



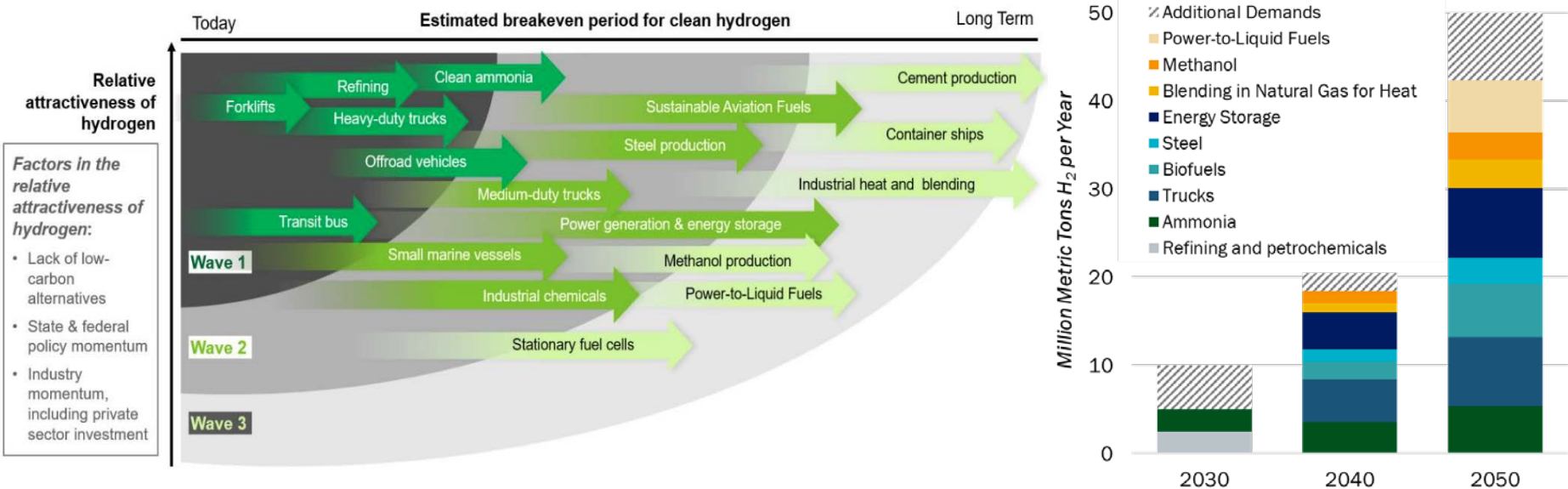
# Performance Demonstration and Analytical Support to Accelerate Hydrogen Technology Commercialization in the U.S.

Mark Ruth

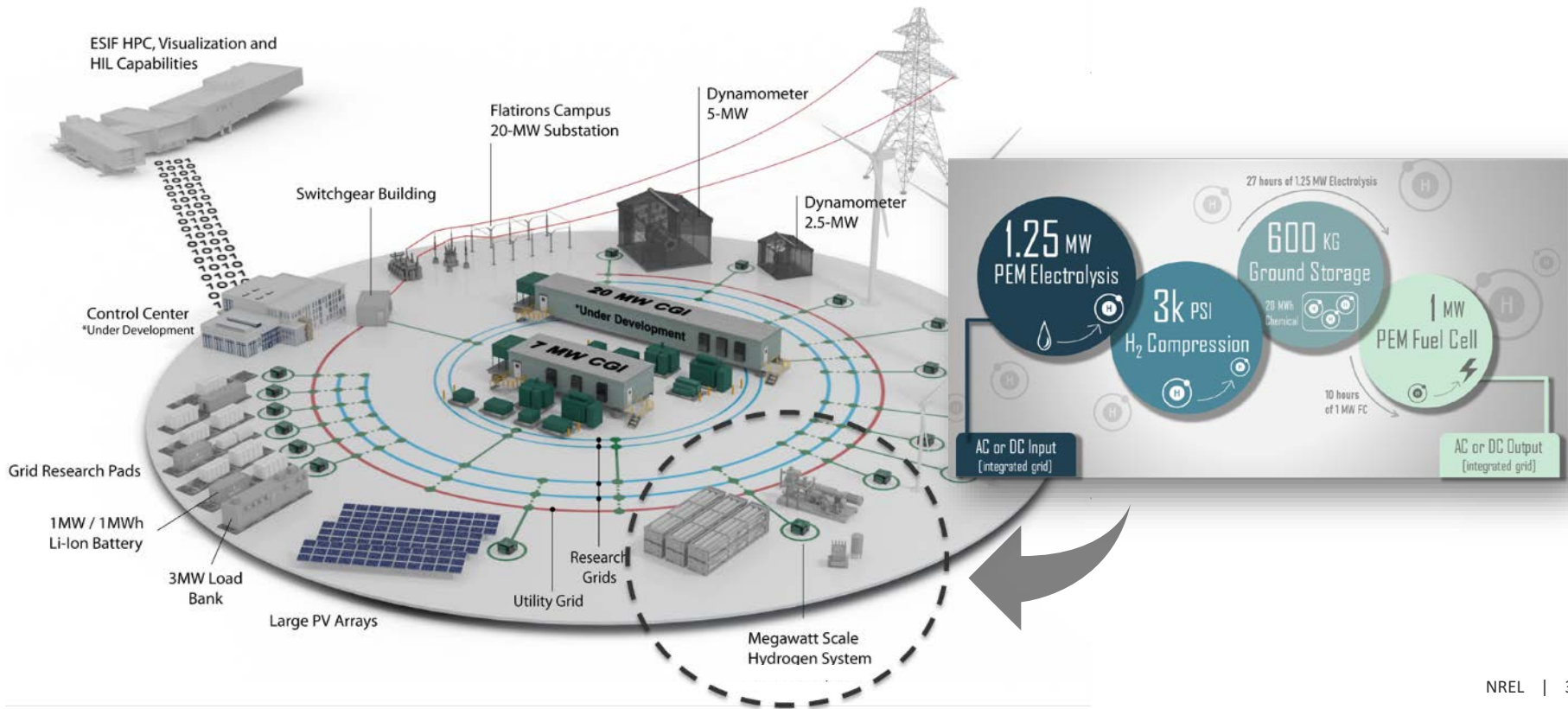
RD20 Technical Session on Addressing  
Hydrogen Implementation Technical Barriers  
December 2, 2024

# 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

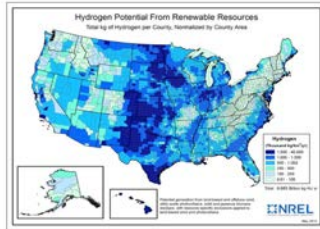
- Demonstrated one of the first advanced wireless vehicle-to-dispenser communications systems (Shell HyConnect) that wirelessly transmitted vehicle tank data per the SAE fueling protocol standards
- 73 kg fill in 7 minutes total time (6 minutes fueling time) into NREL's HD vehicle simulator using the 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 Resources



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

## Hydrogen Production



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

## Storage & Delivery



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

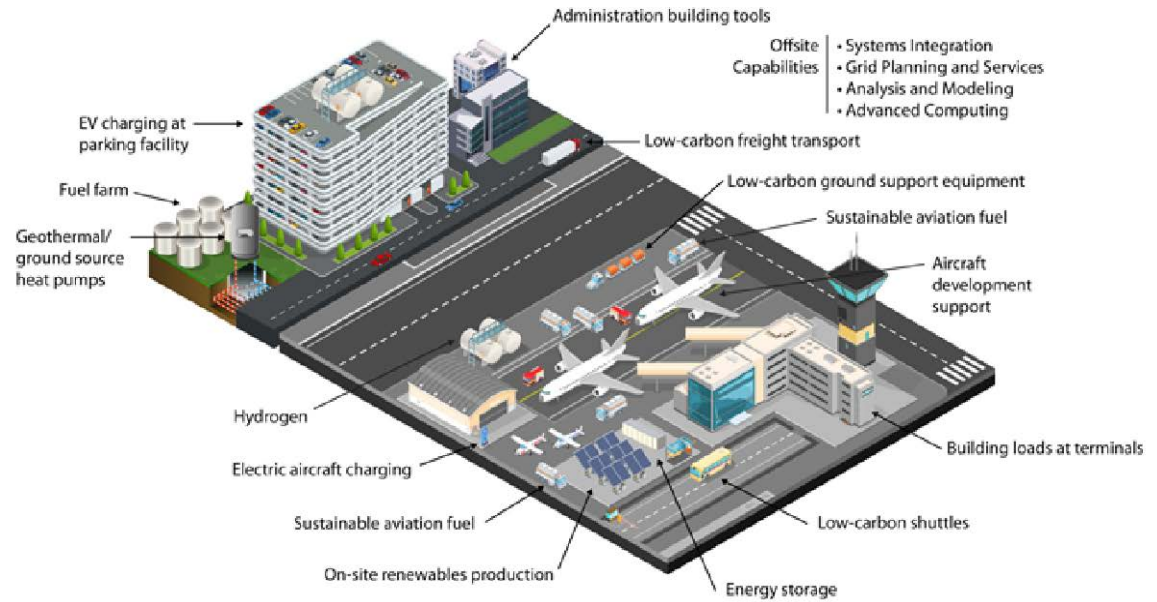
## Retail Station Networks



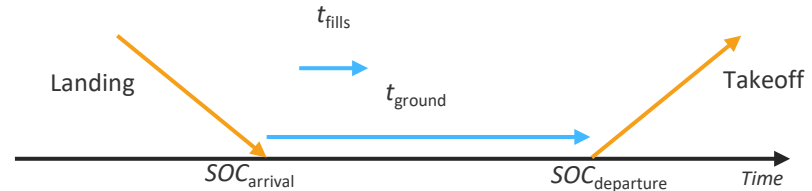
- Coverage stations for FCEV introductions
- Station sizes increase with market growth
- Liquid and pipeline delivery networks compete for large stations

# 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)

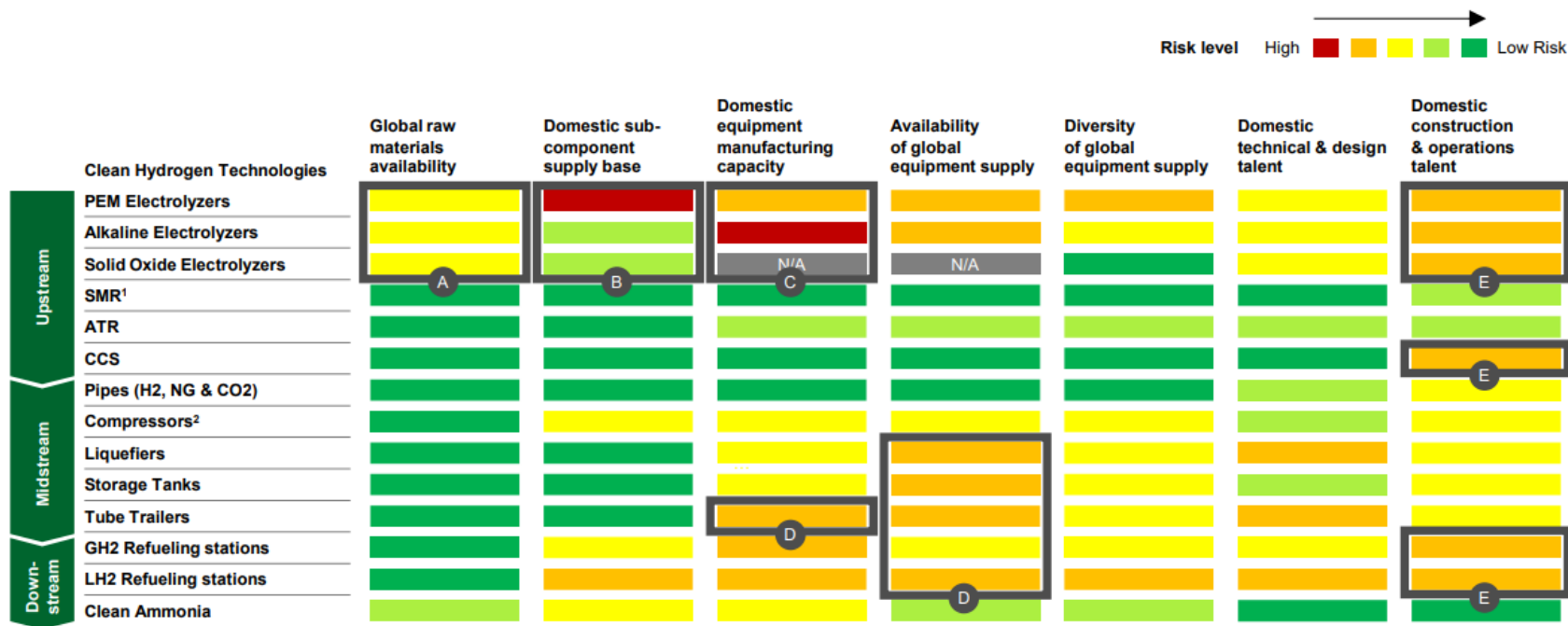


## Timing Considerations



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

# 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

---

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

NREL/PR-8A00-92352

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

