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Update: Renewable Hydrogen Study

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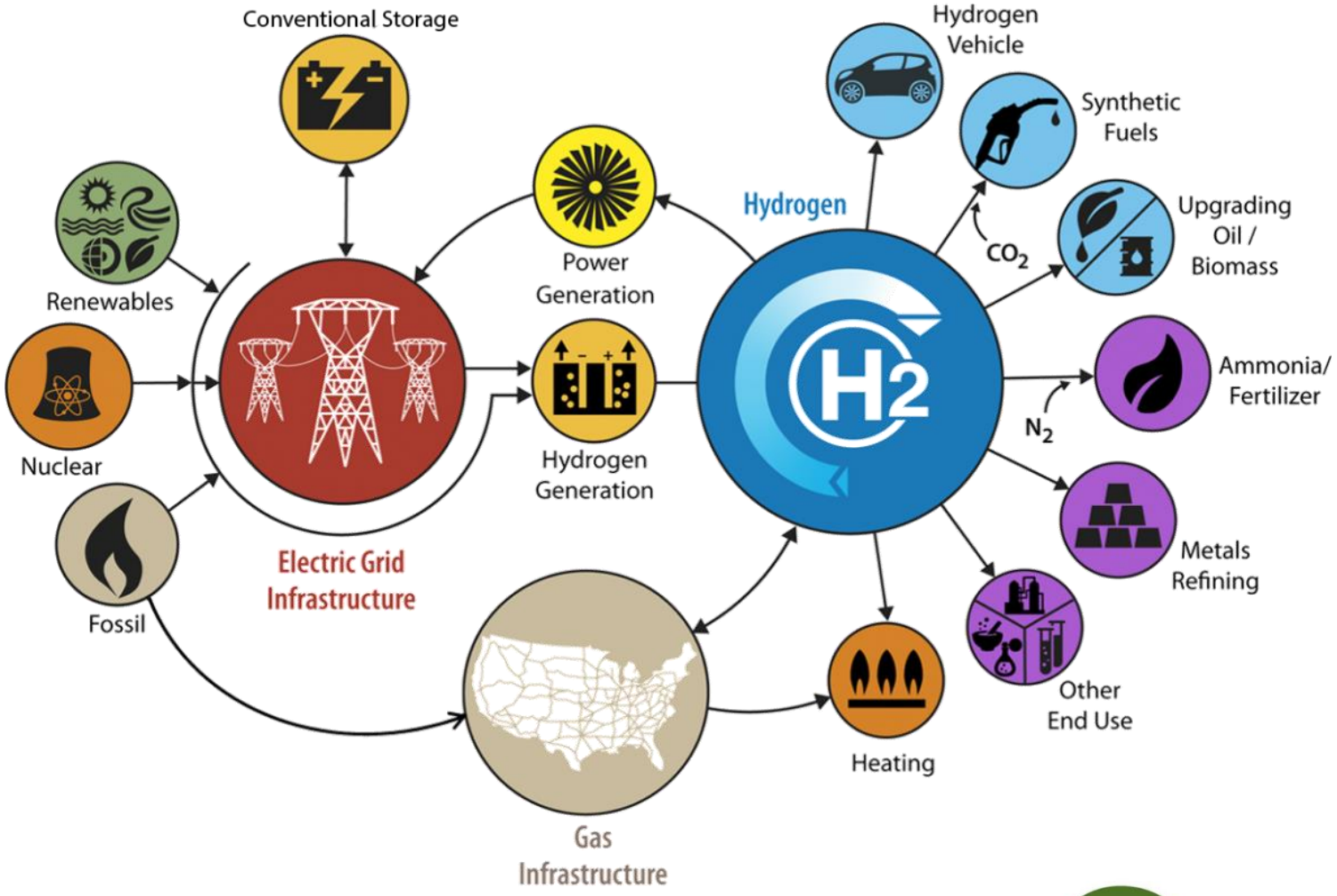
Senate Interim Committee on Energy and Environment

September 22, 2022



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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)

- 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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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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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 only energy sources that *inherently* do not emit GHGs?
  - 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?

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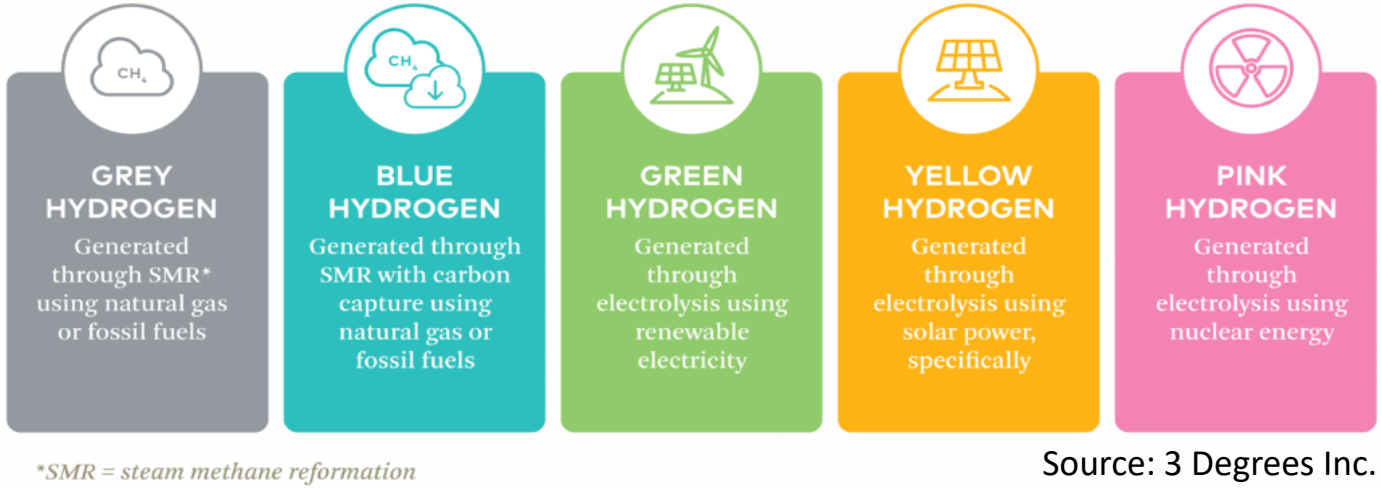
CATEGORIZING HYDROGEN



Source: 3 Degrees Inc.

- Industry moving away from color categorization of hydrogen.
- IIJA defines "**clean** hydrogen" with a carbon intensity at the site of production.
- 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."

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INTERPRETING THE SB 333 DEFINITION OF RENEWABLE HYDROGEN

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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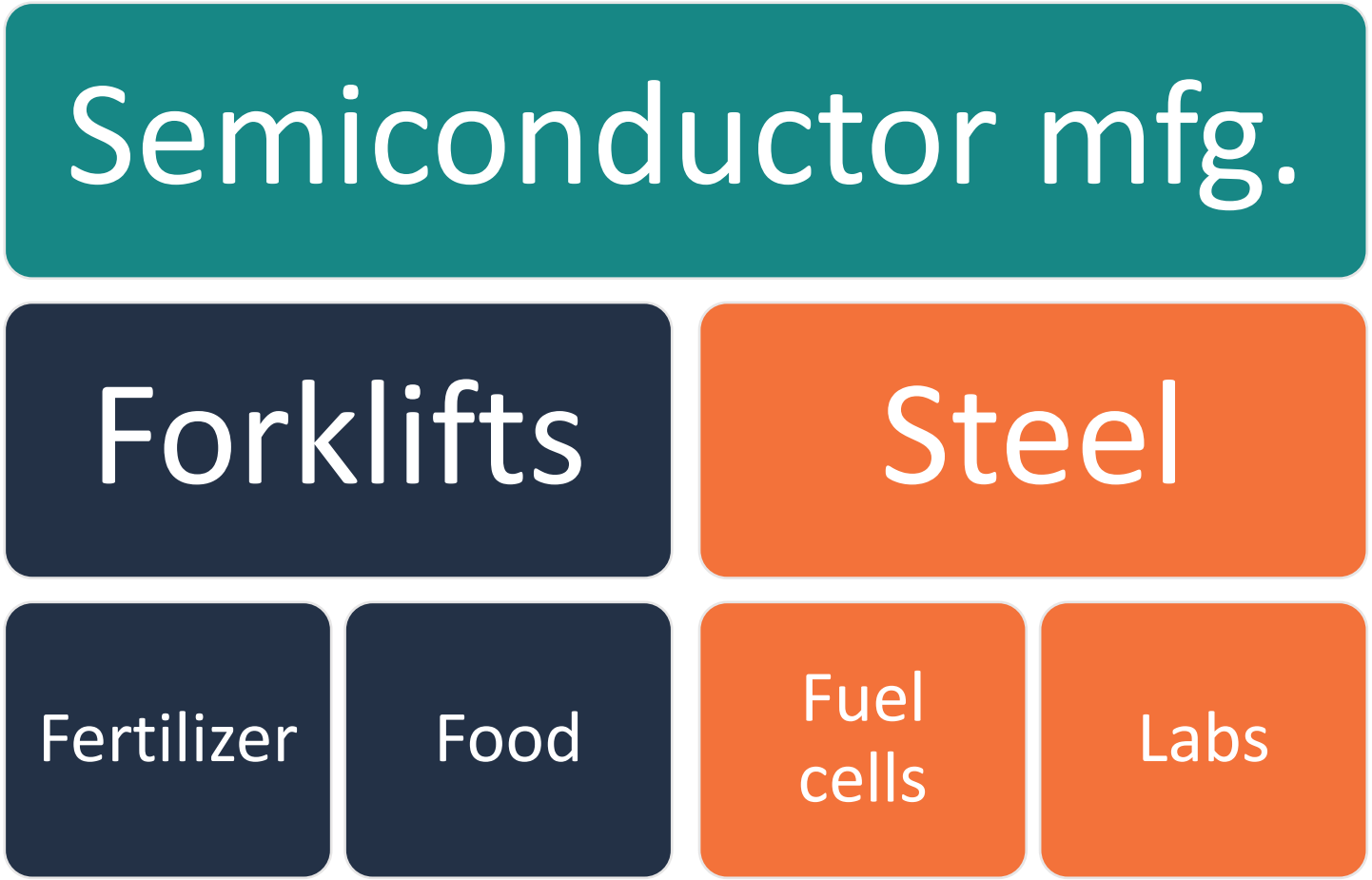
IDENTIFICATION OF THE TOTAL H2 VOLUME CURRENTLY USED ANNUALLY IN OREGON



- Numerous outreach attempts for data gathering.
- Challenging to get data – competitive concerns.
- Possible methods for estimating H2 use but would need further study.

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POTENTIAL APPLICATIONS OF RH2 IN OREGON BY 2030

Potential Applications:

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

Sensitivities:

- Properties of H2
- Efficiencies
- Enabling policies
- Cost of RH2
- Potential local supply of RH2
- Availability of substitutes
- GHG emissions reduction potential

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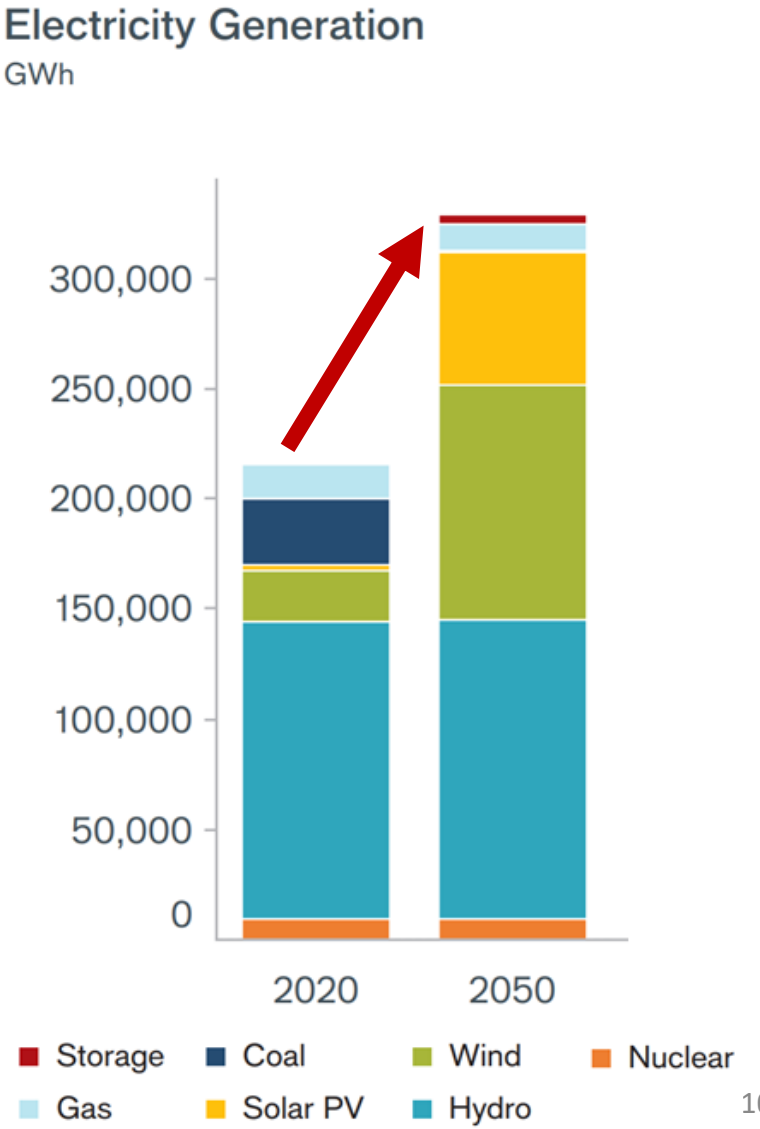
ASSESSMENT OF POTENTIAL FOR COUPLING RENEWABLE ELECTRICITY GENERATION AND RH2 PRODUCTION TO INCREASE RESILIENCY OR PROVIDE FLEXIBLE LOADS

- Models of Pacific NW electricity mix in 2050 show the scale of meeting states' renewable and clean electricity policies.
- Expecting significant growth in demand.
- Analysis by CETI and Evolved Energy Research found we need 80,000 MW of **new** wind and solar to meet it.



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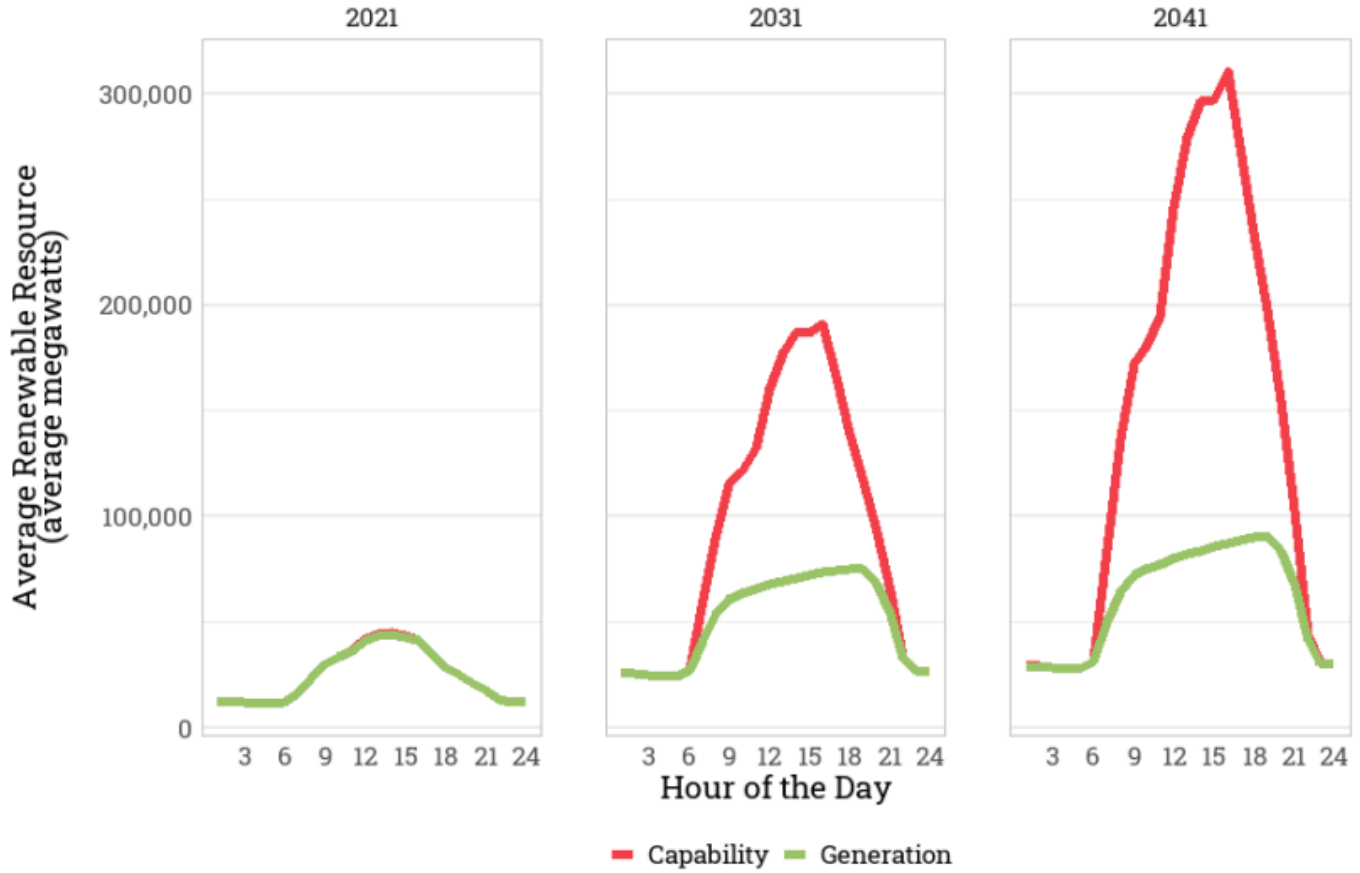
Clean Energy Transition Institute

EVOLVED ENERGY RESEARCH

Source: Pathways to a Clean Energy Future, Figs. 12 and 13, p. 34

COUPLING REGENERATION AND RH2 PRODUCTION (CONT'D)

With more variable renewable energy sources on the grid comes more curtailment in the West. . .

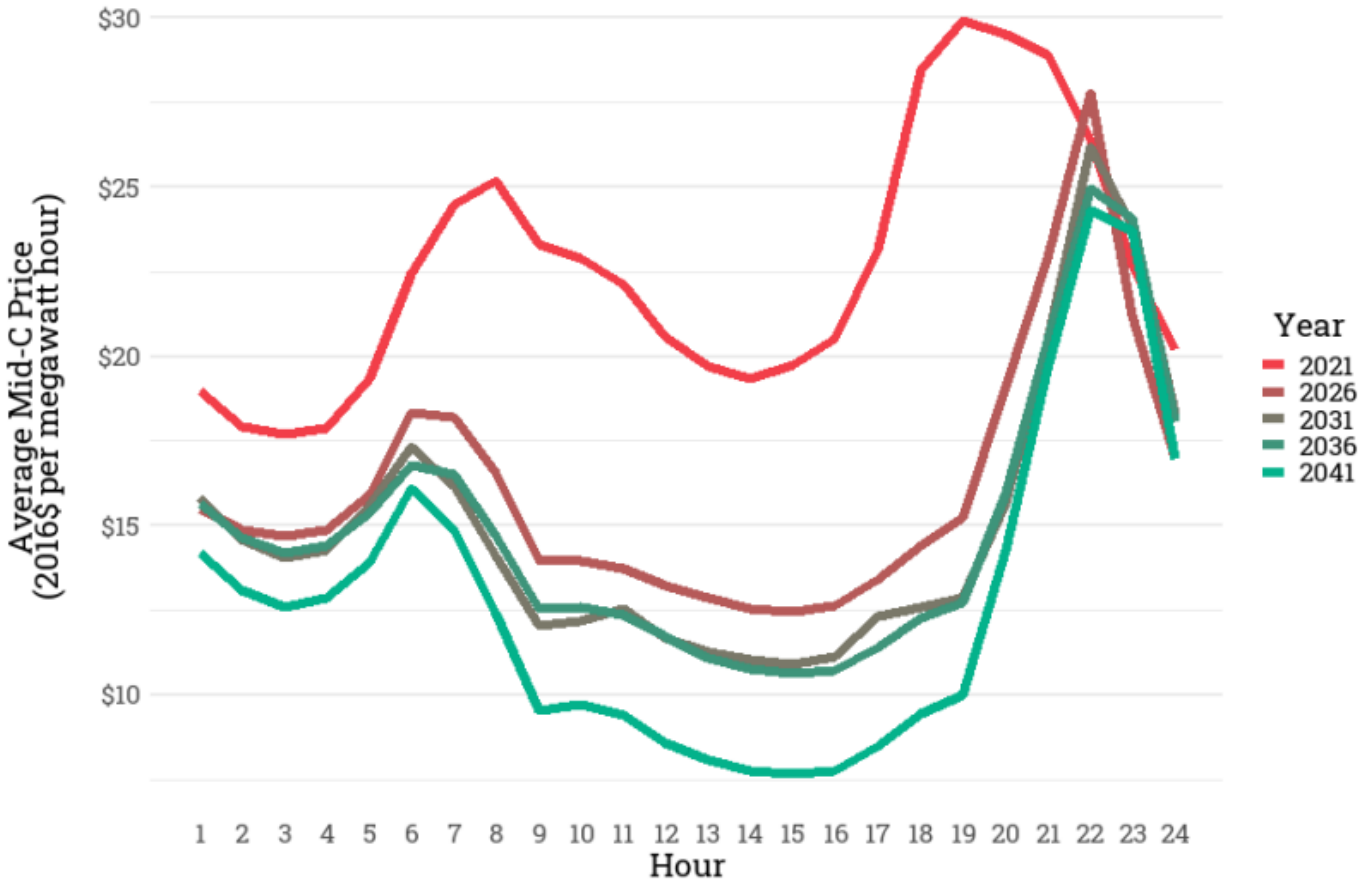


THE 2021 NORTHWEST POWER PLAN

Source: The 2021 Northwest Power Plan, p. 52

COUPLING REGENERATION AND RH2 PRODUCTION (CONT'D)

. . . and large price fluctuations, which represent increasingly steep demand at certain times. . .



THE 2021 NORTHWEST POWER PLAN

Source: The 2021 Northwest Power Plan, p. 54

COUPLING REGENERATION AND RH2 PRODUCTION (CONT'D)

- More variable renewable electricity resources = more potential 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

Study Findings

- RH2 production and use could address all of the issues listed above:
  - Electrolyzers could be big load, but a very flexible one
  - 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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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

Study Findings

- RH2 costs driven by renewable electricity and electrolyzer costs
- Price of RH2 as compared to substitutes, along with policy, will determine uptake
- Federal production tax credit is a big deal and other funding are a big deal!

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

Study Findings

- Current high production costs and relatively low efficiencies
- Creating supply and demand – the chicken and egg problem
- Lack of dedicated infrastructure
- No statutory definition for RH2, lack of tracking and certification
- Need for updated safety and building codes, pipeline injection standards
- Environmental concerns – water usage, NOx emissions
- Lack of general awareness and understanding – need for education

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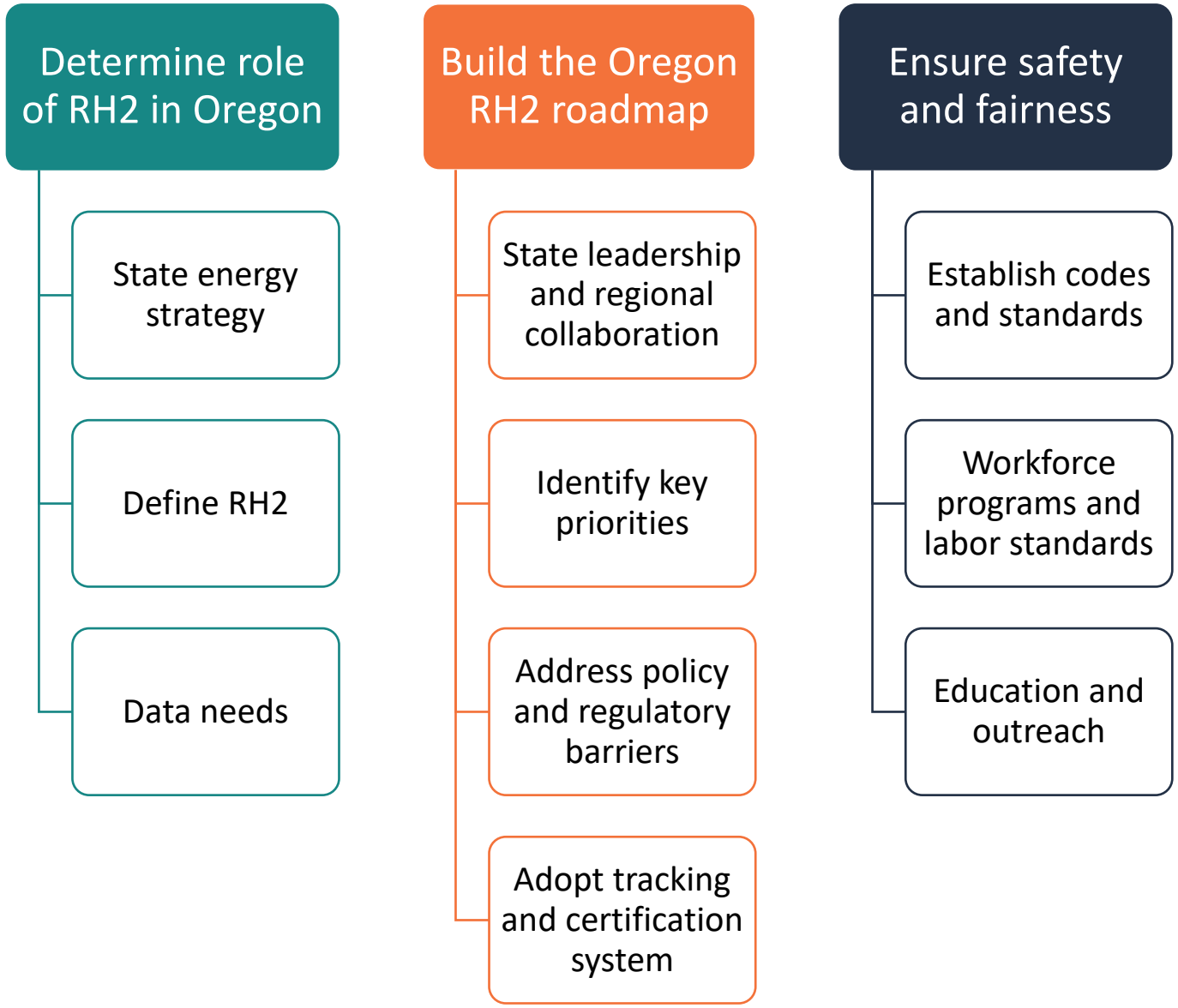
RECOMMENDATIONS IF OREGON WISHES TO BUILD RH2 SECTOR



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