U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Hydrogen and Fuel Cell Technologies Office Update

Dr. Sunita Satyapal, Director, Fuel Cell Technologies Office

Hydrogen and Fuel Cell Technical Advisory Committee (HTAC) Meeting

March 9, 2020– Washington DC

Agenda

- **HTAC Scope**
  - Membership
  - Energy Policy Act (EPACT) 2005 Title VIII
- **Program Updates**
  - Budget, solicitations and recent highlights
  - Requests for input and discussion- Multiyear Plan, Center for Hydrogen Safety, National Lab Facilities
- **Additional Information**
  - Responses to HTAC recommendations, Congressional language, Organizational updates

2020 HTAC Membership

HTAC Member and Affiliation	Expertise
Aszklar, Henry Independent Energy Consultant	**Energy Project Development & Financing**
Freese, Charles F. (Chair) General Motors Company	**Automotive Companies**
Hebner, Robert University of Texas at Austin	**Advanced power and energy technology R&D, government-industry partnerships, and tech-to-market strategies**
Irvin, Nick Southern Company	**Utilities/Advanced Energy Systems R&D**
Koyama, Harol H2 PowerTech	**Stationary Power and Markets**
Leggett, Paul Mithril Capital Management, LLC	**Venture Capital / Investment**
Leo, Anthony FuelCell Energy	**Stationary Fuel Cell and Hydrogen Production Technology Manufacturing**
Markowitz, Morry Fuel Cell and Hydrogen Energy Association (FCHEA)	**Hydrogen and Fuel Cells Industry Association**

HTAC Member and Affiliation	Expertise
Marsh, Andrew Plug Power	**Stationary and Transportation Fuel Cell Technology Manufacturing**
Mount, Robert Power Innovations	**Power management technology and integration**
Nocera, Daniel Harvard University	**Hydrogen Production R&D**
Novachek, Frank Xcel Energy	**Utilities (Electricity and Natural Gas)**
Powell, Joseph (Vice Chair) Shell Global Solutions	**Fuels Production and R&D**
Rogers, Paul The Adjutant General of the Michigan National Guard and Director of Military and Veterans Affairs	**Military Hydrogen and Fuel Cell Applications / R&D**
Rumsey Jennifer California Energy Commission	**Medium- and heavy-duty engine design and manufacturing**
Scott, Janea California Energy Commission	**State Energy Policies and Regulations**
Thompson, Levi University of Delaware	**Catalytic and Absorbent Materials R&D**

Hydrogen and Fuel Cell Technical Advisory Committee (HTAC) Scope

To advise the Secretary of Energy on:

1. The implementation of programs and activities under Title VIII of EPACT

2. The safety, economical, and environmental consequences of fuel cells and technologies to produce, distribute, deliver, store or use hydrogen energy

3. The DOE Hydrogen & Fuel Cells Program Plan

Title VIII Sec. 802- Purposes

1. Enable and promote comprehensive **development**, **demonstration**, and **commercialization** of H_2 and fuel cells with industry
2. Make **critical public investments** in building strong links to private industry, universities and National Labs to expand innovation and industrial growth
3. Build a mature H_2 economy for **fuel diversity** in the U.S.
4. Decrease the **dependency on foreign oil & emissions** and enhance energy security
5. Create, strengthen, and protect a **sustainable national energy economy**

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

Examples of Applications

>500MW
Stationary Power

>30,000
Forklifts

>30
Fuel Cell Buses

>45
H_2 Retail Stations

>8,300
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

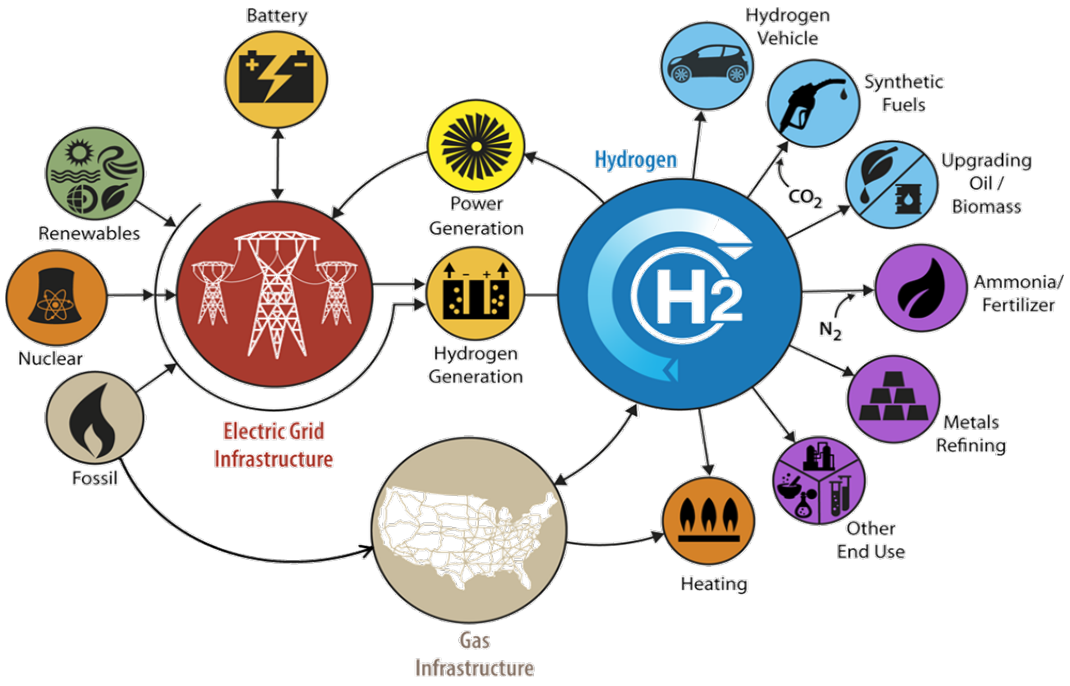
California
200 stations planned - CAFCP goal

Northeast
12 – 20 stations planned

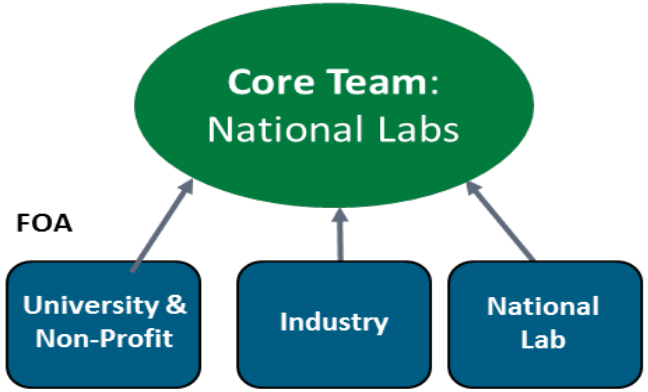
HI, OH, SC, NY, CT, MA, CO, UT, TX, MI, and others

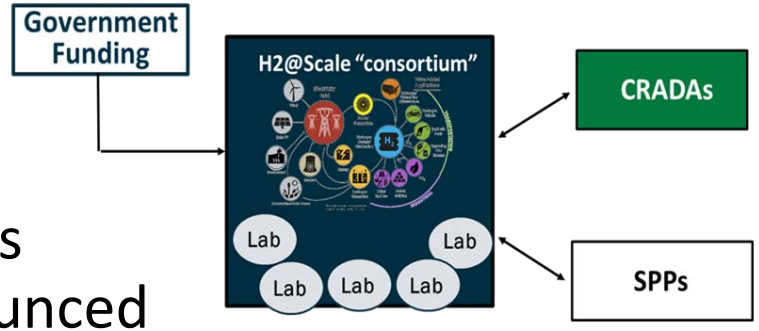
Key Programmatic Area: H2@Scale

H2@Scale: Enabling affordable, reliable, clean, and secure energy across sectors



Includes early stage R&D: Funding Opportunity Announcements (FOAs) for industry, universities and national labs, including consortia





And includes later stage RD&D:

- Leverages private sector for large-scale demos
- New H2@Scale demonstration projects announced
- Texas, Florida, Midwest, complements California deployments

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

Funding and Impact

Examples of Accomplishments

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

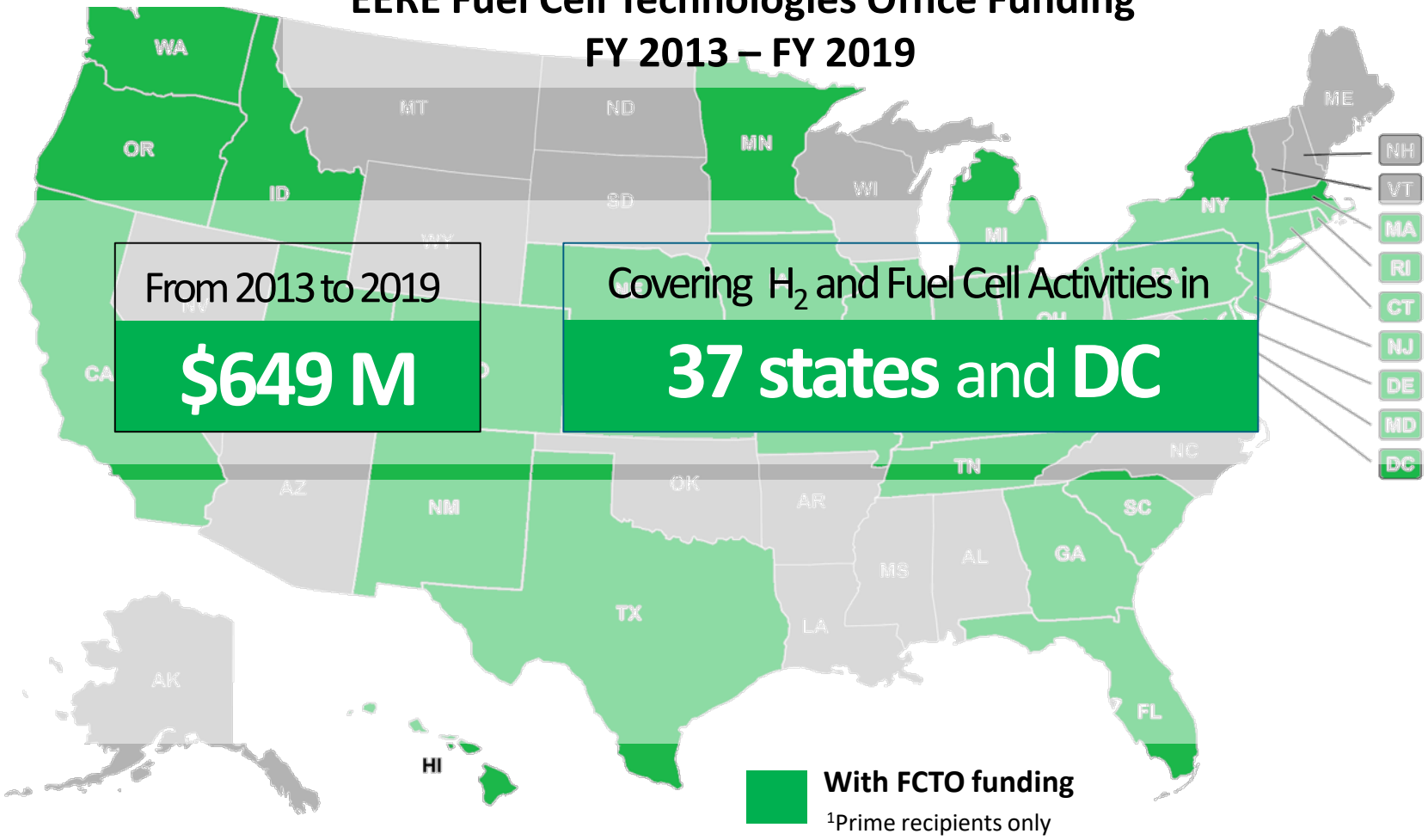
Market Impact

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

EERE Fuel Cell Technologies Office Funding[1]
FY 2013 – FY 2019



[1]Prime recipients only

DOE funded over 100 companies, 100 universities/nonprofits and 13 National Laboratories in the last decade

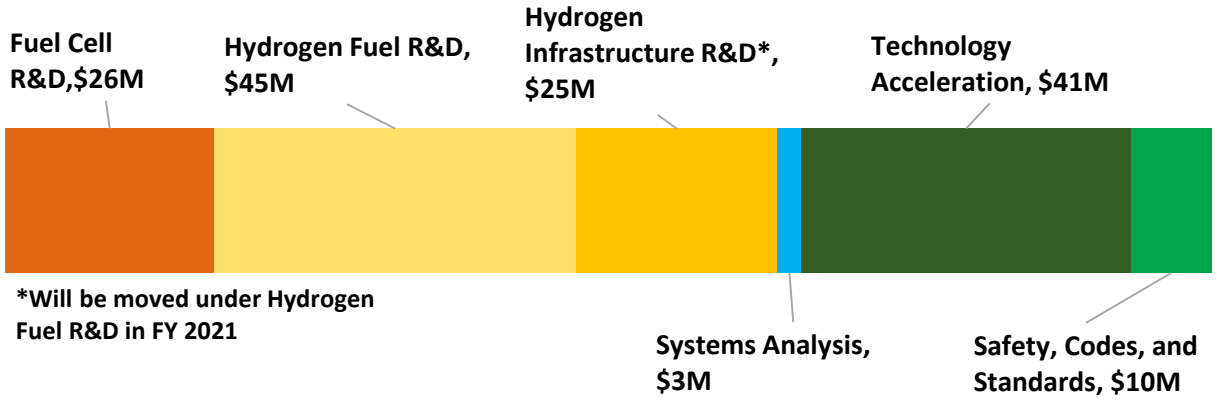
Budget

Fuel Cell Technologies Office (FCTO) within Energy Efficiency and Renewable Energy (EERE)

	FY 2018	FY 2019	FY 2020
Fuel Cell R&D	32,000	30,000	26,000
Hydrogen Fuel R&D	54,000	39,000	45,000
Hydrogen Infrastructure R&D*	-	21,000	25,000
Technology Acceleration	19,000	21,000	41,000
Safety, Codes, and Standards	7,000	7,000	10,000
Systems Analysis	3,000	2,000	3,000
Total	**$115,000**	**$120,000**	**$150,000**

*Will be moved under Hydrogen Fuel R&D in FY 2021

Fuel Cell Technologies Office Hydrogen and Fuel Cells Breakdown FY 2020



DOE Hydrogen and Fuel Cells FY 2020 Appropriations

DOE Office	Funding (in thousands)
EERE (FCTO)	$150,000
Fossil Energy (SOFC)	$30,000
Nuclear Energy (coordinated with FCTO)	$11,000

- Office of Science, Basic Energy Sciences Funding for projects relevant to H_2 and fuel cells (e.g. catalysis, etc.) was $20.5 M in FY 19, TBD in FY 20
- ARPA-E- Funding is based on specific program selected each year: TBD in FY 20

Up to $64M announced under H2@Scale New Markets Funding Opportunity

Topic Area	Total Funding Level	Anticipated # of Awards	Max. Federal Funding per Award	Max. Project Duration (yrs)	Min Required Non-Federal Cost Share %
Topic 1: Electrolyzer Manufacturing R&D	$15M	Up to 4	$5M	3	20%
Topic 2: Advanced Carbon Fiber for Compressed Gas Storage Tanks	$15M	Up to 3	$9M	5	20%
Topic 3A: Fuel Cell R&D for Heavy-Duty Applications - Membranes for Heavy-Duty Applications	$4M	Up to 4	$1M	3	20%
Topic 3B: Fuel Cell R&D for Heavy-Duty Applications - Domestically Manufactured Fuel Cells for Heavy-Duty Applications	$6M	2 to 3	$3M	3	20%
Topic 4: H2@Scale New Markets R&D-HySteel	$8M	1 to 2	$8M	3	20%
Topic 5A: H2@Scale New Markets Demonstrations -Maritime Demonstrations	$8M	1 to 2	$8M	3	50%
Topic 5B: H2@Scale New Markets Demonstrations - Data Center Demonstrations	$6M	1 to 2	$6M	3	50%
Topic 6: Training and Workforce Development for Emerging Hydrogen Technologies	Up to $2M	1	$2M	5	0%
Total:	Up to $64M	Up to 21			

FOA Application Requirements (DE-FOA-0002229 posted online)

- Interested applicants are encouraged to submit application materials through EERE Exchange at https://eere-Exchange.energy.gov, EERE's online application portal
- Applicants needed to submit a **Concept Paper by 5:00pm ET Feb 25, 2020** to be eligible to submit a Full Application

Criteria for Assessing Applications	
Criterion 1: Merit, Innovation, and Impact (50%)	• Merit and Innovation • Impact of Technology Advancement
Criterion 2: Project Research and Market Transformation Plan (30%)	• Research Approach, Workplan and SOPO (Statement of project objectives) • Identification of Risks • Baseline, Metrics, and Deliverables • Market Transformation Plan (NOT applicable to Topic Area 6) • Impact Assessment (applicable ONLY to Topic Area 6)
Criterion 3: Team and Resources (20%)	• Ability to address all aspects of project with high probability of success • Sufficiency of facilities to support the work • Ability to facilitate and expedite further development and commercial deployment of deliverables • Level of participation by project participants • Reasonableness of the budget and spend plan

Opportunity for Funding through Nuclear Energy FOA

Nuclear Energy (DE-FOA-0001817)

- To apply, go to: https://www.id.energy.gov/NEWS/FOA/FOAOpportunities/FOA.htm
- Frequently Asked Questions: www.id.doe.gov

***New cycle open – Application due June 30 2020**

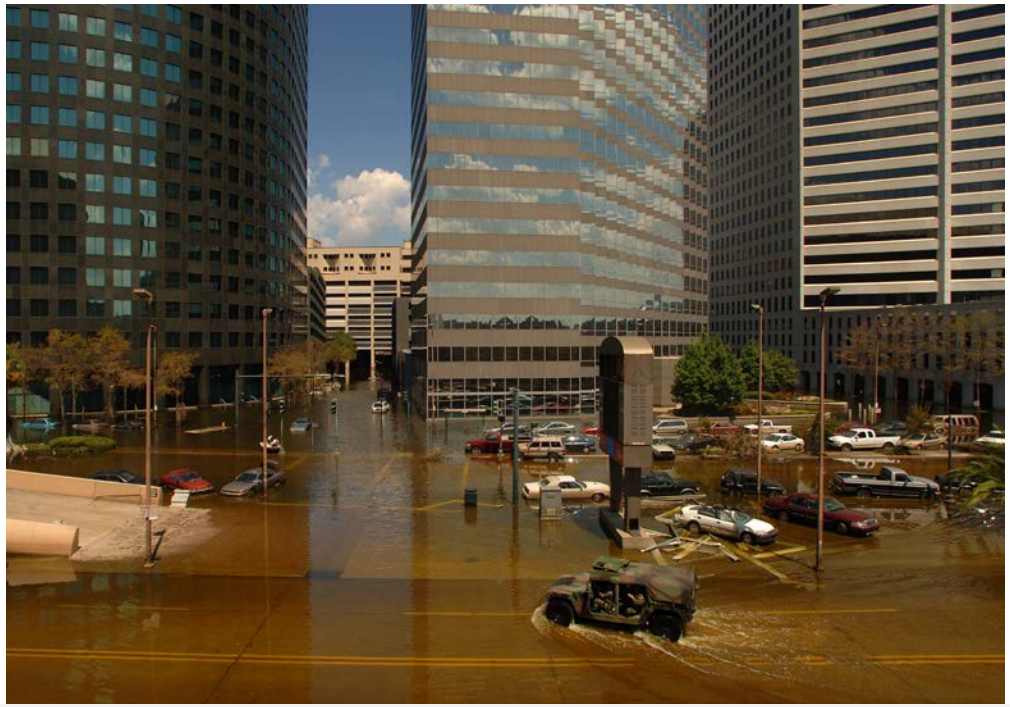
How Hydrogen and Nuclear Synergize

- Heat and electricity from reactors can produce hydrogen to be used as a fuel or industrial commodity, in energy storage, or for other industrial purposes
- Hydrogen can optimize nuclear production when generation exceeds load on the grid
- To learn more about synergies between hydrogen and nuclear, go to **https://www.energy.gov/ne/articles/could-hydrogen-help-save-nuclear**

Interagency Collaboration to Enable Technology in Emergency Relief

U.S. Department of Energy and U.S. Army Issue Solicitation to Develop H2Rescue

FEBRUARY 3, 2020



Press Release
https://www.energy.gov/eere/fuelcells/articles/us-department-energy-and-us-army-issue-solicitation-develop-h2rescue

Opportunity Number and Due Date to Apply to Solicitation
W81EWF20FOA0001 - March 31, 2020

- Example of **interagency collaboration** (DoD and DOE)
- **Up to $1M** (requires equal match of industry contributions)
- Truck to **run on fuel cell/battery and hydrogen** and provide **power, heat and potable water**

Announced February 2020: Industry and Government Collaboration Supporting American's Ingenuity and Enabling Technology Validation in Washington D.C.

The $1M H-Prize Challenge Incentivized Innovation in Community H_2 Fueling

The prize-winning SimpleFuel® team developed an electrolyzer-based appliance capable of refueling a 700 bar fuel cell vehicle at a rate of 1 kg-H_2 in less than 15 minutes

U.S. Department of Energy Joins Industry to Collaborate on Transportation Technology Validation and Assessment

FEBRUARY 10, 2020

Home » U.S. Department of Energy Joins Industry to Collaborate on Transportation Technology Validation and Assessment

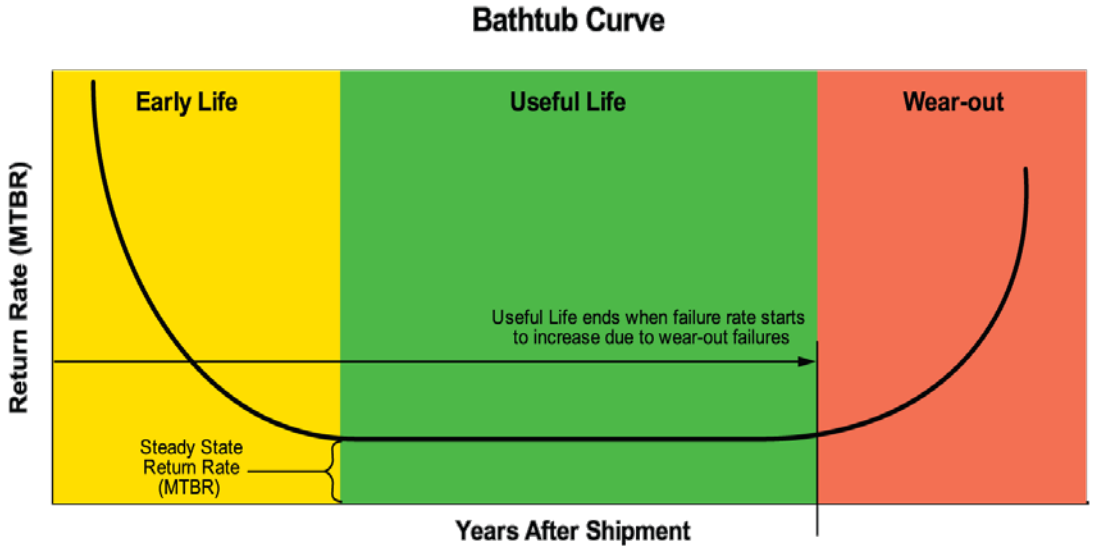
Hyundai Motor Group Executive Vice Chairman Euisun Chung (left) and Under Secretary of Energy Mark W. Menezes (right)

DOE, Hyundai and SimpleFuel collaboration will include:

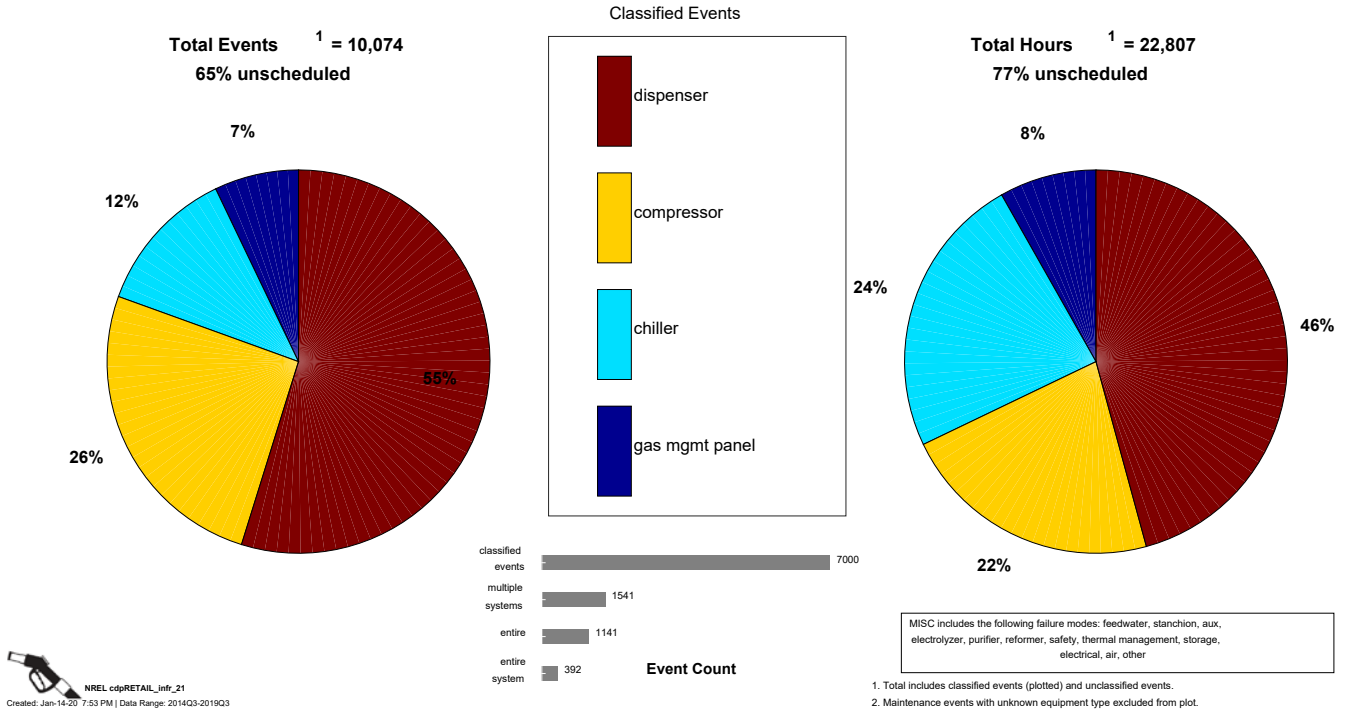
- Data collection and validation on **five Hyundai Nexo fuel cell cars**
- Installation of **SimpleFuel unit to support refueling and identify infrastructure R&D gaps**

Importance of Data Collection and Analysis to Guide

Classical Reliability Engineering Curve Over Life of Equipment



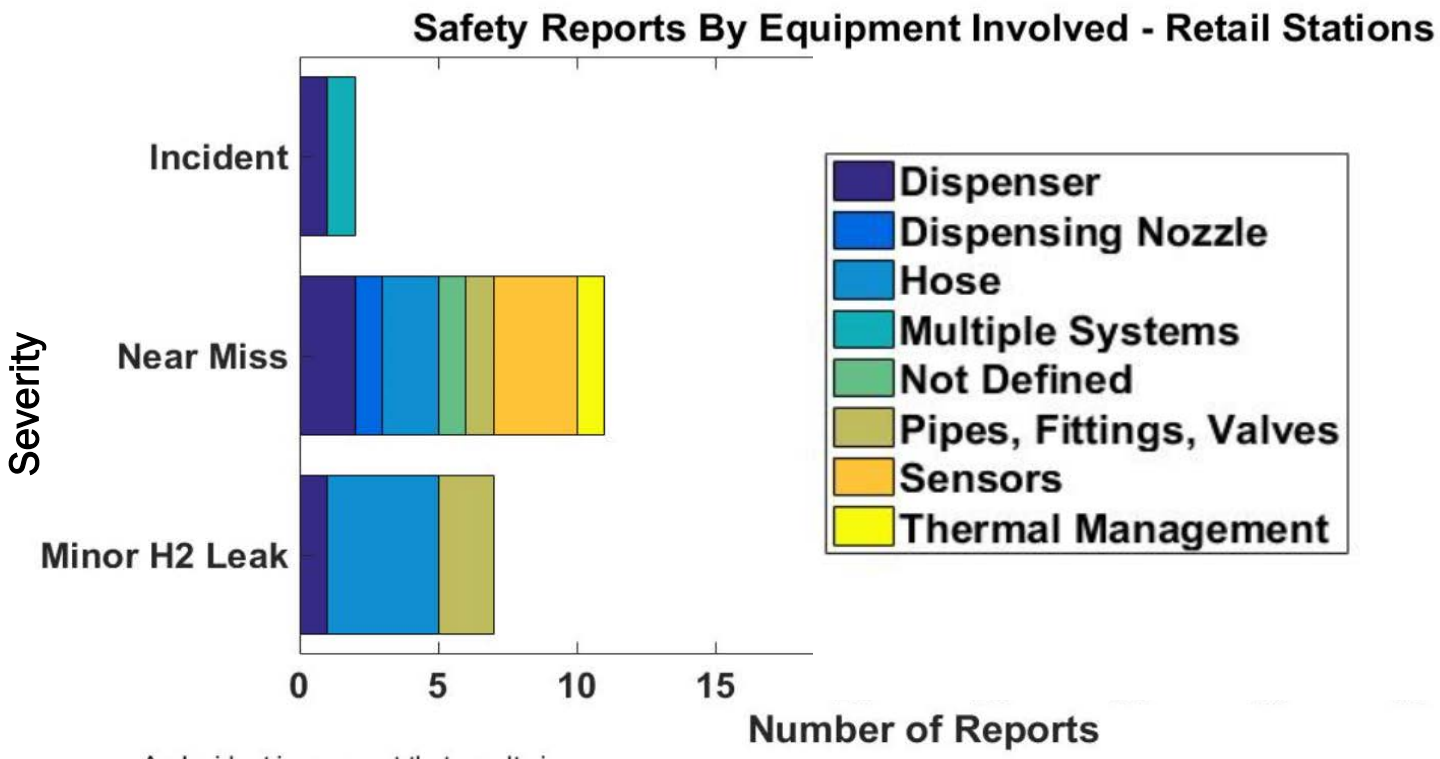
Maintenance by Known Equipment Type – Retail Station[2]



1. Total includes classified events (plotted) and unclassified events.
2. Maintenance events with unknown equipment type excluded from plot.

Example from hydrogen infrastructure data collection, demonstrating challenges with dispenser, compressor, chiller, and gas management

Safety Incident Reports by Type



An Incident is an event that results in:

- a lost time accident and/or injury to personnel
- damage/unplanned downtime for project equipment, facilities or property
- impact to the public or environment
- any hydrogen release that unintentionally ignites
- release of any volatile, hydrogen containing compound (including the hydrocarbons used as common fuels)

A Near Miss is:

- an event that under slightly different circumstances could have become an incident
- any hydrogen release sufficient to sustain a flame if ignited

A Minor H2 Leak is:

- an unplanned hydrogen release insufficient to sustain a flame, and does not accumulate in sufficient quantity to ignite

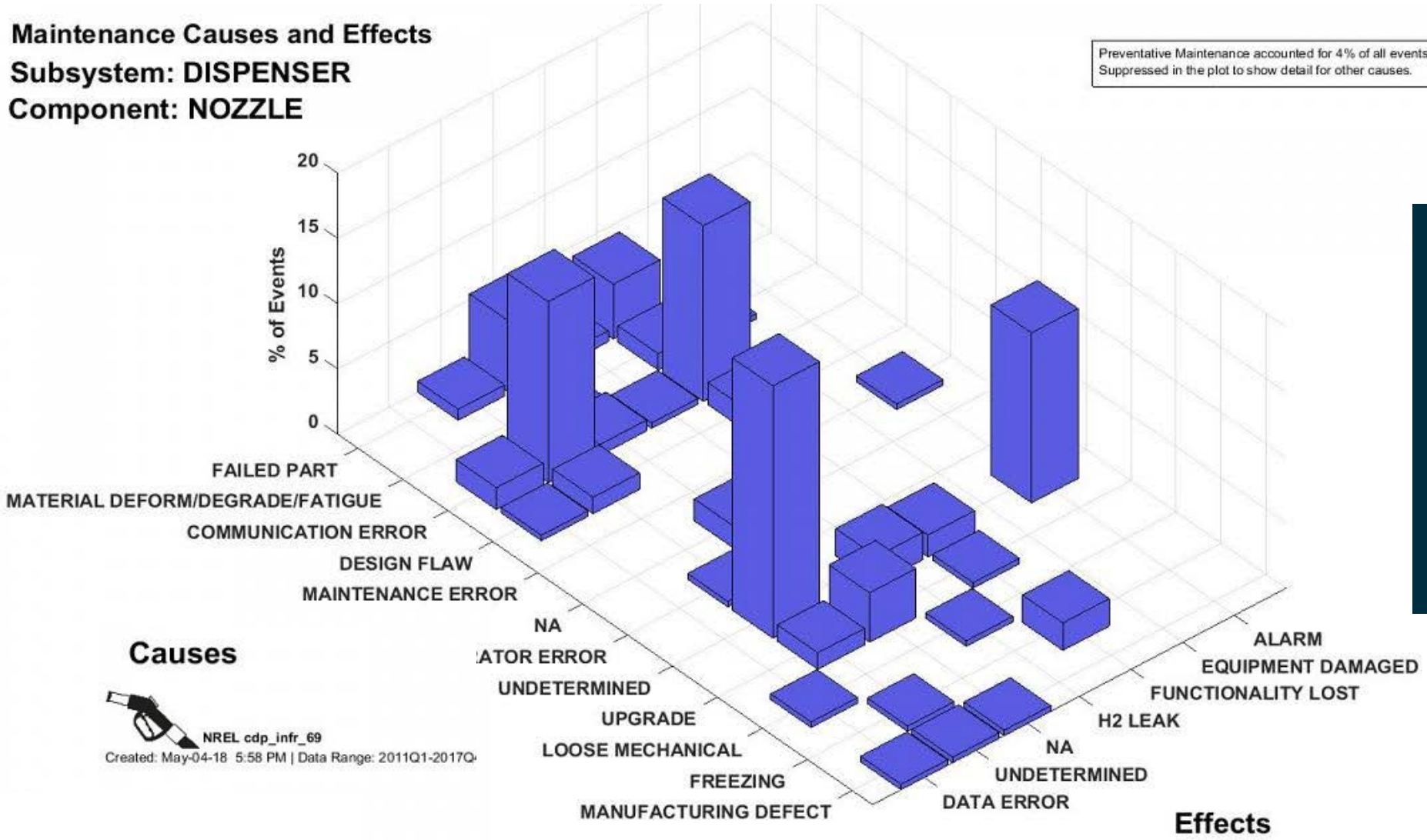
NREL cdpRETAIL_infr_32

Created: Mar-18-19 12:42 PM | Data Range: 2014Q3-2018Q4

Contact:

techval@nrel.gov
-or-
fuelcells@ee.doe.gov

Cause and Effect Analysis of Hydrogen Infrastructure Incidents



Significant number of 'undetermined'

More root cause analysis required

Example of Insight on Hydrogen Components Safety

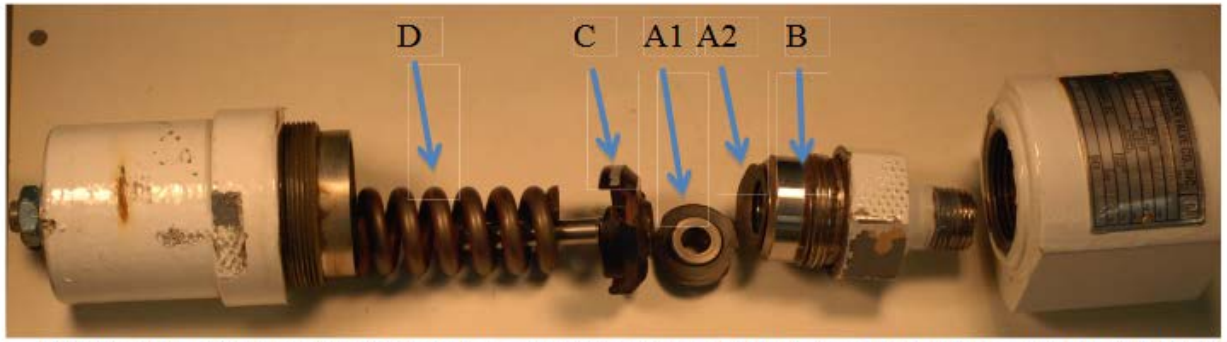


Figure A2. pressure relief valve components: failed nozzle subassembly (A1 and A2 inlet base (B); disk subassembly (C); set spring (D).

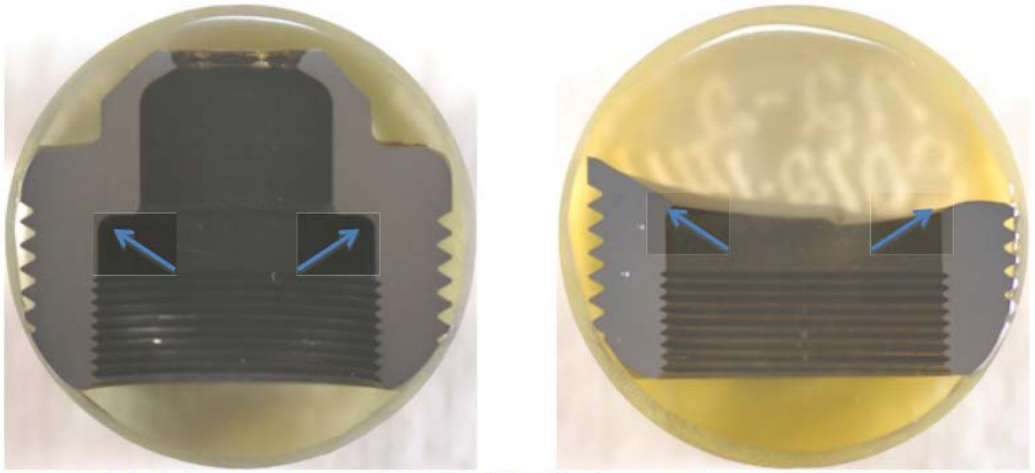


Figure A5. Polished cross sections of (a) functioning nozzle and (b) failed nozzle. The arrows indicate the internal corner associated with failure of the nozzle.

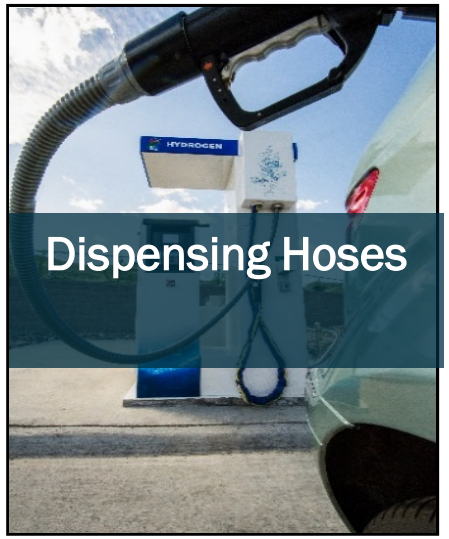
Pressure relief valve failure caused hydrogen release - led to safety concerns and evacuation

Type 440C Stainless Not Suitable For This Application

Cross-cutting Materials Compatibility R&D

H-Mat SM Hydrogen Materials Compatibility Consortium

H-Mat Consortium launched in FY18 to conduct early-stage R&D on hydrogen effects on polymers and metals.



Focus of current activities include:

1) **Reduce expansion of seals in hydrogen by 50%**
2) **Enhance life of vessels by 50% through improved understanding of crack nucleation.**
3) **Enhance fracture toughness of high-strength (>950 MPa) steels by 50%.**

Sandia National Laboratories | Pacific Northwest NATIONAL LABORATORY | OAK RIDGE National Laboratory | Savannah River National Laboratory® OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS | Argonne NATIONAL LABORATORY

For more information:
Website: energy.gov/eere/fuelcells/h-mat-hydrogen-materials-consortium
Email: h-matinfo@pnnl.gov

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

Includes over 40 partners from industry, government and academia

Access to >110 countries, 60,000 members

CENTER FOR Hydrogen SAFETY
Connecting a Global Community

HYDROGEN Safety Panel

HYDROGEN Emergency Response Training Resources

CENTER FOR 水素安全センター Hydrogen SAFETY
Connecting a Global Community

水素は、石油、風力、太陽光、その他のエネルギー資源から作られている。水素はエネルギーキャリアーとして注目されている。

年間7千万トン*

化学工業 石油精製 電子工業 医薬品業界

世界中では毎年7,000万トンの水素が産業用途として生産されている。

輸送分野の水素利用:

汚染物質、炭素排出量、騒音の削減手段として、トラックや船舶にゼロエミッションの燃料電池活用への関心が急速に高まっている。

60 輌 燃料電池電車

www.aiche.org/CHS

Fact Sheet Translated into Japanese

CENTER FOR 水素安全センター Hydrogen SAFETY
Connecting a Global Community

1 H 水素 1.008	2
3 Li リチウム 6.94	4 Be ベリリウム 9.0121831
11 Na ナトリウム 22.98976928	12 Mg マグネシウム 24.305

水素自動車とその水素ステーションは安全に使用できる:

水素は目新しいものではなく、50年以上にわたって産業界で広く使用されており、安全に使用できるように基準、標準、設計手法などが整備されてきた。

あらゆる燃料はエネルギーを持っており、どれも不適切に取り扱うと危険である。他の燃料と同様、水素もその特性に基づいて設計されたシステムで慎重に使用する必要がある。水素ステーションと燃料電池車(FCEV)は、安全確保のために確立された安全基準に基づいて設計されている。

燃料電池車は、従来の内燃式エンジンよりもクリーンで効率的である。タンクから供給された水素と空気中の酸素から電気を発生させ、排出されるのは水蒸気だけである。

水素は、石油、風力、太陽光、その他のエネルギー資源から作られている。水素はエネルギーキャリアーとして注目されている。

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化学工業 石油精製 電子工業 医薬品業界

世界中では毎年7,000万トンの水素が産業用途として生産されている。

1,991 億米ドル
2023年見込みの売上規模

58万台
2023年見込み台数

輸送分野の水素利用:

汚染物質、炭素排出量、騒音の削減手段として、トラックや船舶にゼロエミッションの燃料電池活用への関心が急速に高まっている。

60 輌 燃料電池電車

11,000 台
公道上の水素自動車台数
2018年実績

20,000 台
水素燃料のフォークリフト
2018年実績

Specific Areas of Input Requested

1) **Center for Hydrogen Safety**
   - Follow up planned through subcommittee
2) **Plans/Roadmaps**
   - Multiyear Program Plan under revision
3) **Feedback on National Lab facility plans**
4) **Collaboration & Leveraging Examples**
   - Opportunities for collaboration on H2@Scale, especially for new applications (e.g., HDV, marine, rail, aviation, data centers, etc.)
   - Global Action Agenda/Tokyo Statement and IPHE priorities
   - Prize concepts
   - Training and Workforce development

Multi-year Plan Will Include Applications Across Sectors

	Chemicals and Industrial Applications	Power Generation and Energy Storage	Transportation Fuel
Existing, growing demands	Oil Refining Ammonia Methanol	Back-Up Power and Distributed Generation (e.g. datacenters)	Material Handling/Forklifts Buses LDVs
Emerging future demands	Steel Industrial Heat (e.g. cement) Biofuels Upgrading Synthetic Fuels	Hydrogen Blending Flexible Power Generation Seasonal Energy Storage	M/HDVs Rail Maritime Aviation

Challenges and Opportunities for Hydrogen in Chemical and Industrial Processes - Draft

	Sector	Current Role of Hydrogen	Barriers	Opportunities/Benefits
Chemicals and Industrial Applications	**Oil Refining**	Used to remove impurities (e.g., sulfur) and upgrade heavy crude	Cost of diverse methods of hydrogen supply (e.g. beyond SMR)	Lowering point-source emissions
	Chemicals	Essential feedstock in ammonia and methanol production, used in other smaller-scale processes	Cost of diverse methods of hydrogen supply (e.g. beyond SMR)	Innovative, scalable production technologies
	Steel Production	Hydrogen-containing syngas used for iron refining	Cost of diverse methods of hydrogen supply (e.g. beyond SMR); Reliability and efficiency of existing processes that can use high concentrations of hydrogen	Innovative approaches to hydrogen use that enhance process efficiency; Domestic competitiveness Emissions reduction
	Industrial Heat	Limited to hydrogen-containing by-product gases used for process heat	Availability of cost-competitive hydrogen for heating; Availability of appliances that can operate on high concentrations of hydrogen	Reduce emissions from industrial processes; Use existing natural gas infrastructure for gigawatt-hours of energy storage
	Synthetic Fuels	Fossil-based methods are well established (e.g., methanol synthesis) Hydrogen primarily used in-situ in existing fossil-based processes Demonstrations of renewable synthetic fuel production	Availability of low-cost hydrogen supply and cost-competitive, efficient production methods	High energy density applications (e.g. aviation); Potential as drop-in fuels leveraging existing infrastructure Potential for emissions reductions

Challenges and Opportunities for Hydrogen in Power Generation and Energy Storage - Draft

	Sector	Current Role of Hydrogen	Barriers	Opportunities/Benefits
Power Generation and Energy Storage	Back Up and Off Grid Power	Hydrogen primarily used in-situ (e.g., natural gas reforming for fuel cell back up power)	Footprint of storage infrastructure Cost of hydrogen fuel	Emissions reductions; resiliency
	Hydrogen Blending	Up to 20% blending in ongoing tests and demonstrations in Europe	Availability of low-cost hydrogen supply; Higher percentage blends will require upgrades to infrastructure and end uses	Leverages existing natural gas infrastructure and/or turbines and appliances
	(Flexible) Power Generation	>200 MW of stationary fuel cell power shipped worldwide (though hydrogen typically produced in-situ) Prototype combustion turbines that operate on blends of hydrogen have been developed and tested	Availability of low-cost hydrogen supply; Commercial availability of components that can be used to enable high percentages of hydrogen in combustion turbines	Supports higher penetrations of intermittent renewable energy on the grid by providing demand response and other grid services Emissions reductions
	Seasonal Energy Storage	Bulk storage technologies have been demonstrated in petrochemical buffering applications	Low round-trip efficiency Limited market for long-duration energy storage	Supports higher penetrations of renewable energy on the grid

Challenges and Opportunities for Hydrogen as Transportation Fuel- Draft

	Sector	Current Role of Hydrogen	Barriers	Opportunities/Benefits
Transportation Fuels	Material Handling Equipment	>30,000 MHEs across the US	Investment in fueling infrastructure	Fast fill-time; Performance in warehouse environments (e.g., refrigerated conditions)
	Buses & M/HDV	> 30 buses across the U.S. > 16,000 trucks ordered	High TCO relative to incumbent (diesel), due to cost of hydrogen fuel, cost of fuel cell stack, and cost of hydrogen storage onboard vehicle	Fast fill-times and long range
	LDVs	Over 8,300 vehicles sold or leased; Over 40 retail stations in California	High TCO relative to incumbent, due to cost of hydrogen fuel, cost of fuel cell stack, and cost of hydrogen storage onboard vehicle	Range, energy density for advanced vehicles (e.g. ridesharing, autonomous capabilities)
	Rail	Prototype demonstrations in Germany	Low-cost incumbent technology; Capital intensive	Clustering of demand with regional opportunities
	Maritime	Ongoing demonstration projects for marine vessels and port-side equipment	Volumetric storage requirements on ocean-going vessels; high cost of hydrogen fuel compared to alternatives	Clustering of demand with regional opportunities; Regulatory requirement for desulfurization of marine fuels
	Aviation	Prototypes under R&D	Volumetric storage requirements on aircraft; high cost of hydrogen fuel compared to alternatives	Short flights, air taxis, drones

Hydrogen Supply Methods based on Facility-Level Hydrogen Demand- Draft

	Sector	Approximate Range of Hydrogen Consumption Per Day Per Site/Facility	Hydrogen Supply Methods Possible
Established	Methanol	500-1,000 tonnes/day	On-site production, pipeline
		100-500 tonnes/day	
Emerging			
	⋮		

[1] Slide 13 from: https://www.energy.gov/sites/prod/files/2019/10/f68/fcto-h2-at-ports-workshop-2019-viii3-steele.pdf
[2] https://www.nrel.gov/docs/fy20osti/75355.pdf
[3] Based on ANL analysis of Chicago area

Hydrogen Supply by Sector – For Discussion

Existing demands

- Power Generation
- MHE/Forklifts
- Small Hydrogen Refueling Stations (<1,000 kg/day)
- Electronics
- Heat treating (e.g., metals annealing)

- Manufacturing (e.g., float glass)

- Ammonia
- Methanol
- Oil Refining

Low	Medium	High
< 1 mtpd	10-35 mtpd	100-500+ mtpd
Tube trailers & small onsite	Liquid tankers* & on-site Hydrogen carriers†	Pipeline & large on-site

- Large Hydrogen Refueling Stations (L/M/HDVs)

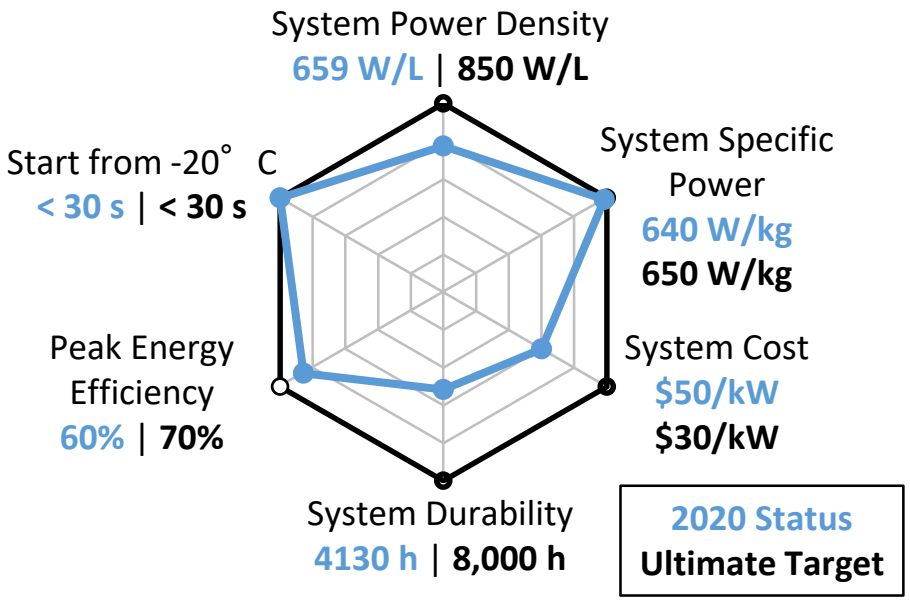
- Aviation
- Maritime
- Rail

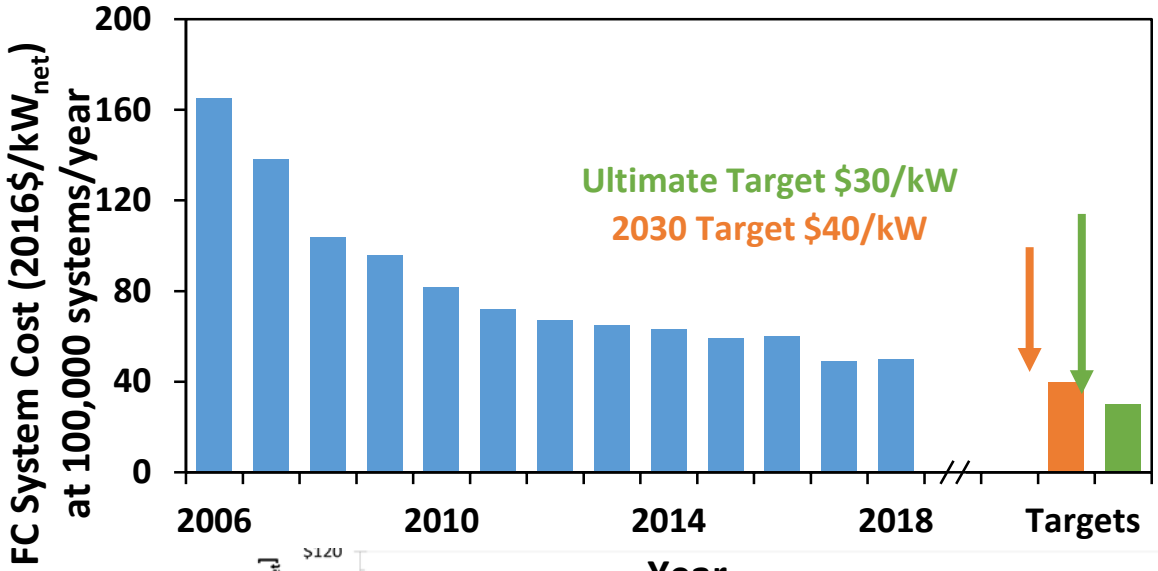
- Iron Refining
- Biofuels
- Synthetic Fuels
- Power Generation and Energy Storage

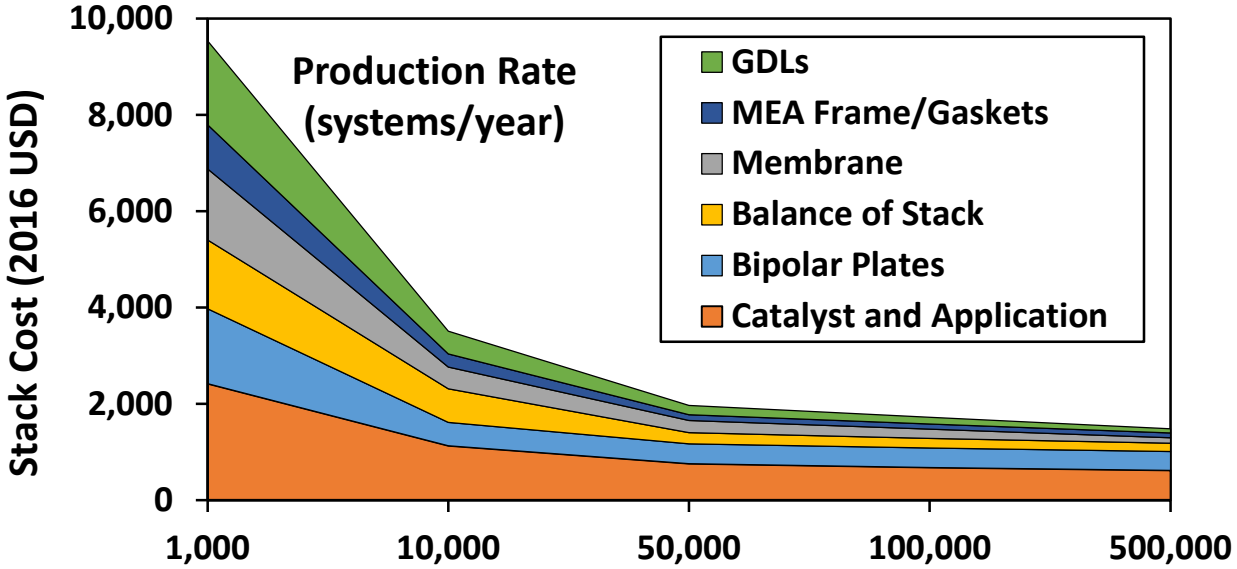
Potential future demands

*Liquid delivery also employed for smaller consumers requiring high purity hydrogen (e.g., transportation applications)
†The use of hydrogen carriers depends more on distance (e.g., for international trade) than facility-level demand

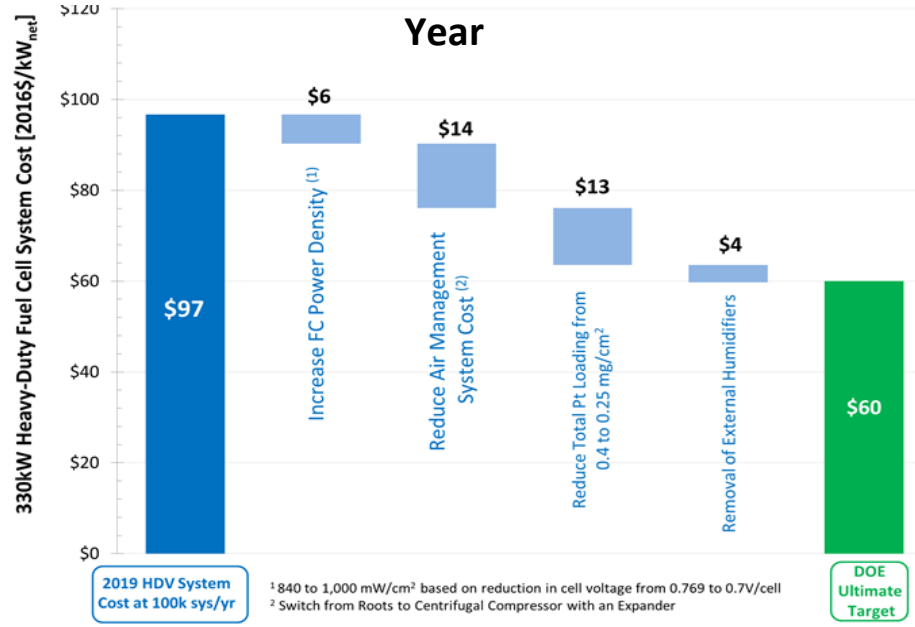
Example: Fuel Cell Status vs Targets for LDV Case- to be completed for HDV and other applications- DOE updates underway







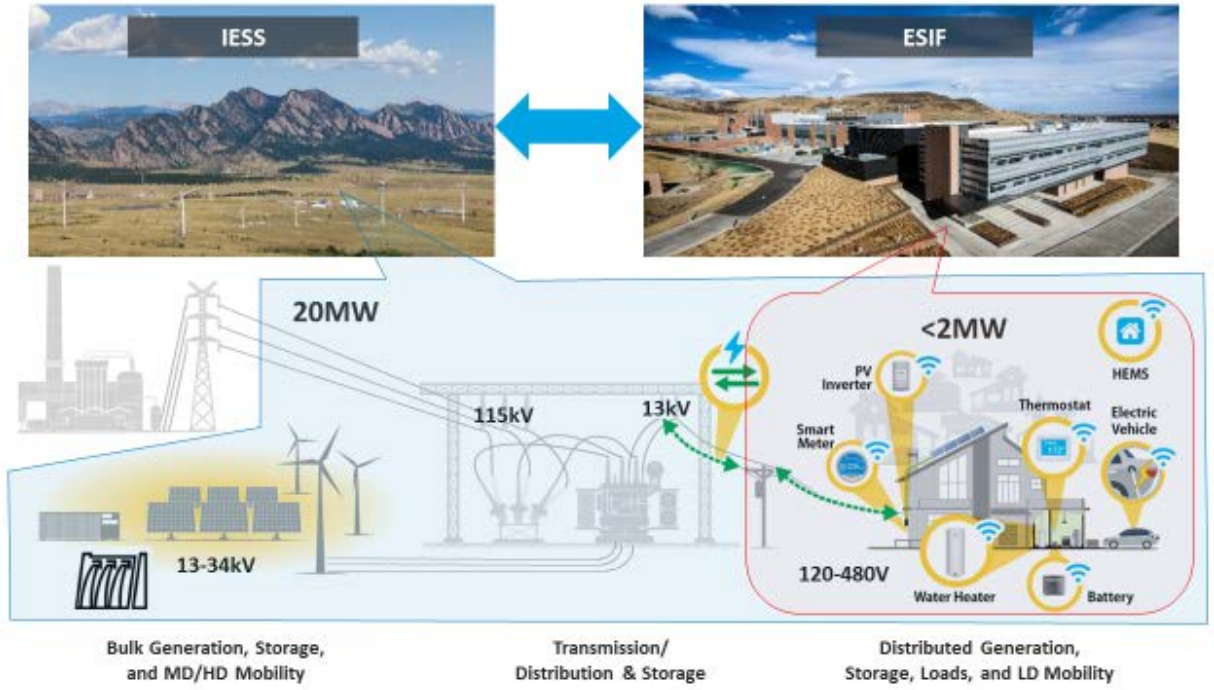
Preliminary Waterfall Chart- updates underway



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?

Student Internship Opportunities

Minority Educational Institution Student Partnership Program Internships (MEISPP)

- 8 – 10 week summer internships with DOE and national laboratories
- Helps students gain professional and technical career experience while working side-by-side with an assigned mentor
- Includes lodging, round trip airfare, and student stipends

EERE Student Volunteer Internship Program (SVIP)

- Internships throughout the year at its Washington, D.C. Headquarters (HQ) and the Golden Field Office (GFO) located in Golden, Colorado
- Academic credit and/or stipends for federal internships at some colleges and universities
- Does not include lodging, round trip airfare, and student stipends

For eligibility & instructions:

MEISPP

https://www.energy.gov/diversity/services/minority-education-and-community-development/minority-educational-institution-0

SVIP

https://www.energy.gov/eere/education/eere-student-volunteer-internship-program-svip

Potential Career Opportunities in Hydrogen and Fuel Cells

Opportunity Title	URL	Opportunity #	Org	Deadline
Development of Advanced Multi-Physics Modeling Techniques for Solid Oxide Fuel Cells-FRP	https://www.zintellect.com/Opportunity/Details/NETL-2019-FRP-Hackett-2	NETL-2019-FRP-Hackett-2	NETL	Mar 31 2020 11:59 PM EST
Fuel Cells Technologies Office (FCTO) opportunity in Hydrogen Storage	https://www.zintellect.com/Opportunity/Details/DOE-EERE-STP-FCT-2020-1801	DOE-EERE-STP-FCT-2020-1801	FCTO	Open till filled (target: mid 2020)
FCTO Hydrogen Infrastructure Technologies Opportunity	https://www.zintellect.com/Opportunity/Details/DOE-EERE-STP-FCT-2020-1802	DOE-EERE-STP-FCT-2020-1802	FCTO	Open till filled (target: mid 2020)
FCTO Opportunity in Fuel Cell Research and Development	https://www.zintellect.com/Opportunity/Details/EERE-STP-FCT-2019-1800	EERE-STP-FCT-2019-1800	FCTO	Open till filled (target: mid 2020)

Fellow roles in:

- Hydrogen storage (e.g. composite materials, carbon fiber)
- Hydrogen infrastructure R&D (e.g. materials compatibility)
- Hydrogen fuel R&D (e.g. hydrogen production)

Areas:

- Engineering
- Chemistry, Materials
- Project Management
- Safety, codes, standards

For More Info:

DOE Fuel Cell Technologies Office
fuelcells@ee.doe.gov

Oak Ridge Institute for Science and Education
https://orise.orau.gov/stem/internships-fellowships-research-opportunities/index.html

Stakeholder Engagement to Support Early Stage R&D

National Hydrogen & Fuel Cell Day
October 8 or 10/8

Safety Information and Training Resources

H2tools.org

INCREASE YOUR H2IQ

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

Workshops enabling H2@scale

- **AMR:** May 19-21, Crystal City, VA
- **H2@Airports:** April 7-8, 2020 in Arlington, VA

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
&
Additional Information

energy.gov/eere/fuelcells

HTAC Recommendations Being Addressed

Recommendations from 2019 HTAC Annual Report	Actions Taken (Examples)
Enhance funding of systems modeling studies for H2@Scale to identify best opportunities for integration of hydrogen into the U.S. energy infrastructure for energy transmission, storage, and dispatch	Enhanced H2@Scale modeling and analysis activities, with plans to publish at least three reports including H2 supply and demand across sectors and H2 resource availability analysis. CRADA projects underway.
Conduct system analysis of future storage and vehicle cost to understand what infrastructure investments are warranted	Working through the U.S. DRIVE partnership to address the impact of advanced onboard hydrogen storage technologies and costs on future hydrogen infrastructure implementation.
Continue to conduct R&D programs to reduce the cost of fuel cells, hydrogen storage, and delivery, and improve durability for commercial applications	FY 19 FOA selections provide more than $55 million to address H2@Scale. The FY 20 FOA announcement will provide up to $64 million for projects aimed at lowering electrolyzer costs, reducing cost of compressed hydrogen storage, lowering fuel cell manufacturing costs, and expanding hydrogen and fuel cell markets. FCTO continues to support national laboratory-industry R&D projects through R&D consortia (**HydroGEN, HyMARC, ElectroCAT, and H-Mat**) and CRADA calls.

HTAC Recommendations Being Addressed

Recommendations from 2019 HTAC Annual Report	Actions Taken (Examples)
Increase emphasis on development and demonstration of solutions for heavy duty transit, marine, and aviation applications that are not readily served by battery electric systems	FY 2019 and 2020 FOAs included topics specific to medium- and heavy-duty trucks and maritime and data center applications (more than $18 million awarded in FY 2019 to projects specifically targeting truck applications). Published R&D targets for Class 8 trucks in December 2019.
Continue support for standardization of codes and best practices for safety system design and approvals.	FCTO continues to support standardization of codes and standards as well as global harmonization, including stable funding of approximately $7 million per year to conduct R&D and provide national laboratory expertise to inform the development of consistent global standards and best practices. FY 2020 appropriations includes $10 million for safety, codes, and standards. International harmonization activities also underway through IPHE Working Group.

HTAC Impact – Examples

- **HTAC Annual Reports and Letters to DOE Secretary**
  - 2007 to Current
- **Subcommittee Outputs**
  - Competitiveness (2019)
  - Communication & Outreach (2018) – material online
  - Hydrogen Safety & Event Response (2017)
  - Manufacturing (2014)
- **Other Examples**
  - Input on Hydrogen Safety Panel and affiliation with AIChE
  - Input on H-Prize – ***1st commercial system exported to Japan, manufactured in the US***

FY 2020 Congressional Language

HOUSE	SENATE	CONFERENCE
Within available funds, the Committee recommends **$35,000,000** for Technology Acceleration activities, of which $5,000,000 is for industry-led manufacturing.	The Committee recommends **$35,000,000** for Technology Acceleration activities, including **$3,000,000** for manufacturing research and development, and **$7,000,000** for industry-led efforts to demonstrate a hydrogen-focused integrated renewable energy production, storage, transportation fuel distribution/retailing system, and fuel cell system deployment. Funding is included to support fuel cell and hydrogen technical and workforce development and training programs.	*[House and Senate language stands]* *Within Technology Acceleration funds, $5,000,000 is for industry-led manufacturing.* *[Senate language stands]*
The Committee recognizes the progress in breakthrough research and cost reduction for stationary, vehicle, motive, and portable power applications of fuel cell and hydrogen energy technology.		*[Senate language stands]*
The Committee recommends not less than **$7,000,000** for safety, codes, and standards.	The Committee further recommends **$10,000,000** for Safety, Codes, and Standards to maintain a robust program and engage State and local regulatory and code officials to support their technical needs relative to infrastructure and vehicle safety. The Department is encouraged to engage on codes and standards for developing fuel cell and hydrogen markets such as heavy-duty trucks. The Department is also encouraged to continue coordination between U.S. and international standard bodies to ensure there is one set of open [non-proprietary] global standards for fuel cell and hydrogen technologies.	The agreement provides **$10,000,000** for safety, codes, and standards. [Senate language stands, though 'encourage' is not considered directive language] [Senate language stands, though 'encourage' is not considered directive language]

FY 2020 Congressional Language

HOUSE	SENATE	CONFERENCE
	Within the amounts recommended, the Committee recommends **$49,000,000** for Hydrogen Fuel Research and Development for efforts to reduce the cost and improve the performance of hydrogen generation and storage systems, hydrogen measurement devices for fueling stations, hydrogen compressor components, and hydrogen station dispensing components.	The agreement provides **$45,000,000** for Hydrogen Fuel Research and Development.
Within available funds, $10,000,000 to cost share the Office of Nuclear Energy hydrogen demonstration project. Within available funds, $7,000,000 is to enable integrated energy systems using high and low temperature electrolyzers with the intent of advancing the H2@Scale concept.		Within available funds, the agreement provides $7,000,000 to enable integrated energy systems using high- and low-temperature electrolyzers with the intent of advancing the H2@Scale concept and $10,000,000 to cost share the Office of Nuclear Energy hydrogen demonstration project.
	The Department shall continue to research novel onboard hydrogen tank systems, as well as trailer delivery systems to reduce cost of delivered hydrogen. Further, the Department is directed to support research and development activities that reduce the use of platinum group metals, provide improvements in electrodes and membranes and balance-of-plant components and systems.	*[Senate language stands]*
The Committee remains supportive of H2@Scale activities that enable wide-scale hydrogen production and use in the United States to enable resiliency of power generation and transmission. The Committee encourages the Department to continue its work on high temperature electrolysis coupled with thermal systems.		*[House language stands, language is not considered directive language]*

FY 2020 Congressional Language

HOUSE	SENATE	CONFERENCE
[No direction.]	The Committee recommends **$3,000,000** for Systems Analysis, including research on in-situ metrology for process control systems for manufacturing of key hydrogen system components.	[*Senate language stands*.]
[No direction.]	Within the amounts recommended, **$26,000,000** is recommended for Hydrogen Infrastructure Research and Development with emphasis on large-scale hydrogen production, including liquefaction plants, hydrogen storage, and development of hydrogen, including pipelines.	The agreement provides **$25,000,000** for Hydrogen Infrastructure R&D.
	Further, the Department is directed to continue the H2@Scale Initiative, which couples current research efforts within the program with new opportunities for using hydrogen to provide grid resiliency and advance a wide range of industrial processes for the production of fuels, chemicals, and materials.	*[Senate language stands]*
	The Committee encourages the Secretary to work with the Secretary of Transportation and industry on coordinating efforts to deploy hydrogen fueling infrastructure.	*[Senate language stands, though 'encourage' is not considered directive language]*
The Committee directs the Vehicle, Bioenergy, and Hydrogen and Fuel Cell Technologies offices to continue to work closely to develop common metrics to evaluate and compare the costs and energy consumption of advanced transportation technologies with existing technologies.	*[No Direction.]*	*[House language stands.]*
[No Direction.]	The Committee encourages regular consultation with industry to avoid duplication of private-sector activities and ensure retention of fuel cell technology and systems development in the United States.	*[Senate language stands, though 'encourage' is not considered directive language]*

Hydrogen and Fuel Cell Technologies – FY 2021 Request

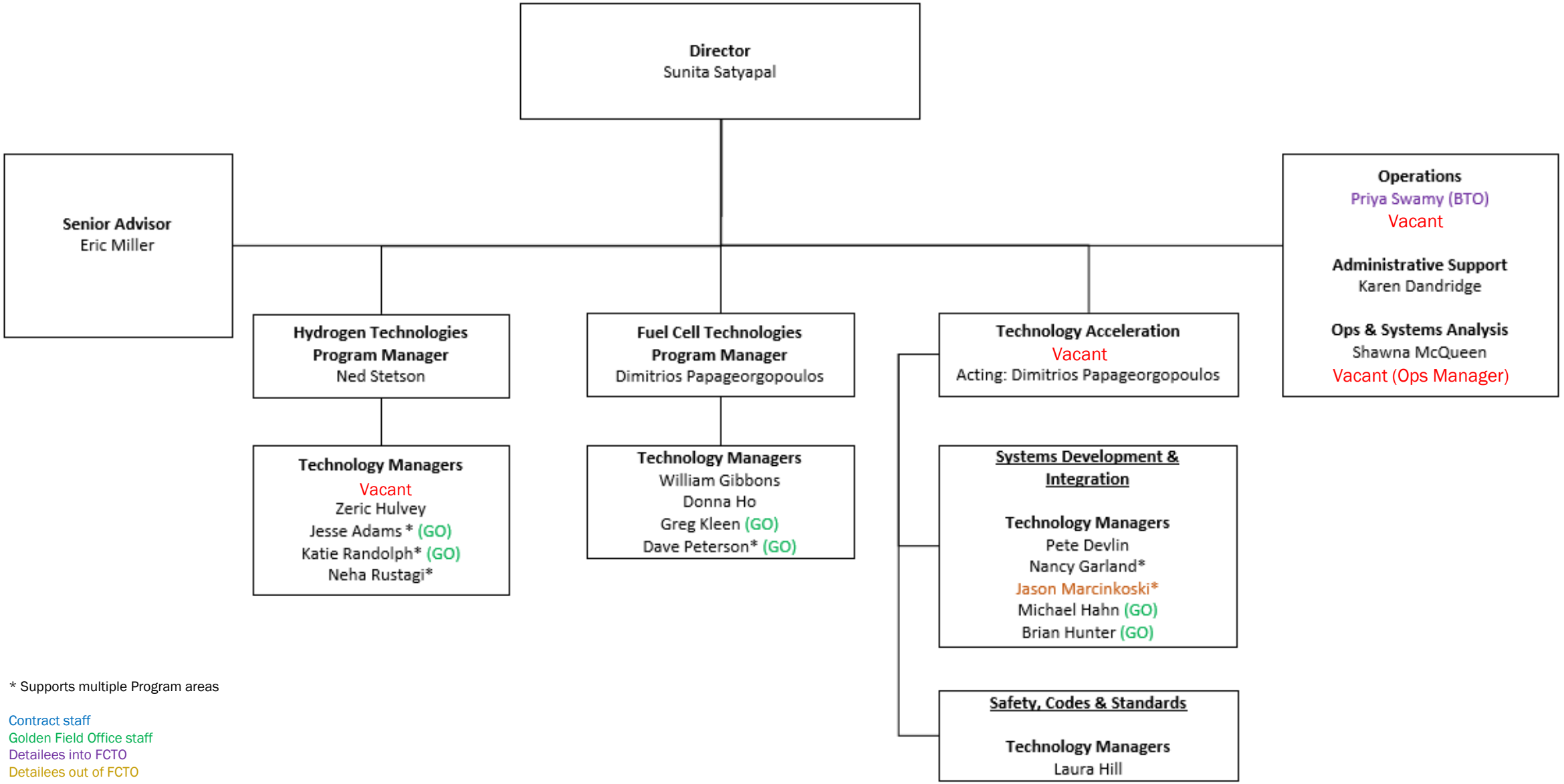
In FY 2021, the Hydrogen and Fuel Cell Program will support early stage R&D on novel hydrogen and fuel cell technologies to achieve application specific goals. For example: Medium and Heavy-Duty truck applications ultimate targets are:

- 30,000 hours fuel cell durability
- $60/kW for fuel cell cost
- $8/kW for onboard hydrogen storage costs

The program will continue to focus on the H2@Scale concept to enable affordable, reliable hydrogen generation, transport, storage and utilization across sectors with increased focus beyond light duty vehicles emphasizing diverse end uses including energy storage, transportation (trucks, marine, rail, aviation), chemicals (ammonia, synthetic fuels), backup power (emergency power, data centers), and industry (steel, iron making).

Subprogram	FY 2020 Enacted ($K)	FY 2021 Request ($K)	FY 2021 vs. FY 2020 ($K)
Fuel Cell Technologies (Formerly Fuel Cell R&D)	26,000	8,000	-18,000
Hydrogen Technologies (Formerly Hydrogen Fuel R&D in FY20)	45,000	23,000	-22,000
Hydrogen Infrastructure R&D (Included in Hydrogen Technologies in FY21)	25,000	0	-25,000
Systems Development and Integration (Formerly Technology Acceleration in FY20)	41,000	10,000	-31,000
Safety, Codes and Standards (Included in Systems Development and Integration in FY21)	10,000	0	-10,000
Data, Modeling and Analysis (Formerly Systems Analysis in FY20)	3,000	1,000	-2,000
Total	**150,000**	**42,000**	**-108,000**

Fuel Cell Technologies Office Org Chart



* Supports multiple Program areas

Contract staff
Golden Field Office staff
Detailees into FCTO
Detailees out of FCTO