



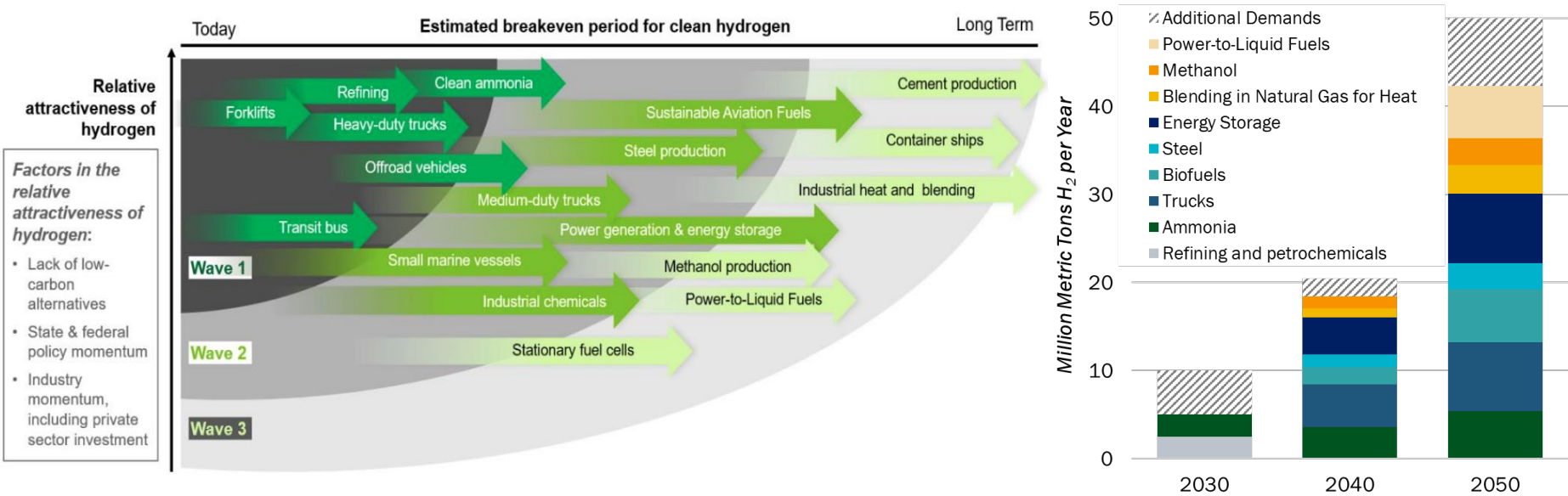
# Performance Demonstration and Analytical Support to Accelerate Hydrogen Technology Commercialization in the U.S.

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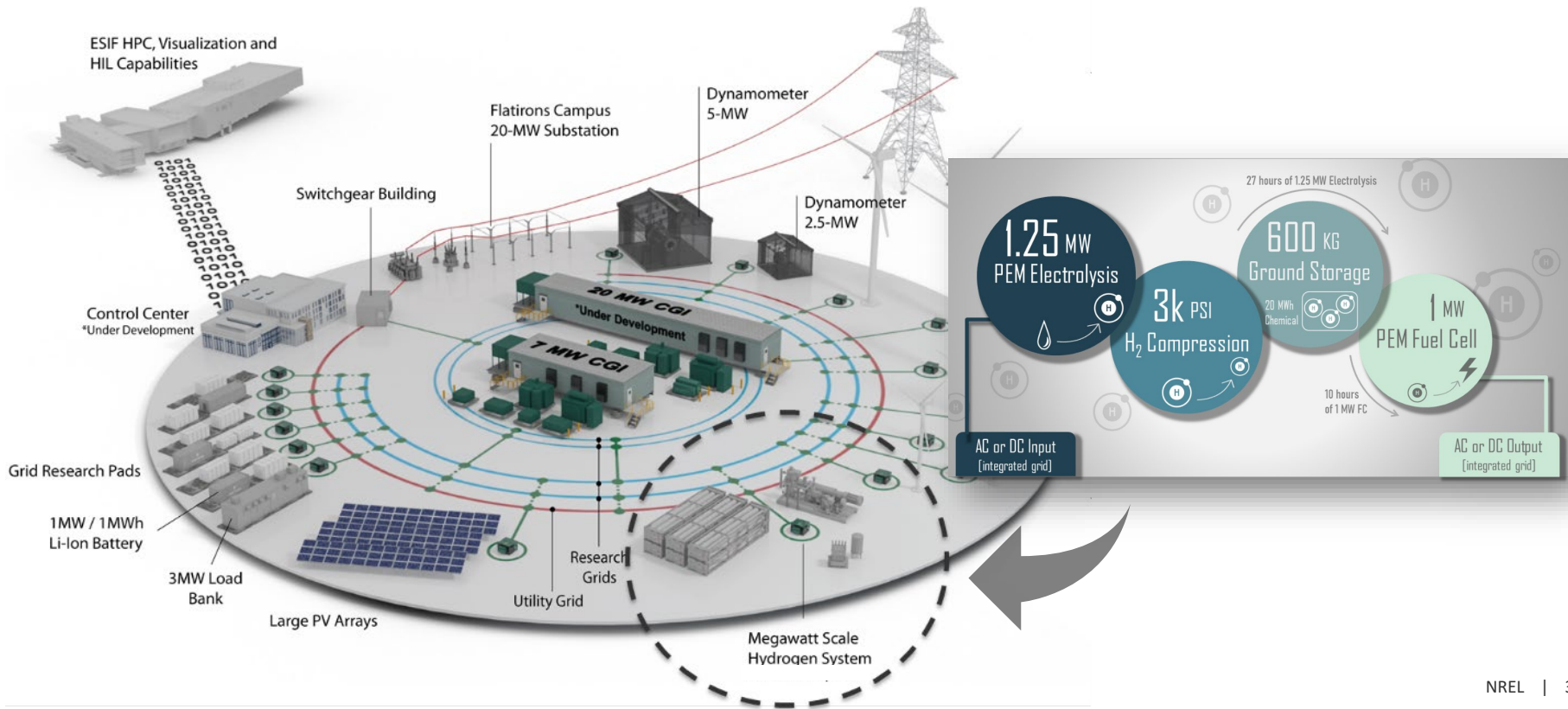
RD20 Technical Session on Addressing  
Hydrogen Implementation Technical Barriers  
December 2, 2024

# Opportunities for Hydrogen in the U.S.

NREL supports the U.S. hydrogen strategy to increase the U.S. hydrogen market from 10 MMT/yr to 50 MMT/yr, supply it with clean hydrogen production for use in multiple sectors through **demonstrations, analysis, and safety and sensor technologies.**



# Demonstration: Roundtrip Hydrogen Energy Storage System at NREL's Advanced Research for Integrated Energy Systems (ARIES)



# Demonstration: Heavy Duty Hydrogen Fueling to Support Standards Development



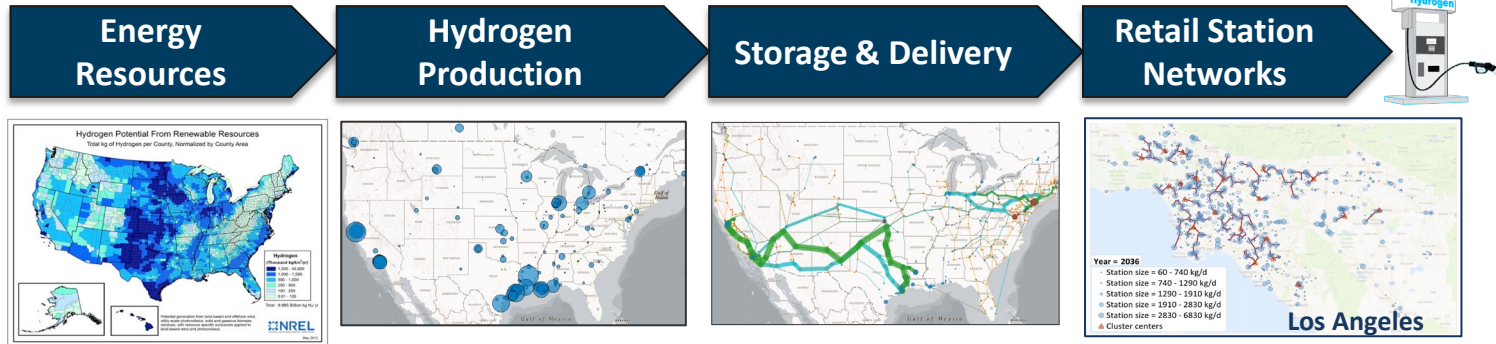
## Wireless Vehicle-to-Dispenser Communications for Heavy Duty Hydrogen Fueling

- Demonstrated one of the first advanced wireless vehicle-to-dispenser communications systems (Shell HyConnect) that wirelessly transmitted vehicle tank data per the SAE fueling protocol standards
- 73 kg fill in 7 minutes total time (6 minutes fueling time) into NREL's HD vehicle simulator using the SAE fueling protocol at 70 MPa, 300 g/s, at -40°C with the industry-supplied HD refueling hardware from Tatsuno and Parker.

# Network Analysis of Hydrogen Systems



The Scenario Evaluation and Regionalization Analysis (SERA) model simulates least-cost hydrogen infrastructure supply systems for urban FCEV markets



- Energy prices (natural gas, electricity, etc.)
- Renewables (biomass, solar, wind)
- Terrain, rights of way, etc.

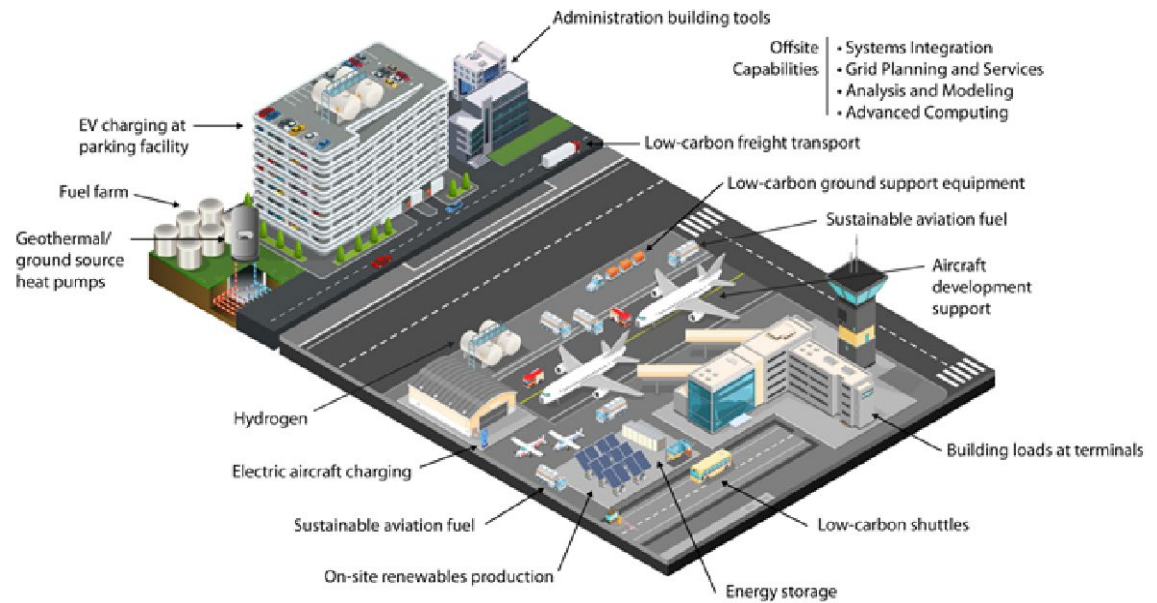
- Central and onsite production facilities
- Capacity sized to meet forecasted demand
- Economies of scale balanced with delivery costs

- Truck delivery, rail, and pipeline.
- Cost is sensitive to volume, distance
- Seasonal and weekly storage
- Networked supply to multiple cities

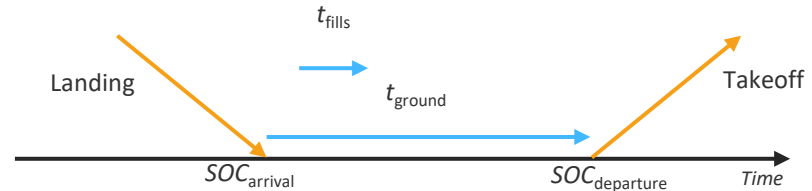
- Coverage stations for FCEV introductions
- Station sizes increase with market growth
- Liquid and pipeline delivery networks compete for large stations

# Site Opportunity Analysis: Airports

**Objective:** Determine H<sub>2</sub> infrastructure requirements and identify scheduling and operational constraints (time for filling, time between fills, required state-of-charges for operations)

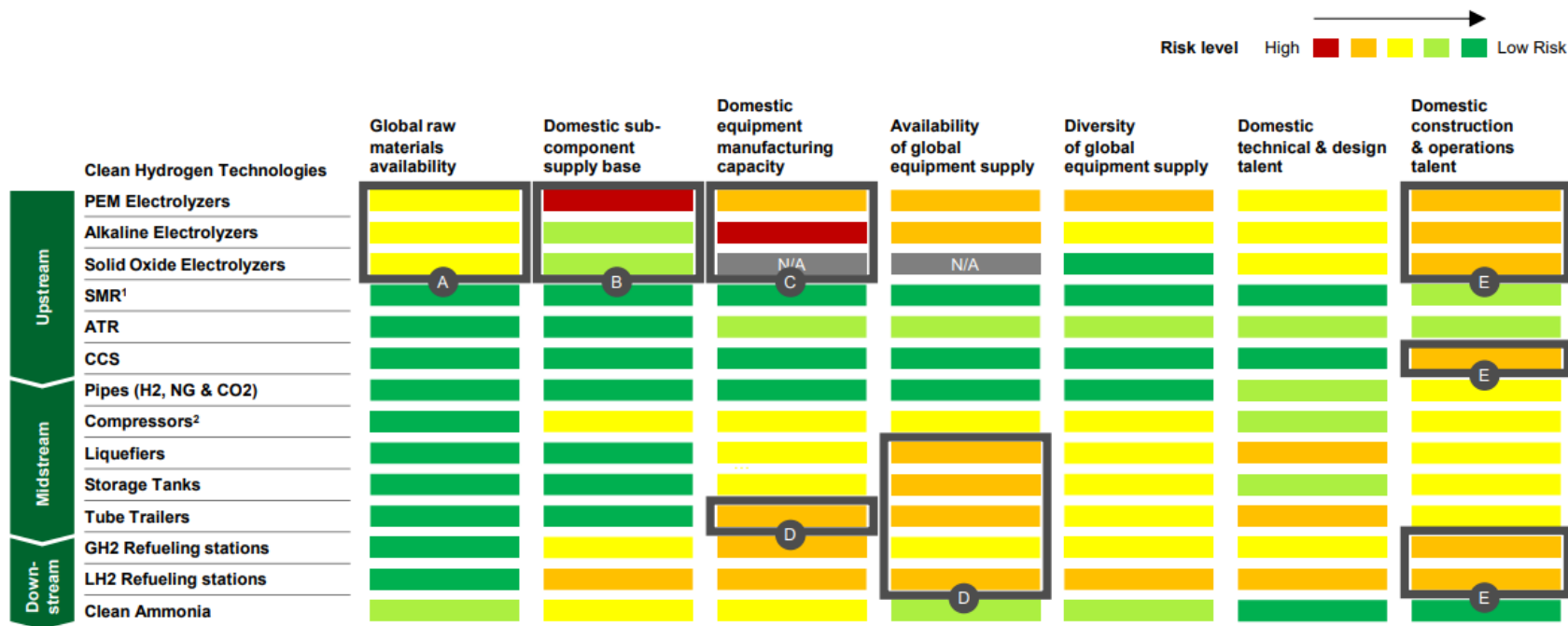


## Timing Considerations



$$d_{H2} = f(SOC_{arrival}, SOC_{departure}, \dots)$$

# Supply Chain Analysis: Vulnerability & Alternative Identification



1: Includes large scale compressors at industrial and productions sites and compressors at refueling facilities | 2: No significant additional build out of Steam Methane Reformers anticipated

Source: Department of Energy Fuel Cells & Electrolyzers Supply Chain Report, ENS Interviews, NREL experts

# Hydrogen Sensor and Safety Technologies

- Safety and process control sensor testing and deployment
- Advanced wide area / stand off detection technology
- Hydrogen release behavior modelling
- Detection as a risk reduction strategy
- Tools development for hydrogen emissions detection and quantitation
- Hydrogen Component Reliability R&D for probabilistic risk reduction (QRA).





# Potential Opportunities for Collaboration

- Technology integration and demonstration
  - Roundtrip energy storage system
  - Heavy duty fueling system
- Analysis
  - Network
  - Site opportunity
  - Supply chain
- Sensor and safety technologies
- And many others!

# Thank You

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

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