

PROGRESS IN Hydrogen and Fuel Cells

The Hydrogen and Fuel Cell Technologies Office (HFTO) focuses on research & development (R&D) and demonstration activities to advance hydrogen and fuel cell technologies for transportation and diverse applications that contribute to U.S. energy independence, security and resiliency, and add to a strong domestic economy. HFTO's funding has enabled significant progress:

Reducing Cost and Improving Durability and Performance of Fuel Cells

Reduced high volume automotive fuel cell costs by 60% since 2006. Cost reductions reflect numerous R&D advances, including a 5x reduction in the platinum content of fuel cell catalysts and the development of durable membrane electrode assemblies. Modeled cost is \$50/kW when produced at 100,000 units per year.

Quadrupled fuel cell durability since 2006. Demonstrated more than 4,100 hour (120,000 miles) durability of fuel cell systems in vehicles operating under real-world conditions with only 10% degradation.

Advancing Technologies for Producing, Delivering, and Storing Hydrogen

Reduced the cost of dispensed hydrogen. Projected costs of hydrogen production, delivery and dispensing for 700 bar fueling (assuming high volume production and widespread deployment) have been reduced to ~\$5-7/gge, making it nearly cost competitive with gasoline.

Reduced the cost of producing hydrogen from renewables. R&D advancements have reduced the cost of electrolyzers by 80% since 2002.

Accelerated hydrogen production R&D. Achieved world records in direct photoelectrochemical hydrogen production and screened more than 1,000 materials for thermochemical hydrogen production.

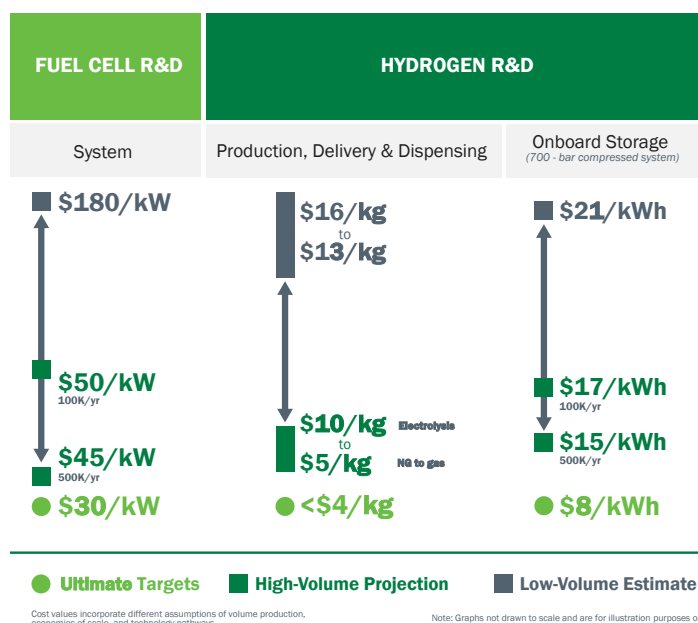
Launched H2FIRST and developed the world's first HyStEP Device. Through the Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST) project, a prototype Hydrogen Station Equipment Performance (HyStEP) testing



HFTO funding enabled the introduction of the world's first hydrogen fuel cell cars. There are more than 8,600 hydrogen fuel cell cars on U.S. road as of June 2020.



HFTO activities align with the H2@Scale initiative envisioning affordable hydrogen production, storage, distribution and utilization across multiple applications and sectors in the economy.



device was developed. The prototype is currently being demonstrated in California, enabling new stations to meet fueling protocol requirements.

Reduced the cost of advanced compressed onboard hydrogen storage systems by 30% since 2013. Advanced theory and modeling activities necessary to develop a material that bonds to hydrogen tightly enough to meet both the gravimetric and volumetric capacities at seven times lower pressure compared to today's technology (100 bar compared to 700 bar).

Lowered cost of stationary hydrogen storage. Advancements in R&D has reduced the cost of 875 bar stationary hydrogen storage by more than 30% since 2011, from \$1,450/kg to \$1,000/kg through wire wrapped pressure vessels.

Established hydrogen technology analysis tools. Developed models and tools now used worldwide for cost analysis of hydrogen production, delivery and infrastructure (H2A, HRSAM, HDSAM, H2FAST).



1,100

H₂ and Fuel Cell

PATENTS

ENABLED BY HFTO FUNDS

APPROX.

35%

OF THOSE PATENTS
ARE FROM
NATIONAL LABS

Formed Consortia

Formed consortia to leverage lab resources for key challenges and to accelerate progress. Activities are aligned with DOE's Energy Materials Network (EMN), and will support the Energy Department's materials research and advanced manufacturing priorities.



Fuel Cell Performance
& Durability



Advanced H₂ Storage
Materials



PGM-Free Catalysts
for Fuel Cells



Renewable H₂ Production



H₂ Materials Compatibility

SAFETY, CODES & STANDARDS

Developed training materials and trained more than 36,000 first-responders and code officials. Training completed through online and in-classroom courses.

Released first-of-its-kind hydrogen resource. Launched H2Tools, a free, online best practices and national hydrogen safety training resource for emergency responders.

TECHNOLOGY ACCELERATION

Advanced manufacturing quality control R&D. Developed quality control techniques to detect defects during manufacturing of fundamental fuel cell components.

Achieved more than 6.3 million driving miles. Independently validated more than 200 fuel cell vehicles on the road, including from Daimler, GM, Honda, Hyundai, and Toyota, with a solid track record of performance.

Validated the durability of fuel cell vehicles to be 4,100 hours. The vehicles are on track to meet the 5,000 hour target (equivalent to 150,000 miles of driving).

First commercial sale of hydrogen in the United States. Launched the first hydrogen station in the United States to receive the seal of approval for commercial sale of hydrogen fuel in California.

Demonstrated the World's first fuel cell airport GSE fleet. Demonstrated fleet of zero-emissions, hydrogen-powered airport ground support equipment (GSE) trucks at the Memphis airport.

Proven field operation for network resilience. Validated the operation of fuel cells for backup power during Hurricane Sandy and in power disruptions across states.

ENCOURAGING NICHE APPLICATIONS AND NEW MARKETS

Catalyzed fuel cell deployments.

Deployed 1,600 early market fuel cell forklifts and backup power units enabling more than 40,000 systems to be deployed or on order by industry without DOE funding.

Fostered an American-made hydrogen refueling system. Launched H-Prize and enabled SimpleFuel, a small-scale hydrogen refueling station using only water and electricity, now being exported.

U.S. DEPARTMENT OF
ENERGY

Office of
**ENERGY EFFICIENCY &
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For more information, visit:
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