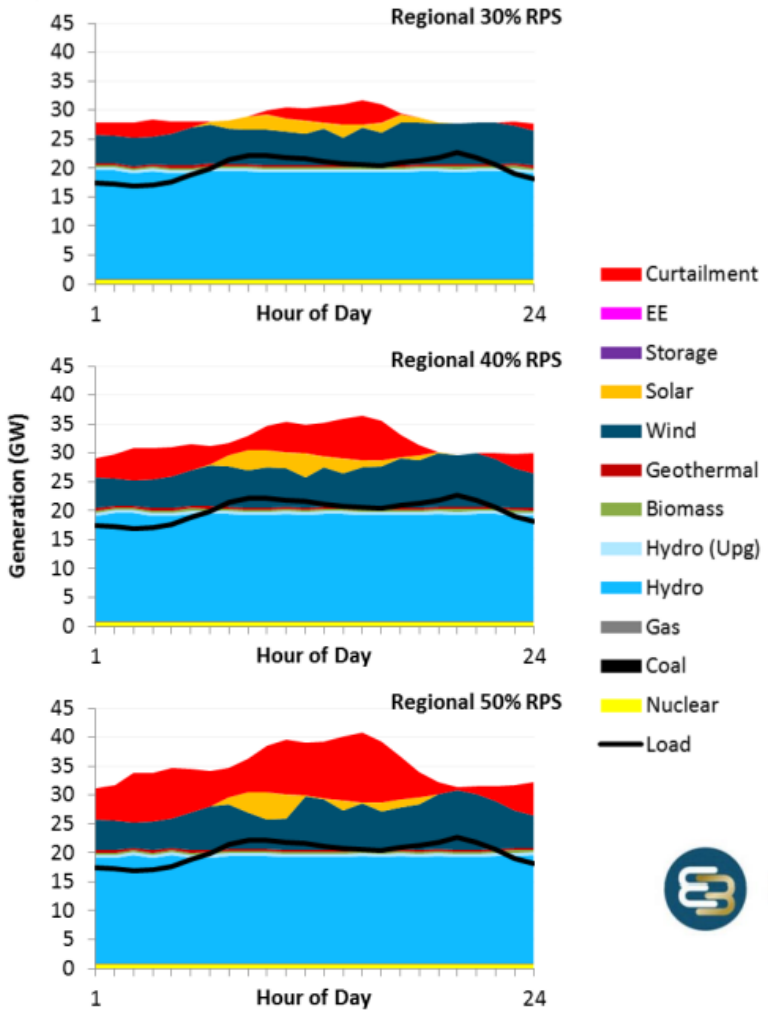
Increasing Renewable Curtailment with Increasing Regional RPS Goals



Energy+Environmental Economics

Source, pg. 83

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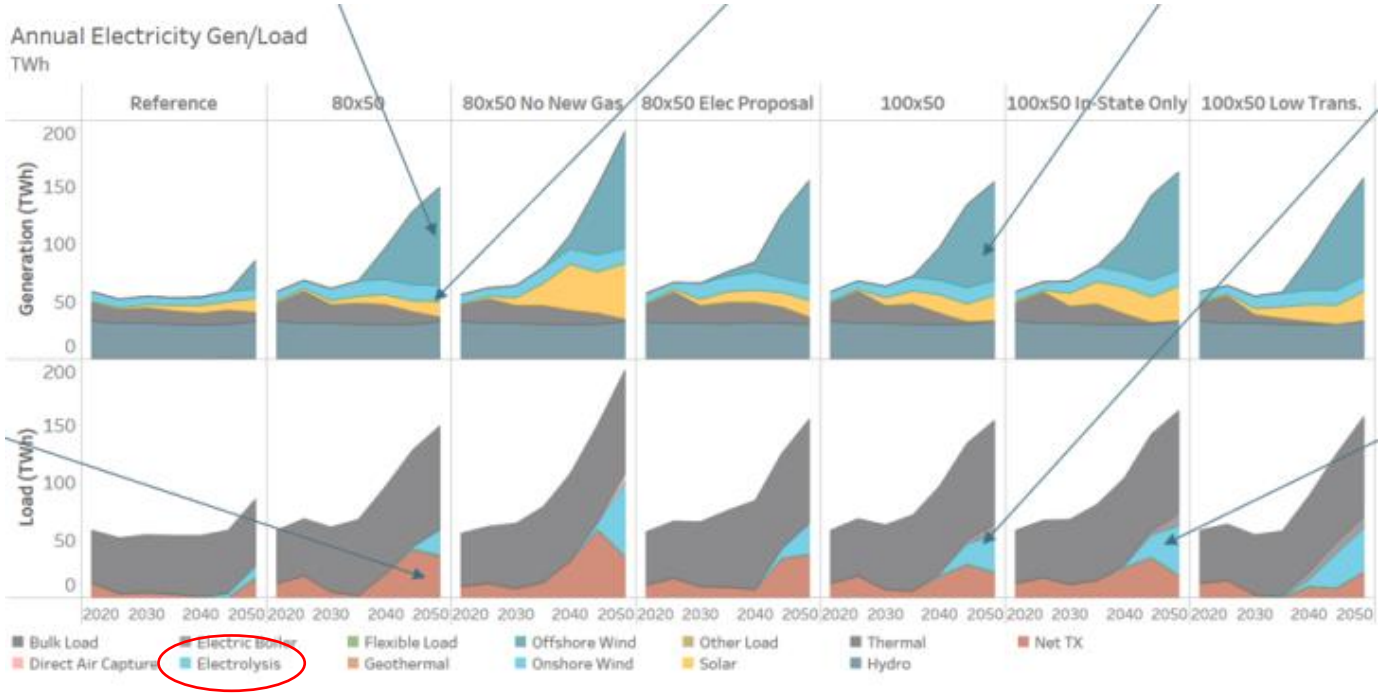
Generation and Load Across Scenarios in Oregon Clean Pathways Study



EVOLVED ENERGY RESEARCH

Source, pg. 38

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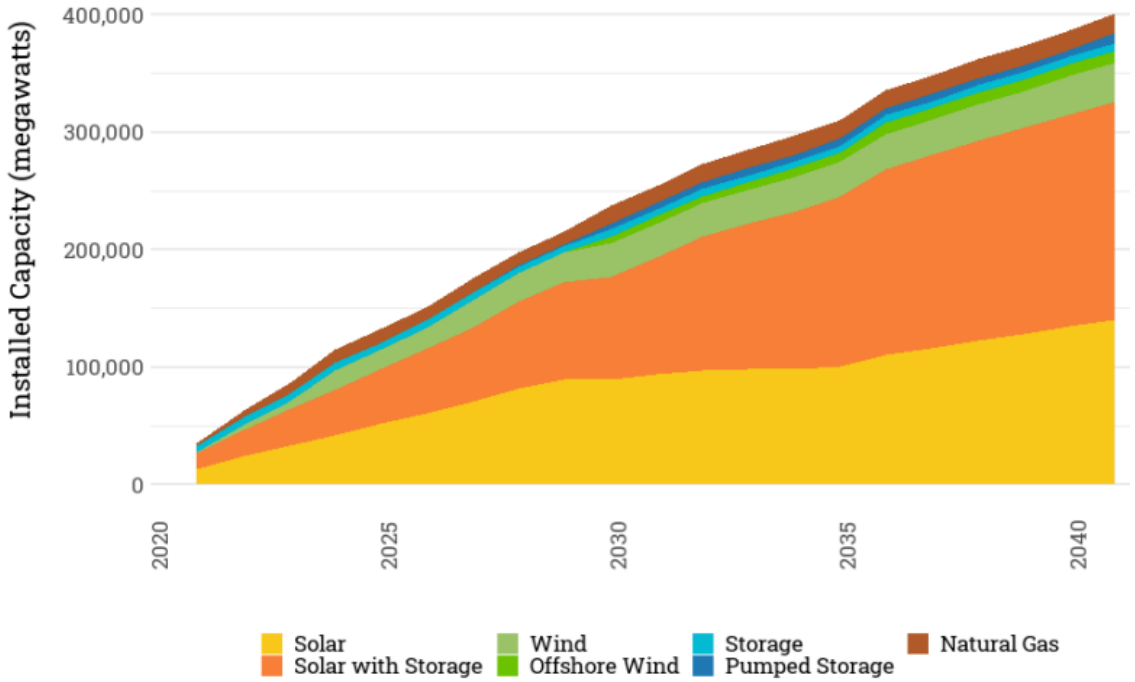
Projected generation additions required across Western states to meet clean energy targets



THE 2021 NORTHWEST POWER PLAN
FOR A SECURE & AFFORDABLE ENERGY FUTURE

Source, pg. 51

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Transmission in Oregon

Energy+Environmental Economics

Source, pg. 29

HOW RH2 MAY SUPPORT EXISTING POLICIES – RPS AND 100% CLEAN

Initial Study Findings

- RH2 from electrolysis likely to be used to help integrate renewables onto the grid, but not expected to be used as a generation resource to meet RPS and 100% Clean in near term.
  - Flexible resource, flexible load, long-duration energy storage.
- Cost of RH2 could be mitigated by use of low-cost renewable power that would otherwise be curtailed.
  - To what degree does lower capacity make up for lower-cost electricity?
- Electrolyzer projects paired with dedicated renewable resources, may help mitigate transmission access issues as Oregon builds more renewables.

PAUSE for clarifying questions

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HOW RH2 MAY SUPPORT EXISTING POLICIES – CPP

Climate Protection Program

- Declining cap on GHGs from fossil fuels, including diesel, natural gas, and propane, used in transportation, residential, commercial, and industrial settings.
- Site-specific GHG targets for manufacturing facilities.

Initial Study Findings

- Deployment of RNG or RH2 likely for natural gas utility compliance.
- RH2 may be compliance approach for covered stationary sources like semiconductor manufacturers (at least four), cement producers (one), steel mill (one), and others.
- RH2 expected to play role in transportation sector (see Clean Fuels Program)

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HOW RH2 MAY SUPPORT EXISTING POLICIES – TRANSPORTATION

Clean Fuels Program

- Requires reductions in avg amount of GHG emissions per unit of fuel energy by 25% below 2015 levels by 2035.
- Hydrogen first used in program in 2021, for forklifts.
- IFC estimated 0.19 million dge of H2 in program by 2025.

ZEV Adoption Targets, Advanced Clean Trucks (ACT) Rule

- ACT requires MD and HD vehicle manufacturers to sell certain % of ZEVs. ZEV definition includes FCEVs.
- ZEV adoption targets for motor vehicles sold in state, but primarily focused on light-duty passenger vehicles.

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HOW RH2 MAY SUPPORT EXISTING POLICIES – TRANSPORTATION

Estimated Future Consumption of Transportation Fuels in Oregon

Fuel Volumes	Units	2022	2023	2024	2025
Gasoline	million gallons	1,374	1,353	1,336	1,306
Diesel	million gallons	756	724	662	614
Ethanol	million gallons	177	193	210	225
Biodiesel	million gallons	88	89	90	92
Renewable Diesel	million gallons	38	78	146	210
Electricity	million gge	9.30	11.75	14.90	18.98
Electricity, On-Road	million gge	7.12	9.81	13.38	18.16
Electricity, Off-Road	million gge	4.63	5.09	5.60	6.16
Natural Gas					
CNG	million dge	0.43	0.24	0.13	0.15
Bio-CNG	million dge	3.83	4.52	5.18	5.79
LNG	million dge				
Bio-LNG	million dge	0.34	0.34	0.34	0.34
Propane					
LPG	million dge	1.01	0.99	0.95	0.90
Renewable Propane	million dge	1.24	1.49	1.77	2.10
Hydrogen	million dge	0.11	0.13	0.16	0.19

State of Oregon DEQ Department of Environmental Quality

Source, pg. 31

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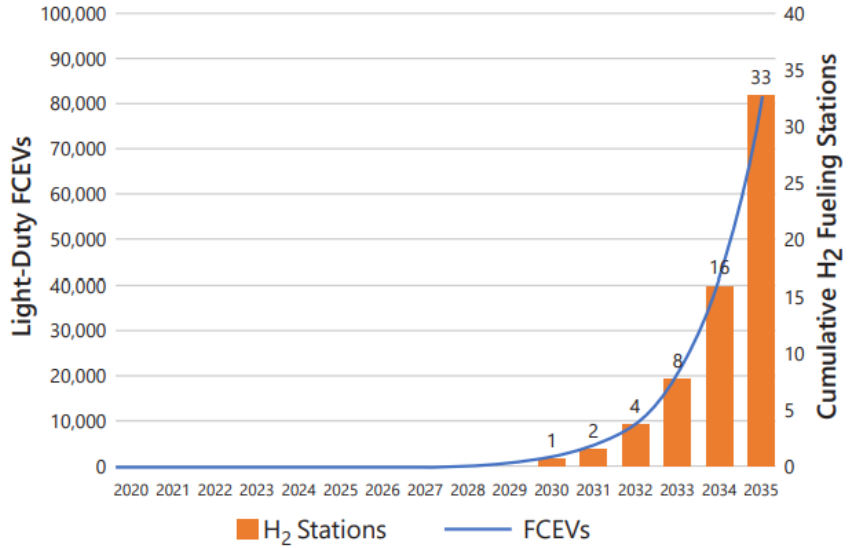
HOW RH2 MAY SUPPORT EXISTING POLICIES – TRANSPORTATION

2035 FCEV Target Assumptions by Use Case

Use Case	Target Assumptions
Light-Duty Vehicles	5% of urban light-duty ZEVs are FCEVs
Transit Buses	10% of TEINA e-buses are FCEVs
Medium-Duty Vehicles	10% of medium-duty TEINA e-VMT are FCEVs
Heavy-Duty Vehicles	25% of heavy-duty TEINA e-VMT are FCEVs

Light-Duty FCEVs and H2 Fueling Stations in OR 2020-2035



Estimated Number of H2 Fueling Stations Required

Use Case	Assumed Capital Cost/ Station	2025 # Stations	2025 Total Capital Cost	2030 # Stations	2030 Total Capital Cost	2035 # Stations	2035 Total Capital Cost	Assumed Capacity
Light-Duty Vehicles: Urban	$1.9M	0	0	1	$2M	33	$63M	1,500kg
Light-Duty Vehicles: Corridor	$1.9M	6	$11M	7	$13M	14	$27M	1,500kg
Total Light-Duty Vehicles		*6*	*$11M*	*8*	*$15M*	*47*	*$90M*	
Medium-Duty Vehicles	$7.5M	0	0	1	$7.5M	8	$60M	5,000kg
Heavy-Duty Vehicles	$7.5M	0	0	1	$7.5M	6	$45M	5,000kg
Transit Buses	$7.5M	0	0	1	$7.5M	5	$37.5M	5,000kg
Total Medium-and Heavy-Duty Vehicles		*0*	*0*	*3*	*$22.5M*	*19*	*$142.5M*	
Capital Costs Total			**$11M**		**$37.5M**		**$232.5M**	

Oregon Department of Transportation

All figures from ODOT's Hydrogen Pathway Study

HOW RH2 MAY SUPPORT EXISTING POLICIES – TRANSPORTATION

Initial Study Findings

- Uptake of RH2 in transportation in Oregon highly dependent on local RH2 supply and development of H2 fueling infrastructure.
- Uptake of H2 fuel cell EVs not expected to gain momentum until after 2030.
- Having MD and HD ZEVs to buy can help drive adoption – but not clear how many will be FCEVs, how competitive prices will be, and timing of H2 fueling available in state.
- Secondary analysis would be needed to estimate how many of expected MD and HD FCEVs adopted in state would then be fueled with RH2 and opposed to H2.

PAUSE for clarifying questions

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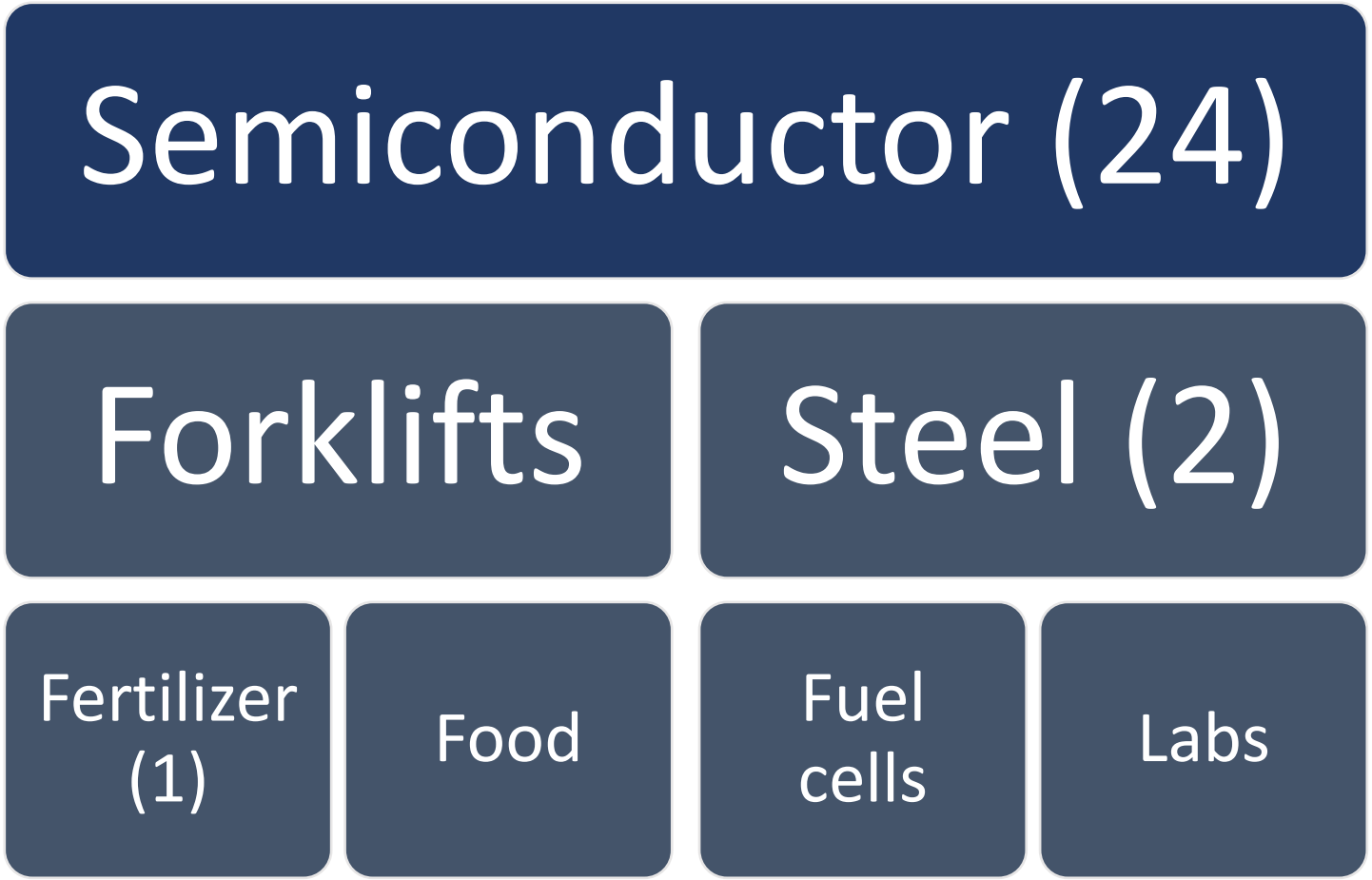
IDENTIFICATION OF THE TOTAL H2 VOLUME CURRENTLY USED ANNUALLY IN OREGON



- Numbers in parentheses are number of firms in Oregon
- Ongoing outreach attempts for data gathering
- Slow success in attaining data
- Possible methods for estimating H2 use
- Possible data from H2 providers

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ID POTENTIAL APPLICATIONS OF RH2 IN OREGON BY 2030

Sensitivities

- Timing and scale of production of RH2 in region
- Enabling policies – PTC for RH2, state support, siting, etc.
- Cost of RH2
- Available FCEV models
- Available fueling infrastructure

Potential Applications

- Substitution of H2 with RH2 where already in use
- Industry w/ high heat demands
- Transportation – MD, HD, offroad equipment
- Back-up power replacement for diesel generators
- Long-duration energy storage
- NG pipeline blending
- Electricity generation
- Short-duration energy storage

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- **Assessment of potential for coupling renewable electricity generation and RH2 production to increase resiliency or provide flexible loads.**
- Discussion of forecasted costs of RH2 and how they might affect adoption of RH2 in Oregon.
- Identification of technological, policy, commercial, and economic barriers to adoption of RH2 in Oregon.

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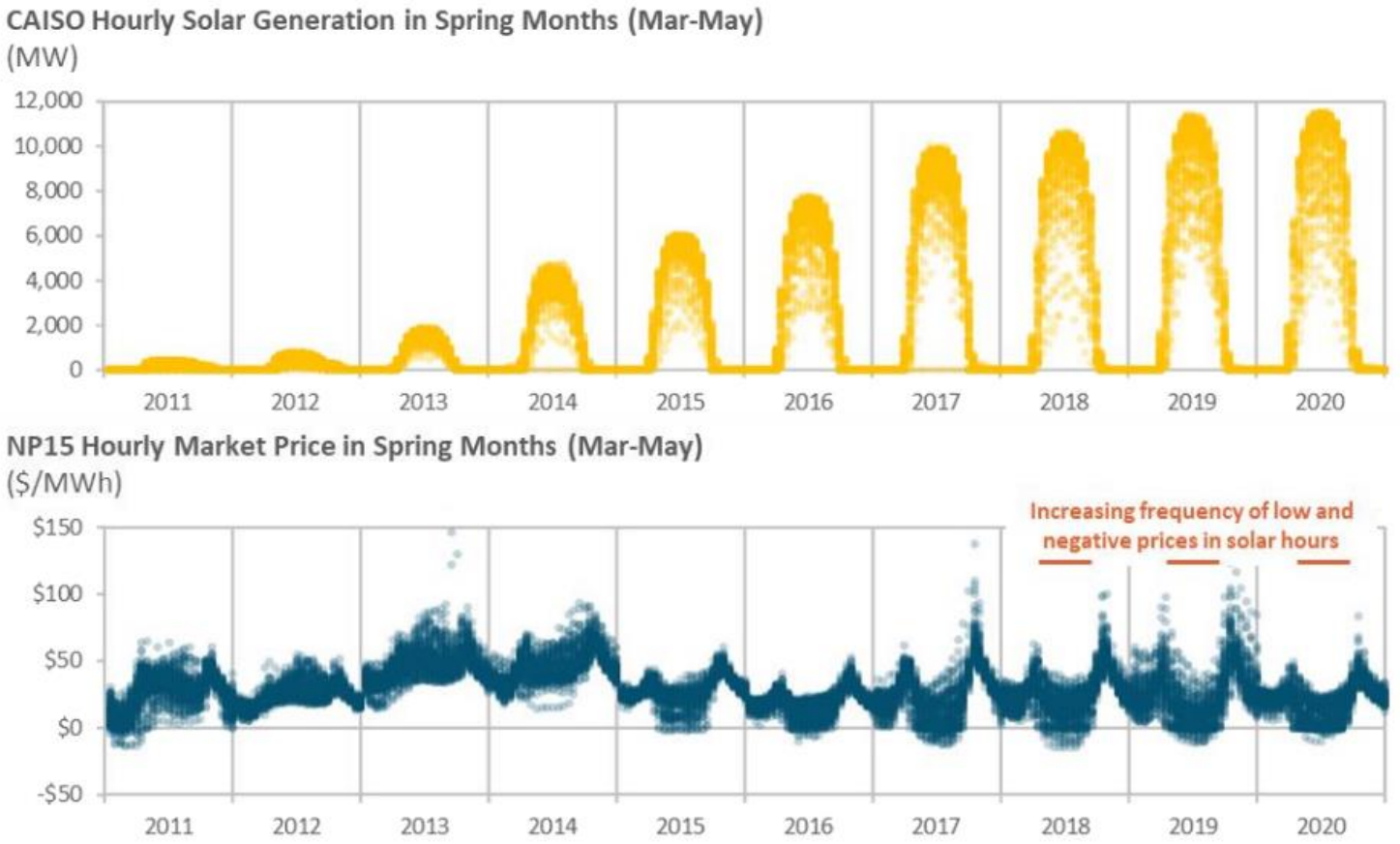
ASSESSMENT OF POTENTIAL FOR COUPLING RENEWABLE ELECTRICITY GENERATION AND RH2 PRODUCTION TO INCREASE RESILIENCY OR PROVIDE FLEXIBLE LOADS

One outcome of overbuilding is that each new megawatt of variable renewable energy becomes less useful and less valuable than the one before it.

This is because an excess of variable renewable electricity at times of peak generation can lead to near-zero wholesale electricity prices given the near-zero operational costs of these generating units.

Figure 2-5. Evolving dynamics in CAISO day-ahead market due to increasing saturation of solar.



Energy+Environmental Economics

Source, pg. 25

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ASSESSMENT OF POTENTIAL FOR COUPLING RENEWABLE ELECTRICITY GENERATION AND RH2 PRODUCTION TO INCREASE RESILIENCY OR PROVIDE FLEXIBLE LOADS

- More variable renewables requires overbuilding and surplus electricity, curtailment
- More surplus increases occurrences of and likelihood for very low or negative electricity prices in many hours
- More variable renewables increases resource adequacy concerns and needs for dispatchable capacity and flexible loads

Initial Study Findings

- RH2 production and use could address all of the issues listed above:
  - Benefit capacity needs by offering ability to deploy resources more efficiently
  - Provide variable loads that can be quickly ramped up or down
  - Provide a sink for RE that would otherwise be curtailed
  - Can be sited to leverage existing infrastructure and avoid grid constraints

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STUDY REQUIREMENTS PER SB 333 (2021)

- High-level analysis of how RH2 may support existing renewable energy and greenhouse gas reduction policies and goals in Oregon.
- Identification of the total H2 volume currently used annually in Oregon.
- Identification of potential applications of RH2 in Oregon by 2030.
- Assessment of potential for coupling renewable electricity generation and RH2 production to increase resiliency or provide flexible loads.
- Discussion of forecasted costs of RH2 and how they might affect adoption of RH2 in Oregon.
- Identification of technological, policy, commercial, and economic barriers to adoption of RH2 in Oregon.

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DISCUSSION OF FORECASTED COSTS OF RH2 AND HOW THEY MIGHT AFFECT ADOPTION OF RH2 IN OREGON

- Forecasted costs are a moving target due to a number of confounding factors:
  - Policy – federal H2 PTC, state policies, utility tariffs, etc.
  - Continuous technological breakthroughs
  - Economies of scale as global adoption ramps up
  - Perturbations in market for substitutes – i.e., Ukraine and natural gas
  - Local supply

Initial Study Findings

- At what cost is RH2 an affordable compliance pathway for Oregon entities under CPP?
- Expected upfront cost and TCO difference between MD and HD FCEVs and BEVs?
- Interplay between infrastructure costs and costs of RH2 itself?
- Likelihood that low-CI H2 production from SMR with CCS becomes dominant?

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IDENTIFICATION OF TECHNOLOGICAL, POLICY, COMMERCIAL, AND ECONOMIC BARRIERS TO ADOPTION OF RH2 IN OREGON

Initial Study Findings

- Regulatory barriers – definitions, certification/tracking, pipeline injection, etc.
- Scale of renewable electricity needed for RH2 production versus RE needed for increasing loads from other decarbonization pathways
- Relatively high wholesale electricity prices compared to other Western states
- Difficulty of siting new RE facilities in Oregon, transmission congestion, etc.
- Access to debt for financing projects, infrastructure
- Current low demand for RH2
- Lack of existing infrastructure for storage, transport, fueling
- Relative lack of FCEV options for vehicles compared to BEVs, established market for BEVs and existing fueling infrastructure
- Education gaps re RH2 for policymakers, stakeholders

QUESTIONS FOR DISCUSSION

- Any concerns with how ODOE includes/excludes various pathways within legislation's definition of RH2?
- For the Oregon H2 inventory, any potential H2 consumers we missed? Any concerns with ODOE estimating this data, if necessary and possible?
- Any information or data on forthcoming technological updates or breakthroughs?
- Are there any areas of the study where your work can provide data or insights?
- If you had to choose three top barriers for production and consumption of RH2 in Oregon, what would they be?

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Questions and comments about the study?
Trillium Lake, Mt. Hood