U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

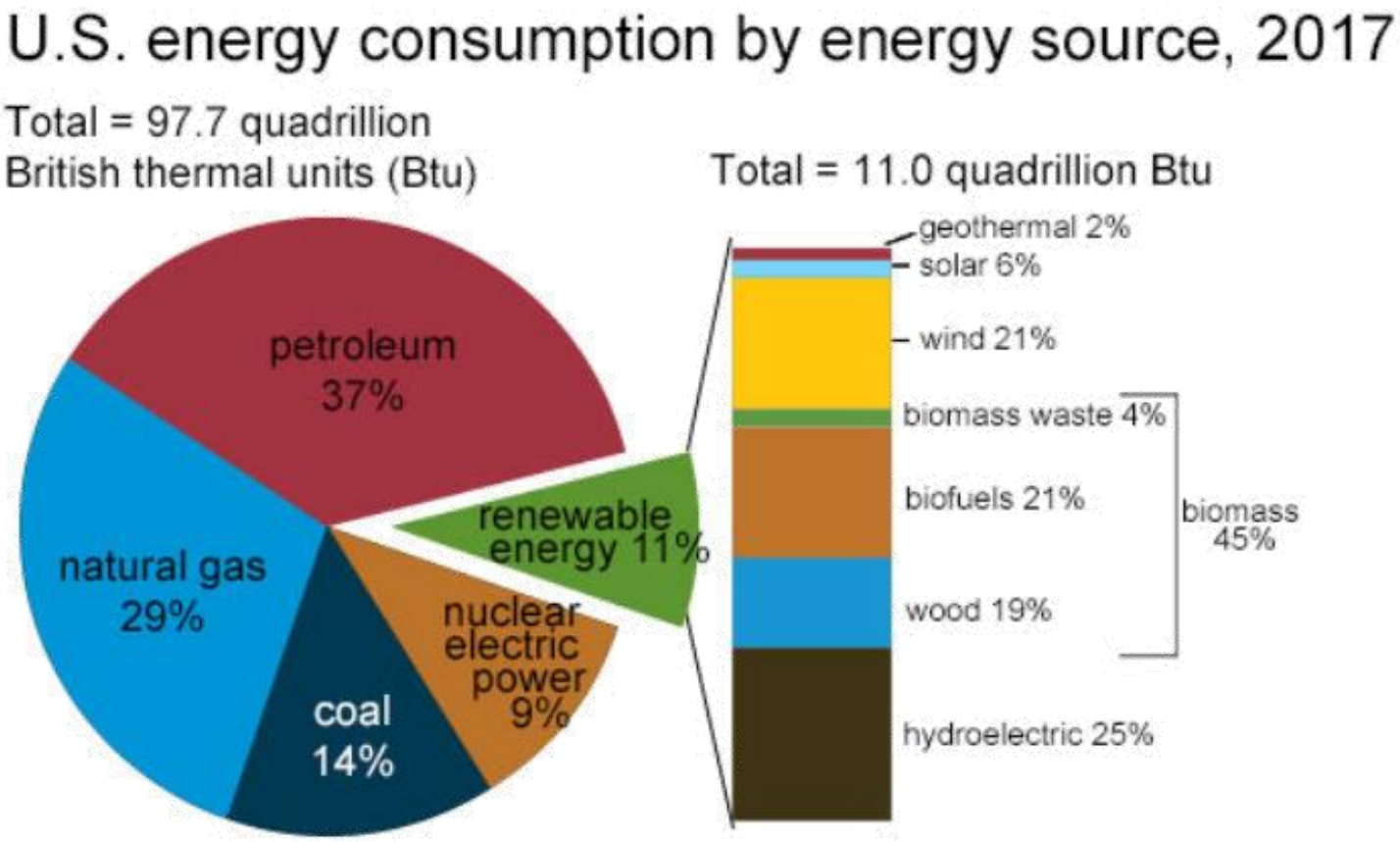
U.S. Department of Energy Hydrogen and Fuel Cell Technology Perspectives

Sunita Satyapal, Director, Fuel Cell Technologies Office

IPHE Industry Forum

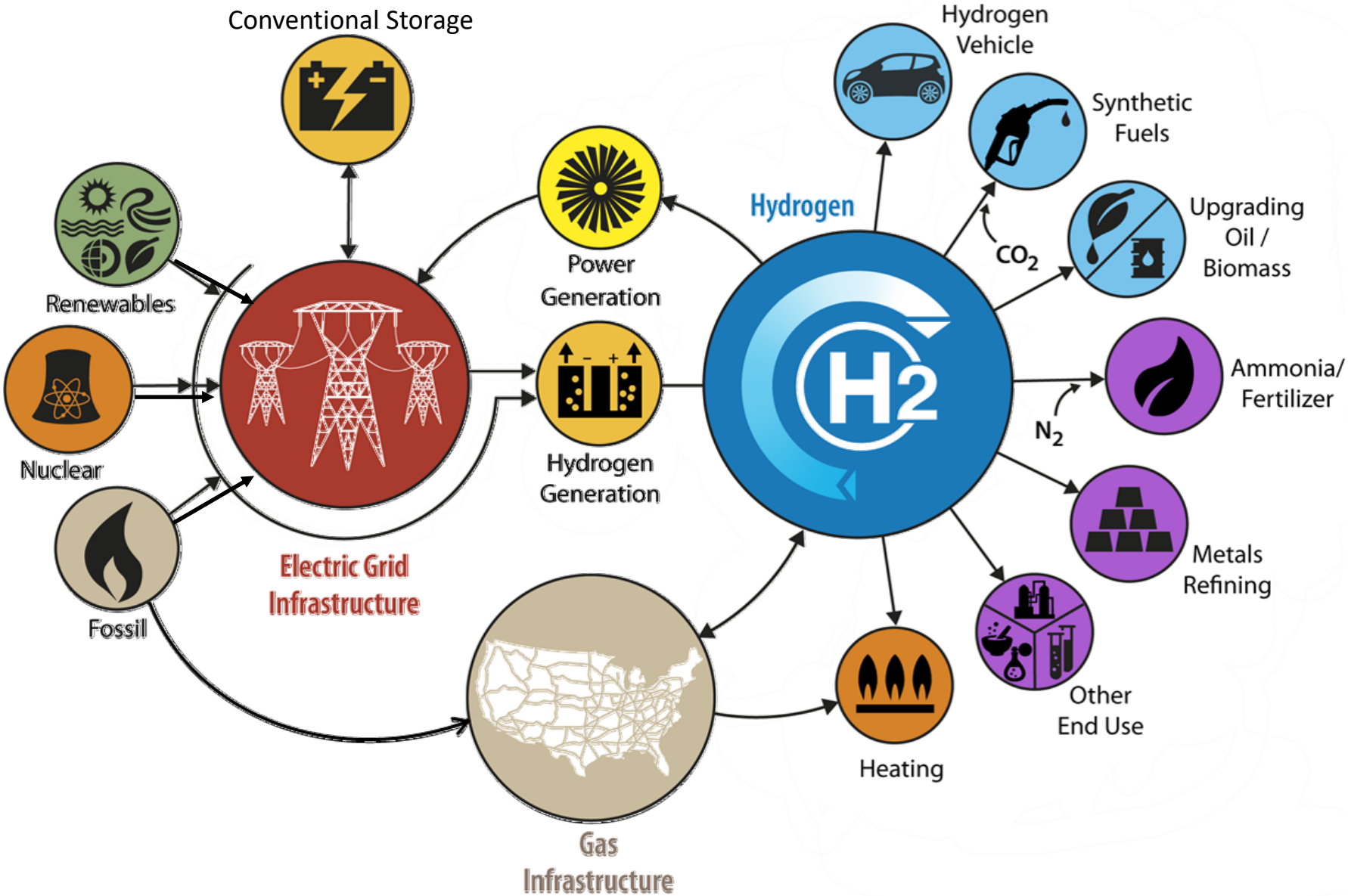
Pretoria, South Africa – December 5, 2018

U.S. energy mix covers wide of energy sources



Note: Sum of components may not equal 100% because of independent rounding.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2018, preliminary data

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



An exciting time for the transportation sector

Honda Clarity

Nearly **5,800** | **sold or leased** in the United States

As of Dec 2017

Hyundai Tucson Fuel Cell SUV

Commercial **fuel cell electric cars are here**

Toyota Mirai

- No petroleum, no pollution
- Refuels in minutes
- More than 360 mi driving range
- Over 60 mpgge

Fuel cells for material handling equipment

More than **23,000 forklifts**

Over **15 million refuelings**

Long-Range, Heavy Duty Applications Emerging

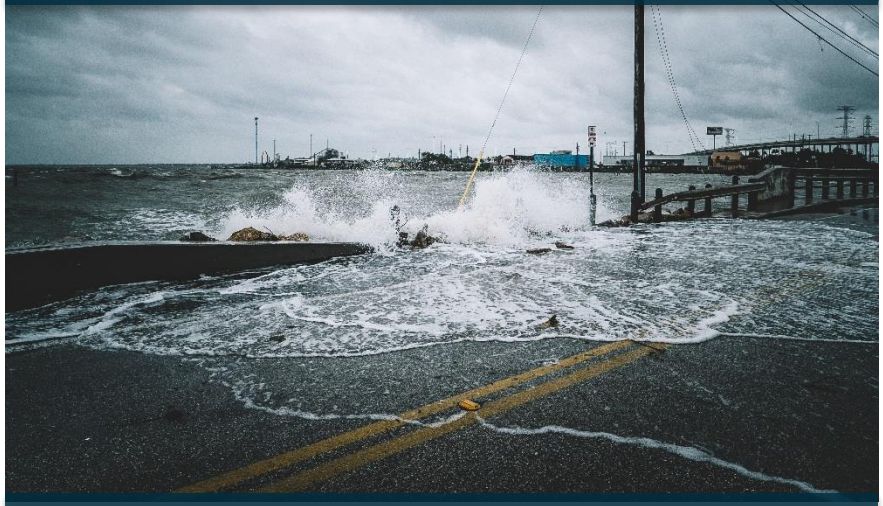
Fuel cell delivery and parcel trucks operating in CA and NY

Fuel cell buses in CA surpass 19M passengers

Industry demonstrates first heavy duty fuel cell truck in CA

Stationary Power Applications Continue to Grow

Fuel cells provided backup power during Hurricane Sandy in the U.S. Northeast



Fuel cells used to power new World Trade Center in NYC

Fuel cell power for maritime ports demonstrated in Honolulu, Hawaii

Over 240 MW of fuel cell stationary power installed across more than 40 US states

Photo Credit: Fukuoka FCE.

Multiple H_2 and Fuel Cell Applications in the U.S.

U.S. Snapshot

Over
>240MW
Backup Power

More than
23,000
Forklifts

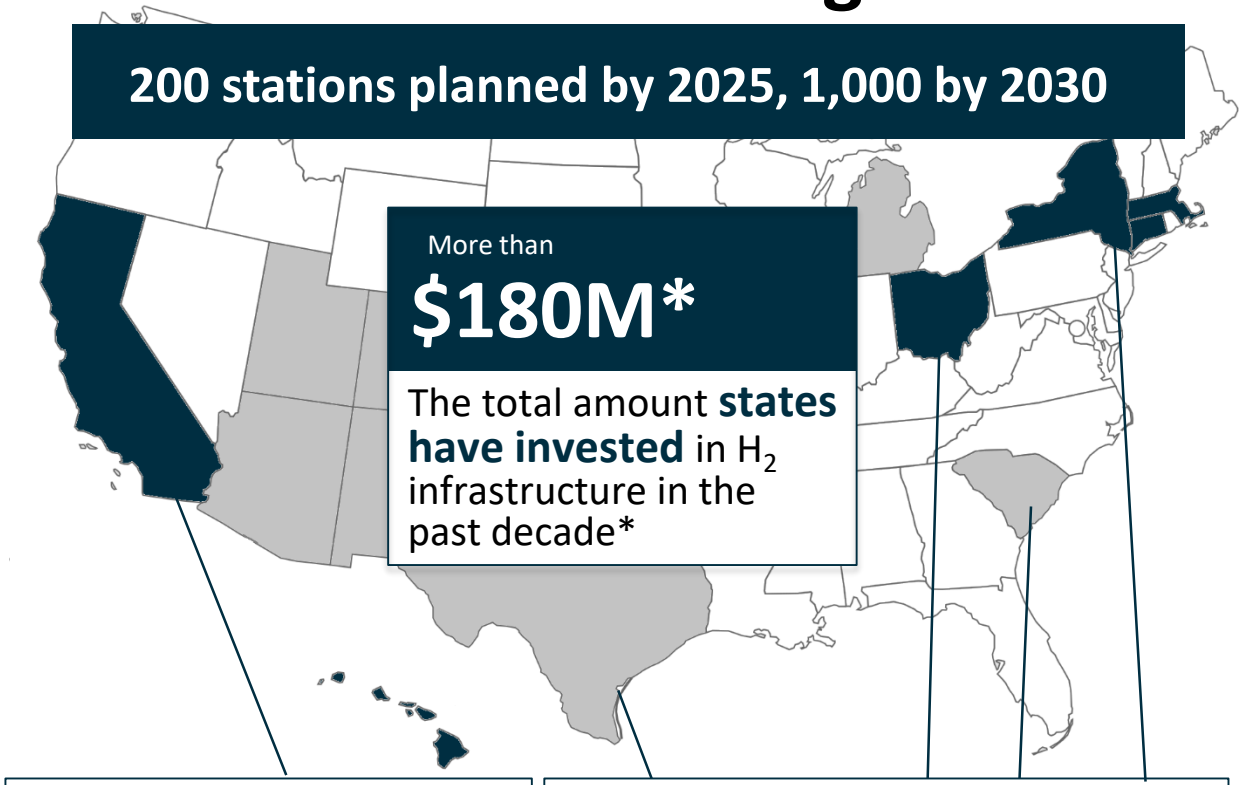
More than
30
Fuel Cell Buses

36
H_2 Retail Stations

Nearly
5,800
Fuel Cell Cars

States with Growing Interest

200 stations planned by 2025, 1,000 by 2030



More than
$180M*

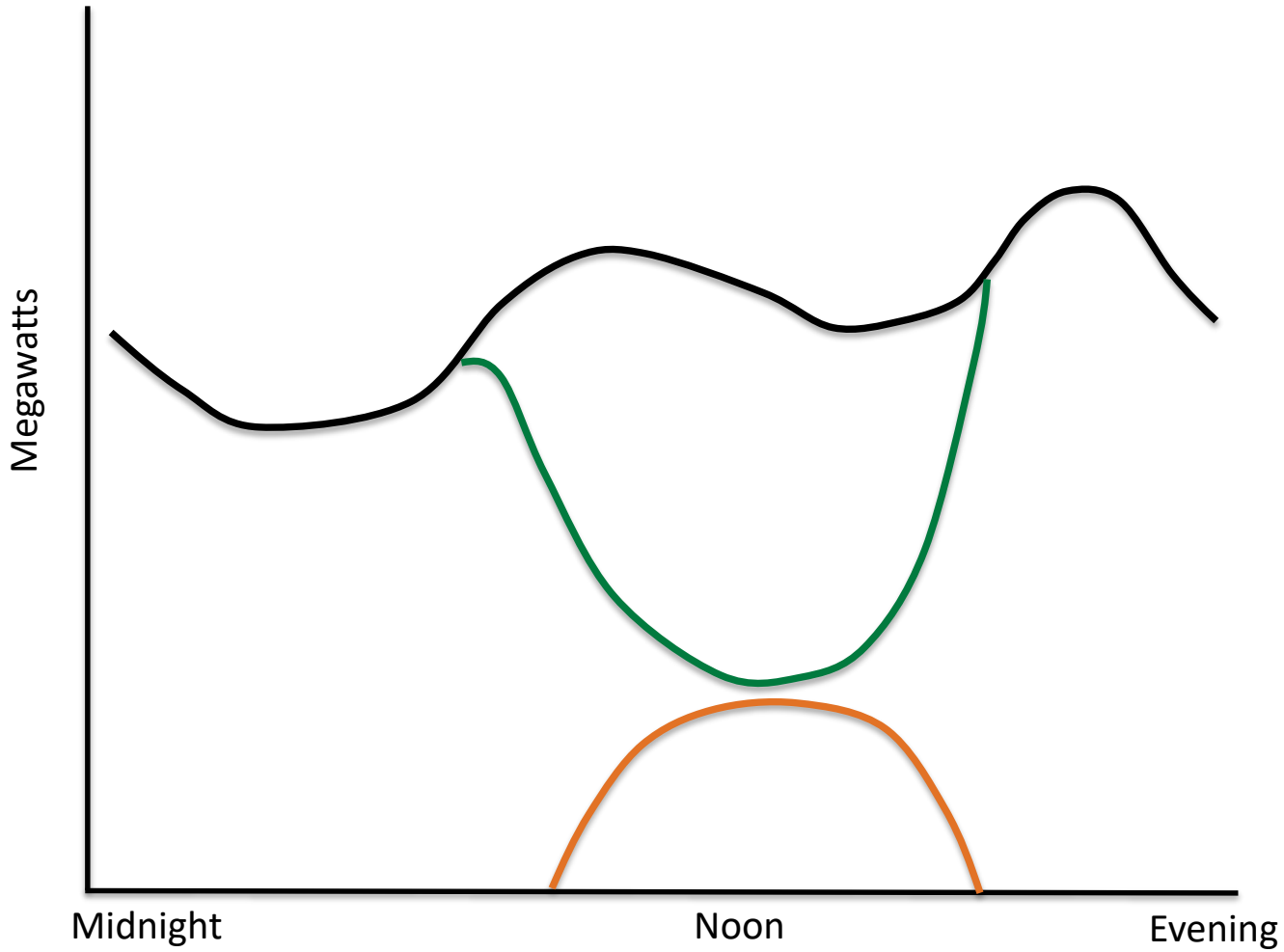
The total amount **states have invested** in H_2 infrastructure in the past decade*

CA
- 1,000 stations by 2030
- Over 30 public stations open
- $150M invested
- $235M announced in 2018

HI, OH, SC, NY, CT, MA, CO, UT, TX, MI, and others with interest
- Over $27M invested
- 12-25 stations planned in the NE

*Excludes recent announcement from CA to invest $235M in electric vehicles

New Driver: The Duck Curve Example

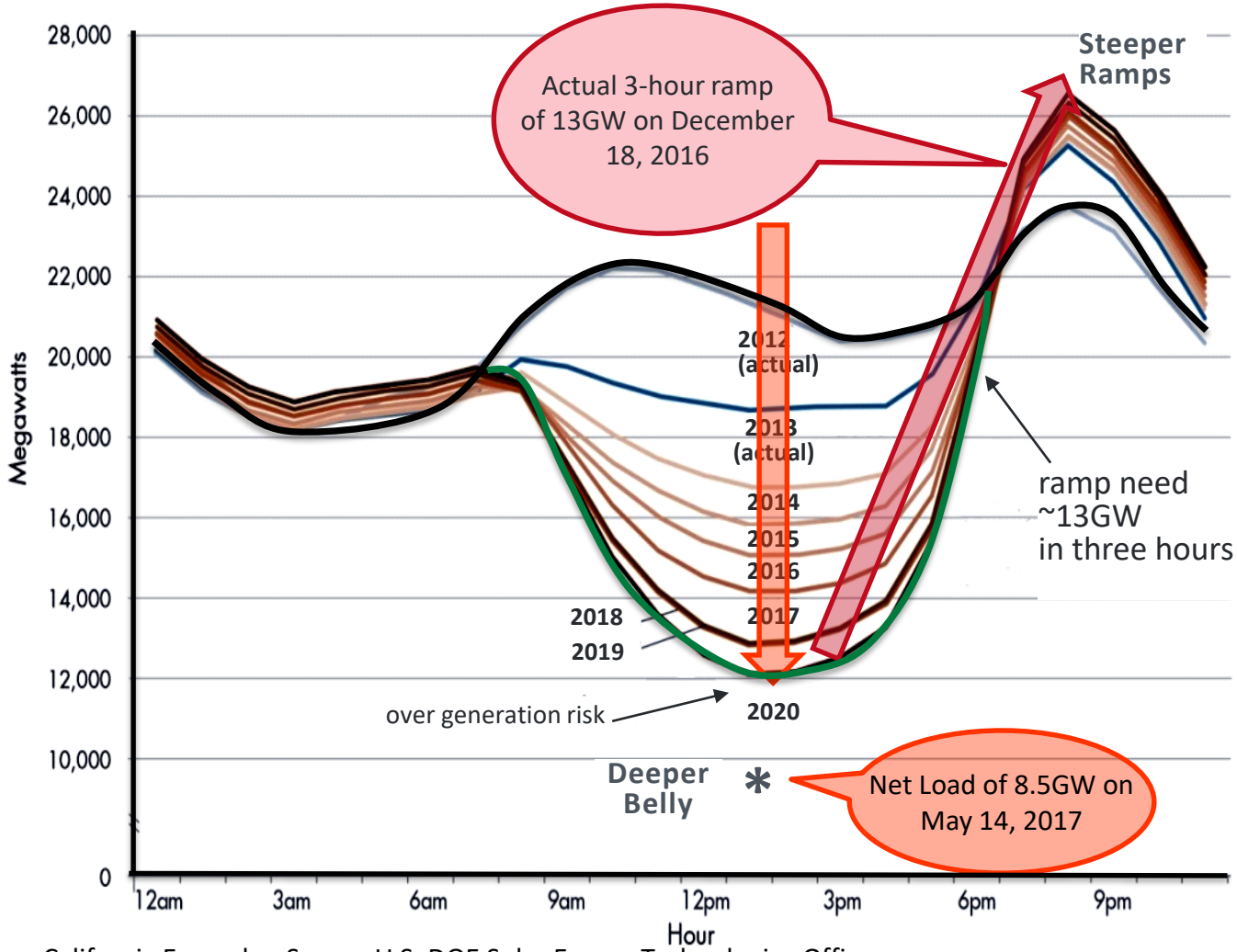


Total Load (demand)

Load (net) on commercial utility grid (duck belly forms)

Solar Productio n

The Duck's belly is getting bigger



California Example- 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

U.S. DOE Fuel Cell Technologies Office

Early R&D Focus

Applied research, development and innovation in emerging hydrogen and fuel cell technologies leading to:

- Energy security
- Energy resiliency
- Strong domestic economy

Early R&D Areas

Fuel Cells

- PGM- free catalysts
- Durable MEAs
- Electrode performance

Hydrogen

- Production pathways
- Delivery components
- Advanced materials for storage

Infrastructure

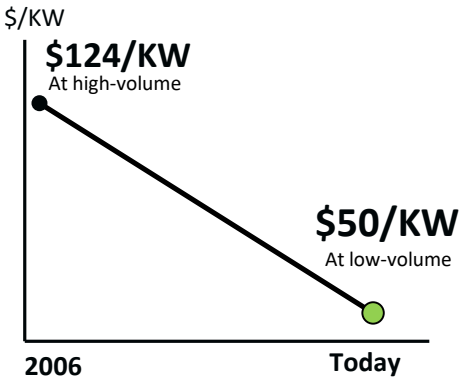
- Safety
- Manufacturing
- Delivery components
- Others

PGM = Platinum group metals

MEA = Membrane Electrode Assembly

Impact

60% Lower Fuel Cell Cost



Greater Fuel Cell Durability

4X more hours

of fuel cell lifetime since 2006

80% Lower Electrolyzer Cost

for H_2 production since 2002

Budget: $120M Fiscal Year 2019 DOE Fuel Cell Technologies Office

Projects with over 100 companies, universities, and national labs

Need to Address Challenges: Data Sharing Guides R&D

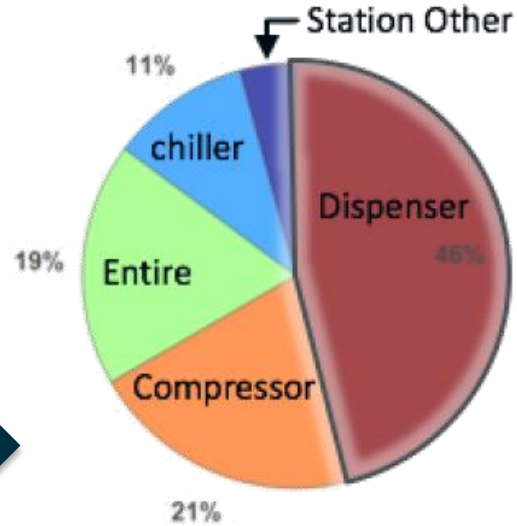
Through NREL's National Fuel Cell Technology Evaluation Center

To Participate

techval@nrel.gov

Need to address infrastructure component reliability

Example: Sources of H_2 Infrastructure Maintenance



Maintenance by Equipment Type
Retail Stations
Total Events: 4,663
Dispenser: 46% of Events

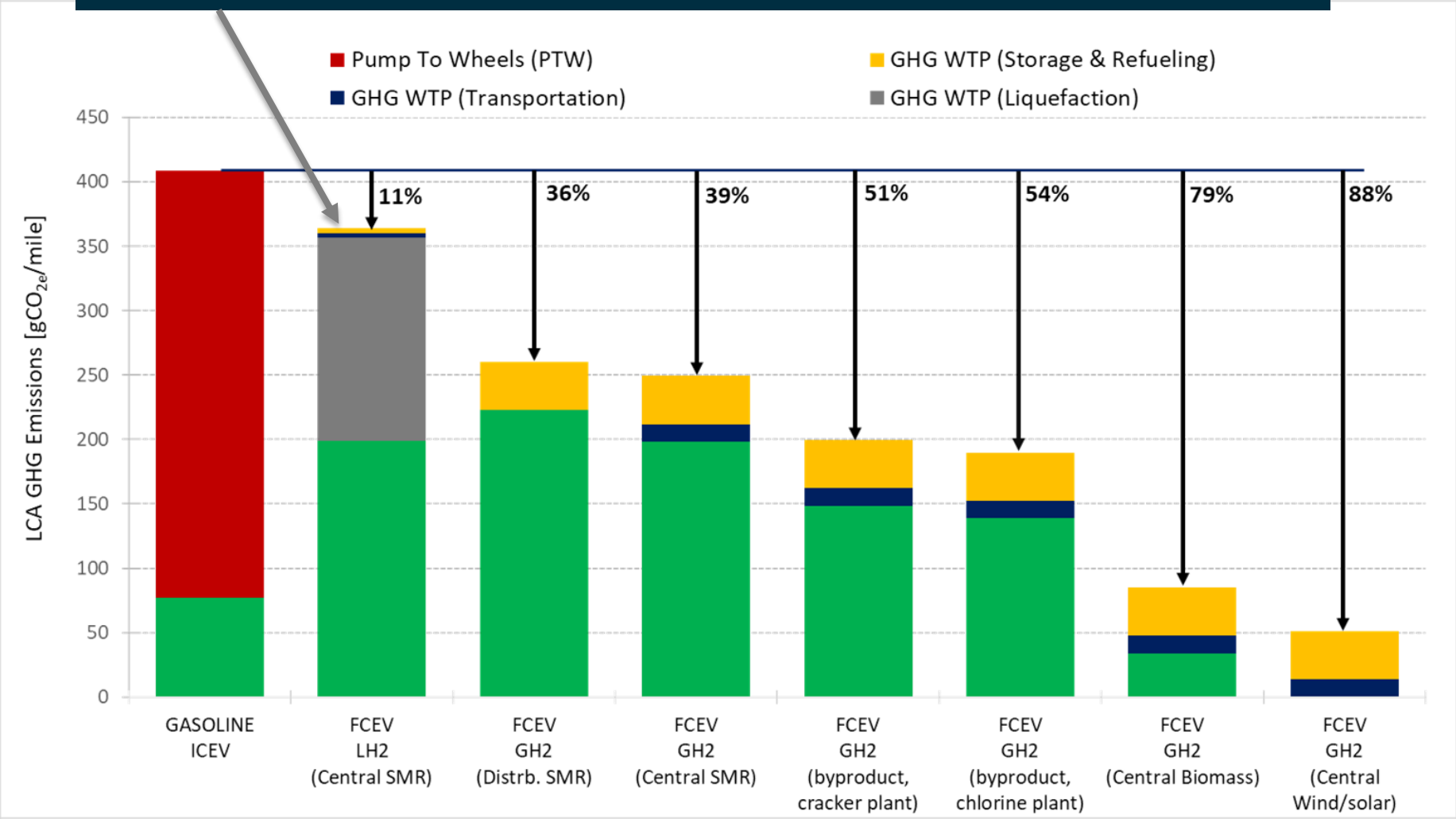
Most maintenance related to compressors and dispensers

- Visit: **energy.gov/eere/fuelcells/hydrogen-analysis-toolbox**

Source: U.S. DOE Fuel Cell Technologies Office

Example of R&D Needs: Upstream Hydrogen Delivery & Dispensing Must be Improved

R&D needed to improve liquefaction efficiency

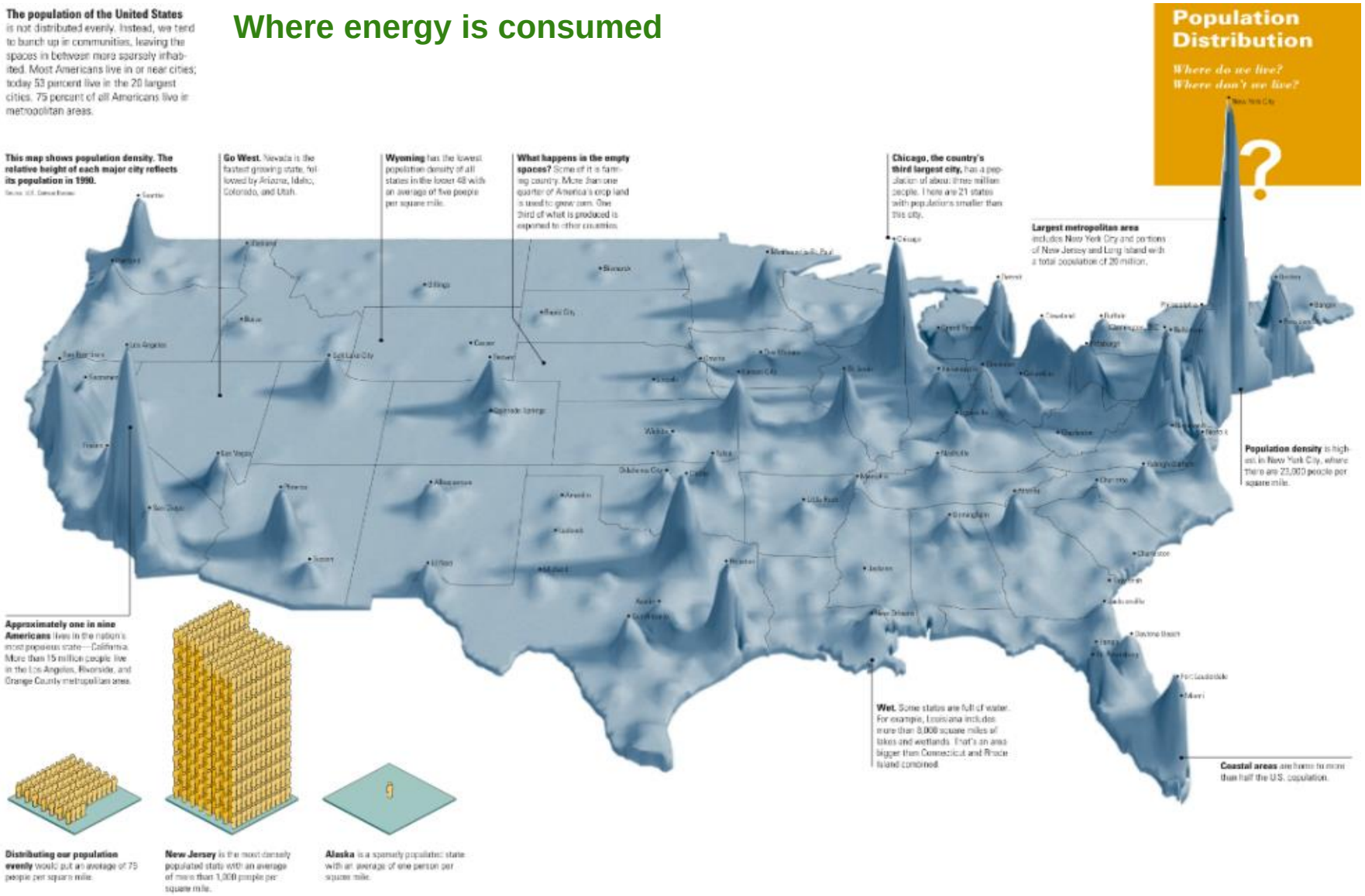


H_2@Scale: Enabling renewable energy transport?

Where we find abundant solar and wind energy

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

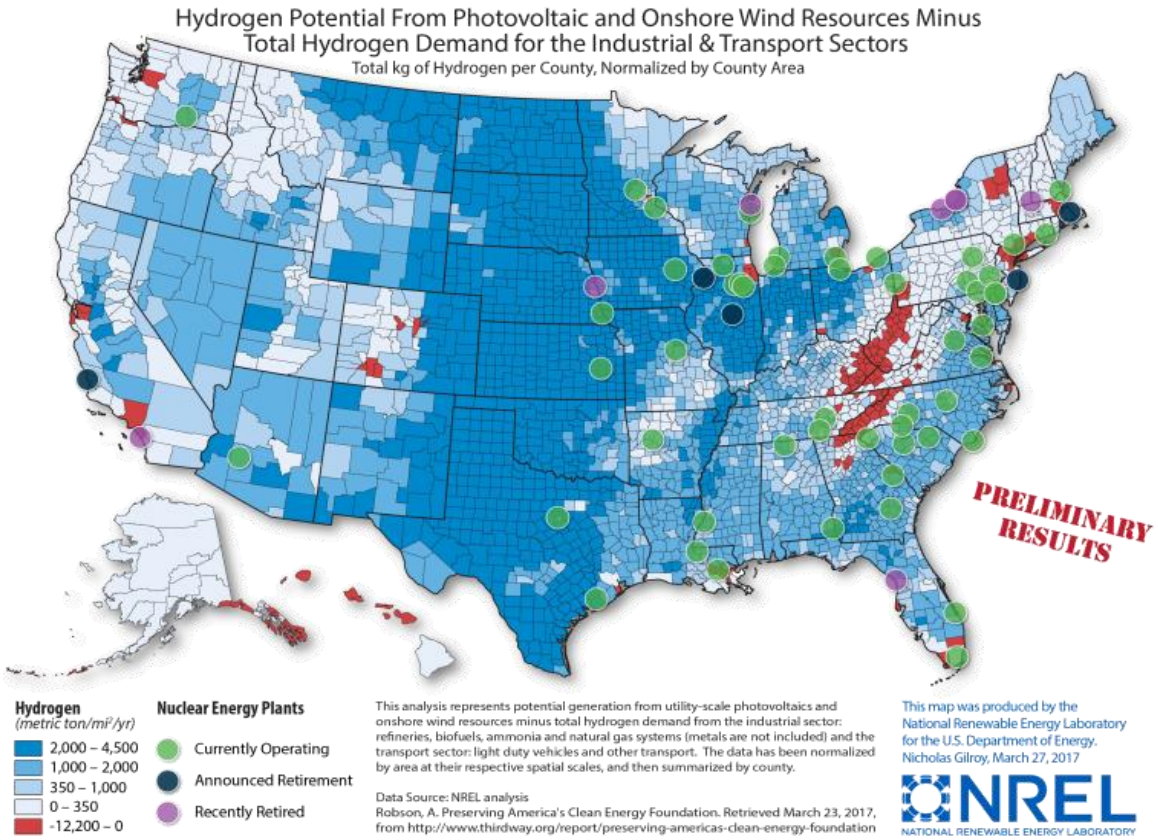
Where energy is consumed



H2@Scale: Nationwide Resource Assessment

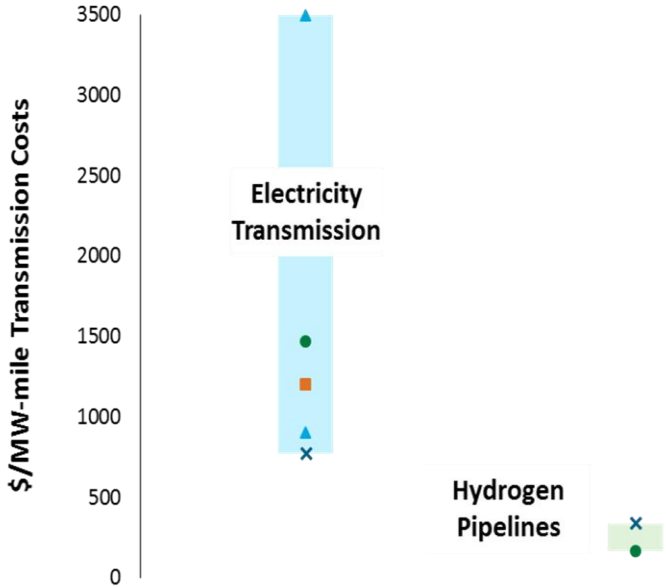
Assessing resource availability. Most regions have sufficient resources.

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



Assessing cost of H_2 vs electricity transmission

(in process)



Key focus areas to realize the H_2@scale vision

MAKE

Increased Low Cost Hydrogen Production

MOVE

More Efficient Hydrogen Transmission

USE

Low Cost Value-added Applications

STORE

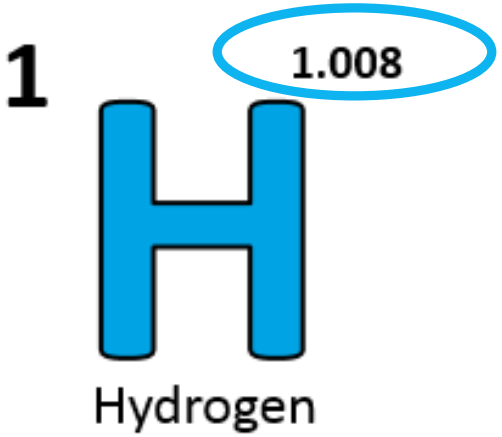
Improved Bulk Storage Technologies

Opportunities for outreach and to increase awareness

Celebrate National Hydrogen & Fuel Cell Day

October 8 or 10/8

(Held on its very own atomic- weight-day)



Information and Training Resources to Increase Awareness

H2tools.org

INCREASE YOUR H2IQ

Download for free at:
energy.gov/eere/fuelcells/downloads/increase-your-h2iq-training-resource

Learn more at: energy.gov/eere/fuelcells

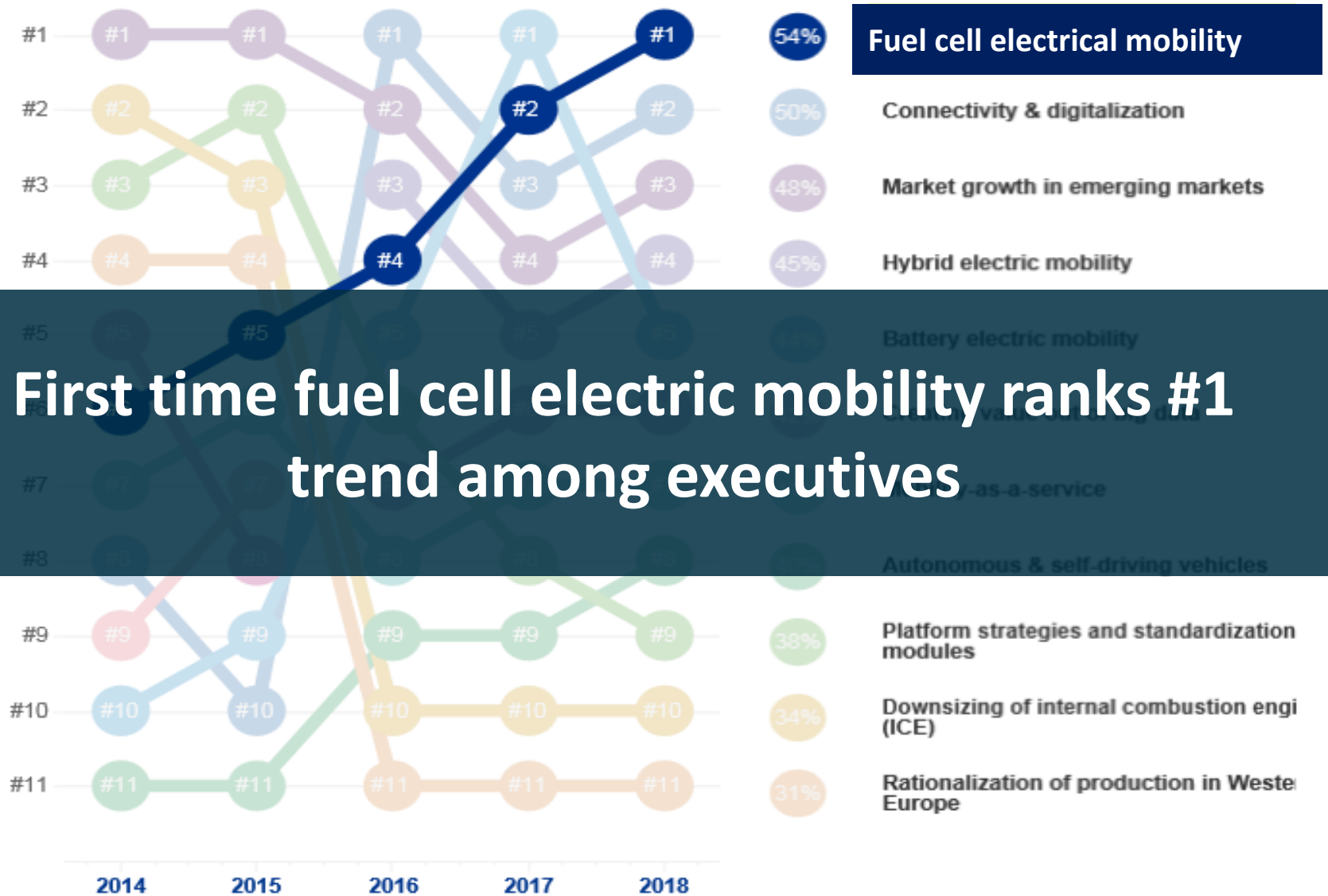
Thank You

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

energy.gov/eere/fuelcells

IPHE: A Global Partnership Advancing Hydrogen and Fuel Cells Technology

Automotive Executives Survey Results



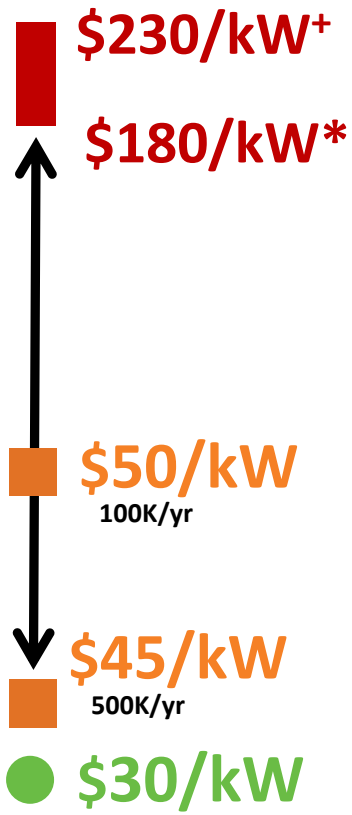
First time fuel cell electric mobility ranks #1 trend among executives

Source: KPMG Global Automotive Executive Survey 2018

DOE Cost Status and Targets for R&D

Fuel Cell R&D

System



+Based on commercially available FCEVs

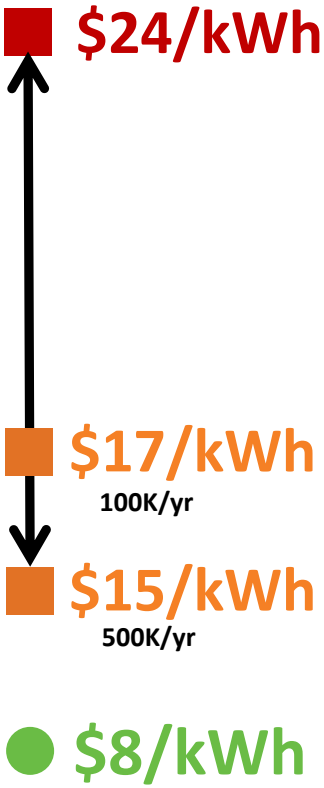
*Based on state of the art technology

Hydrogen R&D

Production, Delivery & Dispensing

Onboard Storage

(700-bar compressed system)



+Range assumes current production from NG and delivery and dispensing.

*Highest possible cost at high vol., assumes H2 from electrolysis at $5/gge and delivery via pipelines and liquid tankers at $5/gge

** Lowest possible cost at high vol., assumes H2 from SMR at $2/gge and delivery via tube trailer at $3/gge

Ultimate Targets | High-Volume Projection | Low-Volume Estimate

Notes: Graphs not drawn to scale and are for illustration purposes only. gge: gallon of gasoline equivalent