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The Hydrogen Hoax

Robert Zubrin

> *"Yes my friends, I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable.... When the deposits of coal are exhausted we shall heat and warm ourselves with water. Water will be the coal of the future."*
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> –Jules Verne, *The Mysterious Island* (1874-5)

Nearly everyone in American politics believes we face an energy crisis, and nearly everyone believes we need a technological solution that will make America "energy independent." Americans are, as President Bush put it in his 2006 State of the Union address, "addicted to oil," and in this case our addiction is enriching and empowering those who seek to destroy us. We are funding, if indirectly, the madrassahs that teach vile hatred of Western civilization and the backward cultures that create death-seeking soldiers for Islam. We are, if unwittingly, arming those who wish to kill us. To cure this self-destructive addiction, the Bush administration has placed a major bet on the so-called "hydrogen economy," both in policy and in rhetoric. Former Energy Secretary Spencer Abraham laid out this vision, in rhapsodic language, in 2002:

> Hydrogen can fuel much more than cars and light trucks, our area of interest. It can also fuel ships, airplanes, and trains. It can be used to generate electricity, for heating, and as a fuel for industrial processes. We envision a future economy in which hydrogen is America's clean energy choice—flexible, affordable, safe, domestically produced, used in all sectors of the economy, and in all regions of the country....
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> Imagine a world running on hydrogen later in this century: Environmental pollution will no longer be a concern. Every nation will have all the energy it needs available within its borders. Personal transportation will be cheaper to operate and easier to maintain. Economic, financial, and intellectual resources devoted today to acquiring adequate energy resources and to handling environmental issues will be turned to other productive tasks for the benefit of the people. Life will get better.

In 2003, President Bush reaffirmed this vision, offering a presidential primer on the scientific, economic, and foreign-policy dimensions of

***Robert Zubrin**, an aerospace engineer, is president of Pioneer Astronautics, a research and development firm. His new book on energy policy will be published in Fall 2007.*

hydrogen power:

> The sources of hydrogen are abundant. The more you have of something relative to demand for that, the cheaper it's going to be, the less expensive it'll be for the consumer.... Hydrogen power is also clean to use. Cars that will run on hydrogen fuel produce only water, not exhaust fumes.... One of the greatest results of using hydrogen power, of course, will be energy independence for this nation.... If we develop hydrogen power to its full potential, we can reduce our demand for oil by over 11 million barrels per day by the year 2040.

It certainly sounds great. Hydrogen, after all, is "the most common element in the universe," as Secretary Abraham pointed out. Since it is so plentiful, surely President Bush must be right when he promises it will be cheap. And when you use it, the waste product will be nothing but water—"environmental pollution will no longer be a concern." Hydrogen will be abundant, cheap, and clean. Why settle for anything less?

Unfortunately, it's all pure bunk. To get serious about energy policy, America needs to abandon, once and for all, the false promise of the hydrogen age.

The New Energy Charlatans

The idea of hydrogen as the fuel of the future dates back to Jules Verne, and by the 1930s was a staple of science fiction. With the advent of nuclear energy after World War II, technologists expected that atomic power would provide electricity "too cheap to meter"—electricity that could be used to produce pure hydrogen at low cost, which could then be used as a fuel. By the 1970s, however, it was apparent that nuclear energy, while potentially competitive with conventional power, did not usher in a new golden age of cheap electricity. Still, researchers devoted to the idea of the "hydrogen economy" soldiered on, and with increased public concern about carbon dioxide emissions in the 1990s and about America's dependence on foreign oil after 9/11, the pro-hydrogen crowd seized a new opportunity to make their pitch. Incredibly, the Bush administration swallowed it, hook, line, and sinker. As a result, over the past six years, billions of dollars have been dished out to national labs, auto companies, fuel-cell firms, and other beneficiaries of government largesse on hydrogen show projects that have no practical application.

The problem with this expenditure is not simply the waste; the government throws away vaster sums on any number of other useless programs all the time. Rather, the real issue is that the myth of the hydrogen economy has masked the administration's total failure to address the nation's vulnerability to energy blackmail. In consequence, despite the obvious relationship between oil dependence and the war with Islamist terrorism, no competent policy for achieving energy security has been put forth. If we are to achieve any progress on this most critical issue, the myth of the hydrogen economy needs to be debunked. It is bad science, bad economics, and bad public policy.

The Real Science of Hydrogen

Hydrogen is only a source of energy if it can be taken in its pure form and reacted with another chemical, such as oxygen. But all the hydrogen on Earth, except that in hydrocarbons, has already been oxidized, so none of it is available as fuel. If you want to get plentiful unbound hydrogen, the closest place it can be found is on the surface of the Sun; mining this hydrogen supply would be quite a trick. After the Sun, the next closest source of free hydrogen would be the atmosphere of Jupiter. Jupiter is surrounded by radiation belts so intense that they are deadly to humans and electronics. It also has a massive gravity field that would severely impair hydrogen export operations. These would also be complicated by the 2.5-year Jupiter-to-Earth flight transit time (during which any liquid hydrogen launched would probably boil away), and the fact that upon reentry at Earth, the imagined hydrogen shipping capsule would face heat loads about eight times higher than those withstood by a space shuttle returning from orbit.

So if we put aside the spectacularly improbable prospect of fueling our planet with extraterrestrial hydrogen imports, the only way to get free hydrogen on Earth is to make it. The trouble is that making hydrogen requires more energy than the hydrogen so produced can provide. Hydrogen, therefore, is not a *source* of energy. It simply is a *carrier* of energy. And it is, as we shall see, an extremely poor one.

The spokesmen for the hydrogen hoax claim that hydrogen will be manufactured from water via electrolysis. It is certainly possible to make hydrogen this way, but it is very expensive—so much so, that only four percent of all hydrogen currently produced in the United States is produced in this manner. The rest is made by breaking down hydrocarbons, through processes like pyrolysis of natural gas or steam reforming of coal.

Neither type of hydrogen is even remotely economical as fuel. The wholesale cost of commercial grade liquid hydrogen (made the cheap way, from hydrocarbons) shipped to large customers in the United States is about \$6 per kilogram. High purity hydrogen made from electrolysis for scientific applications costs considerably more. Dispensed in compressed gas cylinders to retail customers, the current price of commercial grade hydrogen is about \$100 per kilogram. For comparison, a kilogram of hydrogen contains about the same amount of energy as a gallon of gasoline. This means that even if hydrogen cars were available and hydrogen stations existed to fuel them, no one with the power to choose otherwise would ever buy such vehicles. This fact alone makes the hydrogen economy a non-starter in a free society.

And even if you are among those willing to sacrifice freedom and economic rationality for the sake of the environment, and therefore prefer hydrogen for its advertised benefit of reduced carbon dioxide emissions, think again. Because hydrogen is actually made by reforming hydrocarbons, its use as fuel would not reduce greenhouse gas emissions at all. In fact, it would greatly increase them.

To see this, let us consider an example. Let's say you wanted to produce hydrogen. You choose to do it via steam reformation of natural gas, the most common technique used commercially today. The reaction is:

$$CH_4 + 2H_2O \Rightarrow CO_2 + 4H_2 \qquad \Delta H = +59 \text{ kcal/mole} \qquad (1)$$

As the positive enthalpy change indicates, the reaction is endothermic (that is, heat-absorbing) and will need an outside source of energy to drive it forward. This can be obtained by burning some methane, which releases 205 kcal/mole, via the following reaction:

$$CH_4 + 2O_2 \Rightarrow CO_2 + 2H_2O \qquad \Delta H = 205 \text{ kcal/mole} \qquad (2)$$

Assuming an optimistic 72 percent efficiency in using the combustion energy to drive the steam reformation, this would allow us to reform 2.5 moles of methane for every one that we burn (or 5 for every 2). So if we take five units of reaction (1) and add it to two units of reaction (2), the net reaction becomes:

$$7CH_4 + 4O_2 + 10H_2O \Rightarrow 7CO_2 + 4H_2O + 20H_2 \qquad (3)$$

As far as usable fuel is concerned, what we have managed to do is trade seven moles of methane for twenty moles of hydrogen. Seven moles of carbon dioxide have also been produced, exactly as many as would have been produced had we simply used the methane itself as fuel. The seven moles of methane that we used up, however, would have been worth 1435 kilocalories of energy if used directly, while the twenty moles of hydrogen we have produced in exchange for all our trouble are only worth 1320 kilocalories. So for the same amount of carbon dioxide released, *less useful energy* has been produced.

The situation is much worse than this, however, because before the hydrogen can be transported anywhere, it needs to be either compressed or liquefied. To liquefy it, it must be refrigerated down to a temperature of 20 K (20 degrees above absolute zero, or -253 degrees Celsius). At these temperatures, the fundamental laws of thermodynamics make refrigerators extremely inefficient. As a result, about 40 percent of the energy in the hydrogen must be spent to liquefy it. This reduces the actual net energy content of our product fuel to 792 kilocalories. In addition, because it is a cryogenic liquid, still more energy could be expected to be lost as the hydrogen boils away during transport and storage.

As an alternative, one could use high pressure pumps to compress the hydrogen as gas instead of liquefying it for transport. This would only require wasting about 20 percent of the energy in the hydrogen. The problem is that safety-approved, steel compressed-gas tanks capable of storing hydrogen at 5,000 psi weigh approximately 65 times as much as the hydrogen they can contain. So to transport 200 kilograms of compressed hydrogen, roughly equal in energy content to just 200 gallons of gasoline, would require a truck capable of hauling a 13-ton load. Think about that: an entire large truckload delivery would be needed simply to transport enough hydrogen to allow *ten* people to fill up their cars with the energy equivalent of 20 gallons of gasoline each.

Instead of steel tanks, one could propose using (very expensive) lightweight carbon fiber overwrapped tanks, which only weigh about ten times as much as the hydrogen they contain. This would improve the transport weight ratio by a factor of six. Thus, instead of a 13-ton truck, a mere two-ton truckload would be required to supply enough hydrogen to allow a service station to provide fuel for ten customers. This is still hopeless economically, and could probably not be allowed in any case, since carbon fiber tanks have low crash resistance, making such compressed hydrogen transport trucks deadly bombs on the highway.

In principle, a system of pipelines could, at enormous cost, be built for transporting gaseous hydrogen. Yet because hydrogen is so diffuse, with less than one-third the energy content per unit volume as natural gas, these pipes would have to be very big, and large amounts of energy would be required to move the gas along the line. Another problem with this scheme is that the small hydrogen molecules are brilliant escape artists. Hydrogen can not only penetrate readily through the most minutely flawed seal, it can actually diffuse right through solid steel itself. The vast surface area offered by a system of hydrogen pipelines would thus afford ample opportunity for much of the hydrogen to leak away during transport.

As hydrogen diffuses into metals, it also embrittles them, causing deterioration of pipelines, valves, fittings, and storage tanks used throughout the entire distribution system. These would all have to be constantly monitored and regularly inspected, tested, and replaced. Otherwise the distribution system would become a continuous source of catastrophes.

Given these technical difficulties, the implementation of an economically viable method of retail hydrogen distribution from large-scale central production factories is essentially impossible. Because of this, an alternative concept has been proposed wherein methane or methanol fuel would be transported by pipeline or truck, and then steam-reformed into hydrogen at the filling station itself. This would eliminate most of the cost of hydrogen transport, but would increase the cost of the hydrogen itself, since small-scale reformers are less efficient, both economically and energetically, than large-scale industrial units. Also, it is questionable how many service stations would want to buy, operate, and maintain their own steam reforming facility. The station would also need to operate its own 5,000 psi explosion-proof high pressure hydrogen pump, or a cryogenic refrigeration plant, both of which are very unappealing prospects. Such a scheme of distributed production stations would also eliminate any hope of implementing the hydrogen economy's advertised plan to sequester underground the carbon dioxide produced as a byproduct of its hydrogen manufacturing operations. At bottom, the whole idea is ridiculous, since either the methane or methanol used as feedstock at the station to make the hydrogen would be a better automobile fuel, containing more energy, in less volume, at less cost, than the hydrogen it yields.

The idea of producing hydrogen via water electrolysis locally at filling stations is equally preposterous. To see this, consider the following. A kilogram of hydrogen has about the same energy content as a gallon of gasoline, so the owner of a filling station could only expect to obtain the same net income from a kilogram of hydrogen as from a gallon of gas. A reasonable figure for this might be $0.20 per kilogram. To obtain a modest net income of $200 per day from hydrogen sales would therefore require selling 1,000 kilograms per day. Since hydrogen requires about 163,000 kJ/kg to produce via electrolysis (assuming an 85 percent efficient electrolyzer), this means that 163,000,000 kJ = 45,278 kW-hr per day would be required by the station. At current grid power costs of $0.06/kW-hr, this would run the station an electric bill of \$2,717 *per day.* If the electrolysis unit ran around the clock, it would need to be supplied with 1,900 kilowatts of electricity (about a thousand times the power draw of a typical house). This power would need to be supplied by the utility over special heavy-duty lines, and then transformed and rectified into direct current on site for use in the electrolyzer. Electrolyzers use high amp-low voltage power. In this case, at least *several hundred thousand amps* would be required. And the 1,900-kilowatt electrolyzer would not be cheap either. At current prices such a unit would cost the station owner over \$10 million, which mortgaged over thirty years would cost him about \$100,000 per month, assuming it lasted that long. (No one would want to do this, of course, since the same \$10 million invested in five percent bonds would return \$500,000 per year, or seven times the \$200 per day hydrogen sales income under discussion, with no work and no risk.) Then the station owner would still need to buy and operate either a 5,000 psi explosion-proof compressor pump or a cryogenic refrigerator, and build and accept liability for high-pressure or cryogenic hydrogen storage facilities on his properties. Having paid for all that, there would then be the little matter of insurance.

This, as should be obvious, is economic insanity. For just \$6,000 per day, plus insurance costs, you could make \$200, provided you can find fifty customers every day willing to pay triple the going price for automobile fuel. I don't know about you, but if I were running a 7-11, I'd find something else to sell.

The Trouble with Hydrogen Cars

The Queen in Lewis Carroll's *Through the Looking Glass* says that she could believe "six impossible things before breakfast." Such an attitude is necessary to discuss the hydrogen economy, since no part of it is possible. Putting aside the intractable issues of fundamental physics, hydrogen production costs, and distribution show stoppers, let us proceed to discuss the problems associated with the hydrogen cars themselves. In order for hydrogen to be used as fuel in a car, it has to be stored in the car. As at the station, this could be done either in the form of cryogenic liquid hydrogen or as highly compressed gas. In either case, we come up against serious problems caused by the low density of hydrogen. For example, if liquid hydrogen is the form employed, then storing 20 kilograms onboard (equivalent in energy content to 20 gallons of gasoline) would require an insulated cryogenic fuel tank with a volume of some 280 liters (70 gallons). This cryogenic hydrogen would always be boiling away, which would create concerns for those who have to leave their cars parked for any length of time, and which would also turn the atmospheres in underground or otherwise enclosed parking garages into explosive fuel-air mixtures. Public parking garages containing such cars could be expected to explode regularly, since hydrogen is flammable over concentrations in air ranging from 4 to 75 percent, and the minimum energy required for its ignition is about one-twentieth that required for gasoline or natural gas.

Compressed hydrogen is just as unworkable as liquid hydrogen. If 5,000 psi compressed hydrogen were employed, the tank would need to be 650 liters (162 gallons), or eight times the size of a gasoline tank containing equal energy. Because it would have to hold high pressure, this huge tank could not be shaped in an irregular form to fit into the vehicle's empty space in some convenient way. Instead it would have to be a simple shape like a sphere or a domed cylinder, which would make its spatial demands much more difficult to accommodate, and significantly reduce the usable vehicle space within a car of a given size. If made of (usually) crash-safe steel, such a hydrogen tank would weigh 1,300 kilograms (2,860 pounds)—about as much as an entire small car! Lugging this extra weight around would drastically increase the fuel consumption of the vehicle, perhaps doubling it. If, instead of steel, a lightweight carbon fiber overwrapped tank were employed to avoid this penalty, the car would become a deadly explosive firebomb in the event of a crash.

While hydrogen gas can be used as a fuel in internal combustion engines, there is no advantage in doing so. In fact, hydrogen reduces the efficiency of such engines by 20 percent compared to what they can achieve using gasoline. For this reason, nearly all discussion of hydrogen vehicles has centered on power systems driven by fuel cells.

Fuel cells are electrochemical systems that generate electricity directly through the combination of hydrogen and oxygen in solution. Essentially electrolyzers operating in reverse, they are attractive because they have no moving parts (other than small water pumps), and under conditions where the quality of their hydrogen and oxygen feed can be perfectly controlled, they are quite efficient and reliable. These features have provided sufficient advantages to make fuel cells the technology of choice for certain specialty applications, such as the power system for NASA's Apollo capsules and the space shuttle.

Yet despite their successful use for four decades in the space program, and many billions of dollars of research and development funds expended over the years for their improvement and refinement, fuel cells have thus far found little use in broader commercial applications. The reasons for this are threefold. First, in ordinary terrestrial applications, a practical power system must last years, not just the few weeks required to support a manned space flight. Second, on Earth, the oxygen supply for the fuel cell must come from the atmosphere, which contains not only nitrogen (which decreases the fuel cell efficiency compared to a pure oxygen source), but carbon dioxide, carbon monoxide, and many other pollutants. Even in trace form, such pollutants can contaminate the catalysts used in the fuel cells and cause permanent degradation, ultimately rendering the system inoperable. Finally, and decisively, fuel cells are very expensive. For NASA, which spends hundreds of millions of dollars on every shuttle launch, it makes little difference if its 10 kilowatt fuel cell system costs $100,000, a million dollars, or ten million dollars. For a member of the public, however, such costs matter a great deal.

There are many kinds of fuel cells, including alkaline, phosphoric acid, and molten carbonate systems, but for purposes of motor vehicle use the only kind that is suitable and being pursued for development is the proton exchange membrane fuel cell (PEMFC). These, for example, are the kind used by all vehicle fuel cell engines manufactured by the Ballard Power company, of Vancouver, British Columbia, which for the past decade has produced nearly 80 percent of all fuel cell engines worldwide.

PEMFCs use a platinum catalyst, which is very expensive, and despite billions of dollars of R&D efforts to reduce the amount required, it has proven impossible to cut the cost of such systems below about $7,000/kW. This is very unfortunate, because an electric car with a 100-horsepower motor needs about 75 kilowatts of electricity to make it go. At this price, the cost *for just the fuel cell stack* powering the car would be about half a million dollars. Actual costs for *complete* Ballard fuel cell engine systems have been well over a million dollars each. Then there's still the rest of the car to pay for, although with the propulsion system costing this much, the additional cost would seem like a rounding error.

That, however, is not even the worst of it. Operating under road conditions in the real atmosphere, which contains such powerful catalyst poisons (chemicals that will reduce the effectiveness of the fuel cell) as sulfur dioxide, nitrogen dioxide, hydrogen sulfide, carbon monoxide, and ammonia that can permanently incapacitate a PEMFC, the operating lifetimes of fuel cell stacks have been shown to be less than 20 percent those of conventional diesel engines. As the trenchant industry analyst F. David Doty pointedly put it:

> We're still waiting to see a fuel-cell vehicle driven from Miami to Maine via the Smoky Mountains in the winter—even one time, with

> a few stops and restarts in Maine. Then, we need to see one hold up to a forty-minute daily commute for more than two years (preferably at least fifteen years) with minimal maintenance, and come through a highway accident with less than $200,000 in damages.... When lifetime and maintenance are considered, one can argue that vehicle-qualified PEMFCs are currently 400 times more expensive than diesel engines.

It is true that the costs of PEMFC might conceivably be reduced over time due to technology improvements (although no real cost reduction has been achieved over the past decade despite several billion dollars in research investment). Moreover, if somehow the vehicles ever went into mass production, increased demand would likely drive the price of the platinum they contain, and thus the overall system cost, through the roof.

Taken together, the outrageously high costs of fuel-cell cars and hydrogen fuel, combined with the non-existence of a hydrogen distribution and sales infrastructure, and the danger to life and limb involved in driving around a vehicle containing a crash-detonatable hydrogen gas bomb, make the possibility of mass consumer purchases of hydrogen fuel-cell vehicles a non-starter. But let's say some benevolent government bureaucrat with a great deal of your money decided to spend $700 billion to buy, at $1 million each, 700,000 PEMFC powered vehicles (this would represent about four-tenths of one percent of the total U.S. automobile fleet), and then another $300 billion to establish a hydrogen distribution infrastructure. Wouldn't we at least get some environmental benefit for our trillion bucks?

No, we would get no benefit at all. As discussed above, hydrogen is actually produced commercially using fossil fuel energy, much of which is lost in the process, meaning that more fossil fuels need to be burned, and thus more carbon dioxide produced, to provide a vehicle with a given amount of energy using hydrogen than if the vehicle were allowed to burn fossil fuels directly. Even if we ignore costs completely and generate hydrogen for vehicle fuel using water electrolysis, that would also *increase* pollution, since most electricity is actually generated by burning coal and natural gas. Even if the electricity in question came from nuclear, hydro, wind, or solar power, wasting it on hydrogen generation would still increase overall carbon dioxide emissions relative to the alternative of simply putting the power into the grid.

Furthermore, despite all their cost and hype, the fuel cell vehicles themselves offer no increase in efficiency relative to more conventional systems. (In this context, "efficiency" means the percentage of energy in the fuel that is spent on actual work rather than wasted.) While the theoretical efficiency of a hydrogen/oxygen fuel cell approaches 85 percent, the actual efficiency of real PEMFC stacks using hydrogen and air near maximum output (where they must operate, because fuel cell capacity is so expensive) is about 38 percent. If we then factor in an estimated efficiency for the power electronics of 92 percent and a real-world motor efficiency of 85 percent, we obtain an estimate of about 30 percent efficiency for a fuel-cell vehicle. Ordinary internal combustion engine cars can already match this, with systems offering up to 38 percent efficiencies well in sight. Conventional diesel engines operate *today* at about 42 percent efficiency. With variable valve timing, they should be able to attain 58 percent efficiency. That's nearly *twice* the efficiency offered by a fuel cell vehicle, at 1/400th the cost.

Despite these inconvenient facts, the U.S. Department of Energy has continued to hand out billions of dollars of the taxpayers' money to major auto companies and their fuel-cell development partners to produce hydrogen-powered auto-show display vehicles. The agency issues repeated predictions claiming that tens of thousands of these cars will soon be appearing on America's highways, when in fact the Department's past projections of the growth of hydrogen vehicles have all been at least two orders of magnitude higher than reality. As a result, stocks in all the major fuel-cell companies, pumped high by such hype at the expense of naïve investors, are currently selling at less than one-tenth their peak values. Eventually, real markets catch up with reality; hype and hoaxes can only take us so far.

A Real Energy Solution

The problem, however, is not simply economic but political, and the reality check on politicians is not always so swift or so reliable. The longer we buy into the hydrogen hoax, the longer we will avoid developing an energy policy that truly serves America's interests—economic, environmental, and geopolitical. Fortunately, on this front, there is good news, if only we have the will to be serious. Ethanol and methanol are practical liquid fuels that can be handled by the existing fuel distribution infrastructure and produced at prices roughly competitive with gasoline. During 2006, for example, methanol was selling at unsubsidized prices as low as $0.80 per gallon, equivalent on an energy basis to gasoline at $1.50 per gallon. As a path toward energy security, methanol is also extremely attractive, since it can be made from any kind of biomass, coal, natural gas, or municipal waste—resources plentiful in the United States and many other non-OPEC nations. Unfortunately, however, the vast majority of cars on the road cannot use it.

What is needed is government action to break the vertical monopoly on the automobile fuel supply currently held by the petroleum cartel. This could most efficiently be done simply by mandating that all new cars—whether of foreign or domestic manufacture—sold in the United States be "flex-fueled." Such cars, which can run on any mixture of alcohol or gasoline, are currently being produced in the United States for little more (typically an extra $100 to $200) than the same vehicles in non-flex-fueled form. But they only command about 3 percent of the market, because there are so few high-alcohol gas pumps to serve them. Conversely, the reason why there are few high-alcohol pumps is because there are not enough flex-fuel cars on the road to warrant them. If you own a fuel station with three pumps, you are not going to waste one distributing a type of fuel that only 3 percent of cars can use.

Yet within three years of a flex-fuel mandate, there would be at least 50 million cars on the road in the United States capable of using high-alcohol fuel, and at least an equal number overseas. This would be a sufficient market to create a widespread network of high-alcohol fuel pumps. Moreover, this dramatically increased demand for alcohol fuels would greatly exceed the supply capacity of American corn-ethanol producers, which means that we could drop our current tariffs against Latin American sugar-ethanol. A similar circumstance would pertain in Europe and Japan, enabling the elimination of their protectionist measures against Third World agricultural imports. This would solve the problem of trade barriers against farm products that scuttled the recent Doha round of international trade talks, thus benefiting rich and poor nations alike.

By simply exposing the oil cartel to competition from such alternative fuel sources, we could impose a powerful constraint on its ability to run up prices. Combined with an unrelenting tariff policy favoring alcohol over imported oil, we could destroy OPEC completely, and effectively redirect over $600 billion per year that is now going to the treasury of terrorism to the global agricultural and mining sectors. Instead of sending our money to the Islamists to spread fanatical ideology, we could give our business to the world's farmers, coal miners, and other people who actually work for a living. Instead of selling off blocks of stock in Western media companies to Saudi princes, we could be selling tractors to Honduras. Instead of funding terrorism, we could be using our energy dollars to finance world development. That's what a serious energy policy would look like.