COMMENTARY: Global Heating Why We Must Shift to Carbon-Free Fuel

By Peter Hoffmann

In a few days, President Bush will be hosting a climate summit in Washington, and Congress will begin what promises to be a long series of deliberations on climate legislation. At long last, there's basic agreement that we have to get serious about fighting global warming. The elephant in the room is, "how"? One answer—arguably the best one—came from Europe's parliamentarians in Strasbourg last May. The Parliament overwhelmingly adopted a declaration calling for a green hydrogen economy and "a third industrial revolution."

The basic issues are no longer in doubt since the report from Bangkok last spring by the International Panel on Climate Change (IPCC). Under the most severe scenario, the world must stabilize greenhouse gases by 2015—eight years from now!—at 450 parts carbon dioxide (CO_2) per million to keep global temperatures from rising more than 3.6 degrees Centigrade above pre-industrial levels.

A solution that's been studied exhaustively all over the world at least since the 1970s is to substitute the quintessential carbon-free, by definition environmentally benign, chemical hydrogen for fossil fuels.

In the U.S. in recent years, however, hydrogen has largely slipped off the radar screen of environmental interest, elbowed aside in the public's perception by other suggestions.

These include a carbon tax and carbon trading, carbon sequestration, tougher energy conservation, higher energy-efficiency standards, alternatives such as plug-in hybrids, bio-fuels and bio-diesel, ethanol, clean coal, wind and wave power, solar energy and geothermal energy and even advanced nuclear power. All are helpful and are to be applauded, but they won't be sufficient. We must stop putting carbon into the air in the first place—not take it out afterwards—and we must start moving towards a carbon-free fuel—hydrogen, NOW to begin veering away from catastrophe.

Everybody knows by now that the principal culprit is man-made CO_2 produced by burning fossil fuels in trains, planes, automobiles etc. But less well known is that CO_2 stays in the atmosphere a lot longer than previously believed: hundreds, maybe thousands of years, for all practical purposes "forever," according to NASA's James Hansen. Thus, stabilizing and reducing global CO_2 levels by getting rid of carbon must become a global priority.

Both short-term and longer-term approaches are needed, especially given the rapidly growing economies of China and India (Last year, China alone added 96,000 megawatts (MW) of new coal-burning power plants without any CO_2 cleanup to its energy generation capacity—nearly double that of California's total output).

The U.S., as a major contributor to greenhouse gas emissions (China is taking the lead role), must take the lead in drastically reducing emissions and in investing in new technologies which the

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world can adopt. With global energy demand forecast to grow by 60 percent by 2030, the world's growing population will need all the energy it can get. But we will also produce 60 percent more CO2 unless we change our fossil fuel habits.

While the ultimate goal is renewable hydrogen, the magnitude of the energy challenge dictates the use of hydrogen produced from major energy sources such as coal (with carbon sequestration) and nuclear. A vigorous longer-term approach with carbon-free hydrogen and fuel-cell technologies can play a central role. While there are many challenges, there are no apparent show stoppers that couldn't be addressed by a well-funded, dedicated program.

Hydrogen, the Unifier

Hydrogen, an energy carrier and not an energy source, can serve to unite just about all other forms of energy. Today, it is produced most economically from natural gas—ultimately, a dead end. In the future, renewable hydrogen can be obtained by splitting water via electrolysis with solar electricity, for example; from biofuels and biomethane and many other sources like that other energy carrier, electricity, which is also generated from many sources.

There is a beautiful symmetry in the fact that hydrogen and electricity are complementary: hydrogen can be produced from water by running an electric current through it in an electrolyzer. When reversing the process in a fuel cell—an electrolyzer running backwards!—hydrogen recombines electrochemically with the air's oxygen to produce electricity, pure water and some heat. Geoffrey Ballard, founder of fuel cell maker Ballard Power Systems, has coined the term "hydricity" to describe this symbiosis.

Hydrogen can replace fossil fuels in almost all applications. Claude Roulet, an executive with a company intimately linked to Big Oil, Schlumberger Carbon Services, has said that while electricity was the energy carrier of the last two centuries, "hydrogen is the energy carrier of the 21st century."

The U.S. is in danger of falling behind Europe and Japan in recognizing hydrogen's value and in providing the consistent, long-term investment necessary. Here, hydrogen is undervalued even by many clean-energy advocates as still too far in the future, as too inefficient; biofuels or renewably-generated electricity are frequently described as better, nearer-term solutions to the CO2 threat.

The naysayers have it wrong: carmakers, often accused of dragging their heels on innovation, are among the best example of farsighted thinking here. With billions of dollars in future sales and their very survival at stake, the major ones believe hydrogen is key to reducing the global warming threat by avoiding putting CO2 into the atmosphere in the first place.

Several manufacturers such as BMW, GM, DaimlerChrysler, Honda and Toyota are starting to place fleets of around 100 hydrogen cars each--both fuel cell and with internal-combustion engines—Into the hands of ordinary drivers in the U.S., Europe and Asia (including China) to gain operational data, market experience—and as a public relations/public education exercises. En route, the manufacturers have to pass through a financial "Valley of Death," as GM's fuel-cell chief, Byron McCormick, put it to a Department of Energy (DOE) advisory committee in February. The vehicles cost $1 million each.

But costs are going down. Carmakers plan to produce 500 vehicles in the 2010 to 2012 "pilot commercialization phase" at about $250,000 each, McCormick says. The "early commercialization phase" starting around 2013 is expected to see each manufacturer produce perhaps 10,000 vehicles costing around $50,000 in the first year, then dropping to, hopefully, much lower numbers by 2015.

Cutting Costs

- Fuel and fuel-cell costs and a lack of fueling infrastructure are still problematical but solvable with strong political will and close industry and government cooperation. Efforts to figure out these and other problems—onboard hydrogen storage, for instance—have a way to go. A recent survey by Fuel Cell Today found that more than 160 hydrogen stations are likely to be

up and running by the end of the year worldwide. A German web database, HyWeb, says the total number of stations existing, planned, or already shut down is 289.

- GM's research vice president Larry Burns, on the other hand, has said the U.S. would need about 12,000 fueling stations to meet 70 percent of the country's hydrogen fueling needs—a fairly small number considering there are an estimated 170,000 regular gas stations in the U.S. As to fuel costs, GM has said that at $5 per kilogram (kg) of hydrogen (a kg of hydrogen has the same energy content as a gallon of gas), fuel-cell cars potentially could provide transport at about 10 cents/mile, assuming the fuel cell has about 2.5 times the efficiency of comparable gasoline engine. And fuel-cell costs, computed on the basis of producing 500,000 units annually, have been estimated by DOE now to be about $107 per kilowatt (kW) a lot less than the baseline $275 per kW estimate of 2002, but still far above the 2015 target of $30 per kW (very roughly the ballpark cost for today's internal-combustion engines).

The auto manufacturers are not alone. Many strategic thinkers, energy analysts, industry leaders, farsighted politicians such as California Governor Schwarzenegger, investors and venture capitalists agree the best long-term option for a carbon-less, non-CO2-producing economy is hydrogen, and that the time to start phasing it in—building infrastructure, training technicians, educating the public, regulators and politicians--is NOW. Everything else is pretty much transitional: useful and necessary, but ultimately it will have to give way to, or be complemented by, hydrogen.

The Revolution Has Started

The good news is that the revolution has started, with budding, albeit still very expensive, examples sprouting Johnny Appleseed-style all over the globe. Examples:

- The next three Olympic Games in Beijing in 2008, Vancouver in 2010, and London in 2012 will feature hydrogen-powered vehicles, including buses, probably some VIP cars, with both fuel cell and internal combustion engines, as a determined push to help force hydrogen into the transport system and the public's consciousness;
- California fuel cell developer Altergy Systems in Folsom this summer unveiled the world's first automated high-volume fuel cell assembly line for small hydrogen fuel cells for telecommunication and utility companies and governments. Altergy says automation and volume cuts the cost of the units in about half;
- In New Jersey, inventor and long-time hydrogen developer Mike Strizki is now showing visitors his house in Hopewell converted to grid-independent solar hydrogen operation (including hydrogen fuel production for his fuel cell car), subject of a long story May 20 in the New York Times magazine. It's pricey: the conversion cost are about $500,000, Strizki says, but his next project by his company, Advanced Solar Products, in the Cayman Islands is likely to cost less than half of that. Other solar hydrogen houses have been built or converted on Long Island (U.S. Merchant Marine Academy), near Wiscasset, Maine, on Stuart Island, Washington, in Indonesia, and, decades ago, in Freiburg, Germany, and Switzerland;
- H2Gen Innovations, Inc., a six-year-old company in Alexandria, Virginia that sells advanced onsite generators that produce hydrogen from natural gas more efficiently than traditional technologies, recently sold seven units to produce hydrogen needed to help clean up nuclear weapons byproducts at DoE nuclear facilities;
- Iceland, generally regarded as the New Frontier of the coming global hydrogen economy, expects to be able to offer hydrogen-fueled rental cars via Hertz for tourists next spring, and it is equipping a whale-watching tourist ship with a fuel cell for on-board power generation as a precursor and test bed to eventually converting its fishing fleet, mainstay of Iceland's economy, to fuel-cell power. Both Iceland and Norway have ordered a couple of dozen Toyota Priuses converted to hydrogen from a California company, Quantum Fuel Systems Technologies Worldwide, for fleet operations and testing, along with hydrogen cars—both fuel-cell and internal-combustion engines—from DaimlerChrysler and Mazda;
- Hydrogen fuel cells are even taking to the air in Europe: two teams, one in Turin, Italy, sponsored by the European Union, and another organized by Boeing and headquartered in Madrid, are planning to experimentally convert a very light Czech two-seater and an Austrian motorglider, respectively, to hybrid fuel cell/battery electric engines, with the fuel cells for both coming from a British company, Intelligent Energy.

  As Europe's parliamentarians said with their May vote, we need an energy revolution—one with hydrogen as a central technology driver.

PETER HOFFMANN, editor and publisher of the monthly Hydrogen & Fuel Cell Letter, has written two books on hydrogen, The Forever Fuel: The Story of Hydrogen (Westview Press, 1981), and Tomorrow's Energy: Hydrogen, Fuel Cells, and the Prospects for a Cleaner Planet, (MIT Press 2001, Foreword by U.S. Senator Tom Harkin).