

# Hydrogen Potential as Energy Storage and the Grid

Dr. Sunita Satyapal, Director, Fuel Cell Technologies Office

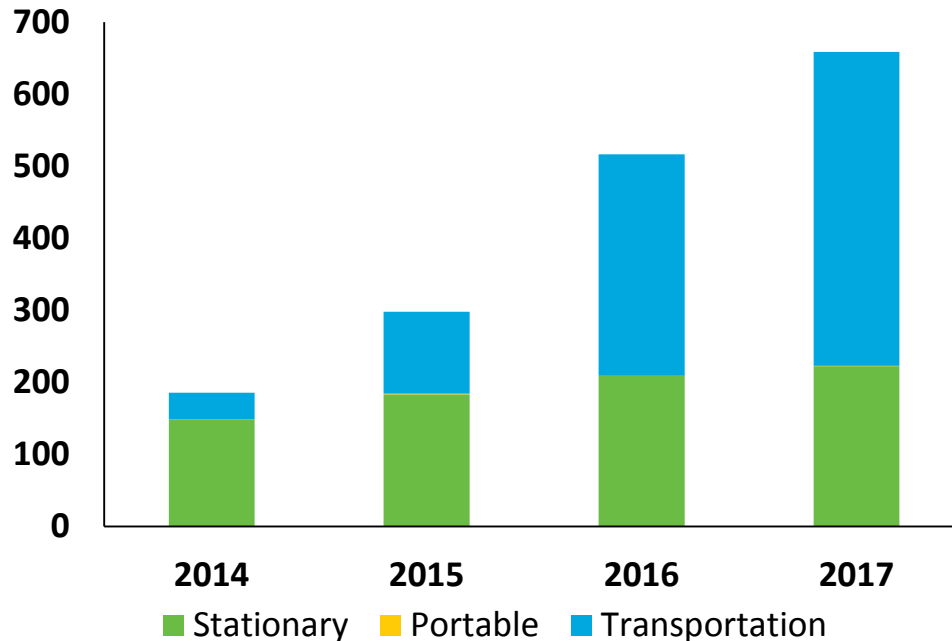
VerdExchange Conference

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\*\*

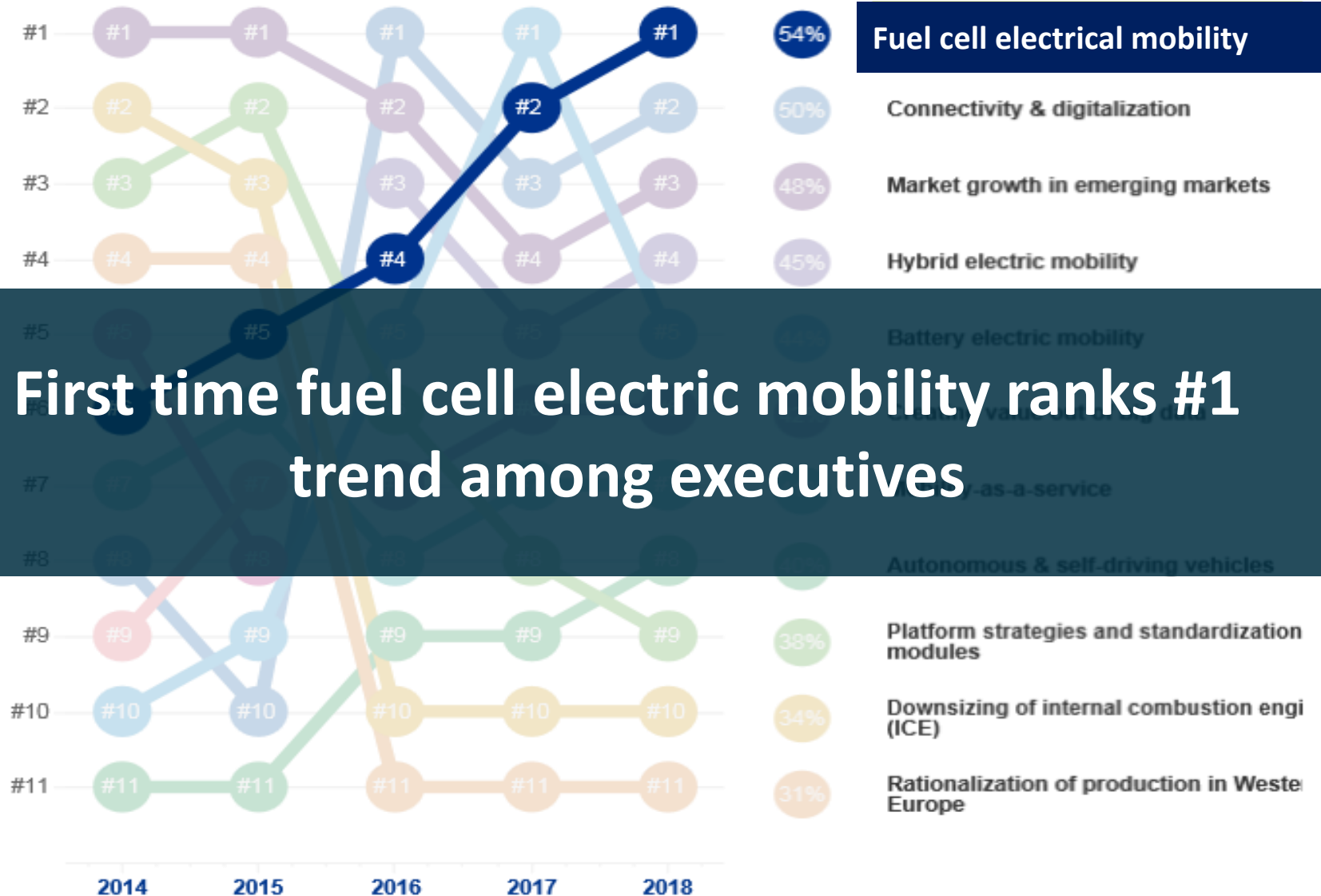
\*DOE and E4tech

\*\*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



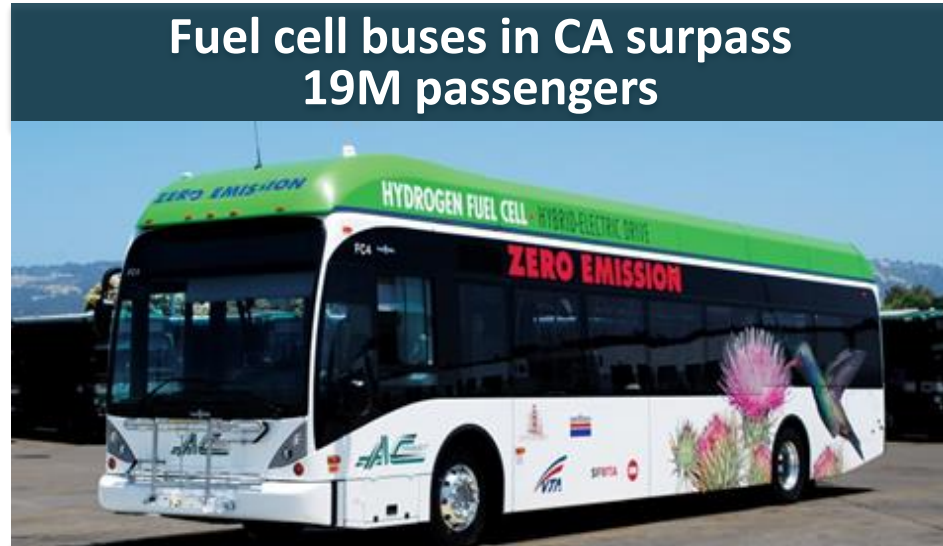
Source: KPMG Global Automotive Executive Survey 2018



# Long-Range, Heavy Duty Applications Emerging



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



**Industry demonstrates first heavy duty fuel cell truck in CA**



# Interest in material handling equipment applications



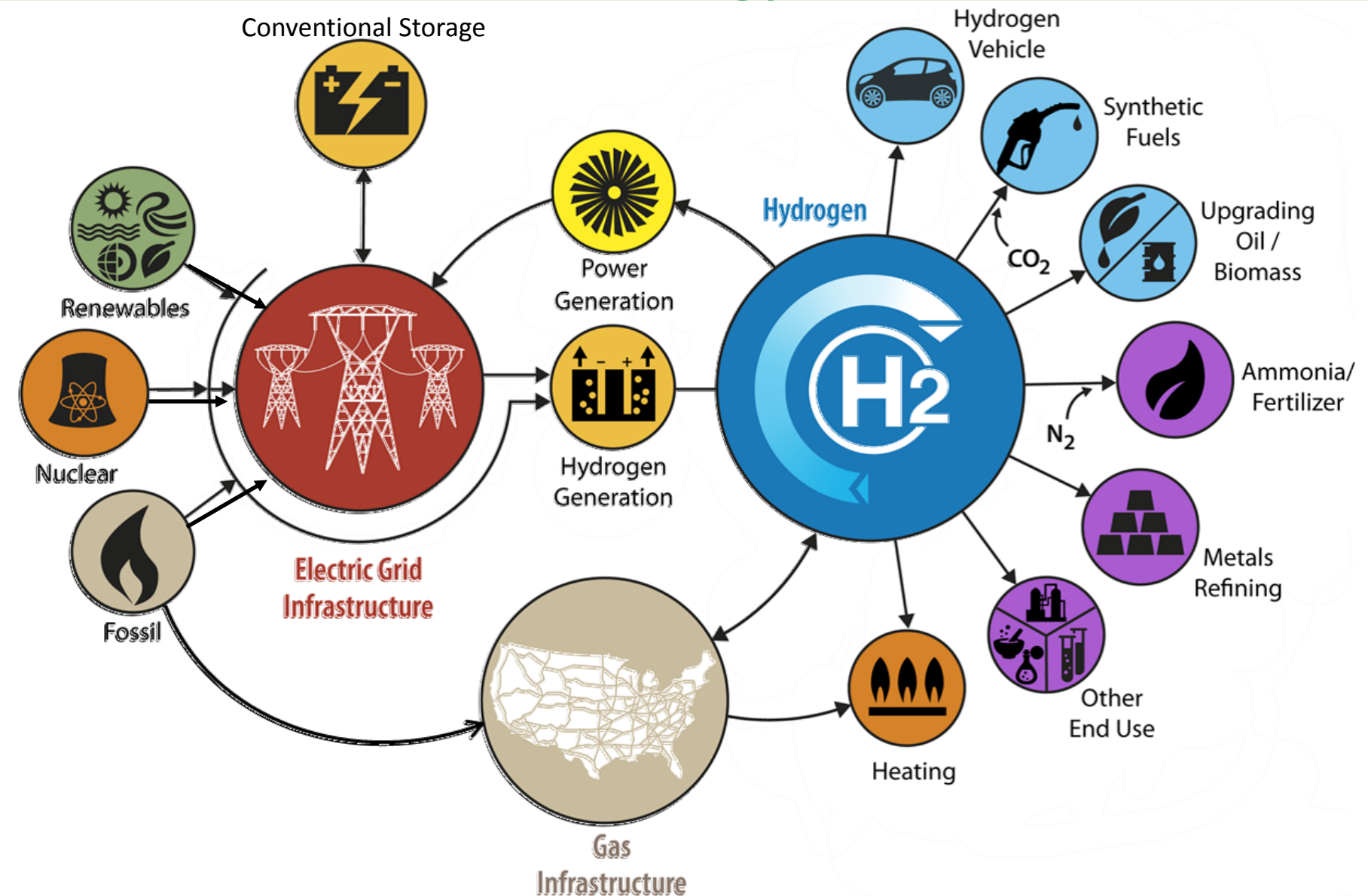
More than 23,000 forklifts

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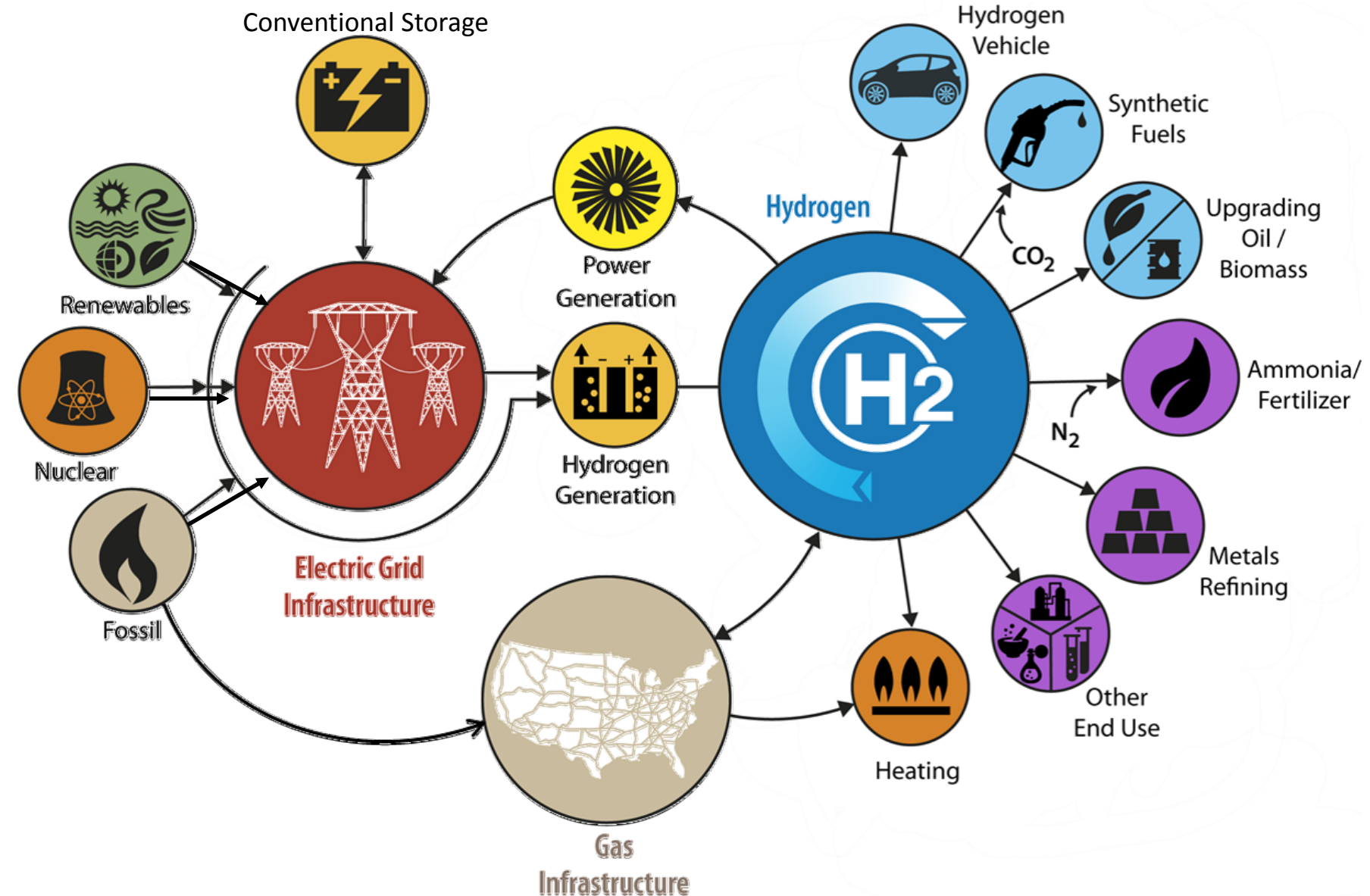
Over 13 million refuelings



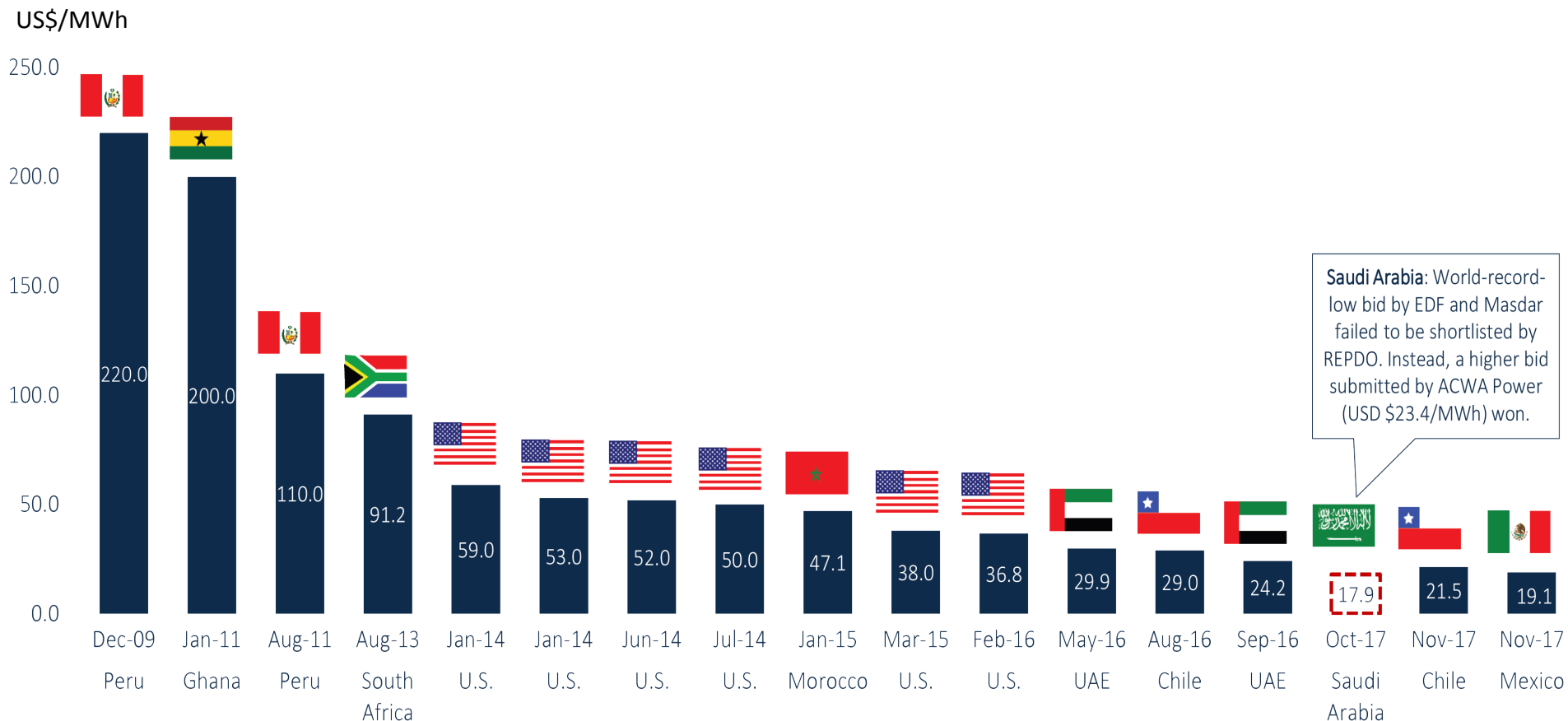
# H<sub>2</sub>@Scale: Enabling affordable, reliable, clean, and secure energy across sectors



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# Record-Low PPA Prices for Utility-Scale Solar

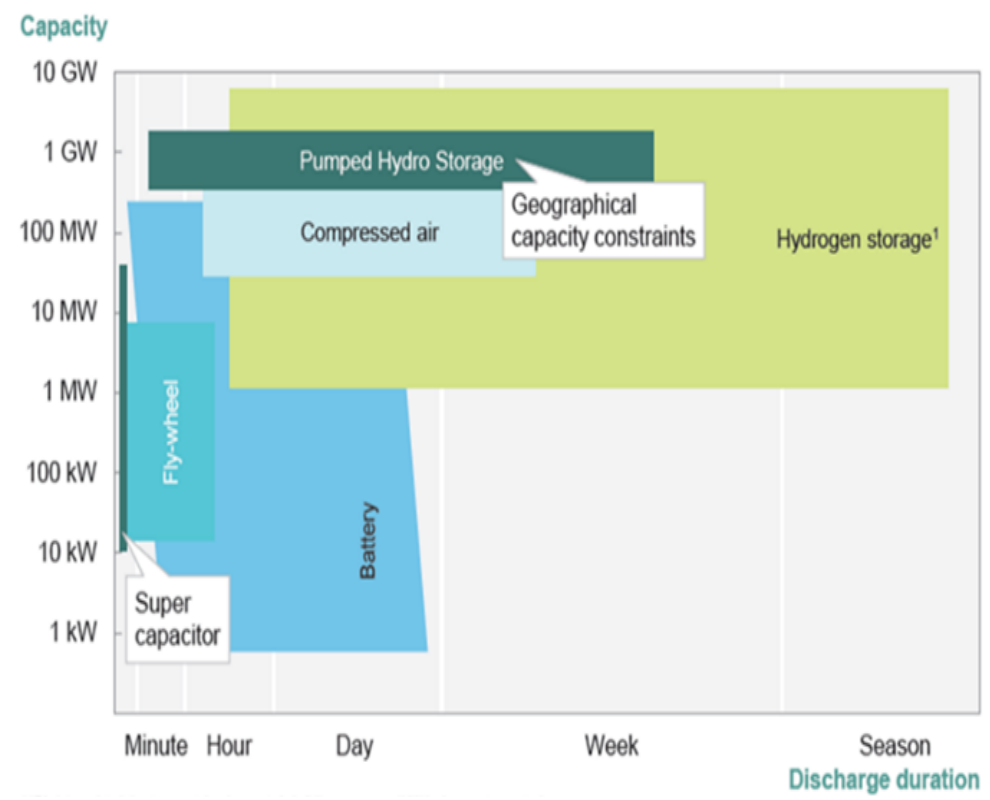


Source: GTM, Dept. of Energy Solar Technologies Office

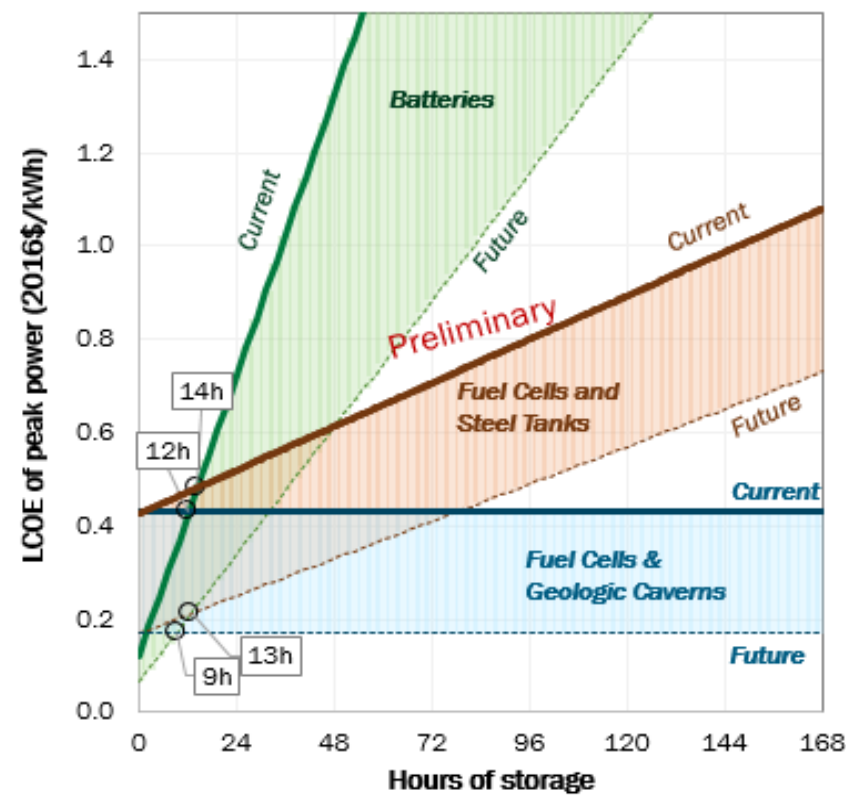


# Potential: High capacity and long term energy storage

- Hydrogen can offer long duration and GWh scale energy storage
- Analysis shows potential for hydrogen to be competitive at > 10 hours



Source: Hydrogen Council



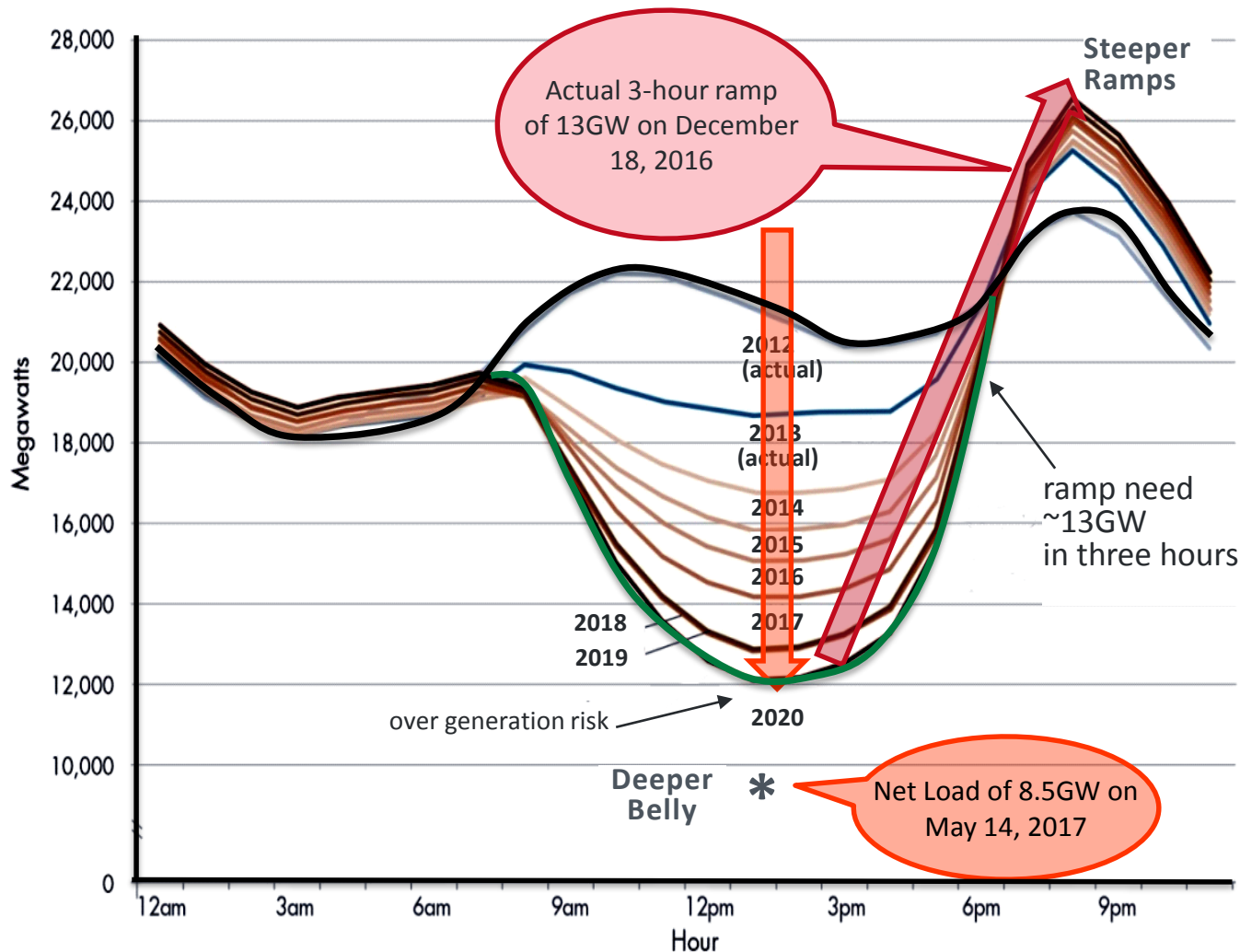
Source: NREL (preliminary)

# The Duck's belly is getting bigger

## 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



Source U.S. DOE Solar Energy Technologies Office

# H<sub>2</sub>@Scale: Electrolyzers can provide grid services

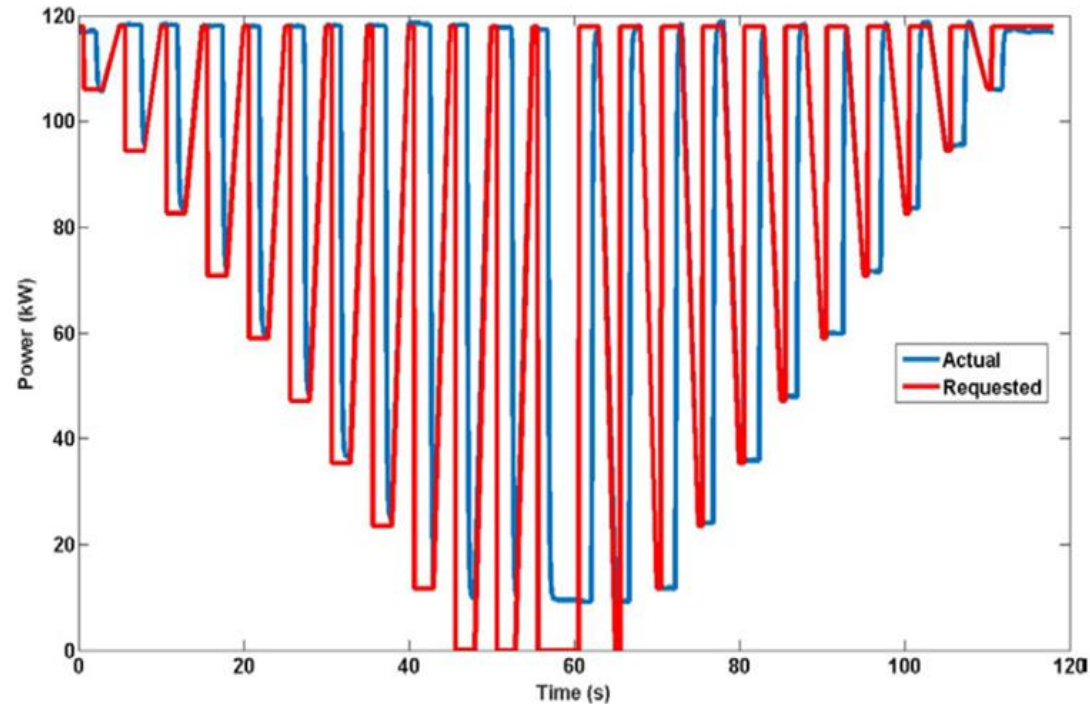
## First Ever Validation of Frequency Regulation with Electrolyzers



*Idaho National Lab (INL)*



*National Renewable Energy Lab (NREL)*

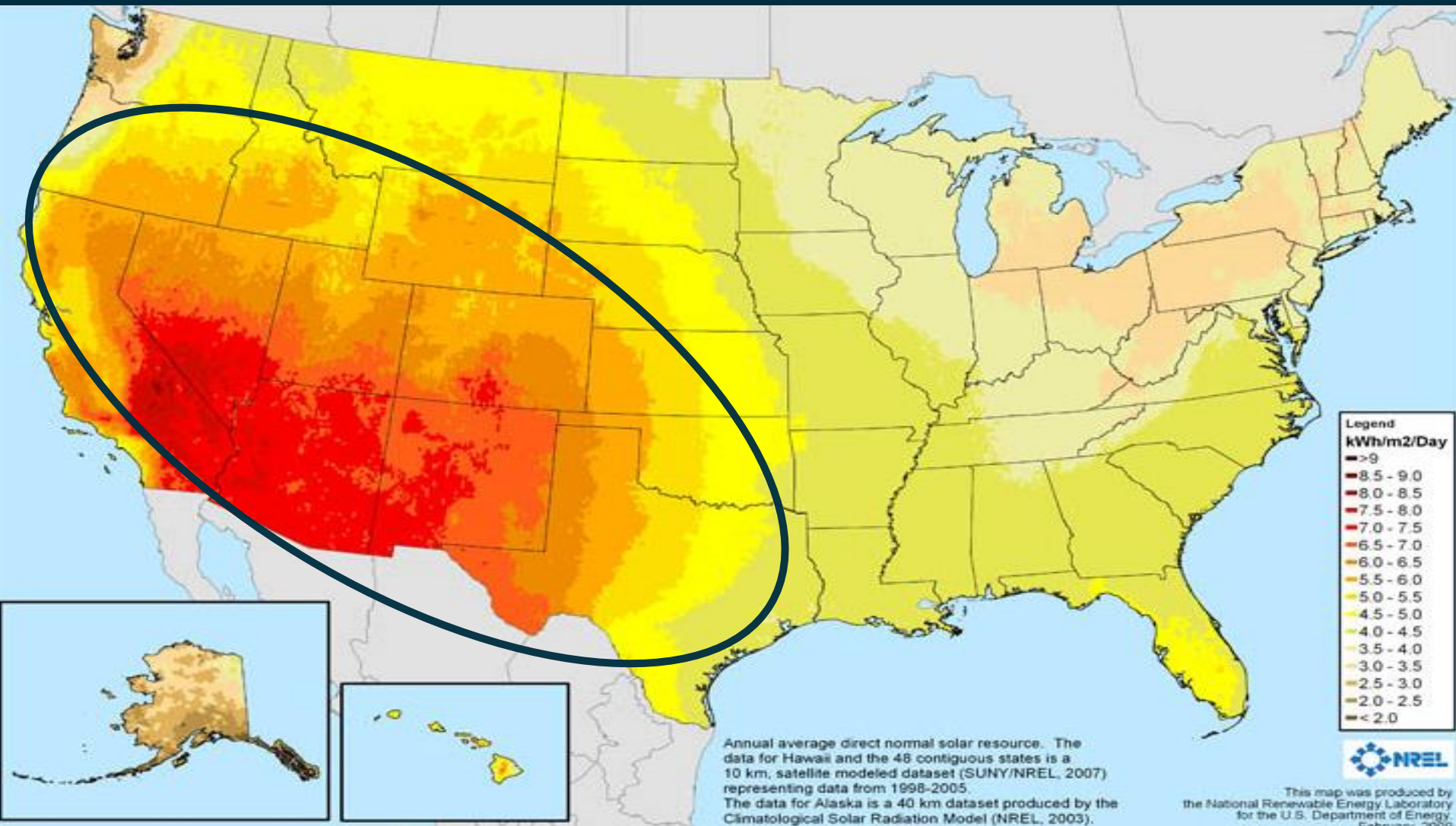


*Lab testing shows dynamic response within seconds and potential for grid services*



# H<sub>2</sub>@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

The population of the United States is not distributed evenly. Instead, we tend to bunch up in communities, leaving the spaces in between more sparsely inhabited. Most Americans live in or near cities; today 53 percent live in the 20 largest cities, 75 percent of all Americans live in metropolitan areas.

## Where energy is consumed

This map shows population density. The relative height of each major city reflects its population in 1990.

Source: U.S. Census Bureau

Go West. Nevada is the fastest growing state, followed by Arizona, Idaho, Colorado, and Utah.

Wyoming has the lowest population density of all states in the lower 48 with an average of two people per square mile.

What happens in the empty spaces? Some of it is farming country. More than one quarter of America's crop land is used to grow corn. One third of what is produced is exported to other countries.

Chicago, the country's third largest city, has a population of about three million people. There are 21 states with populations smaller than this city.

Largest metropolitan area includes New York City and portions of New Jersey and Long Island with a total population of 20 million.

## Population Distribution

Where do we live?  
Where don't we live?



Population density is highest in New York City, where there are 23,000 people per square mile.

Approximately one in nine Americans lives in the nation's most populous state—California. More than 15 million people live in the Los Angeles, Riverside, and Orange County metropolitan area.



Distributing our population evenly would put an average of 75 people per square mile.



New Jersey is the most densely populated state with an average of more than 1,000 people per square mile.

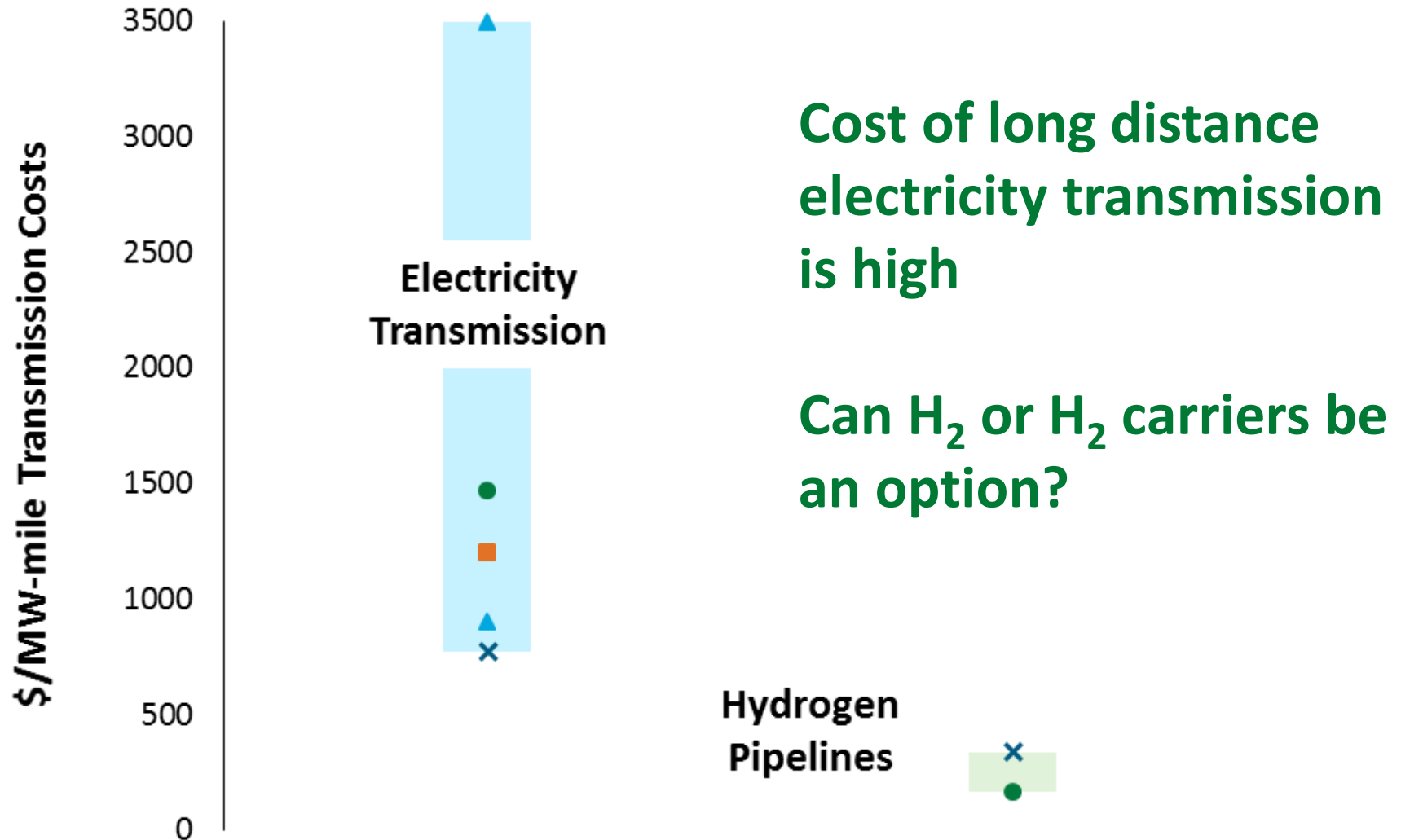


Alaska is a sparsely populated state with an average of one person per square mile.

Wet. Some states are full of water. For example, Louisiana includes more than 8,000 square miles of lakes and wetlands. That's an area bigger than Connecticut and Rhode Island combined.

Coastal areas are home to more than half the U.S. population.

# Preliminary analysis underway to guide future plans





# Analysis and R&D Projects Underway

2030

H<sub>2</sub> Demand

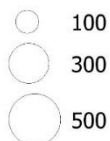


25.6 MMT

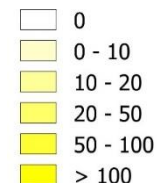
**H2@Scale Consortium**  
**Over 20 projects with DOE Labs, Industry, States**

- Refineries
- Ammonia
- Synthetic fuel
- FCEVs

H<sub>2</sub> demand (1000 MT/yr)



H<sub>2</sub> demand for FCEVs (1000 MT/yr)



**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
<ul style="list-style-type: none"><li>• Coordinate with industry to enable harmonization of relevant regulations, codes and standards such as those for:<ul style="list-style-type: none"><li>• refueling stations,</li><li>• heavy duty transportation,</li><li>• energy storage</li><li>• technologies supporting sectoral integration,</li><li>• maritime</li><li>• other</li></ul></li></ul>	<ul style="list-style-type: none"><li>• Collaborate on relevant infrastructure R&amp;D</li><li>• Share safety lessons learned, best practices on hydrogen safety</li><li>• Collaborate on R&amp;D of risk assessment and mitigation to enable the safe and sustainable use of hydrogen technologies across applications.</li></ul>	<ul style="list-style-type: none"><li>• Collect, analyze and share data and conduct studies</li><li>• Assess impact potential for sustainable production of H2 across pathways</li><li>• Develop business cases and models across value chain and integrated systems analysis across scenarios</li></ul>	<ul style="list-style-type: none"><li>• 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</li><li>• Develop 'train the trainer' programs, to build awareness of hydrogen solutions, especially on safety</li></ul>

# Collaboration: New H<sub>2</sub> Safety Partnership

Leverages new partnership to promote collaboration on safety



**April 1-2, AICHE Meeting, LA**

U.S. DEPARTMENT OF  
**ENERGY**

Office of  
ENERGY EFFICIENCY &  
RENEWABLE ENERGY



**Notice of Intent issued**

**Funding Opportunity to be  
announced soon**

**Includes H2@Scale**

**[www.hydrogen.energy.gov](http://www.hydrogen.energy.gov)**

**Save the Date**

# 2019 Annual Merit Review

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**April 29 - May 1, 2019**

**Washington, DC**

**[hydrogen.energy.gov](https://hydrogen.energy.gov)**

# Thank you

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**[energy.gov/eere/fuelcells](https://energy.gov/eere/fuelcells)**