Renewable Hydrogen: A Long-Term Sustainable Solution

By Julia Thomas, Howard Brown and Paula Pitchford

Hydrogen is the most abundant element in the universe. And while it doesn't exist by itself on Earth, it can be produced from a variety of resources. But to realize the benefits of a hydrogen-powered future — sustainability, increased energy security, diverse energy supply and reduced air pollution and greenhouse gas emissions — hydrogen must be produced cleanly, efficiently and affordably from domestically available renewable resources.

Hydrogen has the long-term potential to reduce our dependence on foreign oil and lower carbon and criteria pollutant emissions from the transportation sector. The U.S. Department of Energy (DOE) set the goal of producing hydrogen from domestic resources at $2.00 to $3.00 per gallon of gasoline equivalent. To reach this goal, however, many technical challenges must be overcome.

Key challenges to developing cost-effective hydrogen technologies include lowering the cost of hydrogen production, delivery, storage and fuel cells. Hydrogen systems also require effective safety codes and standards, not only to ensure that these systems are safe but also to help define design standards for future hydrogen vehicles and infrastructure.

While these challenges are significant, they are not insurmountable. DOE outlines its efforts to overcome these challenges in the Hydrogen, Fuel Cells & Infrastructure Technologies Program's Multi-Year Research, Development, and Demonstration Plan (for more, see www.eere.energy.gov/hydrogenandfuelcells/mypp/index.html).

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Producing Renewable Hydrogen

Producing hydrogen by steam-reforming natural gas, today's most economical method, boosts our reliance on an increasingly scarce fossil fuel and contributes to greenhouse gases. However, it offers some important benefits as well. While hydrogen from renewables is the ultimate goal, hydrogen from domestic natural gas reduces our reliance on imported oil and supports the development of a hydrogen infrastructure and fuel cell vehicle rollout.

DOE's National Renewable Energy Laboratory (NREL) is pursuing several renewable alternatives, including pyrolyzing biomass and reforming the products to hydrogen. NREL researchers are also exploring the use of cost-effective solar, wind, and other renewable technologies to electrolyze water to produce hydrogen. And they are pursuing both *photoelectrochemical* and *photobiological* technologies that could produce hydrogen directly.

The *photoelectrochemical* approach integrates elements of a photovoltaic cell with elements of an electrolyzer, so that the absorption of light energy triggers the splitting of water molecules in an aqueous electrolyte. Because aqueous photovoltaic cells and electrolysis share anode, cathode and electrolyte components, this approach is potentially much more efficient than the separate steps of electricity generation and electrolysis.

The *photobiological* approach takes advantage of the fact that certain microorganisms — such as green algae — naturally split water to produce hydrogen as a way to dissipate the energy they do not need in certain circumstances. Researchers have been creating new genetic forms of these microorganisms that can sustain hydrogen production in the presence of oxygen. One system uses a metabolic switch (sulfur deprivation) to cycle algal cells between a photosynthetic-growth phase and a hydrogen-production phase.

Developing Market-Ready Fuel Cells

Hydrogen fuel cells could revolutionize the way we power our nation, providing clean, more efficient alternatives to burning fossil fuels. However, many challenges must be overcome before fuel cells will be competitive in the marketplace.

NREL's work focuses on improving the performance and cost effectiveness of fuel cell systems, subsystems and components. NREL uses a variety of analysis tools to identify critical design issues for fuel cell vehicles and systems and works with industry to share and apply these tools to address such issues as durability, cost and efficiency.

The ultimate goal of all this research and development is to enable U.S. industry to produce advanced, low-emission, economically competitive fuels and vehicles that will meet our future transportation and environmental needs. And according to a recently published NREL study, the United States has the potential to produce 1 billion tons of hydrogen annually from currently available renewable resources (for more, see www.nrel.gov/docs/fy07osti/41134.pdf). Pursuing all options, we are on the way to greater energy independence. ●

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