

## Careers in Fuel Cell Technologies

*Existing and emerging fuel cell applications hold large job growth potential.*

Fuel cells are among the promising technologies that are expected to transform our energy sector. They represent highly efficient and fuel-flexible technologies that offer diverse benefits. For example, fuel cells can be used in a wide range of applications—from portable electronics, to combined heat and power (CHP) units used for distributed electricity generation, to passenger vehicles.

### Today's Technology and Its Growth Potential

Today's fuel cell technology offers cost-competitive solutions for material handling equipment (such as forklifts) and emergency backup power units. A limited slate of commercial products are also being offered for stationary power generation, and several automakers have fuel cell electric vehicles (FCEVs) on the road while others are coming quickly.

Some of the largest potential future markets for fuel cell technology include light duty vehicles, stationary power generation, portable power, and specialty transportation (such as ground support equipment and buses). Independent analyses show global markets could mature over the next



Growth of fuel cell applications for specialty vehicles, portable power, auxiliary power, backup power, and stationary power are expected to generate a range of new jobs in the near term. Transportation applications, including light-duty vehicles, will also create many more job opportunities over the next 10 to 20 years. *Photo courtesy: NREL*

10–20 years, producing revenues of \$14 to \$31 billion from stationary power, \$11 billion per year from portable power, and \$18–\$97 billion per year from transportation applications.<sup>1</sup>

### DOE Supports Fuel Cell Development

DOE-funded efforts in the offices of Fossil Energy, Nuclear Energy, Science, and Energy Efficiency and Renewable Energy (EERE) have led to significant progress in hydrogen and fuel cells.

EERE's Fuel Cell Technologies Office pursues a broad portfolio of applied research, demonstration, and deployment activities for applications across multiple sectors, using a variety of technical approaches and diverse sources of fuel. These efforts span the full spectrum of technology readiness, from early market applications that are already viable or are expected to become viable in the next few years to midterm markets and longer-term markets. Codes

and standards, in parallel with public education activities, are also pursued to address economic and institutional challenges to widespread market acceptance.

### Outlook for Fuel Cell Technology Careers

As various fuel cell applications gain market share, the industry is expected to undergo significant growth. Employment opportunities will open up in businesses that develop, manufacture, operate, and maintain the fuel cell systems. Jobs will also become available in businesses that produce and deliver the hydrogen and other fuels used by these systems. Many of these jobs require engineering and science backgrounds related to product and technology development. Analyses show that widespread market penetration could create 180,000 new jobs in the United States by 2020, and 675,000 jobs by 2035.<sup>2</sup>

### Modeling the Economic and Employment Benefits of Fuel Cells

DOE has launched two modeling tools for estimating the economic benefits of fuel cells in early market applications and hydrogen infrastructure development. The tools, developed by Argonne National Lab, are called JOBS FC and JOBS H2. JOBS FC estimates the number of jobs created by deploying fuel cells in forklifts backup power, infrastructure development, and prime power applications. JOBS H2 estimates changes in industry expenditures as a result of hydrogen fueling infrastructure deployment and calculates the effects of those changes throughout the economy. Both tools can be found online.

As market demand for hydrogen and fuel cell technologies increases across sectors of our economy, there will be an increasing need for trained and experienced personnel and accompanying services such as qualified maintenance technicians, installers, manufacturing professionals, trainers, insurers, and educators. The DOE has implemented a “train the trainer” approach to education that includes job certifications and curriculum required to support this growing workforce. Inperson training, online training courses, webcasts and webinars are all tools that should be used to reach people in sectors who could benefit from learning about hydrogen and fuel cells. These sectors can include energy service companies, utilities, venture capital firms, insurance and underwriter industries, state government workforce development agencies, government code officials, first responders, and local public and community outreach.

### Educating Future Scientists and Engineers

The Fuel Cell Technologies Office has supported the development of fuel cell education curricula that include general education courses, specialized science and engineering courses, minor and concentration programs, curriculum modules, internships, lab classes and kits, and textbook chapters. The work has been conducted at several universities, including California State University-Los Angeles, Humboldt State University, the University of California-Berkeley, Michigan Technological University, Florida Institute of Technology, the University of North Carolina Charlotte, and the University of North Dakota.

Learning about hydrogen and fuel cells should begin with K-12. The H2Educate program team has helped to create hydrogen and fuel cell curricula and

teaching materials. A National Energy Education Development (NEED) Project, the H2Educate program was designed to target K-12 teachers and students with educational materials, training programs, and curricula evaluation. The program emphasized the development of critical thinking and problem solving skills using inquiry activities that encourage students to consider the trade-offs inherent in energy decisions. All NEED materials are available for educators to download free of charge. Ranging from one hour to one day, NEED has provided training to over 12,000 teachers in 35 states since H2Educate’s inception in 2004. Pre and post data from participating schools and workshops show a 60% increase in student and teacher knowledge.

These projects are designed to introduce hydrogen and fuel cell technology to students across the country, educating the scientists, engineers, and potential end users of tomorrow.

### References and Notes

1. Fuel Cell Economic Development Plan, Connecticut Center for Advanced Technology, Inc., (produced for the Connecticut Department of Economic and Community Development), January 2008
2. “Defining, Estimating, and Forecasting the Renewable Energy and Energy Efficiency Industries in the U.S. and in Colorado, America solar Energy Society, December 2008.
3. Ibid.
4. 2010 Year in Review from [http://cepji.typepad.com/heslin\\_rothenberg\\_farley/](http://cepji.typepad.com/heslin_rothenberg_farley/)

### Fuel Cell Technology Careers

- Mechanical engineers
- Chemists
- Chemical engineers
- Electrical engineers
- Materials scientists
- Laboratory technicians
- Factory workers
- Machinists
- Industrial engineers
- Power plant operators
- Power plant maintenance staff
- Bus, truck and other fleet drivers
- Vehicle technicians
- Fueling infrastructure installers
- Hydrogen production technicians

### Fuel Cells as a Future Jobs Engine

- Widespread adoption of fuel cells could create 180,000 new jobs in the United States by 2020, and 675,000 jobs by 2035.<sup>3</sup>
- The United States holds over 45% of the fuel cell patents awarded between 2002 - 2011.<sup>4</sup>
- Several states—including California, Connecticut, Hawaii, Ohio, New York, and South Carolina—have major hydrogen and fuel cell programs underway.