Demystifying the Hydrogen Myth

Dr. Reuel Shinnar

In the 1970s, the first H_2 mirage collapsed after costing $7 billion dollars to the U.S. and another $6 billion to Europe and Japan. So why the continued fervent interest? And why do we take this mirage so seriously that we expend valuable resources?

The term "H_2 economy" is a misnomer. Our present economy is based on fossil fuels with a small contribution from nuclear energy. H_2 is an inefficient energy carrier, not an energy source. For the next foreseeable 20–30 years, we will still depend on fossil fuels, so what use would H_2 achieve? Conversion of fossil fuels to H_2 inherently involves a large irreversible energy loss. The best lower heating value (LHV) efficiency of a H_2 plant from natural gas is 65%, and of a coal plant is 55%. There is no available energy conversion device based on H_2 that has a sufficiently large advantage to compensate for this loss, and conversion of nuclear or solar electricity to H_2 makes no sense. The electricity alone to produce one million BTU would be about $50, while its market value as hydrogen would be only $16.

It is also claimed that the hydrogen economy would allow carbon to be sequestered. Almost all coal is burned in power plants. We have the technology to build gasifier power plants where the CO can be shifted to hydrogen and the CO_2 removed. If we go down this road, the carbon can be sequestered, if we can find a place to put it, but it has no relevance to the hydrogen economy. The hydrogen doesn't go anywhere outside the power plant.

Electricity is a much more efficient energy source than fuel. In a hybrid car, the gasoline creates the electricity with an efficiency of 35%. In general, we need, on a BTU basis, only a half to one third as much electricity as fossil fuel. So, converting nuclear or solar electricity on a mass basis to H_2 is a thermodynamic crime and technical insanity. Any use of H_2 as a substitute for a fossil fuel will increase our dependence on imported oil and gas, as well as increase global emissions. And, no research can change the second law of thermodynamics.

The ill effects of H_2 can be seen from two examples. One is the General Motors (GM) hydrogen car — the so-called clean car. If H_2 is generated by electrolysis of water, which means to a large extent from coal, its overall efficiency is 10% in H_2 cars vs. 35% in conventional vehicles.

H_2-powered cars would increase both greenhouse and smog-forming emissions by a factor of five — a strange definition of clean energy. It violates all safety instructions presently used in the industry, and H_2 is the most dangerous fuel. By fitting a H_2 car with a properly designed release valve and a delayed detonator, it becomes an undetectable suicide bomb, at least four times as large as a suicide bomber can carry.

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There are only two ways to address the problems of global emissions and energy independence — reduce fuel consumption and build thermal solar and nuclear plants. Eliminating gas-guzzling SUVs and forcing everybody to buy a hybrid car would reduce gasoline consumption by a factor of three. The only purpose of the H_2 car that I can see is to divert the attention from this solution.

The second and the only long-term option is to switch to solar and nuclear energy. The U.S. in the southwest has enough sun for all its present energy needs. We have the technology (thermal solar energy with storage) ready to do so in a way that fits the needs of the grid, and we could gradually start today. Most of our energy needs can be met with much higher efficiency by direct use of electricity. Even for private cars, a hybrid car with a plug-in battery good for 50 miles would reduce gasoline consumption by 80%, and more than 90% compared to present cars. In an electric economy, this 10% could be supplied by bio-based gasoline.

The crisis in our society

Why is the H_2 myth so persistent? I believe it fulfills a deep psychological need. We are a society that has for the last 10 years discussed and computed the potential reduction of global warming by switching from coal to natural gas. But, in the last 6 years, when gas prices increased, we closed several gigawatts of combined-cycle power plants, and replaced them with coal-fired power plants. Now, we are faced with global warming.

The U.S. is capable of solving these problems for the next 100 years at an affordable cost. We have the technology, but lack the will to face the costs. Elected officials from both political parties are not willing to allocate funds for tax incentives or subsidies that would make these solutions possible. Instead, we have created a fantasy, that, through research, the costs will become so low that the free market will adopt solutions that require no subsidies or government intervention. Regrettably, this is not realistic. Furthermore, when energy prices increase sufficiently, we will no longer have the 20-yr lead time required to make solar and nuclear energy our major sources of power.

Basic research can create new ideas, and DOE has an excellent record on basic research. However, its mandate is not basic research, but rather technology development that the free market can adopt, which is not a realistic goal. So, since its mandate is not feasible, DOE has created a fantasyland in which learning curves can achieve the impossible and the ideas that are most unlikely to succeed become the most

attractive. Even a $3 billion/yr research program is inexpensive when compared with the expense of meaningful work. Money for research faces much less opposition and gets strong vocal support from the grant-seeking professional community.

Fantasy fuel cells

Take, for instance, fuel cells. The number of "creative" new uses for fuel cells is impressive and still growing. One example is to use them in combined cycle power plants to increase efficiency to 80%. Since conversion to H_2 has an efficiency of 65%, this idea is clearly a nonstarter. If one wants to design efficient combined cycle power plant, the only problem is the cost, with no penalties for emissions, and both global and conventional pollution.

Another myth is the use of fuel cells for distributed energy to private homes and apartment houses, with backup from the power grid. This is an illusion; the cost of providing a connection for a customer to the grid is a function only of location and capacity, and is independent of consumption. Therefore, the charge to the customer should be separated from the connection fee. The only reason this has not become universal is that the small user is subsidized under the present system. Obviously, the total subsidy must remain small, otherwise the system would collapse. Thus, the whole concept that distributed energy can become a large electricity source is a fraud used to promote non-competitive technologies.

But why should the public be subsidizing an obsolete technology whose low efficiency increases the shortage of gas and triples greenhouse gas emissions? We have no system studies on how much uncontrolled distributed energy the grid can accept before it collapses, and how much an uncontrollable input would reduce the efficiency of the other power sources on the grid.

DOE also spends $90 million/yr on solar cell research that, in the absence of a storage mechanism, can make only a negligible contribution to our energy supply. Only $5 million was spent on thermal solar energy, which is cheaper than solar cells by a factor of two to three and, when properly designed, can meet the requirements of the grid and can complement nuclear energy. Nuclear energy is preferable for base power, while thermal solar plants can be designed to be better for intermediate and peak power. But their design can be improved and the cost reduced only by building larger prototypes, which is really doable technology, but not a candidate for long-range research. Apparently, such technologies are not popular in today's climate.

The only way to solve the problem is to add to the mandate of DOE a major program that is similar to NASA's mission to the moon, or now Mars. The mission should be to achieve 50% of our energy from large-scale solar and nuclear energy plants and reduce global emissions by 50% within 20 years. All the basic technology needed is already available. As with NASA, the project director would have to define the specifications and select the best options by choosing among competitive proposals from companies experienced in the design of large plants that meet the requirements of the grid. No project director with a clear mission and a limited budget could afford to waste billions of dollars over a 40-yr period on such nonsense as H_2 fuel cells.

H_2 and fuel cells may have many applications, but they will not solve large-scale energy or pollution problems. To avoid exposing our children to the potential catastrophic effects of global warming or the sudden collapse of our economy, we should abandon the myth of H_2 and other fantasies, and start to solve real problems. CEP

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We Want to Hear From You

What's your opinion about the hydrogen economy — reality or myth? As can be seen above, the ongoing debate regarding the hydrogen economy is highly polarized. As engineers, analyzing the science behind the hydrogen economy is in our nature. Please send your comments to *CEP* and AIChE's Government Relations Committee by one of three ways:

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