U.S. DEPARTMENT OF
ENERGY
Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

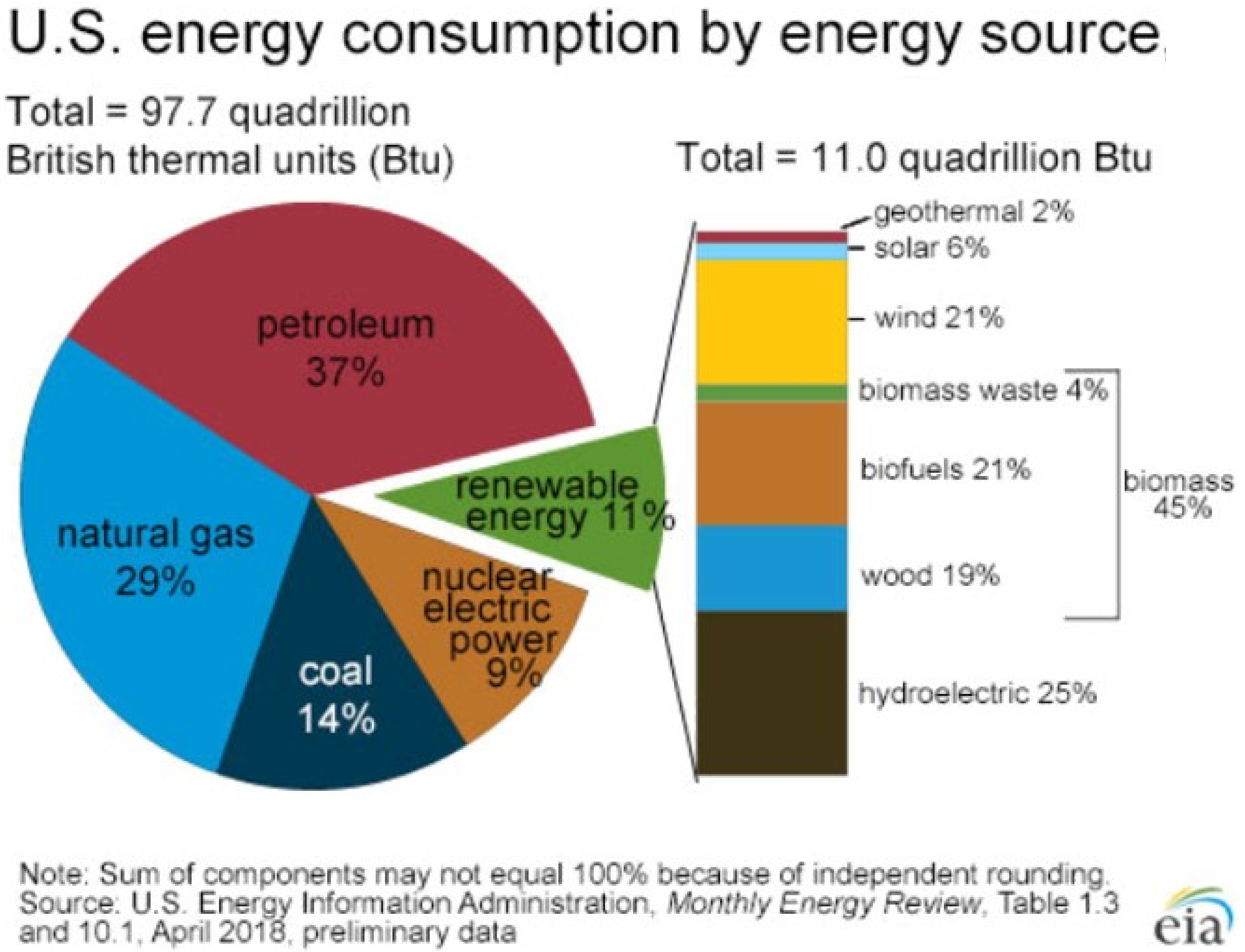
Hydrogen and Fuel Cell Program Overview

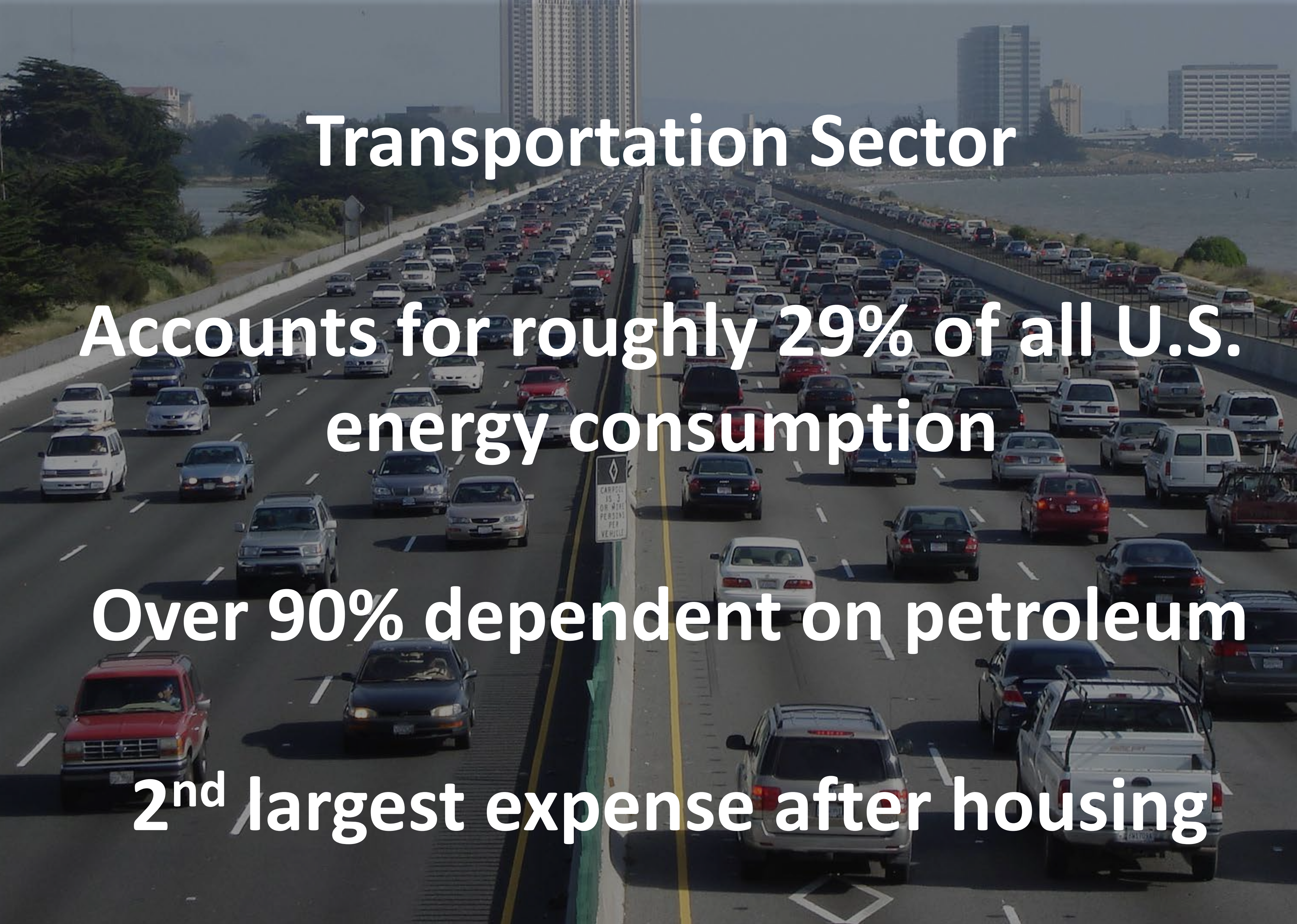
Dr. Sunita Satyapal, Director, Fuel Cell Technologies Office

2019 Annual Merit Review

Crystal City, VA – April 28, 2019

U.S. energy mix covers wide range of energy sources





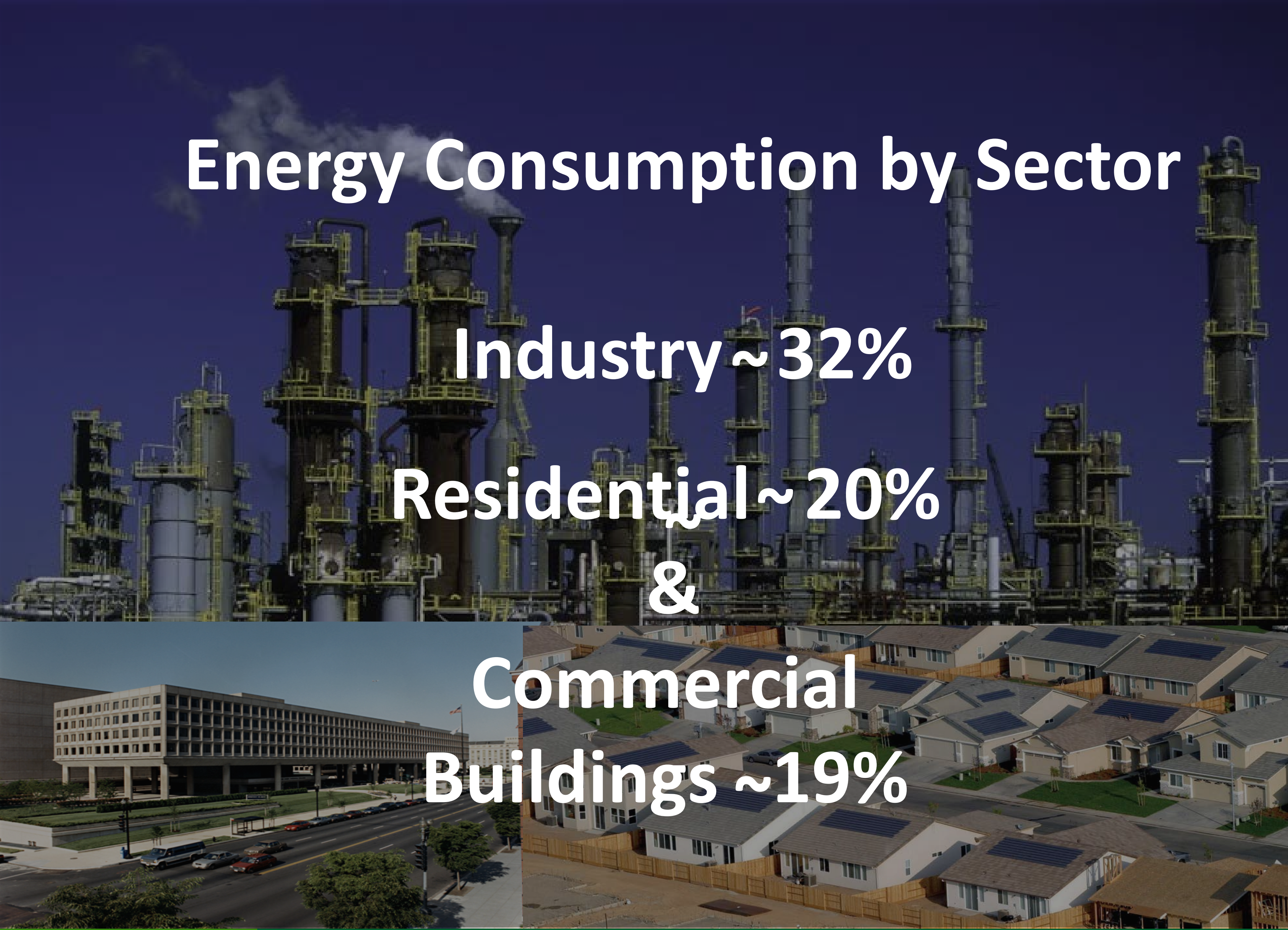
Transportation Sector

Accounts for roughly 29% of all U.S. energy consumption

Over 90% dependent on petroleum

2nd largest expense after housing

Energy Consumption by Sector



Industry ~32%

Residential ~20%

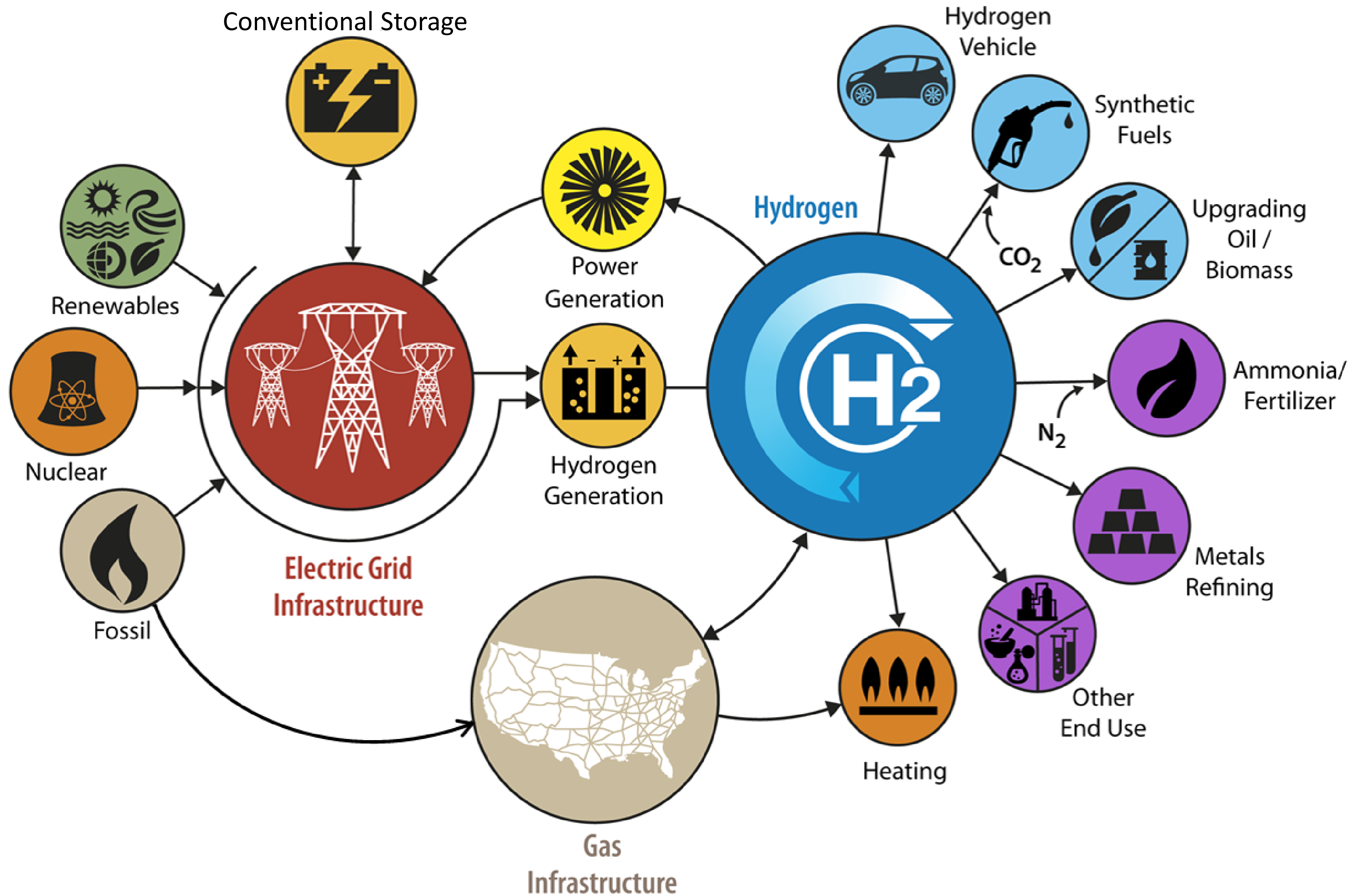
&

Commercial

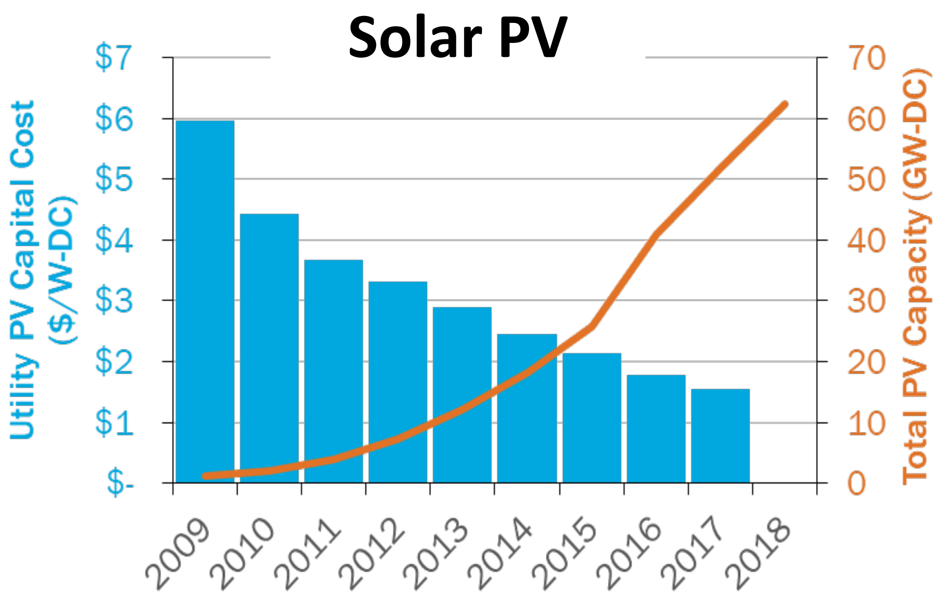
Buildings ~19%

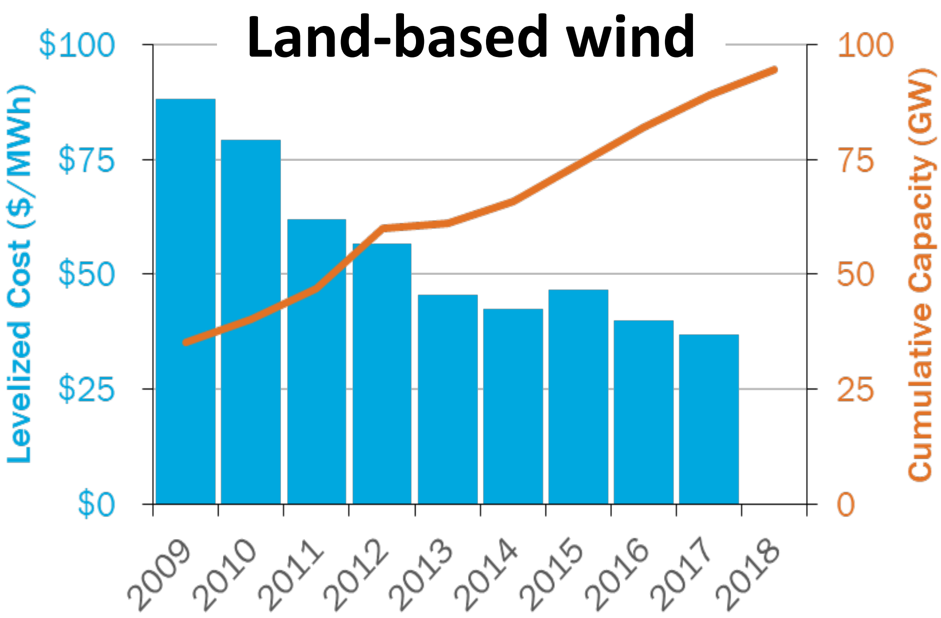
H_2 is one part of an all-of-the-above energy portfolio and can impact all sectors

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



Unprecedented Opportunity with Low Cost Power





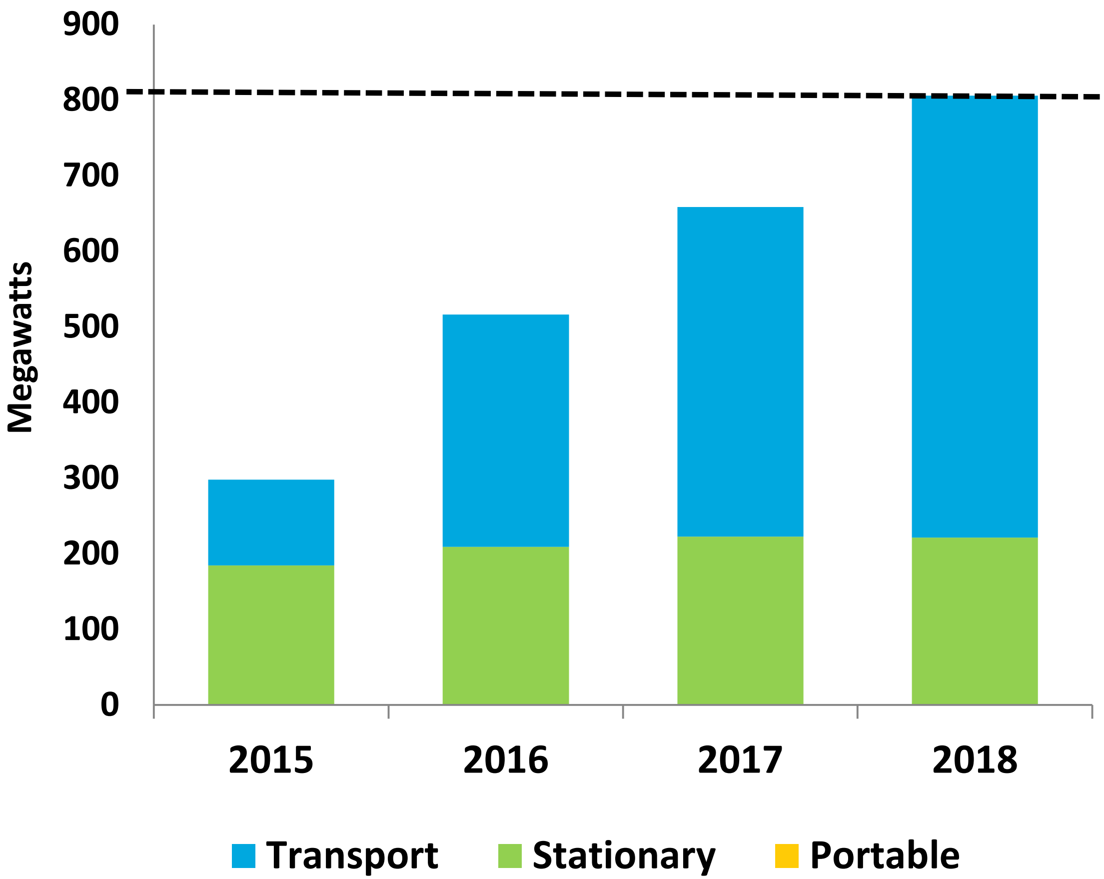
In addition, we see increased interest from nuclear power generators for use of baseload power, and use of low-cost natural gas

Year in Review

Since last AMR

Fuel Cell Shipments - Growth by Application

Fuel Cell Power Shipped (MW)



800 MW
fuel cell power
shipped worldwide

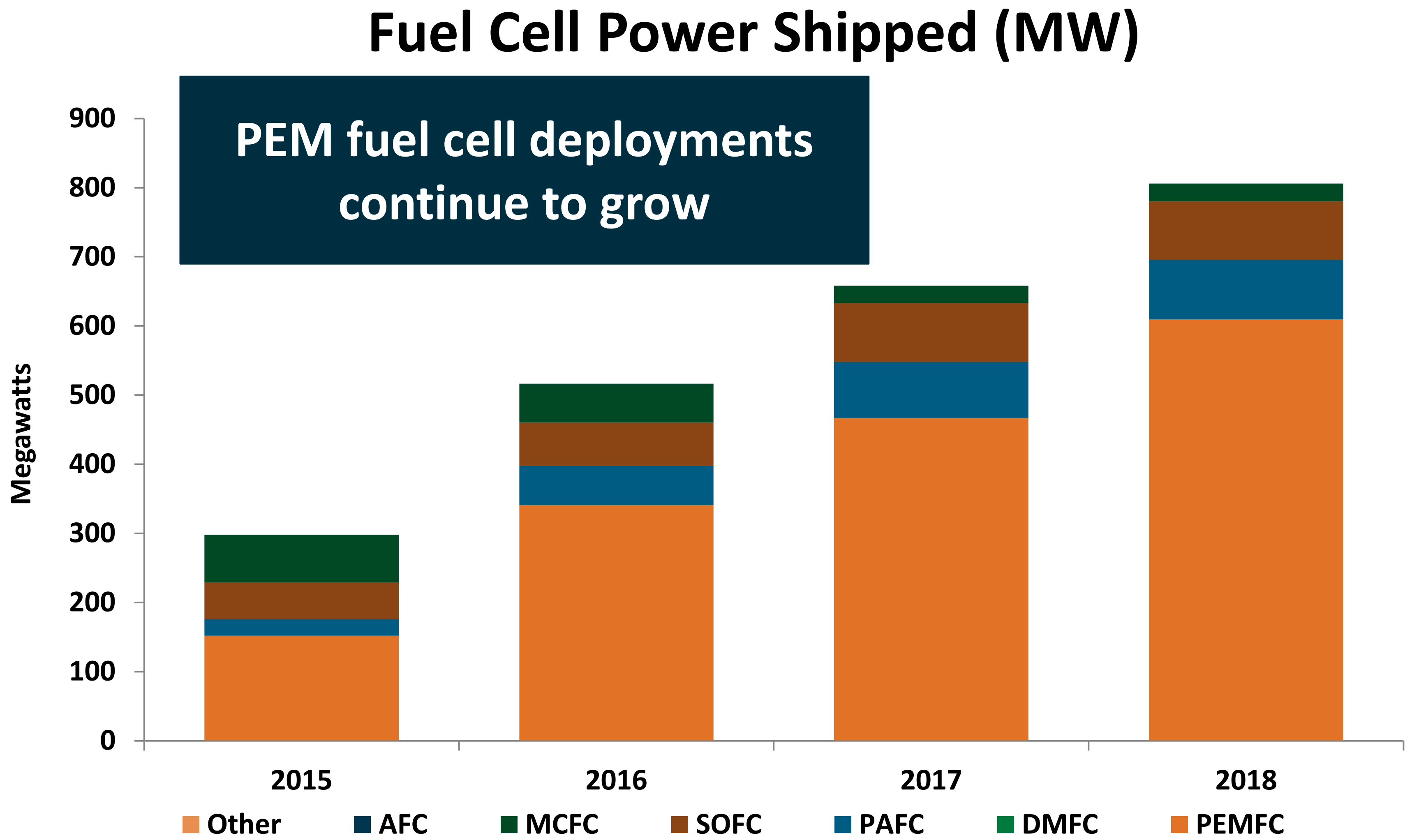
68,500
fuel cell units
shipped worldwide

Approximately
$2.3 Billion
fuel cell revenue*

* Revenue from publicly available

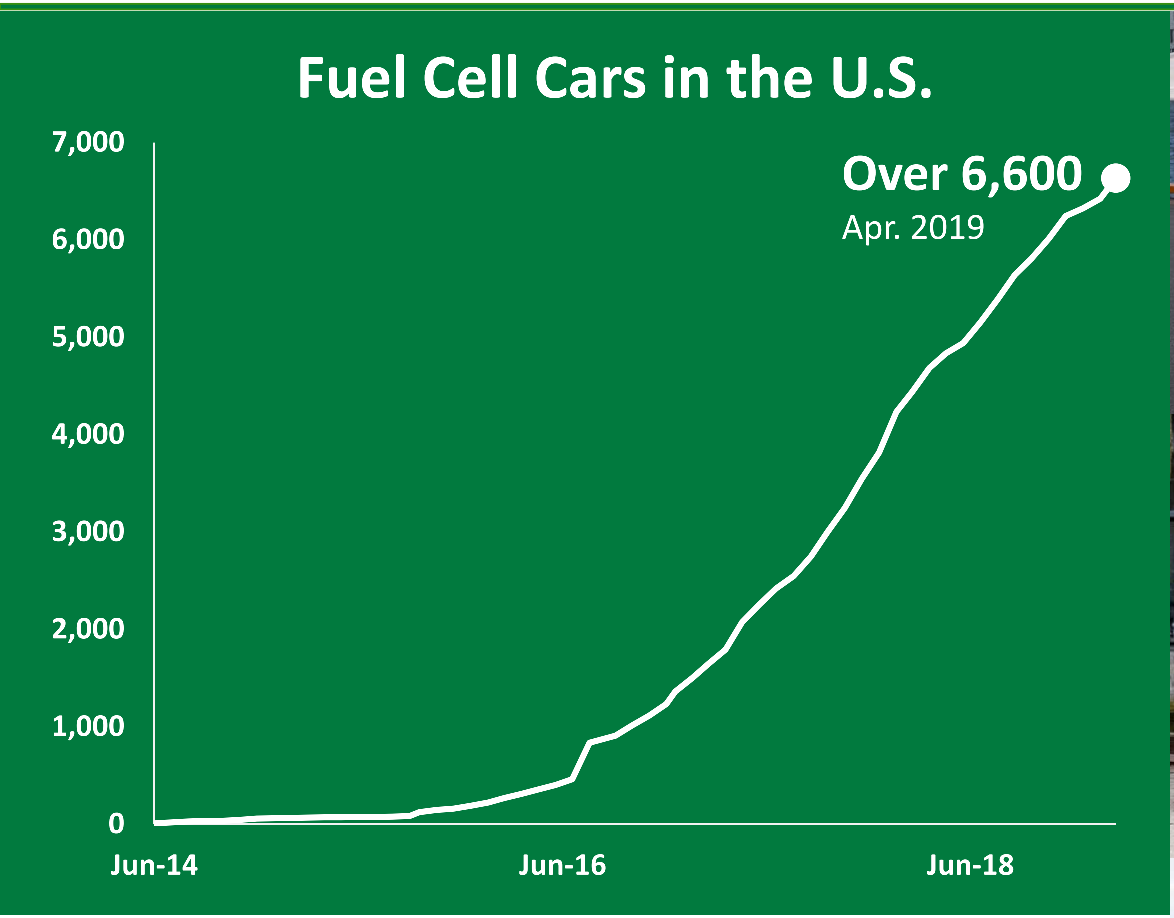
Source: DOE and E4Tech

Growth by Fuel Cell Type



Source: DOE and E4Tech

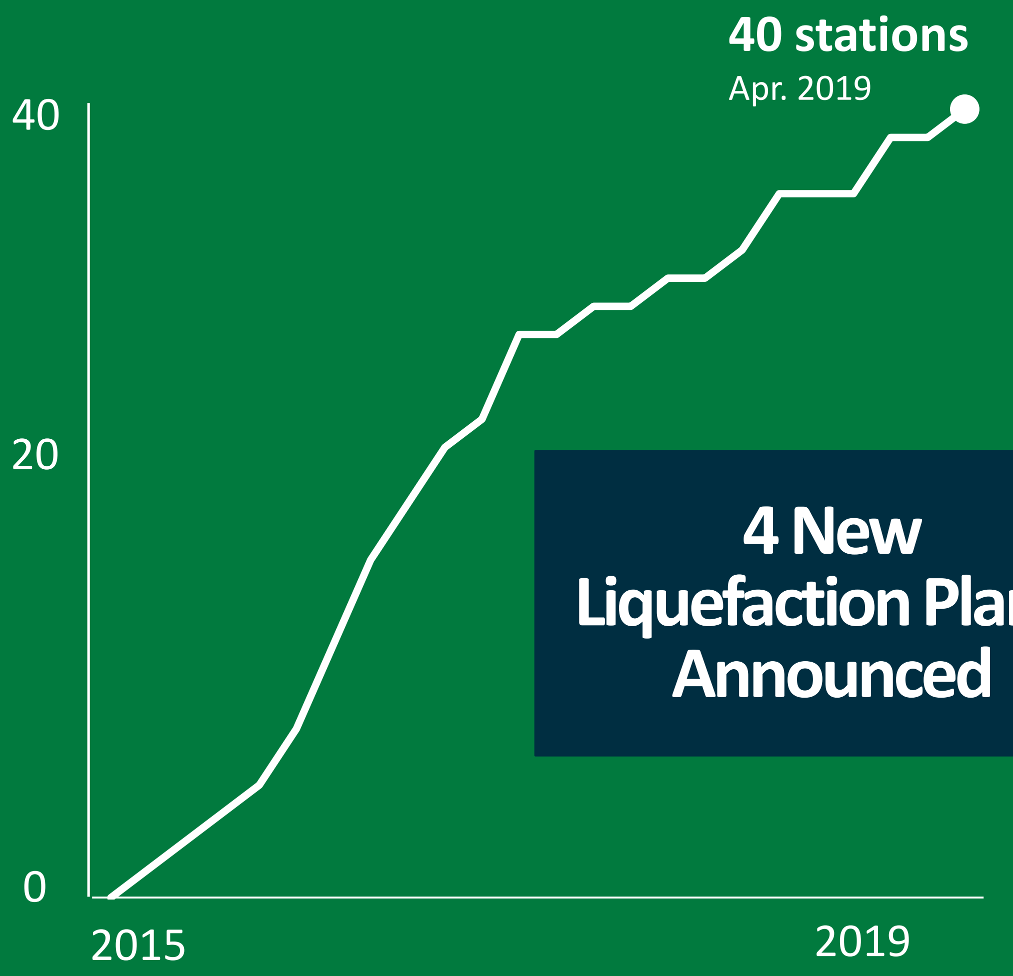
Fuel Cell Passenger Vehicles Status



AMR Ride and Drive – Tomorrow
Test drive all three fuel cell cars
12:30 – 1:45pm

Hydrogen Infrastructure Status

Retail Hydrogen Stations in the U.S.



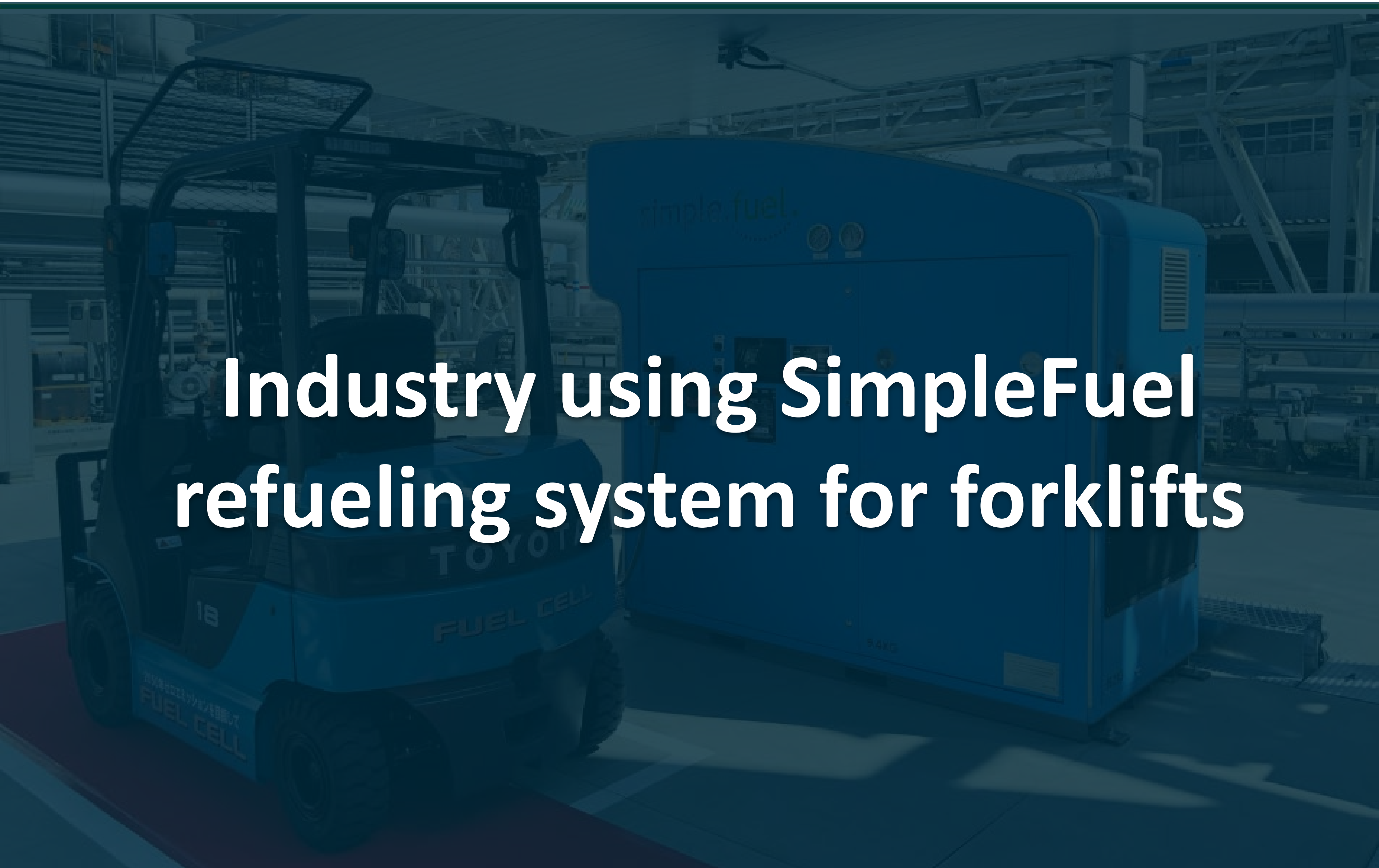
4 New Liquefaction Plants Announced

Material Handling Applications

More than **25,000 forklifts**

Over **19 million refuelings**

H-Prize: Update on Small Scale Fueling ‘Appliance’



Industry using SimpleFuel refueling system for forklifts

U.S. Snapshot of Hydrogen and Fuel Cells Applications

Examples of Applications

>240MW
Backup Power

>25,000
Forklifts

>30
Fuel Cell Buses

>40
H_2 Retail Stations

>6,600
Fuel Cell Cars

Example of Emerging Interest in Transportation

Industry plans for hydrogen fuel cell trucks and supporting infrastructure underway

Program Overview

Program Mission and Strategy

Early R&D Focus

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

- Energy security
- Energy resiliency
- Strong domestic economy

Key R&D Sub-Programs in Budget Request

Fuel Cells	Hydrogen Fuel	Infrastructure R&D
• Cost, durability • Components - catalysts, electrodes, etc • Increase focus beyond LDVs	• Cost of production across pathways • Cost and capacity of storage, including bulk/ energy storage	• Cost and reliability of infrastructure • Delivery components, supply chain • Safety

New in FY19 Budget Request

Enabling

H2@Scale
U.S. Department of Energy

DOE Fuel Cell Technologies Office Organizational Update

Director
Sunita Satyapal

Senior Advisor
Eric Miller

Operations
Priya Swamy (Detail)

Hydrogen Fuel R&D
Program Manager
Ned Stetson

Technology Managers (TMs)

Katie Randolph (Production Lead)
Jesse Adams (Storage Lead)
Bahman Habibzadeh
Zeric Hulvey

Fuel Cells R&D
Program Manager
Dimitrios Papageorgopoulos

TMs

Donna Ho
Greg Kleen
Dave Peterson*

Vacancy

Infrastructure & Systems R&D
Program Manager
Fred Joseck

TMs

Technology Acceleration
Pete Devlin
Nancy Garland*
Jason Marcinkoski*
Michael Hahn
Brian Hunter

Safety Codes and Standards
Laura Hill

Systems Analysis
Neha Rustagi (Delivery Lead)* Shawna McQueen

*Supports multiple areas **New hires in 2019**

Hydrogen and Fuel Cells Funding Across DOE

EERE – Fuel Cell Technologies Office (FCTO)

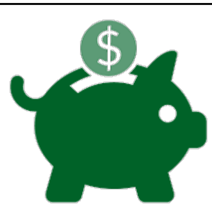
Key Activity	FY 2017 ($ in thousands)	FY 2018 ($ in thousands)	FY 2019 ($ in thousands)
Fuel Cell R&D	32,000	32,000	30,000
Hydrogen Fuel R&D	41,000	54,000	39,000
Hydrogen Infrastructure R&D	-	-	21,000
Systems Analysis	3,000	3,000	2,000
Technology Acceleration	18,000	19,000	21,000
Safety, Codes and Standards	7,000	7,000	7,000
Total	**101,000**	**115,000**	**120,000**

EERE: Office of Energy Efficiency and Renewable Energy

DOE-wide Hydrogen and Fuel Cells Funding

Office	FY 2018 ($ in thousands)
EERE (FCTO)	115,000
Science (Basic/xcut)	19,000
Fossil Energy (SOFC)	30,000
Nuclear Energy (H_2/hybrid specific)	2,000
Total	**~166,000**

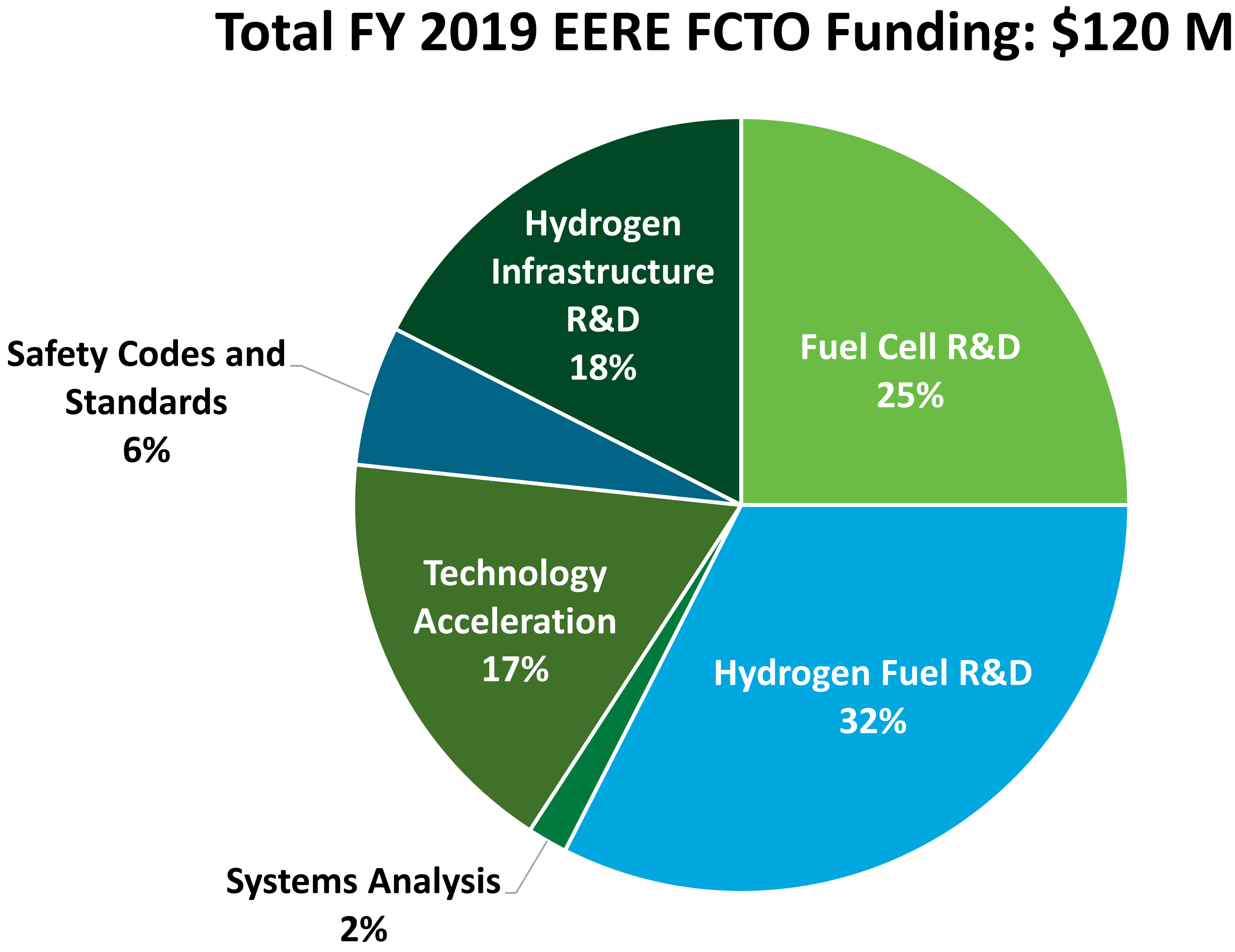
Note: ARPA-E funding dependent on program selected each fiscal year



Approx.
$12M
in the past 3 years

Savings from Active Project Management Go/No Go Decision

Fuel Cell Technologies Appropriations - FY 2019



New FY18 Awards: 28 Projects, ~$38M DOE Funding

Topic	Awardee	DOE Funding
Topic 1: ElectroCat	Northeastern University	$1M
	Indiana University Purdue	$1M
	Vanderbilt University	$0.9M
	Pajarito Powder	$1M
	United Technologies Research Center	$1M
Topic 2a: Production & Fueling	Plug Power	$2M
	Skyre, Inc.	$2M
	Giner ELX, Inc.	$1.7M
Topic 2b: Manufacturing	3M Company	$1.9M
	University of Tennessee Space Institute	$2M
	University of Connecticut	$2M
	Clemson University	$1.6M
	Proton Onsite (NEL)	$2M
Topic 2c: Infrastructure Station Footprint	National Renewable Energy Laboratory	$1.2M
	Washington State University	$1.7M
	Greenway Energy	$2.4M
	Gas Technology Institute	$2.5M
Topic 3a: Fuel Cell Membranes	Rensselaer Polytechnic Institute	$1M
	Pennsylvania State University	$1M
	Drexel University	$1M
	Vanderbilt University	$0.6M
	Xergy, Inc.	$1M
	Lawrence Livermore National Laboratory	$1M
Topic 3b: Liquid & Reversible Fuel Cells	Lawrence Berkeley National Laboratory	$1M
	Northwestern University	$1M
	Giner, Inc.	$1M
	Georgia Institute of Technology	$0.75M
	University of Kansas Center for Research, Inc.	$1M

Funding Opportunity Announcements (FOAs) Announced March 2019

Joint Truck FOA
VTO, FCTO, BETO- $51M Total
$18M for H_2 and FCs (~11 – 24 Awards)

1) **Advanced storage for gaseous fuels** ($3M FCTO, $3M VTO)
2) **High throughput H_2 fueling** technologies for trucks ($6M)
3) **Durable fuel cells with low PGM content** applicable to trucks and similar applications ($6M)

H2@Scale FOA ($31M)
Approximately 30 awards

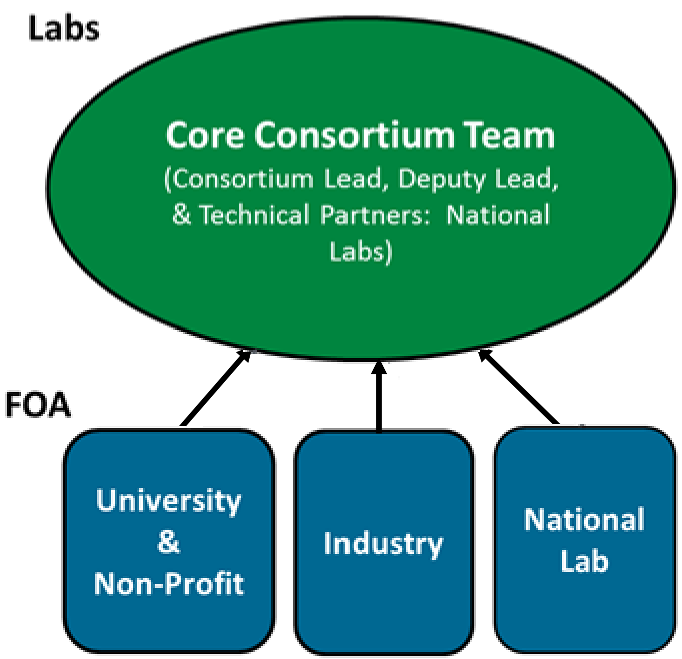
1) **Advanced H_2 storage & infrastructure** R&D ($9M)
2) **Innovative concepts** for hydrogen production & utilization ($12M)
3) **H2@Scale Pilot** Integrated Systems ($10M)

Several hundred concept papers received

Strategy: Leveraging National Labs and Partners

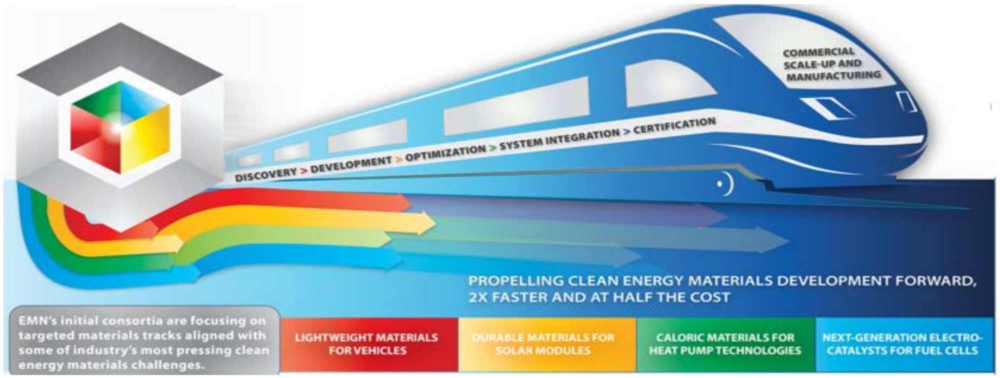
Consortium Approach

Multi-lab core capabilities with steady influx of new partners



Energy Materials Network
U.S. Department of Energy

Framework to Accelerate Progress



Guiding Principles of EMNs

Predictive Simulation Across Scales	Synthesis & Characterization	Rapid Screening	End Use Performance
Process Scalability	Process Control	Real-time Characterization	Reliability Validation

Data Management & Informatics

FCTO Strategic and Tactical Update

Lab-Based Consortia

HydroGEN
Advanced Water Splitting Materials

HyMARC
Hydrogen Materials Advanced Research Consortium

ElectroCat
Electrocatalysis Consortium

FCPAD
FUEL CELL PERFORMANCE AND DURABILITY

Labs- Industry Bridge

- H2@Scale Consortium
- CRADAs
- SPPs (WFOs)
- L'Innovator
- Technology Commercialization Fund

Private Sector

- FOA projects
- SBIRs
- Prizes
- State funding
- Demos & Deployments
- Partnerships
- US National Roadmap (planned)

H-Mat™ Hydrogen Materials Compatibility Consortium

H_2 materials R&D, enable codes & standards, reduce regulatory barriers

Safety – Lessons learned, best practices, enable safe infrastructure

Examples of Applications

DOE Program Impact - Examples

Innovation

Approx. **960** H_2 and fuel cell **patents**

enabled by FCTO funds

Approx. **37%** of H_2 and fuel cell patents

come from National Labs

Market Impact

More than **30** **Technologies** commercialized by private industry

and over **65** **with potential** to be commercial in the next 3-5 years

can be traced back to FCTO R&D

Examples of Progress enabled by DOE FCTO in the last decade

Fuel Cell R&D

Reduced cost 60%

Quadrupled durability

H2 Production R&D

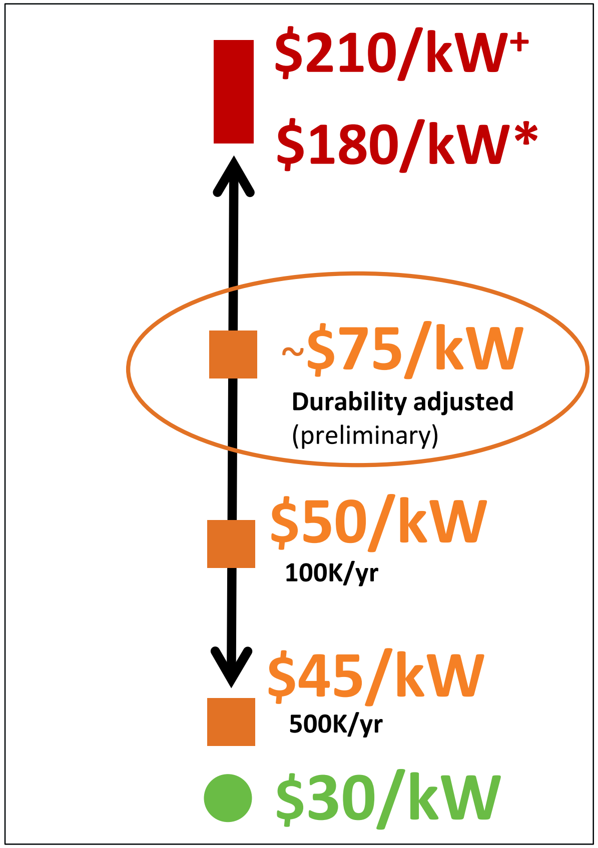
Cut electrolyzer costs 80%

Targets Guide R&D

Fuel Cell R&D

Cost Status

(Fuel cells system cost)



- Low-Volume Estimate
- High-Volume Projection
- Ultimate Target

†Based on commercially available FCEVs

*Based on state of the art technology

Notes: Graphs not drawn to scale and are for illustration purposes only.

Overview: Strategy and Plans

ElectroCat Electrocatalysis Consortium — PGM-free catalysts to ultimately enable $30/kW

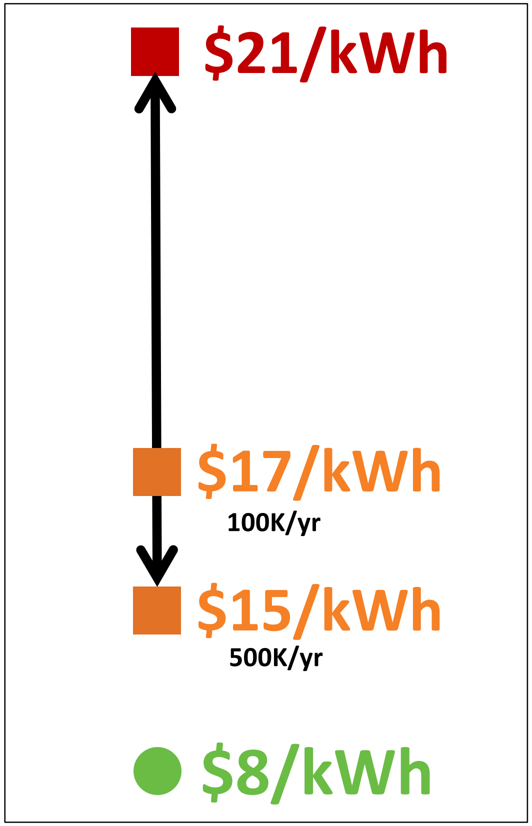
FCPAD Fuel Cell Performance and Durability — Address performance and durability, including low PGMs

- **Expand beyond passenger cars**
  - Heavy duty and other applications
- **Contribute advances to enable H_2**
  - Reversible fuel cells, electrolyzers, electrochemical compression, sensors, etc.

Hydrogen Storage

Cost Status

(700-bar compressed system for onboard storage ǂ)



- **Low-Volume Estimate**
- **High-Volume Projection**
- **Ultimate Target**

Overview: Strategy and Plans

HyMARC — Hydrogen Materials Advanced Research Consortium

Enabling twice the energy density for onboard H_2 storage and $8/kWh

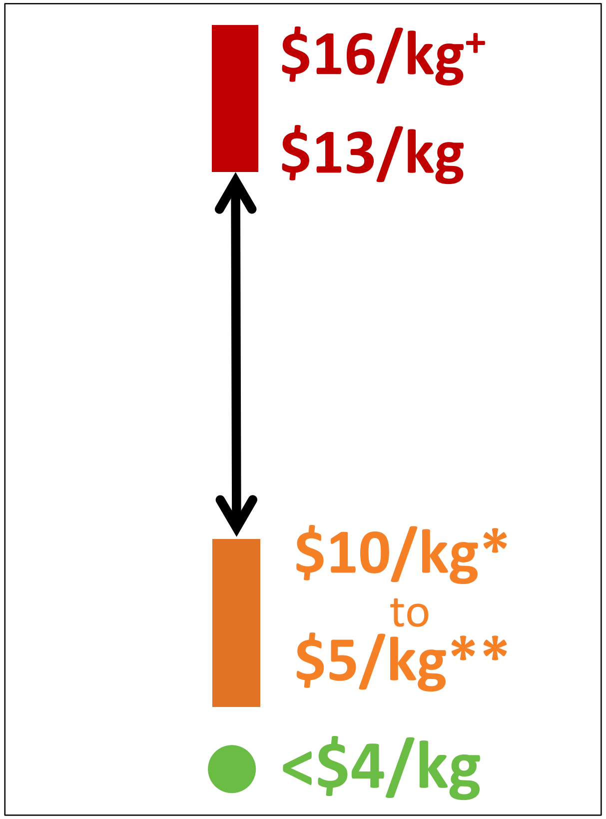
- **Expand beyond on-board LDVs**
  - Stationary, bulk storage
  - H_2 Carriers
- **Continue to increase collaborations**
  - Examples: H-Mat (cryogenic materials), VTO (NG storage), IACMI (C-fiber), NSF, DOD, others

ǂStorage costs based on preliminary 2019 storage cost record. Notes: Graphs not drawn to scale and are for illustration purposes only.

Hydrogen Production

Cost Status

(H_2 cost at the pump)



- Low-Volume Estimate
- High-Volume Projection
- Ultimate Target

Overview: Strategy and Plans

HydroGEN Advanced Water Splitting Materials

Advanced water-splitting materials to reach $2/kg

- **Include diverse domestic resources**
- **Includes co-production of value-add products**
  - NG to $C+H_2$, synfuels, etc.
- **Low T and High T approaches**
  - Synergy with nuclear, solar

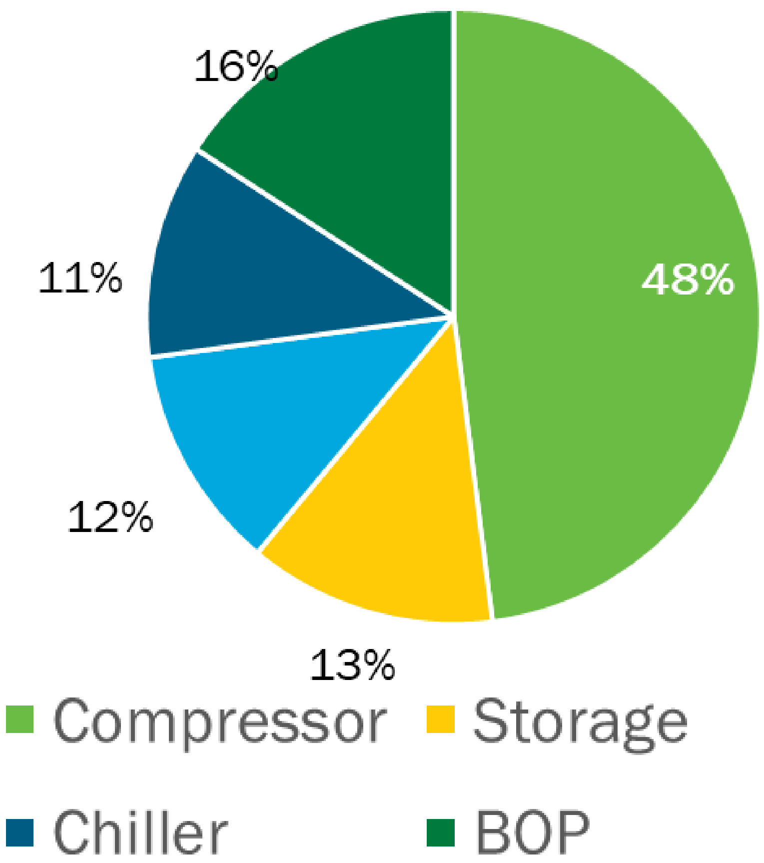
†Range assumes current production from NG and delivery and dispensing
*Highest possible cost at high vol., assumes H2 from electrolysis at $5/gge and delivery via pipelines and liquid tankers at $5/gge
**Lowest possible cost at high vol., assumes H2 from SMR at $2/gge and delivery via tube trailer at $3/gge

Notes: Graphs not drawn to scale and are for illustration purposes only.

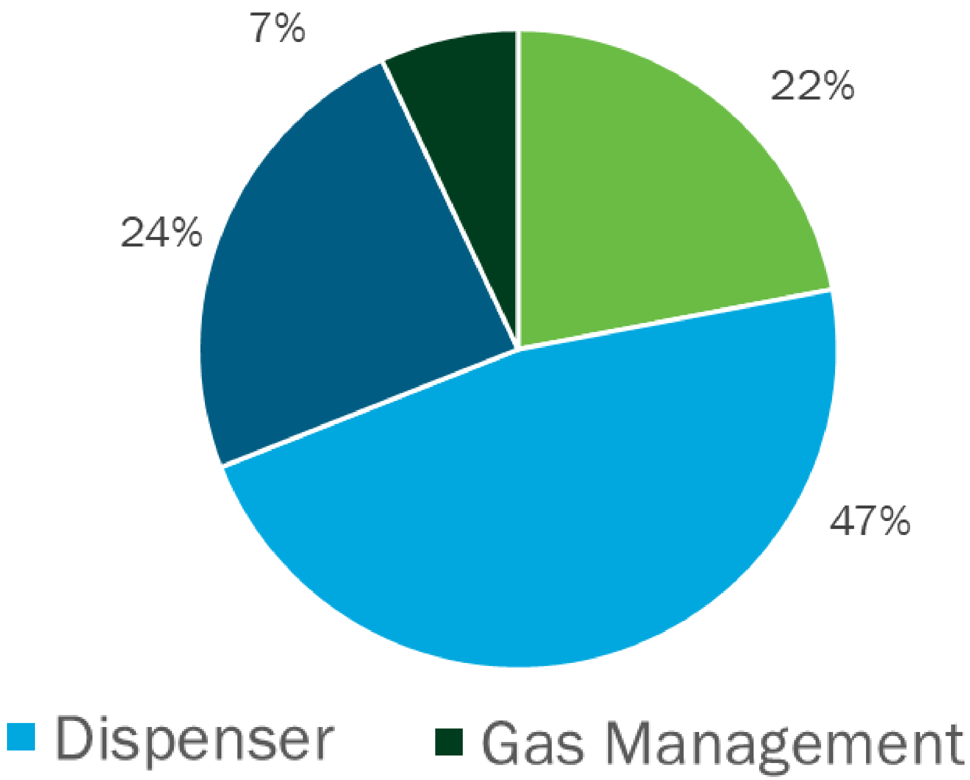
Increased Focus Planned on H_2 Delivery and Infrastructure

Real World Data and Analysis Guides R&D

Capital Costs of Gaseous Stations[1]



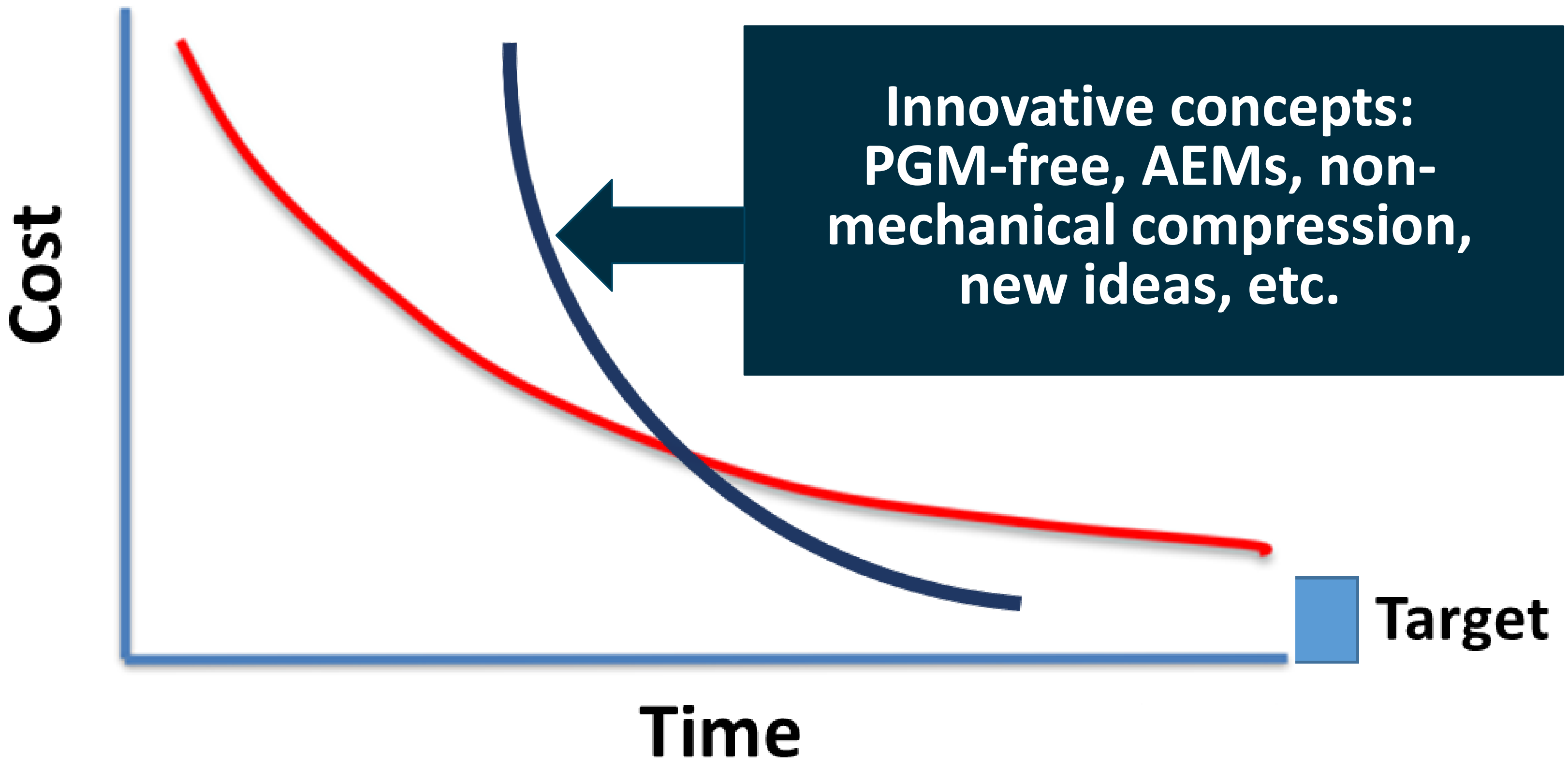
Maintenance Hours at Fueling Stations[2]



1. Assumes 180 kg/day station supplied by tube trailer.
Source: HDSAM, ANL
https://hdsam.es.anl.gov/index.php?content=hdsam

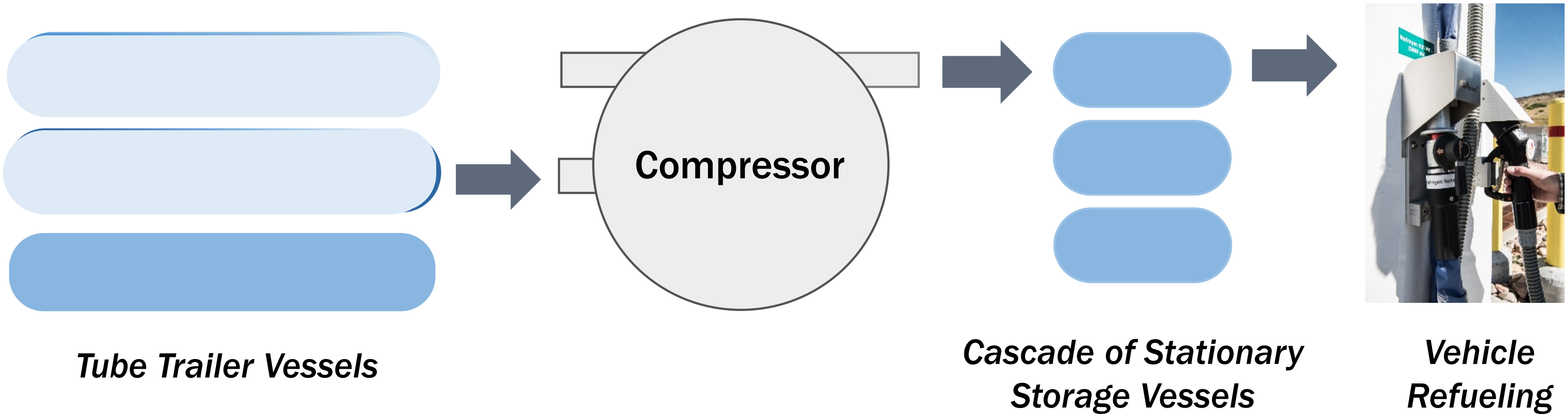
2. Composite Data Product 21, NREL
https://www.nrel.gov/hydrogen/hydrogen-infrastructure-analysis.html

Strategy: Focus on Innovation



Example: Pressure Consolidation Approach

<u>Pressure Consolidation Strategy</u>



Compressor sized mainly based on:

- ➢ Inlet pressure
- ➢ Outlet pressure
- ➢ Flow rate

Pressure consolidation can lower station cost by up to 40%

High inlet pressures are maintained by consolidating H_2 at off-peak times

- ➢ Smaller compressor can achieve required flow rate during peak times

Pressure Consolidation Validation

Strategy developed by ANL in 2014.[1]

NREL and ANL experimentally verified consolidation algorithm predictions to within 5%.[2]

Technology licensed to PDC Machines, Inc.

1. For more information, please see: https://www.energy.gov/sites/prod/files/2017/11/f46/fcto_nov17_h2_scale_session_elgowainy.pdf
2. Final technical report will document experimental findings in summer of 2019.

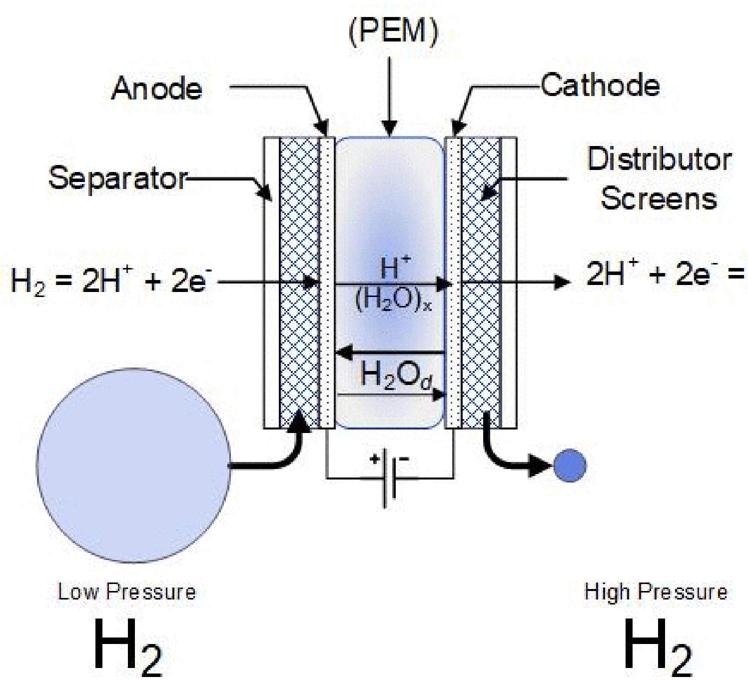
Source: A. Elgowainy, D. Terlip, et al

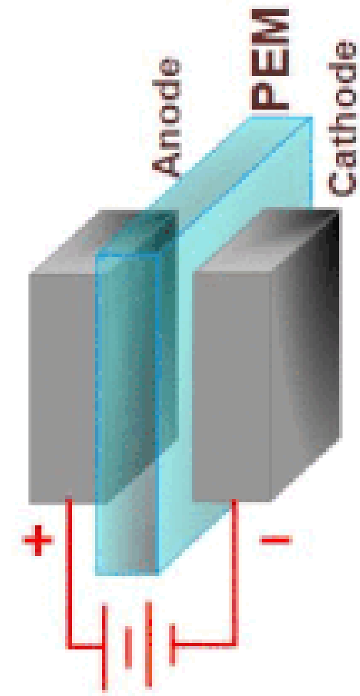
Argonne NATIONAL LABORATORY

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Electrochemical Hydrogen Compression (EHC)

Non-mechanical concepts are in early stages of research, but have potential for higher reliability than conventional reciprocating compressors.





How it Works

Electrical potential drives redox reactions and hydrogen permeation across cell membrane. Pressurized H_2 accumulates at the cathode. Catalysts disassociate and reconstitute H_2

Images courtesy of Giner

Recent EHC Accomplishment

Giner, Inc and collaborators reduced EHC electricity required for

100 to 350 bar by 50%

through novel membranes and stack designs

Achieved **2kWh/kg**

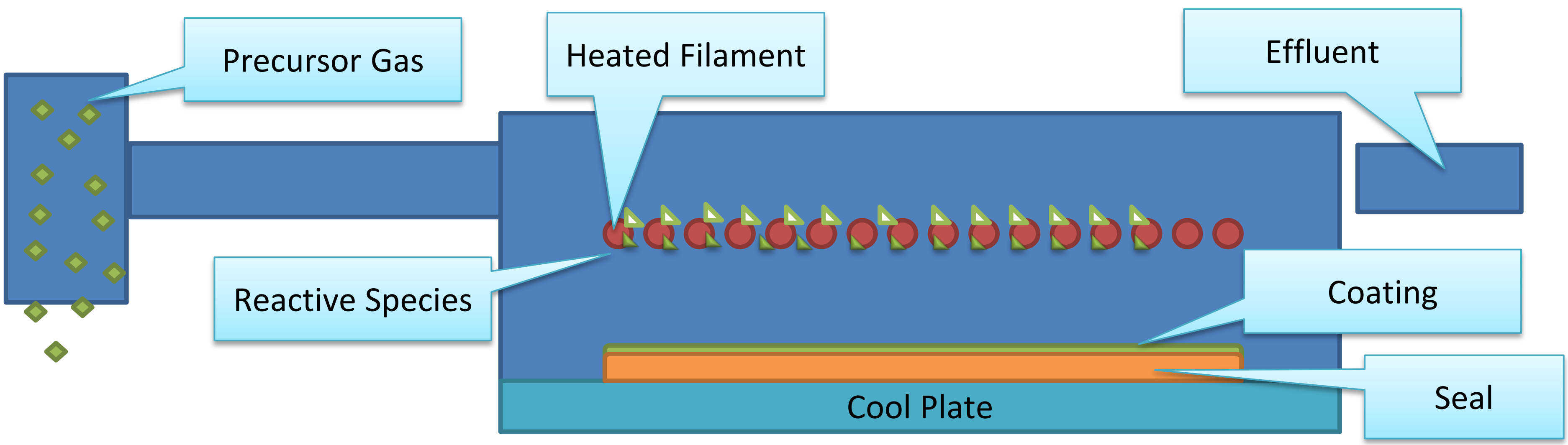
R&D Needs

- *Maintain* efficiency at 40X higher flow rates (up to 40 kg/hr) and >2X higher pressure (up to 875 bar)
- Address losses caused by: temperature rise, membrane resistance, and H_2 backflow
- Enhance conductivity through membrane and catalyst R&D.

Collaborators: NREL, RPI, and Gaia Energy Research Institute

Example: Coatings for Hydrogen Seals

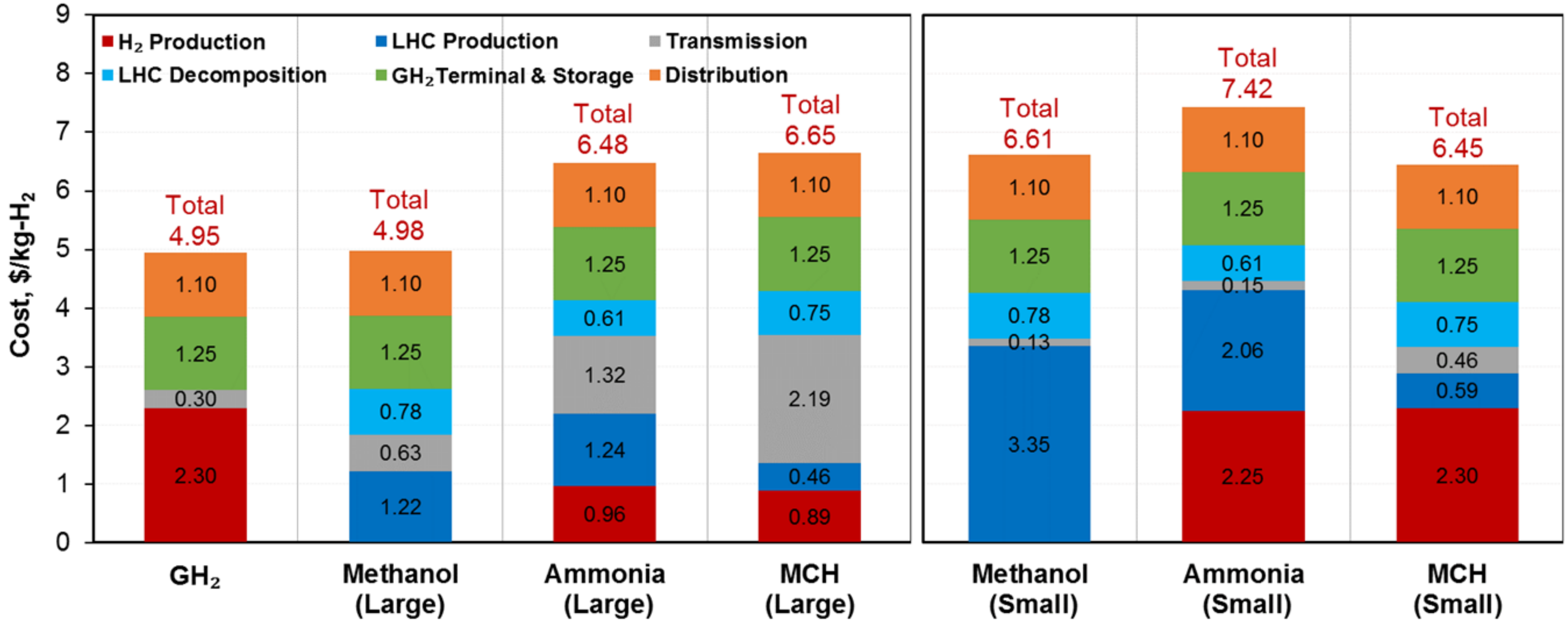
- Improvements in **seal durability** can reduce compressor maintenance
- Coatings developed by GVD Corporation based on MIT research **reduce seal erosion by 70%**
- **Commercialized in hydrogen dispensers** in 2019!



Source: GVD

New H_2 Fuel R&D Area: Hydrogen Carriers

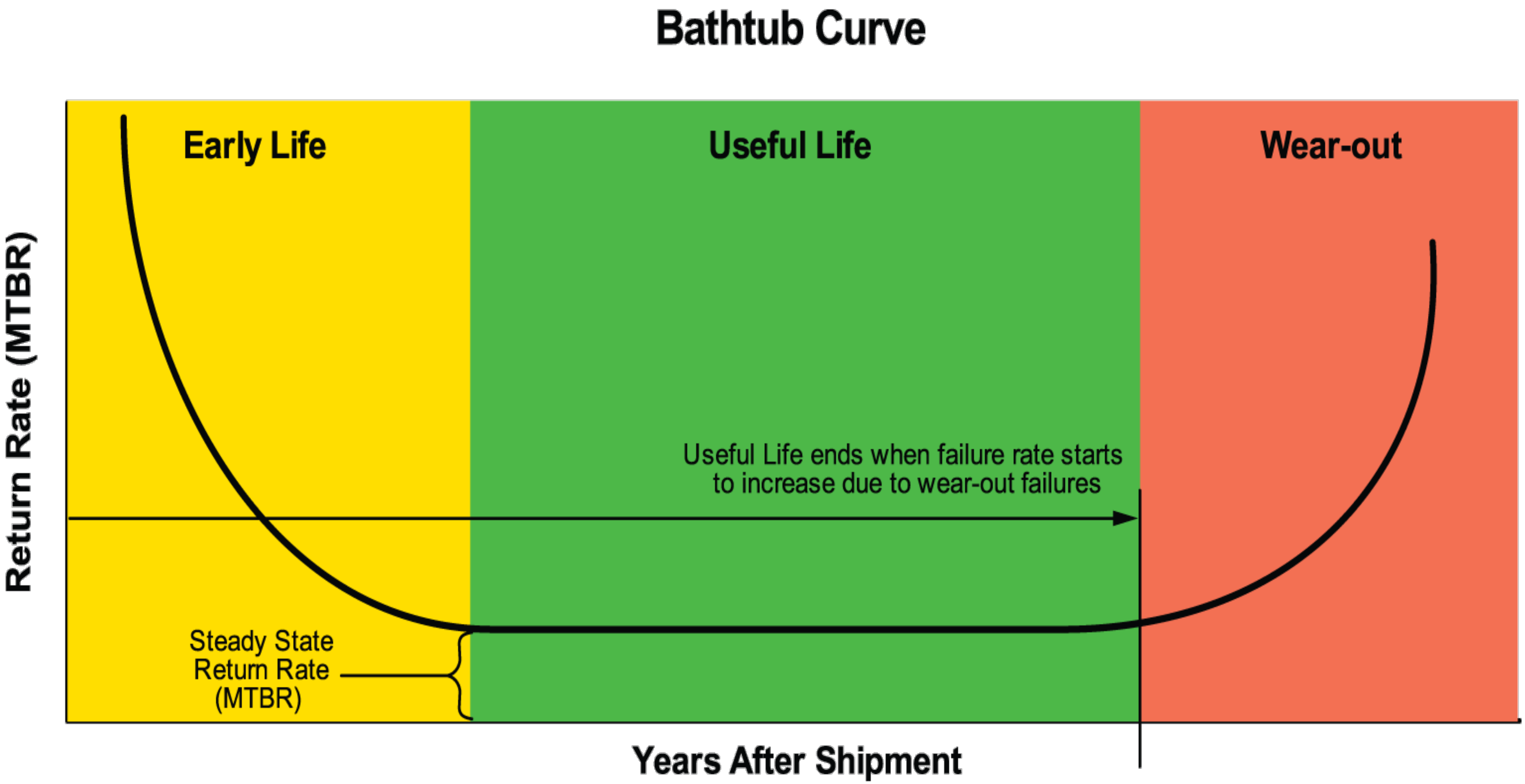
- **Preliminary analysis shows cost of transporting H_2 in carriers** ranges between ~**$5/kg and $7.50/kg**
- At large volumes, **methanol is competitive with compressed H_2 even when transported 3,000 km from gulf coast**



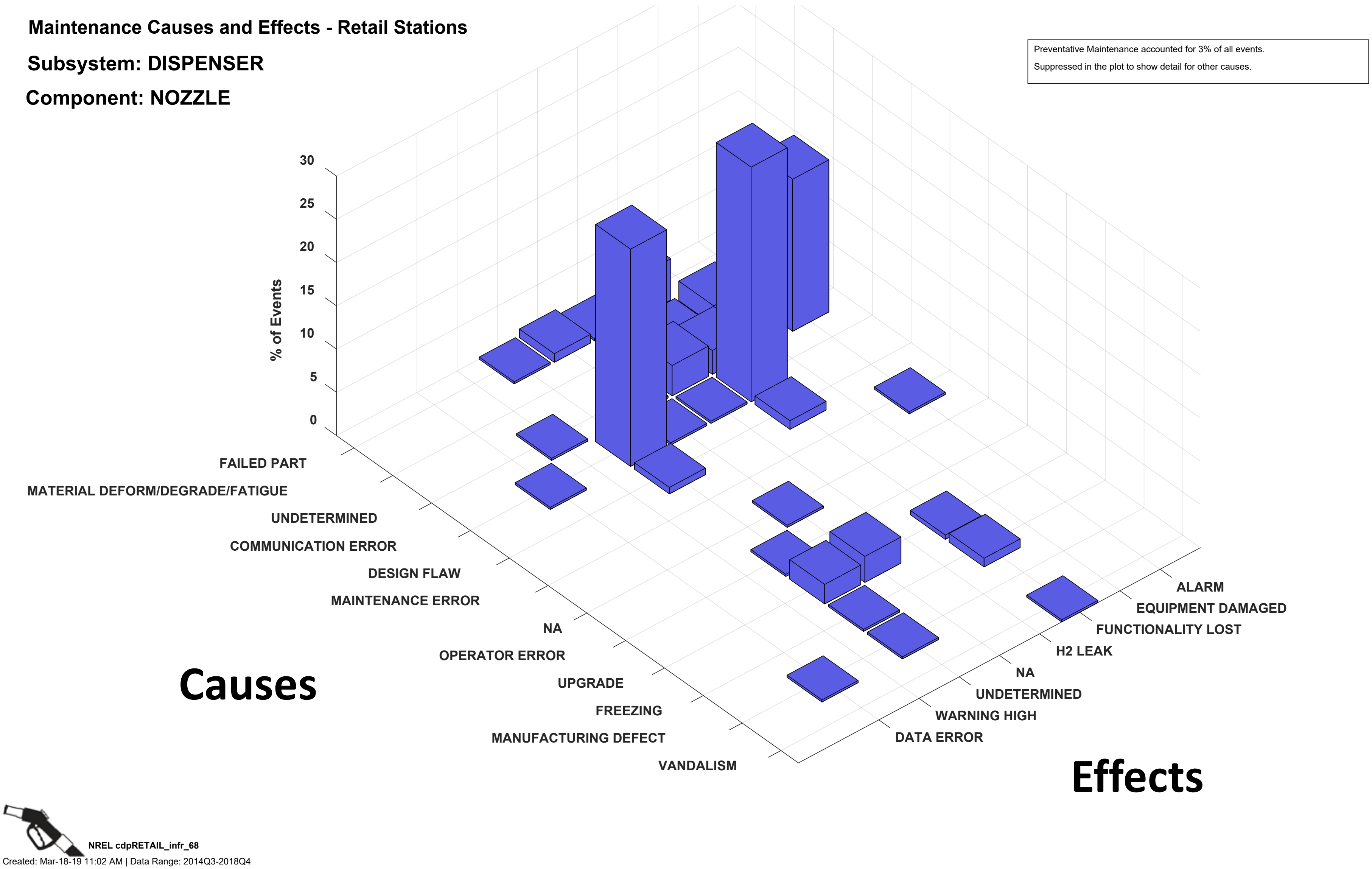
Source: Argonne National Laboratory

Need to increase focus on not just capex but opex

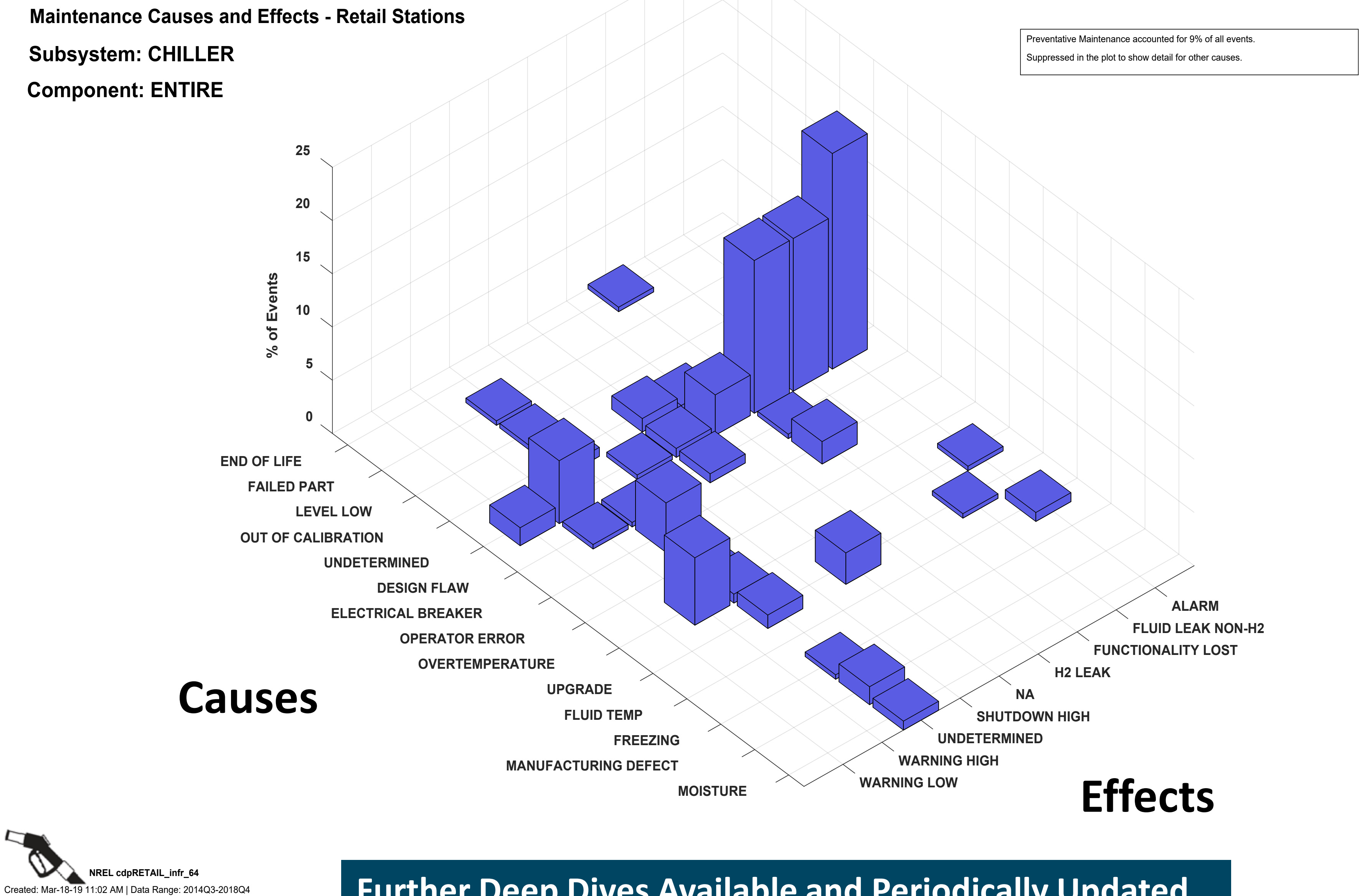
Example from Reliability Engineering



Example: Failure Mode and Effects Analysis (FMEA)



Example: Chiller FMEA



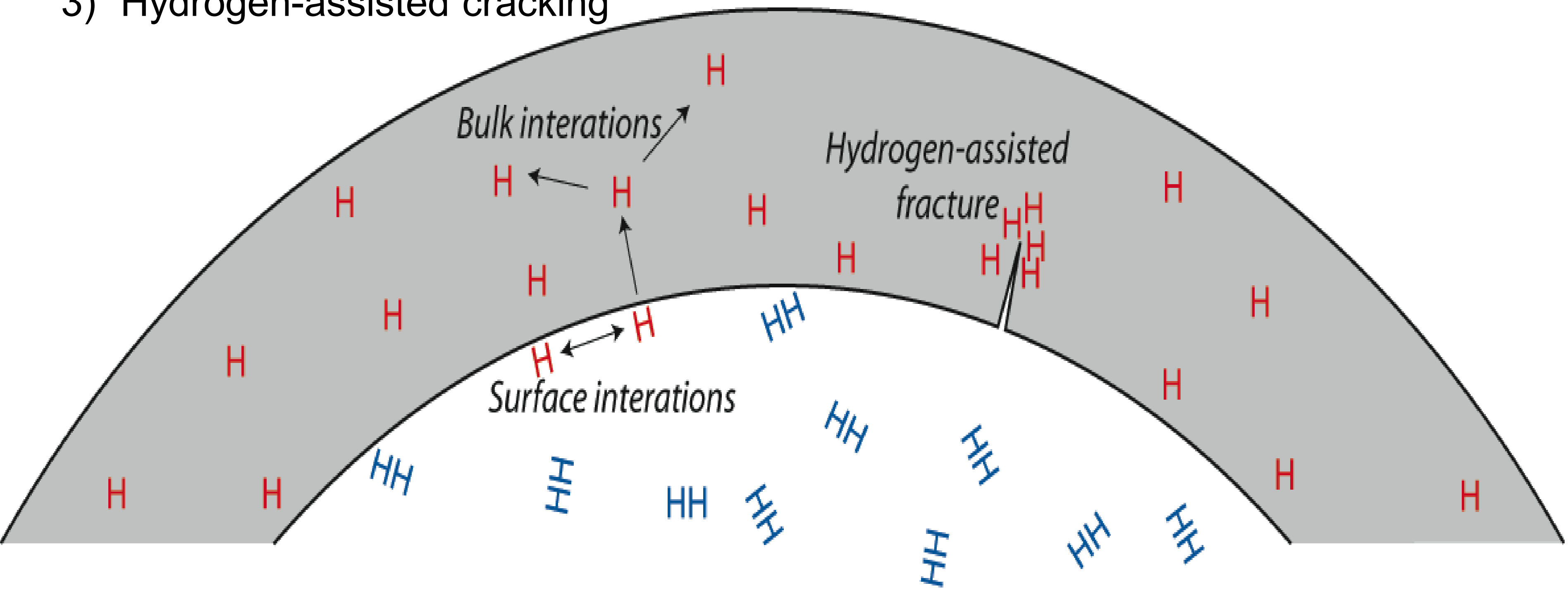
Further Deep Dives Available and Periodically Updated

Materials Compatibility – Hydrogen Embrittlement

Mechanism:

1) Hydrogen-surface interactions
2) Bulk metal-hydrogen interactions
3) Hydrogen-assisted cracking

Appropriate material selection is essential



Understanding of embrittlement enables innovation

Real World Example

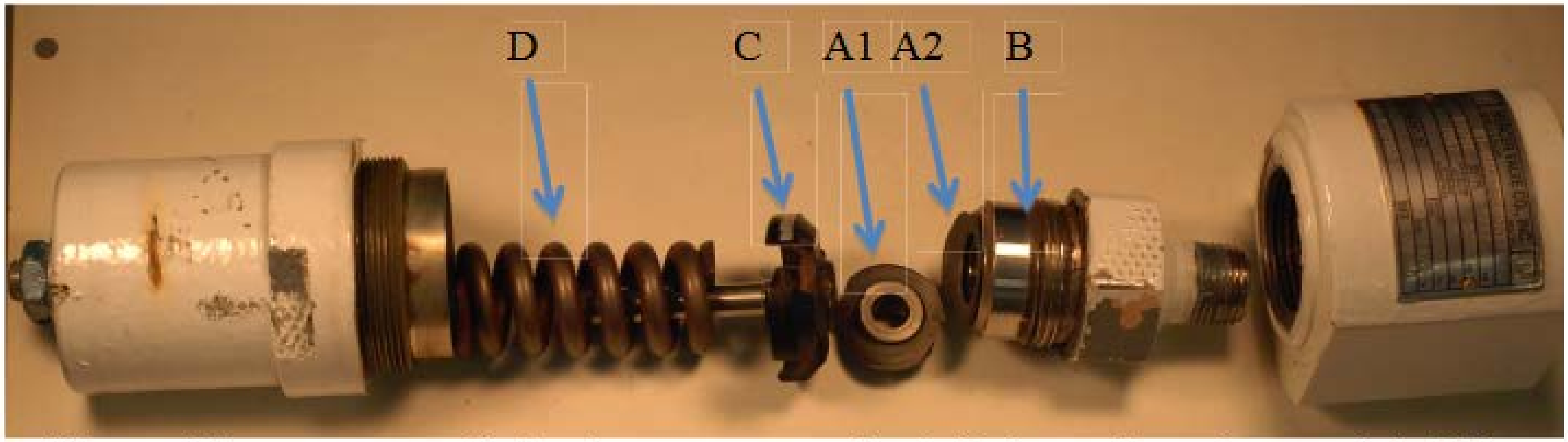


Figure A2. pressure relief valve components: failed nozzle subassembly (A1 and A2); inlet base (B); disk subassembly (C); set spring (D).

Pressure Relief Valve failure caused hydrogen release

Real World Example

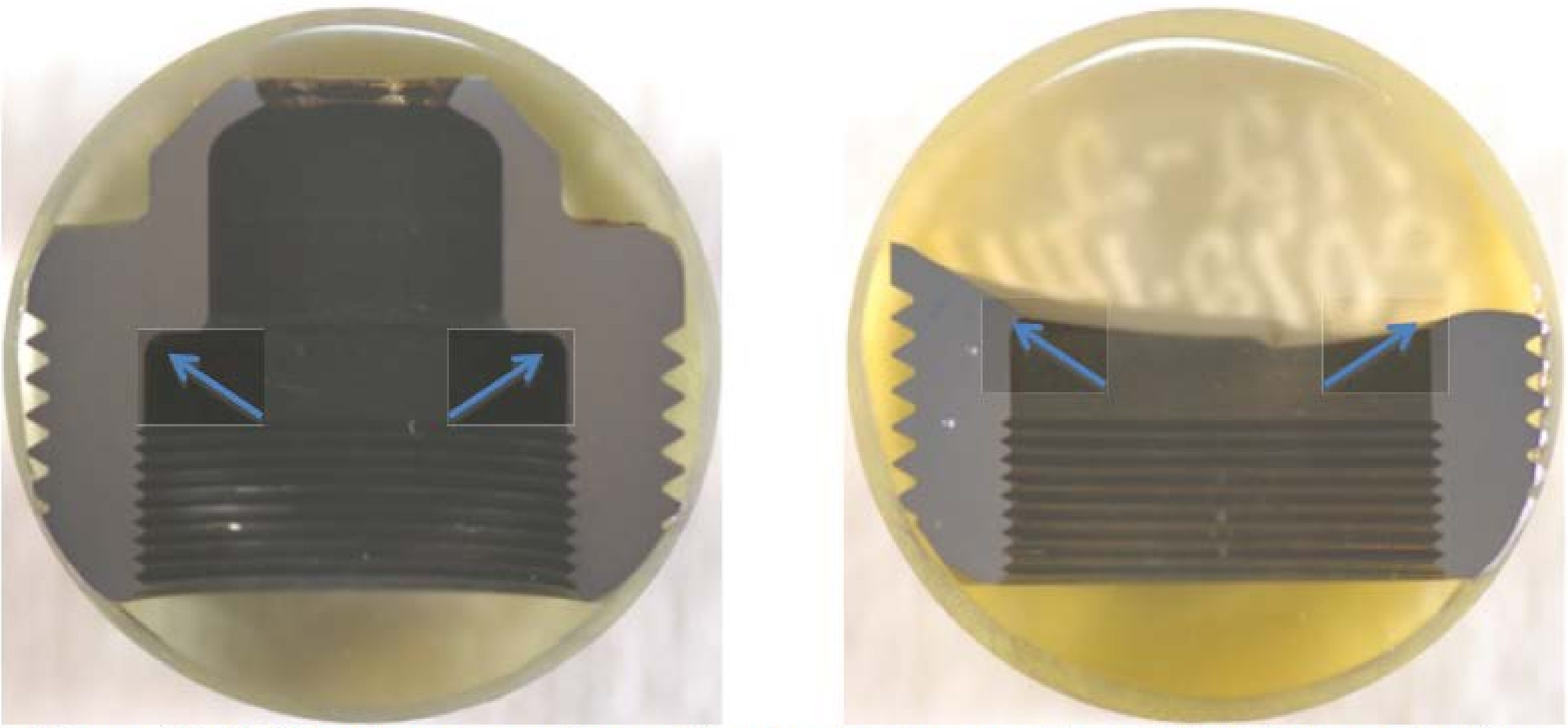


Figure A5. Polished cross sections of (a) functioning nozzle and (b) failed nozzle. The arrows indicate the internal corner associated with failure of the nozzle.

Root Cause Analysis: Type 440C not suitable choice for this application

Source: SNL

Recently Launched: H-Mat Consortium

H-Mat℠ Hydrogen Materials Compatibility Consortium

Pacific Northwest NATIONAL LABORATORY

Sandia National Laboratories

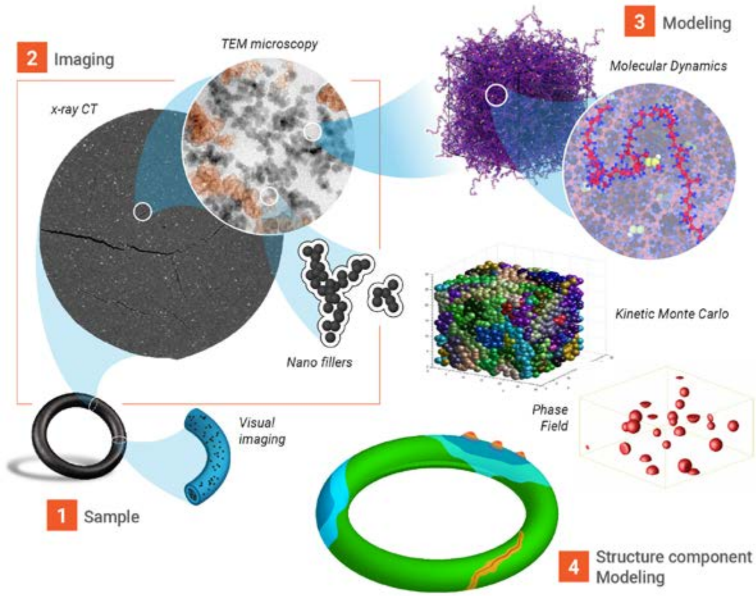
OAK RIDGE National Laboratory

Argonne NATIONAL LABORATORY

SRNL™ SAVANNAH RIVER NATIONAL LABORATORY

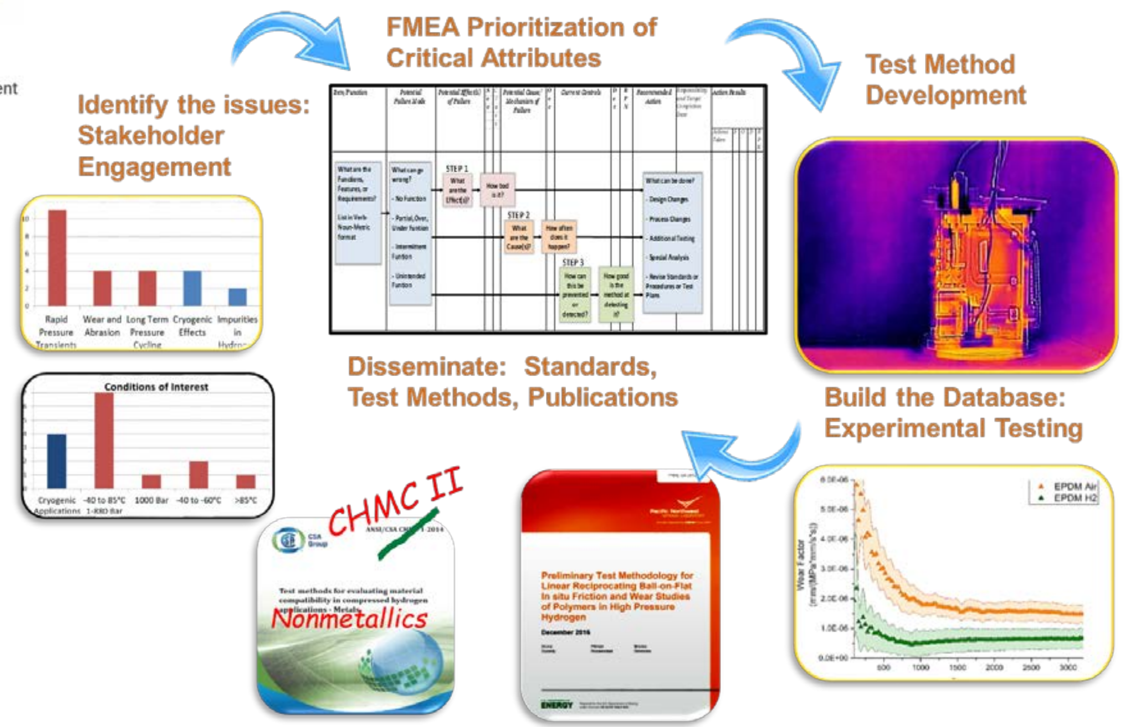
New partners to be added including industry and universities

Approach includes broad stakeholder engagement



Examples of Activities:

- Elucidating degradation mechanisms based on hydrogen-materials interactions
- Components, multi-scale modeling, experimental validation

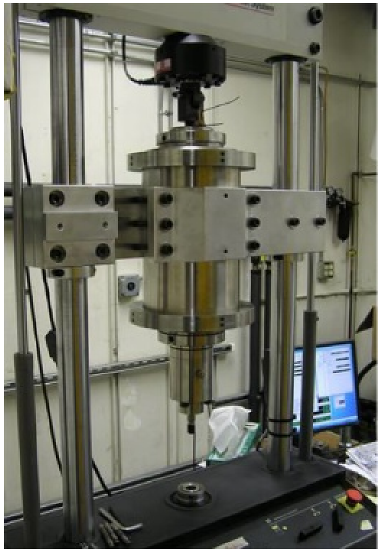


Providing science-based strategies to design materials (micro)structures and morphology with improved resistance to hydrogen degradation

Source: K. Simmons, et al, PNNL, DOE AMR

Enabling codes and standards

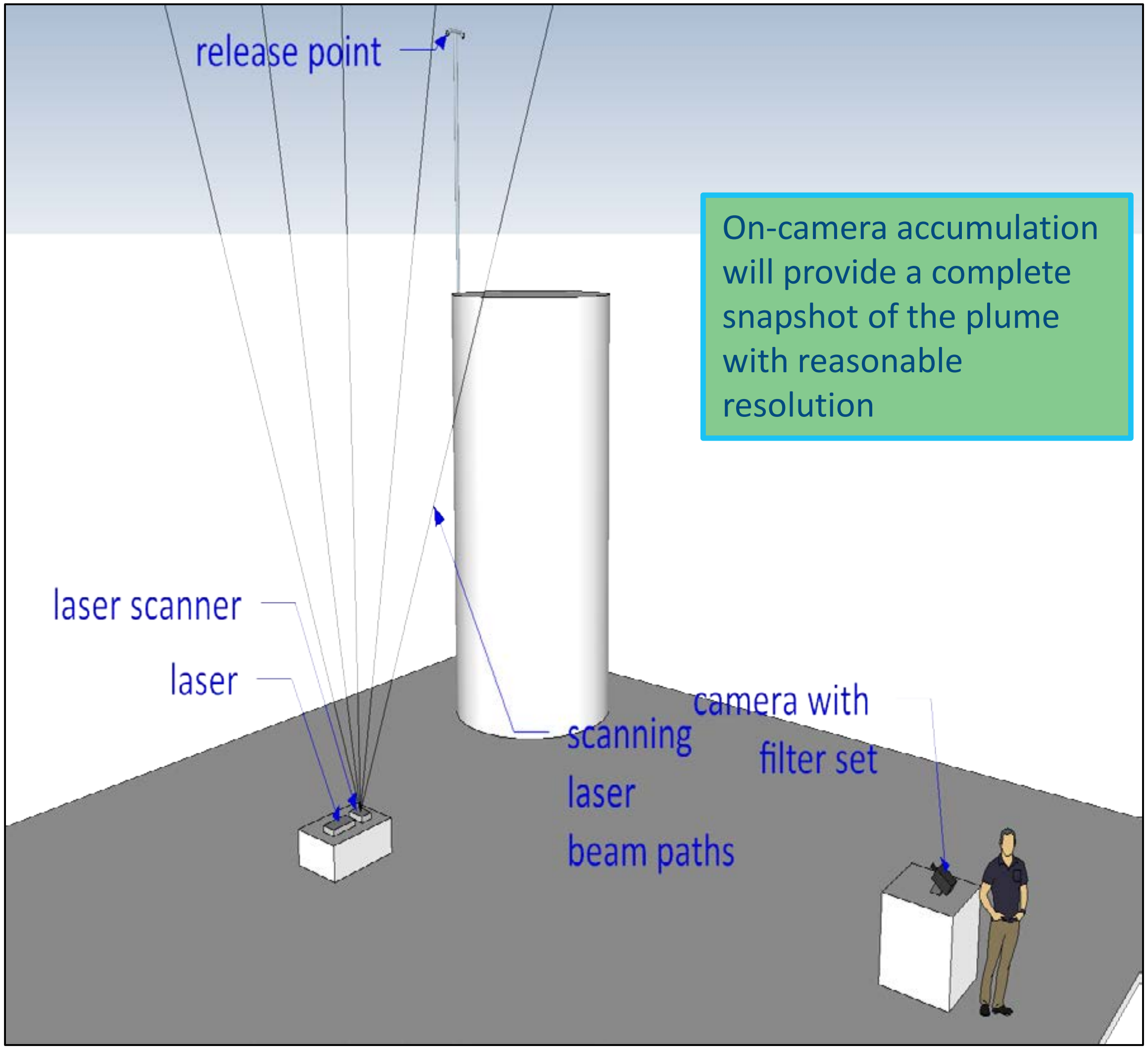
Materials Research to Enable New Pressure Vessel Designs



Code Case 2938 for Pressure Vessel Design Approved in 2018

- Fatigue data generated through collaboration with numerous industry stakeholders
- Sandia generated **"master curves"** of the materials performance of common alloys of high-strength steels
- Master curves can now be used to **eliminate fatigue and toughness experimentation requirements**
- Information on materials behavior can **extend design life** of novel vessel designs (example: 5 to 15 yrs.)

Research to inform codes and standards development

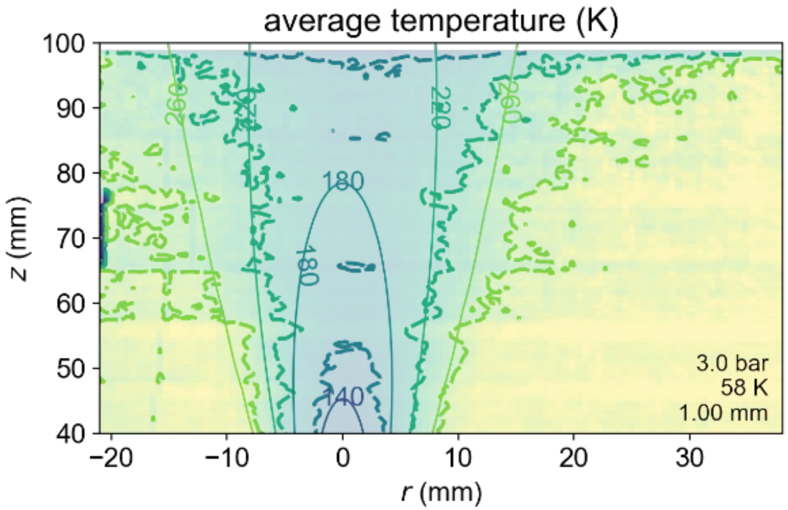


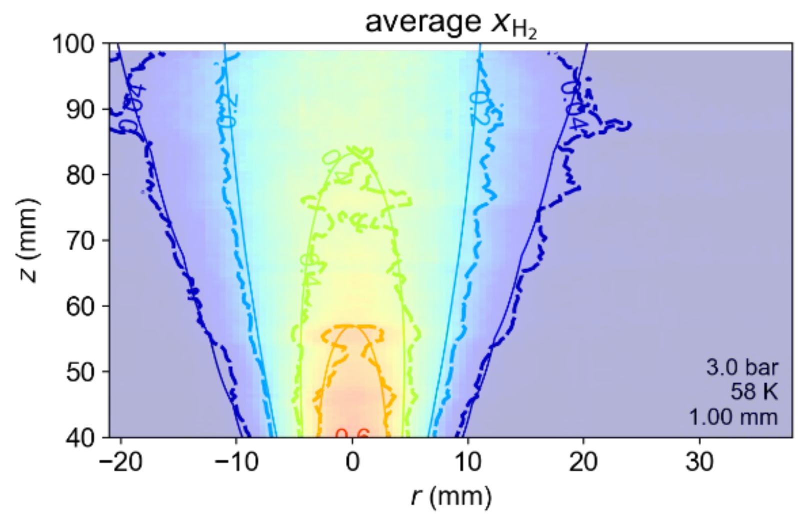
Source:SNL

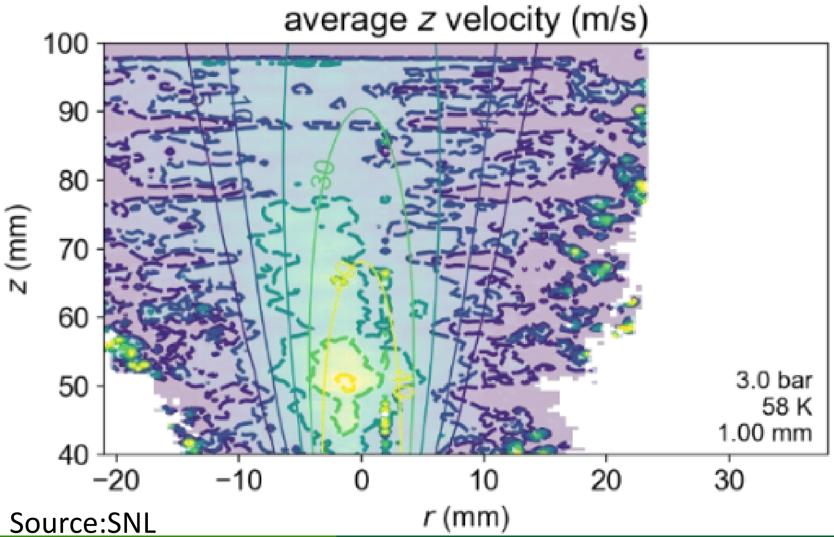
Need to determine hydrogen release behavior to inform setback distances for liquid H_2 stations

Developed laser techniques to detect LH2 releases

Imaged hydrogen from 40 foot standoff distance in the laboratory







Correlated experimental results with models for temperature, concentration, and velocity

Next Step: Outdoor release tests

Source:SNL

Strategy to Enable H2@Scale

Address grid needs & infrastructure

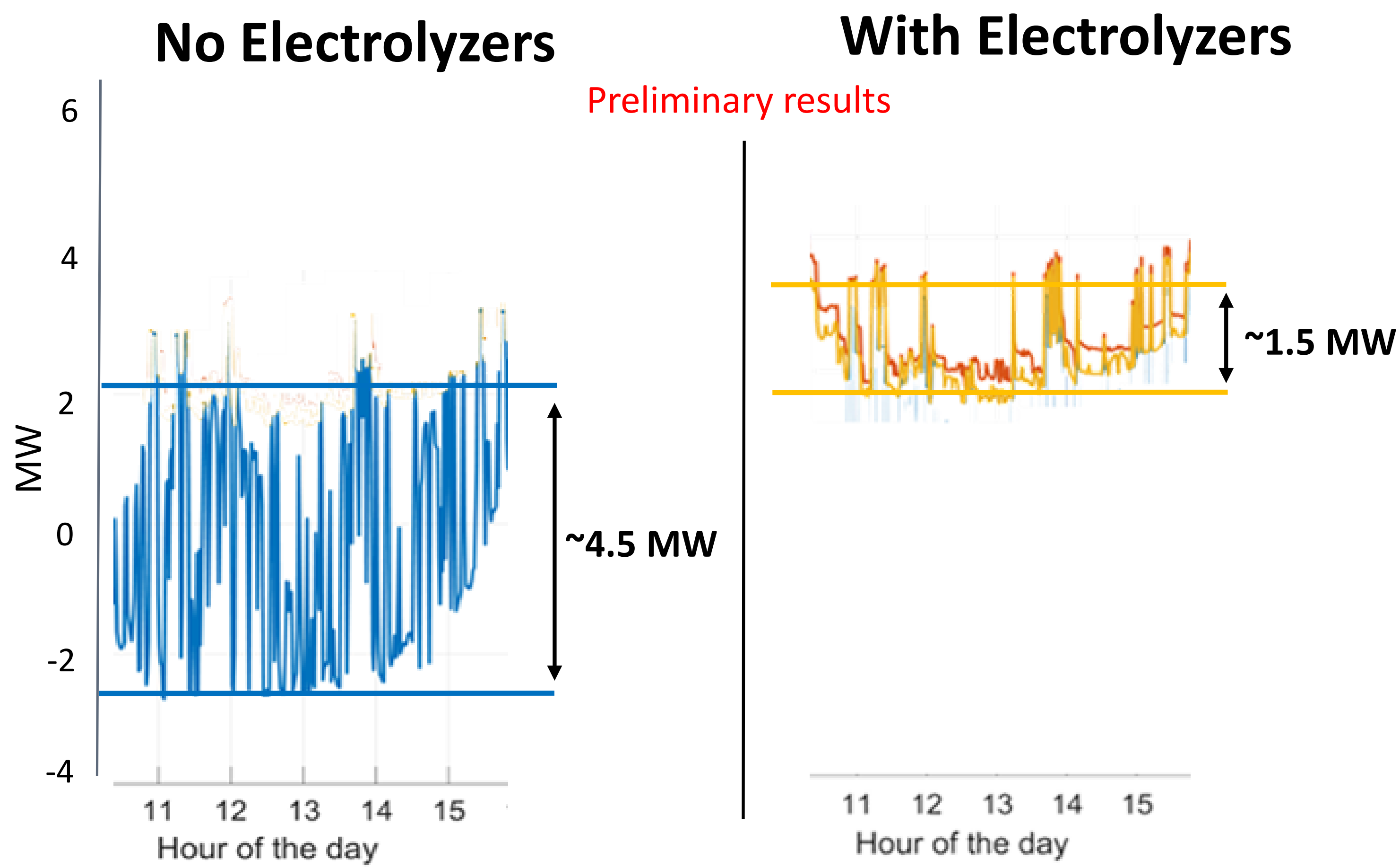
Energy storage, grid services, systems integration

Expand beyond passenger cars

Enable scale and value across sectors to drive down cost and foster infrastructure development

Example: Addressing Grid Needs

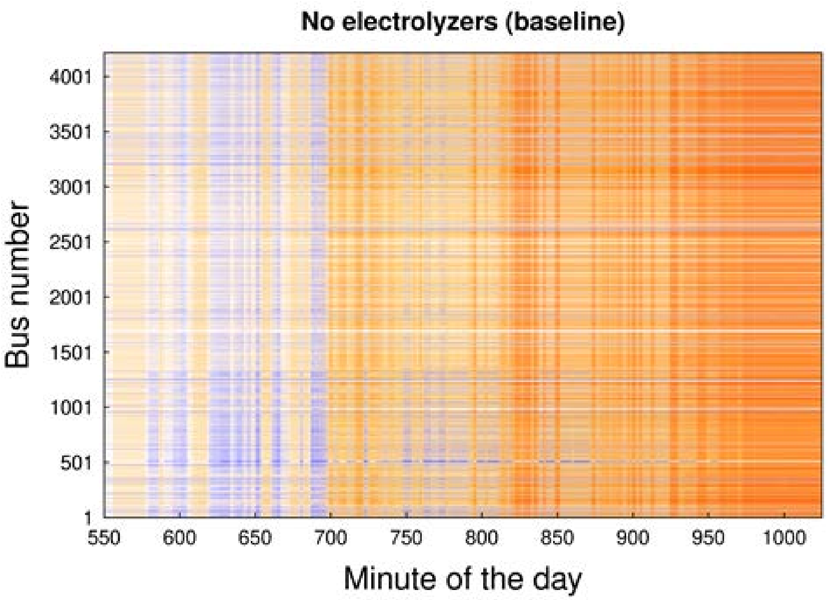
Preliminary study shows electrolyzers can reduce amplitude of power fluctuations by up to 65% in a grid with high renewables

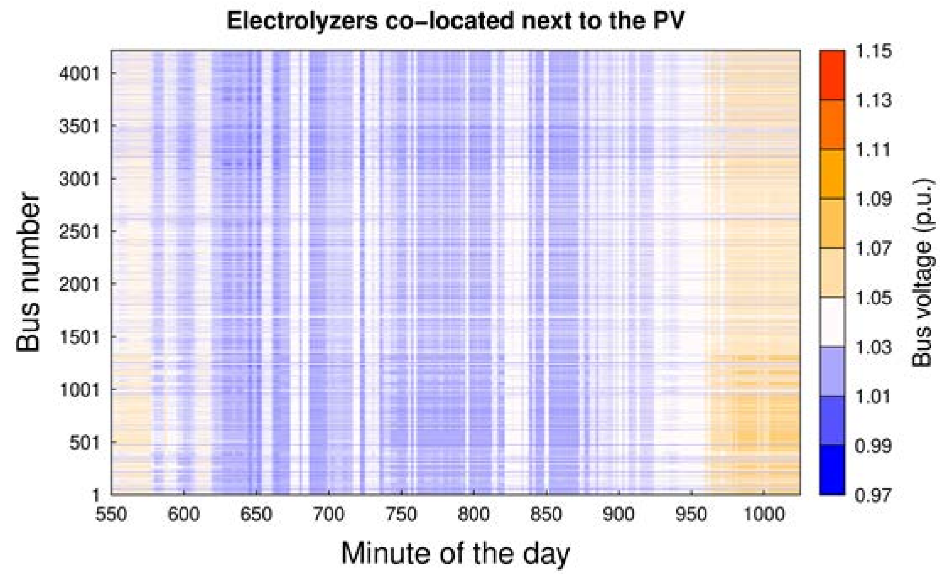


Source: D. Murphy, et al, NREL and INL. Specific case with high solar penetration and electrolyzers used to compensate for power fluctuations

Example: Addressing Grid Needs

Preliminary study shows electrolyzers can reduce voltage deviations in a grid with high renewables





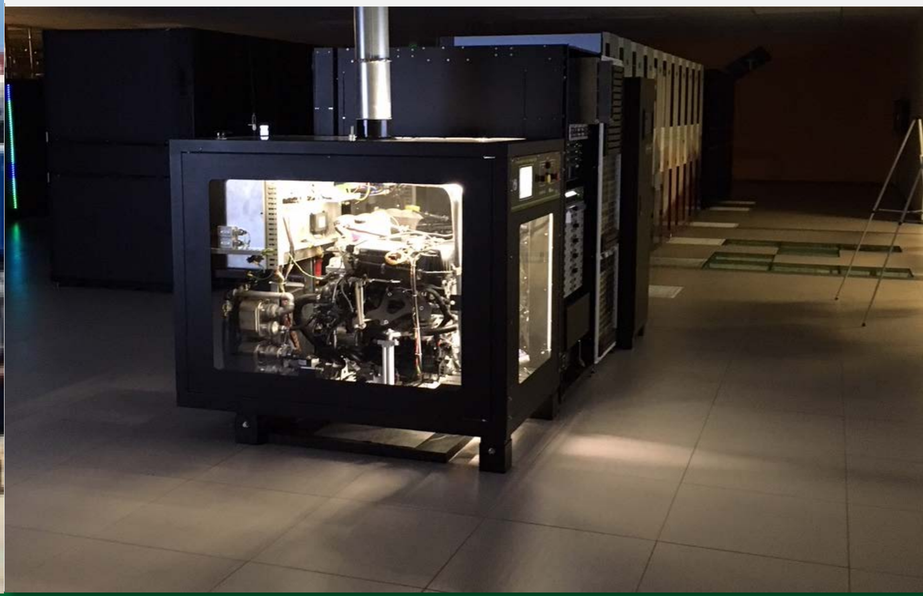
- Voltage profiles for all the nodes in the network over the duration of sunlight hours for a simulated partly cloudy day with 50% PV penetration.
- Voltages exceeding 5% of requirement shown as orange on contour plots.
- Electrolyzer location has impact. More work is needed.

Source: D. Murphy, et al, NREL and INL. Specific case with high solar penetration and electrolyzers

H_2@Rail and H_2@Ports Initiatives

- Collaboration with:
  - DOT-Federal Railroad Administration
  - DOT-Maritime Administration

Data Centers and Energy Storage Applications

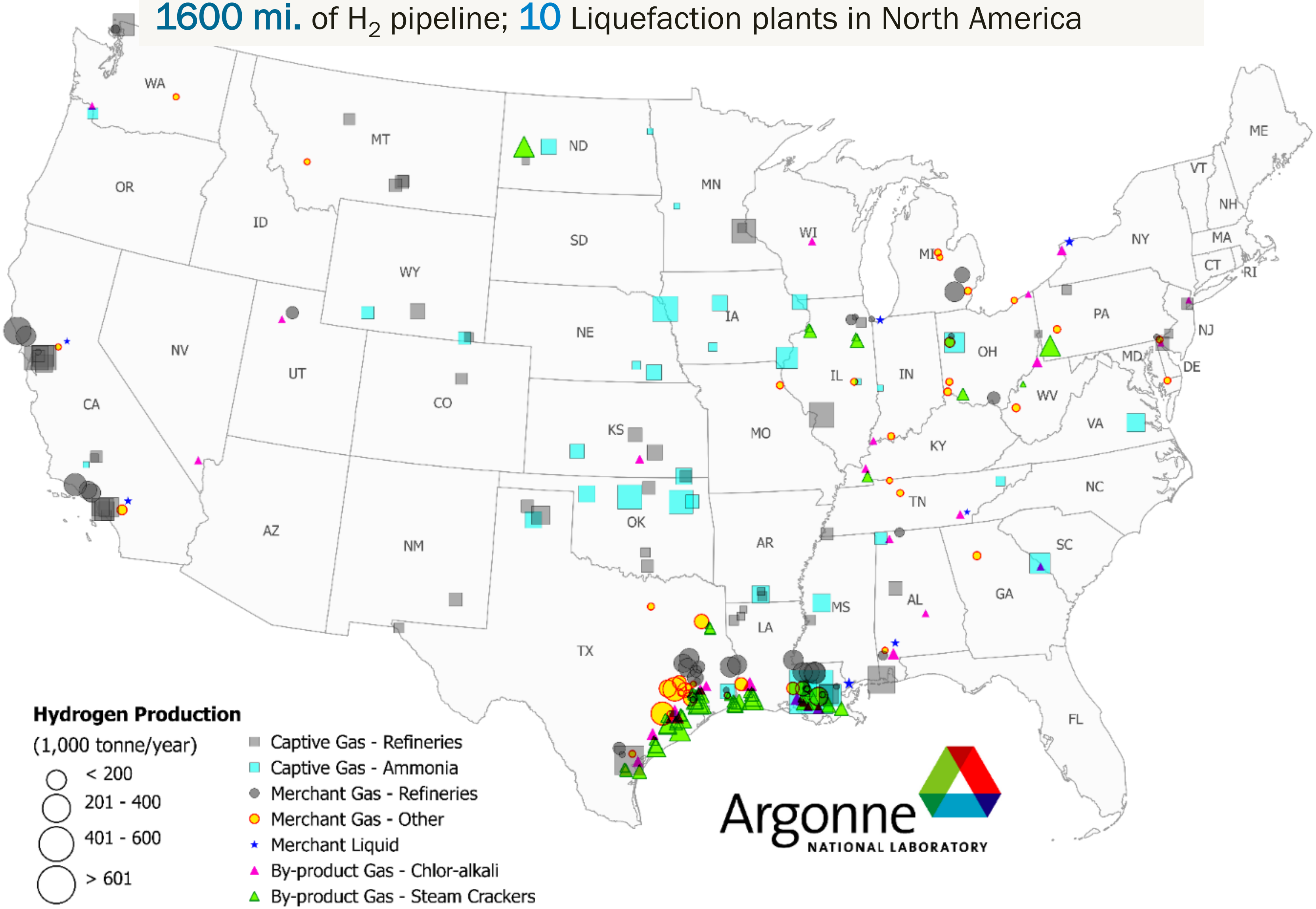


Source: DOT-FRA (top) & SNL (bottom)

Analysis guides activities

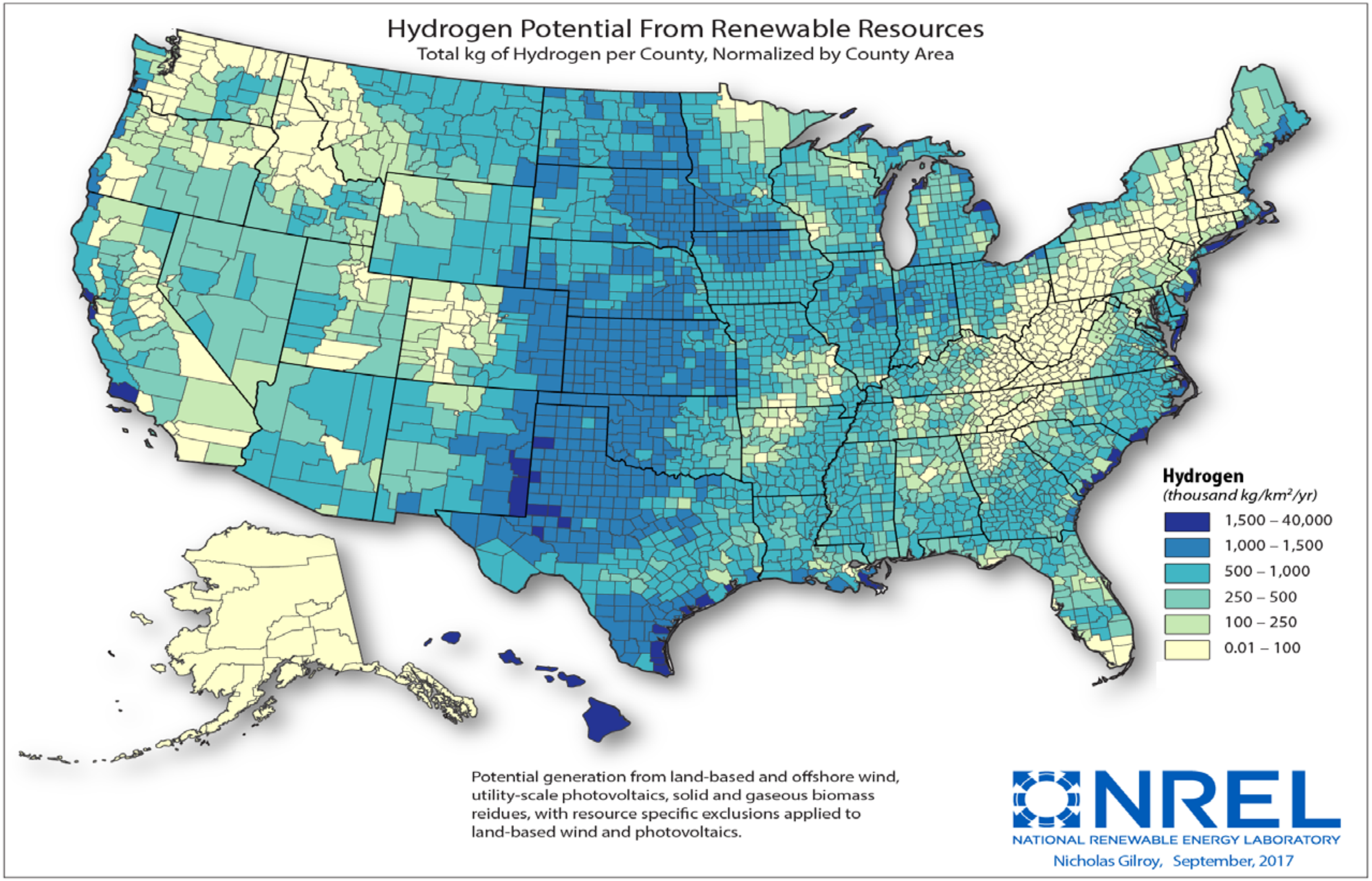
Analysis Activities: 10M Metric Tons H_2/yr Today

1600 mi. of H_2 pipeline; 10 Liquefaction plants in North America

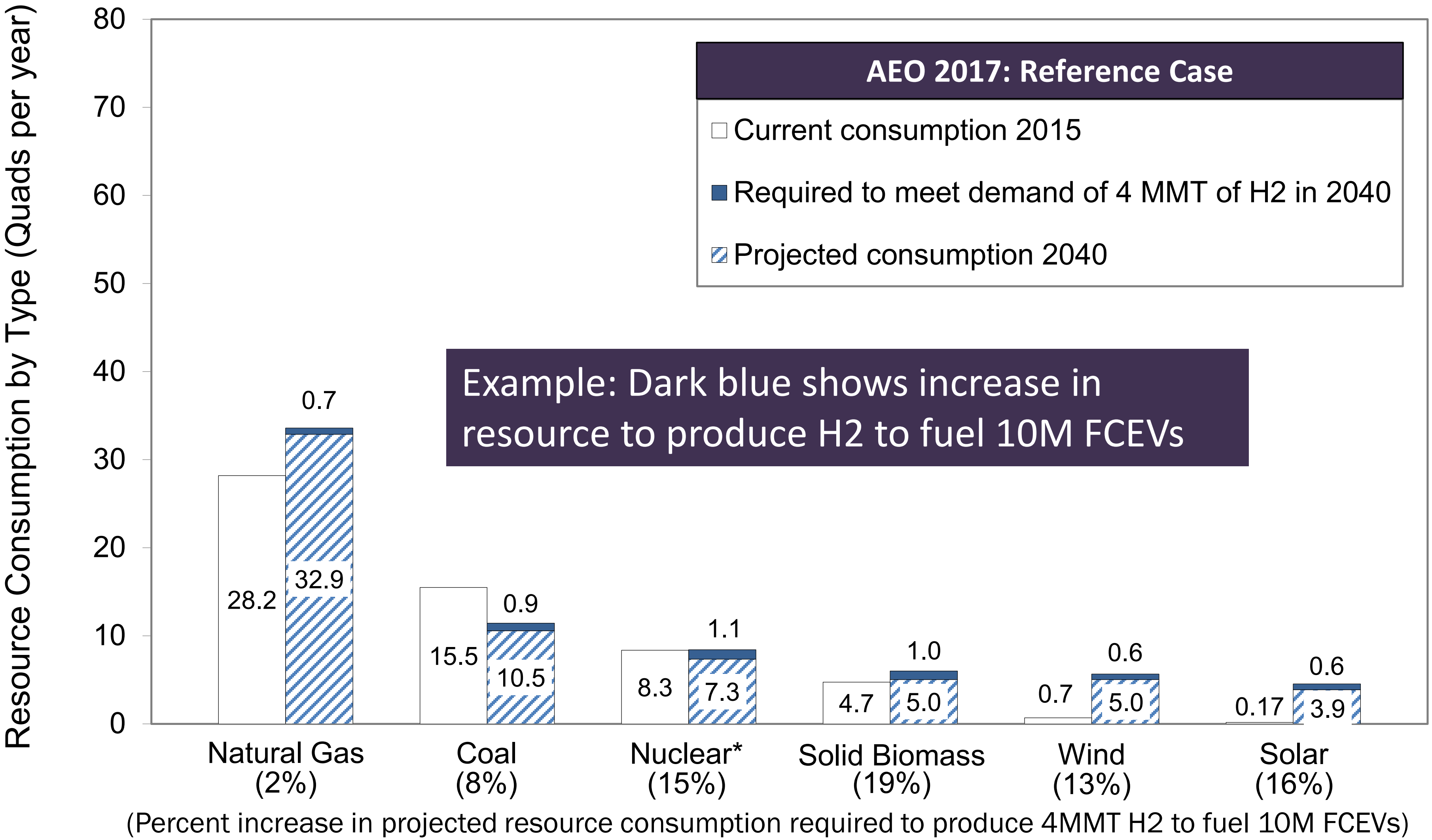


Resource Assessment: Maximum vs. Economic Potential

Preliminary Assessment of Resource Availability to support H2@Scale



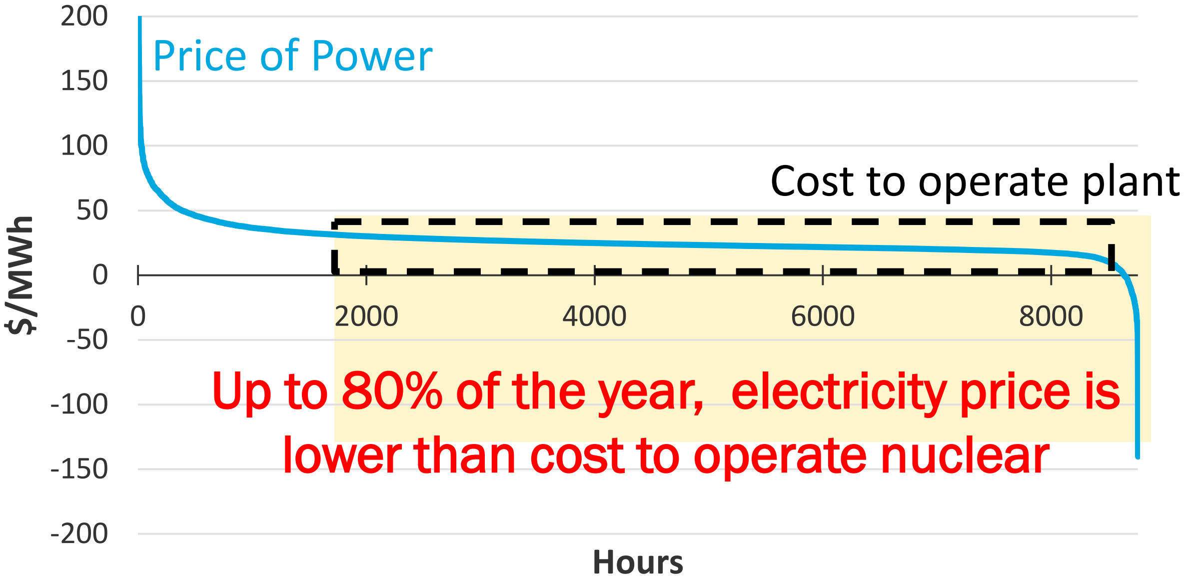
Example: Resource Analysis for Various Scenarios



Source: Connelly, et al, NREL

* Values shown are for high temperature electrolysis.

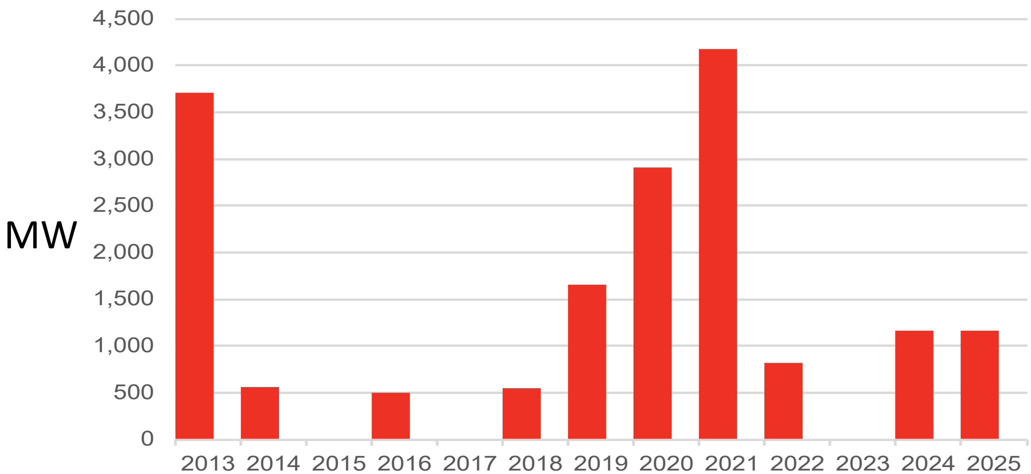
Case Study: Value Proposition for Nuclear Hybrid Systems



The challenge in some regions:

Localized marginal price of electricity < Cost of generating electricity at nuclear plant

Historic and Projected Nuclear Plant Closures in the U.S. (MW)[1]

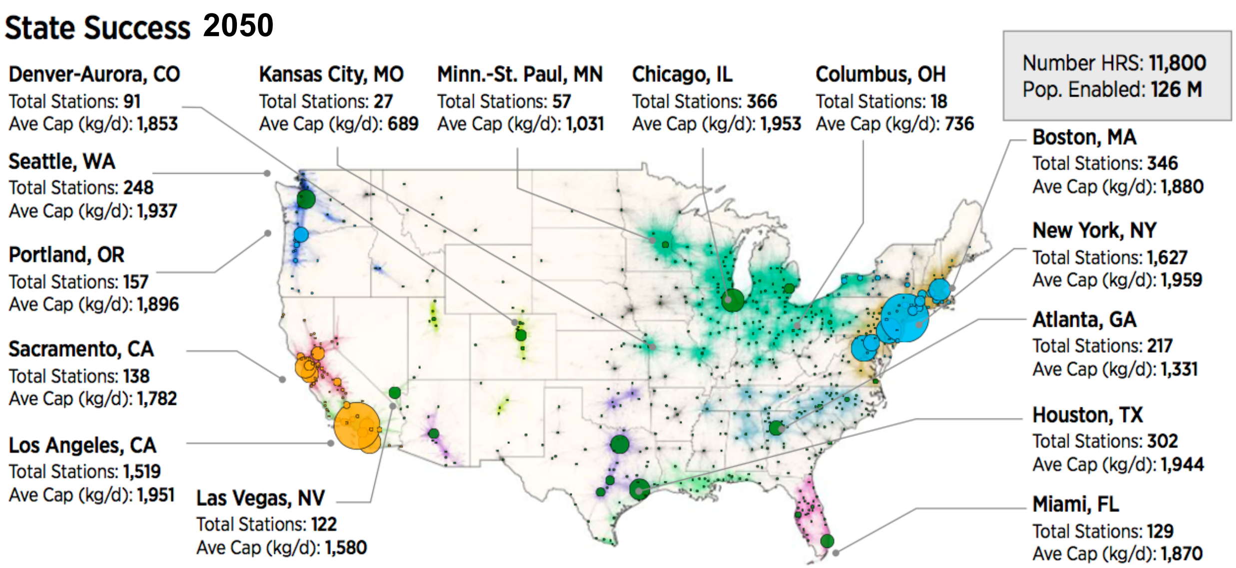


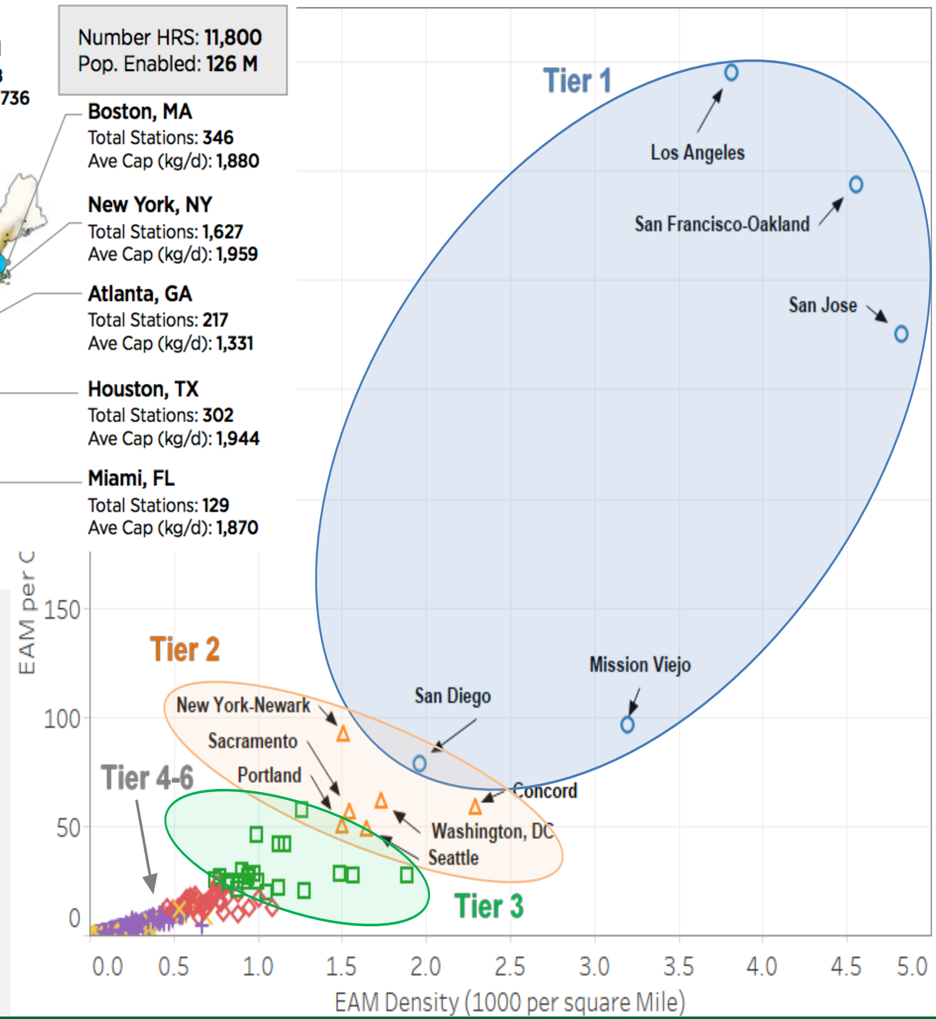
Co-production of hydrogen can create a value stream for nuclear plants to supplement revenue from power generation.

Sources: 1. Bloomberg New Energy Finance, 2019
R. Boardman, et al, INL

Scenario Analysis for Hydrogen Fueling Station Rollout

Modeling the optimal size and placement of hydrogen stations over time under various scenarios





SERA

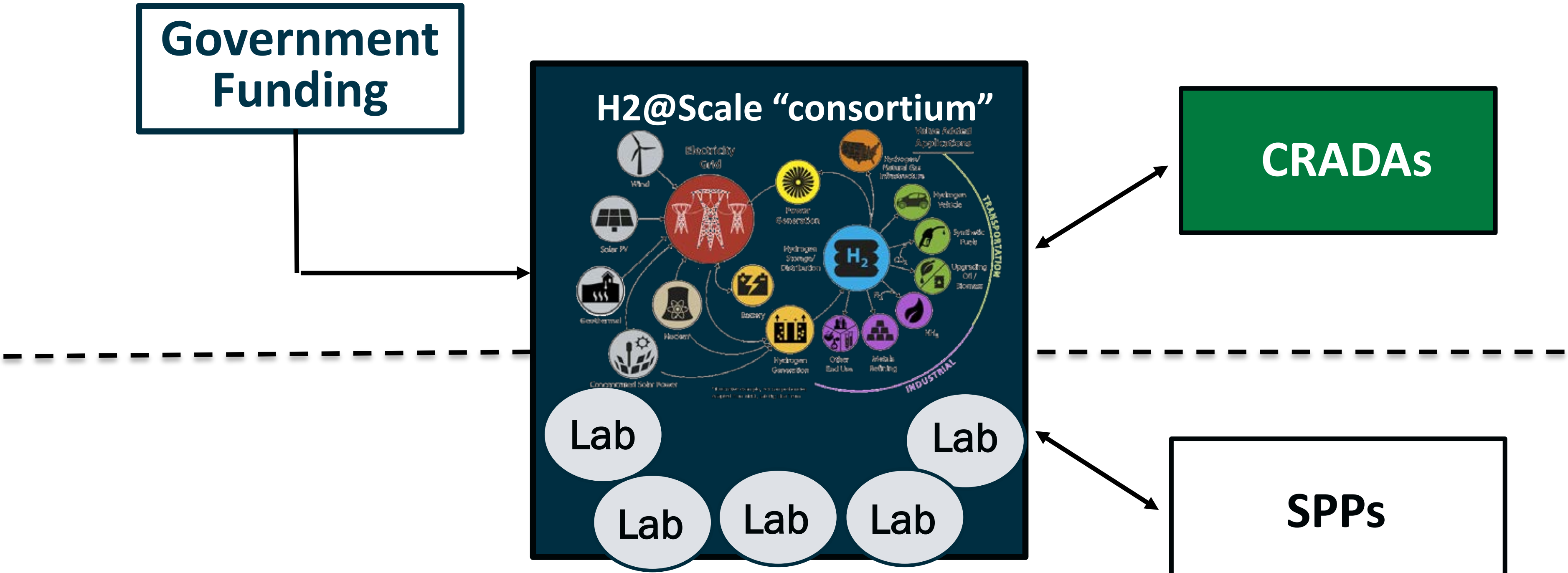
NREL

Tiers represent clusters of sequential FCEV introduction, based on **early adopter metrics,** industry input, and geographical considerations.

Collaboration & Resources

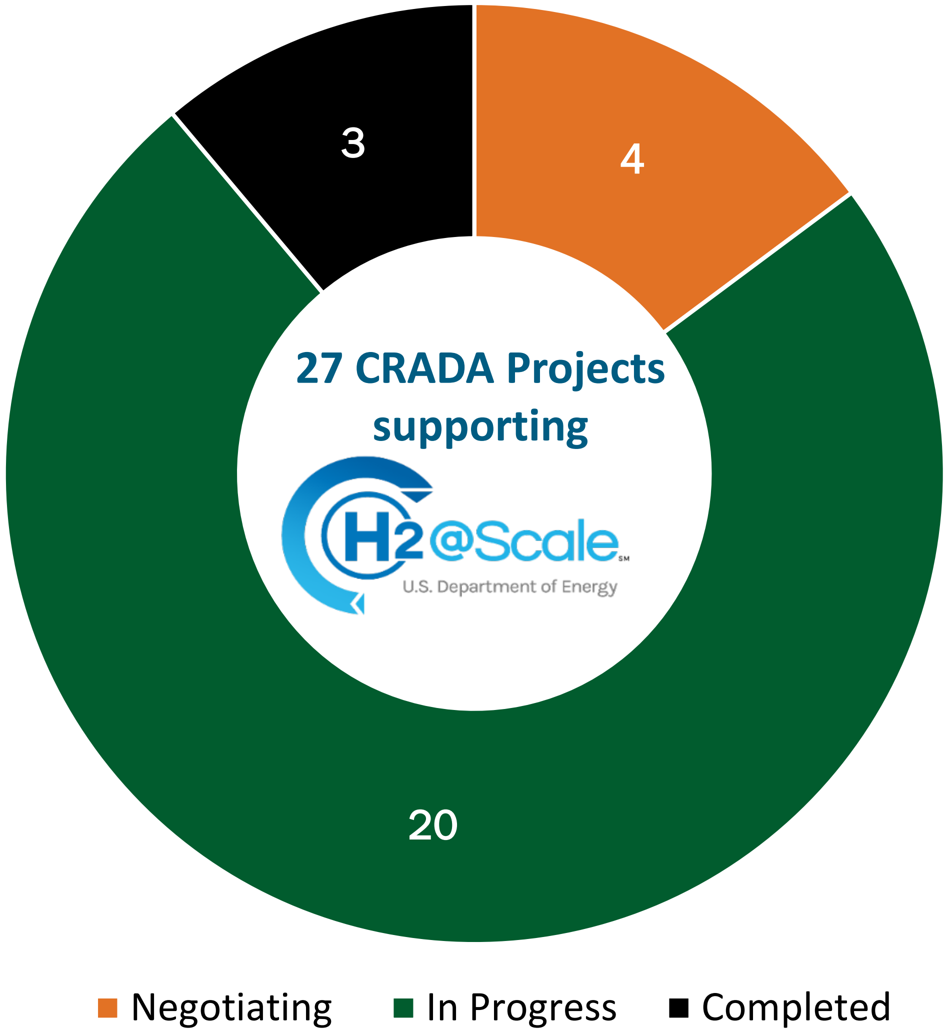
H_2@Scale Consortium

- **Leverages Lab capabilities and expertise to address challenges- materials R&D, analysis, safety R&D, etc.**



CRADA = Cooperative Research and Development Agreement
SPP- Strategic Partnership Project (‘Work for Others’)

H2@Scale CRADA Projects



New projects addressing…

- **Energy systems integration**: hydrogen, renewable methane, natural gas
- **Energy storage:** hydrogen carriers
- **Cost reductions:** production, delivery, storage, and dispensing technologies

New Global Safety Partnership: Center for H_2 Safety (CHS)

DOE Fuel Cell Technologies Office partners with CHS & global industry

AIChE

Pacific Northwest
NATIONAL LABORATORY

CENTER FOR Hydrogen SAFETY

Connecting a Global Community

HYDROGEN
Safety Panel

HYDROGEN
Emergency Response Training Resources

www.aiche.org/CHS

Example Incident - Burst Disk

Incident Report

Tube Trailer Leak through Over-Pressure-Protection Rupture Disk

Incident Date: 2008

Severity:	Was Hydrogen released?	Was there Ignition?
Incident	**Yes**	**No**

Description

A pressure relief device (frangible burst disk) on one of a hydrogen delivery tube trailer's 26 tubes failed prematurely and
released hydrogen while filling a hydrogen storage tank at a government faci
procedures and safety checks, including connection to the facility's regulator
follow-up verification of leak checking by facility personnel, were completed (
process, a person walking near the facility heard the noise of escaping gas t
bursts of gas release. Facility personnel were alerted and the tube trailer ven
incident location.

The hydrogen leak was safely contained and mitigated by the tube trailer ven
response team first noted a decrease in pressure from the shipped pressure
trailer's common supply manifold. The hydrogen leak was located to a single

Safety Event Record Include:

- **Location**
- **Equipment**
- **Probable Causes**
- **Contributing Factors**
- **Injury/Damage**

Examples from H2Tools.org

Equipment	Total Incidents
Piping/Fitting/Valves	102
Hydrogen Storage	49
Vehicle & Fueling System	40
Safety Systems	25
Ventilation System	22
Laboratory Equipment	19
Pressure Relief Devices	16
Motive Power Systems	15
Heating Equipment	14
Electrical Equipment	14
Process Equipment	14
Batteries and Related Equipment	13

Examples:

Piping (36)

Valve (36)

Flexible Tubing (8)

Gasket (6)

Bolts (6)

Cross–Search Categories :

- Settings
- Damage and Injuries
- Probable Causes
- Contributing Factors

Example of International Government Collaboration

The International Partnership for Hydrogen and Fuel Cells in the Economy

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

www.iphe.net

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

Top Priorities

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

Find IPHE on Facebook, Twitter and Linkedin

Follow IPHE **@The_IPHE**

Formed 2003
Over 20 Countries

International Collaborations

Government- Led

CLEAN ENERGY MINISTERIAL
Advancing Clean Energy Together

Focus areas **2019**

H_2

International Energy Agency
Secure • Sustainable • Together

R&D TCPs, policy, analysis, reports

FC H_2

MISSION INNOVATION
Accelerating the Clean Energy Revolution

2017

H_2

Hydrogen Energy Ministerial (HEM)

First meeting- October 2018

IPHE

Formed in 2003, over 20 countries and EC
2/3 of world's GDP
~ $1B/year in funding

www.iphe.net

UN Global Technical Regulations (GTR) H_2

Industry- Led

Industry Associations

Hydrogen Council

Launched in 2017
Over 50 CEOs

Center for Hydrogen Safety

Launched in 2019
Industry & Govt

Widespread Commercialization

Increasing Priority: Enabling and Harmonizing Regulations, Codes and Standards

Hydrogen and Fuel Cells Focus

Hydrogen Ministerial Meeting- Oct 23, 2018

Tokyo Statement set Four areas for global collaboration

- **Harmonization of regulation**, codes and standards
- **Information sharing** on safety and infrastructure
- **Technical studies**
- **Communication, education and outreach**

What can you do?

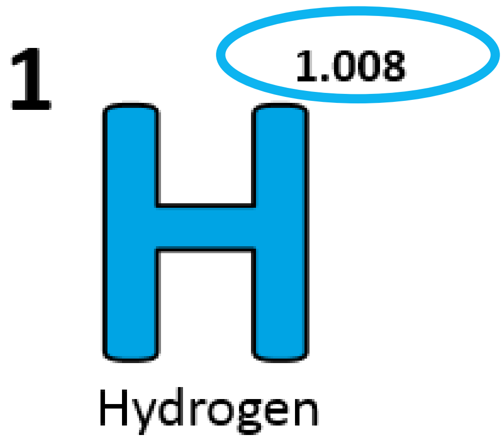
Get involved and help spread the word!

Help Us to Spread the Information

Celebrate National Hydrogen & Fuel Cell Day

October 8 or 10/8

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



Give an *"Increase your H2IQ"* presentation in your community

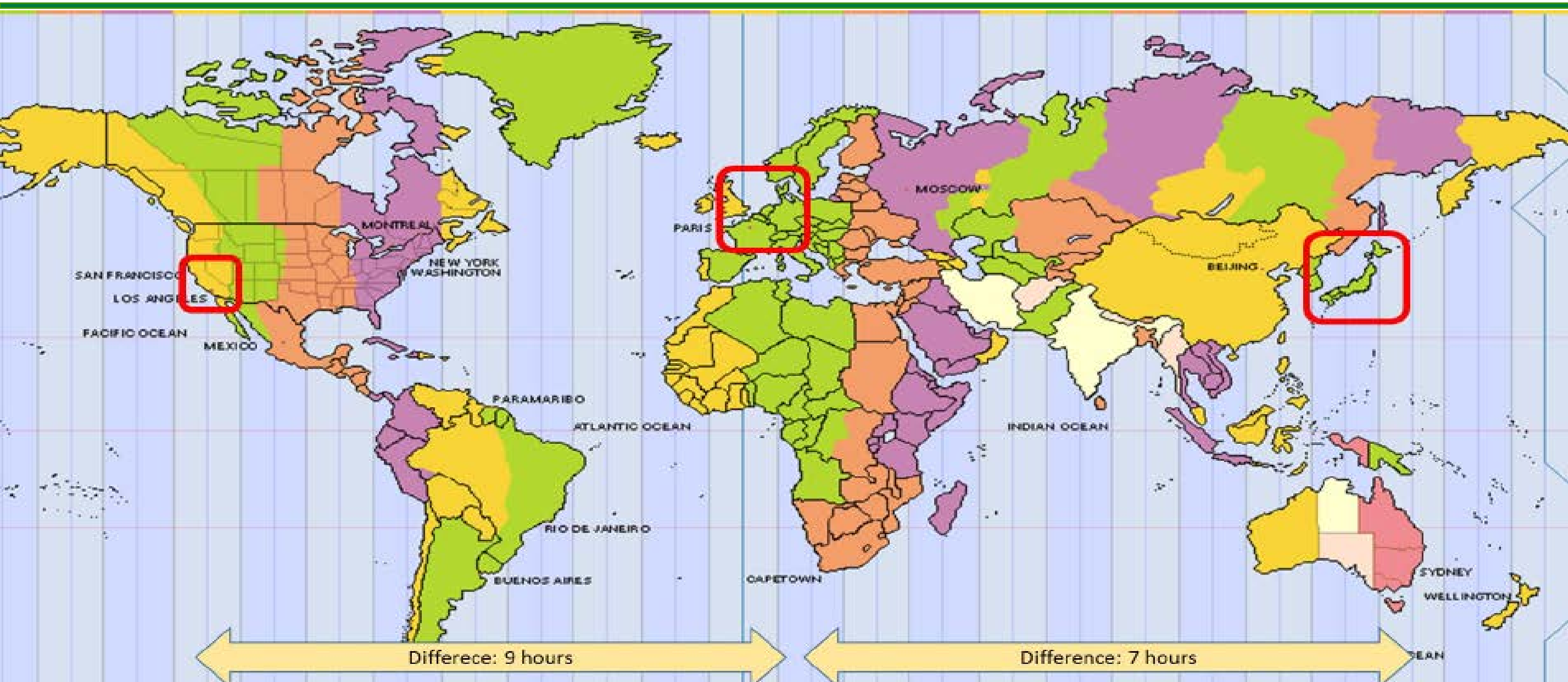
INCREASE YOUR H2IQ

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

Learn more at: energy.gov/eere/fuelcells

DOE Leadership Engagement

Hydrogen and Fuel Cell Day Challenge on Oct 8.



- Builds on H2 Challenge in Netherlands
- Teams drive 10.08 hours and score points along the way
- Start in Japan, continue in Europe and finish in the U.S.
- Players share experience in social media

DOE-wide STEM Initiative

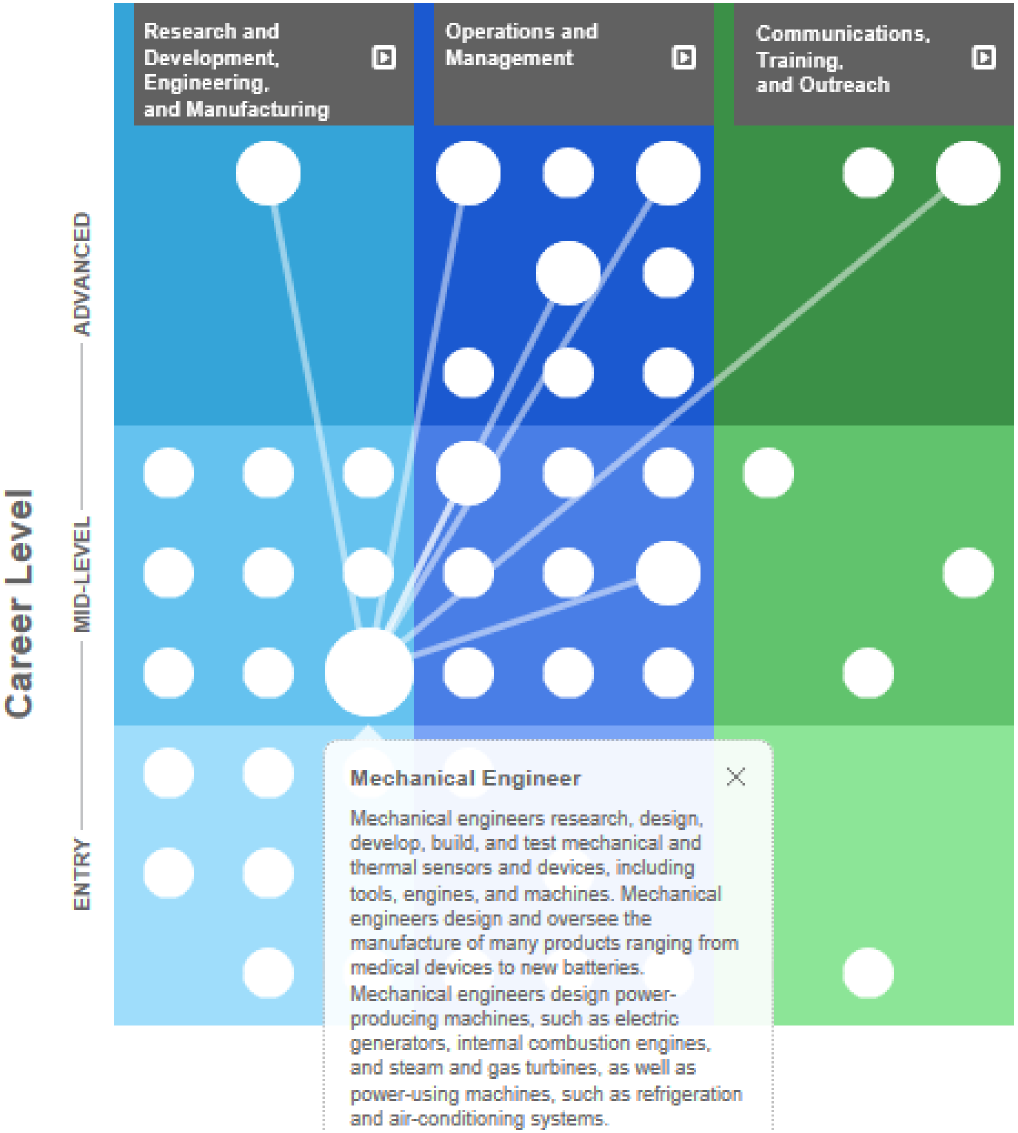
Hydrogen and Fuel Cells Career Map Online

Sectors Identified:

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

Visit online

www.energy.gov/eere/fuelcells/education



Postdoc & Postmasters Fellow Positions Available

Applicants selected will be mentored by EERE Fuel Cell Technologies Office staff and be part of the team.

- **Hydrogen Fuels R&D**
- **Fuel Cells R&D**
- **Infrastructure and Systems R&D**
    - **Technology Acceleration**
    - **Safety, Codes & Standards**
    - **Systems Analysis**

FCTO is currently seeking 4 candidates:

- **1 for Fuel Cells R&D**
- **2 for Technology Acceleration**
- **1 for Safety, Codes & Standards**

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Peter.Devlin@ee.doe.gov
Jason.Marcinkoski@ee.doe.gov
Laura.Hill@ee.doe.gov

To apply: https://www.zintellect.com/Opportunity/Details/EERE-STP-FCT-2019-1800

Bob Rose
1946 - 2018

Pioneer and Advocate for Hydrogen and Fuel Cell Technologies

The Fuel Cell Rose Education Award, led by the American Councils for International Education, will help prepare the global leaders of the future in the hydrogen and fuel cells community.

http://roseaward.americancouncils.org/

Pacific Northwest National Laboratory plans to host the first award recipient.

RISE

Thank You

Dr. Sunita Satyapal
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Fuel Cell Technologies Office
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energy.gov/eere/fuelcells

Hydrogen.energy.gov

Coordination across Offices- Examples

EERE AMO

- New NG reforming options
- Innovative manufacturing for fuel cells & electrolyzers, R2R
- Advanced composites for tanks *(also with VTO)*

EERE BETO

- H_2 from bio-waste-streams
- Circular-Carbon/H2@Scale synergies in bio-fuels

EERE SETO

- H2@Scale/Solar-Fuels synergy
- BOP for STCH H_2 production
- CSP-based solar NG reforming

EERE WETO, WPTO, GTO

- R&D to integrate electrolysis with renewables
- H2@Scale leveraging of regional energy resources

DOE/EERE FCTO

Foundational Early-Stage R&D and H2@Scale

- Hydrogen Fuel: production & storage
- Fuel Cells: for transportation & power
- Infrastructure R&D:
  - Technology Acceleration
  - Safety, Codes & Standards
  - Systems Analysis
- Research Consortia: H2@Scale; H_2 materials compatibility; fuel cell catalysts & durability; advanced water splitting; H_2 storage materials & carriers

NSF

- Academia-based fundamental research relevant to hydrogen and fuel cell R&D *(including co-funding with FCTO consortia)*

NIST, DOT DOD, NASA, etc.

- Examples: standards in H_2 materials & services; next-generation military and space, buses, rail, marine, etc. applications

DOE/SC

- Fundamental processes of energy & matter relevant to H_2 manipulations
- Synergies with EFRCs/Hubs

DOE/FE

- New NG & coal technologies *(including H_2 + byproducts)*
- SOEC/SOFC synergies

DOE/NE

- Integrated and hybrid systems for nuclear H_2

DOE/OE

- H_2 for energy storage & grid ancillary services

DOE/ARPA-E

- Innovative and disruptive concepts related to hydrogen and fuel cells

DOE H_2 & Fuel Cell Working Group – Points of Contact

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