INTERNATIONAL PARTNERSHIP FOR
HYDROGEN AND FUEL CELLS IN THE ECONOMY

IPHE Country Update December 2020: United States

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1. New Initiatives, Programs, and Policies on Hydrogen and Fuel Cells

- The U.S. Department of Energy (DOE) released its Hydrogen Program Plan in November 2020. The Plan is a coordinated effort across multiple offices within the DOE and provides the framework for hydrogen research, development, and demonstration (RD&D) activities. The Hydrogen Program Plan focuses on advancing affordable production, transport, storage, and use of hydrogen across different sectors of the economy.
- Programs and activities in states and various regions continue. For example, in October 2020, the California Energy Commission (CEC) approved a $384 million plan for clean transportation focusing on the adoption of zero-emission cars and trucks to help California reach its emission reduction, energy, and public health goals. Included in the plan is $70 million for hydrogen refuelling infrastructure, as well as $129.8 million for medium- and heavy-duty zero-emission vehicles and infrastructure, and more. The funds will be available over the next three years.

2. Hydrogen and Fuel Cell R&D Update

- The DOE launched the Million Mile Fuel Cell Truck (M^2FCT) and the H2NEW consortia on Hydrogen and Fuel Cell Day 2020 (October 8). Each consortium will be led by a DOE National Laboratory and will identify ways to make hydrogen and fuel cell technologies more affordable and competitive. The M^2FCT consortium will focus on fuel cell durability, performance, and cost for the long-haul trucking market. The H2NEW consortium will focus on improving the durability, efficiency, and affordability of large scale electrolyzers.
- The DOE announced $34 million in R&D funding for solid oxide fuel cells, electrolyzers and reversible fuel cells to advance the commercial readiness of hydrogen production and power generation.
- The DOE released fuel cell performance, cost, and durability targets and status for automotive fuel cells, early market transportation and reversible fuel cells for electric energy storage applications. The fuel cell stack specific power target for light-duty vehicle applications has been updated to 2.7 kilowatts per kilogram of hydrogen. Commercially available automotive fuel cell systems were estimated to cost $165 per kilowatt at a manufacturing volume of 3,000 systems per year. The target for reversible high temperature fuel cell system capital cost is $1,300 per kilowatt at 65% system efficiency.
- The DOE released various Program Records including on the costs of electrolytic hydrogen production with existing technology, hydrogen production from high temperature electrolysis, and hydrogen delivery and dispensing. Using existing technology, the cost of hydrogen production via today's polymer electrolyte membrane (PEM) electrolyzers (at low manufacturing volumes) can

range from $5 to $6 per kilogram of hydrogen assuming electricity prices of $0.05/kWh to $0.07/kWh. Projected hydrogen delivery costs for stations with a capacity of 450 kilograms of hydrogen per day are $11.00 per kilogram for liquid tanker-based stations and $9.50 per kilogram for tube-trailer gaseous stations.

3. Demonstration, Deployments, and Workforce Developments Update

- The DOE's Hydrogen and Fuel Cell Technologies Office announced approximately $64million in funding for 18 projects that will support the DOE's H2@Scale vision. The selected projects will focus on the development of durable and cost-effective hydrogen systems, demonstrations of large-scale hydrogen utilization at ports and data centers, and the development of a robust workforce for the hydrogen and fuel cells technology economy.
- The U.S. will now have four nuclear to hydrogen related projects, including demonstrations in Ohio and Minnesota, for electrolytic hydrogen production at existing nuclear plants.

4. Events and Solicitations

- The DOE hosted the virtual H2@Airports workshop on November 4 - 6 in collaboration with the U.S. Federal Aviation Administration, the U.S. Air Force, and the U.S. Navy. Workshop participants identified potential aviation-related opportunities that support the U.S. DOE's H2@Scale vision.
- The DOE held various H2IQ hours, including one on Hydrogen and Fuel Cell Day which highlighted three H2@Scale demonstration projects.
- The DOE celebrated National Hydrogen and Fuel Cell Day with various communications activities including a H2@scale blog, a DOE mailing on how stakeholders could celebrate the day, and social media engagement including a Facebook Live session by DOE Assistant Secretary Daniel Simmons.
- The 2020 DOE Annual Merit Review and Peer Evaluation Meeting (AMR) was cancelled due to the COVID-19 pandemic. Principal investigator presentations are posted online in lieu of the event.
- The 2021 AMR will be held from June 8-10, 2021 in Arlington, Virginia.

5. Investments: Government and Collaborative Hydrogen and Fuel Cell Funding

- The DOE issued a request for proposals for collaborative projects addresses two priority areas: advancing hydrogen fueling technologies for medium- and heavy-duty fuel cell vehicles and addressing technical barriers to hydrogen blending in natural gas, through a project called HyBlend. Over 20 industrial partners will collaborate with national labs to address technical challenges in the above two topic areas.
- The DOE's Nuclear Energy and Hydrogen and Fuel Cell Technologies offices awarded ~$26 million total for two projects that will advance the operation of light-water nuclear reactors with integrated hydrogen production systems.
- The DOE's Office of Fossil Energy announced $80 million in funding for two projects that will support the development of energy plants with net zero carbon power generation and carbon free hydrogen co-production.
- In November 2020, DOE announced Fiscal Year 2020 small business award topics which include fuel cell membrane assemblies for heavy-duty applications, approaches to minimize boil off losses from liquid hydrogen storage, and efficient chillers for hydrogen pre-cooling at heavy duty hydrogen fueling stations.

6. Regulations, Codes & Standards, and Safety Update

- Version 3.0 of the Hydrogen Risk Assessment Models (HyRAM) software was released in October 2020. Significant changes to the toolkit include more accurate property calculations for a wider range of conditions (including cryogenic conditions), improvements to component leak frequency characterization, and the addition of default overpressure and impulse results.
- The Center for Hydrogen Safety held two virtual conferences in Fall 2020, one in September with a U.S. focus and another in October with a European focus. A third conference, with an Asia-Pacific focus, is planned for Spring 2021.

Additional Reports and Publications

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- DOE National Labs published three H2@Scale technical reports related to resource analysis as well as supply and demand potential for hydrogen. Analysis indicates that the demand potential for hydrogen in the U.S. may be 2 to 4 times higher than today's volumes of 10 million metric tons.

Summary Country Update December 2020: United States

Transportation	Target Number	Current Status	Partnerships, Strategic Approach	Support Mechanism
Fuel Cell Vehicles[1]	1,000,000 by 2030 in CA	~ 9000	Multiple state efforts and industry stakeholders	ZEV state mandate (currently implemented in CA, CT, MA, ME, MD, NJ, NY, OR, RI, and VT); state subsidies (rebates in CA, MA, CT etc.)
FC Bus	No target	>60	Federal Transit Authority (Department of Transportation); CARB; CEC, and multiple states	
Fuel Cell Trucks[2]	$80/kW by 2030 (Interim) $60/kW (Ultimate)	Prototypes by industry being developed and tested.	CTE, FedEx Express, UPS, CEC, SCAQMD, Nikola	ZEV state mandate (e.g., CA)
Forklifts	No target	>35,000	Early market applications strategy	
H_2 Refueling Stations	**Target Number**	**Current Status**	**Partnerships, Strategic Approach**	**Support Mechanism**
70 MPa On-Site Production	1,000 by 2030 in CA	>45 retail stations	State and private sector partnerships	• California - $2.5 billion to build ZEV charging/refueling stations

[1] Includes Fuel Cell Electric Vehicles with Range Extenders

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

70 MPa Delivered	12-20 in Northeast			including 200 hydrogen stations (includes O&M grants) ZEV mandate
35 MPa On-Site Production	No target	N/A	2 stations for bus refuelling (California)	Solicitations from state and local agencies (e.g., South Coast Air Quality Management District, Air Quality Standards Attainment U.S. DOE in California)
35 MPa Delivered	No target			
Stationary	**Target Number[3]**	**Current Status**	**Partnerships, Strategic Approach**	**Support Mechanism**
Small[4]	$1,000/kW for backup units running directly on hydrogen $1,500/kW for combined heat and power units running on natural gas	Installed stationary power (including large, medium and small units) is over 500 MW.	Industry-led	State/regional
Medium[5]	$1,000/kW for combined heat and power units		Industry-led	State/regional

[3] Targets can be units installed and/or total installed capacity in the size range indicated
[4] <5 kW (e.g., Residential Use)
[5] 5kW – 400 kW (e.g., Distributed Residential Use)

	running on natural gas			
Large[6]	No target	N/A	Industry-led	State/regional
District Grid[7]	No target	N/A	Industry-led	State/regional
Regional Grid[8]	No target	N/A	Industry-led	State/regional
Telecom backup	No target	N/A	Industry-led	State/regional
H_2 Production	**Target[9]**	**Current Status**	**Partnerships, Strategic Approach**	**Support Mechanism**
Fossil Fuels[10]	<$2/kg produced	Target already met and surpassed		
Water Electrolysis[11] (PEM, Alkaline, SOEC)	<$2/kg produced	14 MW PEM electrolyzer capacity installed/underway Projected, high-volume, untaxed cost ranges from	Continued government funding/cost share	State/regional (e.g., 33% renewables in CA)

[6] 0.3MW – 10 MW (e.g., Industrial Use)
[7] 1MW – 30 MW (e.g., Grid Stability, Ancillary Services)
[8] 30MW plus (e.g., Grid Storage and Systems Management)
[9] Target can be by quantity (Nm^3, kg, t) and by percentage of total production; also, reference to efficiency capabilities can be a target
[10] Hydrogen produced by reforming processes
[11] Please indicate if targets relate to a specific technology (PEM, Alkaline, SOEC)

		$2 to $7 per kg of H2		
By-product H_2	N/A	N/A		
Energy Storage from Renewables	**Target[12]**	**Current Status**	**Partnership, Strategic Approach**	**Support Mechanism**
Power to Power[13] Capacity	N/A	N/A		
Power to Gas[14] Capacity	N/A	Project in CA is injecting H2 into NG pipeline		California Low Carbon Fuel Standard creates credits for use of low-carbon fuels. Blends of H_2 and natural gas could receive credits under this regulation.

[12] Can be expressed in MW of Installed Capacity to use the electricity from renewable energy generation, and Annual MWh of stored energy capacity

[13] Operator has an obligation to return the electricity stored through the use of hydrogen back to electricity

[14] Operator has the opportunity to provide the stored energy in the form of hydrogen back to the energy system through multiple channels (e.g., merchant product, enriched natural gas, synthetic methane for transportation, heating, electricity)