

## Clean, Efficient, and Reliable Power for the 21st Century

Fuel cells offer a highly efficient and fuel-flexible technology that cleanly produces power and heat with low or zero emissions. Using renewably produced fuels such as hydrogen fuel cells can reduce our nation's dependence on imported oil, leading to a secure energy future for America. With a multitude of end-uses—such as distributed power for backup, primary, and combined heat-and-power systems; automobiles, buses, forklifts and other specialty vehicles; and auxiliary power units and portable electronics—fuel cell applications hold potential to dramatically impact the 21st century clean energy economy.

The need for clean, domestically produced energy has never been greater. The energy challenges facing the nation cannot be solved by any single approach; that's why the U.S. Department of Energy (DOE) is developing a portfolio of clean energy technologies to capture the sun, harness the wind, and utilize earth's natural geothermal energy. DOE also pursues clean energy solutions for transportation, like next-generation biofuels, advanced batteries for electric vehicles, and hydrogen and fuel cell technologies.

Fuel cells and hydrogen, in particular, can play a vital role in diversifying America's clean energy supply. Fuel cells can efficiently produce electricity from a number of domestic fuels, including bio-gas, natural gas, propane, methanol, diesel, and hydrogen. And because they can be built to a variety of scales, fuel cells can provide power for virtually any application. Compared with traditional energy inputs, fuel cells can provide improved performance and reliability in addition to reduced lifecycle costs.

Already successfully competitive in some areas, including markets for material handling equipment and backup power, fuel cells can be competitive in other markets, such as power for critical load facilities and combined-heat-and-power, where they provide unparalleled reliability and enhanced efficiency. Continuing technological progress will enable fuel cells to compete in new markets with more stringent cost, durability, and performance requirements. As the current markets for fuel cells grow and new, larger markets emerge, fuel cells will begin to significantly benefit the nation economically and environmentally.

Fuel cells powering light-duty vehicles provide the greatest petroleum reduction and environmental benefits. However, they also face challenges, including the need to reduce cost and increase durability; to develop lightweight, compact fuel storage systems; to invest significantly in a hydrogen fueling infrastructure; and to develop large-scale manufacturing capability.



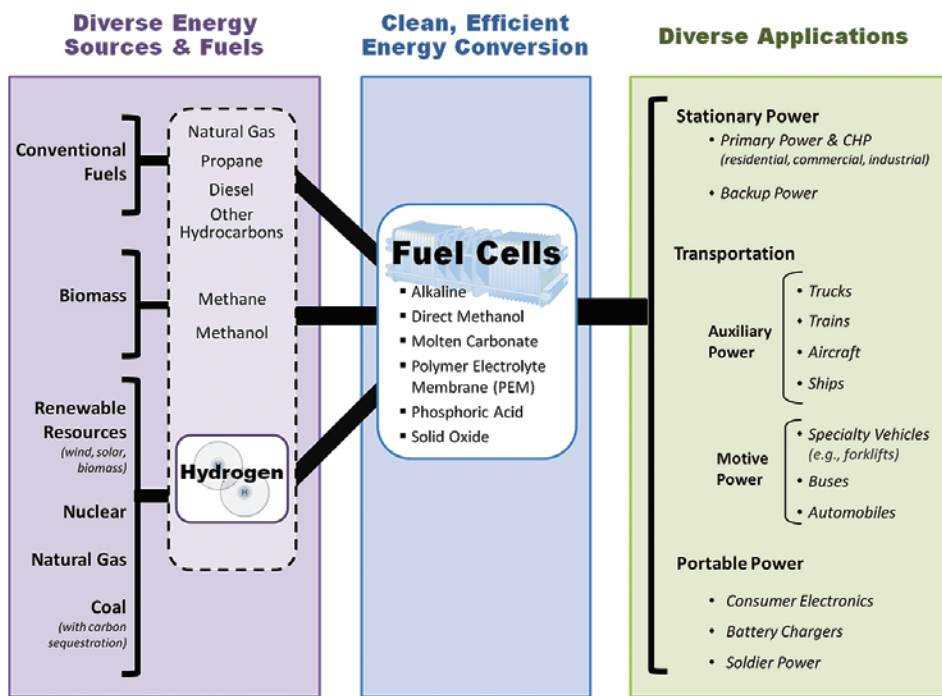
Recovery Act-funded fuel cells are providing clean, efficient, and reliable power for many applications, including auxiliary power, material handling equipment, backup power, and portable power.

*Photos, clockwise from top left: NREL/PIX 14836; Photo courtesy ReliOn NREL/PIX 16642; NREL/PIX 15987; NREL/PIX 16602; NREL/PIX 12508*

### Program Focus

The Fuel Cell Technologies Program maintains a balanced portfolio of activities to spur innovation, economic competitiveness, and job creation so the United States can lead the global clean energy economy. The program's technology portfolio addresses various near-, mid-, and longer-term applications for fuel cells. Fuel cell systems research and development (R&D) is working to reduce cost and improve durability for fuel cells used in transportation, stationary, and portable applications. Hydrogen fuel R&D continues to improve hydrogen-producing technologies from renewable resources, end use delivery, and lightweight, compact, low-cost storage systems. These ongoing efforts will have cross-cutting benefits for other clean energy applications.

Complementing the program's R&D efforts, technology validation work demonstrates technologies under real-world operating conditions and provides key feedback data as the technologies progress. In parallel to its research, development, and deployment activities, the program facilitates fuel



## Energy Storage for Renewable Electricity



Hydrogen and fuel cells can be used in all sectors of the economy, providing a highly efficient means for producing electricity from a number of energy sources (including natural gas and abundant, renewable domestic resources). Hydrogen can also be used for energy storage and delivery, offering potential benefits for intermittent renewable power generation. *Illustration by Fuel Cell Technologies Program, EERE*

cell commercialization through safety, codes, and standards activities, and manufacturing R&D. Systems analysis guides R&D priorities and program goals by identifying research gaps for various applications and quantifying the potential benefits of hydrogen and fuel cells—including reductions in greenhouse gas emissions, criteria pollutants, and petroleum use, as well as economic and employment impacts.

## Program Progress

A sustained R&D effort has helped hydrogen and fuel cells evolve into commercially viable technologies in growing markets. Program-funded efforts have resulted in more than 200 patents and 30 commercial technologies in the market. DOE-supported activities have:

- Reduced the high-volume cost of fuel cells by 30% since 2008 and 80% since 2002 (from \$275/kilowatt in 2002 to \$51/kilowatt in 2010, based on

projections of high-volume manufacturing cost).

- Doubled the durability of fuel cell systems in vehicles operating under real-world conditions. Data in 2006 showed 950-hour durability; today, this number is 2,500 hours, equivalent to approximately 75,000 miles of driving.
- Reduced the cost of producing hydrogen from renewable resources and natural gas.

Hydrogen can now be produced by distributed reforming of natural gas at a projected high-volume cost of \$3.00/gallon gasoline equivalent—which would be cost-competitive with gasoline.<sup>1</sup>

In 2009, the program awarded approximately \$42 million in Recovery Act funding to accelerate the commercialization and deployment of fuel cells. With approximately \$54 million in cost-share funding from industry participants—for a total of nearly \$96 million—the new funding is supporting the deployment of nearly 1,000 fuel cell systems in emergency backup power, material handling, and combined-heat-and-power applications. The project has, to date, created more than 48 jobs and deployed more than 480 fuel cells for use in forklifts or backup power for cell towers at several companies, including Sprint, AT&T, FedEx, Kimberly Clark, and Whole Foods.

## Learn More



[hydrogenandfuelcells.energy.gov](http://hydrogenandfuelcells.energy.gov)

<sup>1</sup> DOE Fuel Cell Technologies Program Accomplishments and Progress, [eere.energy.gov/hydrogenandfuelcells/accomplishments.html](http://eere.energy.gov/hydrogenandfuelcells/accomplishments.html)

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