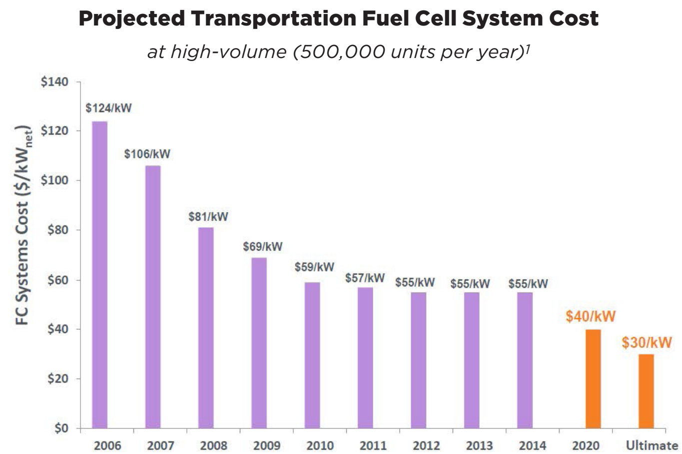
Progress and Accomplishments in Hydrogen and Fuel Cells

The U.S. Department of Energy's (DOE's) efforts have advanced the state of the art of hydrogen and fuel cell technologies—making significant progress toward overcoming key challenges to widespread commercialization. DOE has also made advances by demonstrating and validating the technologies under real-world conditions, supporting early markets through Recovery Act deployments, and leveraging domestic and international partnerships to advance the pace of commercialization.



Reducing the Cost and Improving the Durability and Performance of Fuel Cells

Reduced the cost of automotive fuel cells by more than 50% since 2006 and more than 30% since 2008 (based on projections to high-volume manufacturing).[1]

These cost reductions reflect numerous individual advances in key areas, including a fivefold reduction in the platinum content of fuel cell catalysts and the development of durable membrane electrode assemblies (MEAs) with low platinum group metal (PGM) content.[2] Today fuel cells can be manufactured at high volumes at $55/kW and at low volumes at $280/kW.[1]

Demonstrated more than 2,500 - hour (75,000 miles) durability of fuel cell systems in vehicles operating under real-world conditions, with less than 10% degradation. This is more than double the maximum durability of 950 hours demonstrated in 2006.[3]

Improved the performance of stationary fuel cells, including development of a solid-oxide fuel cell for micro-combined heat and power applications with an almost 25% increase in system power density, which has enabled a more than a 30% reduction in stack volume and 15% reduction in stack weight.[4]

Developed advanced manufacturing methods and materials that enabled a 50% decrease in the cost of gas diffusion layers since 2008.[5]

Improving Technologies for Producing, Delivering, and Storing Hydrogen

Reduced the cost of producing hydrogen from natural gas. Projected costs of hydrogen (assuming high-volume production and wide-spread deployment) have been reduced to ~$2.00 per gallon of gasoline equivalent (gge) produced (<$4.50/gge produced, delivered, and dispensed for 700 bar fueling), for a wide range of natural gas prices - a cost competitive with gasoline.[6]

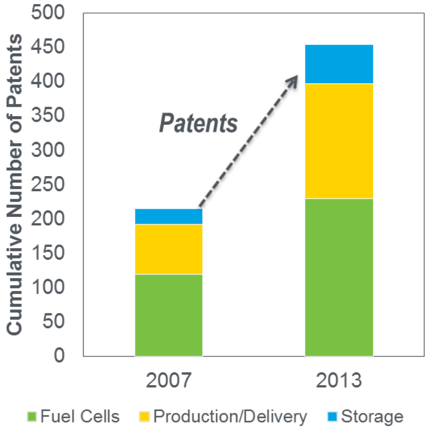
Reduced the cost of producing hydrogen from renewable resources. The modeled, high-volume cost of producing hydrogen from near-term renewable pathways has been reduced to approximately $5.50-$11.00/gge dispensed and untaxed for 350 bar fueling and $6.00-$11.50/gge dispensed and untaxed for 700 bar fueling, including projected economies of scale.[7] Key examples of advances include: reducing the cost of electrolyzer stacks by more than 80% since 2002.[8]

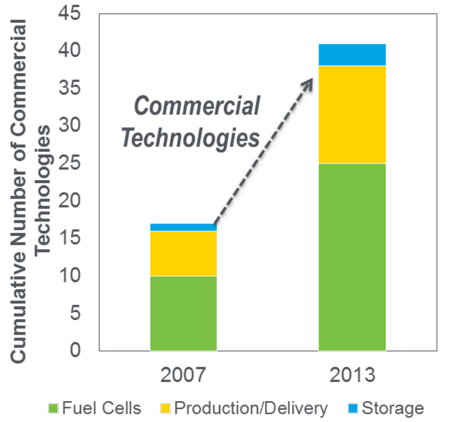
Reduced the cost of delivering hydrogen to the end-user. Since 2011, developed and demonstrated composite tube trailers that can carry 30% more hydrogen (~810kg) at a high volume cost of ~$3.00/kg.[9]

Development of advanced materials-based hydrogen storage technologies and cost reduction of advanced compressed hydrogen storage systems. The DOE has, through the three Hydrogen Storage Materials Centers of Excellence and independent projects, prepared and characterized hundreds of novel materials for use as hydrogen storage materials.[10] An online database, currently with nearly 3000 unique entries, has been established that incorporates the materials' key properties.[11]

Through the Hydrogen Storage Engineering Center of Excellence, complete system models have been developed, validated and are being made publically available, allowing projections of system level performance from material properties.[12] To reduce the cost of 700 bar Type IV hydrogen storage systems, the program has demonstrated that high-strength carbon fiber can be produced from a low-cost mass-produced textile-grade polyacrylicnitrile co-monomered with methyl acetate, with a projected 17% reduction in cost of high-strength carbon fiber.[13]

Accelerating Commercialization





DOE funding has led to 499 patents, 45 commercial technologies, and >65 emerging technologies.[16]

Safety, Codes & Standards

DOE has trained more than 30,000 first-responders and code officials through on-line and in-classroom courses. In addition, DOE has used science-based approaches to develop defensible codes and standards that includes a quantitative risk-informed approach that enabled an update to bulk gas storage separation distances within NFPA 2 and harmonization of the domestic and international fuel quality standards, ISO 14687-2 and SAE J2719 respectively.

Real-World Demonstrations and Technology Validation

Deployed more than 180 fuel cell electric vehicles and 25 hydrogen fueling stations in learning demonstrations. The vehicles have traveled more than 3.5 million miles in more than 500,000 trips, and the fueling stations have completed more than 33,000 refuelings. Key results include demonstrating fuel cell system efficiency of up to 59% (more than double the efficiency of gasoline internal combustion engines), fuel cell system durability of 2,500 hours (about 75,000 miles), and a driving range of more than 250 miles between refueling. DOE also validated one vehicle capable of achieving up to 430 miles on a single fill.[14]

DOE and its partners demonstrated the world's first "tri-generation" station (capable of co-producing hydrogen, heat, and power) at the Fountain Valley wastewater treatment facility in California. The station has co-produced electricity and hydrogen with 54% efficiency and provides up to 100 kg of hydrogen a day, enough to fuel 25 to 50 vehicles.

Encouraging a Growing Market

EERE's success in bringing new fuel cell technologies to market is converting American innovation into American jobs. Major companies—such as Walmart, Coca-Cola, FedEx, Sysco, Wegmans, and Whole Foods—are deploying fuel cell forklifts in their warehouses and distribution facilities. EERE's cost-shared funds toward the deployment of about 700 of these forklifts helped validate the market for this early application of motive fuel cells. In the wake of those initial purchases, private businesses have ordered more than 7,500 additional fuel cell forklifts with no DOE funding. In addition, 900 successful DOE-supported emergency backup power projects led to an additional 4,000 fuel cell systems with no DOE funding.[15] EERE's investment of $95M in specific hydrogen and fuel cell projects led to more than $410M in revenue and an investment of approximately $70M in specific projects led to nearly $390M in additional private investment. These rapidly growing markets have helped create and keep jobs in the United States.

For More Information

More information on the Fuel Cell Technologies Office is available at http://www.hydrogenandfuelcells.energy.gov.

References

For specific information and references, visit the Fuel Cell Technologies web site at http://www1.eere.energy.gov/hydrogenandfuelcells/accomplishments.html.

Governmental and Global Partnerships

In 2013, DOE and other stakeholders launched H2USA, a public private partnership focused on the widespread commercialization of fuel cell electric vehicles. Members include federal agencies, the fuel cell trade association, automakers, hydrogen providers, fuel cell developers, national laboratories, and additional stakeholders. DOE established the Hydrogen and Fuel Cell Interagency Task Force to coordinate research, development, and demonstration (RD&D) as well as federal adoption of hydrogen and fuel cell technologies. The Task Force includes representatives of ten federal agencies.

DOE also works with the **International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE)**—a partnership involving 17 countries and the European Commission—to foster international cooperation and RD&D, common codes and standards, and information sharing. In addition, the Department coordinates with more than 25 countries through the **International Energy Agency's (IEA's)** two implementing agreements on hydrogen and fuel cells.

U.S. DEPARTMENT OF ENERGY

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November 2014

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