U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

# DOE Hydrogen and Fuel Cells Activities Overview


## Sunita Satyapal – Director, Fuel Cell Technologies Office

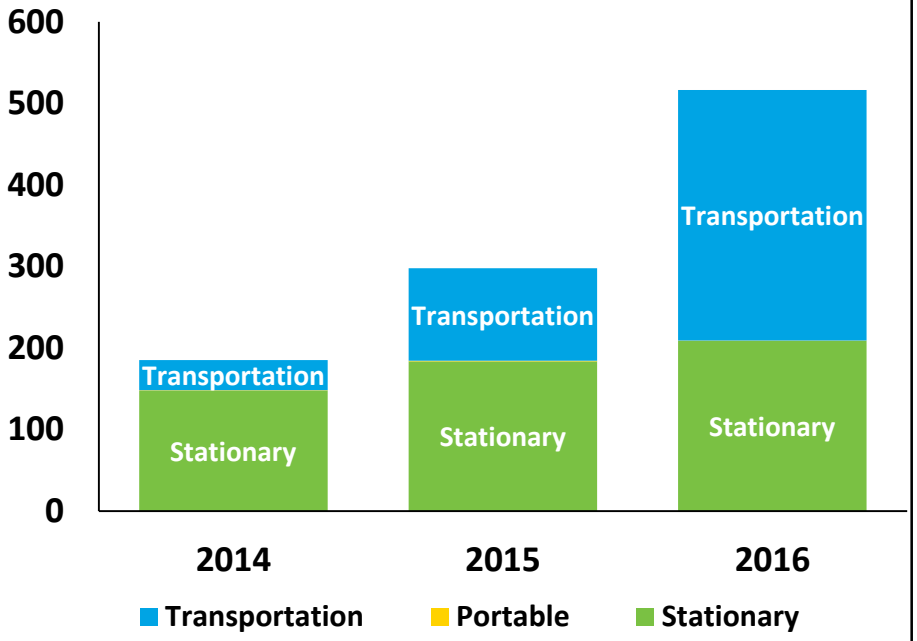

H2@Scale Session – Fuel Cell Seminar

Long Beach, CA- Nov. 7, 2017

# Time for Growth in the Fuel Cell Industry

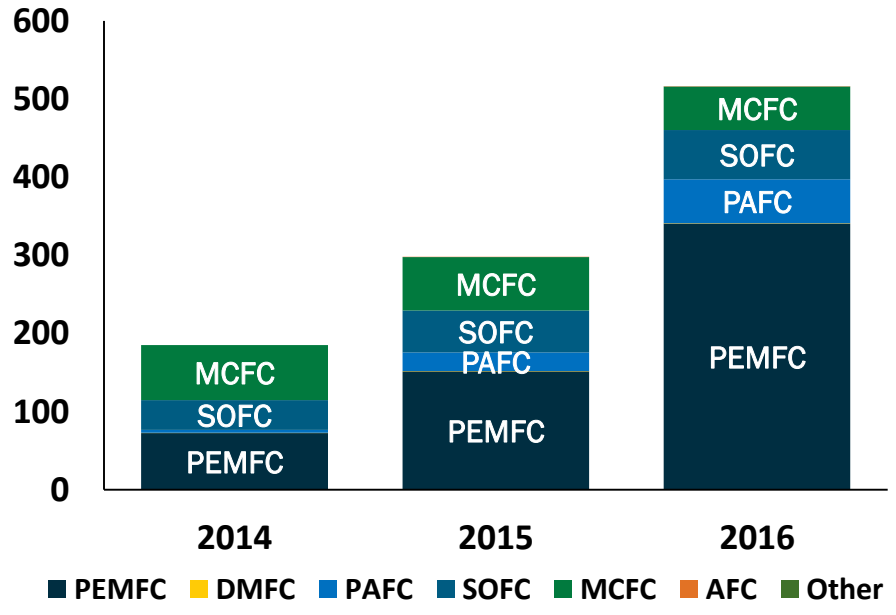
## Total power (in MW) shipped by application

### Growth in Transportation




## Total power (in MW) shipped by fuel cell chemistry

### Growth in PEMFC




**500 MW** fuel cell power shipped worldwide

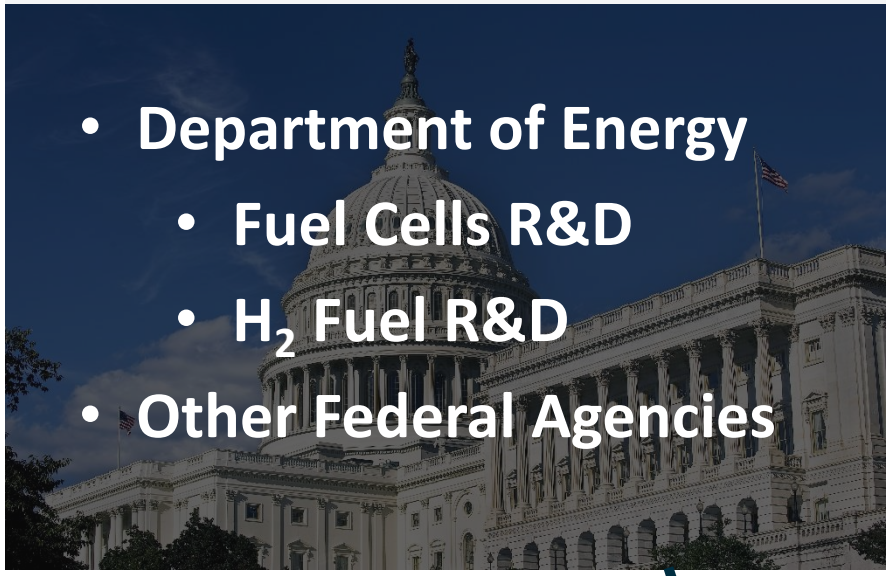
**62,000** fuel cell units shipped worldwide

Approximately **$1.6 Billion** fuel cell revenue

Source: DOE Fuel Cell Technologies Market Report. Available at: https://energy.gov/eere/fuelcells/market-analysis-reports

# Technology Development Roles

## Early- Stage R&D



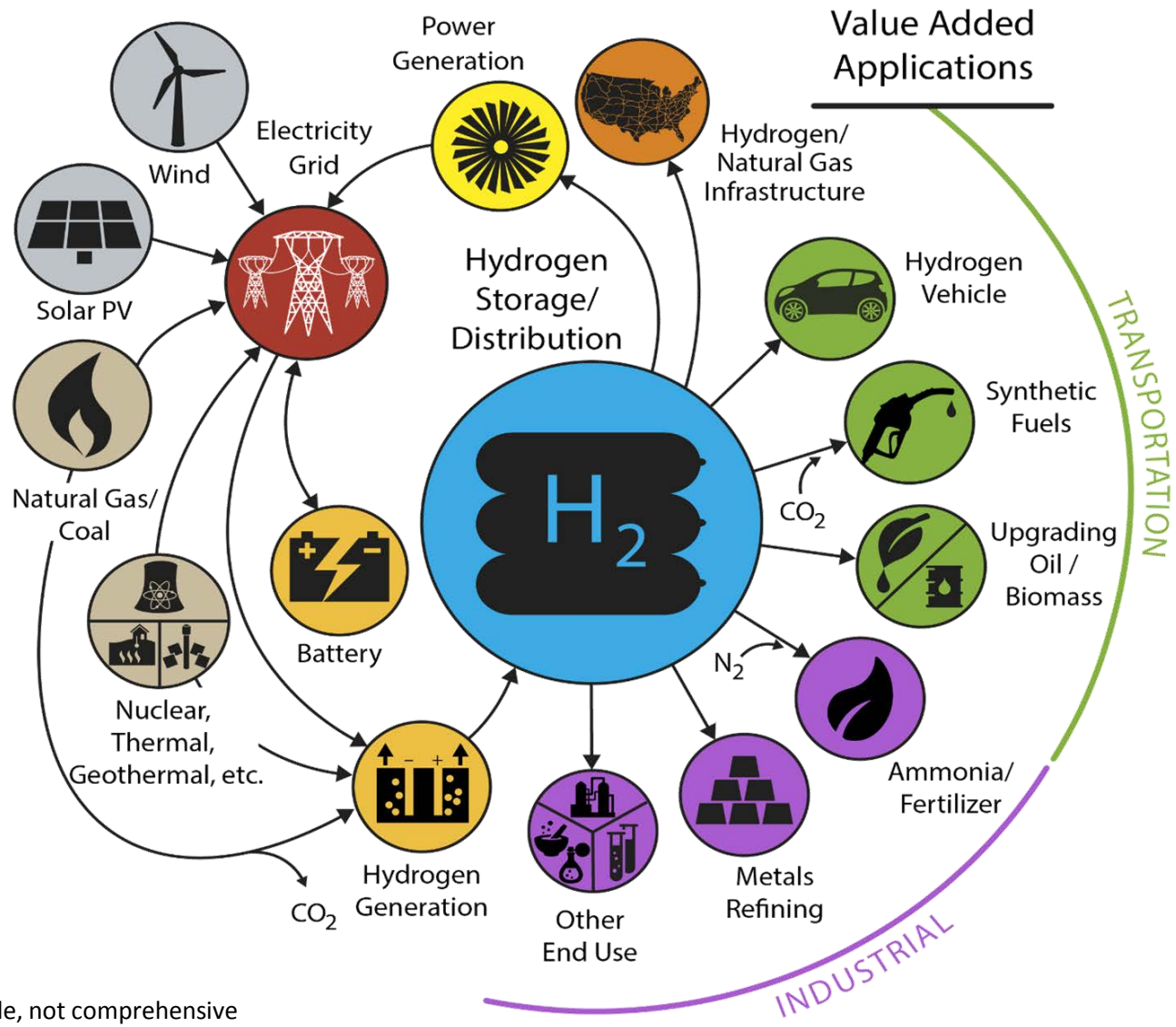
- Department of Energy
  - Fuel Cells R&D
  - $H_2$ Fuel R&D
- Other Federal Agencies

## Demonstration, Deployment & Commercialization

- Private Sector
- Partnerships
  - $H_2$USA
  - CaFCP

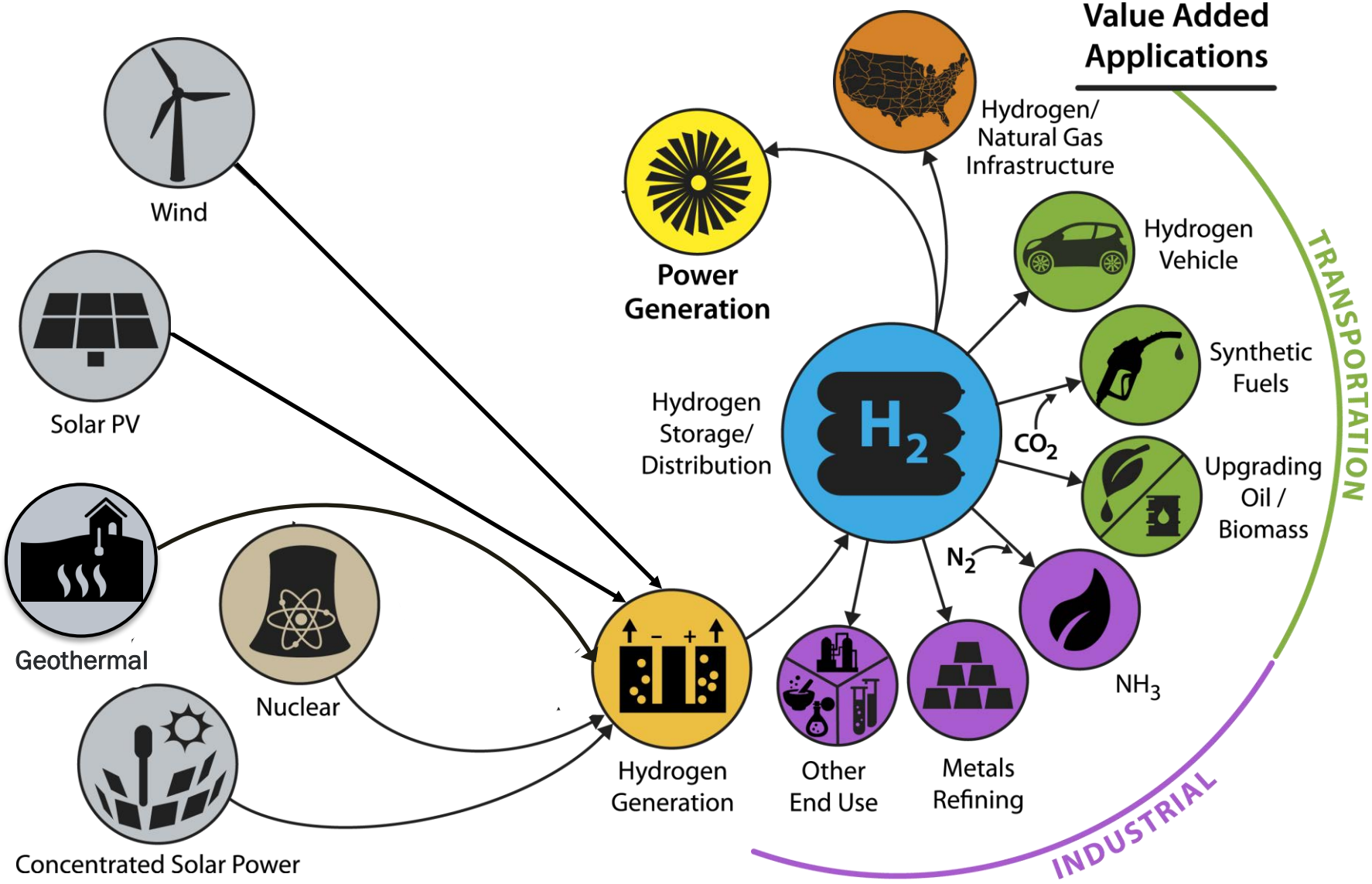
**H2@Scale**

# $H_2$ at Scale Energy System



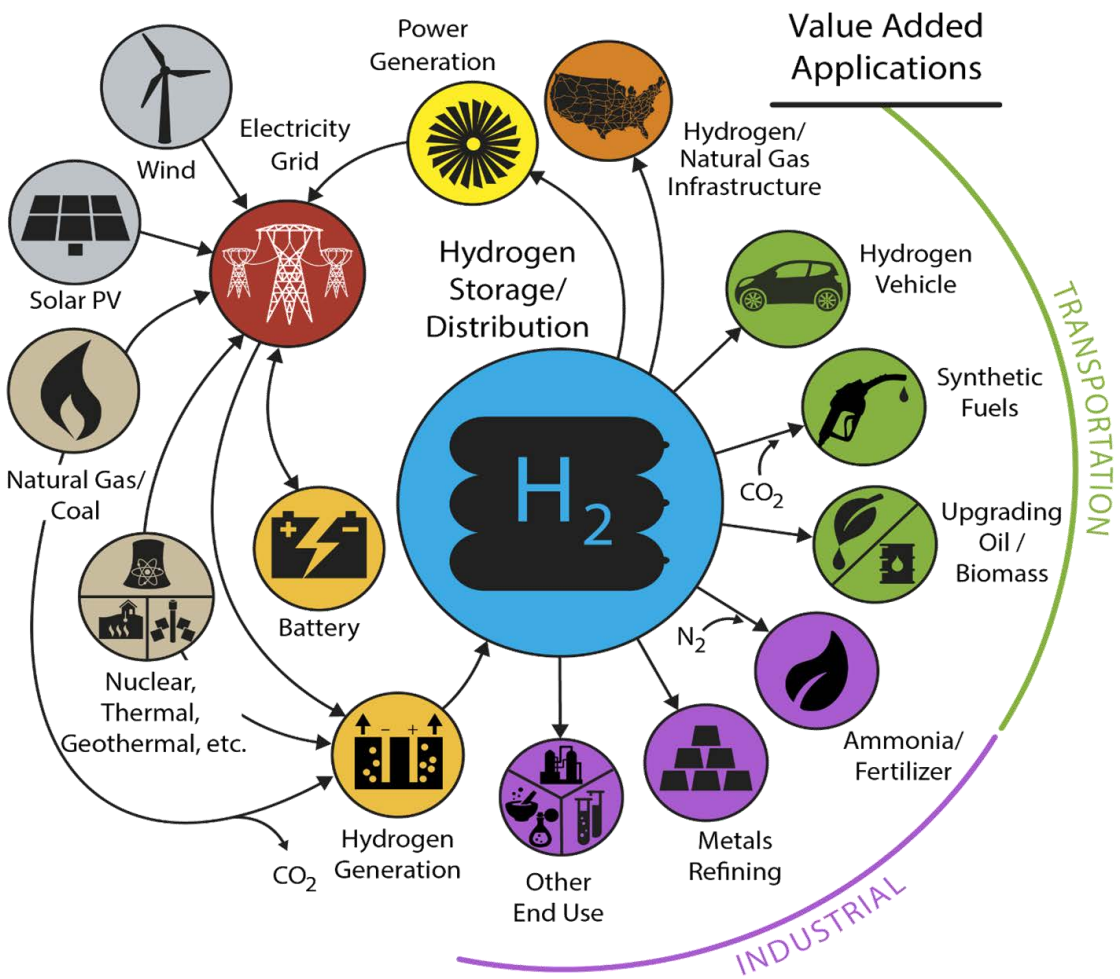

*Illustrative example, not comprehensive
Source: NREL

# $H_2$ at Scale Energy System



# Focus and R&D Needs - Examples

## H2@Scale Energy System




*Illustrative example, not comprehensive
Source: NREL

### Focus

**Modular, scalable concepts for dispatchable:**

- **$H_2$ production, delivery and storage**
- **$H_2$ liquefaction**
- **$H_2$ materials** development
- **$H_2$ integration** with other generation sources

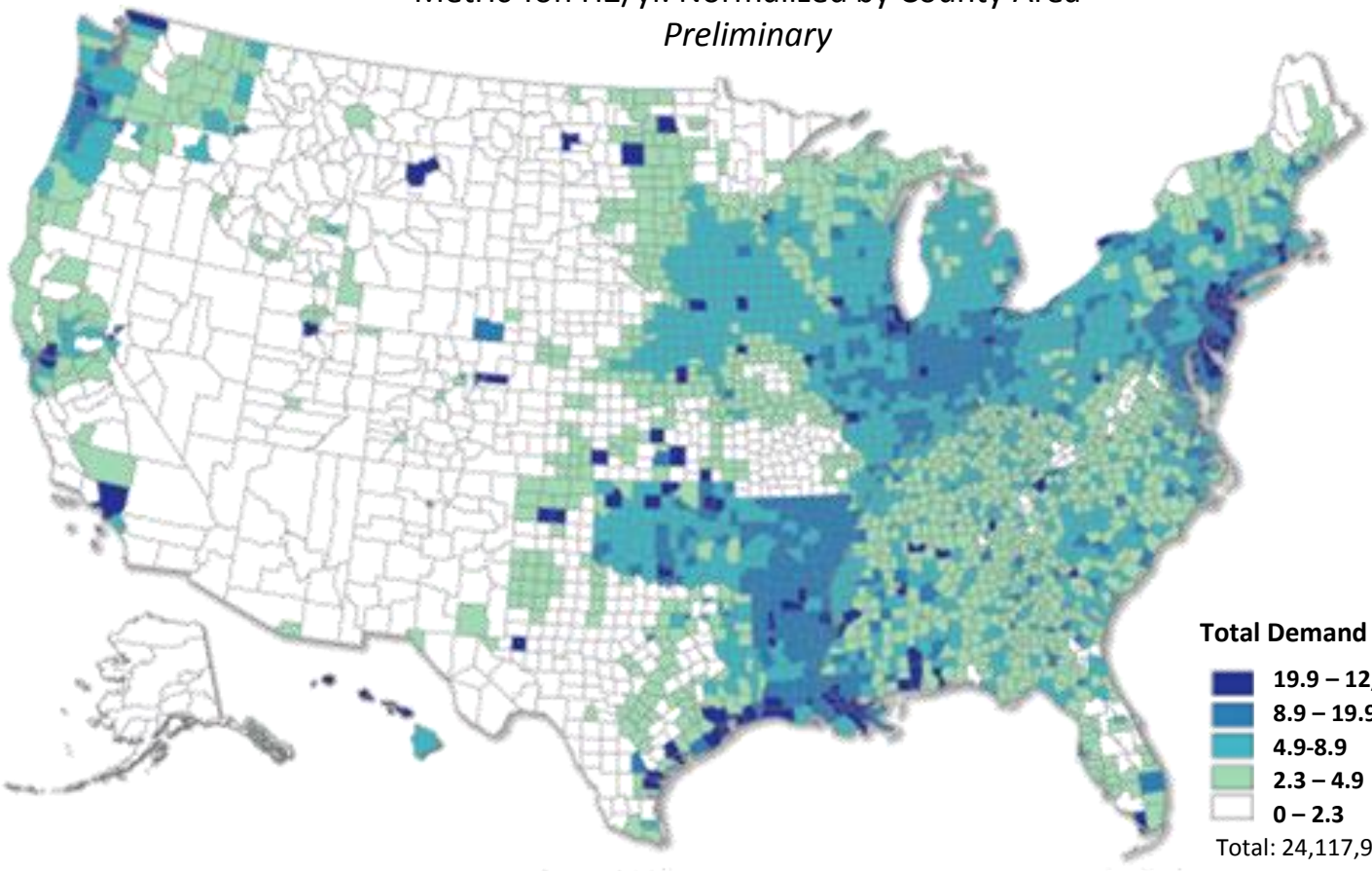
### R&D Needs (examples)

- **High and Low Temp. $H_2$ generation** (i.e. electrolysis)
- **$H_2$ Materials Compatibility**
- **Reliability and Safety of $H_2$ Storage and Distribution**
- **Grid Integration**

# Market Potential for Hydrogen Demand

## 60 Million Metric Tons of Hydrogen/ Year

**Total Hydrogen Demand for the Industrial Sector**
Metric Ton H2/yr. Normalized by County Area
*Preliminary*



**Total Demand** (metric ton H2 per sq mi/yr)

- **19.9 – 12,677**
- **8.9 – 19.9**
- **4.9-8.9**
- **2.3 – 4.9**
- **0 – 2.3**

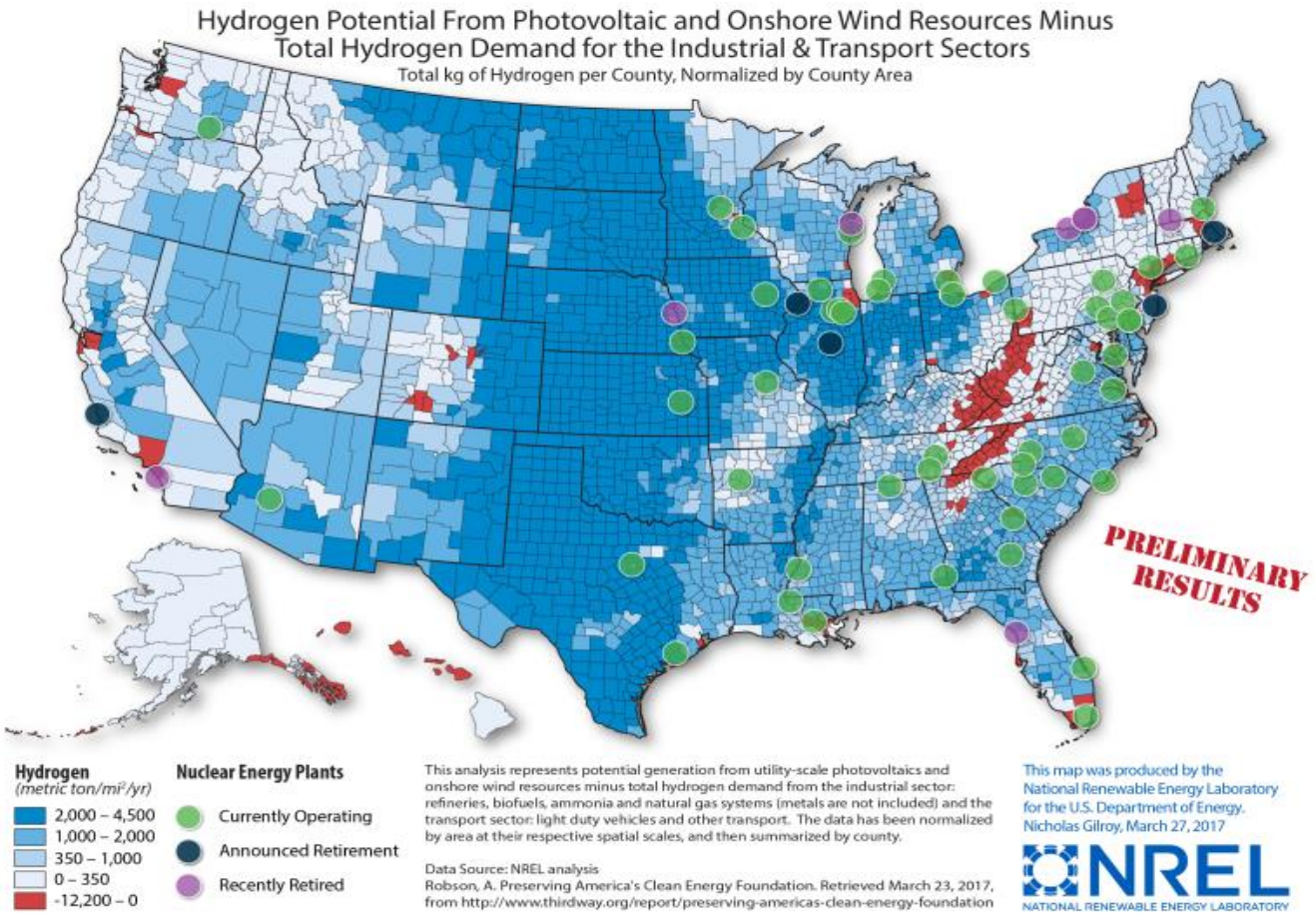
Total: 24,117,925 metric ton H2/yr.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

## Multiple Industries:

- **Refinery**
- **Metals**
- **Ammonia**
- **Natural Gas**
- **Biofuels**
- **LDVs**
- **Other transportation**

# H2@Scale: Nationwide Resource Assessment



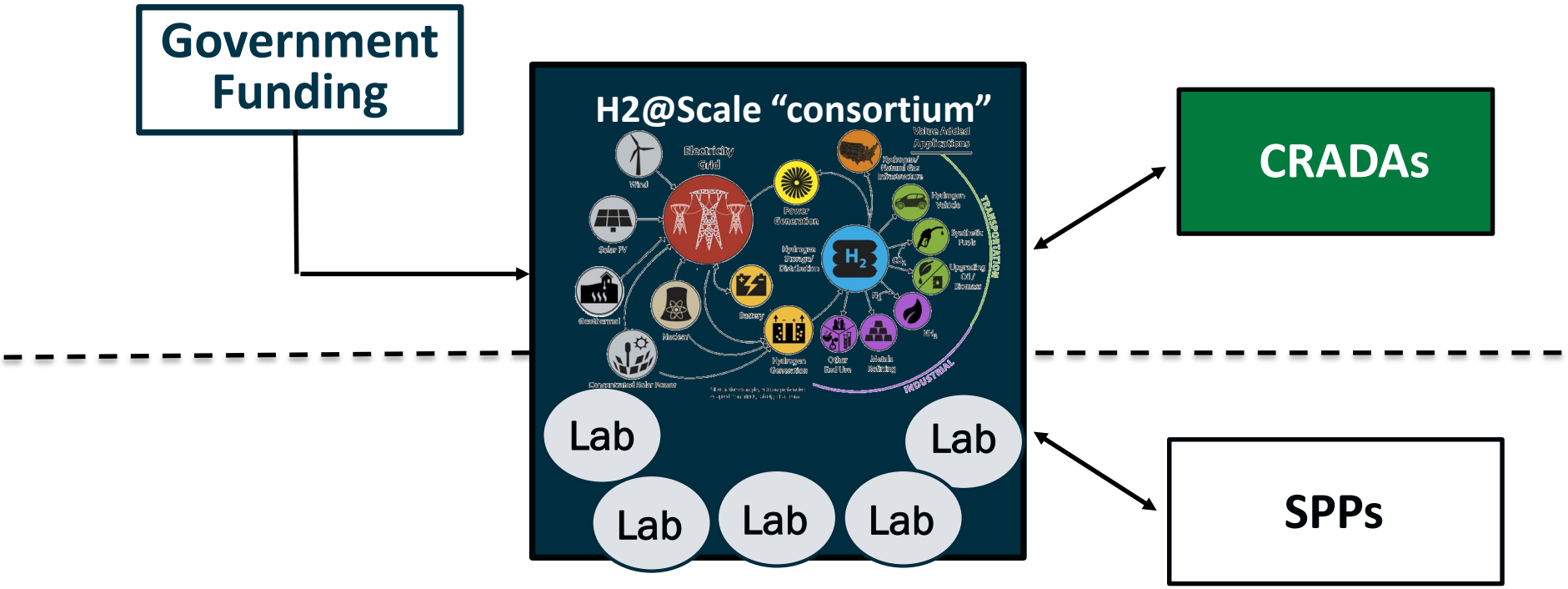

Lab PIs: Mark Ruth, Bryan Pivovar, Richard Boardman, et al

**Labs assess resource availability. Most regions have sufficient resources.**

Red: Only regions where projected industrial & transportation demand exceeds supply.

# How to work with H2@Scale – CRADA Call

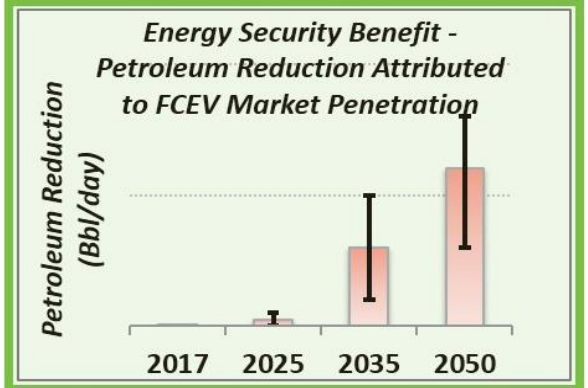
- To leverage **lab capabilities and expertise to address challenges- materials R&D, analysis, safety R&D, etc.**
- **Round 1 closed Sept. 15 – stay tuned for winners and future rounds**




CRADA = Cooperative Research and Development Agreement
SPP- Strategic Partnership Project ('Work for Others')

# H2@Scale R&D Pillars – Examples

## Technoeconomic Modeling and Analysis

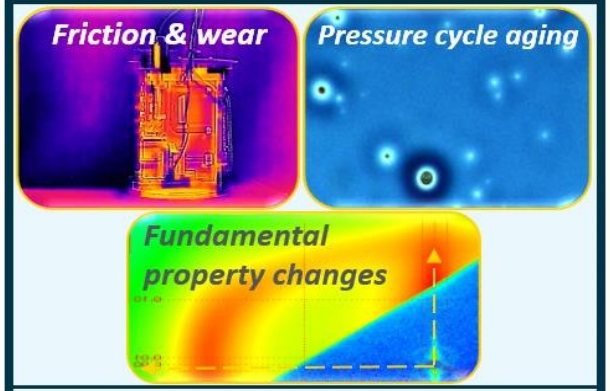



**Labs**

Argonne NATIONAL LABORATORY

NREL NATIONAL RENEWABLE ENERGY LABORATORY

## Hydrogen Materials Compatibility R&D




**Labs**

OAK RIDGE National Laboratory

Sandia National Laboratories

SRNL SAVANNAH RIVER NATIONAL LABORATORY

Pacific Northwest NATIONAL LABORATORY

## Grid simulation and Testing

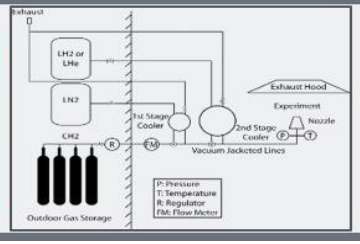
**Labs**

INL Idaho National Laboratory

NREL NATIONAL RENEWABLE ENERGY LABORATORY

## Safety R&D

HyRAM HYDROGEN RISK ASSESSMENT MODELS



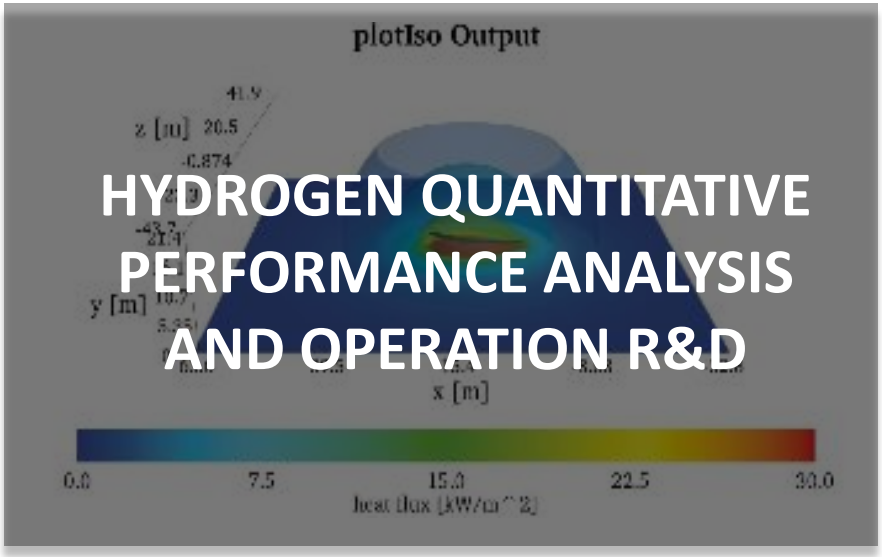

**Labs**

Sandia National Laboratories

NREL NATIONAL RENEWABLE ENERGY LABORATORY

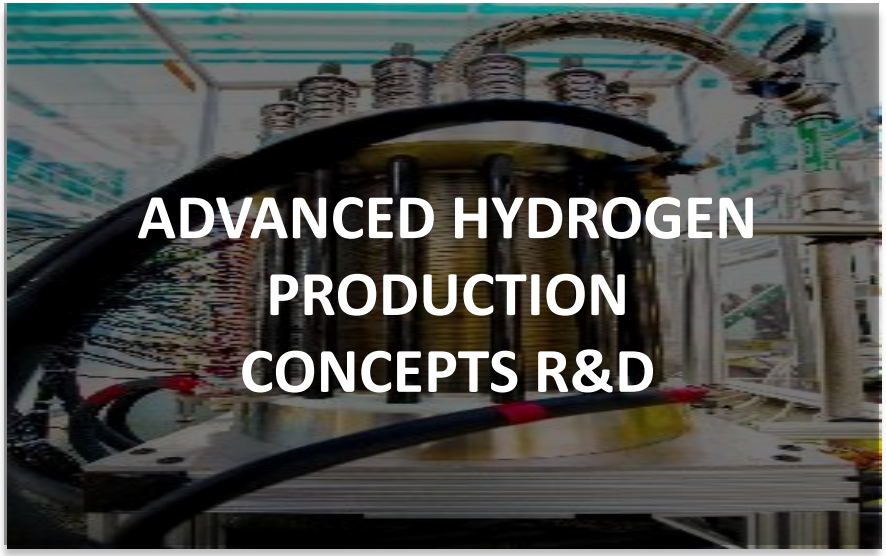
Pacific Northwest NATIONAL LABORATORY

# H2@Scale R&D Working Groups

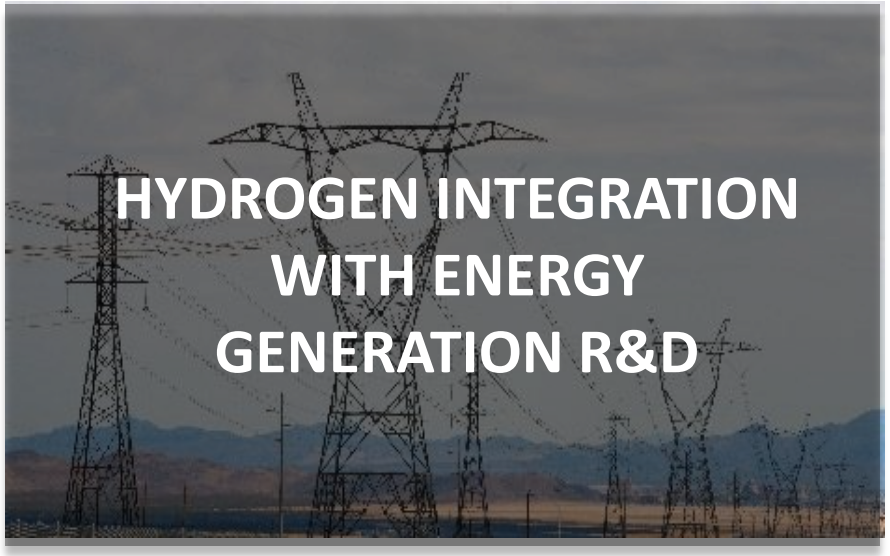



**HYDROGEN QUANTITATIVE PERFORMANCE ANALYSIS AND OPERATION R&D**

**HYDROGEN DISTRIBUTION COMPONENT DEVELOPMENT R&D**

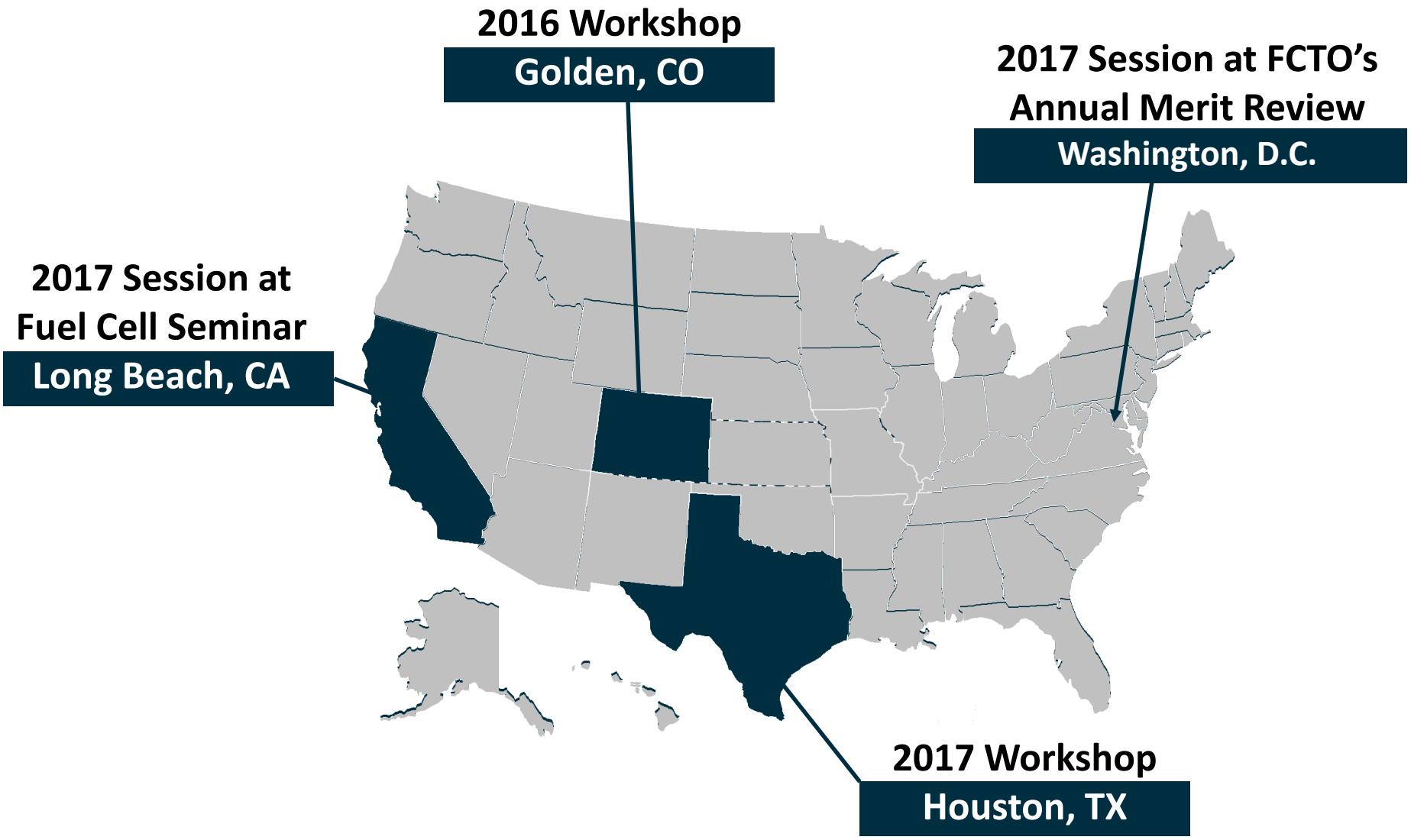


**ADVANCED HYDROGEN PRODUCTION CONCEPTS R&D**



**HYDROGEN INTEGRATION WITH ENERGY GENERATION R&D**

# H2@Scale Stakeholder Feedback – Examples



# H2@Scale CRADA Call Recipients

## First round of Selections Include 22 Applications from…

- Air Liquide
- Aquahydrex
- California Energy Commission
- California Governor's Office of Business and Economic Development
- Connecticut Center for Advanced Technology
- C4-MCP, Inc.
- Electric Power Research Institute
- Exelon
- Frontier Energy
- Giner
- GTA, Inc.
- Honda
- HyET
- NanoSonic
- Pacific Gas & Electric
- PDC
- Quong & Asssociates, Inc.
- RIX
- Southern Company
- Tatsuno
- Terrapower

Argonne NATIONAL LABORATORY
INL Idaho National Laboratory
BERKELEY LAB
NREL NATIONAL RENEWABLE ENERGY LABORATORY
Pacific Northwest NATIONAL LABORATORY
Sandia National Laboratories
SRNL SAVANNAH RIVER NATIONAL LABORATORY OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

***Selections and subsequent working group assignments are subject to negotiation.***


FUEL CELL
Powered by
Hydrogen Fuel Cells

# Save the Date

## 2018 Annual Merit Review

June 13 -15
Washington D.C.

# Objectives for Today

- **Introduce the H2@Scale Consortium**
- **Identify opportunities to align hydrogen technologies** with evolution in power generation, transmission and transportation sectors.
- **Assess hydrogen infrastructure needs** to cost effectively match growth of diverse industries.

# Thank You

**Dr. Sunita Satyapal**
Director
Fuel Cell Technologies Office
Sunita.Satyapal@ee.doe.gov

**energy.gov/eere/fuelcells**