Hydrogen and Fuel Cells Overview: Opportunities for Ports & Maritime Applications

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U.S. Department of Energy

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Authorizes U.S. DOE to lead a comprehensive program to enable commercialization of hydrogen and fuel cells with industry. Includes broad applications: Transportation, utility, industrial, portable, stationary, etc.

Program To-Date

- ~ $150M to $250M/year
- ~ 100 to 200+ Projects/year
- >100 Organizations

Includes RD&D on:
- \( \text{H}_2 \) production, delivery, storage, utilization (including fuel cells)
- Crosscutting: Analysis, systems development/integration, safety, codes and standards, education & outreach

Collaboration

- Federal and State Agencies
- Industry
- Regional partnerships, associations, trade organizations, codes and standards development organizations, etc.
- National labs, institutes, universities
- International
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*
- *$2.3 Billion fuel cell revenue*  

Source: DOE and E4Tech

* Revenue from publicly available
Commercial Hydrogen and Fuel Cell Technologies are now Available

Over 300,000 stationary fuel cells, 12,000 fuel cell cars, 300 stations worldwide. Heavy duty, rail, marine, aviation emerging.
Hydrogen is part of a Comprehensive Energy Strategy
Transportation Is Now #1 Emissions Contributor

- Transportation: 29%
- Electricity: 28%
- Industry: 22%
- Commercial & Residential: 12%
- Agriculture: 9%

SOURCE: United States Environment Protection Agency
Hydrogen Fuel Cell Technologies for Marine Applications

Hydrogen can be used as a zero-emission fuel for marine & port applications

IMO Marine Fuel Sulfur Limits

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<th>Percent by Weight</th>
<th>2005</th>
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Today’s maritime industry:
- Consists of about 2 million marine vessels worldwide
- Transports >90% of goods
- Consumes over 300 million tonnes of fuel consumed/year
- Produces 3% of global CO₂ emissions
- Constitutes the largest source of SOₓ emissions

Emission Control Areas


Hydrogen and ammonia are being pursued internationally as potential renewable, zero-emission marine fuels
Electricity Mix is Changing

Example: Installed Capacity in Texas

Source: ERCOT, DOE H2@Scale Workshop, TX
Example: Hydrogen can help address grid needs

Preliminary study shows electrolyzers can reduce amplitude of power fluctuations 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
Hydrogen can enable long term energy storage and grid services

One hydrogen cavern could provide ~ 100 GWh energy storage

Hydrogen can be used to monetize surplus electricity from the grid, or remote, off-grid energy feedstock (e.g. solar, wind) for days to months.
Co-location of production and use can address delivery cost roadblock.

Where hydrogen is available

Where potential hydrogen users are
H₂@Rail and H₂@Ports Initiatives

U.S. DOE in collaboration with:

- Dept. of Transportation (DOT)-Federal Railroad Administration
- DOT-Maritime Administration

Data Centers and Energy Storage Applications
H2@Ports
to
Scale up Hydrogen

In collaboration with U.S. MARAD, developed and tested hydrogen fuel cell power generator

Model analysis validated in field experiment testing: ~30% energy efficiency gain over diesel engine at part loads

Next Step
Maritime fuel cell generator will be field tested at Scripps Institution of Oceanography in San Diego for cold ironing application

“Clustering” FCEVs Can Drive H2 Demand in Port-Based Distribution Complexes

Representative Port-Based Industrial Complex with Hydrogen Cost < $6/kg
“Hub and Spoke” H2 Fueling Stations Connected by Pipelines
Fuel Consumption at Ports based on Application

Source: L. Steele (PNNL), C. Myers (ORNL)
Potential Hydrogen Demand at U.S. Ports

- Los Angeles: 438,800 Kg H2/Day
- Long Beach: 335,600 Kg H2/Day
- New York: 29,900 Kg H2/Day
- Houston: 61,500 Kg H2/Day
- SEATAC: 37,900 Kg H2/Day

Map showing hydrogen demand at various U.S. ports.
Collaboration & Resources
International Collaborations

The International Partnership for Hydrogen and Fuel Cells in the Economy
Enabling the global adoption of hydrogen and fuel cells in the economy

Mission Innovation Hydrogen Challenge 2017

Clean Energy Ministerial New Hydrogen Initiative Launched 2019

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

Top Priorities
- Share Information
- Inform Future Government R&D
- Foster Collaboration

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Hydrogen Energy Ministerial (HEM)

International Energy Agency (IEA)

Formed 2003
19 Countries and EC
New Global Safety Partnership: Center for H2 Safety launched 2019

IPHE Steering Committee emphasized need to increase visibility of CHS

Over 20 partners
Access to 110 countries and 60,000 members- modeled after industrial process safety center

See www.aiche.org/CHS to join
Summary and Next Steps

Maritime applications can enable large scale use of H₂. This aligns with H2@Scale and can enable energy security, economic value and environmental benefits.

Next Steps

• Conduct analysis on H₂ and fuel cells maritime applications.
  – TCO (underway), impact potential (petroleum, emissions reductions, etc.)
• Develop technical and cost targets.
• Identify barriers and opportunities for RD&D and addressing regulations, codes and standards
• Focus on global collaborations to accelerate progress.
Workshop’s Objectives

Identify R&D needs to accelerate technology development, address barriers to commercialization, identify opportunities for collaboration.

Goals:

• Assess the state of the art for maritime applications using hydrogen fuel cells
• Discuss operational requirements and lessons learned on early fuel cell maritime projects
• Understand current technology gaps and identify collaborative R&D opportunities
• Identify regulatory, and safety, codes and standards issues to develop path forward to address them
Opportunities for outreach and to increase awareness

Celebrate National Hydrogen & Fuel Cell Day
October 8 or 10/08
(Held on its very own atomic-weight day)

Information and Training Resources to Increase Awareness
H2tools.org

Save the Date: May 19-22, 2020
Annual Merit Review
Washington DC

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

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www.hydrogen.energy.gov