

Hydrogen Powers Energy Hopes Experts say it may be the fuel of the future

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Hydrogen, the simplest atom, is everywhere. So perhaps it's not surprising that the most abundant element in the universe would worm its way into the midst of California's deepening energy crisis. Rolling blackouts and skyrocketing utility rates are focusing new attention on the risks of relying solely on the public power grid for electricity.

"The California situation is enlightening a lot of businesses and individuals about the need for an alternative energy source for backup or primary power," said Jim Kirsch, a vice president and head of a power generation unit at Ballard Power Systems in Vancouver, British Columbia.

Many energy experts have long championed hydrogen's potential as a power source - the key ingredient in hydrogen fuel cells that offer a pollution-free alternative to batteries. There's an emerging consensus that "hydrogen will be the fuel of the future," said Robert Stempel, the former chief executive of General Motors, now chairman of Energy Conversion Devices Inc. in Troy, Mich.

New Respect for New Ideas

His company, a pioneer in portable electricity storage, formed a joint venture with Texaco to develop solid-state, metal-hydride hydrogen storage systems for powering clean-running vehicles. There are other methods, too, but the real take-home lesson from the joint venture, according to Texaco CEO Peter I. Bijur, is that oil companies now are embracing technologies "that just 20 years ago we brushed off as a weak threat to our industry."

Ultimately, the idea is to move away from fossil fuels and other traditional energy sources toward what's known as a "hydrogen economy," in which renewable solar and wind generators might be used to produce pure hydrogen fuel out of water. If a practical hydrogen storage system can be perfected, and if fuel cells can ever be mass-produced cheaply enough, today's utility customers would have electricity in a stable, portable form capable of being used whenever needed.

Imagine city streets full of fuel cell-powered vehicles, neighborhood-size power plants using hydrogen, and homes and businesses with stacks of fuel cells in the back yard or basement. These could augment and sometimes supplant electricity supplied through the public grid and might even be wired into a computer-guided "distributed generation" scheme via links to the Internet.

No Quick Fix

All of that is clearly a distant vision. Fuel cells are not quite ready for prime time. They are still expensive to make and the flammable hydrogen fuel is difficult to handle. But while nobody expects fuel cells to be California's power savior right away, a few pieces of the "hydrogen economy" are already starting to take shape.

The most widely touted fuel-cell technology to have emerged from the laboratory stage so far uses what's known as a PEM - for proton or polymer exchange membrane - situated between two electrodes, each coated with a catalyst such as platinum or palladium.

When sandwiched together in this way, hydrogen fuel can be made to separate at one electrode into its constituent free electrons and positively charged hydrogen ions, also called protons. The electrons can then be siphoned off as usable direct current electricity, or converted to alternating current. The protons drift through the PEM, combining with oxygen at the second electrode to produce ordinary water and heat. The individual fuel cells can be arranged in "stacks" of virtually any size.

There's no pollution, and no moving parts to wear out or break down.

Clean Chemistry

"It's very clean and elegant chemistry," said Bill Smith, vice president of business development at Proton Energy Systems in Connecticut.

The process is basically electrolysis in reverse. Similarly, hydrogen to supply the fuel cells can be produced with electricity by cracking water molecules in a device known as an electrolyzer.

"Hydrogen represents stored energy," said chemist Peter Lehman, director of the Schatz Energy Research Center at Humboldt State University. "Energy storage is not easy and it's not cheap."

Regular batteries are good for short-term storage, but they require too much lead to manufacture and generate far too much pollution when discarded to be practical for large-scale use. Other strategies - pumping water uphill, for example, to run a turbine at a hydro station - work well only if circumstances are ideal.

By contrast, the portable hydrogen fuel cell seems to represent the ideal energy "carrier" in a natural cycle, Lehman said. "It's completely sustainable. If the input is solar energy, you end up with a clean and dispatchable energy source," he said.

Driven partly by government clean-air standards and the need to reduce hydrocarbon emissions, corporate America has embarked on a crash program to turn fuel cells into practical products.

"We don't consider it a fringe technology at all," said William M. Wicker, senior vice president for global businesses at Texaco. "Although the traditional oil and gas business is not going away any time soon, hydrogen is going to be a part of our energy future."

A hydrogen-based commercial backup power system is due out this year from Ballard Power, ranked among the leaders in the nascent fuel-cell industry.

The new system is billed as a clean, noiseless alternative to portable diesel generators. Rather than using water to produce hydrogen fuel, however, the system produces its own hydrogen by breaking down an ordinary hydrocarbon fuel, such as propane or natural gas, which the user has to supply.

Big Step Forward

It's clearly not the ideal hydrogen technology, and price and other details, which have not been revealed, could put it out of reach of average consumers. But Kirsch said the new portable backup system should still rank as an important commercial breakthrough.

"As far as we know, this will be the first hydrogen energy product a consumer can walk in and purchase off the shelf," he said.

For many businesses, the disruptions in the California energy supply system are only the latest reasons to embrace the idea of energy self-reliance. Many are talking not in terms of the usual 99.9 percent reliability standard, but rather a new "six-nines standard" of 99.9999 percent.

That's more than most utilities can deliver even in best of times. Hydrogen advocates claim they have at least part of the answer, particularly when the need to reduce energy pollution is taken into the equation.

"The troubles in California really have shined a bright light on the hydrogen story. People are looking for alternatives, and now they are going to be seeing just how close we are to this technology," Kirsch said.

Just how close is arguable beyond a few niche markets.

"The cost of manufacturing the fuel cell itself and the cost of fuel processing are the two big problems we have to solve," Wicker said. "They aren't insurmountable problems at all but the solutions are pretty far in the future."

Pure hydrogen has some ideal characteristics as an energy container, but those same characteristics make it difficult to handle. "Hydrogen definitely has hazards," said Jeff Rinker, general manager of hydrogen at BP, the international oil company, and chairman of the National Hydrogen Association, a trade group. "It would be good if someone came up with an elegant method of storing hydrogen."

Even staunch wind and solar proponents say there's little practical need to worry about fancy storage methods for intermittent supplies, because the public grid has plenty of room for more electrons - even when the sun is shining and the wind is blowing.

"There is a great potential for hydrogen storage in the future, but today the grid itself is capable of effectively being used as storage," said Alan Noguee, director of clean energy programs at the Union of Concerned Scientists in Washington, D.C. "Not until we start getting at least 15 percent of our energy from intermittent sources is there any concern about reliability. Some regions in Europe are getting over 20 percent and are still doing fine."

Hawaii in the Vanguard

Hydrogen's first large-scale commercial use is expected to be not in California but rather in such locations as Iceland and Hawaii, where renewables are much higher on the political radar.

Hawaii state Rep. Hermina Morita, a Democrat who chairs a legislative energy committee, is leading the push to reduce her state's need for imported oil, partly by encouraging alternatives and hydrogen fuel cells.

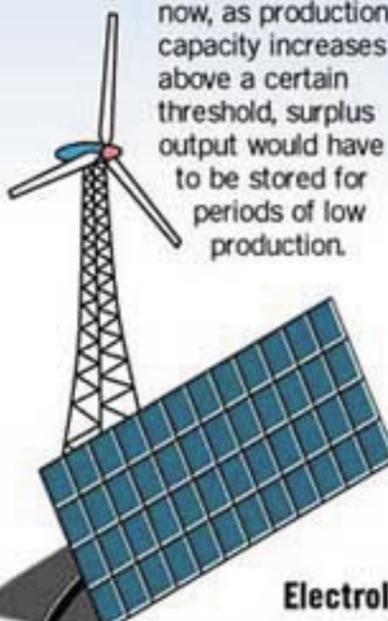
She described it as a "market-based approach" that includes demonstration projects and economic incentives for utility investment. Eventually, she added, California could be part of the picture. Rather than importing energy, she said, "ultimately what we want in Hawaii is to be capable of producing more hydrogen than we need, so we can send the excess to California."

A Hydrogen Economy

In the not-so-distant future, clean-energy advocates expect hydrogen storage to become a key technology for storing energy — a tricky business that promises to become more and more critical as California embraces renewable but intermittent power sources like wind and solar. Here's how it might work:

Storing Non-polluting Electricity

Wind farms and arrays of solar panels feed electricity directly into the grid. Although there's plenty of room for this power now, as production capacity increases above a certain threshold, surplus output would have to be stored for periods of low production.



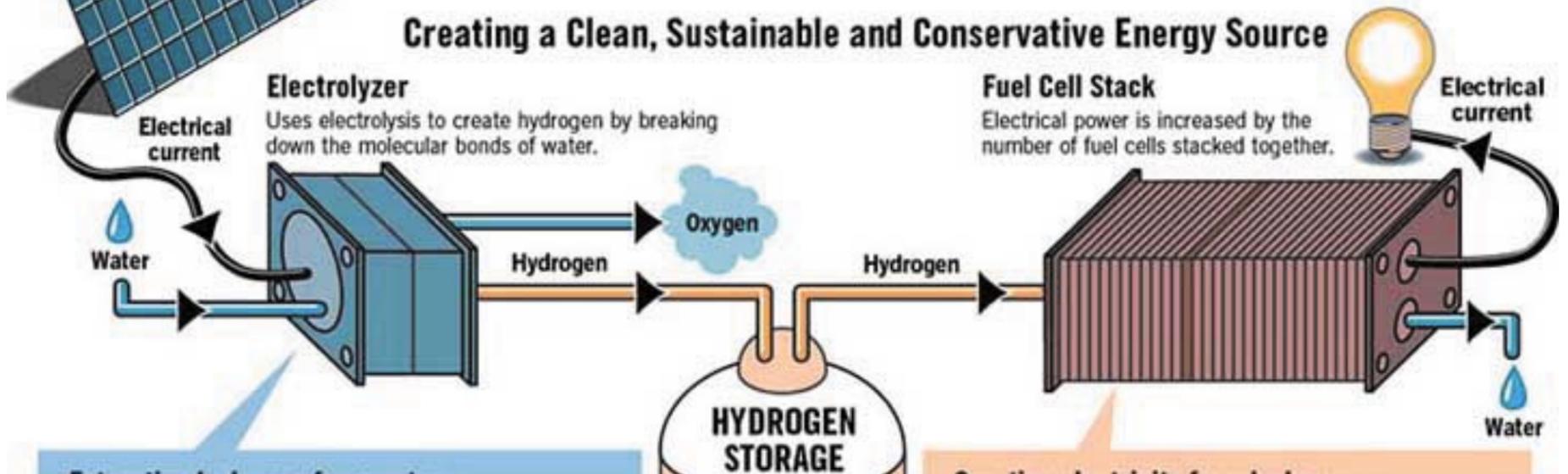
Creating a Clean, Sustainable and Conservative Energy Source

Electrolyzer

Uses electrolysis to create hydrogen by breaking down the molecular bonds of water.

Fuel Cell Stack

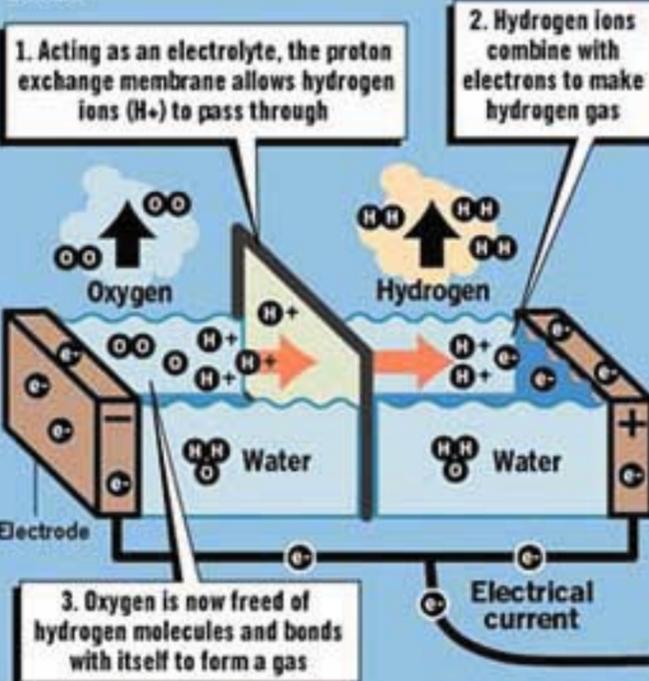
Electrical power is increased by the number of fuel cells stacked together.



Extracting hydrogen from water

An electrolyzer breaks the bond of hydrogen and oxygen molecules in water by using electrical power to force hydrogen ions through a membrane.

A solid membrane in the middle of the device conducts protons, adding positively-charged hydrogen ions to water. The two polarities of electricity—negative and positive—separate and attract oxygen and hydrogen gas respectively. The gases are then drawn off and stored.

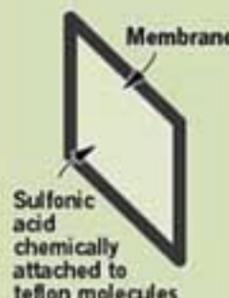


HYDROGEN STORAGE

Hydrogen gas is pressurized and stored in tanks or in a solidstate similar to batteries using metal hydrides.

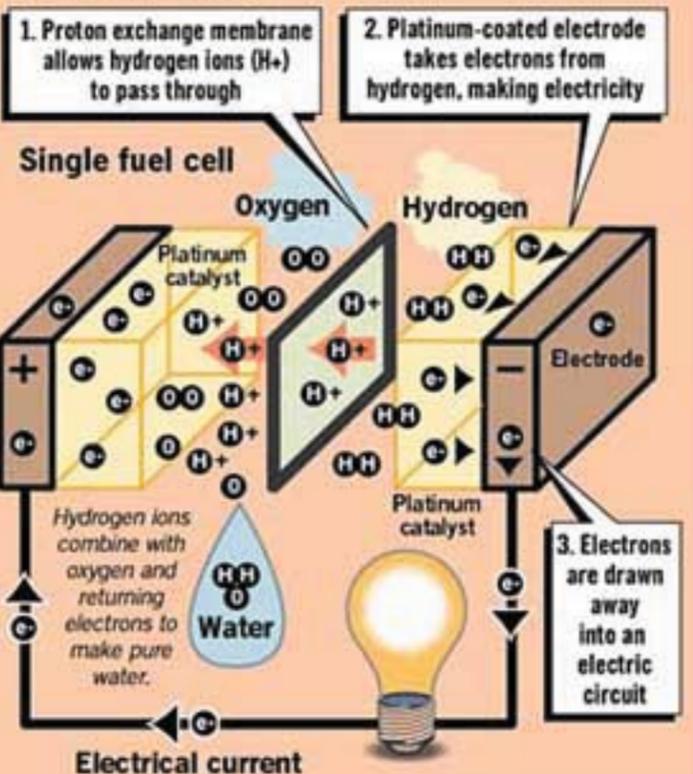
A look at the membrane

The proton exchange membrane is made mostly of teflon with sulfonic acid attached to the teflon polymer. The acid makes it absorb water and work as a proton conductor.



Creating electricity from hydrogen

A fuel cell combines hydrogen and oxygen gas to create electricity. Pure water is also a byproduct. In the fuel cell, a platinum catalyst takes electrons from hydrogen to produce an electrical current. The leftover hydrogen ions flow through a membrane where it is reunited with the electrons and oxygen to create pure water.



Source: Schatz Energy Research Center, Humboldt State University