U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

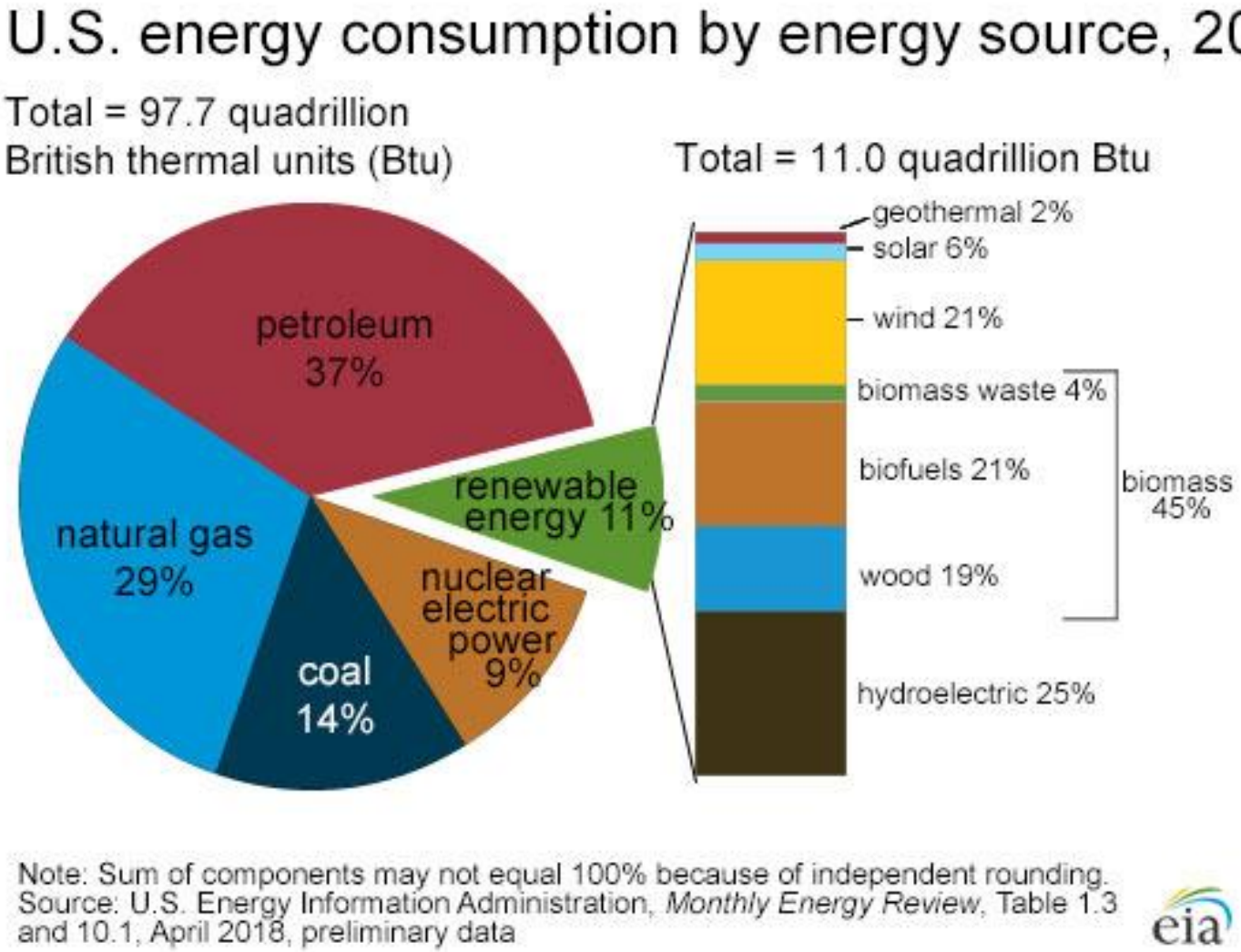
U.S. Department of Energy Hydrogen and Fuel Cell Technology Overview

Greg Kleen, U.S. Dept. Of Energy Fuel Cell Technologies Office

IPHE Education and Outreach Event

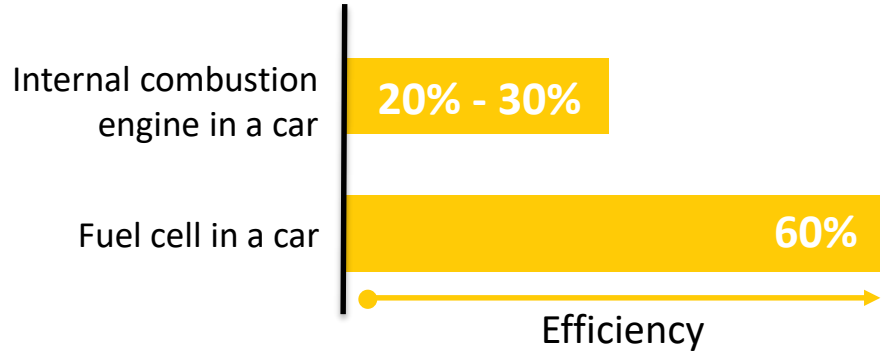
Seoul, South Korea – October 22, 2019

U.S. Energy Portfolio



Why Hydrogen and Fuel Cells?

Efficient



Uses domestic fuels

- Natural gas
- Renewable sources (wind, solar, biomass, etc.)
- Nuclear
- Coal

Convenient

Refuels in minutes

Quiet

No noise in operation

Clean

Zero tailpipe emissions

Versatile and easily scalable

Transportation

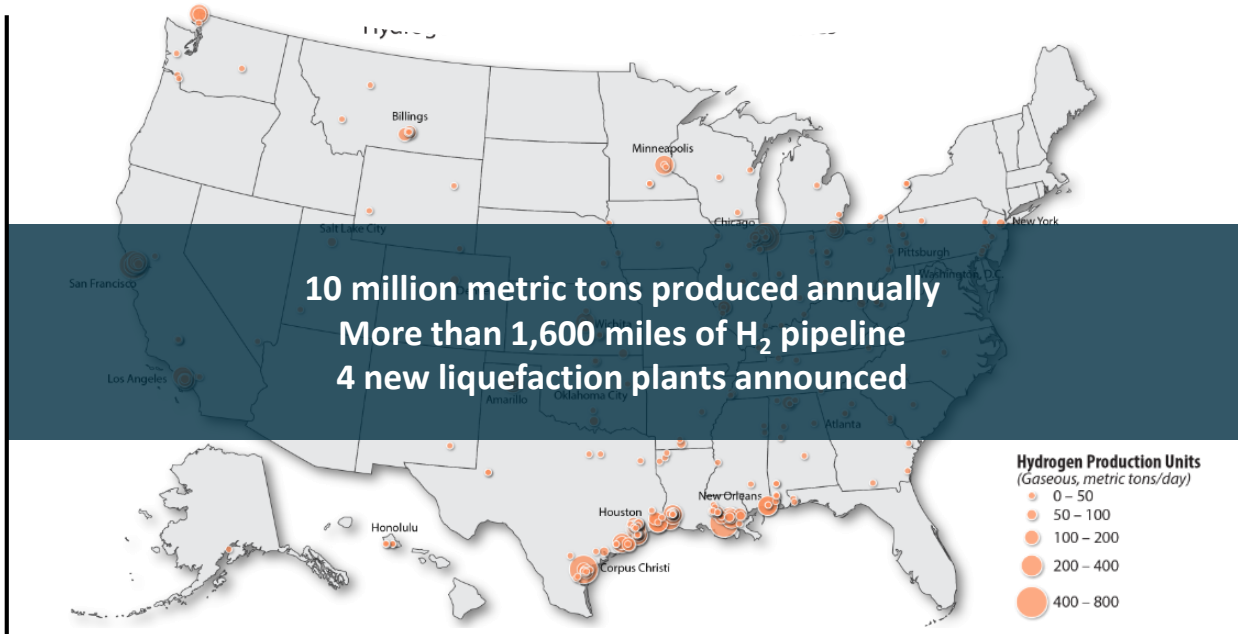
Stationary

Snapshot of Hydrogen and Fuel Cells Applications in the United States

Examples of Applications

- **>500MW** Stationary Power
- **>26,000** Forklifts
- **>30** Fuel Cell Buses
- **>40** H_2 Retail Stations
- **>7,800** Fuel Cell Cars

Hydrogen Production Facilities



10 million metric tons produced annually
More than 1,600 miles of H_2 pipeline
4 new liquefaction plants announced

Hydrogen Stations: Examples of Plans Across States

California
1,000 stations by 2030

Northeast
12 – 20 stations planned

HI, OH, SC, NY, CT, MA, CO, UT, TX, MI, and others with interest

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 Emerging

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

Hydrogen Fuel Cell Cars are Commercially Available

Honda Clarity

Nearly **7,800** | **sold or leased** in the United States


Hyundai Nexo

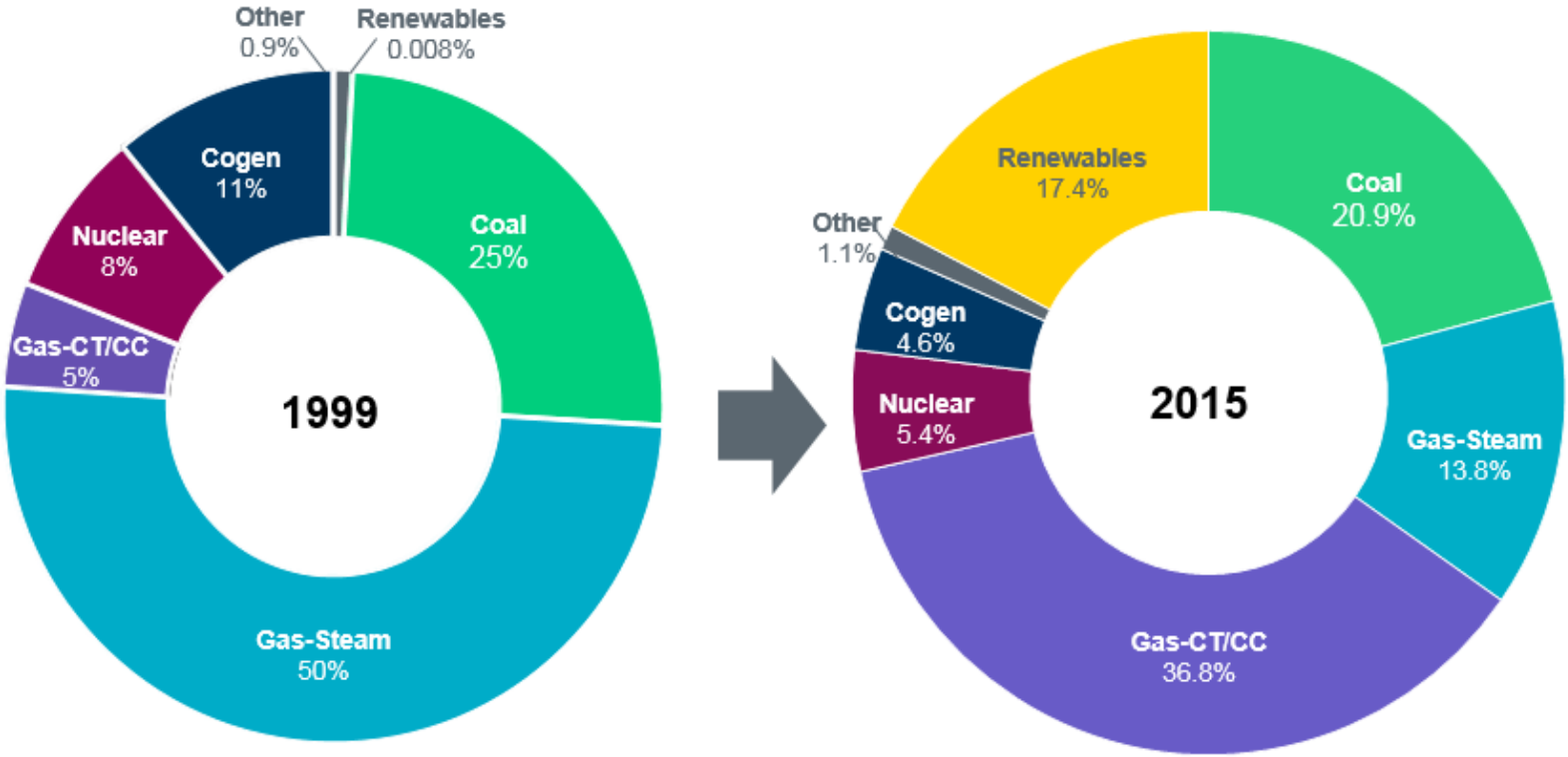
Commercial **fuel cell electric cars are here**


Toyota Mirai

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

Electricity Mix is Changing

Example: Installed Capacity in Texas



Source: ERCOT, DOE H2@Scale Workshop, TX

Hydrogen Energy Storage is Scalable

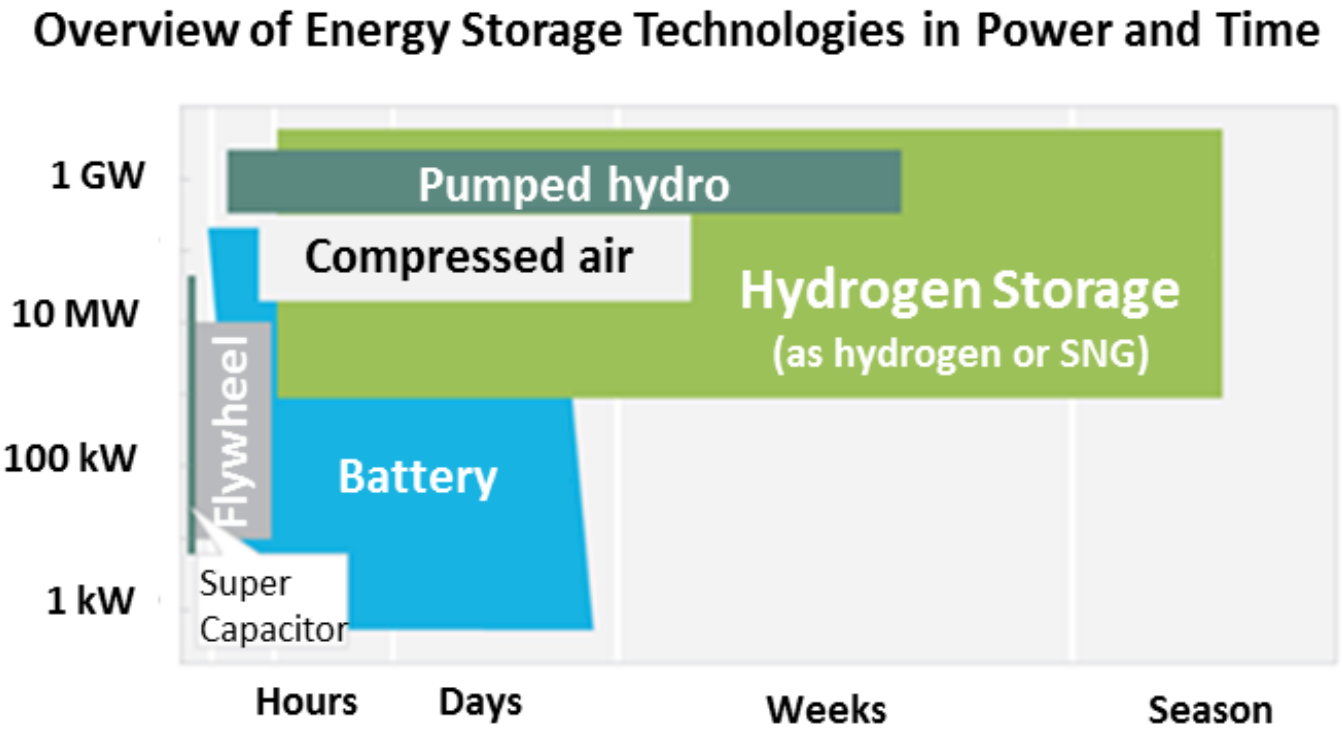
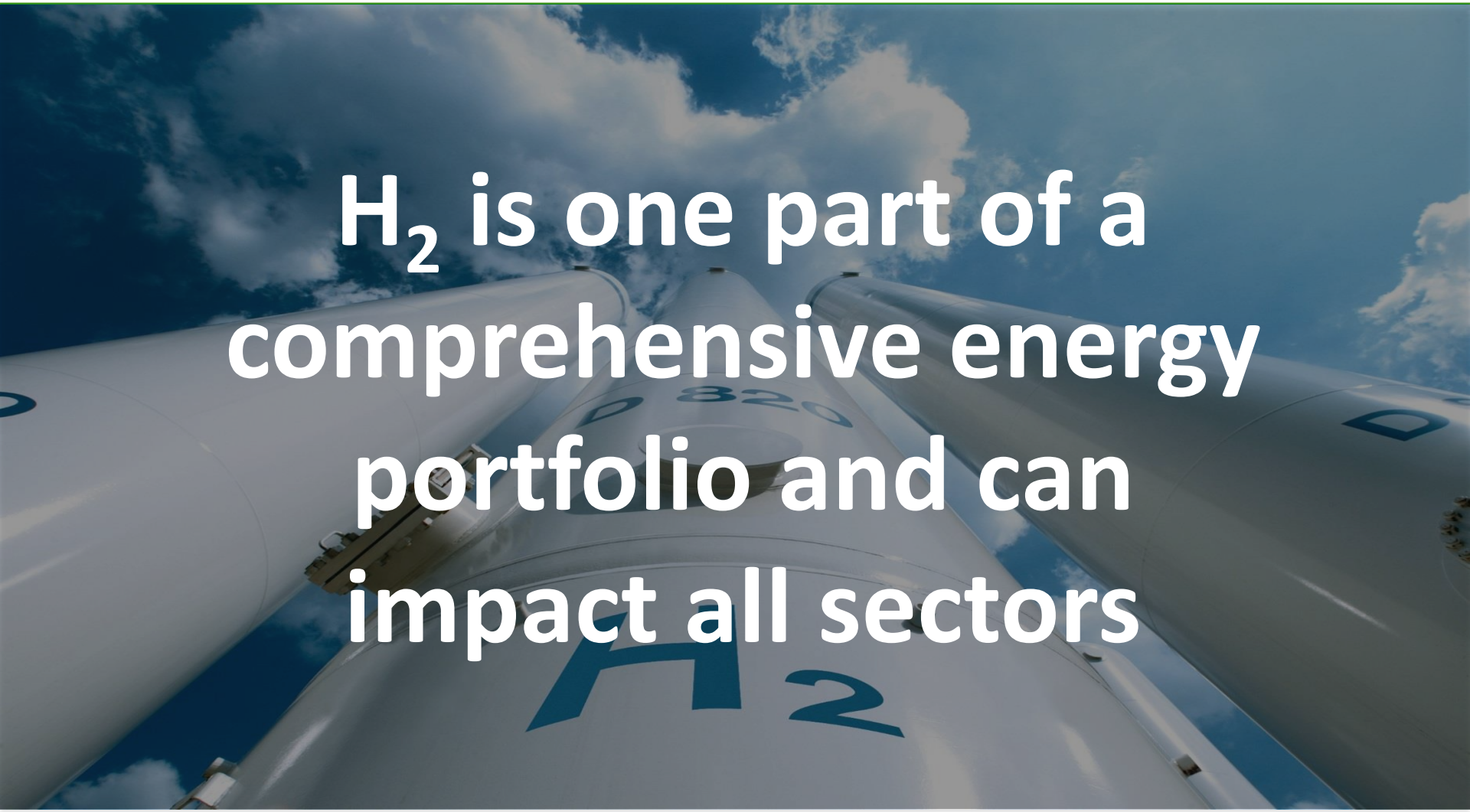


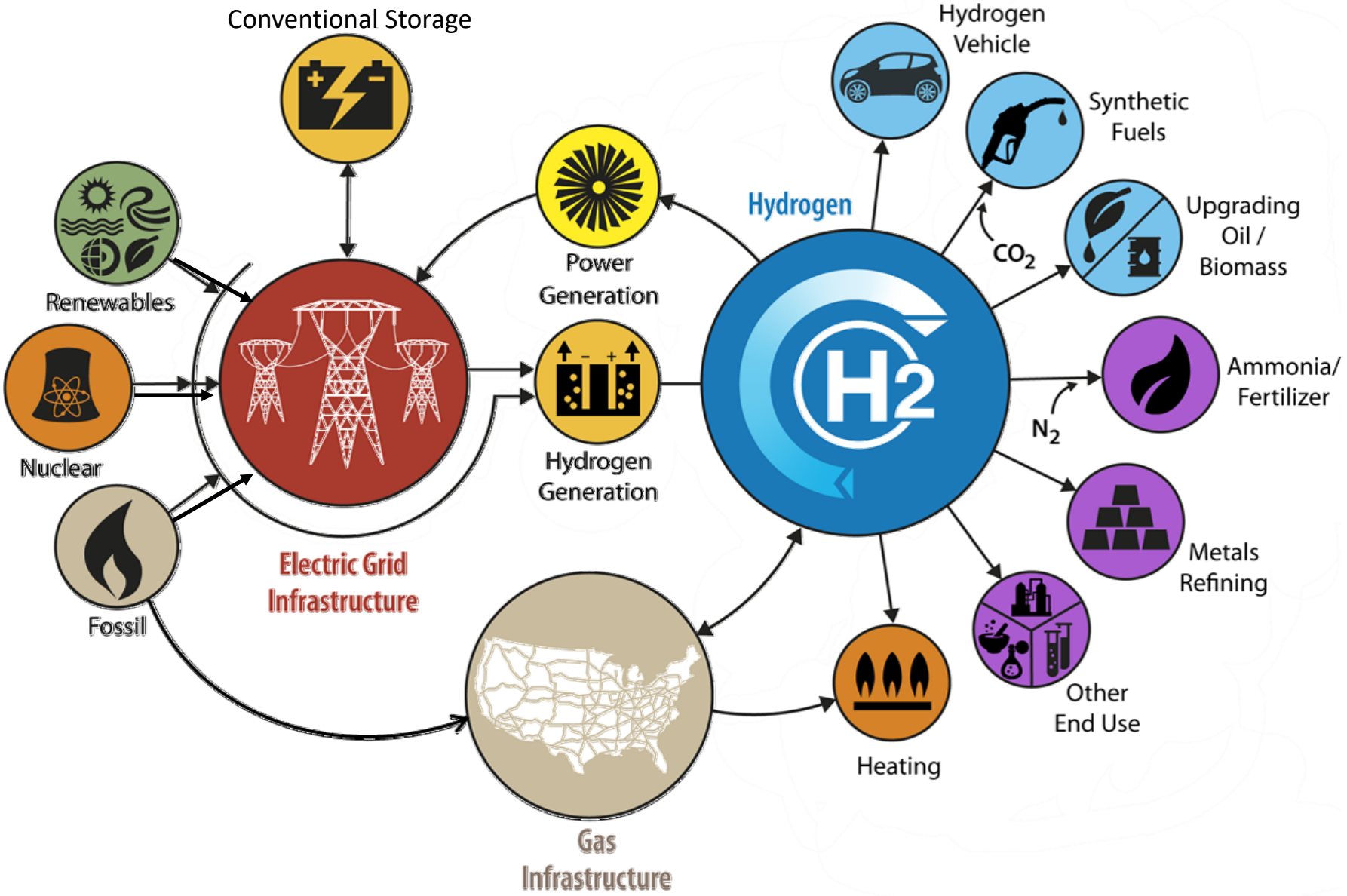
Image: Hydrogen Council

One hydrogen cavern could provide **~ 100 GWh energy storage**

Hydrogen can be used to monetize surplus electricity from the grid, or remote, off-grid energy feedstock (e.g. solar, wind) for days to months.


H_2 is one part of a comprehensive energy portfolio and can impact all sectors

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

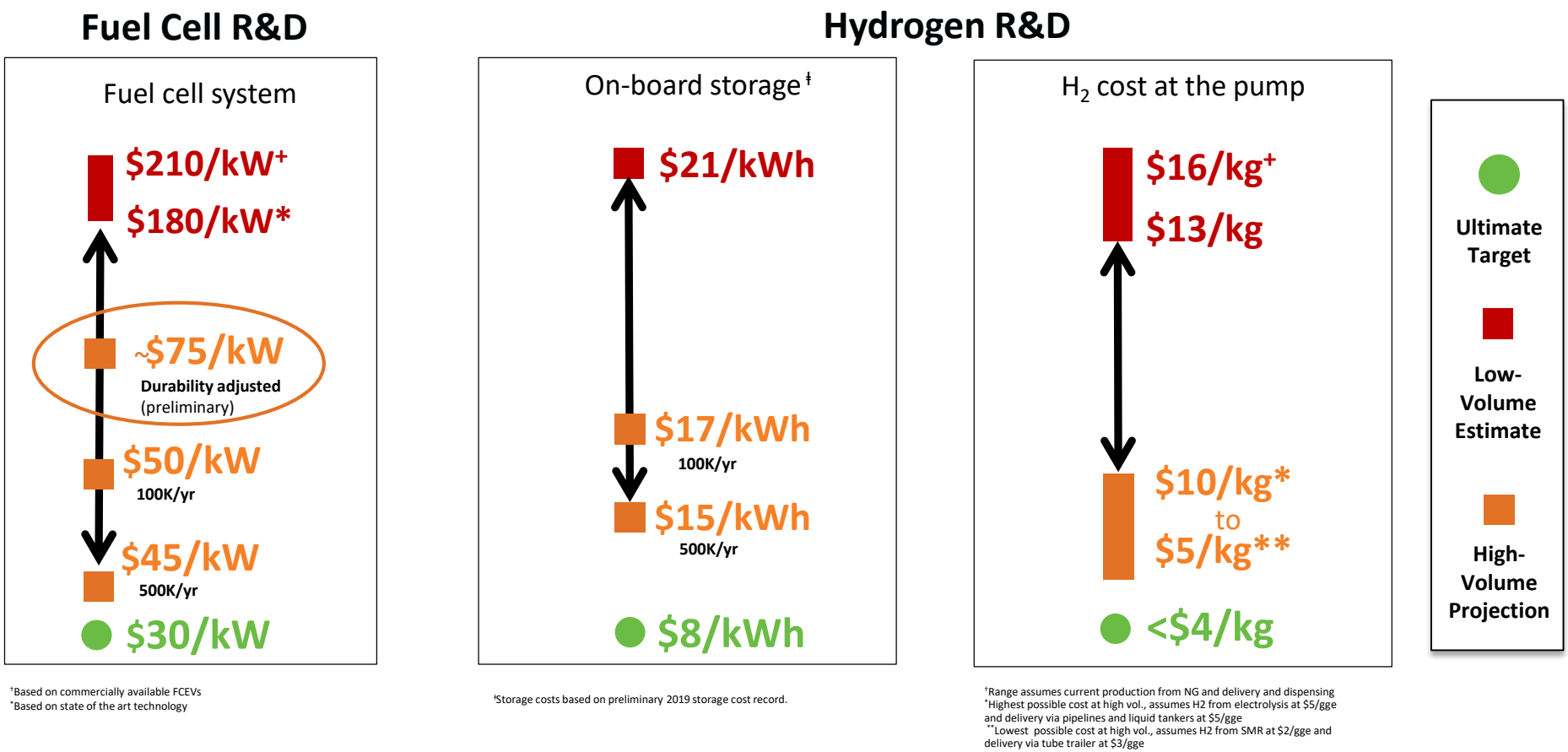


Remaining challenges being addressed

Cost and durability

Infrastructure cost, availability, reliability

Focus is on Affordability: DOE Targets Guide R&D



†Based on commercially available FCEVs
*Based on state of the art technology

ǂStorage costs based on preliminary 2019 storage cost record.

†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

Addressing Challenges through Innovative Approaches

The competition

H2refuel U.S. Department of Energy

- DOE **$1M prize**
- Focuses on system for **small-scale refueling**
- Led to **commercial system** and developed **international interest**

More info: **hydrogenprize.org**

The winning system

simple.fuel.™

- Designed by **three-member team:**
  - Ivys Energy Solutions and McPhy Energy (MA)
  - PDC Machines (PA)
- Produces **H2 via electrolysis**
- Dispenses **1 kg of H_2 in 15 mins** or less
- Allows **700 bar refueling**
- 1st unit **installed in Japan, manufactured in the U.S.**

More info: **www.teamsimplefuel.com**
Email: **connect@ivysinc.com**

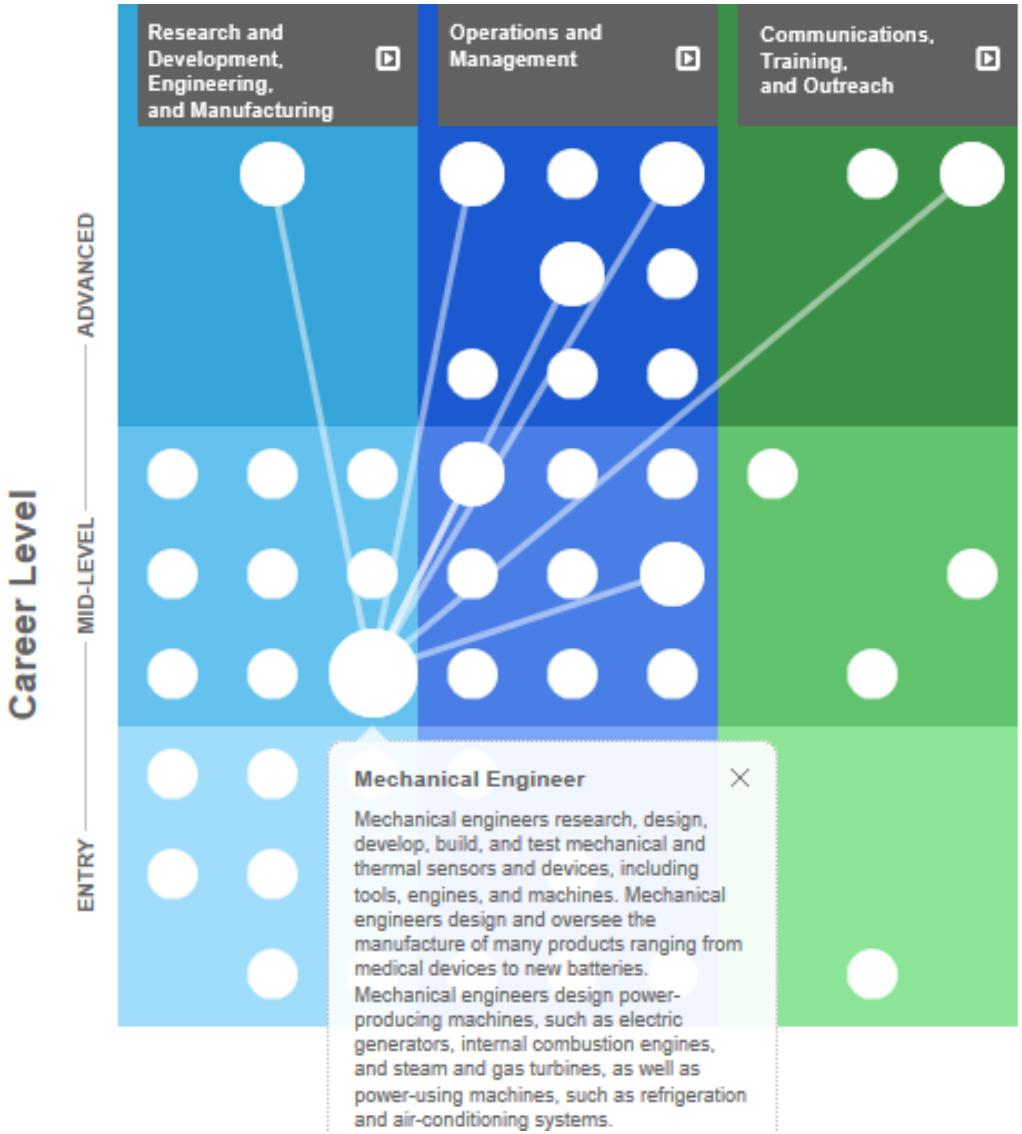
Hydrogen and Fuel Cells Career Map Online

Sectors Identified:

- Research and Development
- Engineering and Manufacturing
- Installations, Operations, and Management
- Communications, Training, and Outreach

Visit online

www.energy.gov/eere/fuelcells/education

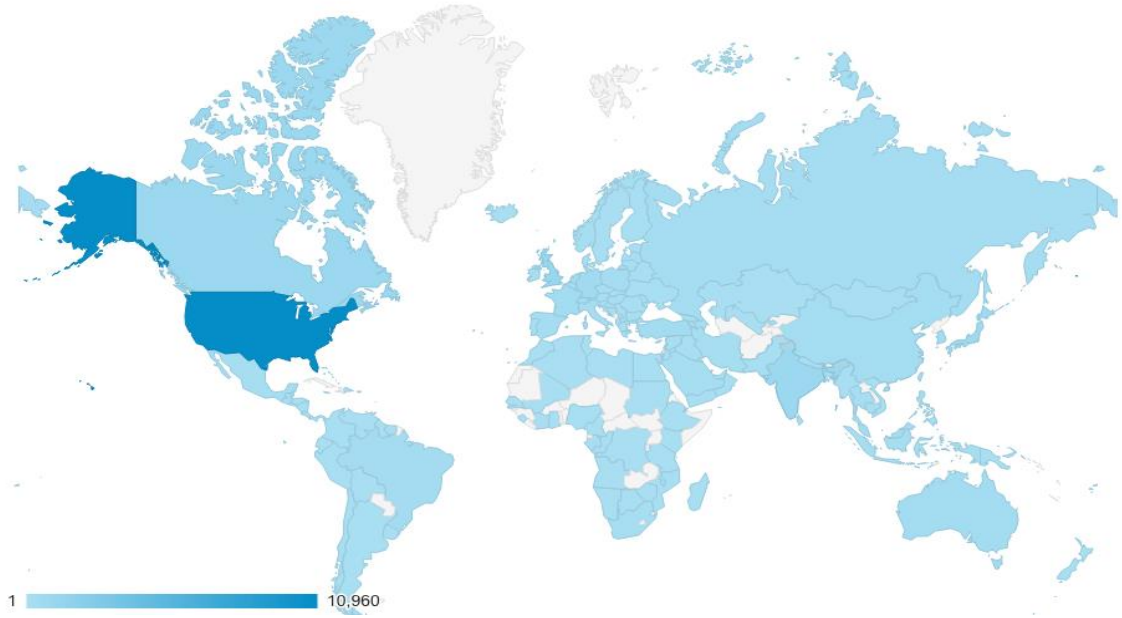


Collaboration Tools: H_2 Safety Information Sharing

H_2Tools.org : A one stop resource for hydrogen safety

h2tools.org

- Includes resources on **safety** best practices, **first responder training**, and **H_2 codes & standards**



- Site visit tracking shows a **global reach: 50%** of visits have been **international after launch**
- Over **250,000 site visits**
- Training resource **translated into Japanese. Interest in other languages.**

Example of Collaboration: Global Center for H_2 Safety (CHS)

IPHE Steering Committee action: Increase awareness of safety partnership. Promotes safe operation, handling and use of hydrogen across all applications.

Hydrogen Council

AIChE

Pacific Northwest NATIONAL LABORATORY

CENTER FOR Hydrogen SAFETY

Connecting a Global Community

HYDROGEN Safety Panel

HYDROGEN Emergency Response Training Resources

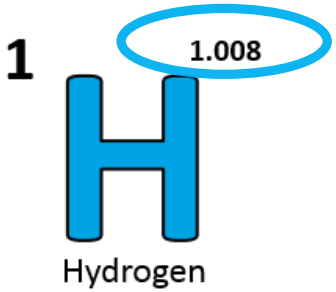
Includes over 20 partners from industry, government and academia

www.aiche.org/CHS

What can you do? Increase Awareness and Outreach

Celebrate National Hydrogen & Fuel Cell Day

October 8 or 10/8



Use Safety Information and Training Resources

H2tools.org

INCREASE YOUR H_2IQ

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

Save the Date

May 19 -21, 2020
Annual Merit Review
Washington DC

Sign up to receive hydrogen and fuel cell updates

www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-newsletter

Learn more at: energy.gov/eere/fuelcells

Thank You

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energy.gov/eere/fuelcells