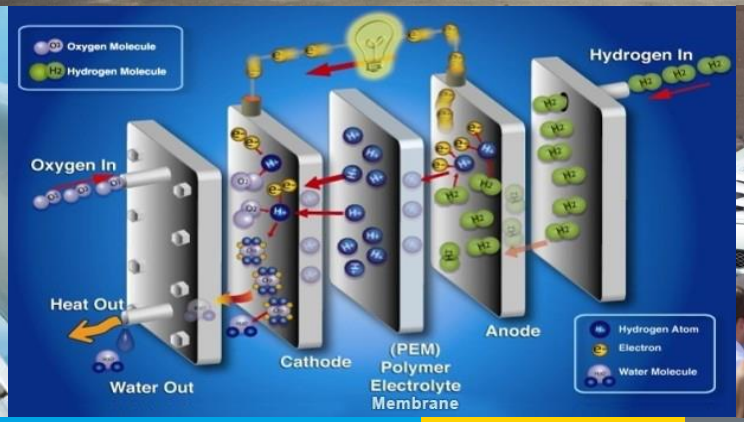
U.S. Department of Energy Hydrogen and Fuel Cells Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



H2@Scale Review
2017 DOE AMR

Washington, DC

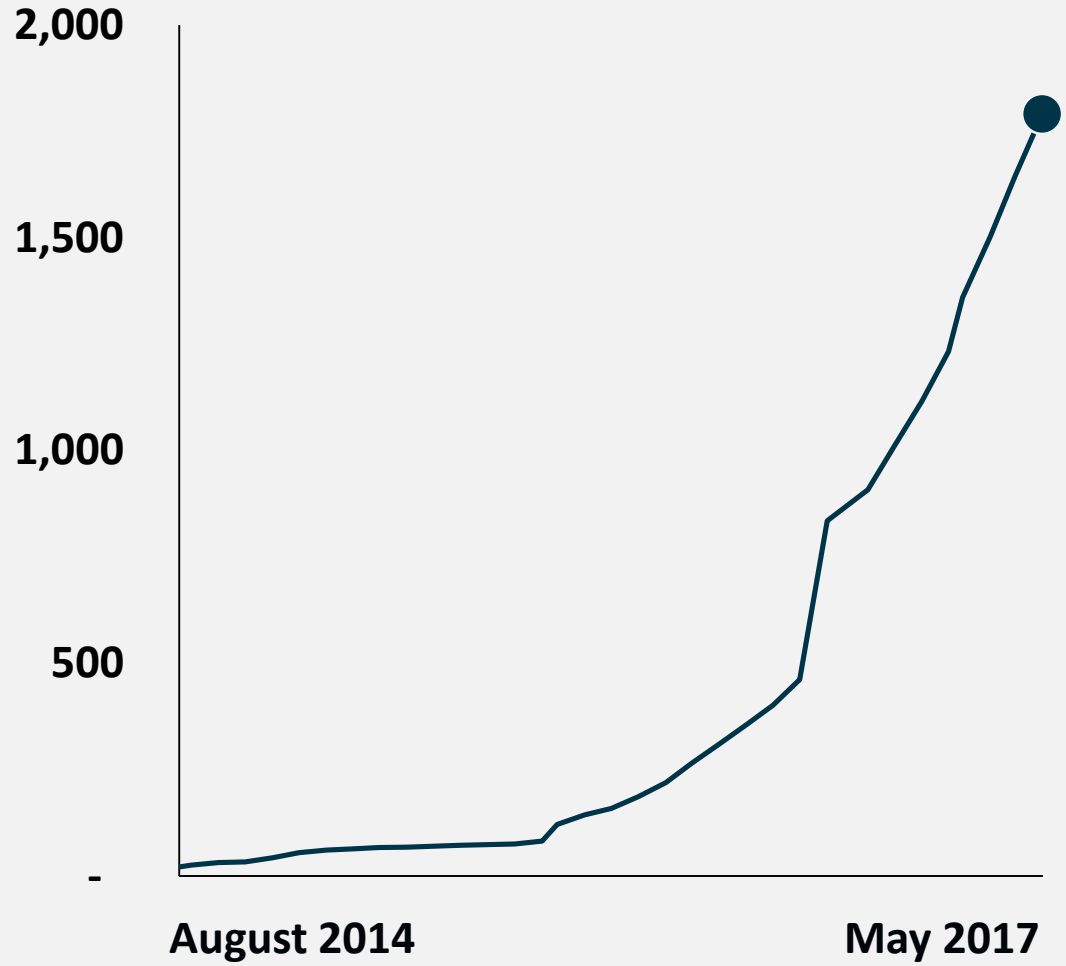
June 9, 2017

Dr. Sunita Satyapal

Director
Fuel Cell Technologies Office
U.S. Department of Energy

U.S. Fuel Cell Car Sales and Expert Outlook

Fuel Cell Car Sales Growing



Note: Cumulative number of vehicles sold/leased. Source: hybridcars.com

2,000 fuel cell cars

sold or leased in the U.S.

78%
of executives

Absolutely or partly **agree that**

Fuel cell cars will be the real breakthrough for electric mobility

KPMG, Global Automotive Executive Survey 2017 (Jan. 2017)

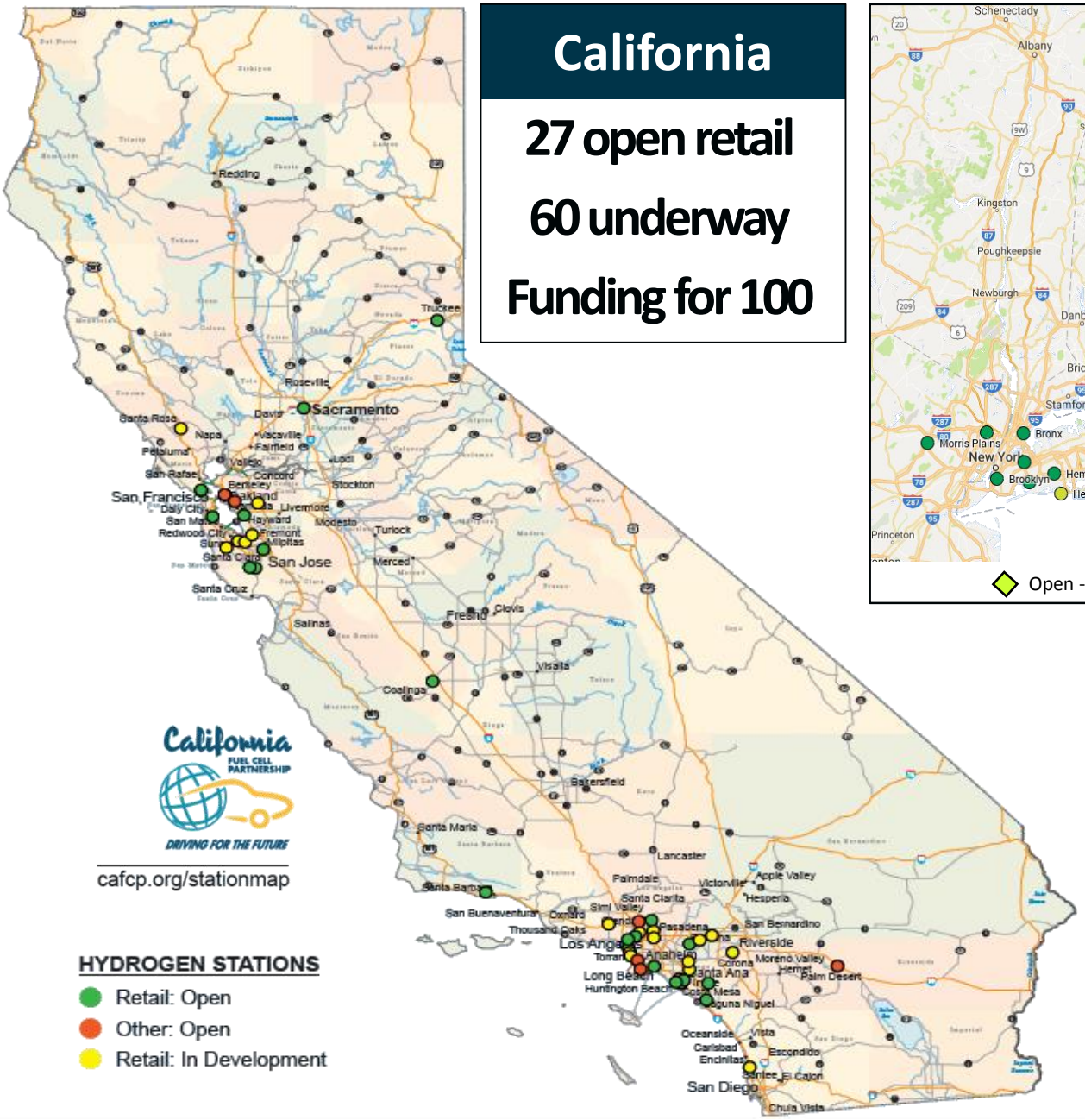
Hydrogen Stations – California and Northeast Area

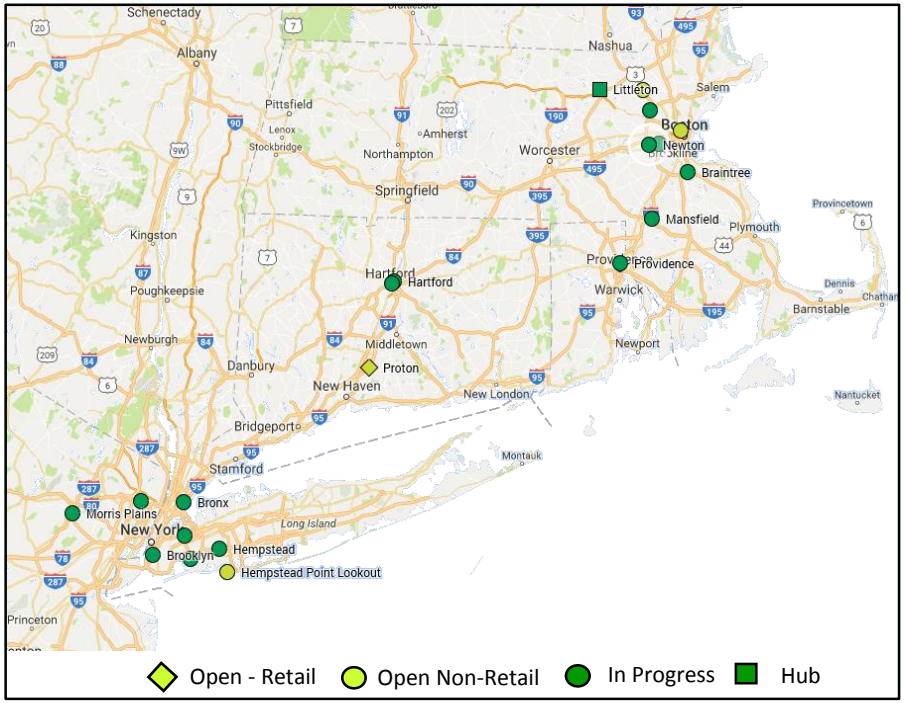
California

27 open retail

60 underway

Funding for 100





Northeast

Approx. 12 to 25 retail planned

2017 Preliminary Jobs Analysis Updates

Approx. **16,000** jobs today

in the **fuel cell car sector in the U.S.**

Source: DOE, U.S. Energy and Employment Report (2017)

Over **200,000** potential jobs

in the future **with fuel cell cars** in the U.S.

Includes Direct and Indirect Jobs in

Manufacturing

Approx.
100,000 jobs

- **Multiple industries** (manufacturing; professional services; wholesale, retail, transportation; etc.)
- **60% in industrial central region**

Distribution and Sales

Approx.
150,000 jobs

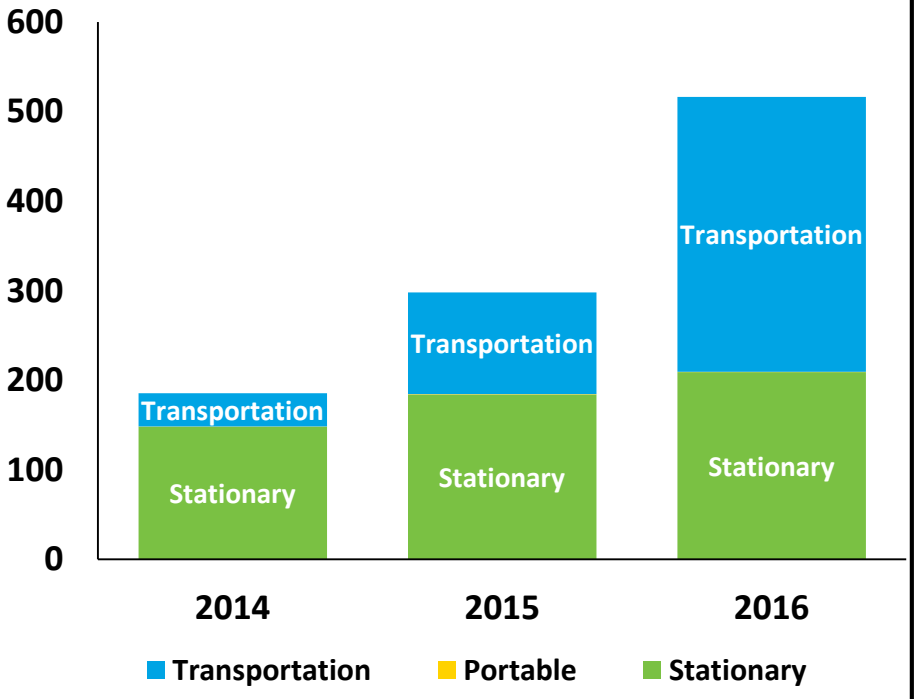
- **50% in Western and Northeast** (highest fuel cell car sales regions)
- **Multiple occupations available** including retail sales**,** vehicle operators, supervisors of sales, mechanics, etc.

Source: Preliminary DOE ANL Employment Study, June 2017, updates underway

2016 Global Shipments – Trends

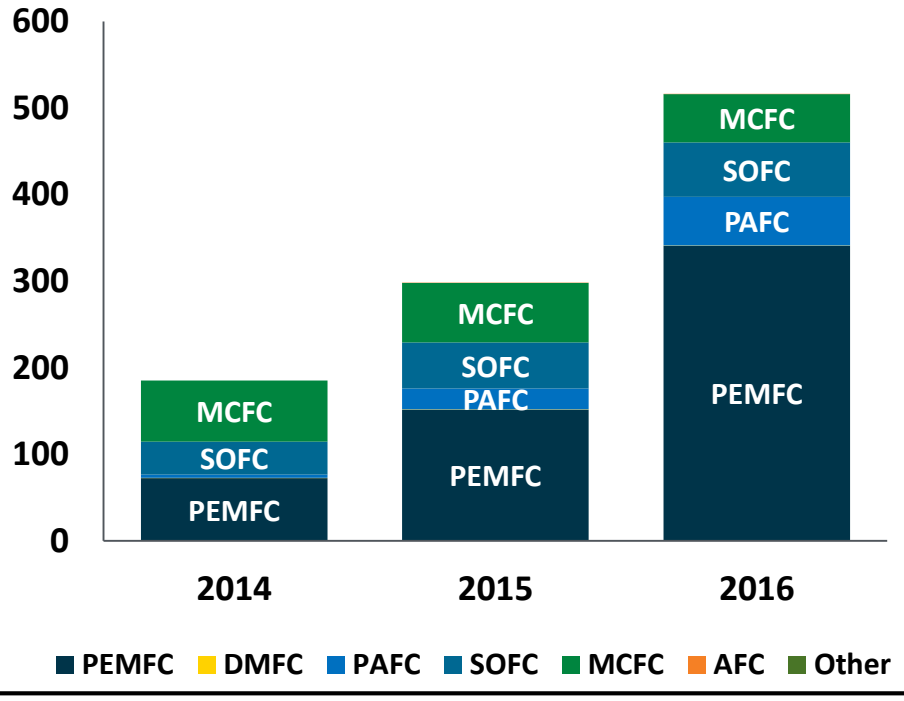
Total power (in MW) shipped by application

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: E4tech

Innovation

650 H_2 and fuel cell **patents** enabled by FCTO funds

Approx. **40%** of H_2 and fuel cell patents come from National Labs

Market Impact

More than **30** **Technologies** commercialized by private industry

and over **75** **with potential** to be commercial in the next 3-5 years

can be traced back to FCTO R&D

Examples of Progress enabled by DOE FCTO in the last decade

Fuel Cell R&D

- Reduced cost 60%
- Quadrupled durability

H2 Production R&D

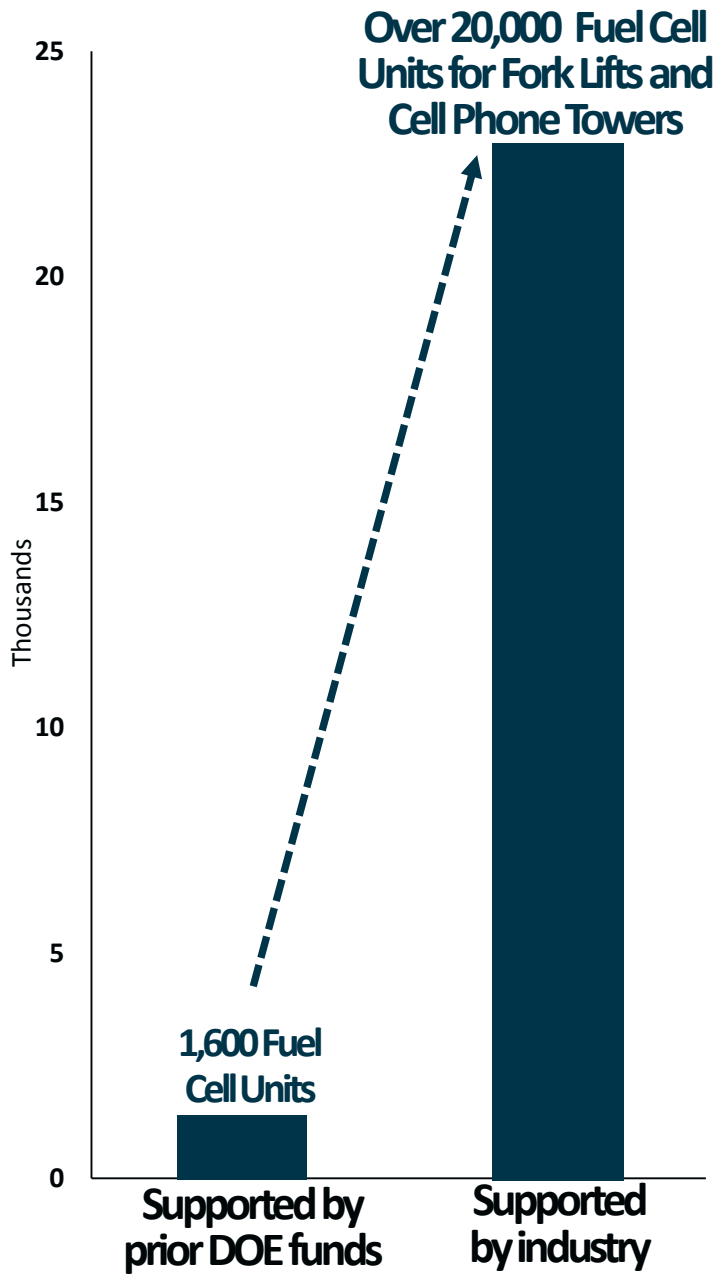
- Cut electrolyzer costs 80%

Industry Orders for Fuel Cells on the Rise

BMW plant in Greer, South Carolina

Over 15,000 fuel cell forklifts deployed or on order

Approx. 6 million hydrogen refuelings to date



DOE-Industry Cost Shared Prototypes

1st fuel cell cargo tow trucks at U.S. airport

New DOE-Industry Cost Shared Prototypes

Fuel Cell Electric Delivery and Parcel Trucks

First of its kind demonstration starting deliveries in the summer!

New DOE-Industry Cost Shared Prototypes

World's first fuel cell for maritime ports

Hydrogen & Fuel Cells Budget (EERE FCTO)

Key Activity	FY 2016 ($ in thousands) Approp.	FY 2017 ($ in thousands) Enacted	FY 2018 ($ in thousands) Request
Fuel Cell R&D	35,000	32,000	15,000
Hydrogen Fuel R&D[1]	41,050	41,000	29,000
Manufacturing R&D	3,000	-	0
Systems Analysis	3,000	3,000	1,000
Technology Validation	7,000	18,000	0
Safety, Codes and Standards	7,000	7,000	0
Market Transformation	3,000	-	0
Technology Acceleration[2]	0	-	0
NREL Site-wide Facilities Support	1,900	-	0
Total	100,950	101,000	45,000

White House Budget Proposal Language FY 2018

- Increased reliance on the **private sector to fund later-stage research, development, and commercialization**
- Focuses resources toward **early-stage research and development**

DOE Basic Energy Sciences FY16 funding relevant to H_2 and fuel cells: $24.7 M

[1]Hydrogen Fuel R&D includes Hydrogen Production & Delivery R&D and Hydrogen Storage R&D
[2]Combines Manufacturing R&D, Technology Validation, Market Transformation.

Stronger emphasis on early R&D and relying on industry for later stage R&D

Collaboration
is
Critical

DOE National Lab System: A Reservoir of Talent for Science and Technology

Founded by DOE nearly 80 years ago

War effort motivated scientific breakthroughs: Manhattan project, radar development

A few $M in **DOE investment** in the ‘40s

Labs at ~ $10B today

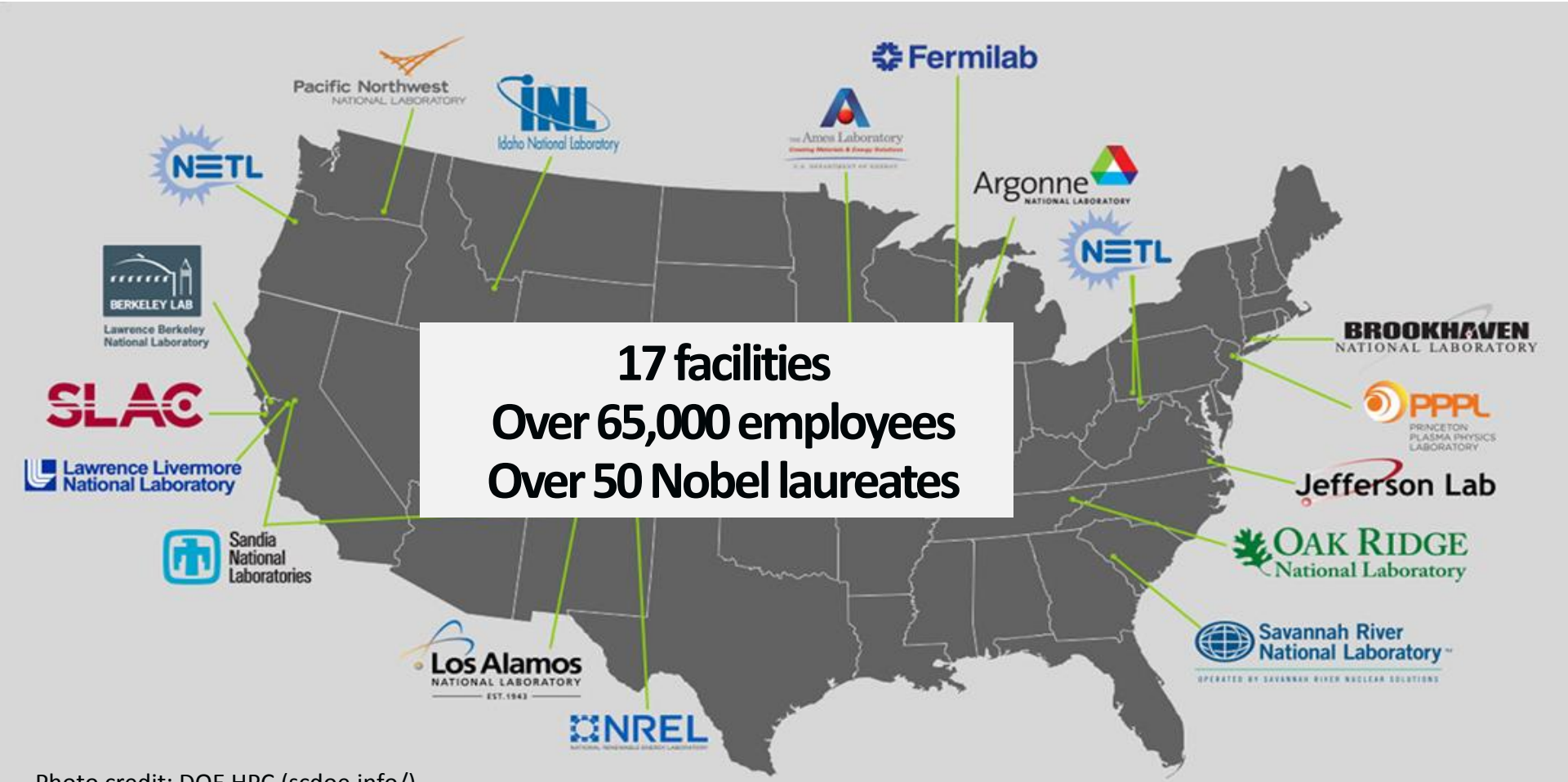


Photo credit: DOE HPC (scdoe.info/)

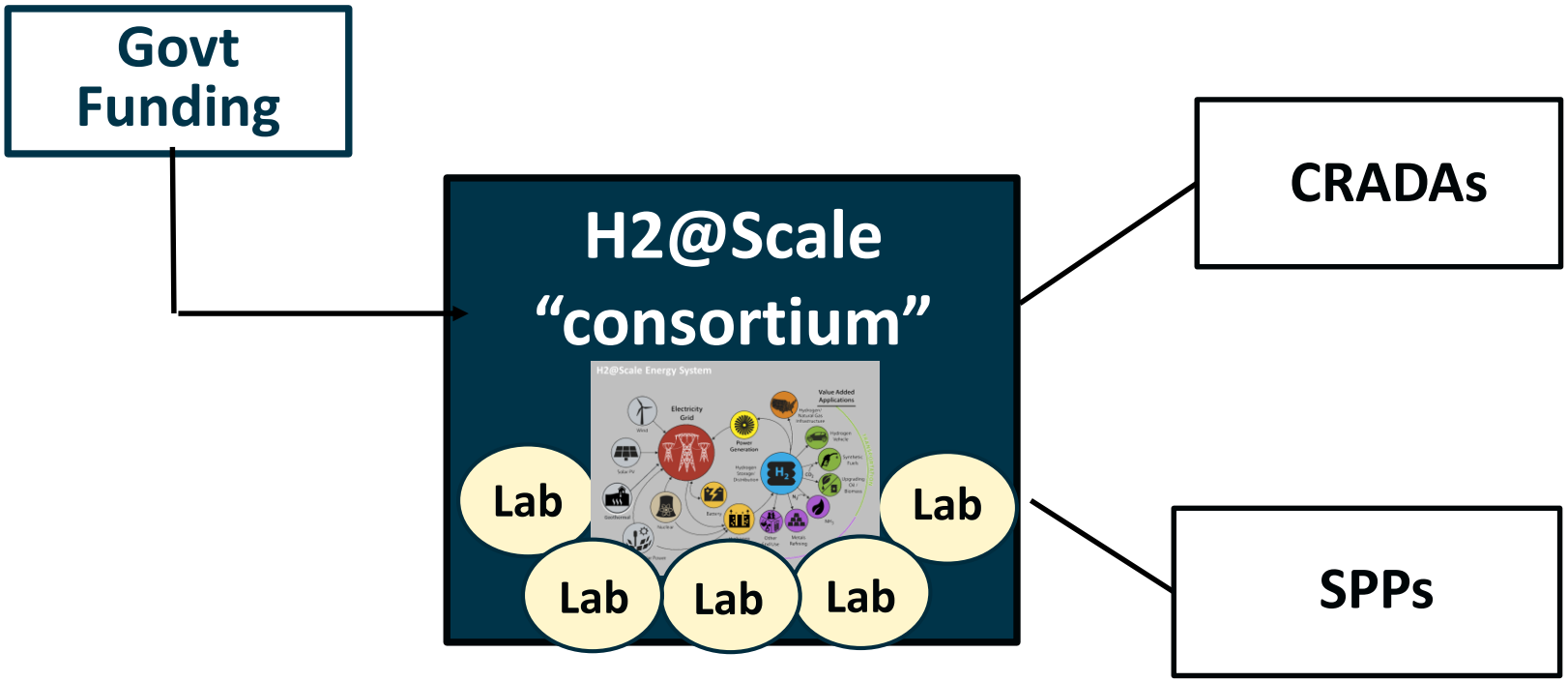
H2@Scale CRADA Call Planned

(Cooperative Research & Development Agreement)

to work with National Labs

Up to $3M in FY17 Funds

Strategy- CRADA Call Planned



CRADA- Cooperative Research and Development Agreement

SPP- Strategic Partnership Project ('Work for Others')

Other Lab Capabilities (Examples- Draft)

Modeling and Analysis

Examples

- Value proposition
- Demand/market projection
- Cost/benefit, financial and application evaluation
- Scenario analysis
- Resource assessment

Labs

Argonne NATIONAL LABORATORY

NREL NATIONAL RENEWABLE ENERGY LABORATORY

H_2 – Materials Compatibility R&D

Examples

- H_2 materials exposure effects testing
- Materials selection and innovation

Labs

OAK RIDGE National Laboratory

Sandia National Laboratories

SRNL SAVANNAH RIVER NATIONAL LABORATORY

Pacific Northwest NATIONAL LABORATORY

Simulation and Testing

Examples

- Grid simulation
- Electrolyzer performance testing
- Model Validation

Labs

INL Idaho National Laboratory

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Pacific Northwest NATIONAL LABORATORY

Safety R&D

Examples

- Hydrogen behavior assessment
- Safety training and outreach
- Certification/permitting
- Quantitative risk assessment
- Safety testing and model validation
- Project/Facility safety review

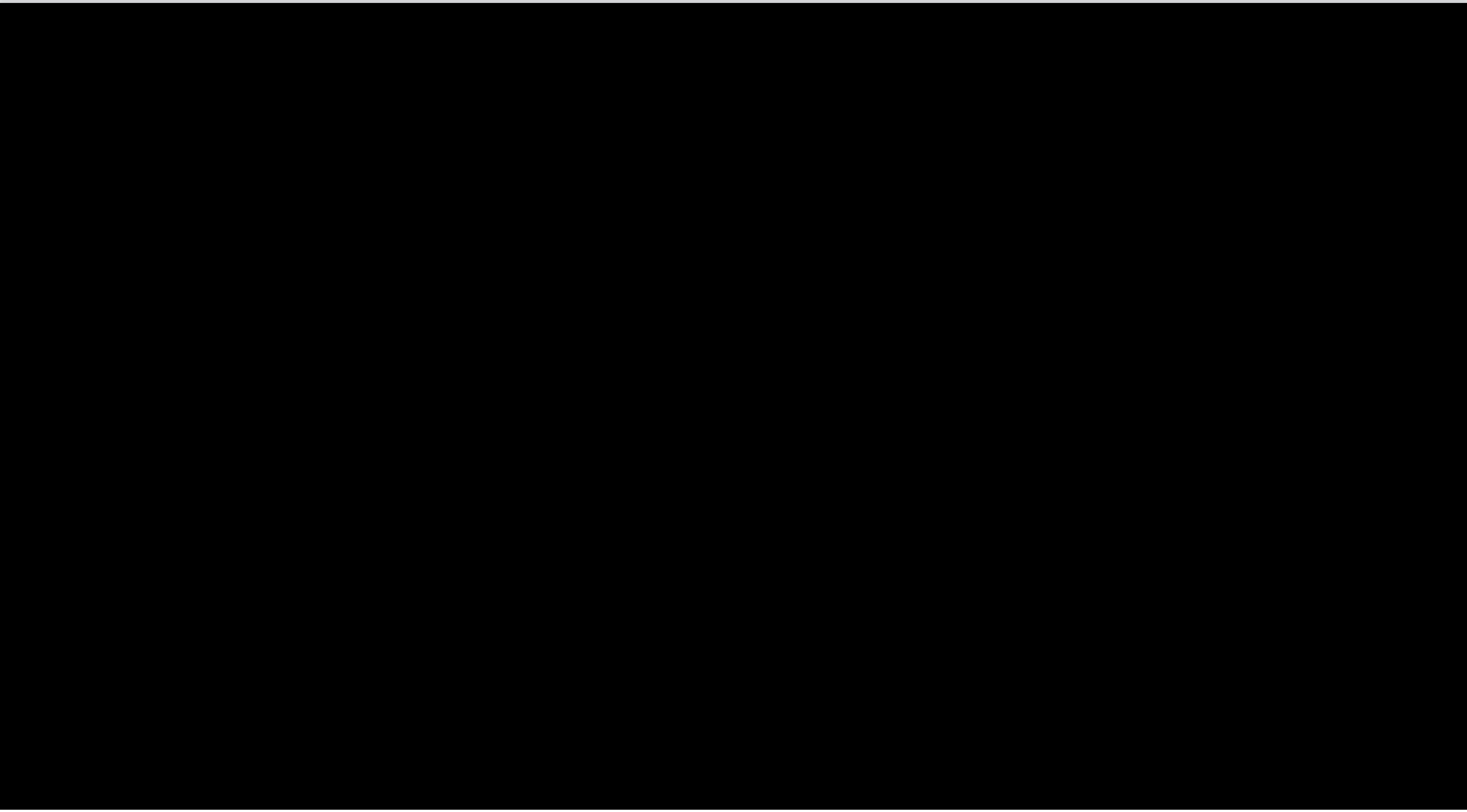
Labs

Sandia National Laboratories

Pacific Northwest NATIONAL LABORATORY

H_2 safety panel

Innovation at the National Labs



Thank You

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