

Advanced Power and Energy Program

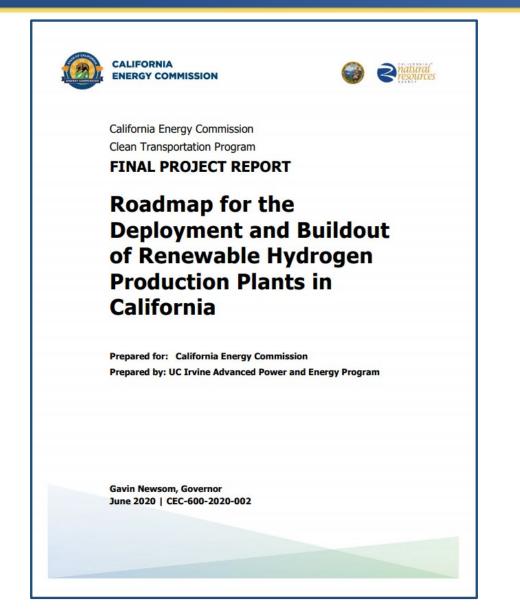


Scaling the Green Hydrogen Sector in California

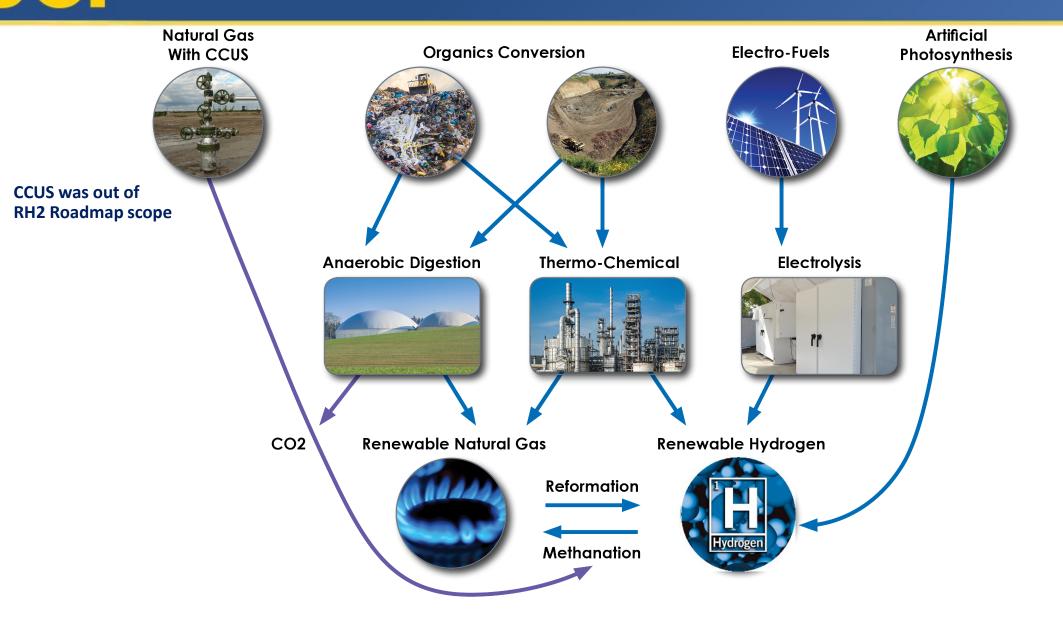
CPUC Strategic Goals Workshop September 20, 2023 Jeff Reed, UC Irvine



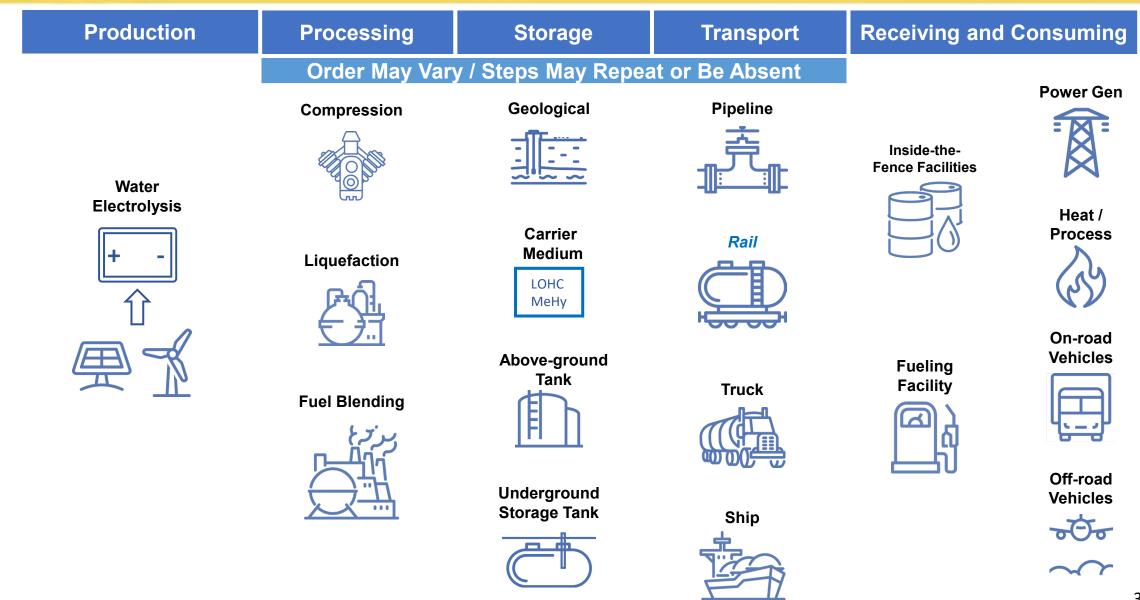
Renewable Hydrogen Roadmap for California – June 2020



Zero-Carbon Hydrogen and Methane Pathways



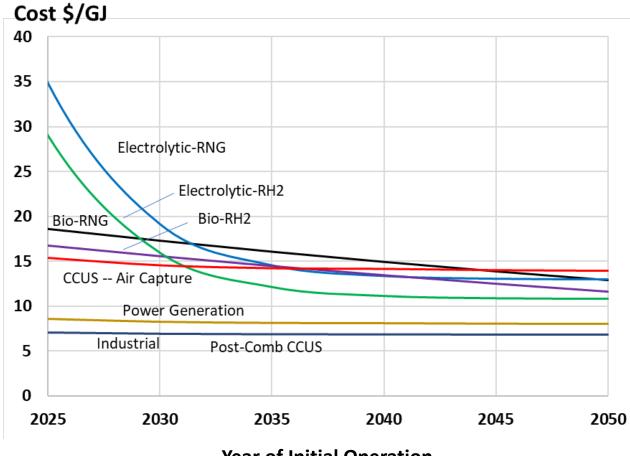
Renewable Hydrogen Production-through-Use Pathways



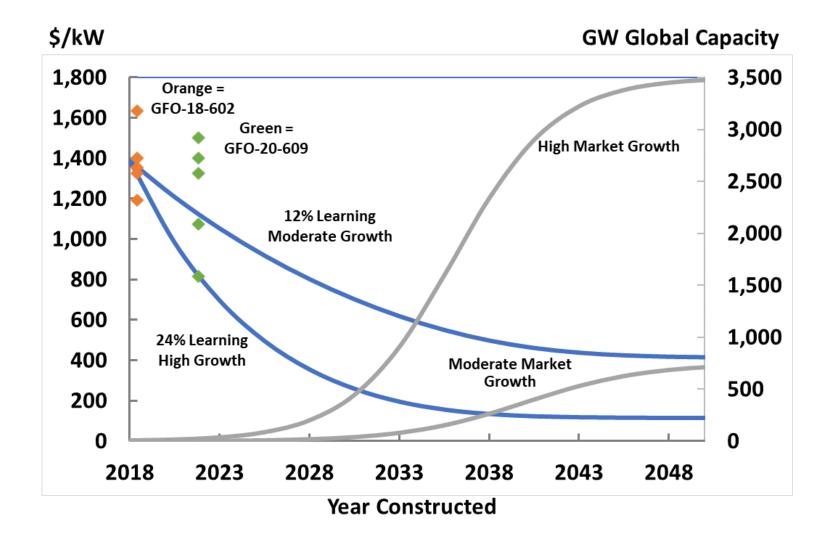
UC Key Questions Regarding Green Hydrogen

- 1. Where are there gaps in technology, if any?
 - Electrolyzer cost precious metal content
 - Understanding of the feasibility of underground hydrogen storage in depleted oil and gas reservoirs
 - Liquefaction technology performance -- efficiency and boil-off
 - Understanding of and mitigation of H2 leakage from production through use (the small indirect global warming impact of hydrogen occurs only if emitted or leaked as hydrogen (versus combustion products)
 - Understanding of NOx impacts and reduction approaches for use of hydrogen in combustion applications (industrial heat and power generation) NOx reductions for power and industrial heat likely achievable
- 2. What role should RD&D play in filling gaps in technology needs?
 - Basic research via DoE and NSF
 - Field demonstration and validation, field measurement, techno-economic and lifecycle analysis, and system planning via state agencies
- 3. At what point does the technology become economically competitive? (What is the goal cost and time horizon)
 - Currently competitive with \$3/kg federal credit
 - Late 2020's to early 2030's without subsidy

Zero-carbon Hydrogen and Methane Cost Projections



Electrolyzer Cost Progression versus 2018 Forecast



UC Key Questions Regarding Green Hydrogen (cont'd)

- 4. What are the market facilitation needs to enable successful business models?
 - Consistent policy and adequate subsidies in the launch and scale phase of the market based on
 - For subsidies based on environmental goals, use pathway impacts rather than binary definitions e.g., carbon intensity not colors and other quantified environmental attributes as appropriate such as NOx reduction
 - Establish time-matching, deliverability, and additionality provisions for GH2 GHG accounting that balance market advancement with acceleration of GHG reductions and apply even-handedly across technologies
 - Establish the regulatory framework and market rules for hydrogen pipelines and hydrogen blending on the natural gas system
 - Establish rates for grid delivered power to electrolyzer that reflect the cost-to-serve inclusive of grid benefits, and establish market rules allowing electrolyzer operators to procure electricity from wholesale generators
 - Streamline permitting, including CEQA maybe a programmatic environmental impact report
- 5. Who should pay for infrastructure?
 - In the mature market, consumers of green hydrogen should pay the full cost of infrastructure
 - Subsidies from ratepayers and taxpayers support launch and scaling of infrastructure should be provided based on the long-term costs and benefits of the technology including the cost of externalities and commensurate with subsidies provided to "similarly situated" technologies and pathways

When Awarded, Supporting the CA GH2 Hub is Priority #1



- Port communities
- Tribal communities
- Extensive renewables
- 8 jobs per \$1M invested in H₂

California

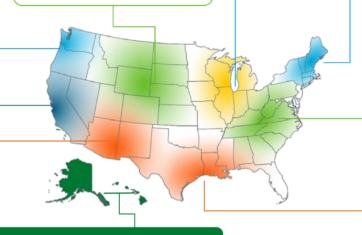
- Diverse populations
- Extensive infrastructure
- Emissions regulations
- 40,000+ jobs

Southwest

- Tribal and Hispanic communities
- Underutilized solar
- Nuclear power
- Up to 2B tonnes/yr emission reduction potential

Central U.S.

- Ample wind
- Geological storage
- Railway transport
- Nuclear resources
- >630,000 tonnes/yr CO₂ reduction



Alaska and Hawaii

- Extensive renewables geothermal, solar, ocean
- Backup power
- Isolated communities
- 86,000 tonnes/yr emission reduction

Great Lakes

Major national corridors • Nuclear power • 60,000+ jobs

New England

- Offshore wind
- Fishing communities
- Backup power and winter heating
- ~120K tons CO₂/year reduction

Appalachia

- Retiring fossil plants
- Mining, refining transferable skills
- Carbon capture and sequestration
- 70,000 tons/yr H₂ production

Gulf Coast

- Existing infrastructure
- Multiple opportunity zones
- Renewable resources
- 1,000s of jobs
- Chemical industry



Thank You



#RH2@APEP RENEWABLE HYDROGEN

UCI ADVANCED POWER AND ENERGY PROGRAM

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