



# The Technical, Demand, and Economic Potential of H2@Scale within the United States

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# Demand Potential

**Demand potential of hydrogen market by 2050 is >9X.**

**Other applications are possible based on technology and policy growth as well as smaller applications**

Application	Demand Potential (MMT/yr)	2015 Market for On-Purpose H2 (MMT/yr)
Refineries and the chemical processing industry (CPI) <sup>a</sup>	8	6
Metals	12	0
Ammonia	4	3
Biofuels	4	0
Synthetic fuels and chemicals	14	1
Natural gas supplementation	10	0
Seasonal energy storage for the electricity grid	15	0
<b>Industry and Storage Subtotal</b>	<b>67</b>	<b>10</b>
Light-duty fuel cell electric vehicles (FCEVs)	21	0
Medium- & Heavy-Duty FCEVs	11	0
<b>Transportation Fuel Subtotal</b>	<b>32</b>	<b>0</b>
<b>Total</b>	<b>99</b>	<b>10</b>

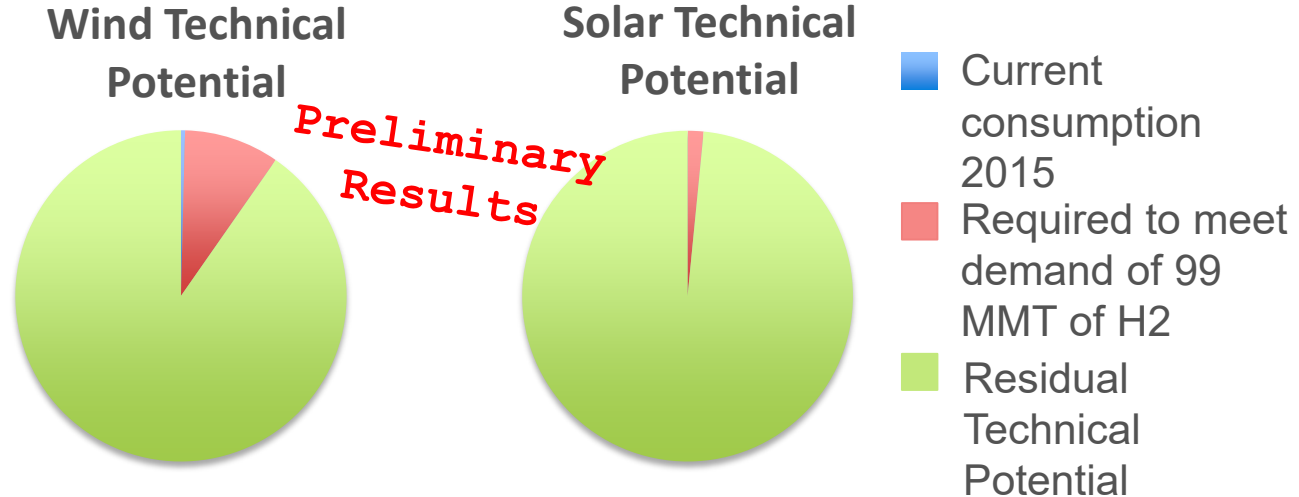
**Preliminary Results**

Definition: The demand potential is the estimated market size constrained by the services for which society currently uses energy, real-world geography, system performance, and by optimistic market shares but not by economic calculations.

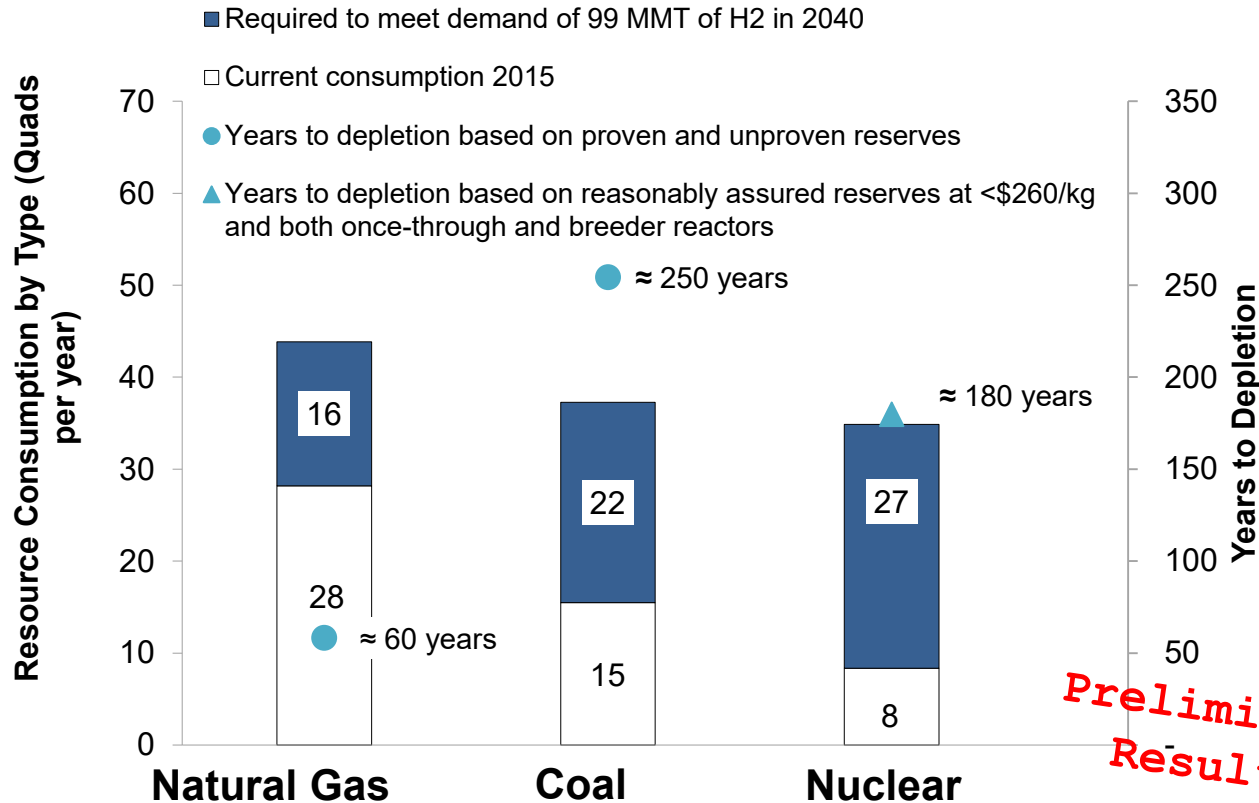
# Technical Potential Supply from Renewable Resources

	EIA 2015 current consumption (quads/yr)	Required to meet demand of 99 MMT / yr (quads/yr)	Technical Potential (quads/yr)
Solid Biomass	4.7	24	19
Wind Electrolysis	0.68	16	170
Solar Electrolysis	0.17	16	1,000

**Total demand including hydrogen is satisfied by  $\approx 10\%$  of wind,  $2\%$  of solar, and  $\approx 150\%$  of biomass technical potential**



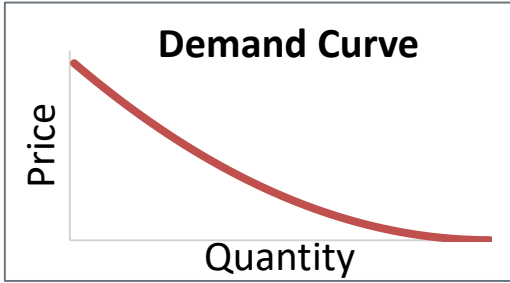
# Technical Potential of Fossil and Nuclear Resources



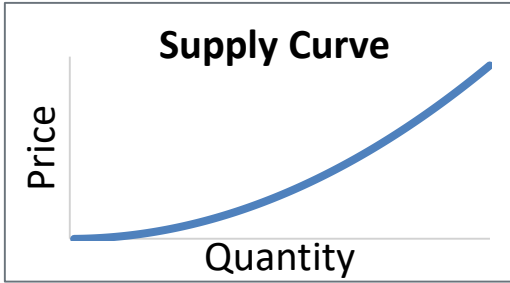
Hydrogen can be produced from diverse domestic resources to meet aggressive growth in demand

*Preliminary Results*

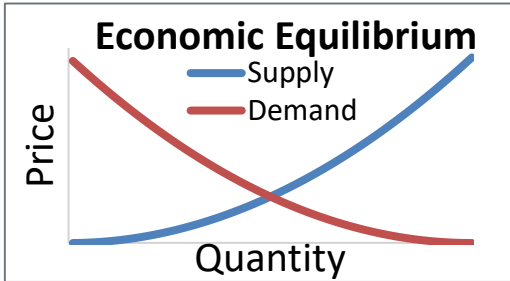
# Economic Potential Methodology: Market Equilibrium



**Demand Curve:** how much are consumers willing and able to pay for a good?



**Supply Curve:** threshold prices showing how much are producers willing and able to produce at each?



**Economic Equilibrium:** Quantity where demand price is equal to the supply price.

- No excess supply or demand.
- Market pushes price and quantity to equilibrium.

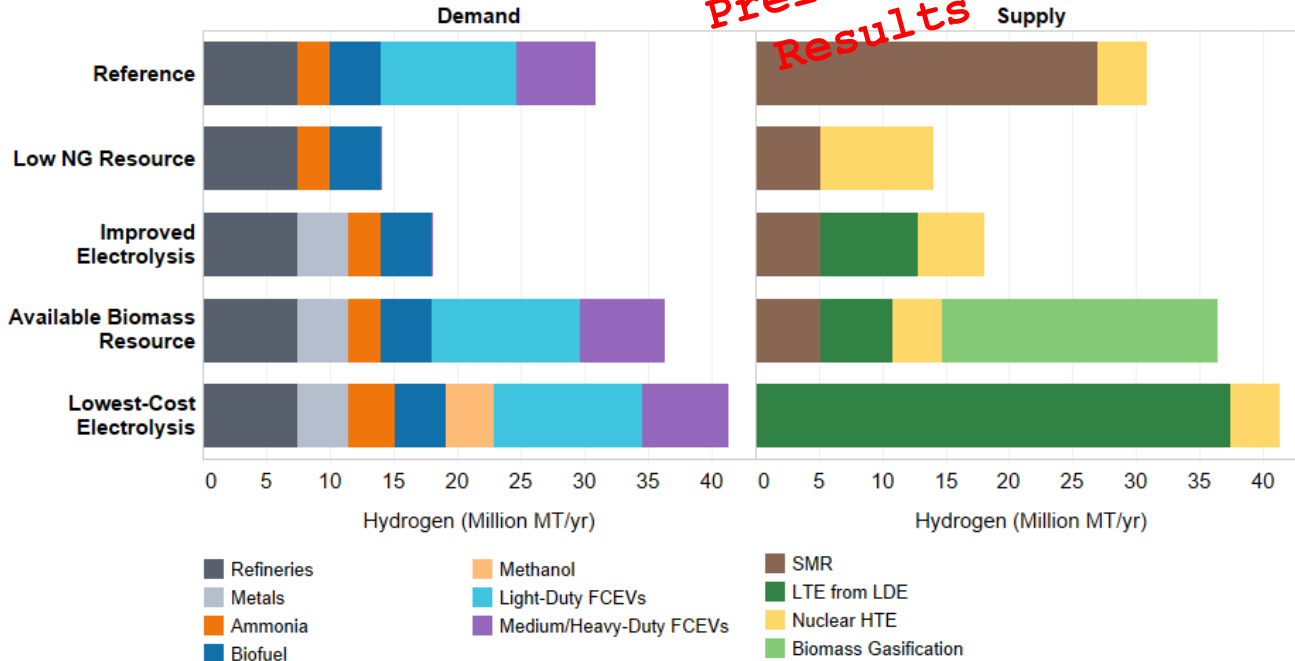
# Economic Potential: Five National Scenarios

Scenario Name	Reference	Low NG Resource	Improved Electrolysis	Available Biomass Resource	Lowest-Cost Electrolysis
Natural gas price assumption	Reference	Higher			
Low-Temperature Electrolysis (LTE) capital costs	Current Trajectory		Improvements		Aggressive Assumptions
Low-cost, Dispatch-constrained Electricity purchase assumption	Current Trajectory		Improvements		Aggressive Assumptions
Biomass	Not available			Available	Not Available
Metals demand	Competitive Market		Premium Available		

Key differences in scenarios: 1) natural gas price assumption, 2) electrolyzer cost assumption, 3) electrolyzers' access to grid service markets, 4) increased threshold price in metals industry, & 5) competition for biomass resource

# Economic Potential Results

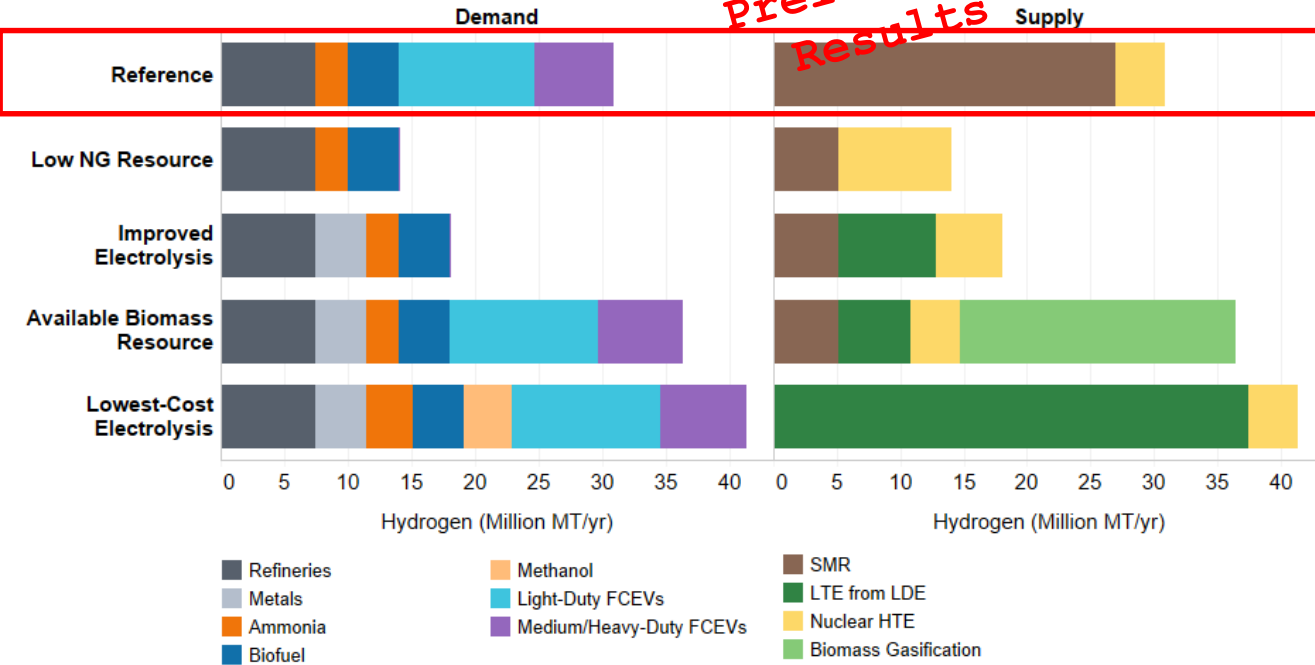
**Preliminary Results**



The economic potential of hydrogen demand in the U.S. is **1.4-4X** current annual consumption.

# Reference Scenario

**Preliminary Results**

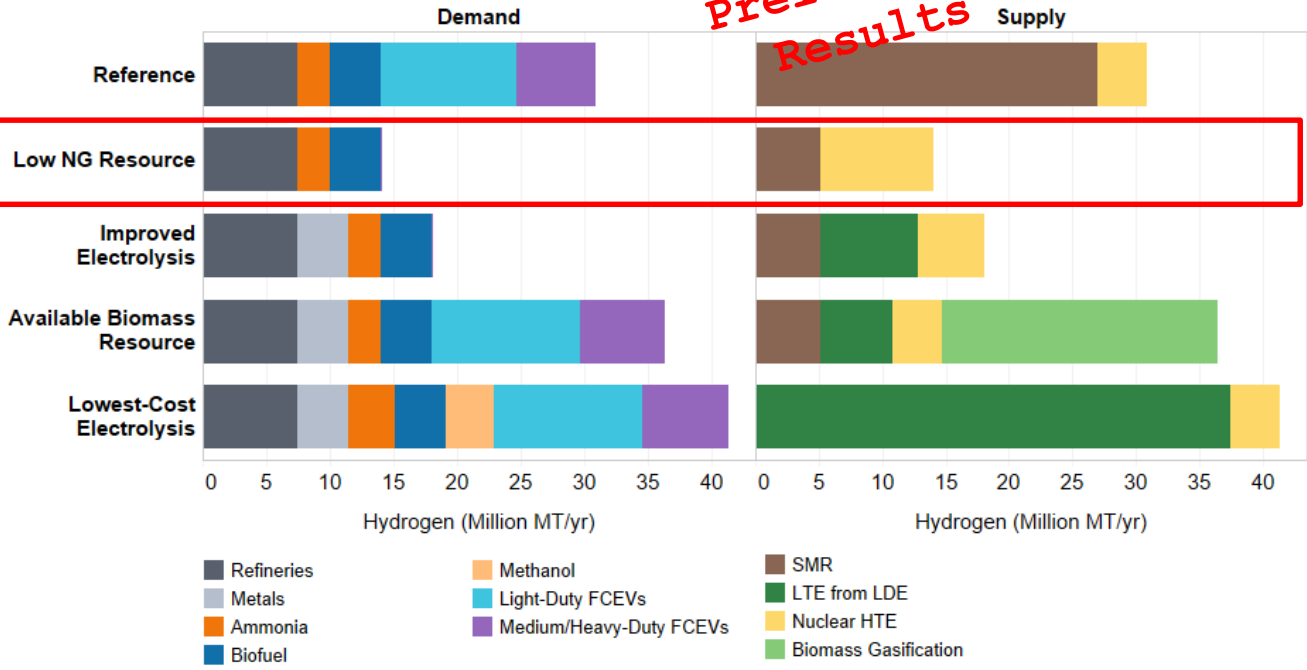


- Lowest natural gas prices; thus, higher penetrations of FCEVs
- About 10% of U.S. nuclear generation to H<sub>2</sub>
- Refineries and ammonia demands based on growing markets
- Biofuels demand limited to Renewable Fuels Standard



# Low Natural Gas Resource Scenario

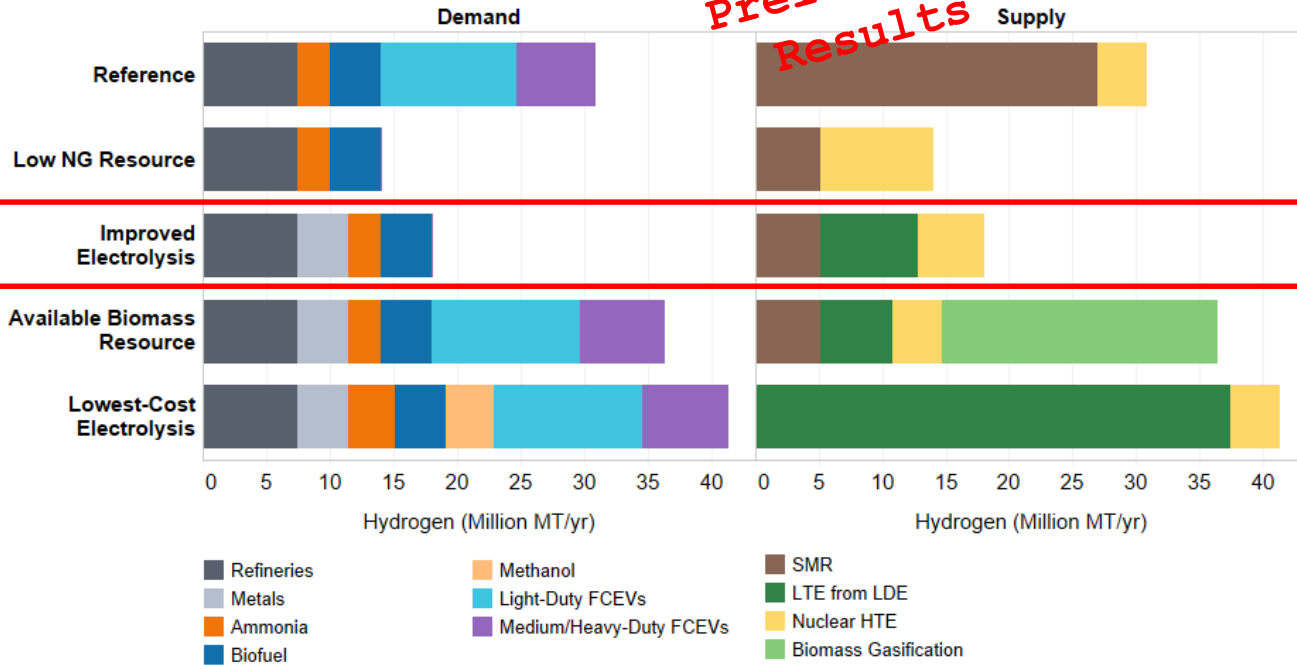
**Preliminary Results**



- Higher natural gas prices than reference scenario
- Thus, negligible growth in hydrogen demand
- Only economic demands: refining, ammonia, biofuels

# Improved Electrolysis Scenario

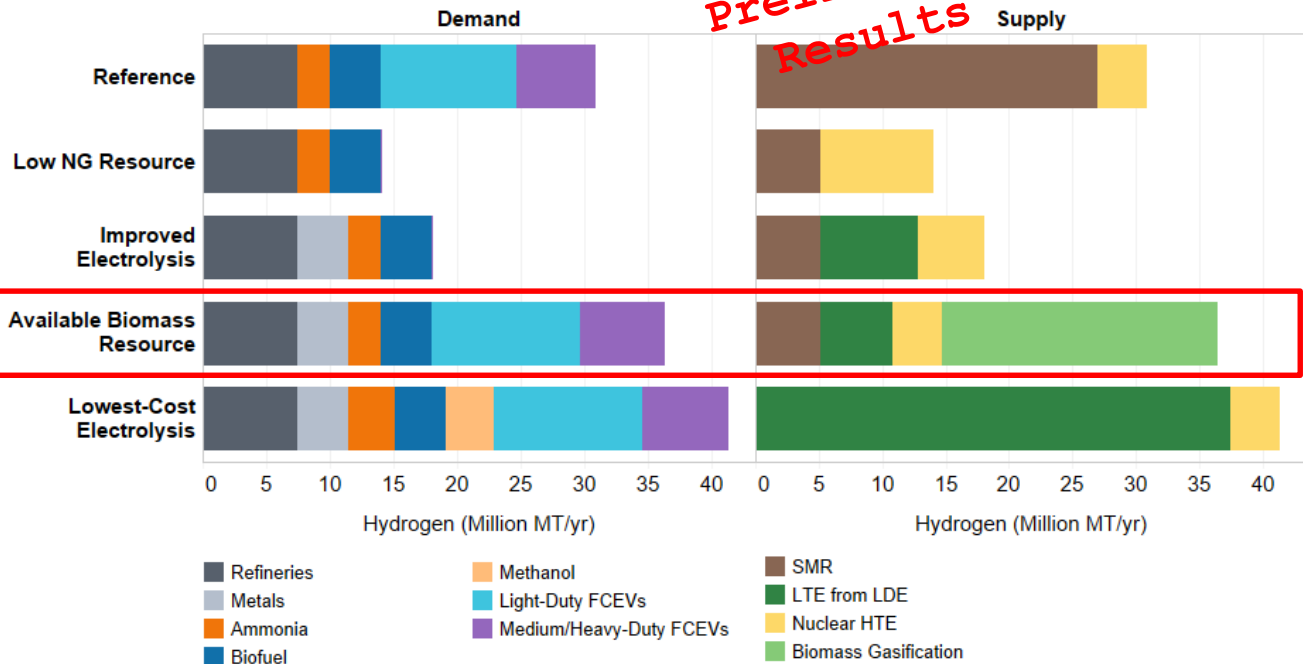
**Preliminary Results**



- Low-Temperature electrolyzer (LTE) purchase cost reduced to \$200/kW & reduced electricity price adder
- Supply growth due to electrolytic hydrogen
- Increased willingness to pay for H2 for metals refining
- Leads to demand for growing domestic metals refining industry

# Available Biomass Resource Scenario

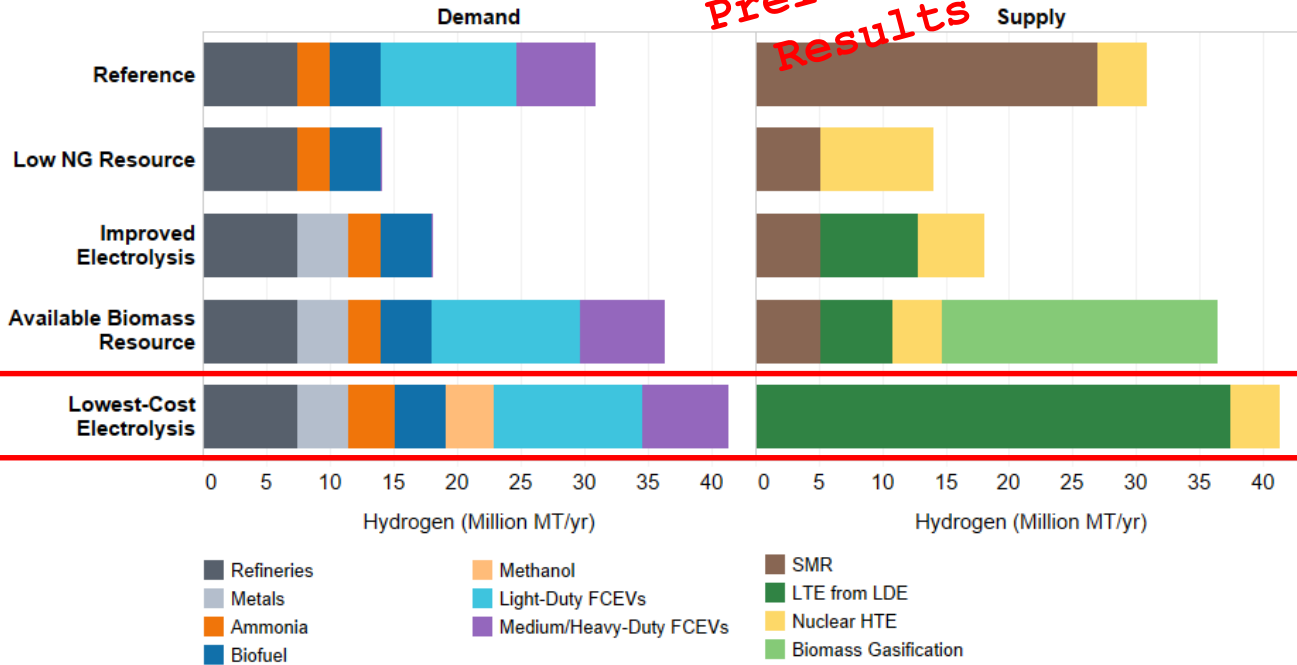
**Preliminary Results**



- Only scenario with biomass available for hydrogen production
- Lowest cost biomass resource assumed available
- Lower cost hydrogen allows demand growth

# Lowest-Cost Electrolysis Scenario

**Preliminary Results**



- Low-Temperature electrolyzer (LTE) purchase cost reduced to \$100/kW & no electricity price adder
- Electrolytic hydrogen less costly than steam methane reforming
- Larger ammonia and chemicals opportunities than other scenarios

# Key Conclusions

- **The potential demand of hydrogen demand in the U.S. is >9X current annual consumption.**
- **The economic potential of hydrogen demand in the U.S. is 1.4-4X current annual consumption.**
  - Range across 5 scenarios developed using a variety of economic and R&D success assumptions
- **Up to 20% of current nuclear power plants could improve their profitability by producing hydrogen.**

# For More Details

- Power-to-Gas Technical Session
  - Thursday at 1:30 in room 103 A/B
- Two presentations
  - H2@Scale: Economic Potential of Hydrogen as an Energy Intermediate
  - Electrolysis' Potential Value for Supporting the Electrical Grid

# Thank You

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[www.nrel.gov](http://www.nrel.gov)

NREL/PR-6A20-75337

## Additional information on H2@Scale can be found at:

[https://www.hydrogen.energy.gov/pdfs/review18/h2000\\_pivovar\\_2018\\_o.pdf](https://www.hydrogen.energy.gov/pdfs/review18/h2000_pivovar_2018_o.pdf)

[https://www.hydrogen.energy.gov/pdfs/review19/sa171\\_ruth\\_2019\\_o.pdf](https://www.hydrogen.energy.gov/pdfs/review19/sa171_ruth_2019_o.pdf)

<http://energy.gov/eere/fuelcells/downloads/h2-scale-potential-opportunity-webinar>

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