Today’s Topic:
The Latest on EERE’s Hydrogen and Fuel Cells R&D Portfolio

This presentation is part of the monthly H2IQ hour to highlight research and development activities funded by U.S. Department of Energy’s Fuel Cell Technologies Office (FCTO) within the Office of Energy Efficiency and Renewable Energy (EERE)
The #H2IQ Hour

During Q&A session:

Please type your questions into the Q&A Box

Select a question and then type your answer here. There’s a 256-character limit.
Update on DOE’s Hydrogen and Fuel Cells R&D Portfolio

Dr. Sunita Satyapal, Director, U.S. Department of Energy Hydrogen and Fuel Cells Program, Fuel Cell Technologies Office

H2IQ Hour

February 18, 2020
Agenda

• **Budget Update and Key Priorities**
  – FY2020 Appropriations Plans

• **Recent Activities**
  – Workshops and Target Updates
  – H2@Scale New Demo Projects

• **Collaborations**
  – International Activities
  – Collaboration Announcements

• **Funding Opportunities**
  – Updates and Save the date for upcoming events
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")
**Budget**

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

<table>
<thead>
<tr>
<th></th>
<th>FY 2018</th>
<th>FY 2019</th>
<th>FY 2020</th>
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<tbody>
<tr>
<td>Fuel Cell R&amp;D</td>
<td>32,000</td>
<td>30,000</td>
<td>26,000</td>
</tr>
<tr>
<td>Hydrogen Fuel R&amp;D</td>
<td>54,000</td>
<td>39,000</td>
<td>45,000</td>
</tr>
<tr>
<td>Hydrogen Infrastructure R&amp;D*</td>
<td>-</td>
<td>21,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Technology Acceleration</td>
<td>19,000</td>
<td>21,000</td>
<td>41,000</td>
</tr>
<tr>
<td>Safety, Codes, and Standards</td>
<td>7,000</td>
<td>7,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Systems Analysis</td>
<td>3,000</td>
<td>2,000</td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$115,000</strong></td>
<td><strong>$120,000</strong></td>
<td><strong>$150,000</strong></td>
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</table>

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

**FCTO – Hydrogen and Fuel Cells Breakdown FY 2020**

- **Fuel Cell R&D**, $26M
- **Hydrogen Fuel R&D**, $45M
- **Hydrogen Infrastructure R&D***, $25M
- **Technology Acceleration**, $41M
- **Systems Analysis**, $3M
- **Safety, Codes, and Standards**, $10M

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

**DOE Hydrogen and Fuel Cells Appropriations**

<table>
<thead>
<tr>
<th>DOE Office</th>
<th>Funding (in thousands)</th>
</tr>
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<tbody>
<tr>
<td>EERE (FCTO)</td>
<td>$150,000</td>
</tr>
<tr>
<td>Fossil Energy (SOFC)</td>
<td>$30,000</td>
</tr>
<tr>
<td>Nuclear Energy</td>
<td>$11,000*</td>
</tr>
</tbody>
</table>

* For coordination between NE and EERE FCTO on nuclear to hydrogen
Office of Science, Basic Energy Sciences Funding is for FY18 ~ $19 million for projects relevant to H2 and fuel cells (e.g. catalysis, etc.); FY 20 TBD For coordinated project with EERE ARPA-E - Funding based on specific program selected each year; FY20 TBD
Interest growing in End use applications across sectors

Heavy duty vehicles, steel manufacturing, ammonia, energy storage, liquid fuels, critical loads, natural gas blending, exports, and more
## Opportunities Identified in H2@Ports, H2@Rail, H2@Datacenters Workshops

### H2@Datacenters
- Collaboration between DOE, industry, end users
- RD&D & techno-economic assessment needs
  - Prime or backup power for critical loads of data centers
  - Scenario development to enable cost effective fuel cells and hydrogen storage
  - Potential additional revenue streams

### H2@Ports
- Collaboration between DOE, DOT - Maritime Administration, FCH JU, European Commission, global industry, end users and ports, states
- RD&D & techno-economic assessment needs
  - Power system options and TCO
  - Cluster approach to increase scale
  - Regulations and standards

### H2@Rail
- Collaboration between DOE, DOT -Federal Railroad Administration, global industry, end users, states
- RD&D & techno-economic assessment needs
  - Prime power system development
  - Rail system operations and TCO
  - Regulations, safety, codes, standards

TCO: Total cost of ownership

Workshop details available at: https://www.energy.gov/eere/fuelcells/workshop-and-meeting-proceedings
Targets to Guide Long Term R&D for Heavy-Duty Vehicles

Fuel Cell Truck Targets Developed to Enable Comparable Total Cost of Ownership with Diesel Trucks

https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

Developed through industry workshop, input and analysis on long term stretch goals to guide R&D community

### Table 1. Technical System Targets: Class 8 Long-Haul Tractor-Trailers

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Units</th>
<th>Targets for Class 8 Tractor-Trailers</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Interim (2030)</td>
</tr>
<tr>
<td>Fuel Cell System Lifetime^1,^2</td>
<td>hours</td>
<td>25,000</td>
</tr>
<tr>
<td>Fuel Cell System Cost^1,^3,^4</td>
<td>$/kW</td>
<td>80</td>
</tr>
<tr>
<td>Fuel Cell Efficiency (peak)</td>
<td>%</td>
<td>68</td>
</tr>
<tr>
<td>Hydrogen Fill Rate</td>
<td>kg H₂/min</td>
<td>8</td>
</tr>
<tr>
<td>Storage System Cycle Life^5</td>
<td>cycles</td>
<td>5,000</td>
</tr>
<tr>
<td>Pressurized Storage System Cycle Life^6</td>
<td>cycles</td>
<td>11,000</td>
</tr>
<tr>
<td>Hydrogen Storage System Cost^4,^7,^8</td>
<td>$/kWh ($/kg H₂ stored)</td>
<td>9 (300)</td>
</tr>
</tbody>
</table>
Key Areas of Participant Interest

**Carbon Fiber Cost**
- Precursor cost is the largest component
- Strength remains an important quality
- Processing refinements could yield marginal gains

**Overall Cost of Storage/Station**
- Storage designs influence station hardware and operation:
  - Storage temperature limits while fueling
  - Chillers required to reach -40°C
  - Cold effects on reliability

**Balance of Composite**
- Alternative resin systems:
  - Cost reduction
  - Thermal resistance
  - Fiber/resin integration
  - Fiber winding pattern/translation efficiency

For workshop presentations and summary report visit
Examples of Activities to Enable H2@Scale

Assessing resource availability. Most regions have sufficient resources.

Hydrogen Availability

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

Hydrogen Demand Potential

Includes 1 project by Office of Nuclear Energy

4 new H2@scale demonstration projects in Texas, Florida and Midwest.
Example of H2@Scale Project: Integrated Hydrogen Production and Consumption for Improved Utility Operations – Orlando, FL

Partners
- Giner ELX Inc
- Orlando Utilities Commission
- General Motors
- OneH2
- UCF-FSEC

Duration
- 36 Months

Total budget
- ~$8.5M

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

Integration Concepts Being Considered

Solar Power
- PV Installation at Texas Advanced Computing Center
- UT-CEM Microgrid emulated solar power from Austin Energy

Wind Power
- UT-CEM Microgrid emulated wind power from West Texas

Data Center
- Combination of solar, wind, and hydrogen power generation with grid interconnect and battery energy storage
- Operated by Texas Advanced Computing Center

On-site Electrolysis
- Using renewable solar and wind power generation
- Sourced by GTI

On-site Fuel Cell Power
- Using combination of renewable H2 generation pathways
- Fuel cell provided by Hydrogenics

On-site SMR
- Using renewable natural gas
- Provided by GTI and One H2

On-site Fueling Station and FCEVs
- Using combination of renewable H2 generation pathways
- Fueling station provided by Air Liquide
- Light-duty fuel cell vehicles provided by Toyota
- Fuel cell aerial drones provided by Guinn Partners / DMI

Partners
- Frontier Energy
- University of Texas at Austin
- GTI
- Toyota
- Air Liquide
- Waste Management
- OneH2
- Hydrogenics

Duration
- 36 Months

Total budget
- $12.7M

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

IPHE is active on social media!
Find IPHE on Facebook, Twitter and LinkedIn
Follow IPHE @The_IPHE

www.iphe.net

Mission Innovation Hydrogen Challenge 2017
Clean Energy Ministerial New Hydrogen Initiative Launched 2019

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

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

www.iphe.net

Hydrogen Energy Ministerial (HEM)
International Energy Agency (IEA)

Formed 2003
19 Countries and EC

Elected Chair and Vice-Chair, 2018
Save the Date – March 18: Hydrogen as main topic in upcoming Nuclear Innovation Clean Energy Future (NICE) webinar

Opportunities for Hydrogen

In the lead up to the June 2020 Eleventh CEM meeting in Viña del Mar Chile, tune in to the webinar and hear how ministers and stakeholders plan to accelerate action to realize hydrogen’s potential. Hear from experts from the United States, Canada, Japan and the IEA about new technologies in this arena that advance a clean and integrated systems approach.

**When**
March 18, 2020, 8:00 am – 9:30 am EST

**Where To Register**
https://attendee.gotowebinar.com/register/8279771562413966605
Example of Collaboration: Global Center for H₂ Safety (CHS)

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

Includes over 40 partners from industry, government and academia

Access to >110 countries, 60,000 members

www.aiche.org/CHS
The $1M H-Prize Challenge Incentivized Innovation in Community H₂ 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-H₂ in less than 15 minutes.

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
Funding Opportunities
Nearly $300M in Funding Announced

- **Hydrogen and Fuel Cells - $64M (DE-FOA-0002229)**
  - Concept papers due Feb 25; full applications due April 20.
  - 6 Topics include: electrolyzer manufacturing; carbon fiber for compressed gas tanks; fuel cells and membranes for heavy duty applications; new markets for hydrogen (e.g. steel production); demonstrations for emerging applications (e.g. maritime, data centers), and workforce and training development.

- **Vehicles - $133M (DE-FOA-0002197)**
  - Concept papers due February 21; full applications due April 14.
  - 16 Topics include: advanced batteries and electrification in support of the recently-announced DOE Energy Storage Grand Challenge; advanced engine and fuel technologies, including technologies for off-road applications and alternative fueled engines; lightweight materials; new mobility technologies and alternative fuels technology demonstrations.

- **Bioenergy - $96M (DE-FOA-0002203)**
  - Concept papers due March 5; full applications due April 30
  - 7 Topics include: Scale up of Bench Applications to Biomass to Plastics Recycling to Restore Natural Resources to Scalable CO2 Electrolysis.
Up to $64M announced under H2@Scale New Markets Funding Opportunity (DE-FOA-0002229 posted online)

<table>
<thead>
<tr>
<th>Topic Area</th>
<th>Total Funding Level</th>
<th>Anticipated Number of Awards</th>
<th>Max. Federal Funding per Award</th>
<th>Max. Project Duration (years)</th>
<th>Min Required Non-Federal Cost Share %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topic 1: Electrolyzer Manufacturing R&amp;D</td>
<td>$15M</td>
<td>Up to 4</td>
<td>$5M</td>
<td>3</td>
<td>20%</td>
</tr>
<tr>
<td>Topic 2: Advanced Carbon Fiber for Compressed Gas Storage Tanks</td>
<td>$15M</td>
<td>Up to 3</td>
<td>$9M</td>
<td>5</td>
<td>20%</td>
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<tr>
<td>Topic 3A: Fuel Cell R&amp;D for Heavy-Duty Applications - Membranes for Heavy-Duty Applications</td>
<td>$4M</td>
<td>Up to 4</td>
<td>$1M</td>
<td>3</td>
<td>20%</td>
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<tr>
<td>Topic 3B: Fuel Cell R&amp;D for Heavy-Duty Applications - Domestically Manufactured Fuel Cells for Heavy-Duty Applications</td>
<td>$6M</td>
<td>2 to 3</td>
<td>$3M</td>
<td>3</td>
<td>20%</td>
</tr>
<tr>
<td>Topic 4: H2@Scale New Markets R&amp;D-HySteel</td>
<td>$8M</td>
<td>1 to 2</td>
<td>$8M</td>
<td>3</td>
<td>20%</td>
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<tr>
<td>Topic 5A: H2@Scale New Markets Demonstrations-Maritime Demonstrations</td>
<td>$8M</td>
<td>1 to 2</td>
<td>$8M</td>
<td>3</td>
<td>50%</td>
</tr>
<tr>
<td>Topic 5B: H2@Scale New Markets Demonstrations-Data Center Demonstrations</td>
<td>$6M</td>
<td>1 to 2</td>
<td>$6M</td>
<td>3</td>
<td>50%</td>
</tr>
<tr>
<td>Topic 6: Training and Workforce Development for Emerging Hydrogen Technologies</td>
<td>Up to $2M</td>
<td>1</td>
<td>$2M</td>
<td>5</td>
<td>0%</td>
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<tr>
<td><strong>Total:</strong></td>
<td><strong>Up to $64M</strong></td>
<td><strong>Up to 21</strong></td>
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FOA Application Requirements (DE-FOA-0002229 posted online)

- Applicants must submit a **Concept Paper by 5:00pm ET Feb 25, 2020** to be eligible to submit a Full Application
- To apply to this FOA, applicants must register with and submit application materials through EERE Exchange at [https://eere-Exchange.energy.gov](https://eere-Exchange.energy.gov), EERE’s online application portal

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

Expected Timeframe for Award Negotiations: July – September 2020
Opportunity for Funding through Nuclear Energy FOA

Nuclear Energy (DE-FOA-0001817)

• Concept papers due Feb 28
• To apply, go to: https://www.id.energy.gov/NEWS/FOA/FOAOpportunities/FOA.htm
• Frequently Asked Questions: www.id.doe.gov

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

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
DOE-wide STEM Initiative
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

**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

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<thead>
<tr>
<th>Opportunity Title</th>
<th>URL</th>
<th>Opportunity #</th>
<th>Org</th>
<th>Deadline</th>
</tr>
</thead>
</table>
Mark your calendars in advance: National Hydrogen & Fuel Cell Day
October 8 or 10/08
(Held on its very own atomic-weight-day)

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

Save the Date
May 19-21, 2020
DOE AMR
(Annual Merit Review)
Washington DC

www.hydrogen.energy.gov

Sign up to receive hydrogen and fuel cell updates
www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-newsletter

Learn more at: energy.gov/eere/fuelcells
Thank You

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Director, DOE Hydrogen and Fuel Cells Program
Sunita.Satyapal@ee.doe.gov

Looking for more info?
#H2IQ

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