THE NEW ATLANTIS
A JOURNAL OF TECHNOLOGY & SOCIETY

CORRESPONDENCE

Rethinking the Hydrogen Economy

In 1957, Sir Harold Spencer Jones, the British astronomer, declared that "Space travel is bunk." Two weeks later, the Sputnik satellite orbited the earth.

The same pessimism unfortunately has infected Robert Zubrin's article, "The Hydrogen Hoax" [Winter 2007]. The author tries to persuade readers that efforts to develop fuel cells and employ hydrogen as an energy source are exercises in futility. Infections often can be cured. What makes Zubrin's condition terminal is tunnel vision. As if he were trying to understand the game of baseball by examining an old team photo with a microscope, he cannot, or chooses not, to see the larger picture.

For those unfamiliar with them, fuel cells are devices that harness the chemical energy of hydrogen or a hydrogen-rich fuel directly to produce electricity. Think of them as electrochemical engines. There is no combustion in a fuel cell. Because they rely on chemistry and not combustion, fuel cells have inherent advantages over combustion systems, including higher efficiency and extraordinarily low emissions. Most, though not all, hydrogen proponents link fuel cells and hydrogen in their vision of a "hydrogen economy."

Fuel cells are a family of technologies; while there are significant differences among them, they are related closely enough to be discussed collectively. Fuel cells are being developed for an extraordinary variety of markets, from remote sensors to portable electronic equipment, from backup power and combined heat and power systems to peak utility power, from automobiles to ships. Dozens of products are on offer, albeit aimed at niche markets, with more on the way.

America needs to secure its energy supply in the face of increasing global competition and the threat of supply interruptions; to reduce smog and address other air pollution health challenges; and to reduce, dramatically, our emissions of carbon and other global warming gases. We must deal with all of these interrelated challenges, all linked to the combustion of carbon rich fuels.

Hydrogen and fuel cells offer a way to address—and ultimately, to overcome—all three challenges simultaneously. It is this combination of benefits, and not some harebrained political fantasy, that has stimulated the worldwide interest in accelerating the transition to a hydrogen economy.

This is not to say that a transition to hydrogen is a certainty. There is much to do. There is a thoughtful yet passionate debate underway about the relative merits of the various technology and fuel options. But Zubrin has chosen to use words like hoax, charlatan, insanity and catastrophe. What makes him so angry?

Regardless of the motivation, his argument simply does not stand up to analysis. Fundamentally, he overlooks the game-changing nature of hydrogen and fuel cells. In evaluating fuel-cell vehicles and fuels, he chooses to examine the parts, rather than the whole. This is an error from which he never recovers.

His point that it takes energy to make hydrogen is indisputable. Extracting any fuel takes energy—even getting gasoline from well to tank costs, optimistically, 12 percent of the energy of the gasoline. It takes more energy to generate hydrogen than to make gasoline, but since a fuel cell is more efficient than combustion engines, fuel-cell vehicles—even today's prototypes—offer attractive *overall* efficiencies.

In fact, independent analysts have concluded, repeatedly and over the course of many years, that fuel cell vehicles provide greater benefits than other options, and the best scenarios promise true independence—freedom from hostile sources of oil, freedom from smog, and an unequaled response to global warming. Analyses from Argonne National Laboratory, the National Academy of Sciences, a distinguished German institute, Stanford University, and the University of California, all have quantified the benefits of fuel-cell vehicles. These include well-to-wheels efficiency benefits typically of 30 percent or more, utilizing natural gas as the hydrogen feedstock, even when compared with a Toyota Prius-like vehicle and using optimistic assumptions about the Prius's performance. Health benefits are measured in thousands of lives saved and millions of illnesses avoided.

Fuel-cell vehicles themselves are twice as efficient as gasoline vehicles, or more. Zubrin makes an error by comparing combustion engines at their maximum efficiency. In the real world, a diesel vehicle is about 25 percent more efficient than a typical gasoline counterpart, while a hybrid's performance depends on engineering and duty cycles; some hybrids deliver as little as 10 percent or 15 percent improvement. It is important to note that even when analysts use optimistic assumptions about the combustion systems, fuel cells do better in well-to-wheels analyses. And any system that burns hydrocarbons produces unwanted emissions; pollutants are the products of incomplete combustion.

As for vehicle costs, today's prototypes are no measure of the price automakers will ask for fuel-cell vehicles when they begin making commercial quantities. Units must be competitively priced, and component costs must allow it. The major automakers are pursuing development—not merely research—of fuel-cell vehicles.

Zubrin spends considerable time on the question of hydrogen infrastructure. His scare tactics—$100-a-gallon hydrogen, impossibly huge fuel tanks, deadly transport truck "bombs"—are conceptually inaccurate and do not match the current reality. A hydrogen infrastructure already exists, albeit one serving industrial customers and not individual consumers. This infrastructure safely and routinely delivers billions of kilograms of hydrogen annually in the U.S., by truck and, for decades, by pipeline.

The transition to a consumer infrastructure is in its infancy, but has already begun. Washington, D.C. boasts a hydrogen dispenser. A dozen states have them too, and California's plans call for thirty or more in the near future.

Numerous studies have concluded that hydrogen will be, and in some areas already is, priced competitively with gasoline. One could purchase hydrogen at the pump in Arizona in 2006 cheaper than one could buy gasoline at a nearby pump. The current "delivered" cost of hydrogen from wind power is estimated at $4 to $6 per kilogram, competitive with today's gasoline prices when the higher efficiency of fuel-cell engines is considered.

Without trying to dissect Zubrin's formulas, a good rule of thumb is that it takes between 40 and 60 kilowatt-hours to generate a kilogram of hydrogen, depending on the efficiency of the system. Thus it will make sense to generate hydrogen at off-peak times where possible; in some areas of the U.S. the spot market price for an industrial user off-peak is less than four cents. A recent Stanford study estimated the "unsubsidized near term (2010) cost" for wind generated hydrogen could be in a range from $1.12 to $3.20.

Certainly new infrastructure will take money and effort. But so will the cost of installing an infrastructure for alcohol fuels, or expanding the diesel infrastructure. Worldwide, the cost of meeting gasoline demand by 2030 may be $3 trillion, according to the International Energy Agency. It is a matter of allocation of resources.

Zubrin argues that the federal government is gambling recklessly on hydrogen, has "placed a major bet," and "has continued to hand out billions of dollars." Supporters wish his claims were true; they are not. Federal support for fuel cell and hydrogen research to date is a small fraction of the investment made in solar or wind power, to say nothing of coal, gas, oil, and nuclear technologies. For the current fiscal year, the Department of Energy's hydrogen and fuel cell budget is $194 million, compared to $199 million for biomass, $208 million for solar and wind, and $783 million for fossil fuels. Given the stakes, federal support ought to total billions; it does not.

There is much promise in biofuels, although serious questions remain about net energy, food-fuel competition, land use, and biodiversity. The technologies to move beyond corn ethanol are still in development. The Union of Concerned Scientists calculates, optimistically, that by 2050, biomass could supply half the nation's transportation energy needs—but, as they point out, that still leaves the other half.

Biofuels make excellent hydrogen carriers. If we can gasify sustainable feedstocks, we can actually tilt the carbon cycle in our favor, providing a net carbon reduction. There is less benefit in a strategy that simply burns the fuel.

The current reliance on fossil fuels for transportation energy is unsustainable. But we are in a deep hole. No solution is short term; no solution is cheap or easy. All the advanced options require more research, development, demonstration, even trial and error. And all the realistic options must stay on the table. Now is not the time to limit our options.

Call me an insane charlatan gambler if you must. But I am betting on a hydrogen future, not necessarily because we desire it, but because we need it if we are to meet the combined energy challenges of the current century.

Robert R. Rose
Executive Director
U.S. Fuel Cell Council
Washington, D.C.