U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Hydrogen Potential as Energy Storage and the Grid

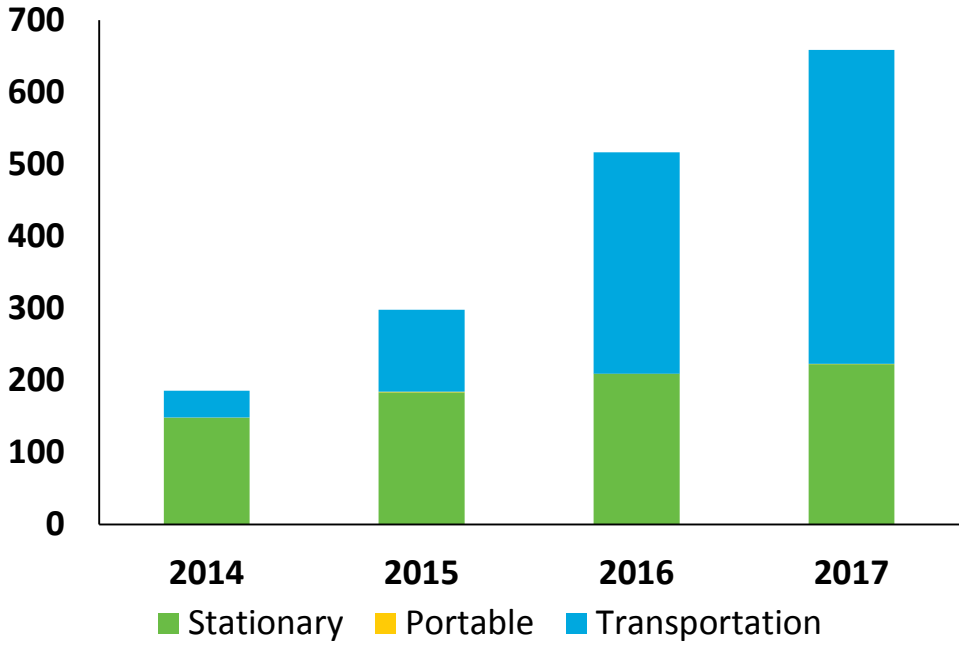
Dr. Sunita Satyapal, Director, Fuel Cell Technologies Office

VerdExchange Conference

January 18, 2019 – Los Angeles, CA

An exciting time for hydrogen and fuel cells

650 Fuel Cell Power Shipped (MW) worldwide in 2017*



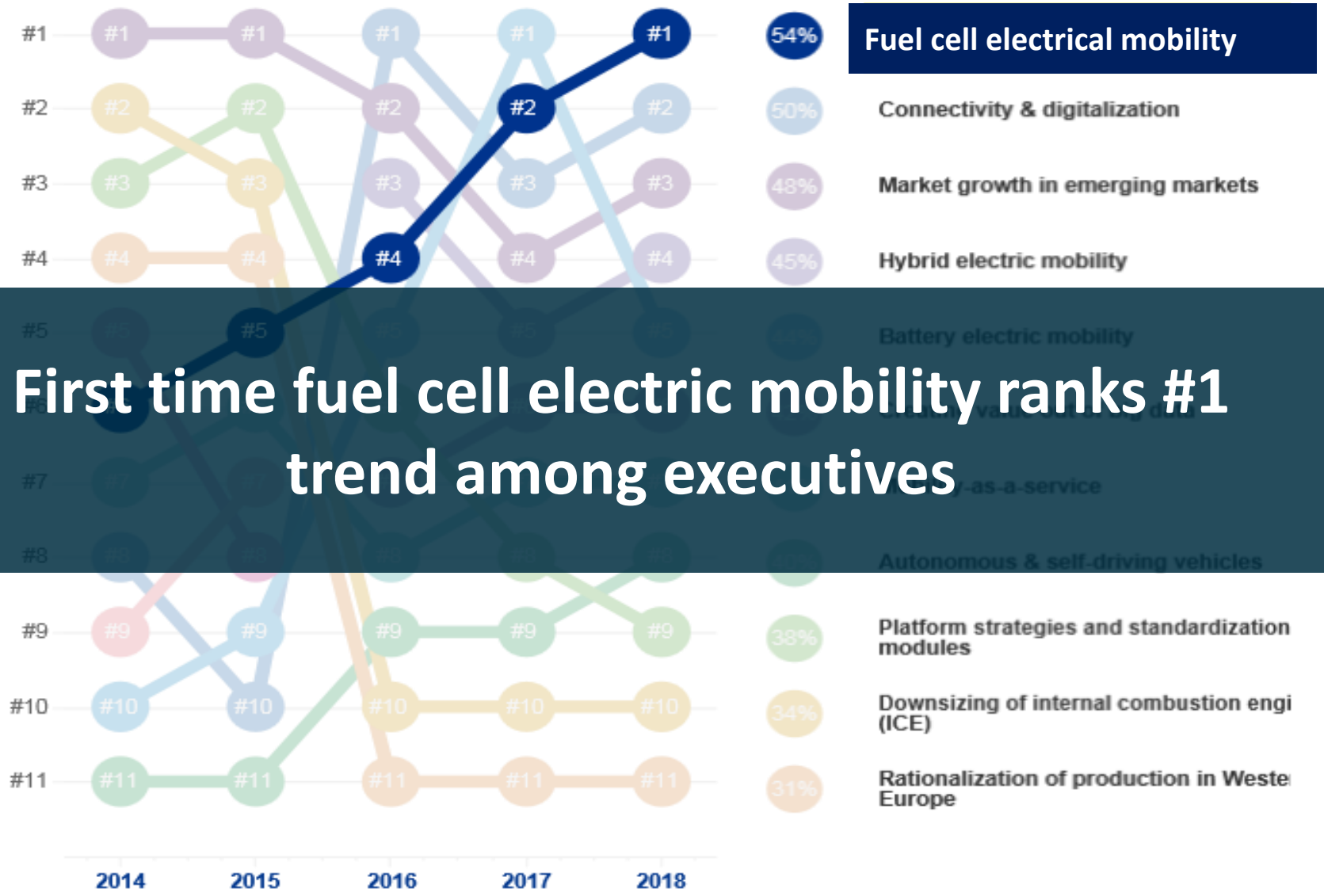
Sales in 2017

- 70,000 fuel cell units shipped*
- Global sales for electrolyzers estimated at over 100MW/year**

*DOE and E4tech
**Courtesy of NOW, E4tech and partners: A collaborative effort to assess electrolyzer market potential

Over 6,200 fuel cell cars sold or leased in the United States. Over 360 mi driving range.

Automotive Executives Survey Results



First time fuel cell electric mobility ranks #1 trend among executives

Source: KPMG Global Automotive Executive Survey 2018

Long-Range, Heavy Duty Applications Emerging

Fuel cell delivery and parcel trucks starting deliveries in CA and NY

Fuel cell buses in CA surpass 19M passengers

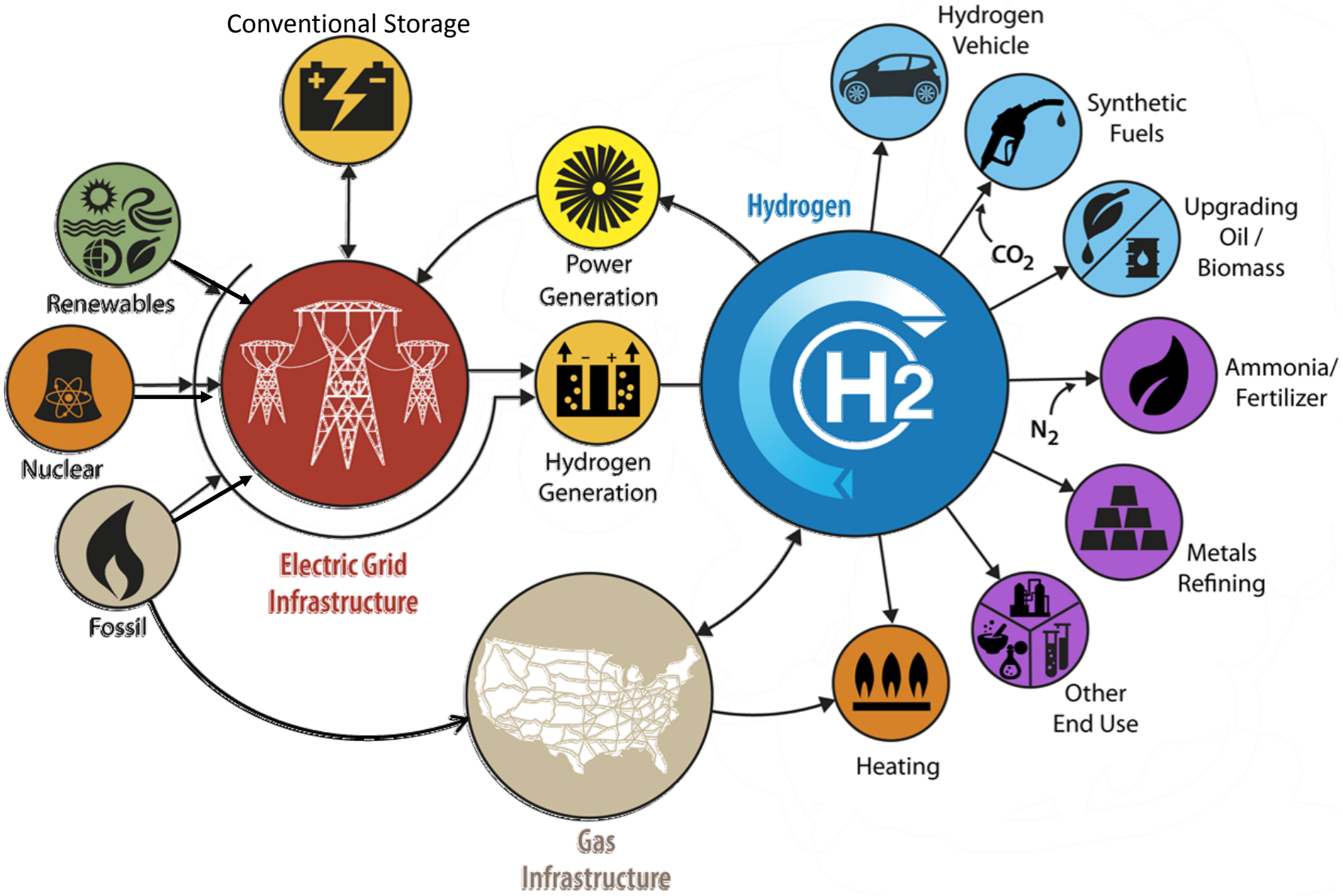
Industry demonstrates first heavy duty fuel cell truck in CA

Interest in material handling equipment applications

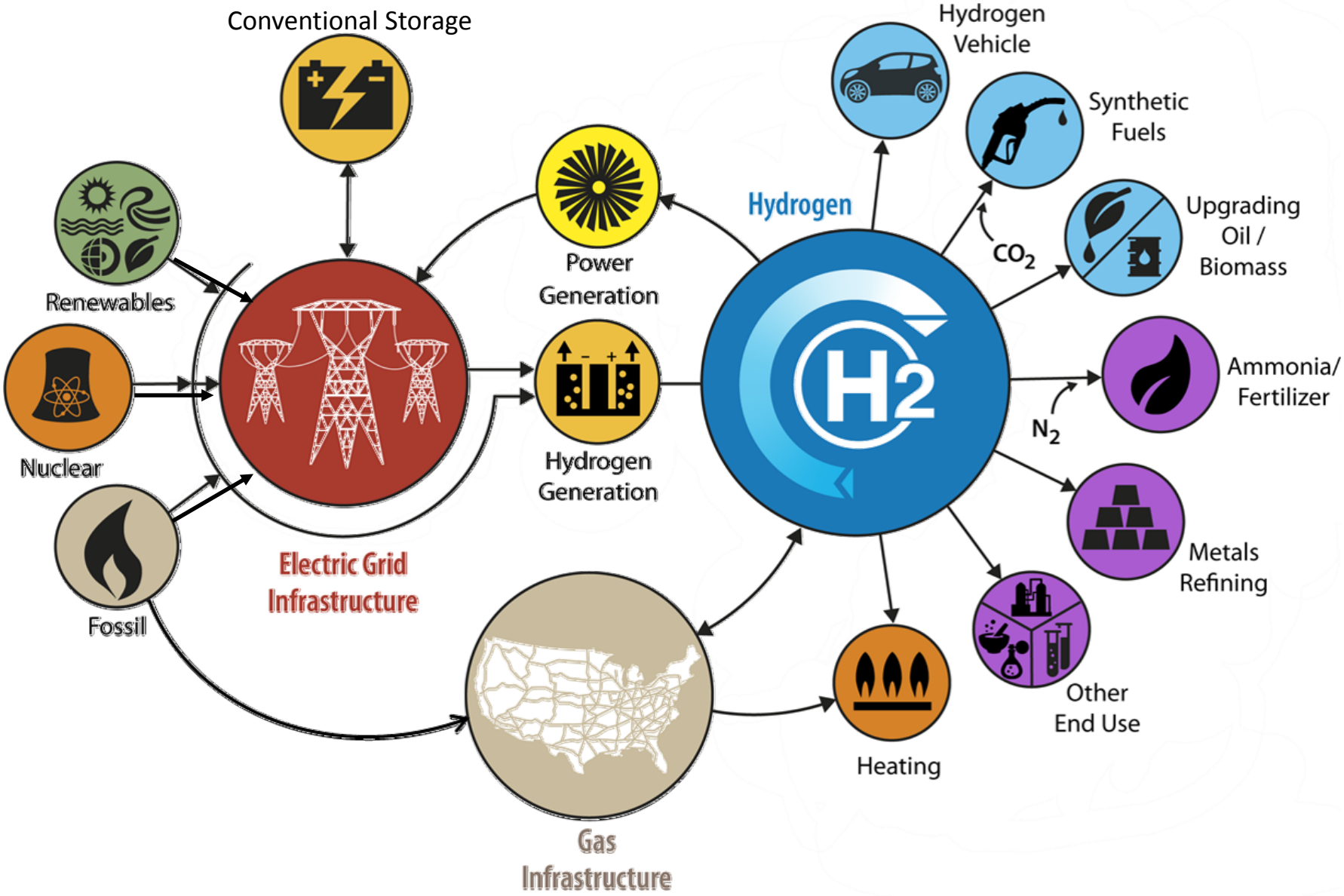
More than **23,000 forklifts**

Over **13 million refuelings**

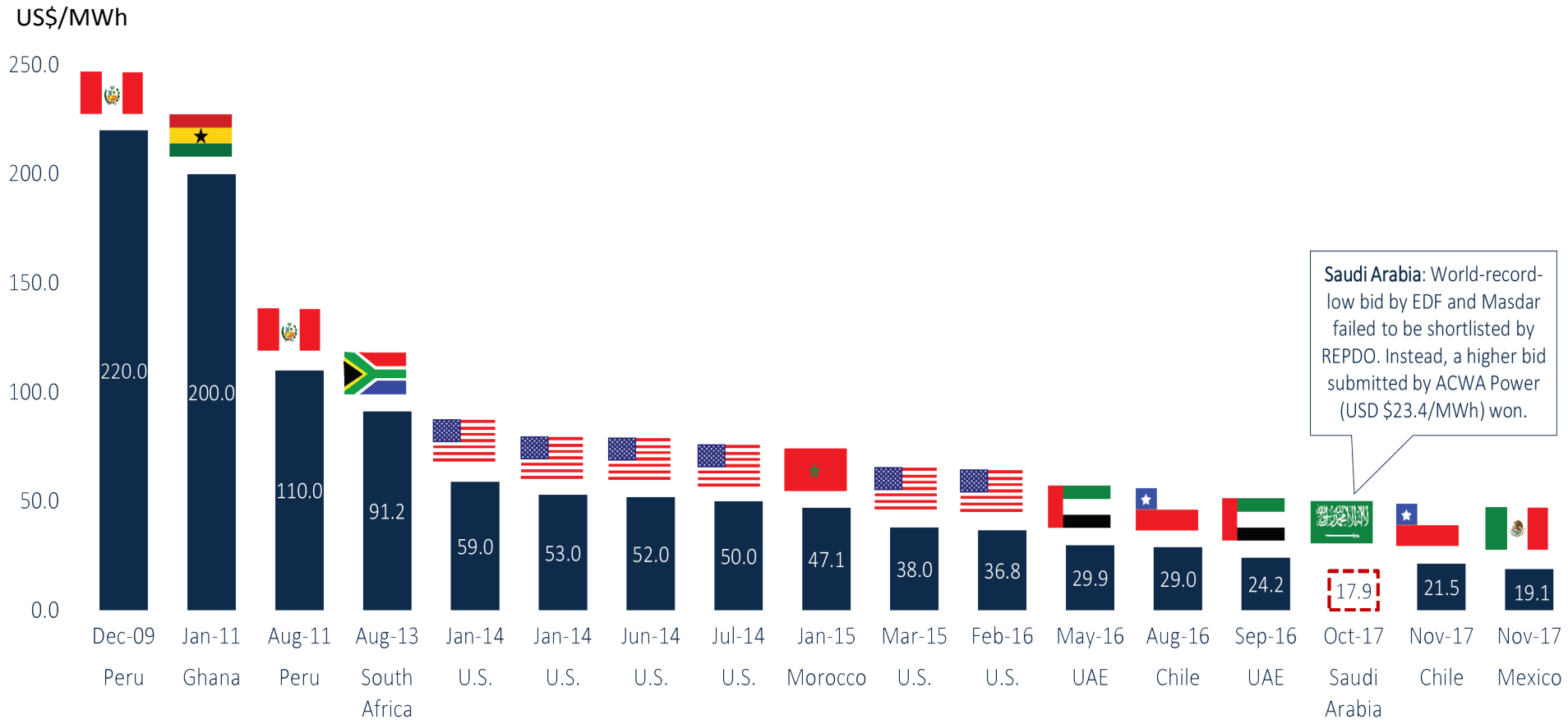
H_2@Scale: Enabling affordable, reliable, clean, and secure energy across sectors



H_2@Scale: Enabling affordable, reliable, clean, and secure energy across sectors



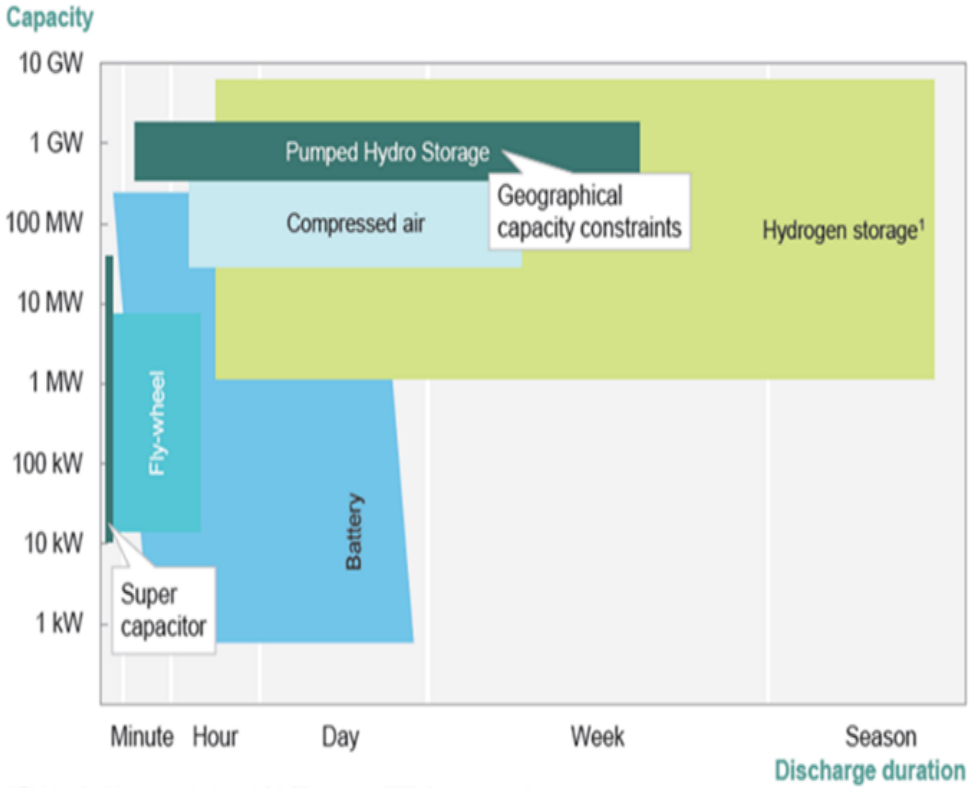
Record-Low PPA Prices for Utility-Scale Solar



Source: GTM, Dept. of Energy Solar Technologies Office

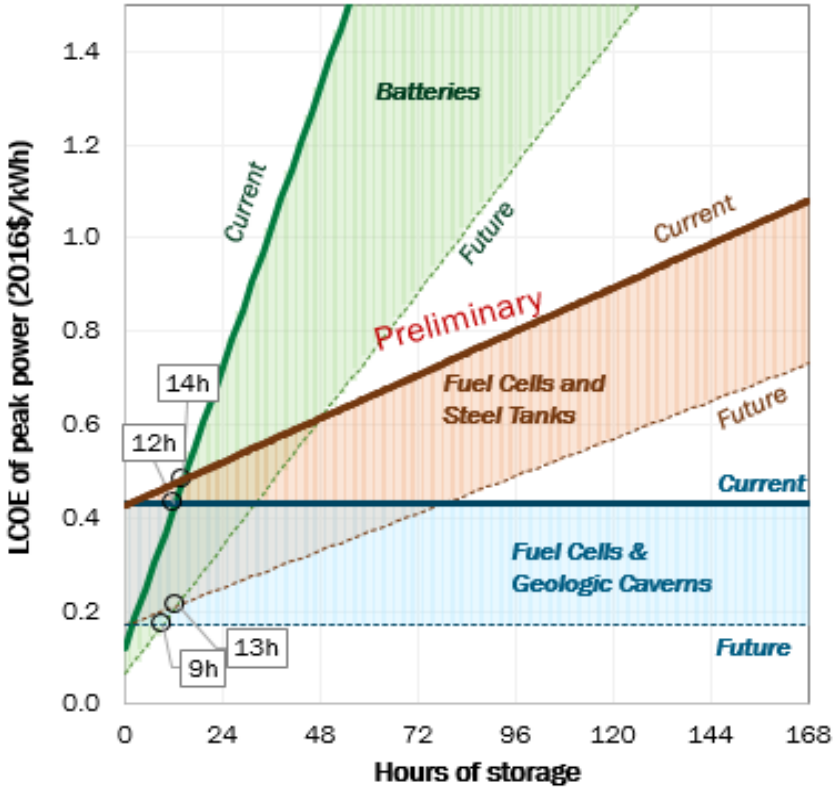
Potential: High capacity and long term energy storage

- **Hydrogen can offer long duration and GWh scale energy storage**



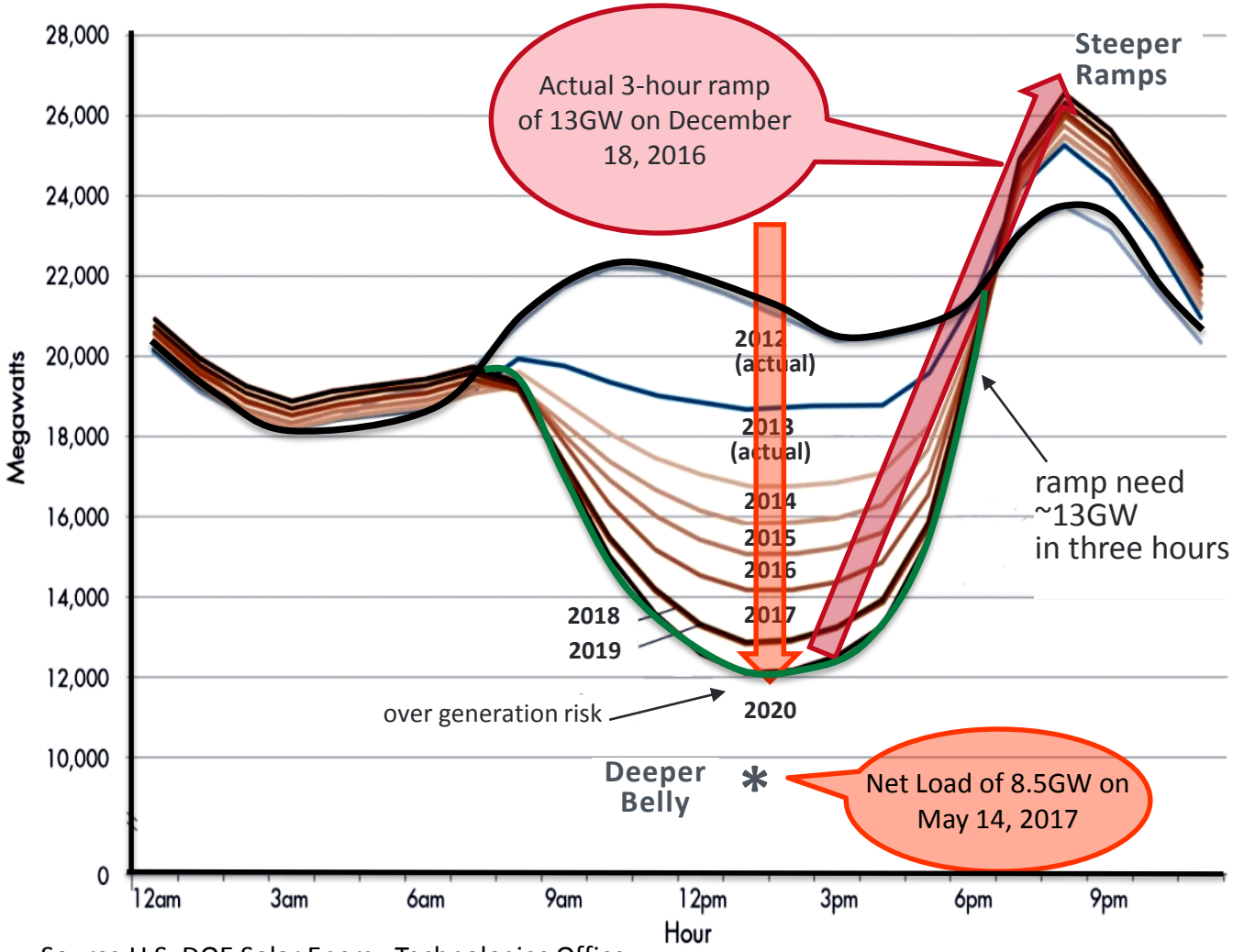
Source: Hydrogen Council

- **Analysis shows potential for hydrogen to be competitive at > 10 hours**



Source: NREL (preliminary)

The Duck's belly is getting bigger



Source U.S. DOE Solar Energy Technologies Office

Two Concerns:

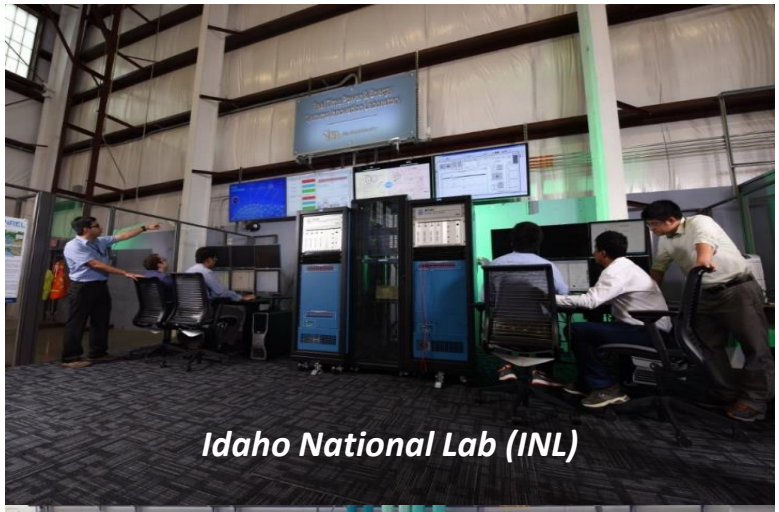
- **Low Net Load:** flexibility to reduce baseload generation resources is limited
- **High Ramp Rates in Evening:** flexibility of other generation to ramp up is limited

Can be addressed by

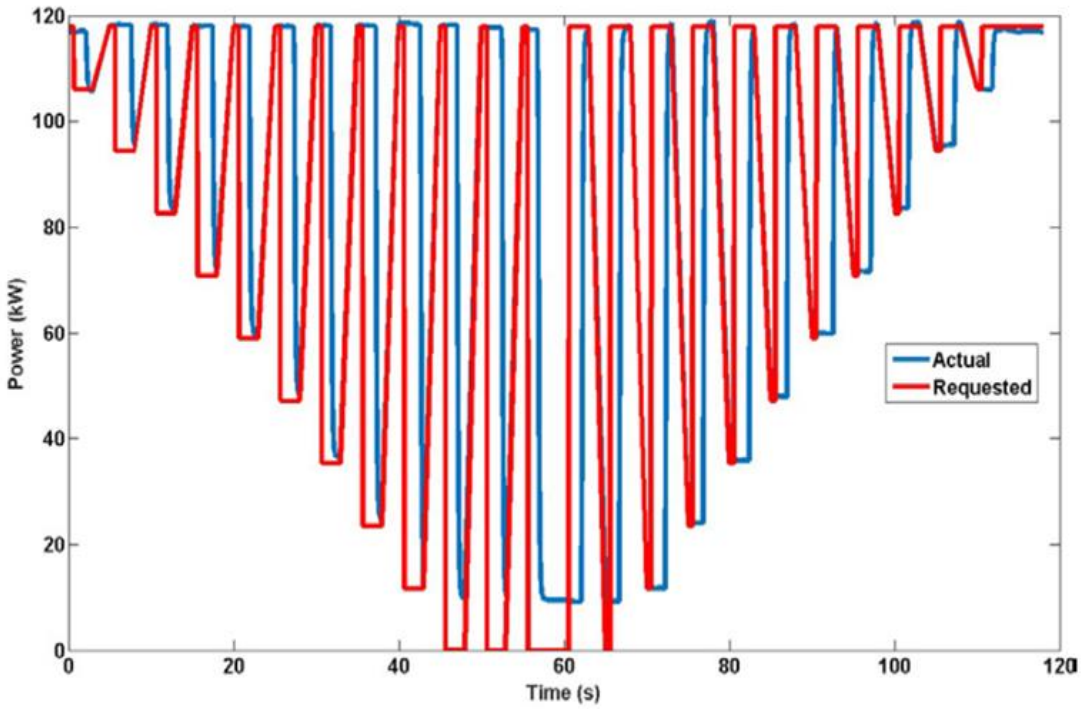
H2@Scale℠ U.S. Department of Energy

H_2@Scale: Electrolyzers can provide grid services

First Ever Validation of Frequency Regulation with Electrolyzers


Idaho National Lab (INL)

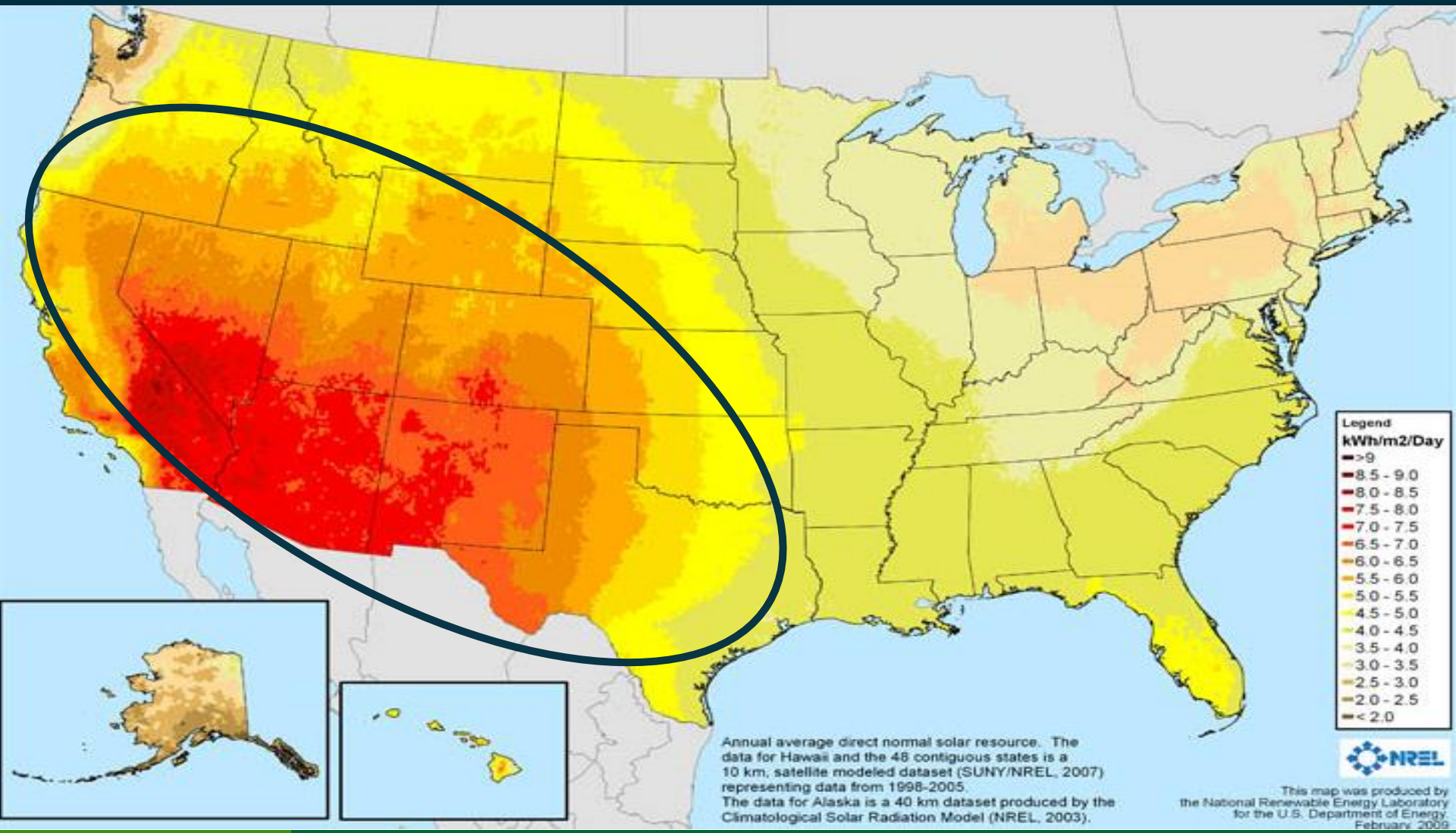

National Renewable Energy Lab (NREL)



Lab testing shows dynamic response within seconds and potential for grid services

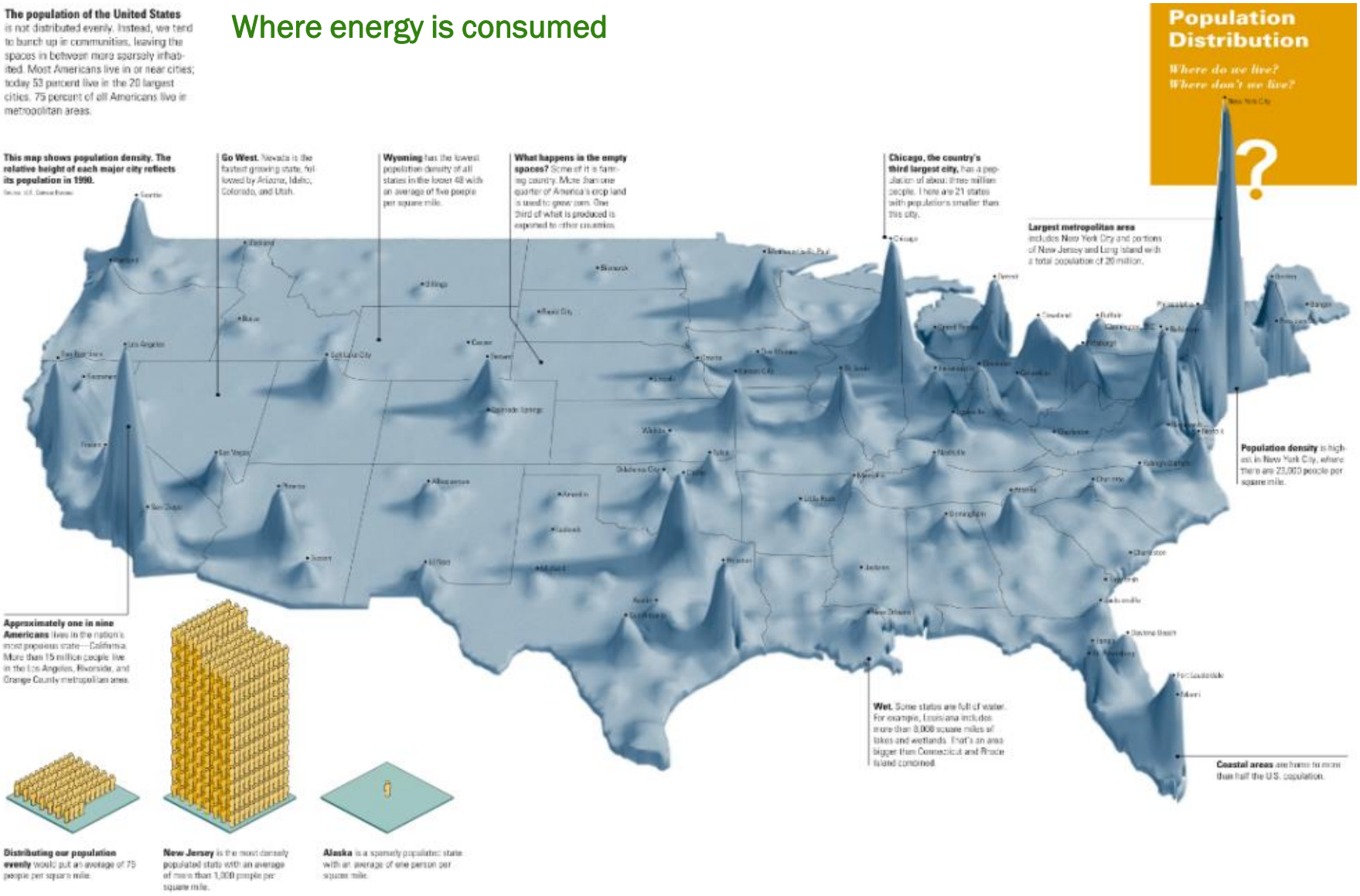
H_2@Scale: Enabling renewable energy transport?

Where we find abundant solar and wind energy

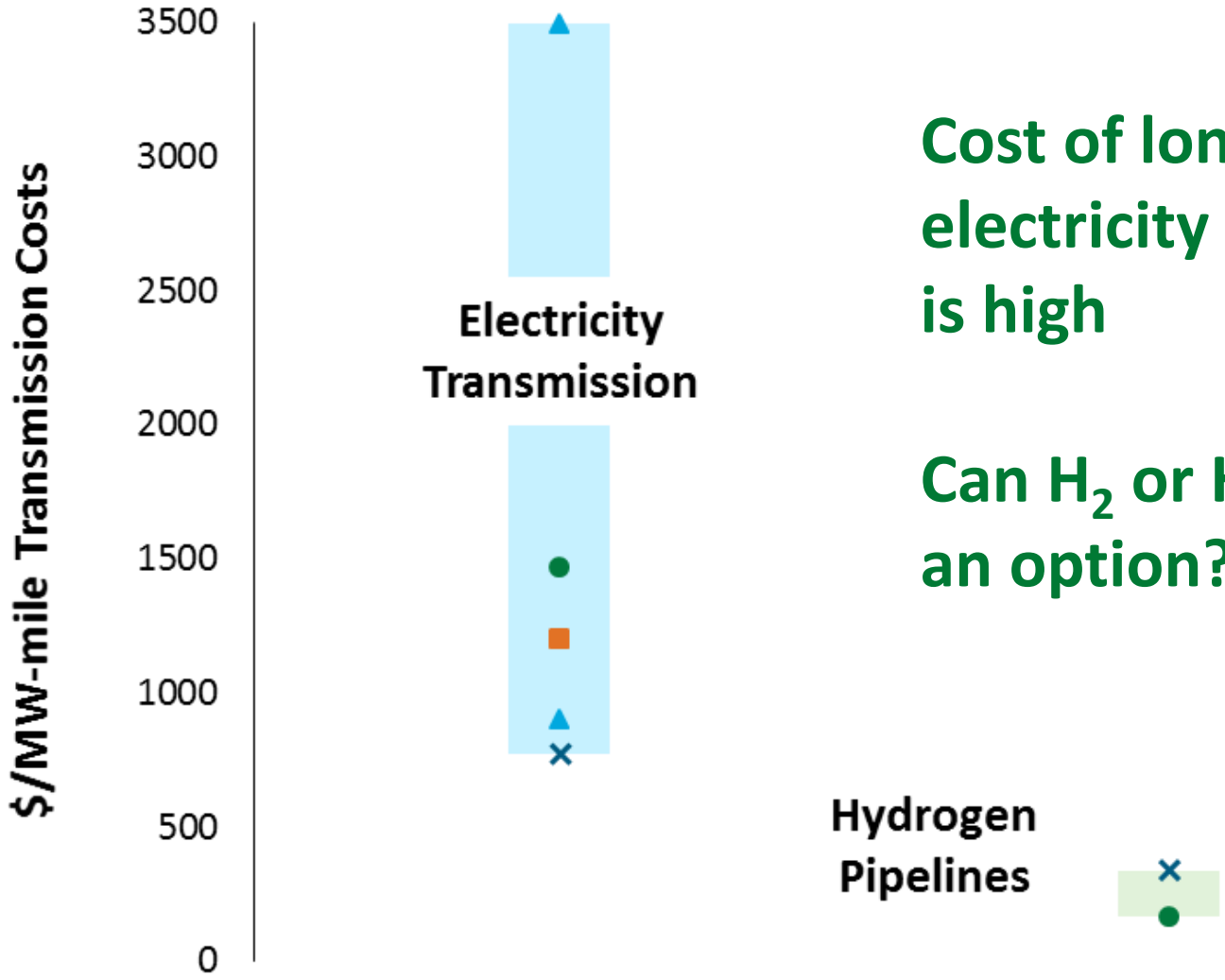


…and deliver it or co-locate distributed generation with demand for certain applications

Where energy is consumed



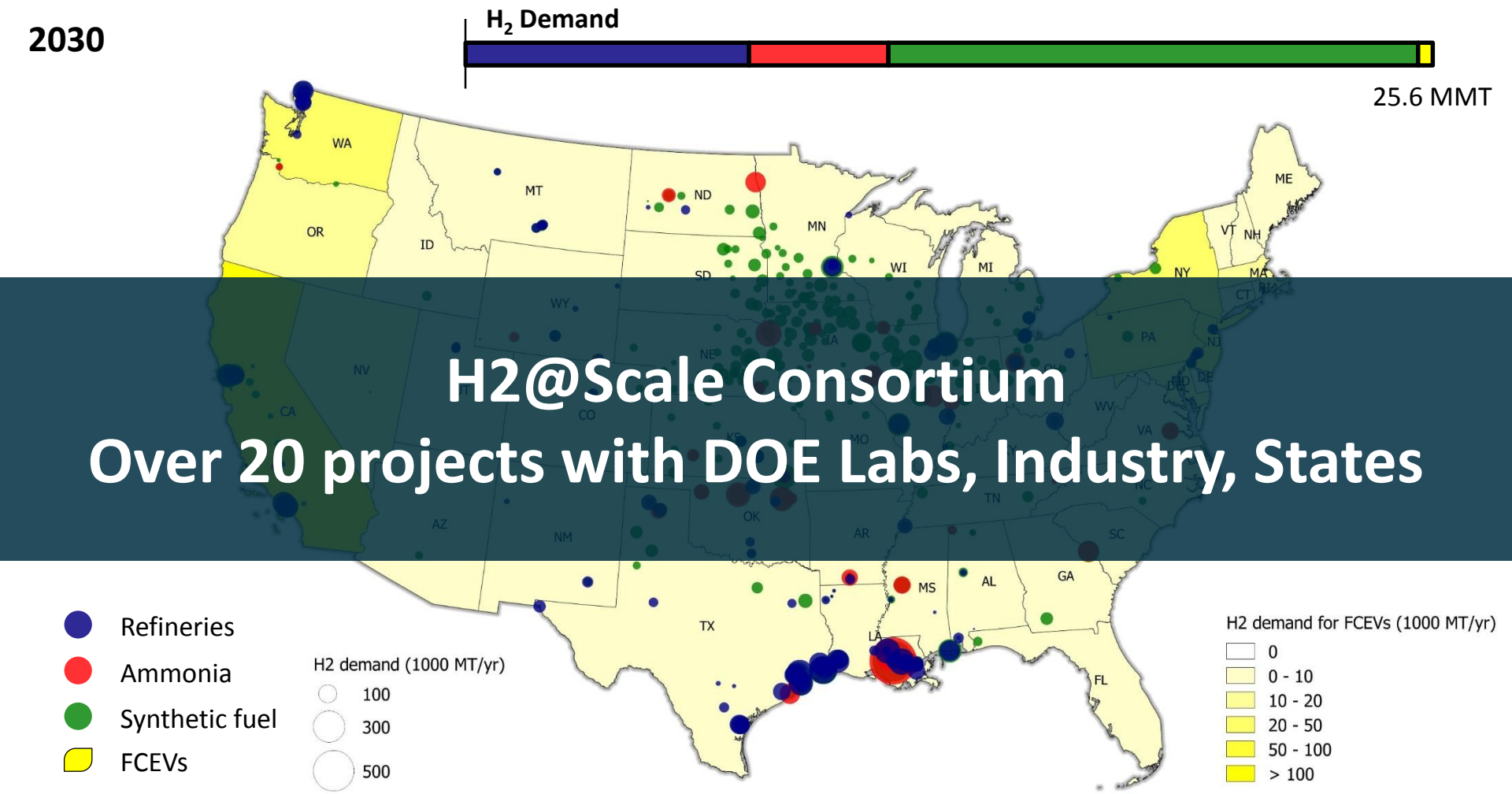
Preliminary analysis underway to guide future plans



Cost of long distance electricity transmission is high

Can H_2 or H_2 carriers be an option?

Analysis and R&D Projects Underway



Nearly 30 million metric tons of potential hydrogen demand in the U.S.

Source: Elgowainy, et al, ANL

International Engagement and Collaboration

International Partnership for Hydrogen and Fuel Cells in the Economy

- **Increase** international **collaboration to accelerate progress**
- **Working Groups:**
  - Regulations, Codes and Standards, Safety
  - Education & Outreach

U.S. elected IPHE Chair May 2018

Japan Vice Chair

EC, Germany, France, Canada support

- Launched 2003 and includes 18 countries and the European Commission
- Coordination with IEA, Mission Innovation, and Energy Ministerials

Tokyo Statement – Document Guiding International Commitment to Collaborate on Hydrogen

Harmonization of Codes and Standards	Information Sharing, Safety, Infr. Supply Chain	Studies and Evaluations of Impact Potential	Communication and Outreach
• Coordinate with industry to enable harmonization of relevant regulations, codes and standards such as those for: • refueling stations, • heavy duty transportation, • energy storage • technologies supporting sectoral integration, • maritime • other	• Collaborate on relevant infrastructure R&D • Share safety lessons learned, best practices on hydrogen safety • Collaborate on R&D of risk assessment and mitigation to enable the safe and sustainable use of hydrogen technologies across applications.	• Collect, analyze and share data and conduct studies • Assess impact potential for sustainable production of H2 across pathways • Develop business cases and models across value chain and integrated systems analysis across scenarios	• Work together to promote appropriate outreach and awareness programs and initiatives to educate a broad range of stakeholder groups on H2 and fuel cell technologies • Develop 'train the trainer' programs, to build awareness of hydrogen solutions, especially on safety

Collaboration: New H_2 Safety Partnership

Leverages new partnership to promote collaboration on safety

April 1-2, AICHE Meeting, LA

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Funding Opportunity

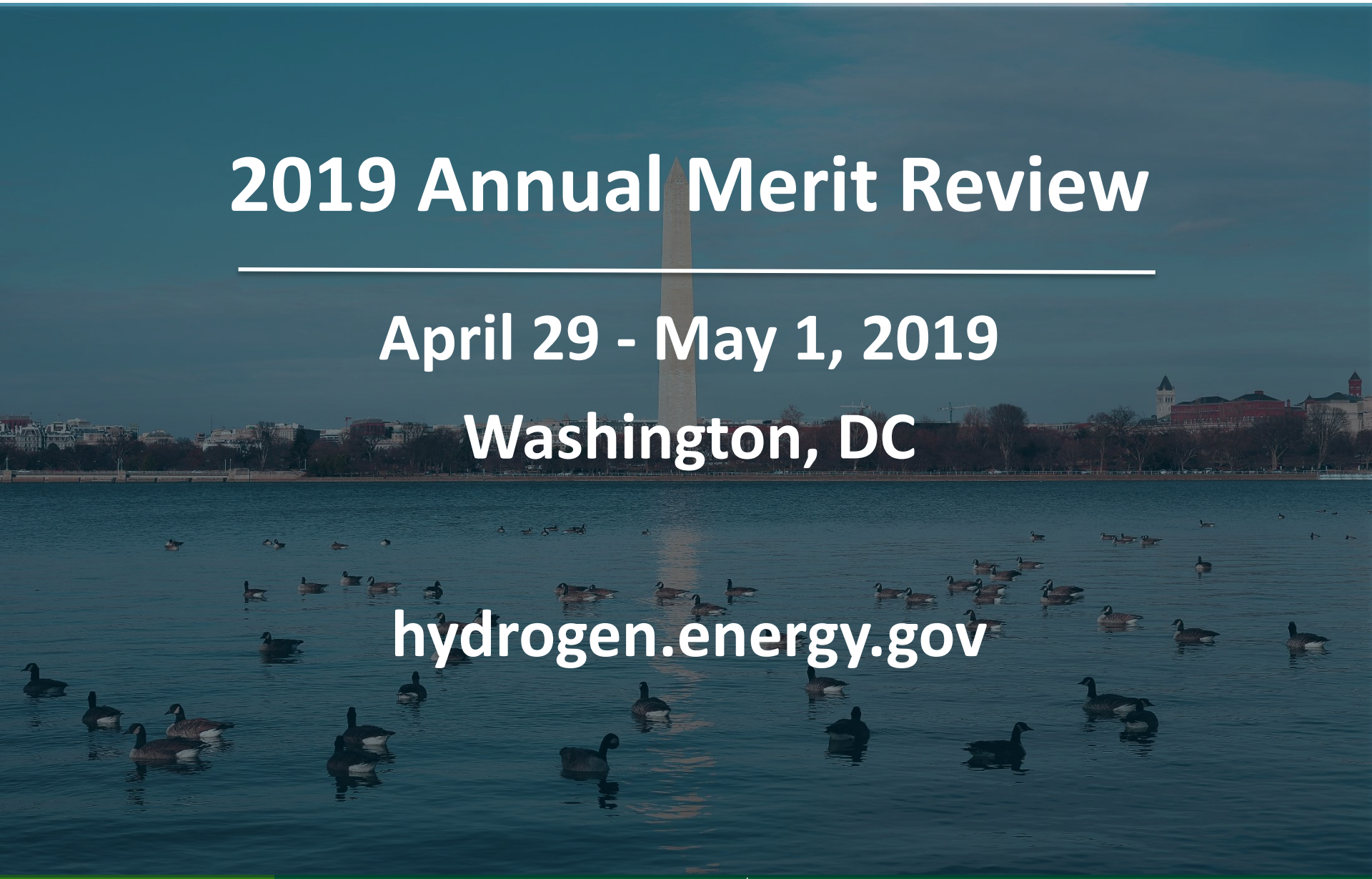
Notice of Intent issued

Funding Opportunity to be announced soon

Includes H2@Scale

www.hydrogen.energy.gov

Save the Date



2019 Annual Merit Review

April 29 - May 1, 2019

Washington, DC

hydrogen.energy.gov

Thank you

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energy.gov/eere/fuelcells