U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

U.S. R&D Activities to Advance Power-to-Gas Technologies

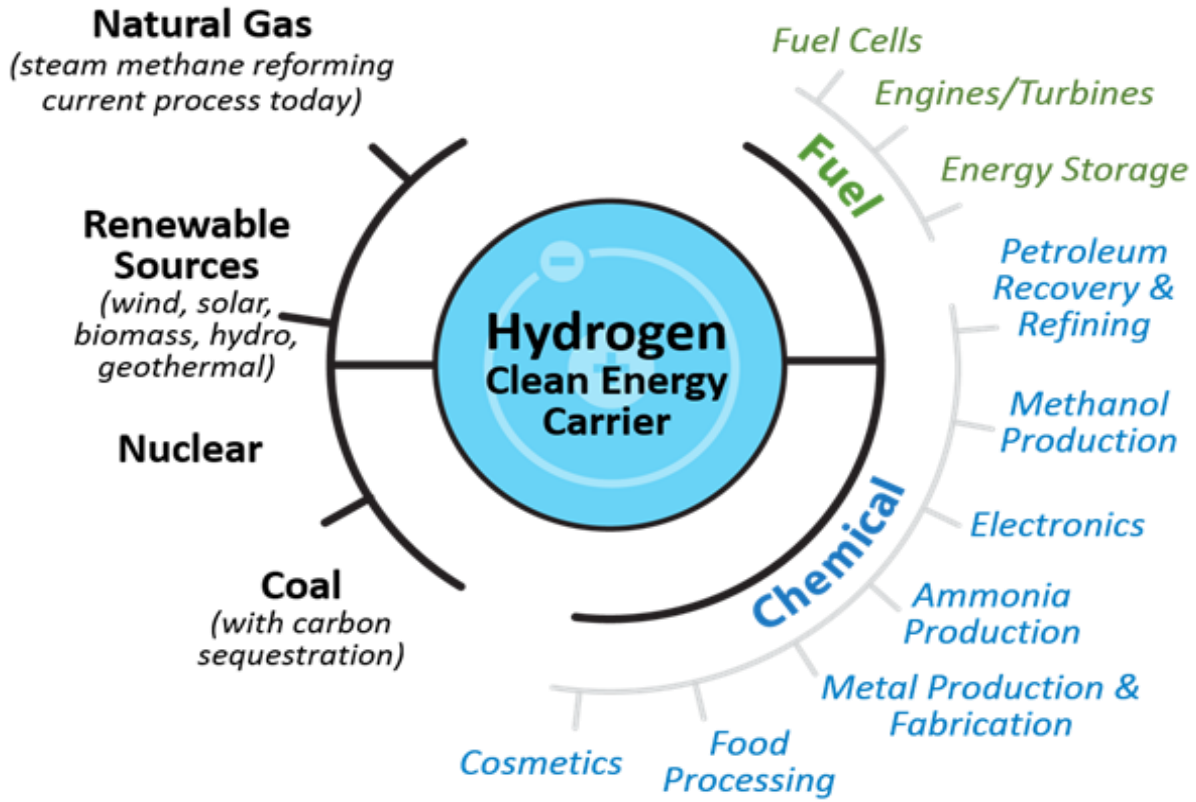
Neha Rustagi - Technology Manger– U.S. DOE Hydrogen and Fuel Cell Technologies Office

Electricity Advisory Committee Meeting

May 28, 2020

Hydrogen – One Part of a Comprehensive Energy Strategy

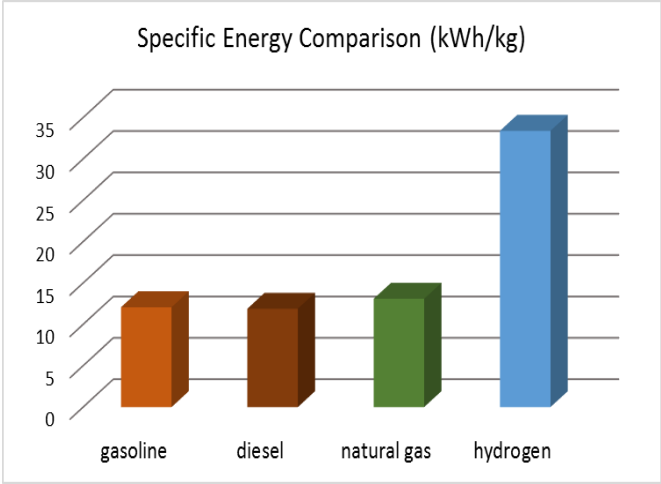
H_2 can be produced from diverse domestic sources



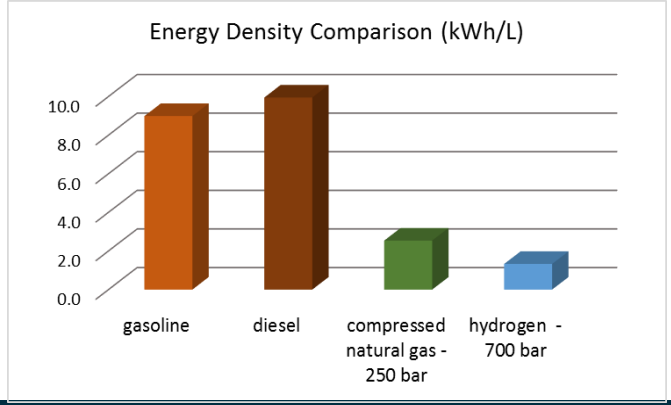
Many applications rely on or could benefit from H_2

High energy content by mass

Nearly 3x more than conventional fuels



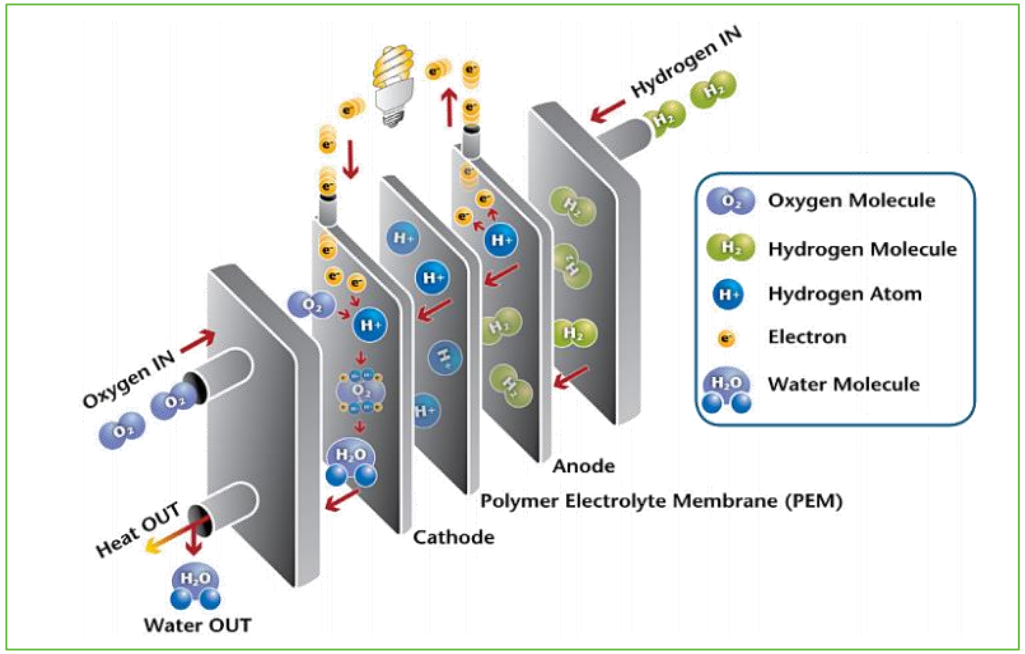
Low energy content by volume

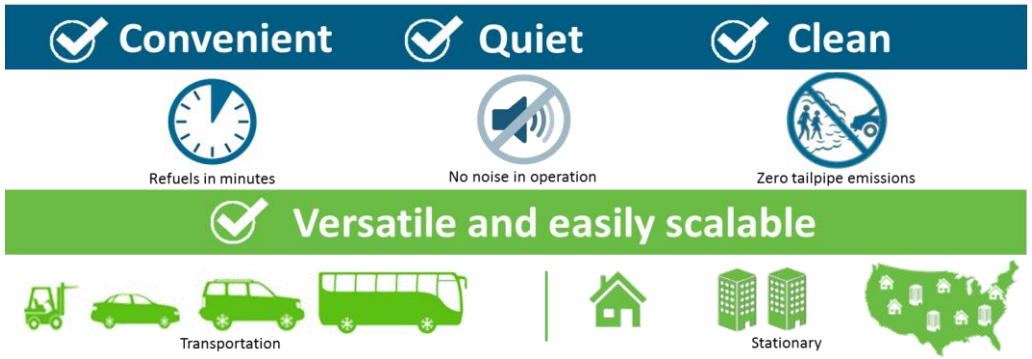


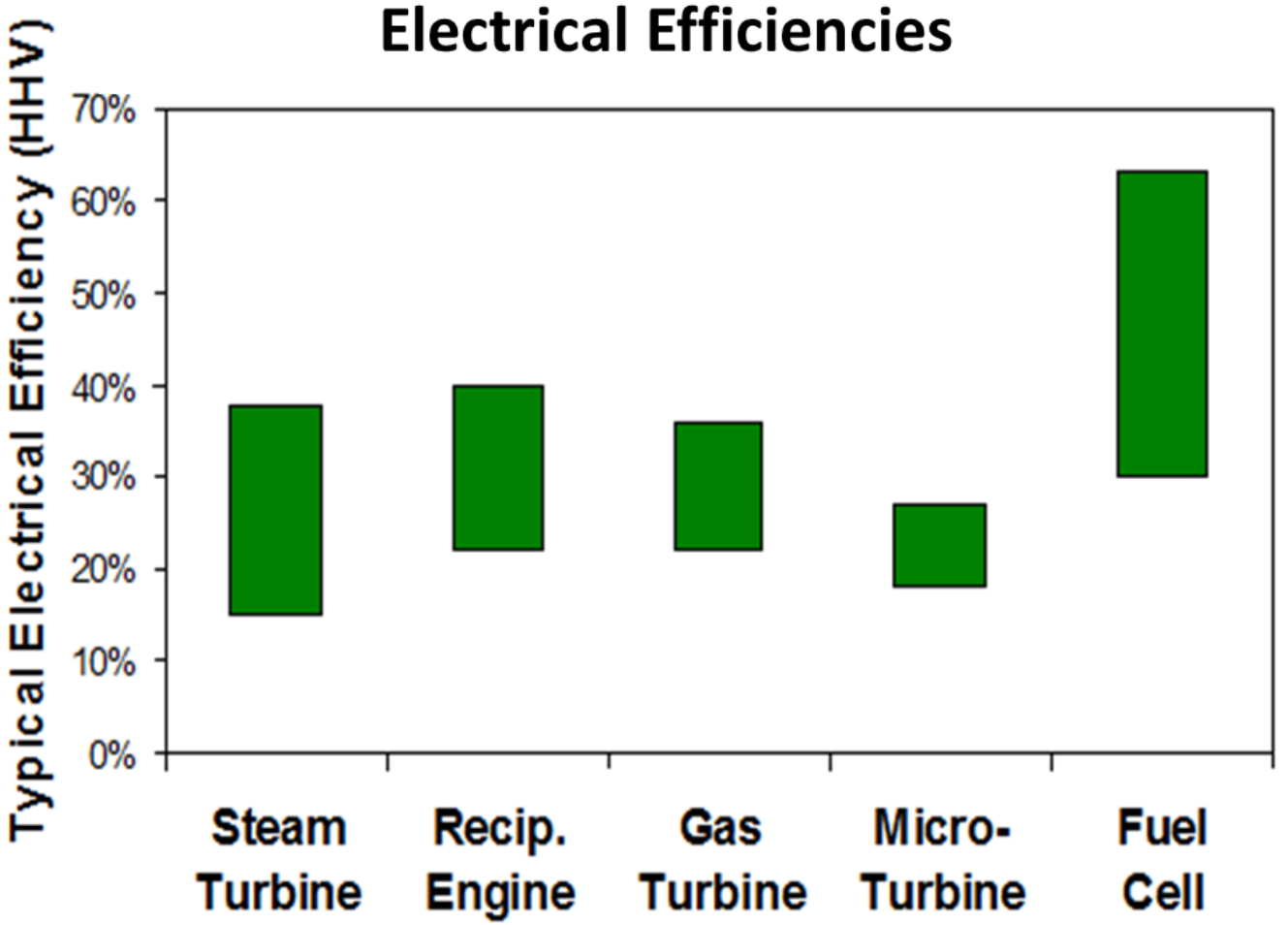
Clean , sustainable, versatile, and efficient energy carrier

Fuel Cell Basics

Fuel cells can operate on hydrogen or other fuels and do not involve combustion so have high electrical efficiencies.







Snapshot of Hydrogen and Fuel Cells Applications in the U.S.

Examples of Applications

>500MW
Stationary Power

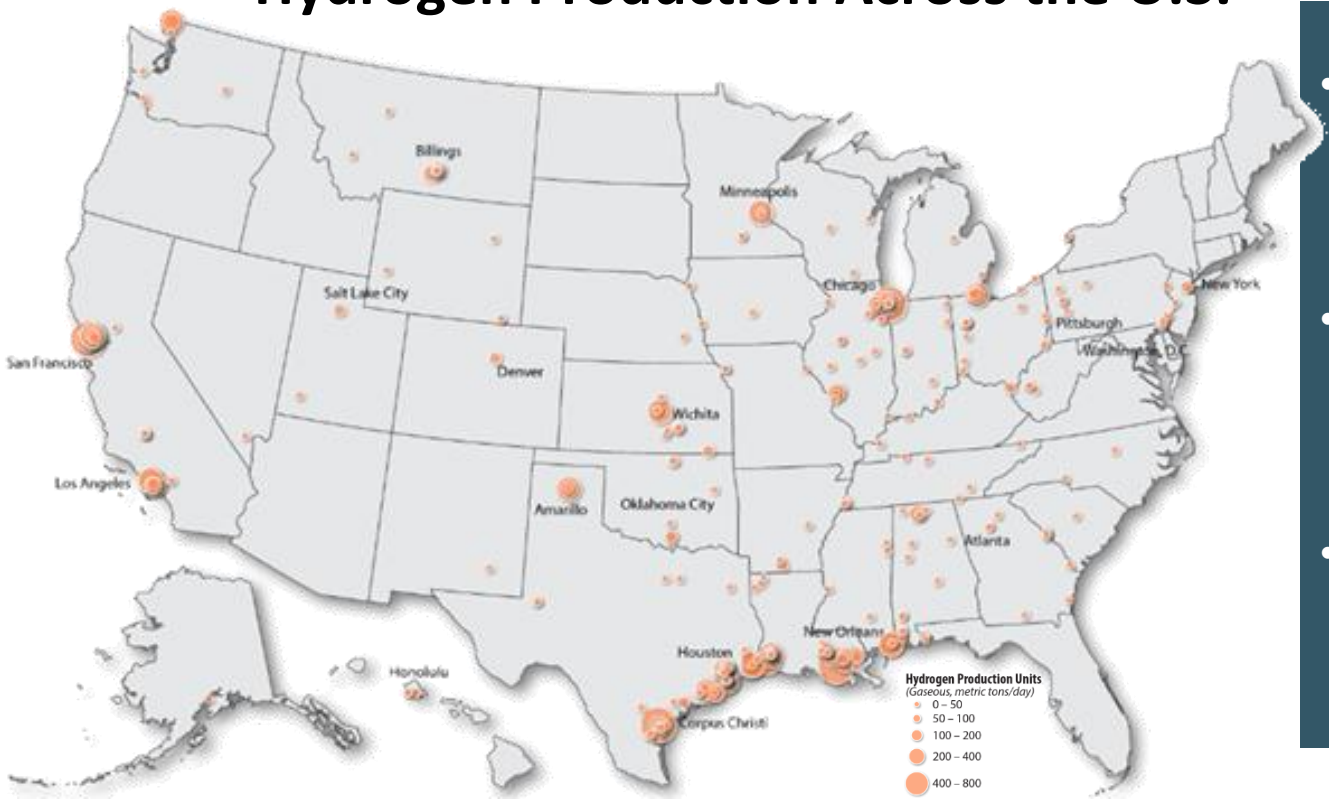
>33,000
Forklifts

>30
Fuel Cell Buses

>41
H_2 Retail Stations

>8,500
Fuel Cell Cars

Hydrogen Production Across the U.S.



- 10 million metric tons produced annually
- More than 1,600 miles of H_2 pipeline
- World's largest H_2 storage cavern

Hydrogen Stations: Examples of Plans Across States

California
200 stations planned - CAFCP goal

Northeast
12 – 20 stations planned

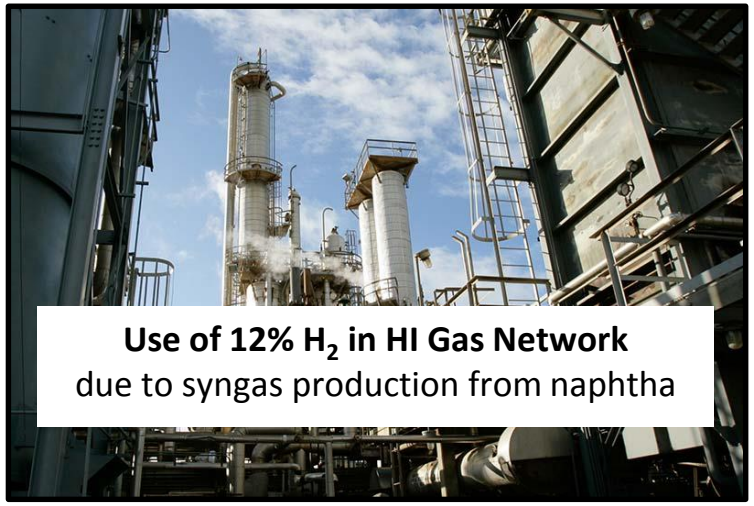
HI, OH, SC, NY, CT, MA, CO, UT, TX, MI, and others

Examples of Large-Scale Power-to-Gas and Blend Demonstrations Worldwide

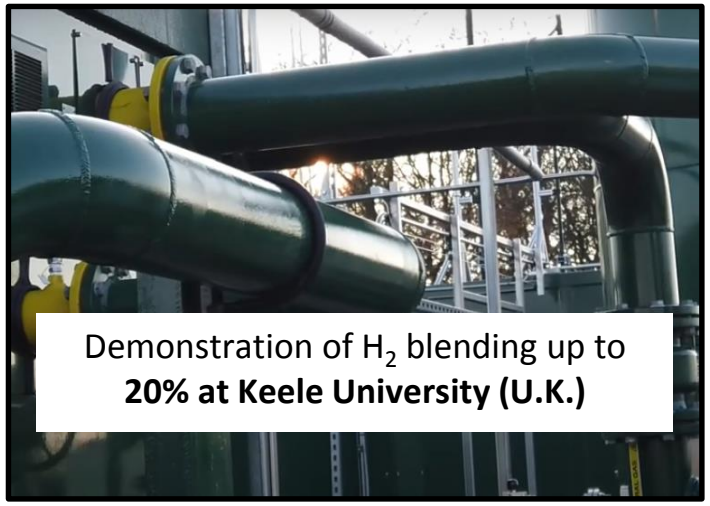
Germany: 6-MW wind-to-H_2 plant using electrolyzers

Austria: 6-MW electrolyzer for steel plant

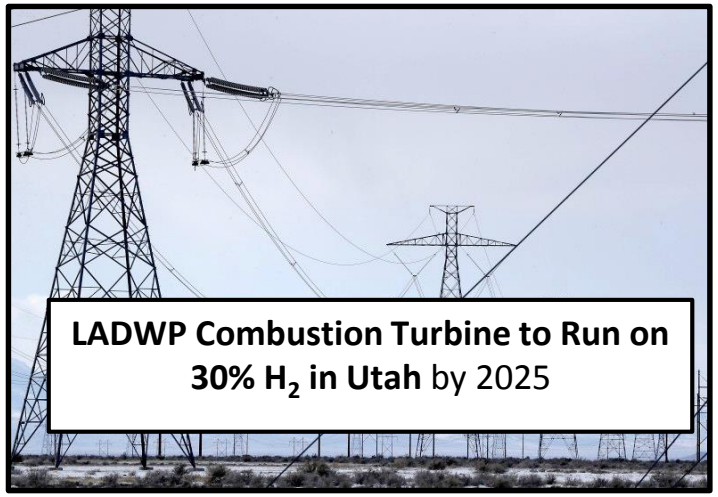
Netherlands: NortH2 project to develop 10 GW wind-to-H_2 by 2027



Use of 12% H_2 in HI Gas Network due to syngas production from naphtha

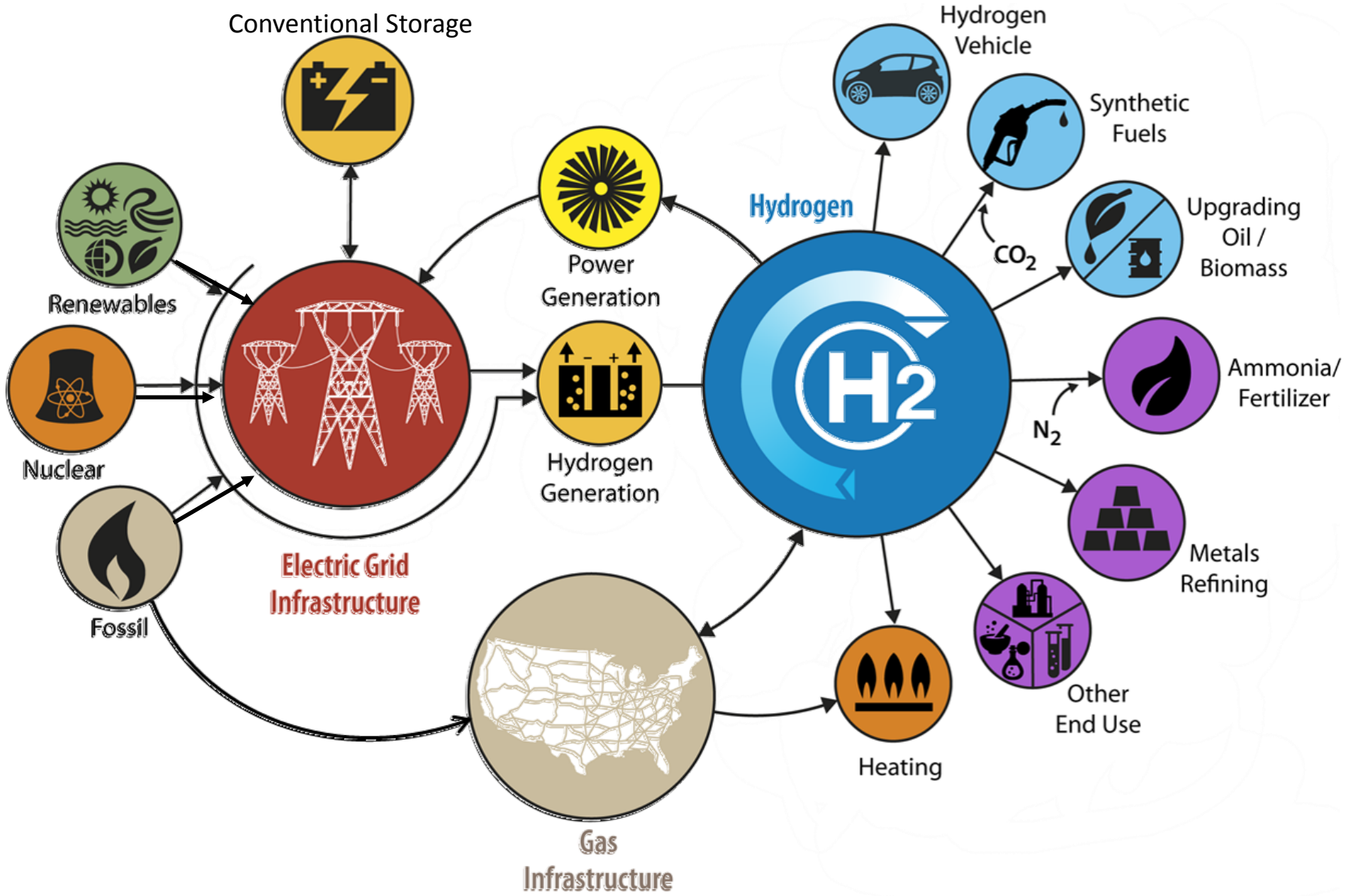


Demonstration of H_2 blending up to **20% at Keele University (U.K.)**



LADWP Combustion Turbine to Run on 30% H_2 in Utah by 2025

H2@scale: Enabling Affordable, Reliable, Clean, and Secure Energy Across Sectors



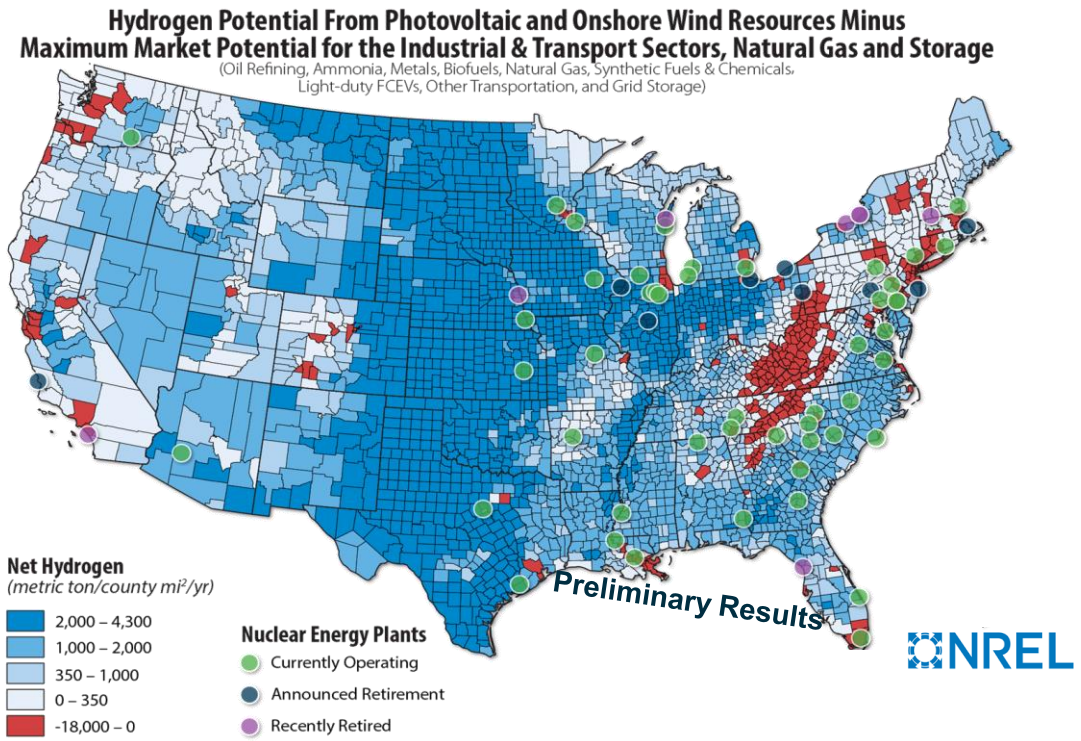
Examples of Activities to Enable H2@Scale

Assessing resource availability.
Most regions have sufficient resources.

3* new H2@scale demonstration projects in Texas, Florida and Midwest.

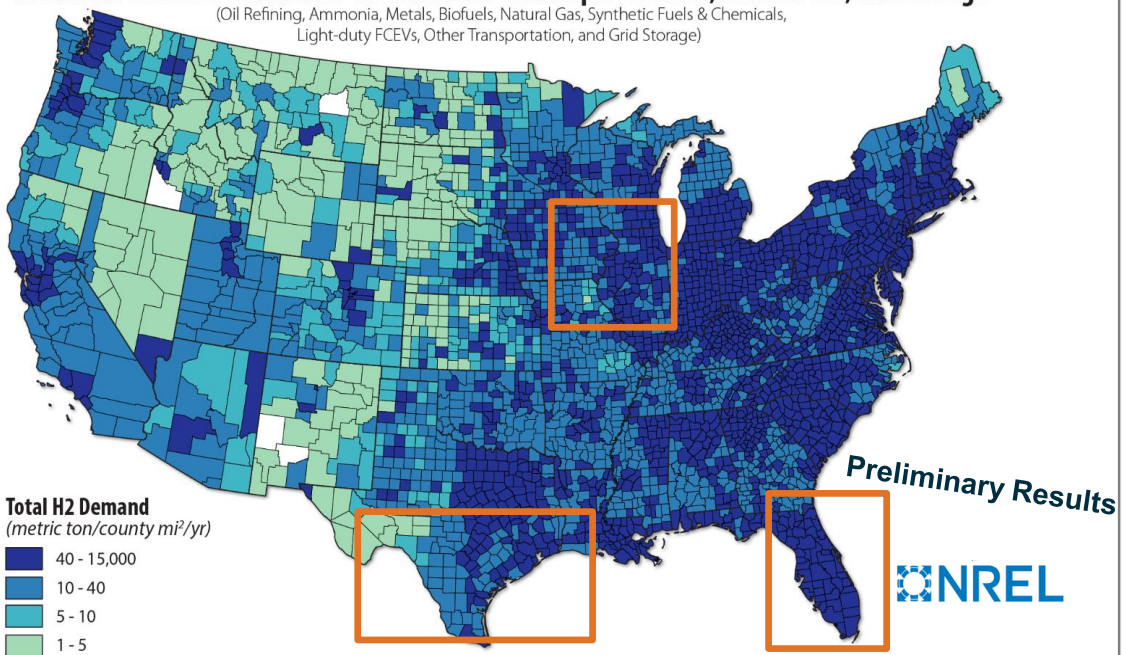
*Includes 1 project by Office of Nuclear Energy

Hydrogen Availability



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

Hydrogen Demand Potential



Increased Activities on Hydrogen, Energy Storage, Hybrid Systems

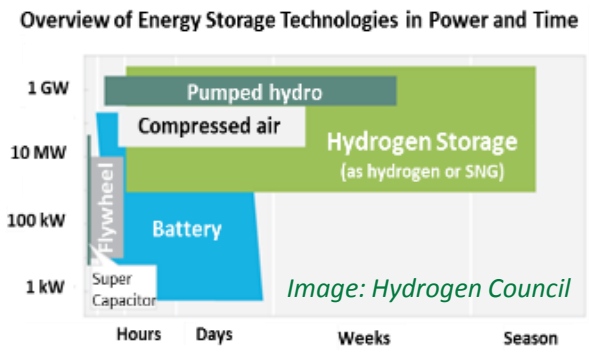


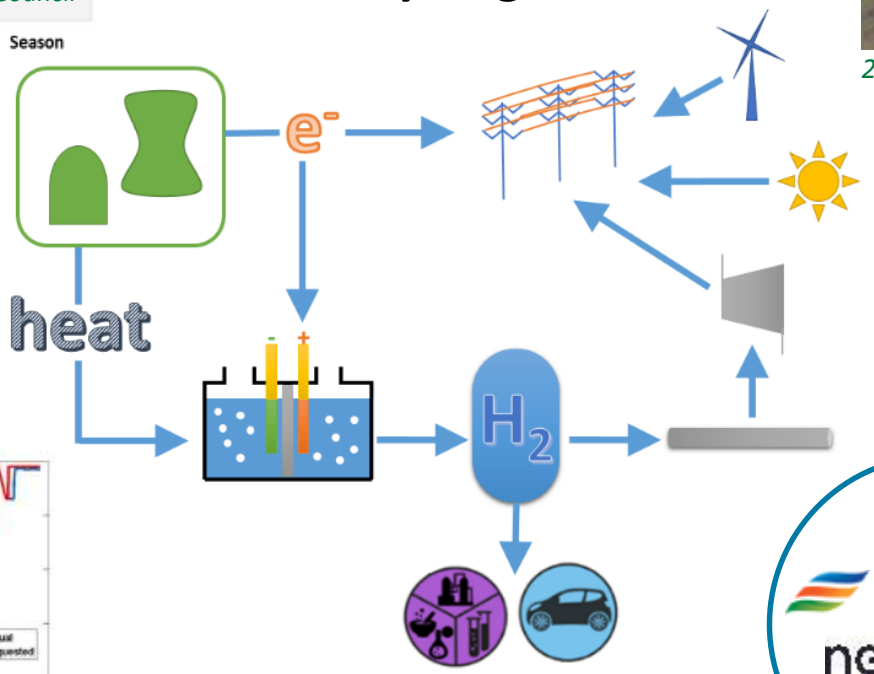
Image: Hydrogen Council

H_2 energy storage

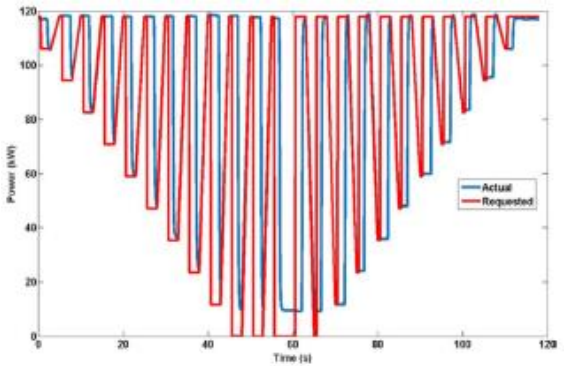
Increased opportunities for nuclear and hydrogen

25 kW high-temperature electrolysis @ INL Energy Systems Laboratory

Thermal Integration



Dynamic response



Dynamic electrolyzer response – INL & NREL

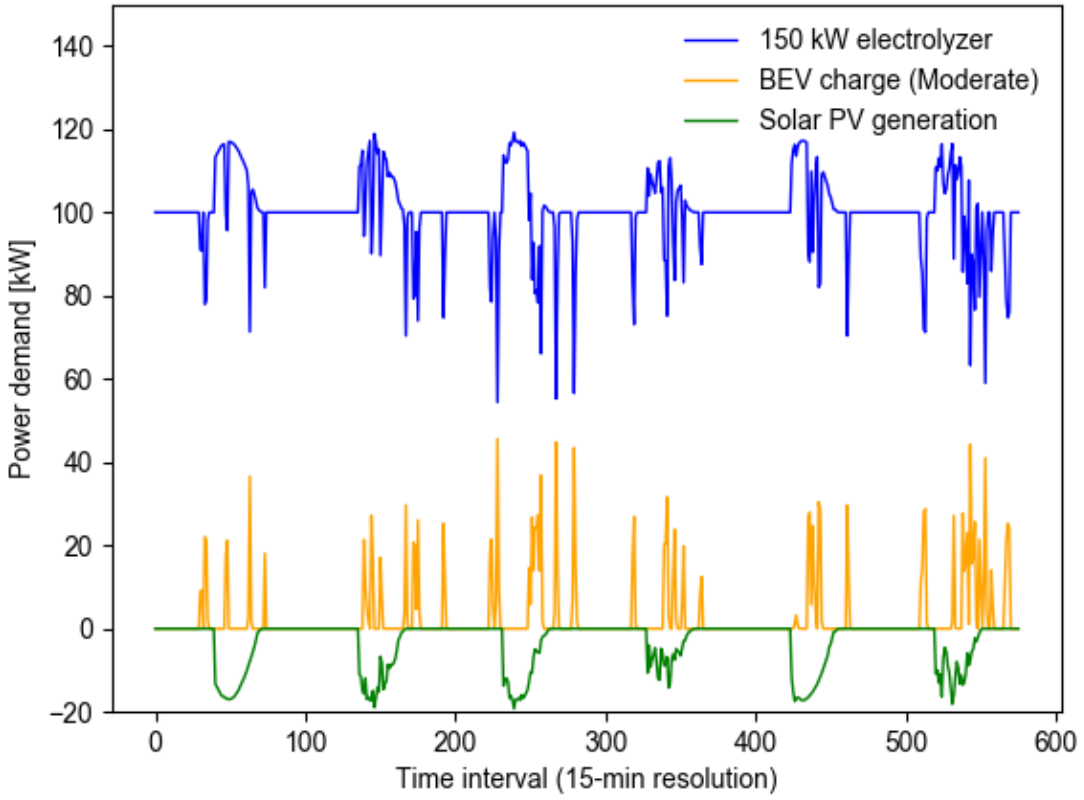
Multiple end use applications

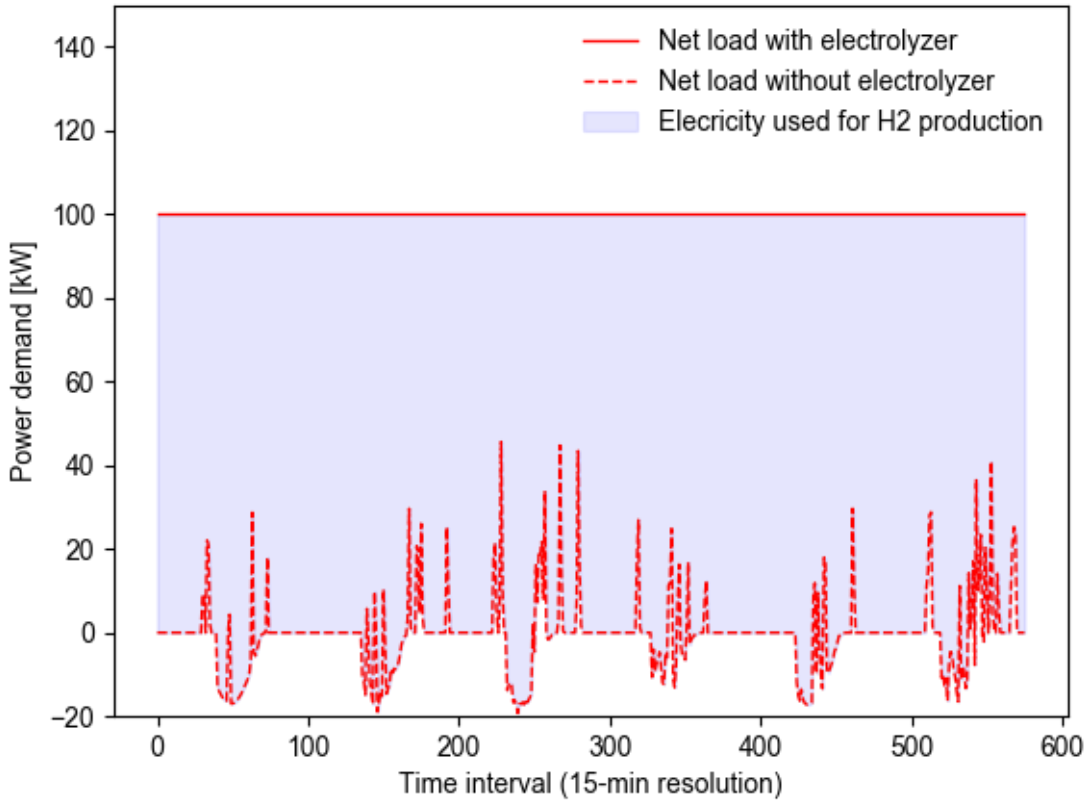
DOE Industry demos

Recently announced demonstrations

Case Study- Electrolyzer Integration with Fast Charging

Dynamic Control of Electrolyzer Dispatch Balances Simulated Grid Load During Fast Charging of BEVs integrated with Solar Generation

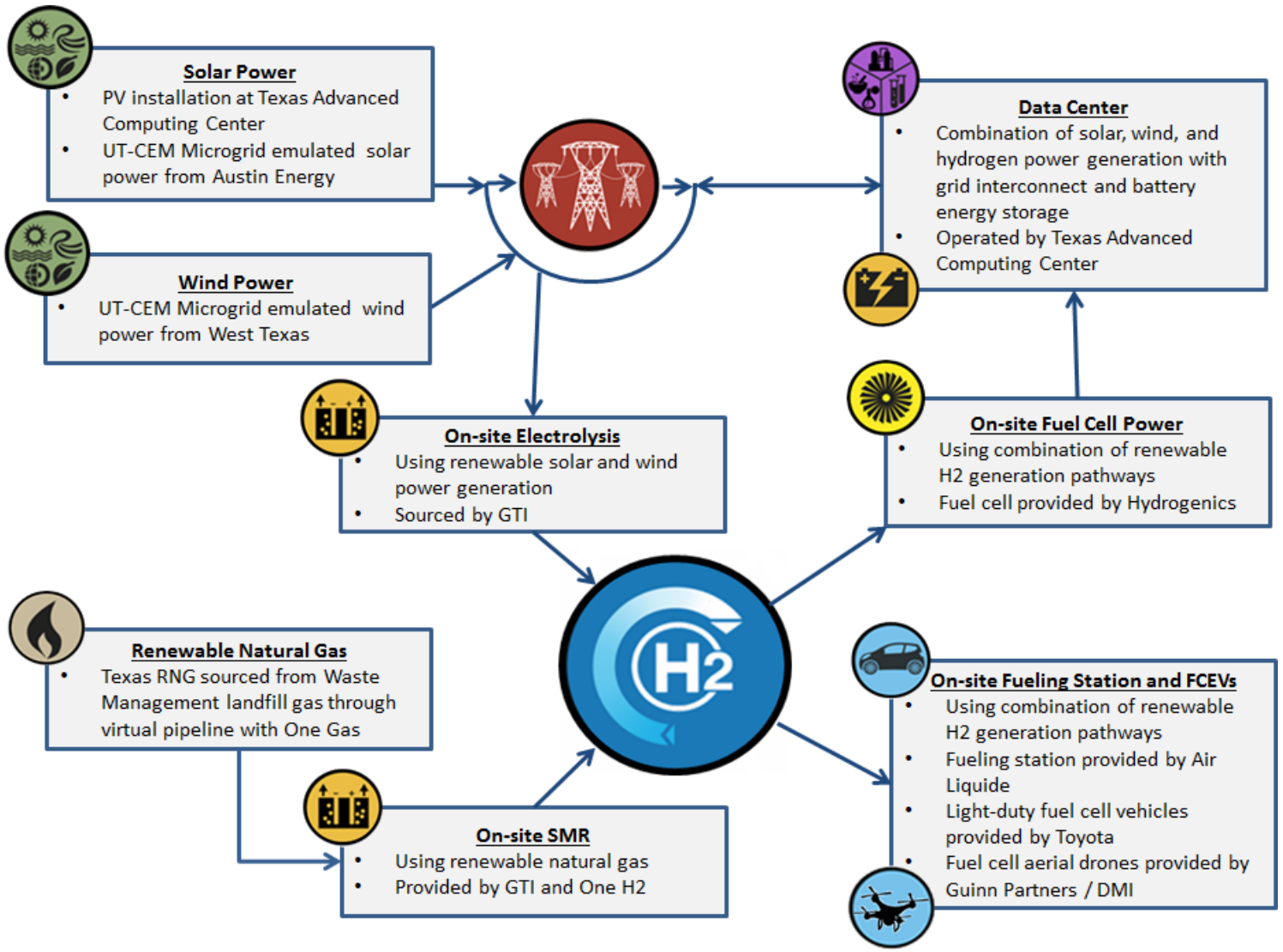




Source: National Renewable Energy Laboratory

Example of H2@Scale Project: Demonstration and Framework for H2@Scale in Texas and Beyond

Integration Concepts Being Considered



Partners

Frontier Energy

University of Texas at Austin

GTI

Toyota

Waste Management

OneH2

SoCalGas

Idea Smith

Duration

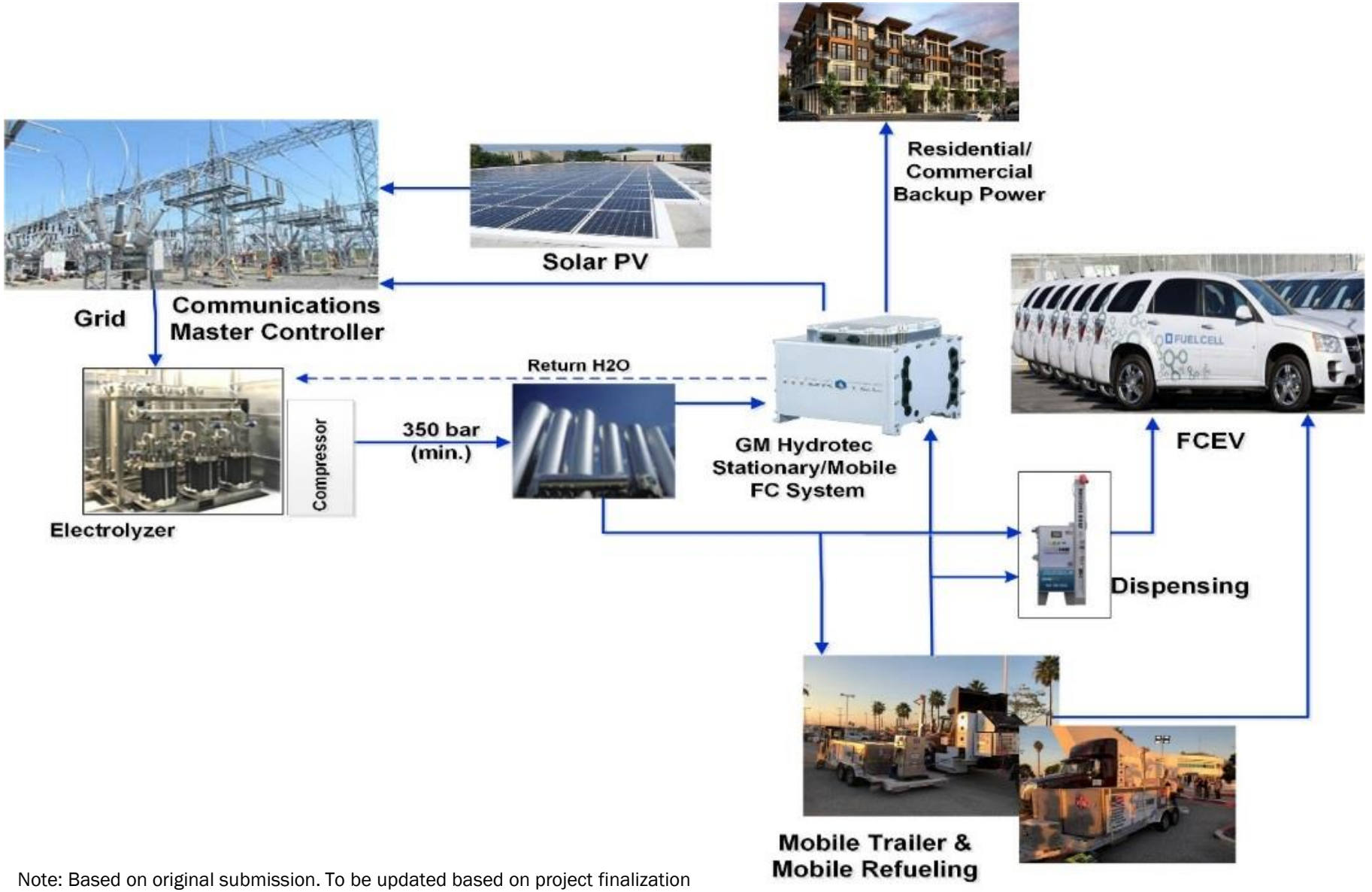
36 Months

Total budget

$10.8M

Note: Based on original submission. To be updated based on project finalization

Example of H2@Scale Project: Integrated Hydrogen Production and Consumption for Improved Utility Operations – Orlando, FL



Partners

Giner ELX Inc

Orlando Utilities Commission (OUC)
General Motors
OneH2
UCF-FSEC
NREL

Duration

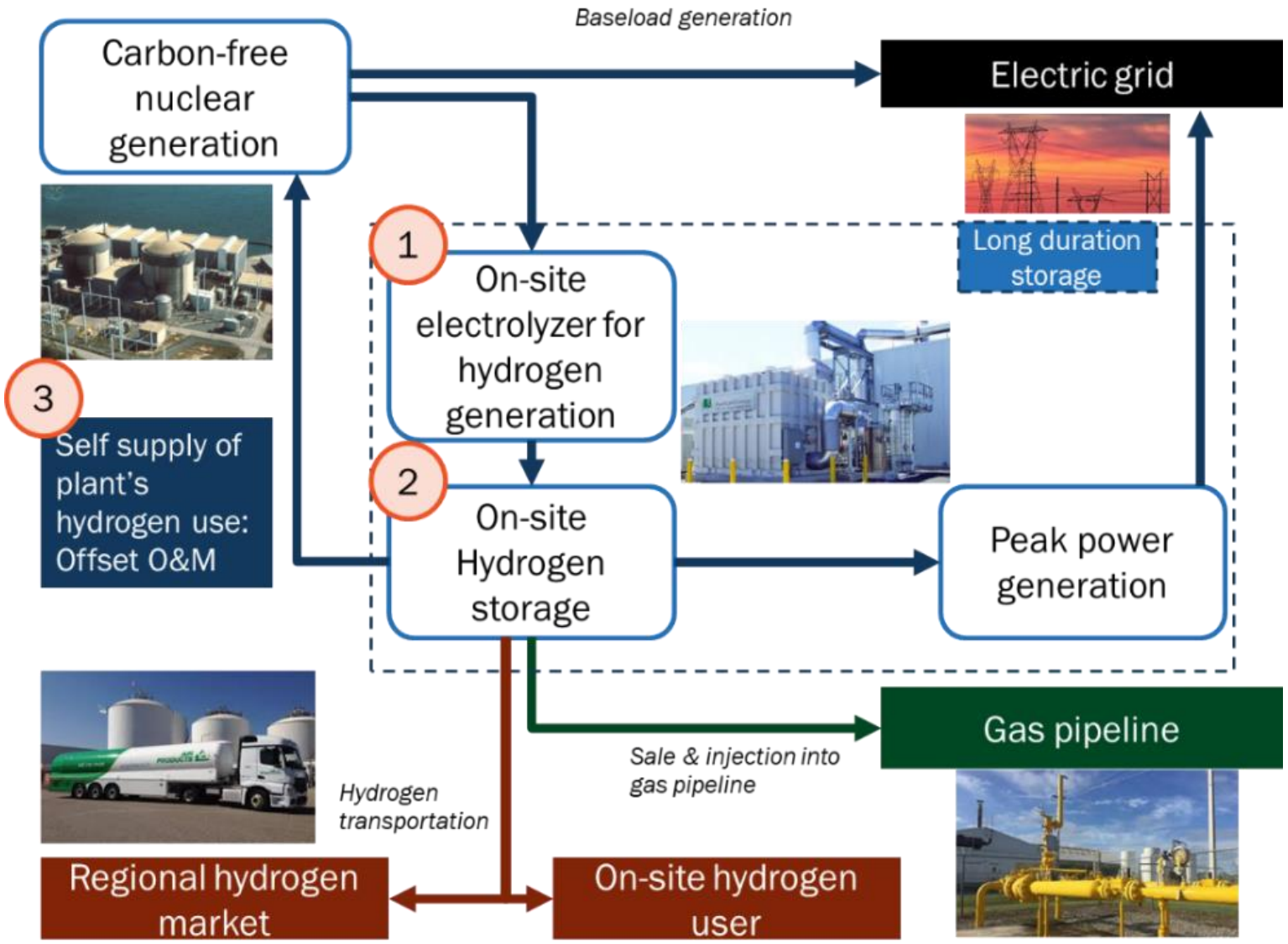
36 Months

Total budget

~$8.8M

Note: Based on original submission. To be updated based on project finalization

Example of H2@Scale Project: Electrolyzer Operation at Nuclear Plant and In-House Hydrogen Supply



Partners

Exelon
Nel Hydrogen
INL
NREL
ANL

Duration

36 months

Total budget

$7.2M

Note: Based on original submission. To be updated based on project finalization

First Ever Carbon-Free, Power-to-Gas System in U.S.

Flagship Power-to-gas Project

Funded By EERE In Partnership With Southern California Gas Company (SoCalGas)

- Approx. $2.5 million funded through EERE's Solar, Hydrogen and Fuel Cells, and Bioenergy Offices along with cost share by SoCalGas
- Process uses a low-temperature water electrolyzer to produce hydrogen from **renewable power**, then feeds the hydrogen and carbon dioxide into a bioreactor where methanogens produce methane and water
- With minor filtration, the product gas from the bioreactor will meet pipeline quality, allowing it to be injected into the **existing natural gas infrastructure**

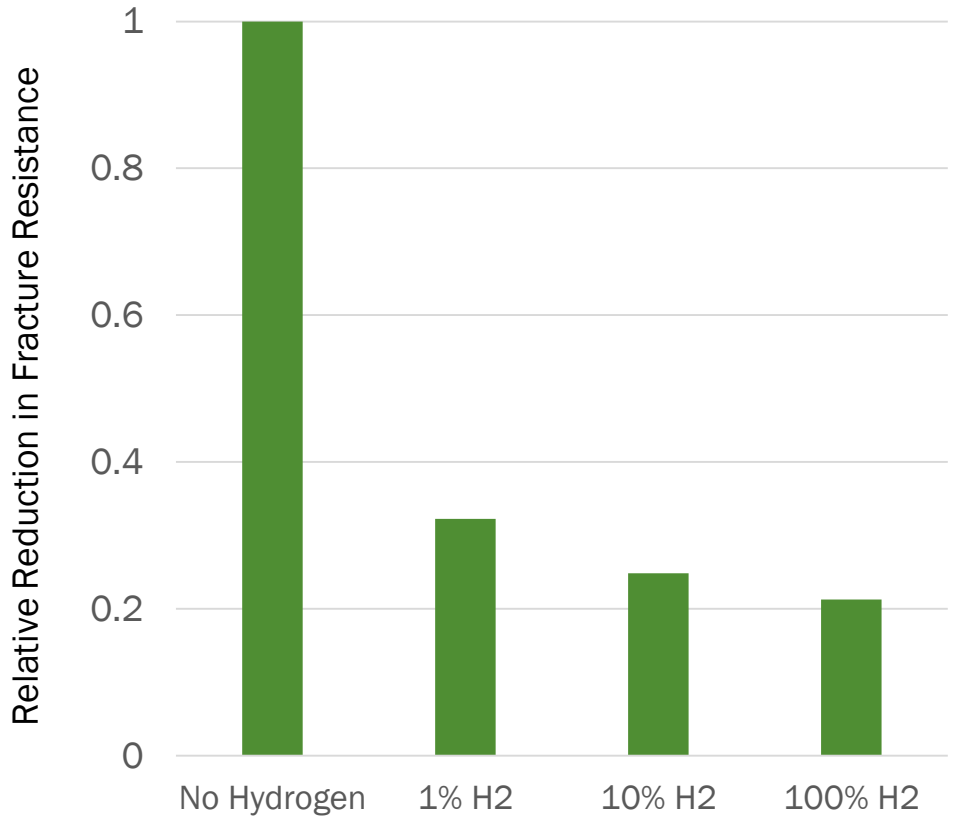
- The pilot project at 250 kW will be used to determine the commercial viability of this power-to-gas approach to energy storage and provide insights into megawatt-scale system designs
- By combining these insights with renewable energy resource data, the research team will identify optimal locations in California and the western half of the U.S. where this grid-scale energy storage would be the most economical

Press Release
https://www.nrel.gov/esif/partnerships-southern-california-gas.html

H-Mat Consortium on Materials Compatibility R&D

- **H_2 effects on the strength and life of materials inform component design**
  - Prior R&D has assessed performance of steels and fiber reinforced polymer piping in pure H_2, leading to modifications to the ASME B31.12 Hydrogen Piping and Pipelines Code
- **Trace constituents in natural gas may mitigate H_2 effects**

Future R&D will address impact of blends on strength and life of current and emerging natural gas pipeline materials



Example data on effects of H_2 on pipeline steels. Impurities may mitigate these effects Image source: Briottet, et. al.

Collaborations

IPHE: A Government Partnership on Hydrogen & Fuel Cells, working along with other global initiatives

The International Partnership for Hydrogen and Fuel Cells in the Economy

Enabling the global adoption of hydrogen and fuel cells in the economy

Elected Chair and Vice-Chair, 2018

Working Groups: Education & Outreach
Regulations, Codes, Standards & Safety

Top Priorities

- SHARE INFORMATION
- INFORM FUTURE GOVERNMENT RD&D
- FOSTER COLLABORATION

Mission Innovation Hydrogen Challenge 2017

Clean Energy Ministerial New Hydrogen Initiative Launched 2019

Find IPHE on Facebook, Twitter and LinkedIn
Follow IPHE **@The_IPHE**

www.iphe.net

Formed 2003
19 Countries and EC

Hydrogen Energy Ministerial (HEM)

International Energy Agency (IEA)

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.

IPHE

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 40 partners from industry, government and academia

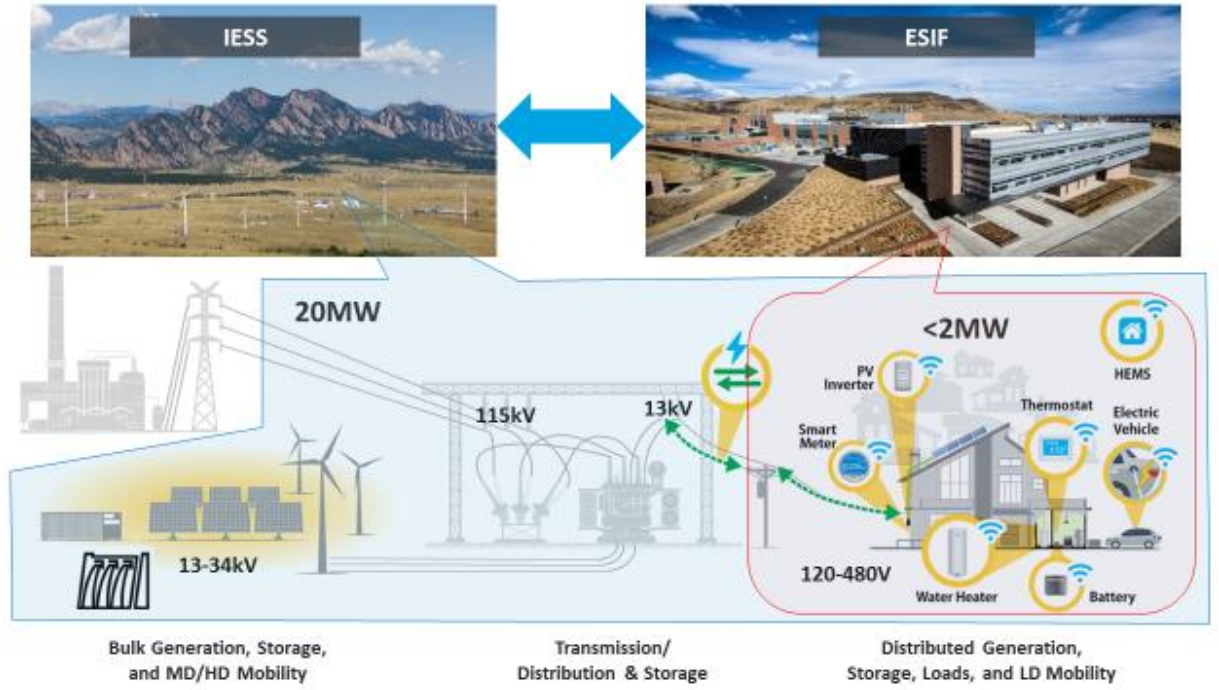
Access to >110 countries, 60,000 members

www.aiche.org/CHS

Advanced Research on Integrated Energy Systems (ARIES) Initiative

ARIES Vision (NREL, in collaboration with other labs and industry)

- Address the fundamental challenges of how to scale up the physical size of new energy technologies and the number of interconnected devices into larger systems.
- Determine how the integration of multiple diverse technologies into future energy systems can provide a range of benefits including improved efficiency, security, and resiliency, lower costs, and greater customer choice.



Key Questions:

1) What key benefits will this new capability provide to you and/or your organization?
2) What other R&D challenges should be addressed that will ensure success and impact for industry?
3) Are the capabilities described above relevant to stakeholders?
4) Is there an interest on the part of owners and operators of commercial or large-scale energy generation in partnering?
5) What other facilities, equipment, and capabilities may be required?
6) What technology innovations and advances can be envisioned with the availability of ARIES?

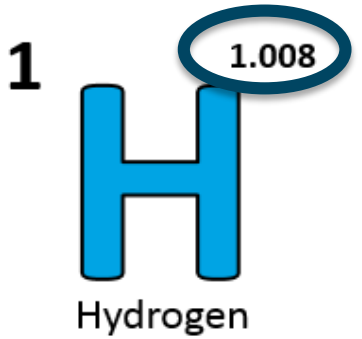
Use resources available to share knowledge

Download the H2IQ resource for free:
energy.gov/eere/fuelcells/downloads/increase-your-h2iq-training-resource

Join monthly H2IQ hours to learn more about hydrogen and fuel cell topics
energy.gov/eere/fuelcells/fuel-cell-technologies-office-webinars

Visit H2tools.org for hydrogen safety and lessons learned

h2tools.org/



Oct 8 - Hydrogen and Fuel Cells Day
(Held on its very own atomic-weight-day)

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
hydrogen.energy.gov

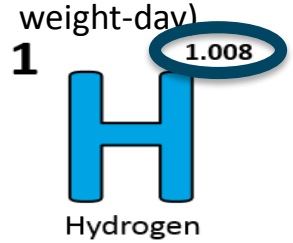
Resources and Announcements

Save the Date

June 8-10, 2021 Annual Merit Review and Peer Evaluation Meeting for the Hydrogen and Fuel Cells Program in Arlington, VA

Oct 8 - Hydrogen and Fuel Cells Day

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



Resources

Visit H2tools.org for hydrogen safety and lessons learned

https://h2tools.org/

INCREASE YOUR H2IQ

Download the H2IQ resource for free:
energy.gov/eere/fuelcells/downloads/increase-your-h2iq-training-resource

Join monthly H2IQ hours to learn more about hydrogen and fuel cell topics
energy.gov/eere/fuelcells/fuel-cell-technologies-office-webinars

Learn more:

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 AND www.hydrogen.energy.gov

Thank You

Neha Rustagi
DOE Hydrogen and Fuel Cells Program
neha.rustagi@ee.doe.gov

Looking for more info?

#H2IQ

www.energy.gov/fuelcells
www.hydrogen.energy.gov