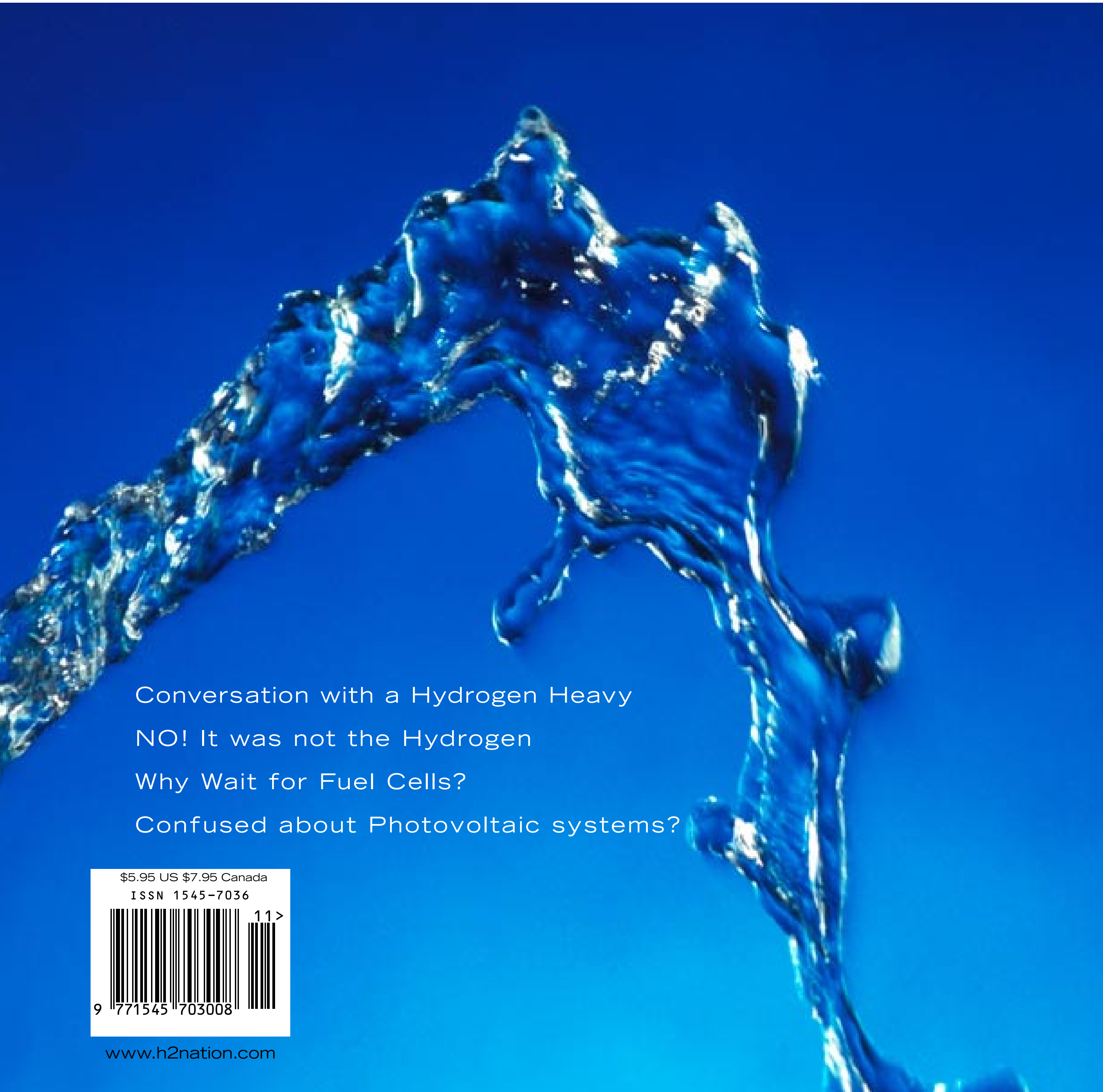
YOUR GUIDE TO THE HYDROGEN ECONOMY

H2Nation

Hydrogen / Solar / Wind Energy

Vol. 1 Issue 1 Nov/Dec 2003



Conversation with a Hydrogen Heavy

NO! It was not the Hydrogen

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Confused about Photovoltaic systems?

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Someday, you will produce your own fuel!

Someday, you will produce your own electricity!

Someday, their source will be clean!

Someday?

H2Nation Premier

Features

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Welcome To H2Nation Magazine

The magazine you now hold has been created with the impassioned hope that it will serve as a catalyst to help you, our nation, and others in the world, make the decisions necessary for, and the transition into a new, renewable, and less politically-charged, energy future. Combining the efforts of our readers, editors, and advertisers, we will work together toward an energy future based on hydrogen; hydrogen derived from our own abundant resources: wind power, solar in its many forms,and bio fuels from farmers and producers throughout this land.

In a letter to President Bush dated August 29, 2001, Prince Abdullah of Saudi Arabia wrote: "A time comes when people and nations part. We are at a crossroad. It is time for the United States and Saudi Arabia to look for separate interests."

We concur in that statement. The conclusion of the war with Iraq notwithstanding, it is imperative that we in America make some tough, long-term, political decisions regarding our presence in the Middle East, and our choice of energy sources.

Because oil and other fossil fuels have been in use for more than one hundred years, and during that time have become embedded and entrenched in nearly every aspect of our nation's life, the transition to the exclusive use of hydrogen and other renewable energy may be a difficult one. The visionary, Arthur C. Clarke, has said: "In this inconceivably enormous universe, we can never run out of energy or matter. But, we can all too easily run out of brainpower."

It is the goal of H2Nation to serve as a road map for all those interested in contributing an "unlimited source of brainpower" toward our arrival at a common, final destination. We will serve as a conduit between those who produce, develop, design, or sell renewable energy devices and products, and those who desire to purchase and use them. Each issue will focus on the latest innovations in our renewable energy challenge.

Our editorials and feature articles will give you hands-on information and tools for practical use. We hope the information we provide will help eliminate any fear and reluctance that some may feel upon being introduced to a new and dynamic technology. It is hoped that you will go forward with confidence, using H2Nation as a constant reference and welcome companion in our mutual journey on the renewable energy highway. We hope you enjoy this premier issue.

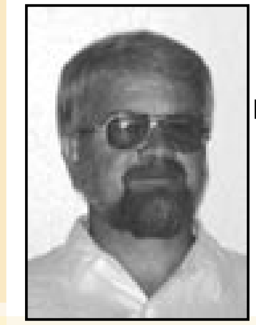
We look forward to your contributions and suggestions.
H2Nation Staff

Contributing Writers

John Addison

The Answer My Friend p.54

John Addison is president of OPTIMARK Inc. and a board member of the California Hydrogen Business Council. He is the author of the book, "Revenue Rocket."



Lawrence Elliott

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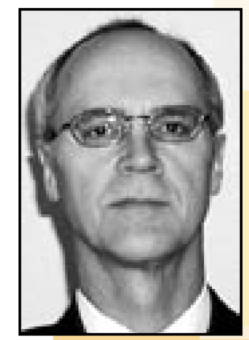
Involved in renewable energy since 1974. Wind, solar thermal,solar electric system designer. Mechanical/Electronic Engineering training. Active in design and research of fuel cell and hydrogen systems for last 10 years. Owner Ion Technologies, a fuel cell/renewable hydrogen integration and sales company. Frequent contributor to renewable energy publications



Bob Willis

The Hydrogen Fuel Cell vs. Internal Combustion Engine Debate p.38

Dedicated to bringing about the Renewable Hydrogen Economy, Bob Willis works as a volunteer for Hydrogen Now!, a non-profit organization dedicated to promoting renewable hydrogen. He also provides consulting services for start up hydrogen and renewable energy businesses.

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H2U

The Institute of Hy-er Learning

In this issue, we look at the basic bits of information one will need to replace conventional fossil fuels with hydrogen.

"How do you measure hydrogen volume and energy content relative to gasoline or diesel fuel?"

For now we will concentrate on gaseous hydrogen, but in future articles we will include liquid hydrogen and metal hydrides.

A common question from many is: "How do you measure hydrogen volume and energy content relative to gasoline or diesel fuel?" Most of us think in terms of miles per gallon. We fill up at the pump and expect to drive a specific number of miles; however, when it comes to hydrogen we have less confidence in our expectations. It is hoped that this article will help with your calculations.

Hydrogen as a gas is the lightest element in the universe. In terms of energy density, or the amount of usable energy for a given weight, it is better than any other fuel. In terms of energy density for a given cubic foot, or cubic meter, or other measure of volume, hydrogen has a low density. So, for storage we will need either a very large tank at atmospheric pressure (known in engineering terms as "1 bar") or we will have to compress the hydrogen to get more fuel into a smaller space.

To make our calculations easier we will use a common unit of energy measurement for all our fuel comparisons, thanks to the 18th century British who designed a method of measuring how much useful work a given ton of coal could perform when delivered to steam engines. They called it a BTU or British Thermal Unit, and defined it as the amount of energy or heat needed to raise one pound of water one degree Fahrenheit. Gasoline contains approximately 127,000 BTU's per gallon. Diesel fuel does better at about 134,000 per gallon. Hydrogen in its gaseous form contains about 74,000 BTU's per pound.

Gasoline and diesel each weigh about 6.5 pounds per gallon. At room temperature and 1 bar (atmospheric pressure at sea level or 14.7 pounds per square inch) hydrogen weighs about .052 pounds per cubic foot or .520 pounds per hundred cubic foot. In order to calculate the size of a tank we will need for a vehicle, we must first convert our hydrogen to a unit of measure that is approximately equivalent to that of a gallon of gasoline. We need a workable ratio.

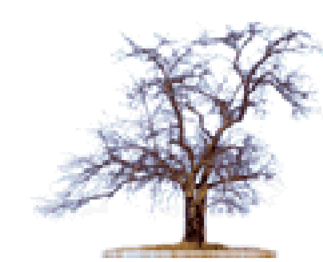
Since 100 cubic feet of hydrogen has about 32,000 BTU's and gasoline has about 123,000 BTU's per gallon, we will divide the gasoline by the hydrogen, or 123,000/32,000, and come up with 3.8. We will need 3.8 x 100 cubic feet or 380 cubic feet of hydrogen to equal one gallon of gasoline. At a little over a half-pound per hundred cubic feet, hydrogen will weigh just under two pounds when compared to a gallon of gasoline weighing 6.5 pounds per gallon. For those more familiar with the metric system, 1kg of hydrogen is equal, approximately, to one gallon of gasoline. These are just rough figures that if done in engineering terms would be more precise; however, as they are, they will keep us from having to get too technical.

The weight difference may seem like a big advantage for hydrogen, but in reality it is not. The gallon of gasoline can be contained in a lightweight tank because it is not pressurized and the small volume is very energy dense. Let's assume we want to haul our 380 cubic feet of hydrogen at the same pressure as gasoline. If we build a rectangular tank as long as the car (maybe 12 feet) and just as wide (maybe 5 feet) and we make it 2 feet tall, we could haul about 120 cubic feet which is less than half of the volume we need. Even if we construct a tank six feet tall, we will still be short of our 380 cubic feet needed to equal a gallon of gasoline. When the tank needed to haul the equivalent of one gallon of gasoline is bigger than the entire car it can be seen that this is not very practical.

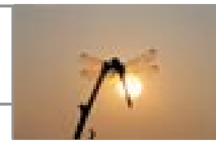
One solution? Compress the hydrogen. Let's assume we want to carry about 15 gallons of gasoline-equivalent which is about average in most vehicles. That means we will need about 5700 cubic feet of hydrogen or 380 (equivalent to 1 gallon of gasoline) cubic feet times 15. We know the cubic volume needed and we can assume 3600 psi for now. These tanks are commercially available and won't break most budgets. So let's pick a tank. To keep it simple we will use a tank that can hold at least 15 gallons. Most engineers don't like to complicate the design process, so they have developed what are known as constants, and these are used in many mathematical equations to help reduce complexity. Luckily for us, we have a constant we can use that allows us to calculate our cubic volume of hydrogen when only gallons and pressure are known elements. Volume as gallons times pressure in bars multiplied times the constant .1337 will give us a close approximation of the amount of hydrogen or other gases contained in our tank. The word bar described in the equation is just another constant that represents one atmosphere of pressure at sea level or 14.7 psi. Now we simply need to divide our required pressure of 3600 psi by 14.7 to obtain our number of bars, customarily rounded to 250 bar. We had estimated our needs at 5700 cubic feet, so let us see if a 15 gallon tank is large enough. Fifteen gallons times 250 bar times .1337 calculates out to approximately five hundred and one cubic feet. This falls short of our required capacity by a factor of ten.

These numbers are approximations, because increasing temperatures encountered when filling high-pressure tanks play a role in our total capacity. Also, this reveals something that is all too obvious to hydrogen systems designers and that is: storing energy in the form of hydrogen (in comparison to what we all take for granted when dealing with gasoline) is a challenge.

That does not mean that these challenges cannot be overcome. In later articles we will look at many forms of hydrogen storage, metal hydrides, and liquid hydrogen, all of which present not only additional challenges, but also great opportunities. ❂



LETTERS



Timothy from Chicago, Illinois, wrote in the Comments section of our website:

I want to use hydrogen to heat and power homes that I want to build. I know they have the technology--but after reading and requesting more info/data on working units or kits--they seem to be evasive or clam up. What's the deal? I am a producer, if I get the right data and funds, like so many other people, I am ready and willing to start regular use of separating and using hydrogen to power homes. Where can I get needed data/ costs?

And our Senior Science Editor answered:

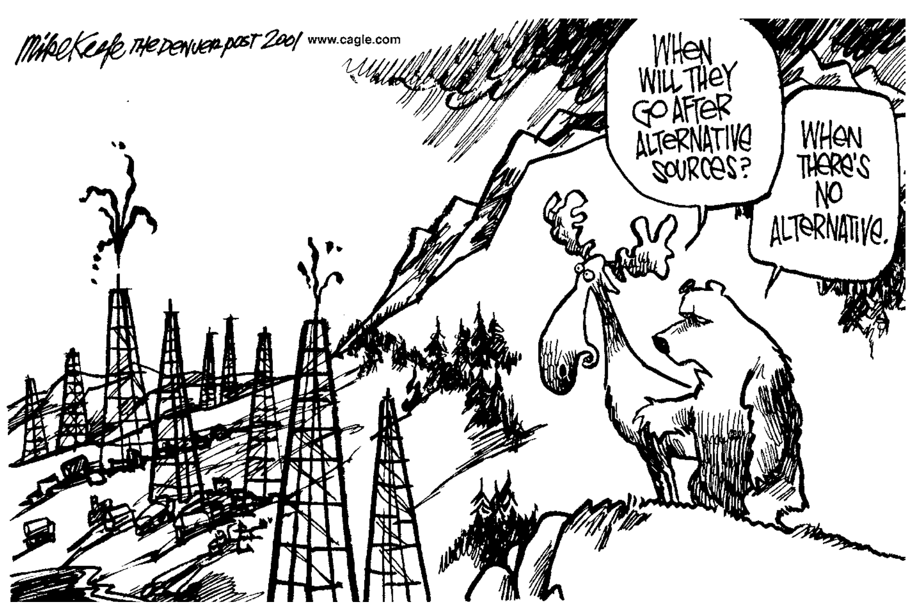
Hello Timothy.
You are not alone in your frustration regarding what appears to be a lack of concrete information about, or pricing of, equipment for the production and use of hydrogen.

I am not aware of any company that has commercial equipment available for common use that is "clamming up" as you say, or is unwilling to sell to the open market. The goal of any company is to make a profit, so I think what you and others may be seeing at the present time is the development of a brand new industry that must first perfect the technology, then try to find the proper market with marketing strategies to follow. Hydrogen used in anything other than industrial settings is something new and many safety and performance issues must be worked out before this equipment is readily available for public purchase. The primary goal for H2Nation Magazine, now and in the future, will be to showcase products that are commercially available so that potential consumers such as you can make informed choices. These technologies will then enter the mainstream.

Bill from Ashville, North Carolina, wrote:

Hello, H2Nation: Just visited your web site and I'm thinking about buying a subscription. I do have a question first though. I see that your magazine is listing hydrogen and fuel cells as well as some renewable energy sources like wind and solar power. I am more interested in hydrogen that can be made from these sources rather than from natural gas or something else that is a fossil fuel. Is this the type of article you will be carrying? Thanks

Yes, Bill, our magazine will be focusing on hydrogen derived from renewable forms of energy. We will also have regular coverage of what is going on in the "renewables" industry, and we'll be featuring articles about individuals or groups making use of renewables in many forms: solar, wind power, bio mass and others. We feel that the ultimate goal should be renewably derived hydrogen for fuel cells, internal combustion engines, etc. We also realize that initially much of the hydrogen production will remain fossil fuel derived simply because of its cost advantage. If this nonrenewable hydrogen helps to build a bridge between our current energy use and that of future renewables in a more orderly, cost effective and especially rapid fashion, then we feel coverage of all forms of hydrogen development is warranted. It is of primary importance that the technical and cost issues associated with fuel cells, hydrogen storage and distribution be solved. There is no reason we can't follow dual paths in pursuit of these goals.



Hello from Plymouth Minnesota. I really like your web site and I hope you are successful. I do have one question if you can answer it. Can hydrogen be produced that can substitute for the propane gas I now have to use? Is it the same?
Thank you. Jan Osterhaut.

Thank you, Jan, for the compliments on our new web site. Glad you like it.

The answer to your question is: " yes, you can produce hydrogen using electrolysis powered by various sources, and in many cases hydrogen can be used as a substitute for propane." The issue here is that hydrogen is more energy carrier or storage medium than energy source. Hydrogen can be a direct substitute for propane, but you must look at the total overall energy input versus output. In a case where hydrogen would be produced using renewables, it might be far more efficient and cost effective to use the original power directly rather than first converting to hydrogen. Only a careful design review and proper planning will determine this issue. In future articles we will be explaining how renewables and hydrogen should be combined, focusing on overall efficiency and practicality of use.

Dear H2Nation. I am a science teacher and would like to know if your magazine will have anything about hydrogen and fuel cells that students will find interesting.
Allen.......... Sun Valley .Idaho

Dear Allen: One of our primary goals in publishing this magazine is to educate. In the future, we will be supplying articles and information that both students and teachers will find informative and interesting.

Q&A

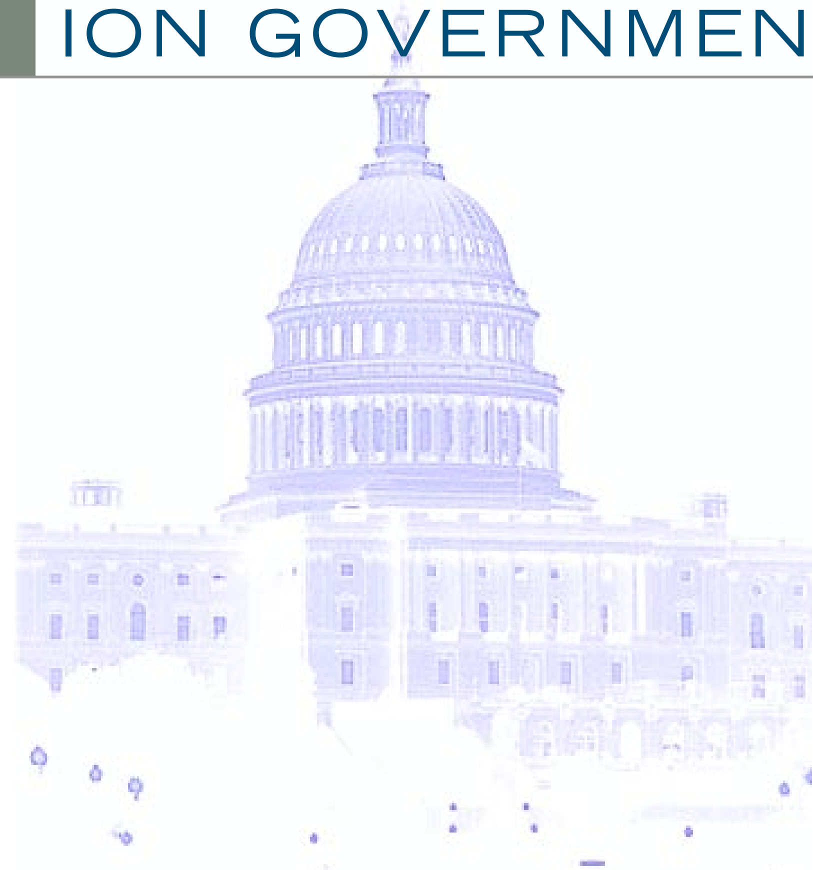
How is hydrogen produced?
Most of the hydrogen produced in the United States is made by steam reforming of natural gas, which is currently the most cost-effective way to produce hydrogen. There are many other ways to produce hydrogen, including electrolysis.

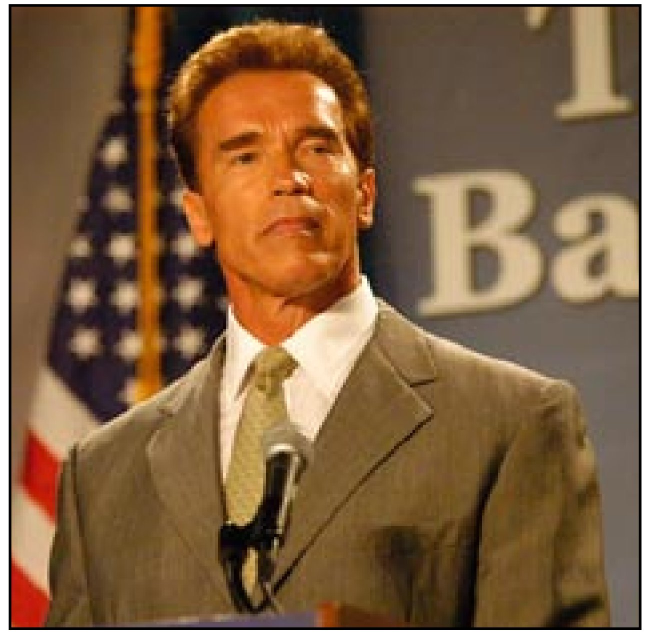
How does an electrolyzer produce hydrogen from water?
An electrolyzer uses an electric current to separate water into its components, hydrogen and oxygen. The electricity enters the water at the cathode, a negatively charged electrode, passes through the water and exits via the anode, the positively charged electrode. The hydrogen is collected at the cathode and oxygen is collected at the anode.

How much water is used to make hydrogen?
Electrolysis does not require significant amounts of water. The hydrogen extracted from a gallon of water using a hydrogen generator could drive a hydrogen fuel cell vehicle as far as gasoline vehicles travel today on a gallon of gasoline.

How much energy is required to produce hydrogen via electrolysis of water?
The energy required to produce hydrogen via electrolysis (assuming 1.23 V) is about 32.9 kW-hr/kg. A kilogram is about 2.2 lb. For 1 mole (2 g) of hydrogen the energy is about 0.0660 kW-hr/mole.
Because a Watt is Voltage x Current, this is equivalent to Power x Rate x Time. The power in this case is the voltage required to split water into hydrogen and oxygen (1.23 V at 25°C). The rate is the current flow and relates directly to how fast hydrogen is produced. Time, of course, is how long the reaction runs. It turns out that voltage and current flow are interrelated. To run the water splitting reaction at a higher rate (generating more hydrogen in a given time), more voltage must be applied (similar to pushing down on the accelerator of a car; more gas is used to make the car go faster.) For commercial electrolysis systems that operate at about 1 A/cm^2, a voltage of 1.75 V is required. This translates into about 46.8 kW-hr/kg, which corresponds to an energy efficiency of 70%. Lowering the voltage for electrolysis, which will increase the energy efficiency of the process, is an important area for research.

Are there any hydrogen filling stations in the U.S. Today?
Yes. Currently, there are filling stations at the SunLine Transit Agency near Palm Springs, California; the California Fuel Cell Partnership in Sacramento, California; and the City of Las Vegas, Nevada. Plans are also in place to open several more over the next 2-3 years throughout the U.S.





AMERICA LOVES HEROES.

In an iconic society such as ours, we are always looking for a hero to save us, to lend support to new ideas and lofty goals. "The Hydrogen Economy" has been promoted as an alternative to our present fossil-fuel-based economy for years. Leaders at many levels in our society have worked hard to make the "Hydrogen Economy" a reality to no avail. Acceptance by the public has been slow to non-existent. However, in California an icon has arisen who may change it all.

Arnold Schwarzenegger talks to supporters at a Carpenteria,CA rally. Speakers included (left to right) Gene Johnson of Bakman Water and Terry Tamminen of Environment Now

Now that Arnold Schwarzenegger has been elected by an overwhelming majority, it appears he has been given a mandate to bring about changes in California politics. It is conceivable that he could change the way citizens of California (and possibly all Americans) will fuel their vehicles. Two weeks prior to his recent election, candidate Arnold Schwarzenegger gave a speech in Carpenteria, California, that was one of his best, and in many ways, his most important. With the off-shore oil rigs of the Santa Barbara Channel as his back-drop, he laid out his plan to establish hydrogen fueling stations every twenty miles along major California highways. He announced his plan to convert his Hummer to hydrogen fuel use instead of gasoline.

Governor Schwarzenegger's program for building hydrogen fueling stations is called the 2010 Initiative, indicating 2010 as his goal year for completion of all the California hydrogen fueling stations. His leadership, at this early stage, may already have had an impact upon our neighbors to the north.

The government of Canada recently announced that a $215 million dollar investment will be made to extend Canada's emerging hydrogen economy. Alan Rock, Minister of Industry, and Herb Dhaliwal, Minister of Natural Resources, have expressed an interest in using some of this investment to build hydrogen fueling stations from British Columbia to their border with Washington State. It is hoped that Washington and Oregon will then continue this development and eventually link up with those stations in California.

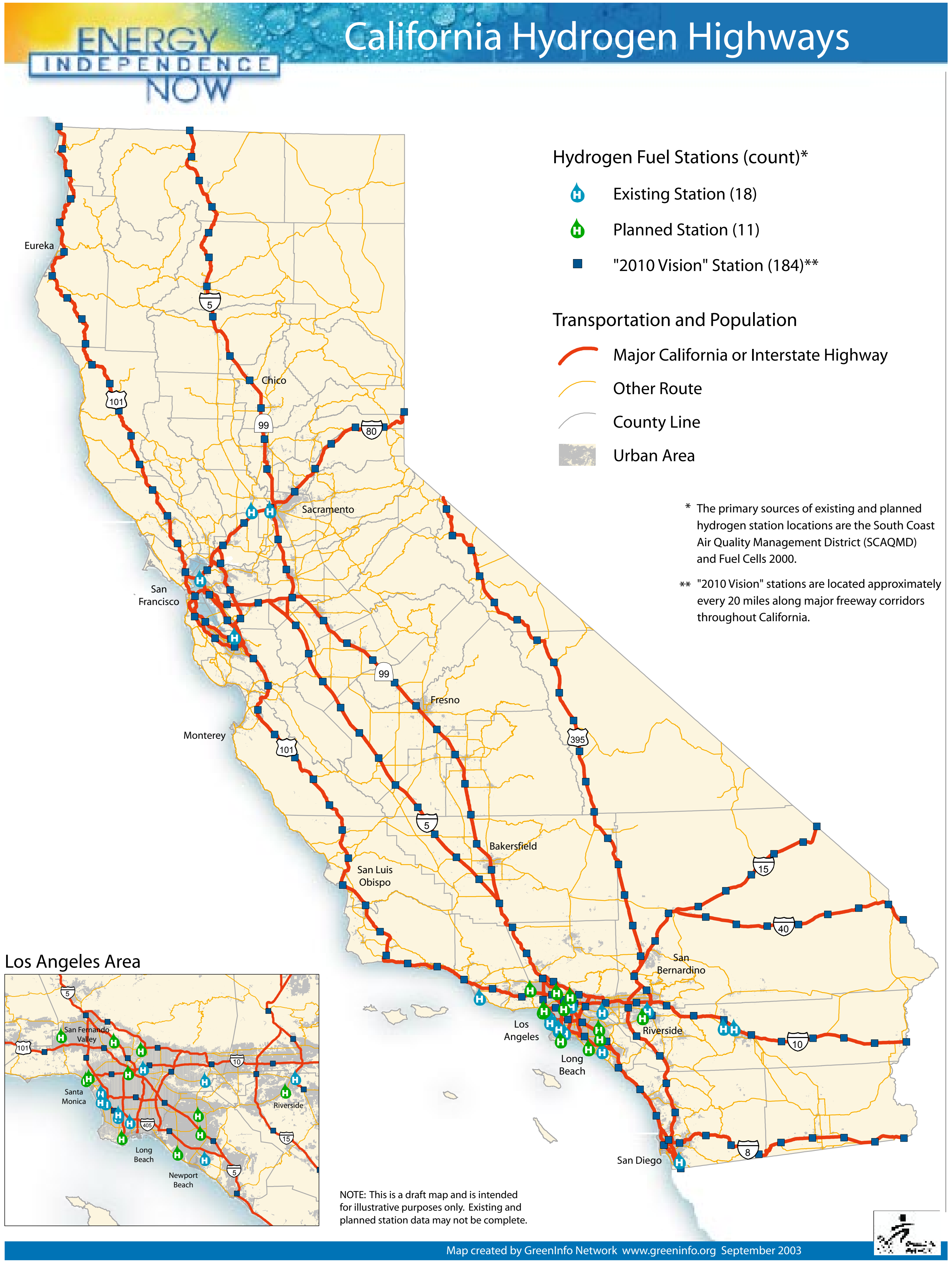
As the new governor of California begins his official duties, there are few hydrogen stations in his state. Those that do exist are simply demonstrators and not true commercial stations. It is a certainty that the governor will want convenient stations at which to fill his Hummer. This will require not only a willingness on the part of the state to help fund this project, but will require private investment both in the stations and in the equipment necessary for supplying the hydrogen; and that will surely help relieve some of California's unemployment problems.

Walter W. "Chip" Schroeder is the CEO of Proton Energy. This Connecticut company may have the key to supplying hydrogen production equipment. They say: "Our core technology transforms electricity into hydrogen fuel." And further quoting them: "What the Schwarzenegger team recognizes is that Proton's products enable the use of hydrogen as a non-depleting and non-polluting fuel for cars and in distributed energy applications to supplement our over-stressed electric power systems."

Hydrogen planned as fuel for converted Hummer

The need for electricity to generate the hydrogen and do it in a non-polluting manner will also have benefits for the California economy. New installations of solar electric power systems will boost employment in both installation and design in addition to increasing production in many of California's existing photovoltaic manufacturing plants. Much of the production from present and planned wind projects can supply power and also generate additional employment.

The changes that Governor Schwarzenegger proposes are nothing short of monumental, both in our fueling habits and in how we view our energy future. California has a huge budget deficit and the U.S. has an ever-increasing trade deficit, fueled in large part by our dependence on imported foreign oil. By developing the "Hydrogen Highway" in California, and then across our entire continent, giant steps could be made toward alleviating unemployment and our trade and budget deficits. We hope Governor Schwarzenegger will get the help he needs to make the "Hydrogen Economy" a reality. We owe it not only to ourselves, but to all future generations.✪



Map courtesy of energyindependencenow.com

"Build a better mouse trap and the world will beat a path to your door"

When Fuel Maker of Toronto, Canada, and American Honda Motors teamed up to deliver a new product, mouse traps may not have been on their minds, but perhaps folks the world over will be "beating a path" to their cleaner automotive fuel and delivery system.

Fuel Maker has been manufacturing a line of natural gas boost compressors since 1989. They take low pressures commonly supplied by natural gas lines and increase them to pressures that allow the use of natural gas in fork lifts and other applications that normally use propane gas. Emissions in warehouses and factories are greatly reduced using this method and now it looks like that same advantage will be coming to homeowners who choose natural gas to power their automobiles. The complete unit is appropriately named Phill.

This compressor that hangs on your garage wall will soon be available for a projected retail cost of $1000. It will allow a slow filling of compressed natural gas tanks to high pressure while you sleep. Typical times are less than 5 hours. A connection to a 110 volt outlet and a connection to your existing natural gas line will be all you need to complete an installation.

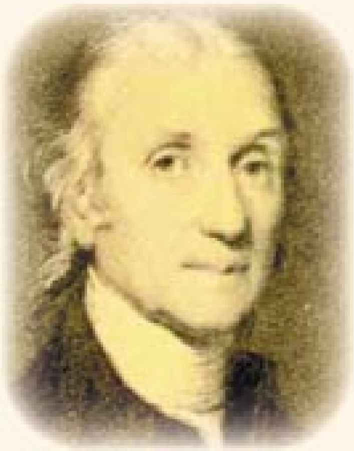
Honda has plans to supply these units for fueling the Civic GX. With its 1.7 liter 4 cylinder engine, driving performance on natural gas should be comparable to the gasoline model. Range on one fill-up is projected to be 220 miles. EPA standards rate this vehicle as a SULEV which is the cleanest emission standard. Full introduction is expected in 2004.

Honda's willingness to take a chance on an entirely new fueling system and products such as Phill, modified to compress hydrogen, could possibly make the present hydrogen infrastructure problem moot. Hydrogen produced at home or at commercial sites from renewable sources of energy such as photovoltaic panels could be compressed and delivered in the same manner as natural gas. It is hoped that Fuel Maker or other manufacturers will begin to supply hydrogen fueling hardware that is adaptable to non-centralized fuel production and processing applications.

Several auto manufactures are now developing vehicles that are tuned to operate from hydrogen fuel. The lower energy density of hydrogen versus natural gas is an issue when range is considered.

However getting the early adopters in our economy to feel comfortable with home fueling is a first step to securing enough empirically derived designs and modifications to make the hydrogen fueling of vehicles far more common than it is now. American Honda and Fuel Maker are to be applauded in their efforts to think outside of the box and bring innovative products to market that will assure us all a cleaner future.

Fast Facts



Henry Cavendish

Hydrogen Facts

Origin of the name: Hydrogen
From the Greek words "hydro" and "genes" meaning "water" and "generator"
1766–Renowned English chemist and physicist Henry Cavendish was the first to recognize hydrogen gas as a distinct substance. He also described the composition of water as a combination of hydrogen and oxygen.

Christian Friedrich Schoenbein

Fuel Cell Facts

1838-The first fuel cell effect was discovered by the Swiss professor Christian Friedrich Schoenbein (1799 – 1868) from the University of Basel.
1839-Sir William Robert Grove, a Welsh judge, inventor and physicist conceived the first "gas battery", now better known as the "fuel cell".

Edmund Becquerel

Photovoltaic Facts

1838-At the age of nineteen, physicist Edmund Becquerel, was the first scientist to publish observations about this natural 'photovoltaic' phenomenon of materials.
1883-Inventor Charles Fritz created a solar cell that produced usable electricity from sunlight .
1954-Bell Laboratories experimentation with semiconductors unexpectedly invented the first practical solar modules

No! It was Not the Hydrogen

By Larry Elliott

A powerful, spring thunderstorm has just moved through the mid-Atlantic states from Maryland on through Maine, leaving behind a cool, steady drizzle and an occasional lightning flash. It is May 6, 1937. Bucking head winds all the way across the Atlantic and running behind schedule, the world's largest flying object slowly moves southwesterly toward a small, rain-soaked airfield just outside Lakehurst, New Jersey.

The Hindenburg resting in its Hanger

The captain, Max Pruss, is anxious to get the Zeppelin LZ129 tied down and secured. As the airship floats one hundred feet above the ground, tie down ropes are lowered to the waiting ground crew. In a few minutes the passengers and crew should be safely on the ground; but, before they can disembark, a fire breaks out at the rear of the ship and in less than 37 seconds a blackened, twisted, aluminum skeleton is all that remains of the mighty Hindenburg.

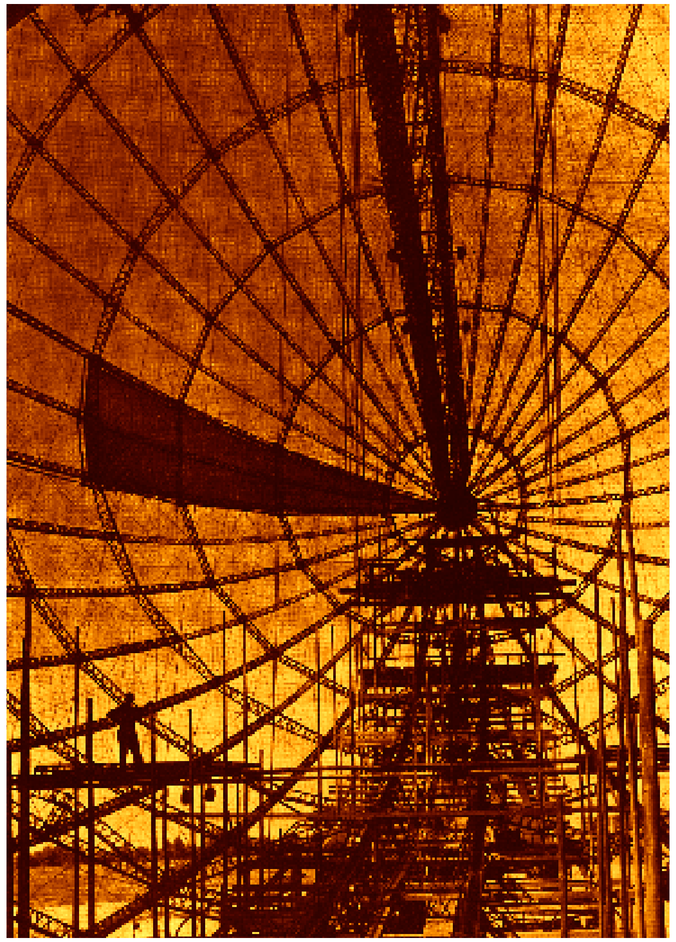
The era of hydrogen-filled airships came to an end on that tragic night in 1937. Now, half a century after the disaster, one undeserved legacy still remains. Any mention of the Hindenburg disaster immediately brings to mind the word hydrogen; and hydrogen, disaster, danger and death are all too often considered intimately related.

Although the Hindenburg disappeared in a ball of flame, it has been conclusively shown since then that the hydrogen gas giving the great ship its buoyancy was not the source of the fire. It has been proved that the real danger to the airship was the aluminum powder and nitrate doping used on the outer skin to reflect sunlight and reduce interior temperatures. Today, a similar formula is used as rocket fuel. Most of the passengers were burned by the diesel fuel used to power the engines and by the burning fabric cover that gave the airship its shape.

There have been several theories presented over the years explaining the cause of the fire; however, most researchers have concluded that, although the hydrogen contributed to the rapid burn of the airship, there is little or no evidence to indicate it actually caused the accident. Yet even now, sixty years after the disaster, the seven million cubic feet of hydrogen gas that gave the ship its buoyancy is still considered unsafe and something to fear.

It is my hope that this article will help dispel the general public's fear of hydrogen and will show that hydrogen, although having some unique properties, is no more dangerous than gasoline, natural gas, propane or any other flammable fuel. In fact, after a review of the historical uses of hydrogen and its excellent safety record, it is hoped that all will understand that this clean and abundant element is superior in many ways to any other commonly used fuel. Rather than seeing the Hindenburg tragedy as a black mark upon the use of hydrogen for fuel, it could be seen as an illustration of the many safety advantages hydrogen has over the more common fuels. Now, let's dispel the hysteria that inhibits the broader application of hydrogen as we promote a future hydrogen economy.

First, let me take you on a short trip back in time. Long before hydrogen was considered as a fuel source, the Germans were using it as a lifting gas for their famous fleet of Zeppelins. In the first year of the new 20th century, the LZ 1 was first flown. That airship was over 400 feet long and close to forty feet in diameter. It used almost four hundred thousand cubic feet of hydrogen to provide buoyancy. By May 31, 1915, a newer Zeppelin, the LZ 38 had become the first airship to bomb London in World War I. This ship was more than 500 feet long and 60 feet in diameter. It held more than a million cubic feet of hydrogen gas in several bags installed inside its metal skeleton. Bear in mind, when regarding the safety of the hydrogen used in these airships, thousands of animal skins were sewn into bags in which to store the hydrogen. Crewmembers were known to



Hindenburg under constuction

carry sewing kits to make repairs in flight. They walked along metal catwalks inside the ships framework and had to wear special shoes that reduced static charges. Yet, in spite of the crude nature of the construction, these early airships had remarkable safety records. The LZ 127 better known as the Graf Zeppelin completed over one million miles of travel, including many trans-Atlantic flights while navigating through lightning storms with complete safety. This same technology also proved quite safe in combat in World War I, as many Zeppelins returned riddled with bullet holes. It was not until incendiary projectiles were used that operations in combat were eliminated.

Since we are traveling back in time, let's go a little further and discover what the father of the internal combustion engine thought about a choice of fuel. Shortly after our Civil War, a German by the name of Nicolaus Otto developed the four-stroke internal combustion engine. He had several choices of fuel for his new engine. It was common back then to have a ready source of gas to illuminate street lamps and lighting in homes and buildings. Known as producer gas, it was primarily made from coal burned in an air-starved container, thus forming a crude form of hydrogen gas combined with carbon monoxide and trace elements.

Another fuel available to Otto was the new waste product of the kerosene industry. It was a volatile and toxic substance and more a nuisance to dispose of than a useful fuel.

He avoided using it primarily because he considered it to be far too dangerous, and that it had little future as a fuel for his new engines. Otto found that using hydrogen or producer gas was far safer and more powerful than this unwanted waste product of the new oil refineries. And what was this nasty, toxic substance? At the time it was known as benzene; but, today we know it as gasoline or petrol. Thanks to the invention of the carburetor this substance is now preferred over Otto's favorite choice. In spite of gasoline's dominance in the early 20th century hydrogen still found many uses.

Many will find it surprising that after World War II the use of hydrogen greatly accelerated in an unexpected way. Processed foods became more popular in our affluent new economy, and hydrogen gas found a new use in turning vegetable oils into substitutes for lard and butter. The oil and gas industry had for years used large quantities of hydrogen in refinery processes. Hydrogen also found many uses in the manufacture of specialty metals for jet engines and space vehicles. Miles of pipelines carried hydrogen for these uses for decades, yet the safety record has been excellent. So why does hydrogen have such an undeserved reputation as being dangerous?

If you look for the element Hydrogen in a periodic table in most chemistry books you will have little trouble finding it, because it is the first element listed. The listing order is based on the atomic weight of the elements, so it is evident that hydrogen would be the lightest. Hydrogen is also the smallest atom. These properties give hydrogen some unique qualities that can be

both an advantage as well as a disadvantage when we use it as a fuel.

First let's look at the small size of the molecule. Hydrogen has a tendency to pass through solids like metals and plastics and at first glance this may appear to be a problem when looking at the safety of hydrogen use and storage. In reality the rate at which hydrogen gas can pass through metals is extremely low. When connections and fittings using o-rings are properly designed, the permeability rate is very low and causes few problems in terms of loss of fuel or safety.

In the case of a leak, hydrogen's lightness and buoyancy become a definite advantage over the heavier molecules found in propane or gasoline. Unless the leak is severe or the tanks are enclosed in a well-sealed environment, the hydrogen will float upward at a rate of over 17,000 miles per hour, the equivalent of escape velocity. Gasoline and propane will both fall, since they are heavier than air, and will gather in pools or concentrate at the floor or ground level. Hydrogen's tendency to seek an escape route or to disperse very quickly is a definite advantage. In tests performed to certify hydrogen tanks for the Department of Transportation, high-velocity bullets and heavy projectiles have been used to penetrate the tanks, and even when the tanks were under pressures greater than 5,000 pounds per square inch there were no explosions of either the tanks or the hydrogen.

"Future generations may still recall the Hindenburg; but, by then, the word hydrogen will be synonymous with clear air and energy freedom, rather than death and disaster."

A tank of gasoline or propane subjected to the same tests would have far different results. The liquid gasoline would spill out and vaporize, and any spark or flame would set it ablaze. A lit cigarette would be sufficient to do this. The same cigarette would not ignite hydrogen. Propane is usually thought of as a gas, but when under pressure in the tank, it is a liquid. A sudden puncture of the tank would cause the propane to expand in volume almost instantly and the vapors would remain at ground level. If the same tank were filled with natural gas, there would be an advantage in it being lighter than air and rising; but, its rate of dispersion would still be far slower than hydrogen.

The real danger in the leak of hydrogen in air is a tendency for explosion. Often it is said that since hydrogen can explode in as little as a 4% air to hydrogen ratio or as high as a 75% air to hydrogen ratio it is inherently more dangerous than other fuels. The trick here is that the hydrogen must be confined to be explosive. In most cases this is hard to do especially when proper venting is included in system design. In reality, gasoline in its vapor form can explode in as little as a 1% air to fuel ratio; yet, that fact has not prevented its widespread use.

A little research into the Hindenburg tragedy will reveal that even though it contained over seven million cubic feet of hydrogen it did not explode. The thirty-two passengers who perished, either died from burning diesel fuel or jumped to their deaths. Those seventy-seven passengers who lived rode the Hindenburg to the ground as it burned. It took less than thirty seven seconds for complete destruction. If the hydrogen had actually exploded it would have happened all at once and no one would have lived through it. Although it is certain that hydrogen contributed to the burning rate, the lack of confinement prevented an explosion. The energy content of the seven million cubic feet of hydrogen was equivalent to over eighteen thousand gallons of gasoline and was stored above the passengers. One can only imagine the terror and death the spilling and igniting of this quantity of gasoline would have caused.

Even when one compares hydrogen to a more benign fuel such as diesel, the advantage of hydrogen in terms of safety becomes evident. Engineers have speculated that had the airliners flown into the World Trade Center been fueled with liquid hydrogen the buildings would not have collapsed. The jet fuel or diesel was spilled out and pooled on the floors, where it continued to burn until the structural steel was weakened and the ultimate collapse was unavoidable. Hydrogen probably would not have exploded and would have dispersed in just a few seconds.

> **"When hydrogen is compared realistically with other fuels in common use, the safety issue soon becomes a non-issue."**

When we take a serious look at hydrogen as a substitute fuel for gasoline, diesel, propane or natural gas, we find its safety advantages far outweigh its few disadvantages. If gasoline or propane had not been in widespread use for the better part of a century, it is doubtful they would have an easy time today getting approval from safety regulators. When we realize that a tank full of gasoline has the explosive power of a stick of dynamite, and we regularly store our vehicles in basement garages, it then becomes apparent that a properly designed vehicle using hydrogen fuel could be parked in the same garage with the same confidence, and that it could be done safely.

Although fire and explosion are safety issues in any use of fuel, there is another safety hazard involving gasoline or propane that is most often overlooked. Not only are they both flammable, but they are also extremely toxic. This toxicity is rarely mentioned when making comparisons between competing fuel sources.

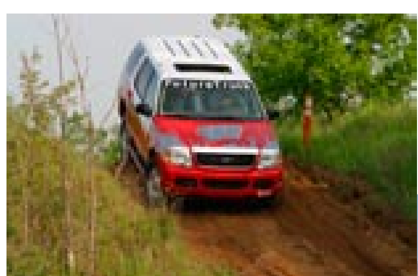
Hydrogen is completely benign in terms of toxicity. If breathed in, it can displace air or oxygen, but the concentration would need to be quite high to even cause shortness of breath. We don't often give it much thought, but two-thirds of the water we drink is made up of hydrogen; yet, we cannot live without water.

When hydrogen is compared realistically with other fuels in common use, the safety issue soon becomes a non-issue. Proper system design and safety engineering will ensure that a future hydrogen economy will be accepted by the general public and perhaps gasoline and other fossil fuels will be seen in the negative light that once shone unfairly on hydrogen.

Future generations may still recall the Hindenburg; but, by then, the word hydrogen will be synonymous with clear air and energy freedom, rather than death and disaster. ❂

America's appetite for SUV's and light trucks appears to be growing in spite of recent increases in fuel costs.

This trend increases the consumption of gasoline and diesel fuel and furthers our dependence on foreign oil.



What options do we have?

Perhaps an answer will be found in the coming together of university engineering students, the U.S Department of Energy, Ford Motor Company and Argonne National Laboratory in a competition known as Future Truck. Universities from around the country are supplied with stock vehicles from various manufacturers and given the task of modifying them to deliver at least a 25% increase in fuel economy without sacrificing performance or increasing emissions. To meet these challenges, teams of students employ cutting-edge automotive technologies, including advanced propulsion systems, lightweight materials, and alternative fuels such as hydrogen, ethanol and bio diesel. In the recent 2003 Future Truck Competition, all teams used a hybrid configuration in which an internal combustion engine was coupled with an electric motor and a battery storage system.

Team Paradigm shown in front of their winning vehicle, Moolander

Moolander moving through the obstacle course

For two consecutive years, University of Wisconsin has taken home the gold as the top competitor. The university engineering team, known as "Team Paradigm," using a 2002 Ford Explorer called Moolander, (in keeping with Wisconsin's well-known dairy traditions) made dramatic as well as subtle changes in the original design to win against competitors from fifteen universities. The combining of engineering skills of students and advisors with the generous donations of equipment from industry suppliers such as Ballard Power and Delphi helped increase the Explorer's fuel economy by a wide margin; all the while retaining the performance of the original design.

The Wisconsin team began with the modification of their SUV engine. Contrary to conventional design that stresses massive engine displacement and large numbers of cylinders, a Ford Lynx engine with only four cylinders and 1.8 liters was used in the Moolander. This engine is a direct-injected, common-rail diesel frequently found installed in autos and light trucks supplied to the European market. As originally delivered, the Explorer used a V6 having over twice the displacement. Reducing the engine displacement was the first step in the redesign.

The Wisconsin team chose a parallel hybrid configuration. A parallel hybrid has both an electric motor and an engine driving a common drive shaft. In a series hybrid the electric drive motor supplies all the power to the wheels. Delphi, an automotive components supplier, donated a three-phase, AC, high-voltage motor originally used in the now discontinued GM EV1. This motor is coupled to the drive shaft after the connection to the five-speed, Borg Warner, manual transmission and is known as a post-parallel hybrid drive. The design requires a reduction gearbox to match the high rpm of the motor to the lower rpm of the drive shaft. Fortunately, Ballard Power had a planetary gearbox they could donate that would couple the motor to the driveshaft with a reduction ratio of 3.1 and also would fit in the limited space encountered under the chassis. This combination supplies a hybrid drive of a continuous 60 Kw's or close to an additional 80 hp. One feature of a hybrid design that helps increase its efficiency is its ability to recover some of the kinetic energy generated in the forward momentum of the vehicle during braking. When descending a steep hill or approaching a stop, the motor acts as a generator that not only supplies braking, but recharges the batteries.

The batteries chosen for this design are those used in the Toyota Prius hybrid. Two 276-volt banks of Panasonic NiMh (nickel metal hydride) batteries store power for delivery when there is a need to pass or accelerate; and, in addition, absorb power when in the braking mode known as “regenerative mode.” A prismatic shape of cells is employed in the Panasonic batteries for the Prius that is unique, allowing large capacity in a small volume. Each battery stack is about the size of six loaves of bread, weighs about 110 lbs and stores 2.2 ampere hours of energy.

Another modification of the original design that contributes to overall performance is the substitution of aluminum for many of the steel parts such as frame rails, bumper attachments, etc. When the Wisconsin team set out to redesign the Explorer they were committed to using only those designs that lent themselves to ease of recycling at the end of the vehicle’s useful life, designs they felt could be incorporated on the assembly line.

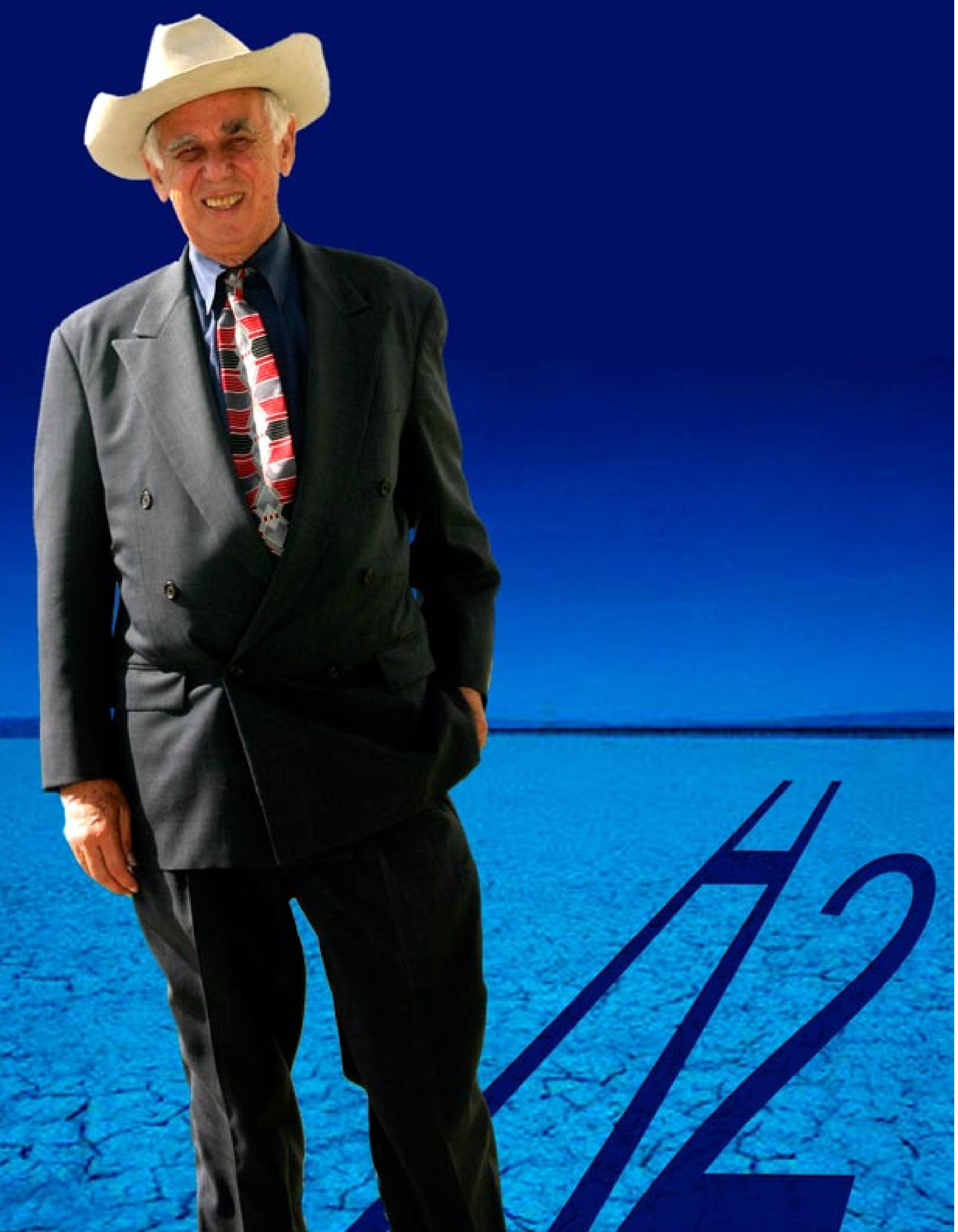
Once all of the modifications were completed and the bugs worked out, it was time to put Moolander to the test. In the 2003 Future Truck competition, the emissions and performance figures compared to stock were quite impressive. Of primary significance was the 35% increase in fuel economy over the stock model that gave the Explorer a score of 21.2 mpg. Initial dynamometer testing registered 38.5 mpg which gives some indication of just how far they may be able to stretch the fuel economy. However, “real world” performance figures may always be lower. These figures should be kept in mind as we see future CAFE standards requiring a minor increase of only 10% in light trucks. In emissions reduction the team managed to reduce the GHG (green house gas emissions) by 39%. Two of the teams used bio diesel and managed to reduce GHG by 50%.

In terms of the performance of the vehicle in acceleration and off-road use, no compromises from the stock design were exhibited. Wisconsin’s overall point score was 841 and they gained this in five critical areas. They took best score in fuel efficiency, design inspection, workmanship, technical report, and off-road performance.

Recently Wisconsin’s Moolander took part in the latest annual Michelin Challenge Bibendum held this year in California’s wine country. Infineon Raceway in Sonoma was home to over sixty vehicles in categories ranging from compacts and SUV’s to full-size sedans and for the first time heavy trucks and buses. Hybrids, fuel cell vehicles, advanced diesels including bio diesel, and even a one-of-a-kind Toyota Prius Hybrid, converted to operate with hydrogen, were on display and in competition. The Wisconsin team scored very well in competition in many categories.

Great strides are being made in engineering and developing vehicles that will reduce fuel consumption, decrease or even eliminate emissions, and allow drivers to have a much broader selection from which to choose. We congratulate University of Wisconsin, all of their sponsors and supporters, and all the other great university teams for their efforts and successes in this regard.❂

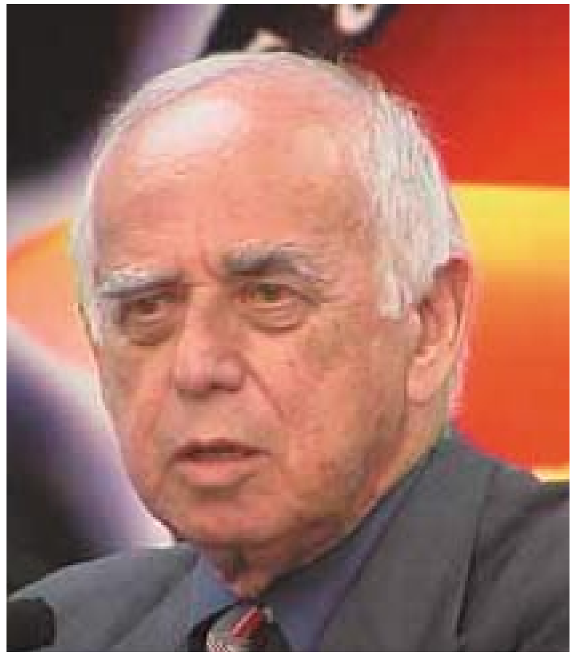
Further details on Moolander and the Wisconsin team can be found on their web site at www.cae.wisc.edu/~vehicle
In addition, all of the competition results for the vehicles in this year’s Challenge Bibendum can be found at
www.challengebibendum.com



Casting a Tall Shadow

S.David Freeman

A talk with a Global Thought Leader



S.David Freeman
Candid and Outspoken!
Someone who tells It like It Is!

An engineer and lawyer, Mr. Freeman, has served in various high-level government positions, including energy adviser to President Jimmy Carter. He previously had been an energy consultant to the U.S. Senate Commerce Committee and an Executive Assistant to the Chairman of the Federal Power Commission.

Mr. Freeman's extensive experience includes top positions at New York Power Authority, Tennessee Valley Authority (TVA), Lower Colorado River Authority and Sacramento Municipal Utility District (SMUD). In these positions, he successfully introduced energy conservation and efficiency projects, established a reputation for reaching out to community groups and developed solid and respectable relations with labor.

"As a matter of fact- hydrogen as a fuel - and I think most of the experts will agree with me, is safer than gasoline."

H2N: Our first question is that the primary objection to the use of hydrogen seems to be the perception that it is far too dangerous. What in your view is needed to overcome this perception of the general public?

FREEMAN: Well, I'm going to disagree with you. I don't think that the primary objection to the use of hydrogen fuel today is the perception of danger. I think the primary reason is that people don't know that the internal combustion engine loves hydrogen, and the people don't know that it is an option. Now, one of the concerns among the tiny number of people who do know something about hydrogen, is the misconception about the Hindenberg -- and it wasn't a hydrogen fire at all. It was the outside lining on the Hindenberg. So, it's simply a lack of knowledge. What's holding back the hydrogen revolution is that ordinary people don't know it's possible.

H2N: That's an excellent response to exactly what we at H2Nation are doing. We're trying to address this fear.

FREEMAN: Well, look people, it's not that dangerous – it's not dangerous at all. As a matter of fact – hydrogen as a fuel – and I think most of the experts will agree with me – that it is safer than gasoline. And one fundamental reason is that hydrogen is lighter than air. If you have a car wreck with hydrogen as the fuel, you're not going to have the kind of fire that you'd have with gasoline, because hydrogen will just go up into the atmosphere and combine with the oxygen in the air. It's lighter than air. And so, most of the fatalities are mainly those that come after a crash as the gasoline burns. That is a huge additional safety factor in hydrogen. Anything under pressure, theoretically, is capable of being dangerous, but the technology that is being developed for hydrogen tanks is being certified by all the safety people. The tank with 5,000 psi has been used for years and we are now up to 10,000 psi being certified this year. And besides, if I might just be blunt with you – I kinda resent starting off with the question about safety, because when we decided to go to the moon and Jack Kennedy said "We'll go to the moon by the year 2,000" a reporter didn't jump up and say "Mr. President, this is unsafe." No: we decided, as a nation, that's what we needed to do -- and that is what we wanted to do -- and we did it. Now, the problems that hydrogen seeks to solve – and can solve – are two of the most awesome problems that we face. On the one hand, it's local air pollution and global warming; and on the other hand it's security – the oil money feeding the terrorists. So, when you start off by understanding why we need a hydrogen revolution now, then the attitude has got to be that we can solve any of those technical issues that come up. But there are not that many to solve.

And, of course, much more fundamental is the issue of how you are going to make the hydrogen, because it doesn't exist in nature all by itself. In that way, it's kinda like uranium – which is not found by itself. But the question is, if we separate it with renewable energy, then we have a fuel cycle that's completely free of carbon and completely sustainable. And we've left something for our children and our grandchildren that they can be proud of; but, if hydrogen turns out to be just another chapter in the fossil fuel age we have blown it. We have missed the major opportunity of the twenty-first century. So, to answer the safety question though, I've looked into it very thoroughly -- and if you talk to anyone who knows anything about the subject, they will tell you -- if you compare all of the dangers involved in gasoline and all the dangers involved in hydrogen -- if we move to hydrogen then we move toward a safer fuel.

H2N: Since you are so heavily involved in the goings-on, lets say, of California hydrogen and the US perspective – do you feel that the United States – are we at the forefront of the hydrogen and renewables? Or do you think that we have fallen somewhat behind Germany, Japan, and some of the other countries?

FREEMAN: Well, it's more embarrassing than that – we are behind Iceland---

H2N: That's true – less than a million people ---

FREEMAN: --- three hundred thousand people and they are way ahead of us – so we don't have any bragging rights, yet I think we are in the ballpark on renewables. However, in terms of hydrogen we really haven't got our britches on yet.

*" It's more embarrassing than that! We are behind **Iceland!**"*

H2N: Will your initiative put hydrogen out front by promoting its use in internal combustion engines?

FREEMAN: Of course, it would accelerate it ahead by a number of decades. I mean – look -- the fuel cell (and I've used this analogy before) is like the rabbit in a dog race. You know – it's out there – it's something we are chasing – we just don't quite catch it. And the automobile industry, either on purpose, or inadvertently because they just don't want to change, are using the fuel cell and kind of creating with their large amount of money and propaganda the impression that the fuel cell and hydrogen are Siamese twins and one can't be done without the other. And yet, if you talk to their engineers -- if you talk to anybody that knows anything, its common knowledge that the internal combustion engine can run well on hydrogen and it's not a big deal to adjust the engine to run, and that we've got hydrogen fuel tanks and this can be done. So, my effort to say "Hydrogen Now" I think will bring us into the beginning of the hydrogen revolution. If we sit around like ninnies and wait for the automobile companies to perfect the fuel cell, we'll get one or two percent of the cars fifteen years from now running on hydrogen, but you realize – it's an easier job to do the internal combustion engine. Let me tell you something that people don't quite understand. It's not just the automobile industry's selfish motives – it's the scientific community's fundamental desire to try to do the hardest thing possible. Now, it's human nature – if you are a physicist, or somebody in the academic, scientific world – you are not interested in the simple little engineering job of tinkering with an engine. You want to take on something that you feel is a contribution – and so, the motivation and the interest is in climbing the scientific Mt. Everest. How else could fusion power be getting the big money year after year for fifty damn years and not produce anything? The allure of creating the sun here on earth – I think that explains why everybody's excited about doing something real tough. Let me put it this way -- any time we get a little cocky about how smart we are – just remember this: the wheel and suitcases have been around together for two thousand years – and it took two thousand years to connect the damned things. We hauled our suitcases around for two thousand years while there was a wheel already invented, and we hadn't even put the two together. So, there are a lot of dots that haven't been connected. And one of them is that you can just tinker with the cars a bit, put hydrogen fuel tanks on them, and run them on hydrogen.

H2N: A recent report was issued that the hydrogen economy would affect our planet's ozone layer. You probably saw this spread around. Would you like to comment on that?

FREEMAN: Well, you know, there's always somebody that can find a speck on the dark side of the moon and get their name in the paper as the result of finding it. We are a contrary society. I think that was an article that assumes that hydrogen was going to leak all over the place.

H2N: Ten to twenty percent.

FREEMAN: Yes, well, if there are ten to twenty percent leaks, we haven't done the job very well. Sure, there's going to be a tiny amount of leakage, but --you know-- we really should not solve the two most pressing problems on earth just because it might add a tiny, tiny bit to the ozone problem. I guess my answer is – that the perfect is the enemy of the good.

H2N: Would you agree that a lot of that negative press is coming out simply because hydrogen is the better solution, and it's basically the king of the hill now and it's the one to go after?

FREEMAN: I think I'd put it a little differently. Anytime anybody comes up with a good idea, there are people that feel it's their job to poke a hole in it. It's just like in a political race. Once somebody becomes the front-runner everybody wants to bump 'em off. And hydrogen is finally getting a little bit of attention and these guys that like to write things so that they can get their name in the paper and get a grant for an additional research project will dream up some way to get some press. Rather than being for the positive solution, they write negative articles. It's a free press. You are going to get some ---I think it's about as ridiculous as an article I read the other day that said we shouldn't do hydrogen because it was going to be based on fossil fuels. Well, of course we shouldn't do it if it's based on fossil fuels. My faith is in the common sense of the American people – if they can find out about it -- but right now hydrogen combustion engines in motor vehicles are treated as if they were military secrets.

You can't find anything in the general press, and frankly, I've submitted articles that have not been printed. The Sacramento News and Review wrote a very large, front page article that I inspired, but somehow or another, you know, I'm not paranoid, but I have to think that the amount of advertising that's being done by the automobile industry has some influence on what the papers are printing. Also, I think it sounds like an idea that's too good to be true – and people are skeptical.

H2N: They look at it as "pie in the sky."

FREEMAN: Yeah, and the reason I mentioned the luggage and the wheel is that there are some really good ideas that seem very simple. I'm sure that right after the fellow invented the wheel, people said "Well, you know, that's no big deal. Why didn't we think of that?" And the fact is, that nobody thought of it. So, we just have to go on and make it happen. And the support for it will be tremendous. If enough Americans become knowledgeable to the point where they would go to the showroom and ask for a car that runs on hydrogen, I think Detroit would respond.

H2N: We know that you have expressed in the past, and still do desire to see most of the hydrogen come from renewables. Besides electrolysis, what other technology do you see on the horizon that may be a little more efficient, maybe a little more ubiquitous?

FREEMAN: We can make the hydrogen with existing technology – electrolysis. Any place on earth where you have water and electricity you can make hydrogen. And, of course, in the future, we'll make that electricity entirely from solar, wind, or biomass, and then we have really done something important for our lungs, our kids, and our fear of terrorism.

Biomass is, I think, a very, very strong competitor in terms of cost. My concern is that a biomass project takes time to put together because you have to gather the biomass over a large area. If you want something to happen, you just have to remember the fundamental fact that in every place in America and throughout most of Europe, there exists electricity and water-- in every existing filling station, every home, every office building, and those are the two elements that you need for electrolysis. Now I think that we do not have twenty or twenty-five years to fool around. The reason I think that the urgency is great, is not just global warming, not just for the fact that we have an epidemic of asthma in most cities among the kids – it's not just that alone -- it's the fact that China and India have yet to build an automobile infrastructure, and they're either going to build a gasoline infrastructure; or if we can move swiftly enough, it can be a hydrogen infrastructure. And that motivates me to feel that the next five years are the ballgame – and that's why I'm devoting more and more of my time to this movement – because I think it's a life or death issue for this high-energy civilization.

> "We've chewed up the last twenty-five years on that quest for an electric car and the cost of that to the automobile industry was murder."

We've chewed up the last twenty-five years on that quest for an electric car and the cost of that to the automobile industry was murder. They just went through it. And, of course, it didn't fulfill our grandest dreams because the batteries never did get good enough to get a long range.

But, hydrogen -- we've got it -- there's no debate any more. The Ford Motor Company has built a concept car, the Model U, that's an SUV, a hydrogen hybrid, 300 mile range, that gets the equivalent of about forty-five miles per gallon – I mean what more do you need to prove it? The chairman of the Ford Motor Company introduced it personally as the equivalent of the T-Model for the twenty-first century. So, this is not a Sierra Club thing. It is not an Amory Lovins thing. This is Detroit saying "it is here and now" and what we need is a market for it. So, I'm delighted to speak to you guys because we need to get this word out to ordinary, patriotic, environmentally-sensitive Americans – which is just about all of us – I mean if you add environmental-sensitivity and patriotism I think you've got ninety-nine percent of us.

H2N: I'm sure you are aware of – since you have been in the industry so long – the speculation over the time line for when crude oil and natural gas reserves will see a peak – you've probably seen Colin Campbell on Hubbert's Peak and all that. Most "experts" seem to focus on the latter part of this decade or the middle of next. Do you agree – and, if so, how does this play into the development of the hydrogen economy?

FREEMAN: Well, let's take some steps. Natural gas is already tight. There's no debate about natural gas being tight. Just look at the price of it. It has doubled in the last year. And the people that are proposing that this hydrogen revolution be based on natural gas are just in a dream world. They haven't been out there like I have in the electric power industry

> "So, if your concern is global warming, if your concern is air pollution, you automatically go to renewables to make your hydrogen!"

trying to buy gas and seeing the price just run away on us -- so I think it's foolish to suggest that you can get a huge volume of hydrogen motor vehicles running on hydrogen made from natural gas. It's already peaked out. Now, true, there's gas around the world, and you can get some LNG and stuff. You are going to need that to meet the existing needs for natural gas for boiler fuel and home heating and all.

Here is a fact about the gas wells that needs to be printed. The gas wells in the United States deplete at about twenty percent a year – so we have to find twenty percent more gas just to stay even. A gas well is like a double declining balance sheet. It goes down real fast. So, a gas well will pump real good the first year and then it goes down considerably after the first couple of years. So, you can just preclude authoritatively this natural gas. Oh, you could get started with a few vehicles with it, but it's not the answer.

H2N: So, you would say that in spite of the increased drilling and the fact that the government (let's say the powers that be) keep telling us that it's the environmentalists who restrict us from drilling that is causing the real shortage – you're saying that basically ---

FREEMAN: I'm saying it's a big lie. I'm saying maybe they are not deliberately misleading people, but they're wrong. Look at the facts. Production of natural gas in the United States has been going steadily downward since 1970. This is not a new thing. We leveled off for a few years, but the trend is always downward. Now, I stood there with Jimmy Carter, the second Sunday he was President, when we went to Pittsburgh because there was a natural gas shortage, and President Carter said that we will have a continuous shortage of natural gas from now on – that we ought to stop using it as boiler fuel because it's valuable for fertilizer and other chemical uses.

H2N: They even passed an act, didn't they?

FREEMAN: They did. They banned it for a while. And it's interesting that bills have been introduced in Congress in the last few weeks to put that law back into effect. So, we just need this – and the debate about natural gas being the source of hydrogen. Now, a lot of these folks are talking about coal--

H2N: --clean coal. (laughs) We've seen that more often.

FREEMAN: --- and they use the fancy word "sequester." Now, let's take a few steps back. Does anybody that knows anything about geology, or has anything to do with the earth, really believe that

> "A hydrogen SUV is a patriotic statement."

we can take all that carbon that comes out when you convert coal into hydrogen and stuff it into the earth and expect it not to come back out? There are good people doing research on this subject, but they are doing it because they have grant money that pays them to do it. Look-- forget the costs – which are huge – but just the practicality of it. Those guys looked for twenty years and can't even find a hole in the ground to put nuclear fuel.

H2N: Right.

FREEMAN: So, if your concern is global warming, if your concern is air pollution, you automatically go to renewables to make your hydrogen. Hopefully we can do it chemically some day. Some day we're going to have hydrogen drives where the hydrogen is encased in metals and there'll be advances; but, we can build the T-Model hydrogen car today.

H2N: Right. And we hope to play a role personally in making that happen in the months ahead. That's why I'm so deep into this because I definitely want to be a part of this.

FREEMAN: Wait a minute. We didn't answer about oil.

H2N: Oh, right.

FREEMAN: Now, the world of oil is perhaps a decade down the road, but if we don't start the revolution for hydrogen now, we will not have enough hydrogen vehicles in the world to offset the growth of oil in time. And it's not when you run out, I think people should understand, the day that goes to hell in a hand basket is the day that you peak out.

And that day – certainly, you can guess about it, but nobody thinks it's more than twenty years off. And most people think that it's less than twenty years off. We've seen spikes in the price of oil already because of the influence of OPEC and the fact that the Middle East is, shall we say, a troublesome area.

H2N: And twenty years is a blink of an eye.

FREEMAN: Well, if we don't start today, we can't possibly have a large percentage of hydrogen cars in twenty years unless we start.

H2N: Well, speaking of the cars, this was my other question: I know it's a short-term trend, but the SUV – Americans are so enamored with the SUV. When you go out in the street, SUV's are all you see anymore. And since the vast majority of these people see very little reason to switch to an even more expensive fuel (which it's gotta be – it's gotta be more expensive than oil, at least initially and probably down the road), how do you envision actually getting this "Hydrogen Now" mission to be a reality when this is what we confront every day?

FREEMAN: Oh, I think you are pointing to the opportunity for hydrogen. My view is that we start the hydrogen revolution with the SUV. There is enough peer pressure now that if people feel like saying "yeah, I want my SUV and I'm gonna keep it," and having said that they may take a little bit of stuff from their neighbors and peers. But when they say "let the s.o.b.'s have their SUV's – just run 'em on hydrogen" then they become patriots. As I said, a hydrogen SUV is a patriotic statement. It is an environmentally sensitive statement. There's nothing wrong with people having big cars if they run them on a carbon-free, sustainable, fuel cycle. Like some smart alecks say, "it ain't the guns that kill people, it's the bullets." Well, it ain't the SUV's that are polluting the air and putting us in danger of feeding the terrorists with money, it's the oil. And I think we can convert the SUV from a badge of dishonor to a patriotic statement. I think that's where the first market is – these big vehicles and fast vehicles. For instance, we're working with Carol Shelby on a cool Cobra – that runs on hydrogen. So, we want to get off of this teeny car sacrifice kick. And, as far as the fuel costs, if people who bought the SUV's were worried about the fuel costs, they wouldn't be buying them, my friend. The cost of hydrogen, over time, is going to be lower than the cost of gasoline. If we don't do hydrogen, the cost of oil is going to go rapidly upward. And I think that as we reduce the cost of renewables and advance this technology, those curves will cross; but, in the meantime, the people that own SUV's are not the people that are worried about fuel costs, because if they were worried about it, they wouldn't buy an SUV to begin with. They couldn't afford to.

H2N: True. True. You don't mind if we use your s.o.b.'s and SUV's as long as we keep it "s.o.b.'s?

FREEMAN: Yeah. OK. Great. OK. Quotation marks! (laughs) These are terms of endearment.✪

Why wait for Fuel Cells? Convert the car you drive today!

by Larry Elliott

For years now, various media sources have been promoting the virtues and benefits of using fuel cells, especially in vehicles; primarily because their inherent efficiency and lack of pollution make them an ideal candidate to replace the internal combustion engine.

Even President Bush gave fuel cells and hydrogen a plug in his latest State of the Union speech.

Unfortunately, there is a big question mark about the source of hydrogen for these fuel cells; and the fuel cell itself (as presently designed) has some reliability and cost issues.

Although it will be some time before fuel cells become cost effective in vehicles, establishing the fueling infrastructure needed to fuel them can be completed now. But you may ask: "If we spend the money now to build the fueling stations, who will our customers be if fuel cells remain a future prospect?"

The answer is: that we can begin to convert internal combustion engine vehicles to operate with hydrogen in the vehicles we own right now – today. This would be nothing new, since the original four stroke combustion engines designed by Nicolas Otto in the 19th century ran quite well with gaseous hydrogen. In fact, Otto preferred hydrogen to the waste product of the new oil industry known as gasoline. He felt that gasoline was far too dangerous to use as fuel.

As a longtime advocate of using hydrogen in vehicles, and now as senior science editor of this magazine, I felt it was only appropriate that I put my money and technical skills into the challenge of converting an existing vehicle to use hydrogen.

Late last year, I began my search for just the right vehicle. Ironically, after much searching, calculating, pondering and discussion, I finally selected (of all vehicles) an SUV. Now, there are SUV's, and then there are SUV's. Most examples on the road today appear kin to military assault vehicles, minus the rocket launchers and machine guns; but, in a few cases manufacturers have created vehicles with many of the attributes of the SUV without the shortcomings, such as gargantuan size and massive fuel consumption.

My final selection for conversion was a 1993 Geo Tracker with four-wheel drive. I used several primary considerations in making my selection.

First and foremost, the vehicle had to be small enough to be lightweight and practical; but, it also had to have ample space in which to install the pressurized fuel tanks needed to carry the gaseous hydrogen. The station wagon layout of the tracker lent itself fairly well to this consideration, although I did have to sacrifice the two back seats.

In addition, I felt that the engine should be in as good mechanical condition as possible, since even a hydrogen engine, should it have oil consumption problems, will pollute.

Next, I had to consider the type of fuel delivery system that had already been installed. I had made the decision early to use gaseous fuel injectors in my conversion, rather than using the simpler method of allowing fuel to be introduced into the intake manifold based on vacuum and a diaphragm type regulator, such as those used in propane conversions.

The injector gave me more precise control over the mass flow of fuel into the engine and allowed me to use the modified ECM, or engine control module, to operate both the gaseous injector as well as the original gasoline injector, thereby giving me a true dual-fuel vehicle.

My next major consideration in selection of the Geo Tracker was the fact that it was a four-wheel drive. Now you might be asking why I would want the added weight of four-wheel drive when operation in snow and mud would be a minor issue. Well, from the start I knew that in order to achieve maximum efficiency and therefore maximum range on a given quantity of hydrogen I would need to look at a hybrid drive system. The Toyota Prius and Honda hybrids use electric motors coupled between the engine and transmission. This is an excellent means of creating a seamless and smooth coupling of electric motor and engine, better done as an OEM design change rather than a conversion. It is simply beyond the capabilities of most who would attempt it. The four-wheel drive option allows me to remove the drive shaft from the front drive and substitute an electric drive. This gives me several options. I can simply shift to two-wheel drive and operate the vehicle normally. I can place the transmission in neutral, shut down the engine and operate as a front-wheel drive vehicle. I can put the shift lever in four-wheel drive low or high and have full functioning four-wheel drive. Or I can be in two-wheel drive and allow the front drive to add to my horsepower for passing and also use the regen mode for maximum efficiency.

Since there is no mechanical coupling between front and rear differentials, running at highway speed in four wheel drive is not a problem. This particular Tracker also has the auto hub option which reduces parasitic drag from the added drive train. Because I did not want the added weight of batteries to supply storage of both primary power and absorption of regen power I selected a lightweight bank of UltraCapacitors. They take up very little room, weigh less than 25 lbs., and have the capability of very high current delivery and current absorption rates. In order to keep this conversion within my budget and also to keep it simple, I decided to use off-the-shelf, permanent magnet, traction-drive motors like those used in large golf carts and NEV's, or neighborhood electric vehicles. Because one motor did not have the horsepower needed, I chose to gear belt couple them together. Two motors also required the use of two controllers, since no controller with true regen had the capacity necessary to operate both motors at high power.

Two 61 liter 3600 psi fuel tanks with temporary mounting

My choice of pressure tanks was a set of older but unused 3600 psi tanks normally used in natural gas vehicles. Since they are of the older type 2 their weight is quite a bit more than the lighter weight type 3 and 4 now available. Budget constraints meant I would sacrifice a bit of efficiency because of the weight penalty. Since the tanks were never used for natural gas I could now also use them as a fuel supply for my fuel cell demonstrations. The mercaptan used in natural gas as the "skunk smell" will linger in used tanks for a very long time and would poison the membranes.

The high pressure delivered from the tanks requires the installation of a pressure regulator to feed the 100 to 150 pounds of pressure needed by the fuel injector. Ideally you would have the regulator installed inside the tank as most of the factory fuel cell vehicles do.

This eliminates the presence of high pressure lines extending from the tanks to the engine compartment. Again budget constraints dictated my choice of regulator. Because of adding an additional fuel injector rather than substituting the one already installed, it was necessary to machine out an injector block and install it just above the intake to the throttle body.

Custom built box to enclose the tanks

Safety was a primary consideration in every conversion I made to this vehicle, so installing a hydrogen leak detector inside the vehicle where the tanks are placed was of prime importance. This detector activates a piezo buzzer and will shut down all electrical equipment upon detection of no more than a %2 concentration of hydrogen. This is %2 lower than hydrogen's explosive limit which gives me a good factor of safety.

This lower explosive limit, coupled with hydrogen's lower ignition energy level, dictates that the ignition timing be adjusted closer to top dead center when operating on hydrogen.

A new instrument package was also installed to keep an eye on current and voltage levels of the drive system as well as capacitor and motor temperature and of course a hydrogen fuel gauge was designed that measures capacity as a function of tank pressure,

Each one of the modifications done to this vehicle required some level of engineering; and also, may not be exactly appropriate for the type of vehicle you may choose to convert.

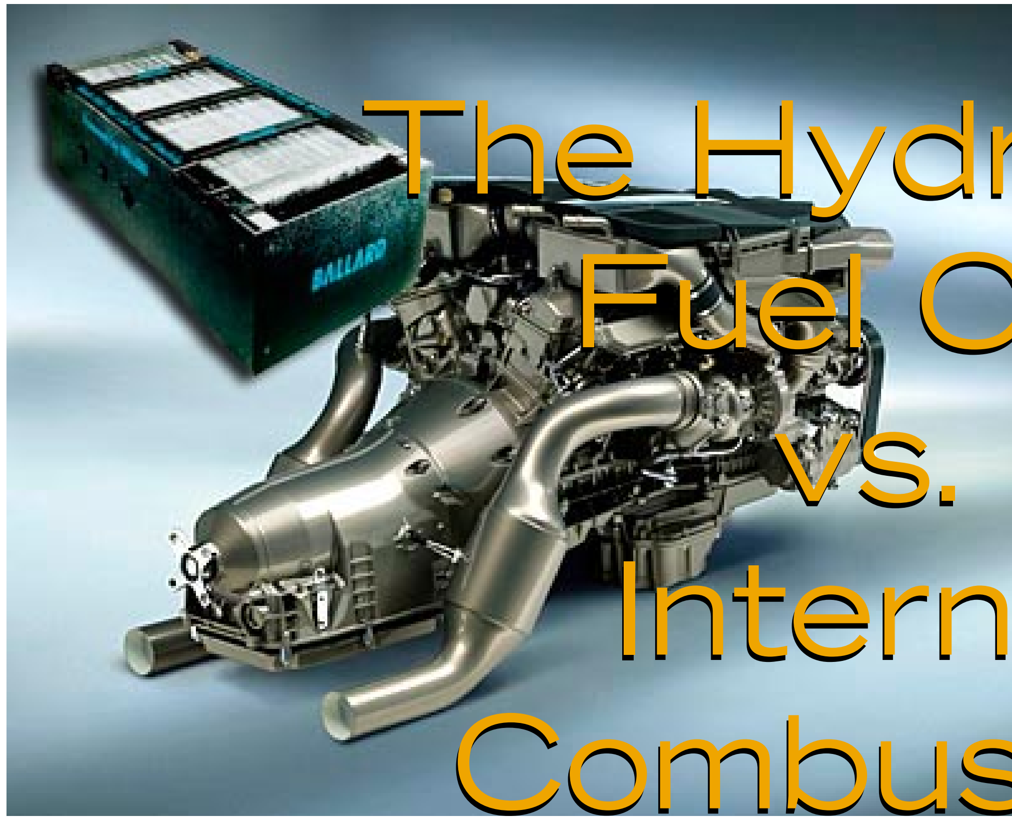
Fuel lines, PRV and pressure regulator

Wind power,photovoltaics and electrolyzer as h2 source

In a future six part series of articles, we will supply details on how each conversion was made and how each performs.

We look forward to reader's feedback on conversions they may be planning or are presently engaged in. Any interesting and unique designs submitted will be published in future issues of H2Nation.

Custom machined fuel block and h2 injector



The Hydrogen Fuel Cell vs. Internal Combustion Engine Debate

By Bob Willis

Fuel cells are getting a lot of attention these days. Some people see them as the panacea for automobile pollution and our foreign oil problems. When people think of hydrogen, they think of fuel cells. Fuel cells were a high point of President Bush's State of the Union Address. They can even be used to create electricity at your home, eliminating the possibility of your house going dark when the rest of the neighborhood has no power.

Many people think that the fuel cell is the only way to use hydrogen to propel a vehicle, and that the internal combustion engine (ICE) will be completely replaced by the fuel cell electric-drive motor. William Clay Ford, Jr., the CEO of Ford Motor Co., has claimed that fuel cells will "finally end the 100-year reign of the internal combustion engine."

On the other hand, there are many challenges in getting fuel cell automobiles to market. Cold weather is a huge problem for fuel cells; in some cases resulting in frozen fuel cells, or extreme difficulty getting them to run. Other problems that need to be solved before fuel cells can go into mass production include reliability, longevity and cost. A fuel cell car today would cost about ten times as much as an ordinary gasoline-powered automobile. Who would pay $200,000 for a hydrogen fuel cell car, when a similarly featured ICE car would cost only $20,000?

The fuel cell is not the only way to use hydrogen in order to propel a vehicle, generate electricity or warm a building. Although fuel cells are nonpolluting, their only emission being water vapor, internal combustion engines running on hydrogen can actually clean the air while you drive. Air that goes into the engine typically contains hydrocarbons, pollens and other pollutants that get burned, thus making the air cleaner than it was before it entered the engine. Recent advances in the hydrogen-burning internal combustion engine in automobiles include the Ford Model U concept car and the BMW 745h. The Ford Model U runs on pure hydrogen and is built from the same engine Ford uses in the Ranger pickup truck. The BMW 745h is a V8 engine that runs on either gasoline or hydrogen at the flip of a switch.

BMW 745h

It was preceded by the 745hl, which was ready for production years ago. BMW also has come out with a hydrogen-powered prototype of its popular Mini. In the early 1990s, Mazda demonstrated that its rotary engine was shown to be very compatible with hydrogen as its fuel.

Using hydrogen in an internal combustion engine is not a new idea. The first internal combustion engines actually ran on various types of gases that were typically used to provide lighting in street lamps and in homes. One of the most common of these gases was known as "Town Gas," a mixture of hydrogen and carbon monoxide. "Coal Gas" was another illuminating gas that consisted of hydrogen, methane, carbon monoxide and ethylene. So, the first internal combustion engines actually used hydrogen as their primary fuel.

Most of the automobiles on the road today can be converted to run on hydrogen. German engineer, Rudolph Erren, converted over 1000 vehicles, including trucks, cars and buses, to run on hydrogen in the 1930s. Converting your vehicle will provide several benefits, including:

1) Longer engine life. Since there is no carbon in hydrogen, there will be no carbon buildup on the cylinder walls and spark plugs. Since there is no sulfur in hydrogen, no corrosive acids will be produced to eat away at engine parts.
2) Reduced or negative emissions. The air actually becomes cleaner when you drive.
3) No more oil changes. Simply replace the oil filter and top off at regular intervals.
4) Hydrogen ICE vehicles start in the coldest weather.
5) Dependence on foreign oil can be reduced
6) Reduction in gases that produce global warming

Engineers still haven't solved the problem of membrane fouling that basically kills the cells. Hydrogen and natural gas are similar, in that they both have no odor. A sulfur containing odorant called "mercaptan" is added to natural gas in order to make it detectible by sense of smell. Mercaptan can also be added to hydrogen in the same manner that it is added to natural gas. However, such additives will contaminate a fuel cell and turn it into a very expensive paper weight. Hydrogen that is destined to be used in a fuel cell can have no additives that could contaminate the fuel cell. Fuel cells require a hydrogen purity of 99.999%. Internal combustion engines that burn hydrogen, by contrast, will not be damaged or fouled by adding an odorant to the gas.

Ford, working in conjunction with Ballard Power Systems, has also produced a hydrogen internal combustion engine that is being used to generate electricity. This engine is actually a modified V-10 engine that is also used in Ford F250 and F350 trucks. It is bundled and sold by Stuart Energy as the Hydrogen Energy Station (HES). The HES combines hydrogen production, from electrolysis, with storage and electricity generation.

Mass production of fuel cells for automobiles will result in an exponential growth of the use of platinum and copper. Platinum is used in the fuel cell itself. Copper is used in the electric motor that propels a fuel cell car. Platinum is one of the most expensive metals because it is rare. Copper, while in comparative abundance, will grow scarce once fuel cell automobiles reach full production levels. The demand for copper in China has increased over the past couple of years to the point where that country is now engaged in a worldwide search for cheap sources overseas. China has become a large producer of finished goods such as electronics, many of which require copper. The need for more copper is going to drastically increase the number of copper mines throughout the world. According to China's People's Daily newspaper, only 34.9% of the copper used in China today comes from domestic resources.

The amount of copper that will be used in the production of these electric motors will have a huge impact on world copper markets. The copper industry appears to be unaware of the impact that will come from the manufacture of millions of fuel cell automobiles.

If copper shortages become severe, copper motor windings can be replaced with aluminum. However, the motors will be much larger, and require additional space under the hood.

Why use ICEs now instead of fuel cells for automobiles?

1) Fuel cells are not ready today.
2) Manufacturing electric motors for fuel cells will put a great strain on the world copper market.

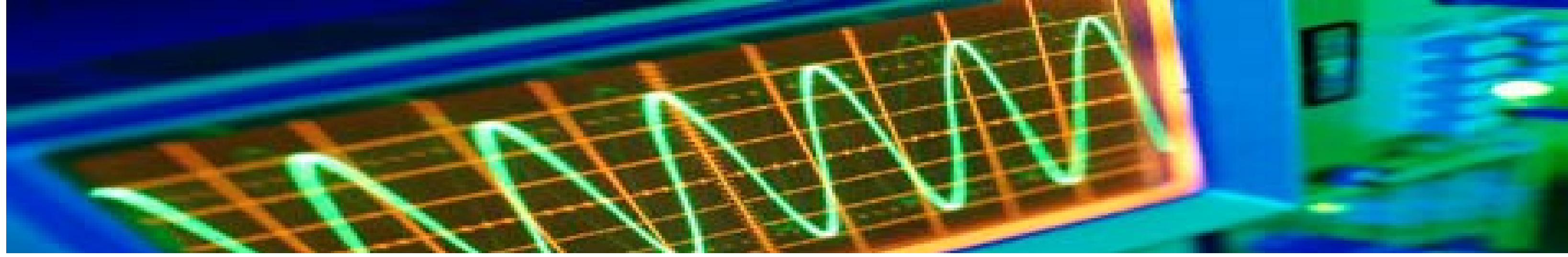
3) Fuel cells will not start in very cold weather. Hydrogen ICE automobiles will start in weather that is too cold for even gasoline engines to start.
4) Fuel cells cost about ten times as much as ICEs.
5) Fuel cells require a much higher hydrogen purity. ICE engines can use hydrogen full of impurities, without damaging the engine.

The fuel cell is the ultimate solution for propelling a vehicle with hydrogen. It offers higher efficiency and a quieter ride. However, it is a long-term goal, with many challenges ahead of it. In the meantime, the ICE will help to bring fuel cells into mass production sooner. It is an interim step on the path to fuel cells. Competition from ICEs will spur faster fuel cell development, while creating the demand for building the hydrogen production and distribution infrastructure

We don't have to wait ten or twenty years for all of the fuel cell problems to be solved. We have the technology to produce hydrogen ICE cars today, resulting in the immediate reduction of air pollution and foreign oil imports. Using ICEs, our automobiles can run on Hydrogen Now!✪

Bob Willis works for Hydrogen Now!, a nonprofit organization dedicated to advancing the use of renewable hydrogen.
See the website for more information:
http://www.hydrogennow.org

BMW V12 from the 745h



Bench Mark Review

We at H2 Nation Publishing have a goal to take as much of our office, experimental lab, and machine shop power loads off the grid as practical. In keeping with this effort, we began a series of tests to determine the best methods for integrating various fuel cells, inverters, batteries and photovoltaic panels into a complete power system.

We recently purchased several, older model, Avista Independence 1000, fuel cell systems. To better determine their proper application in our final system, we set up a series of tests using balance of systems components from several manufacturers.

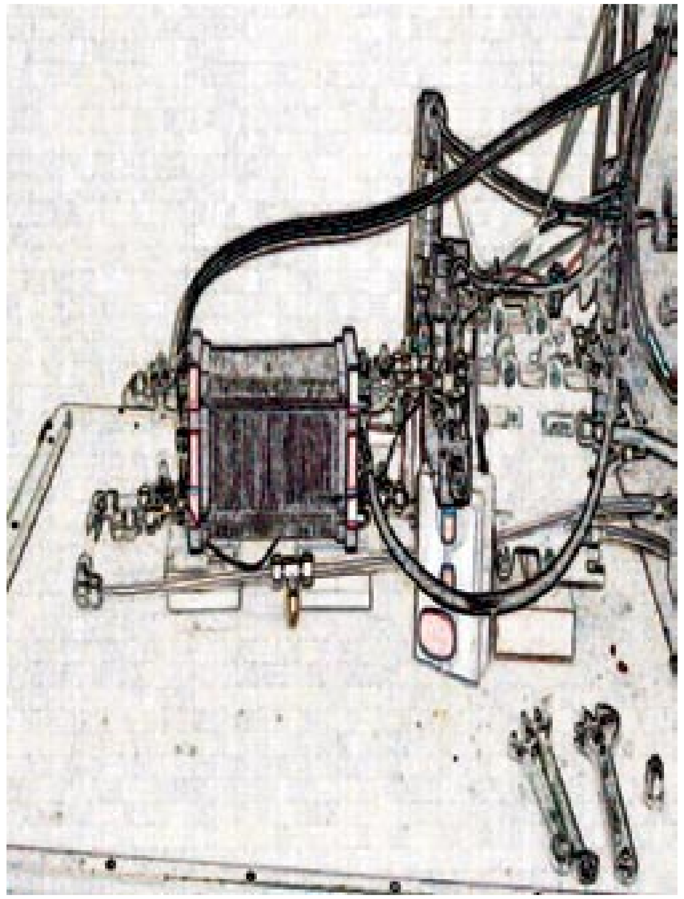
Various loads from computers and office machines, to air compressors, machine shop equipment and laboratory instruments will be powered throughout the day. Our goal is to supply as much continuous power as our 4 kw solar array will allow during the day, as well as to supply reliable backup power from the fuel cells using hydrogen produced through electrolysis. In addition to taking up less space and lowering our expenses, we wish to keep our battery bank size to a minimum. With a very small battery bank we needed to solve the problem of voltage sags when large surge loads were turned on.

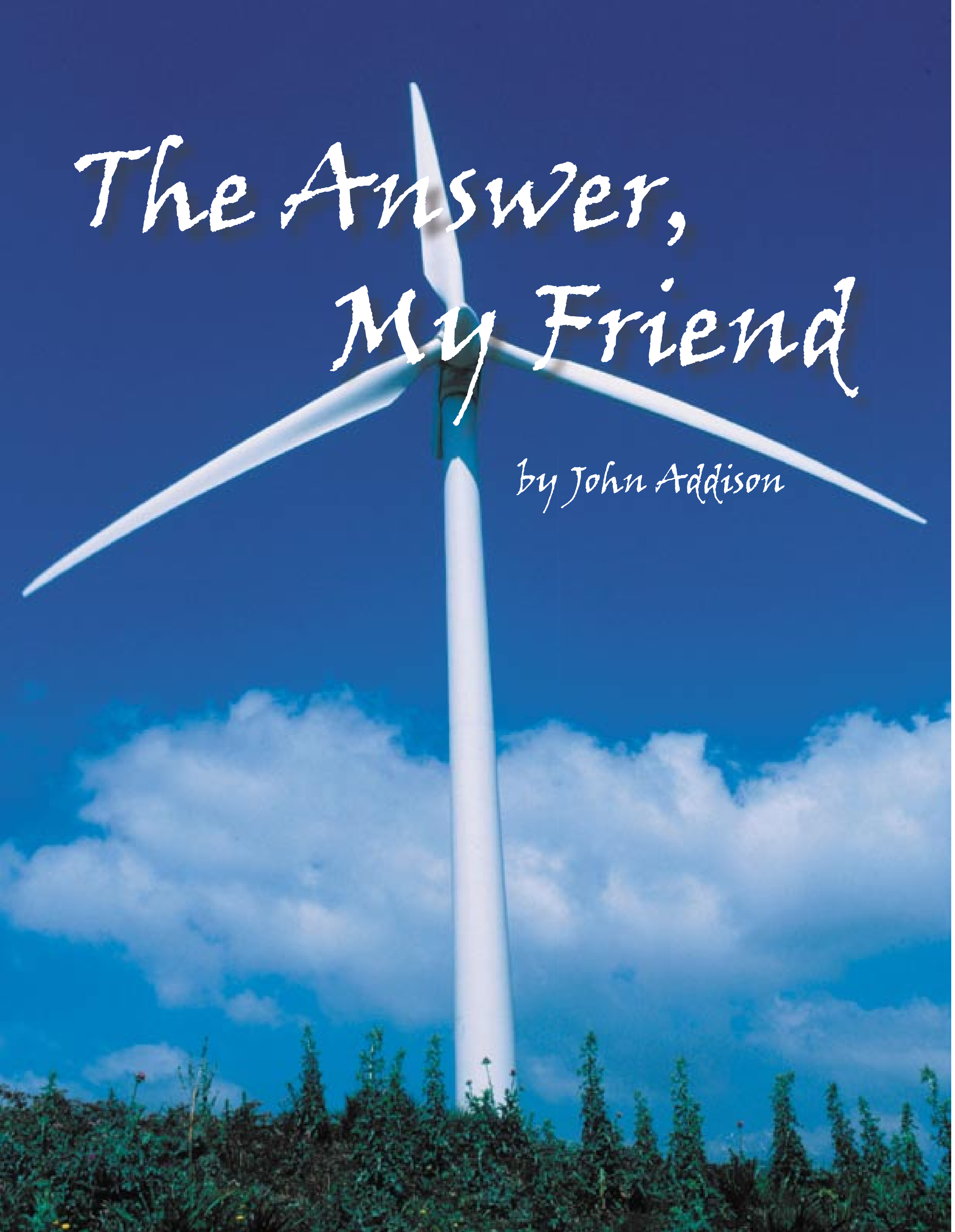
A test bench was set up using one Avista fuel cell, a 26 amp hour, 48 volt, lead acid battery bank from Hawker, a 60 volt nominal, 2700 farad Ultra Capacitor stack from Maxwell Technologies and an Outback FX2548 inverter.

The Ultra Capacitors can easily supply over 600 amps of surge current. The batteries cannot deliver anywhere near this amount without damage. We decided to wire the battery bank and capacitors in parallel to determine if it was possible to use the best features of both storage methods. The fuel cell was set up to supply primary power with no input from the PV array. The Avista units can be programmed to supply power directly to a load or supply fully regulated power to a battery bank. Using the battery charge mode we began the tests. The capacitors were first charged to about 45 volts using a current limited power supply since when discharged they present essentially a dead short to the fuel cell control which causes shutdown. Once the capacitors and batteries were paralleled with the inverter and fuel cell and voltages stabilized at around 49 volts, tests began.

We were able to start and run loads such as a large 6 horse power (name plate rated) compressor, a 2 hp lathe, single phase milling machine, and even a small 110 volt wire feed welder. With the capacitors supplying surge current we were able to start loads far in excess of the ability of the batteries alone. We experienced voltage sag only when the loads were switched on and off more frequently than we would normally expect in everyday use.

This test setup was only preliminary and will be ongoing until we determine a final design. Our Benchmark feature will be in every future addition of H2Nation.✪





The Answer, My Friend

by John Addison

Question: What generated enough power for 35 million people, without adding to global warming?

The song was right.

"The answer, my friend, is blowing in the wind."
(Bob Dylan 1962)

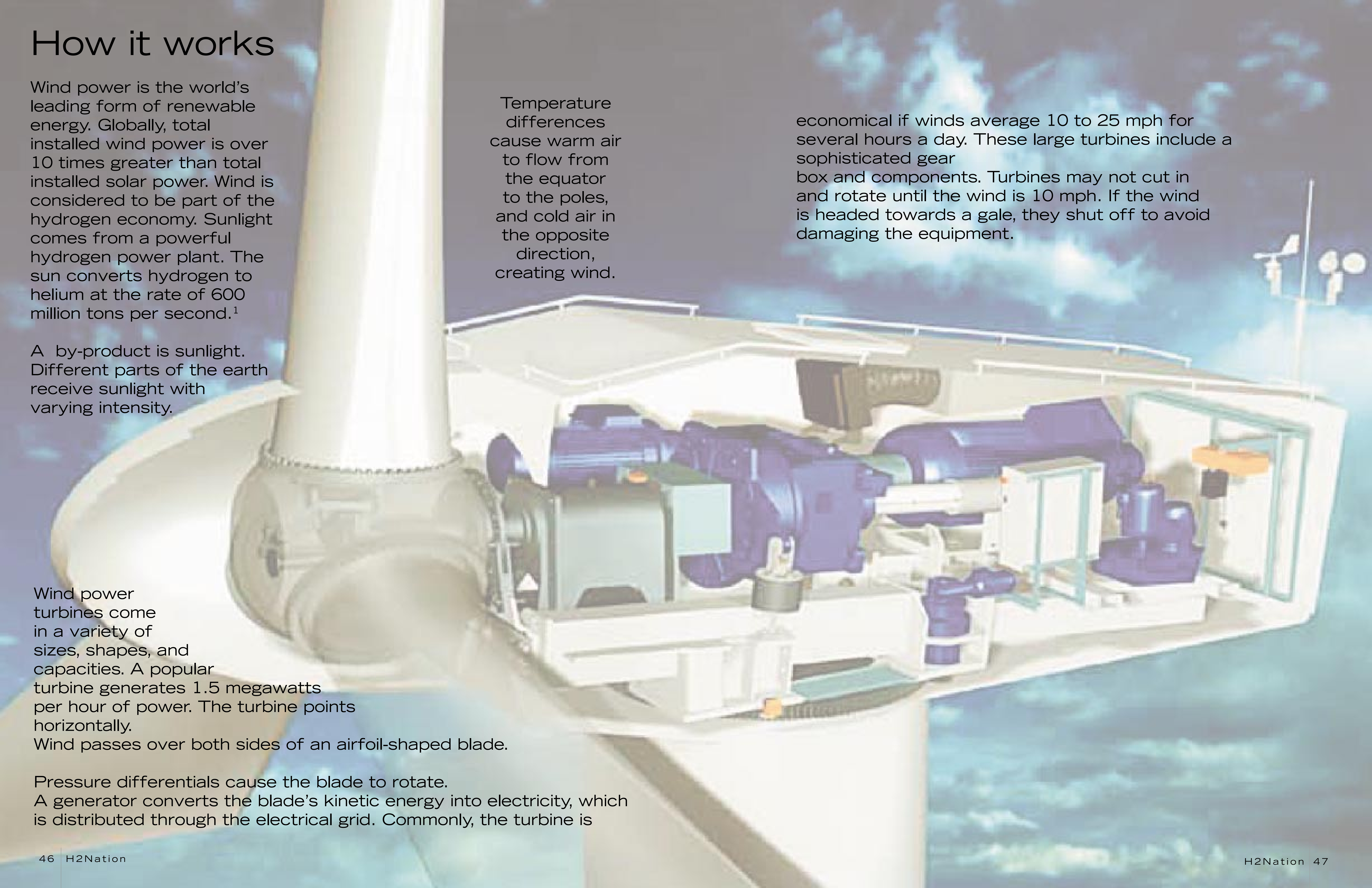
Wind is a compelling answer to the desire for more electric power without the increased use of coal and natural gas, major contributors to global warming. In many parts of the world, wind is the least expensive way to generate power.

How it works

Wind power is the world's leading form of renewable energy. Globally, total installed wind power is over 10 times greater than total installed solar power. Wind is considered to be part of the hydrogen economy. Sunlight comes from a powerful hydrogen power plant. The sun converts hydrogen to helium at the rate of 600 million tons per second.[1]

A by-product is sunlight. Different parts of the earth receive sunlight with varying intensity.

Temperature differences cause warm air to flow from the equator to the poles, and cold air in the opposite direction, creating wind.



Wind power turbines come in a variety of sizes, shapes, and capacities. A popular turbine generates 1.5 megawatts per hour of power. The turbine points horizontally.
Wind passes over both sides of an airfoil-shaped blade.

Pressure differentials cause the blade to rotate.
A generator converts the blade's kinetic energy into electricity, which is distributed through the electrical grid. Commonly, the turbine is economical if winds average 10 to 25 mph for several hours a day. These large turbines include a sophisticated gear box and components. Turbines may not cut in and rotate until the wind is 10 mph. If the wind is headed towards a gale, they shut off to avoid damaging the equipment.

State Mega Watt Production

AR 0.1	NY 48.5
AK 0.9	ND 4.8
CA 1832.2	OR 218.4
CO 61.2	PA 34.5
HI 8.6	SD 3.0
IA 422.7	TN 2.0
KS 113.7	TX 1095.5
ME 0.1	UT 0.2
MA 1.0	VT 6.0
MI 2.4	WA 228.2
MN 360.6	WI 53.0
MO 0.1	WY 140.6
NE 14.0	

Follow the Money

Leading corporations are making money with wind, and investing heavily in its expansion. Four of the five top producers are large public corporations. Turbine manufacturers 2002 market share:[1]

- Vestas (Denmark) 22.2%
- Enercon (Germany) 18.5%
- NEG Micon (Denmark) 14.3%
- Gamesa (Spain)11.8%
- General Electric (USA) 8.8%

Europe is ahead of the USA

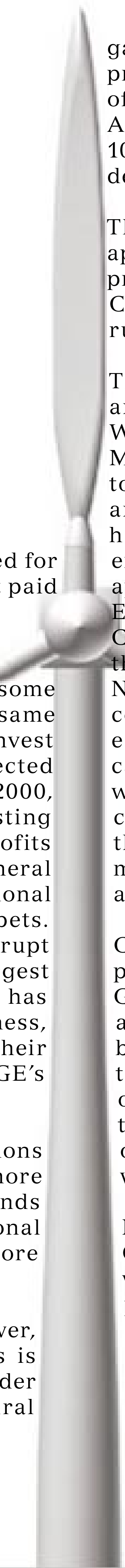
Germany leads in installed wind power, then Spain, the United States and Denmark.[2] While growth is aggressive in many countries, uncertainties make it difficult to forecast in the U.S. Rather than heavily taxing emissions from fossil fuel plants, the U.S. offers an energy production tax credit (PTC) to support electricity generated from wind and other renewable sources. The credit provides a 1.8 cent per kilowatt-hour benefit for the first ten years of a facility's operation. Congress allowed this tax credit to expire on December 31, 2001. The PTC has expired twice since it was originally enacted into law. In March of 2002, the credit was extended only until December 31, 2003.[3] Continued uncertainty caused Vestas, the world-leading wind manufacturer, to cancel its planned manufacturing site in Oregon. Instead, it invested in Spain.

California and Texas are the two major wind power producing states. These states are driven by the need for more low-cost clean energy. Significant producers also include Iowa, Minnesota, Washington, and Oregon, where wind is plentiful and consumer demand is high. California is projected to provide 44% of the total renewable energy growth of the entire U.S.[1]

Electric utilities continue to invest heavily in new natural gas power plants. The current supply shortage is over 3 billion cubic feet of natural gas per day, according to some energy experts.[2] This shortage is part of the administration's argument that drilling in Alaska must expand. This is not necessary. While the price of natural gas rises, the cost of wind power continues to drop. Wind farms on 6% of our soil could power the entire United States, with zero need for fossil fuel power.[3]

Factors Driving Success

- Cost drop of wind power to 4 cents per kilowatt hour
- Continued cost drops as the average capacity per turbine grows
- Growing cost of natural gas
- Increased global demand for electricity
- Offshore wind farms
- Government incentives and support
- Kyoto treaty
- Profits for leading corporations



Much of this land could continue to be used for agriculture. Farmers love it when they get paid for their wind harvest.

Big investment from big business

The quest for profits is leading some companies to drill the earth, while the same quest is leading other companies to invest in wind power. Vestas' revenue is expected to grow from over $600,000,000 in 2000, to $1,700,000,000 in 2003. After investing heavily in future expansion, Vestas' profits exceeded $70 million last year. General Electric, the world leader in conventional power plant turbines, is hedging its bets. It bought the wind business from bankrupt Enron, and made GE Wind the fifth largest wind turbine manufacturer. Since GE has a track record of being #1 in any business, its major competitors are intensifying their expansion while nervously watching for GE's next move.

Steady winds make some offshore locations ideal for wind power. In Europe, 12 offshore operations are currently powering thousands of homes and businesses. Seventy additional operations are in development.[4] Offshore wind power is growing rapidly.

Most people say that they want more power, but "not in my backyard (NIMBY)." This is a major challenge when an energy provider wants new power plants using coal, natural gas, or nuclear. Unfortunately, it is also a problem with wind power. The coastal waters off New England are described as the Saudi Arabia of wind development. An enormous 10GW of clean power has been identified for development.

The use of offshore wind turbines has not been approved in the USA. While the Danes may be proud of their 20 wind turbines along beautiful Copenhagen Harbor, in the US "NIMBY" is the rule of the day.

There is intense debate between the advocates and adversaries of the 420 megawatt Cape Wind Project. Some living in Cape Cod, Massachusetts, do not want to view wind towers offshore. Jim Gordon, president of EMI and former natural gas power plant executive, has spent over $8 million in preparing environmental studies and regulatory applications to gain approval for Cape Wind. Environmental groups, such as the Union of Concerned Scientists and Greenpeace, support the development; the Alliance to Protect Nantucket Sound opposes it. While the debate continues, using coal to generate the power equivalent to Cape Wind creates 250 tons of carbon dioxide emissions per hour. Global warming continues.[5] Wind power also avoids coal power's billion-dollar health damage to the general population from NOx, sulfur, and mercury emissions. Coal miner deaths are also avoided.

Cape Wind has powerful opponents and powerful friends. Cape Wind would give General Electric significant competitive advantage for future offshore wind projects by installing 130 of its new 3.6 megawatt turbines. GE Power reports 2002 revenue of about $23 billion. It is determined to be the world power leader, skilled in a range of energy technologies from natural gas to wind.

Innovation and Alternatives

Offshore is one of many innovations that we will see in wind power. Since wind power is often sited on farms, biomass energy production is planned for many sites. Common logistics, balance of system, and grid connection can be used. Another innovation with major potential is wind-powered electrolysis that splits H_2O into hydrogen and oxygen. Hydrogen is delivered to fuel cells that power buildings and vehicles. Currently this is economically challenging. We will explore this in a future article.

The transition to wind power is driven by a number of factors including rising costs of natural gas, falling cost of wind power as large efficient generators come online, increased demand for electricity, and profits to corporations investing in wind operations. In addition to wind manufacturers and engineering firms such as Vestas and GE Power, there are hundreds of electricity providers. $8 billion FPL Group is rapidly diversifying beyond natural gas and nuclear power plants by investing in wind power. FPL and PacifiCorp are installing 300 megawatts from more than 450 wind turbines to serve the energy needs of about one-third of the residential customers in Portland, Oregon. This project takes FPL to over a gigawatt of wind power, and it's just getting started.

Shell is more than an oil company. Shell added over 60 megawatts of wind power to its energy portfolio in 2002. Shell, General Electric, and FPL do not see wind power as the universal panacea. Wind is more attractive in some areas than others. Wind power can be limited by availability, variability, imbalance, and infrastructure. Wind is not always available, causing some turbines to be idle for hours each day. Wind speed is variable. Mother Nature rarely accommodates with wind blowing at ideal speed during peak electrical demand, thus creating an imbalance between supply and demand. These challenges create the need for a second source of power, adding to the total infrastructure requirements. In spite of these challenges, with proper site selection wind is the best way to add incremental power to the electrical grids of many nations.

It is forecasted that by 2020 that 12% of all global electricity will be produced by wind, according to the European Wind Energy Association (www.ewea.org). By 2020, wind power will save 1,856,000,000 tons of carbon emissions that cause global warming. In 17 years, wind power is forecasted to employ 1.5 million people. This forecast is based on the modest assumption that growth of wind power installation will drop from the 36% average of the past five years, to 25% declining to 10% growth. The forecast also assumes more people, using more energy, and increasingly forgetting to turn off the TV when they leave the room. The global growth of wind power is unstoppable as larger turbines and offshore wind farms increasingly make wind the least expensive source of electricity.

 John Addison is president of OPTIMARK Inc. and a board member of the California Hydrogen Business Council. He is the author of the book, Revenue Rocket. A free 15-page book summary is at www.optimarkworks.com/books.

(Endnotes)

[1] Union of Concerned Scientists (http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=1180) 5/03.

[2] American Wind Energy Association (http://www.awea.org/news/news030618gas.html) 6/18/03.

[3] Union of Concerned Scientists (http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=46)

[4] RE World 5/03.

[5] 600 ton per hour benchmark from European Wind Energy Association (www.ewea.org) Windforce 12 report.

The promise of a clean, never-ending (renewable) power and fuel supply in the United States depends on our ability to harness energy from sources such as the wind, sunlight, organic matter, the Earth's internal heat, and rivers. However, making this promise a reality requires workers dedicated to leading this country toward a sustainable energy future.

HELP WANTED!

Marketplace Trends

The renewable energy industry involves many political, economic, environmental, and technological factors that interact with each other to influence marketplace trends. It is helpful to understand some of these factors because an increase in the market for a certain technology can equal an increase in job opportunities.

There is currently a movement to restructure the power industry. Driven partially by the Energy Policy Act of 1992, the movement intends to provide customers with the opportunity to choose their power provider by decreasing regulation of and introducing competition among utilities. Restructuring is primarily occurring on a state-by-state basis.

Many companies that sell energy produced from renewable sources view the move toward utility restructuring as a great opportunity. In fact, in many states, restructuring has given rise to the glimmerings of a new industry—green power marketing. The concept of green power marketing is based on the assumption that consumers will choose and pay more for renewable energy products/services that reflect their environmental values. Green power marketing programs put a price on the environmental value of a product to overcome the cost barrier that has historically limited the generation of renewable energy on a large scale.

Green marketing pilot programs show that the demand for renewable power products in a competitive marketplace may be quite large. Consumer demand for green power—along with the progress of utility restructuring and proposed state and federal mandates/incentives for consumers and utilities to purchase green power—could substantially strengthen the renewable power industry. This, in turn, may further decrease costs of renewable power and increase the number of jobs available in the renewable energy industry.

In addition to domestic markets, international markets for renewable energy systems are growing. International markets are driven by large remote needs for electricity, growing environmental concerns, and in some cases, a limited availability of fossil fuels.

Job Opportunities

There are a wide variety of professions available in the renewable energy industry. This fact can make it challenging to find the right professional niche, but it also provides the opportunity for individuals with many different types and degrees of training to get involved with renewable energy.

Some jobs—such as those in communications, community outreach, sales/marketing, and business support (e.g., corporate planning and finance, accounting, human resources, law, and information technology)—can be found in almost every renewable energy field. Other jobs are specific to individual renewable energy technologies, as shown in the following discussion of the five main renewable energy power sources: wind, solar, bioenergy, geothermal, and hydropower.

Wind Power

People have been using energy from the wind for hundreds of years. Windmills have been used for pumping water or grinding grain. And today, the windmill's modern equivalent—a wind turbine—can use the wind's energy to generate electricity. A single, small- or intermediate-sized wind turbine can generate enough electricity to power a house or farm, while a number of large, utility-scale wind turbines can form wind plants or wind farms that generate enough electricity for tens of thousands of homes.

As the cost of generating electricity from wind power continues to fall, many electricity providers are starting to view wind as an attractive, renewable alternative to fossil fuels (such as coal and natural gas), which are not renewable. The wind industry has grown at a rate of 25 percent per year, making wind power the fastest-growing source of electricity-generation in the world during the 1990s. Although Europe has experienced the majority of growth in the wind industry, the United States installed 905 megawatts (MW) of capacity in 1999—a record year for new wind projects. The nation's total wind capacity reached 2500 MW in December 1999 and is expected to approach 5000 MW by the end of 2001.

Jobs in Wind Power

The wind industry employs both professional and skilled workers in a number of different capacities. New wind projects require people with business, meteorological, and engineering experience to plan and build projects. Meteorologists help engineers identify appropriate sites with suitable wind conditions. Engineers then design the wind plant, working with the utility companies and communities. Construction workers are needed to build the wind plant. And mechanical and electrical technicians, called "windsmiths," are required to operate and maintain the wind turbines.

Both industry and research laboratories constantly try to improve the design and efficiency of wind turbines. These research and development (R&D)

groups generally employ mechanical, electrical, and aeronautical engineers with advanced degrees, as well as experienced technicians. However, others with technical backgrounds may also find jobs.

SolarPower

Anyone who has visited Florida in July knows that the sun can produce heat. And in 1839, French physicist Edmund Bequerel discovered that sunlight could also produce electricity (known as the photoelectric effect). Knowledge of the sun's ability to produce both heat and electricity has led to the invention of numerous technologies for capturing the sun's energy. The most common technologies produced and used in the United States today include photovoltaics, concentrating solar power (also known as solar thermal electric) systems, solar hot water systems, and passive solar building design.

Photovoltaics

Photovoltaic (PV) cells, also known as solar cells, produce electricity directly from sunlight. When a PV cell is exposed to the sun, the cell, which is made of semiconductor materials, absorbs a portion of the light that strikes it. If the energy from the absorbed light strikes electrons in the outer shell of an atom, these electrons are freed from their parent atoms. Free electrons can then travel into a circuit in the form of electricity. PV cells can be hooked together to meet many different types of electricity requirements, from pumping water to operating calculators and watches, and lighting homes and communities.

PV has traditionally been used in locations where it is expensive or impossible to send electricity through power lines. An increasing number of utility companies are experimenting with using PV to fill their small or more expensive power needs. Some homeowners and commercial building owners are integrating PV systems into their building designs to offset utility power demand and improve power reliability.

The growing demand for reliable electricity internationally has contributed to the growth of the U.S. PV industry—approximately 70 percent of PV systems manufactured in the United States are sold to other countries.

Concentrating Solar Power

Although the mechanics of each method differs, all three concentrating solar power (CSP) technologies—parabolic troughs, power towers, and parabolic dishes—use mirrors to focus incoming sunlight onto a receiver. The receiver collects the sun's energy in the form of heat, which can then be used directly or converted into electricity using a generator.

These technologies are currently in different stages of development. Troughs have a proven track record as a technology that can function effectively for large-scale power needs (such as those of a utility company) and are currently the least expensive way to produce solar electricity. Power towers have also demonstrated an ability to function on a large, utility scale, while parabolic dish systems, still under development, show promise for small-scale projects.

CSP technologies have caught the attention of some U.S. utility companies, as well as others interested in tapping into the projected consumer demand for green power supplies, even though the cost of using these technologies to generate electricity is still somewhat high.

SolarHotWater

Energy from the sun can

also be used to heat water for buildings and swimming pools. Solar water heating systems for buildings typically include a solar collector, in which fluid is heated by the sun, and a storage tank, which holds the hot fluid after it has been heated by the collector. Systems using fluids other than water require the additional step of passing water through a heat exchanger to heat the water. Swimming pool systems are very simple; they generally consist of collectors made of black plastic or rubber through which pool water is pumped to be heated.

Advances in solar hot water technology for buildings have dramatically cut the cost of solar water heaters from about $.20 per kilowatt-hour (kWh) in 1980 to $.08 to $.10 per kWh in 2000. As a result, solar hot water systems are increasingly being installed in schools, hospitals, prisons, and other government-owned facilities across the country. However, the number of solar hot water systems purchased in the United States is still quite small compared to the number purchased in the rest of the world. In 1997, for example, Americans purchased approximately 25,000 systems. Of the systems purchased, the majority were for heating residential swimming pools.

Passive Solar Building Design

Building orientation, types of construction materials, glass selection, and architectural features all affect the overall energy performance of a building. For a passive solar building, designers consider these features early in the design process along with taking advantage of solar energy to heat and light a building. They also design the building to be cool in summer.

It may cost more to design a passive solar building, but the savings achieved from decreasing the size of the mechanical and electrical systems to heat/cool and light the building, as well as energy cost savings, more than make up the difference.

Jobs in Solar Power

Growth of the solar power industry creates high-wage, skilled jobs throughout the country for individuals with many different types of training. R&D groups at national laboratories, universities, and private companies develop and continually improve solar products to lower their costs and improve their reliability. Individuals employed in solar R&D generally have professional degrees in electrical, mechanical, and chemical engineering; materials science, and/or physics. Many of the people involved with technologies that are still under development, such as parabolic dish systems, focus on R&D.

As each technology progresses from the R&D phase toward full-scale commercialization, an increasing number of both professional and skilled workers are needed to sell, manufacture, design, install, and maintain equipment. The PV and solar hot water industries currently employ the majority of these workers, including electricians, engineers, technicians, and technical managers. As utility-scale CSP technologies become commercially viable, the CSP industry will eventually require an increasing number of these workers, as well as engineers and construction workers to design and build power plants. The passive solar industry involves many of these professions as well, but also employs architects and builders.

Bioenergy

The energy stored in biomass (organic matter) is called bioenergy. People have been burning biomass, such as trees and straw, to cook and warm themselves for thousands of years. Today we not only heat 25 million homes with wood, we also produce 10.2 billion watts of electricity (less than 1 percent of what we use as a nation) from wood waste and waste from other biomass. And we derive up to 0.4 percent of all our transportation fuels (about 1.5 billion gallons) from corn, which is used to produce ethanol.

While we have always used wood and other biomass for heat, the production of electricity and fuels has grown from virtually nothing 20 years ago to what it is today, helping bioenergy become second only to hydropower as the largest source of renewable energy in the world. In addition, we use biomass instead of petroleum to produce between 11 to 15 billion pounds of consumer products, including plastics, glues, furniture, paints, and chemicals.

But as bioenergy technologies and biobased products stand poised to help achieve energy independence for our nation, the conversion of biomass into fuels and products still remains more difficult than the processes used for petroleum or coal.

Jobs in Bioenergy

Universities, national laboratories, and industry are working together to find solutions to the difficult problems surrounding the production and use of

biomass for energy and products. These R&D efforts require chemists, agricultural specialists, microbiologists, biochemists, and engineers, just to name a few.

Biofuel, biopower, and biobased product plants are most cost-effective when located near their source of biomass. Thus, bioenergy industry development has a special appeal because it creates direct and indirect jobs in rural areas of the country, and may prove to be a profitable complement for many existing agricultural and forestry businesses.

Engineers and construction workers are needed to design and build bioenergy plants, while electrical/electronic and mechanical technicians, engineers (mechanical, electrical, and chemical), mechanics, and equipment operators are needed to run and maintain these plants. Some may even require individuals cross-trained in areas such as engineering and biology, or chemistry and agriculture.

Jobs in bioenergy today cut across a wide spectrum of specialties and skills. And if R&D and industrial efforts succeed in making bioenergy more commercially profitable, we may see a dramatic increase in the number of bioenergy-related jobs. We'll need more farmers and foresters to produce and harvest biomass resources, more truckers to transport the resources to the power and fuel plants, and more operators to run facilities.

Geothermal Energy

Heat from the earth, called geothermal energy, is yet another renewable energy resource that people have used over the years. Geothermal energy heats water seeping into underground reservoirs, which can then be tapped for a variety of uses.

Low to medium temperature (70° to 225°F) water reservoirs can be used directly to heat buildings, grow and dry crops, melt snow on sidewalks, and for fish farms. This is called the direct use of geothermal energy. The energy produced from high temperature reservoirs (225° to 600°F) can spin a turbine to generate electricity.

Current drilling technology limits the development of geothermal resources to relatively shallow, water- or steam-filled reservoirs, most of which are found in the western part of the United States. Researchers are developing new technologies for capturing the heat in the deeper, "dry" rocks, which would support drilling almost anywhere.

Geothermal heat pumps (GHPs) allow us to take advantage of the Earth's constant temperature (around 55°F) just a few yards beneath the surface to heat and cool buildings, and to produce hot water. GHPs transfer heat between the building and the ground by circulating fluid through underground pipes. Currently, the majority of GHPs produced in the United States are purchased domestically, primarily in the Midwest. But as technology improvements reduce the costs of installing GHPs, the demand for this technology will continue to grow throughout the country.

Jobs in Geothermal Energy

The geothermal industry employs both skilled workers and those with professional degrees.

Developing hot water reservoirs requires geologists, geochemists, geophysicists, hydrologists, reservoir engineers, mud loggers, hydraulic engineers, and drillers to locate, assess, and access the reservoirs. Environmental scientists prepare environmental impact studies, and permit and leasing specialists obtain the land rights.

Geothermal direct-use technologies create jobs for heating engineers, and in the building and agricultural industries. For electricity production, engineers (electrical and mechanical) and construction workers—along with electrical technicians, electricians, electrical machinists, welders, riggers, and mechanics—are needed to design and construct power plants.

Mechanical engineers, geologists, drilling crews, and heating, ventilation, and air conditioning contractors are needed to manufacture and install GHPs. In addition, mechanical and electronic engineers, geologists, chemists, and materials scientists are required for ongoing R&D.

Hydropower

Hydropower, which uses the energy of flowing water to produce electricity, is the largest and least expensive source of renewable energy produced in the United States today. In fact, hydropower now generates approximately 10 percent of the electricity used in our country (wind, solar, geothermal, and biomass combined produce less than 1 percent). Most hydropower projects use a dam and a reservoir to retain water from a river. When the stored water is released, it passes through and rotates turbines, which spin generators to produce electricity. Water stored in a reservoir can be accessed quickly for use during times when the demand for electricity is high. Other hydropower plants, called "run of the river" projects, do not require dams. Instead, a portion of a river's water is diverted into a canal or pipe to spin turbines.

Many large-scale dam projects have been criticized for altering wildlife habitats, impeding fish migration, and affecting water quality and flow patterns. As a result of increased environmental regulation, the National Hydropower Association forecasts a decline in hydropower use through 2020. R&D efforts have succeeded in reducing many of these environmental impacts through the use of fish ladders (to aid fish migration), fish screens, new turbine designs, and reservoir aeration. Although funding has been limited, current research focuses on the development of a "next generation turbine,"

which is expected to further increase fish survival rates and improve environmental conditions.

Jobs in Hydropower

As with many of the other renewable energy technologies, the design, construction, and maintenance of hydropower plants requires electrical and mechanical engineers, technicians, and skilled workers. If the hydropower project also involves managing the reservoir and the surrounding land, the developer will also hire recreation planners, resource managers, and educators. In addition, state and federal licensing laws now require current or prospective hydropower plant developers to assess the environmental effects of their operation. Thus, the hydropower industry now also employs environmental scientists (biologists, hydrologists, ecologists, and wildlife habitat specialists, for example) to assess environmental impacts and address environmental remediation. Environmental scientists, as well as engineers, also participate in R&D efforts through private companies, national laboratories, and universities.

A career in renewable energy is a valuable way for individuals with a wide range of skills and interests to help guide the United States toward a secure, environmentally conscious energy future. For more information on energy careers, specific renewable technologies, and market forecasts, consult the resource list below.

U.S. PV Training Organizations

B.C. Solar
P.O. Box 1102
Post Falls, Idaho 82854
Phone: (208) 667-9608

Eclectic Electric
127 Avenida del Monte
Sandia Park, New Mexico 87047
Phone: (505) 281-9538

Energy Products and Services, Inc.
321 Little Grove Lane
Fort Myers, Florida 33917-3928
Phone: (941) 997-7669
Fax: (941) 997-8828

Enersol Associates
1 Summer Street
Somerville, Massachusetts 02143
Phone: (617) 628-3550
Fax: (617) 623-5845
email: jenersol@igc.apc.org

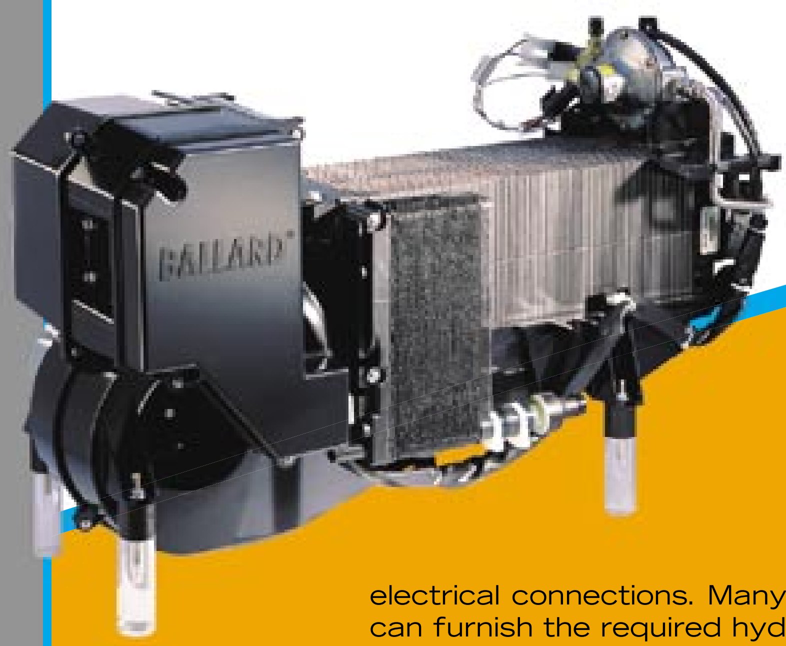
Institute of Energy Conversion (IEC), U. Delaware
Newark, Delaware 19716
Phone: (302) 831-6220
Fax: (302) 831-6226
email: rwb@udel.edu
Internet: http://www.udel.edu/iec

HYGEAR

RE / HYDROGEN PRODUCT REVIEW

Ballard Nexa™

Power Module



In almost any renewable energy system that is used in off-grid applications, the need for a backup source of power in cloudy or windless conditions has always been a necessity. Until now, only gasoline or diesel powered generators with their noise, smell and fire hazards have been available. All of these problems may be a nonissue if the Ballard Nexa fuel cell is employed as a backup power source. Since this fuel cell delivers unregulated DC power at 24 volts with a maximum of 1200 watts and 46 amps, most off-grid systems designers will find the Nexa easy to connect to the existing DC buss using off-the-shelf regulators. The Nexa comes ready-to-run with control software, and simple fuel and electrical connections. Many welding supply shops can furnish the required hydrogen. Power normally wasted in charge regulation of the storage batteries could also be use to produce the necessary hydrogen using an electrolyzer. The hydrogen could be stored in hydride or pressure tanks. The Nexa is UL listed, weighs less than 13 kg/29 lbs, is whisper quiet, and its only emission is pure water.

Contact : http://www.ballard.com

Outback Inverters are designed for Off-Grid / Fuel Cell /RE applications

Outback Power produces a complete line of powerful and reliable sinewave inverters, power regulators and balance of systems components for renewable energy. Inverters are available in sealed or vented versions with power levels from 2000 watts to 3600 watts. They are available in 12, 24, and 48 volt DC. Up to 8 units can be stacked to deliver 110/220 split phase, or they can be configured to deliver 208 volt three-phase power. They also produce the MX 60 charge regulator that can be set to regulate at 12,24,48 or any voltage in between that does not exceed 120 volts input from photovoltaics, fuel cells or micro hydro. The design is a true MPPT controller that delivers maximum efficiency. ETL and UL approved DC and AC breaker and distribution panels and combiner boxes for off-grid or grid intertie applications are available.

Contact:
http://www.outbackpower.com

HYGEAR

HY-GEAR

Palcan

Fuel Cell and PalPac™ Power Products will target scooter, electric bike, personal mobility device (wheelchairs etc.), neighbourhood electric vehicle (NEV), fork lift and portable and backup power markets. This range of initial markets testifies to the flexibility of the Palcan technology.

Their 2 Kw fuel cell stack system will power the next global transportation solution. The fuel cell powered scooter is a highly marketable alternative designed specifically to address the world's need for a low-end mass transport vehicle. Palcan's unique fuel cell uses the Company's metal hydride hydrogen storage technology to power the scooter. The Asian and European markets are direct targets for Palcan's prototype power supply. It is aimed directly at the market for smaller internal combustion engines (ICE) developed for two and three wheeled applications. These include rickshaws, small transport vehicles and scooters. Market survey reports estimate European production at 24 million two-wheeled scooters annually. In Asia, the market dwarfs that number as the smaller ICE engines exhaust effluent is a considerable environmental nuisance and governments are in need of solutions.

Contact: http://www.fuelcellstore.com

Portapack VE100

100W system provides portable power whenever and wherever you need it.

Simply plug in like the mains. Portapack VE100 will provide up to 100 watts of power as long as it has a hydrogen source. Ideal for recharging batteries in portable electronic devices such as remote monitoring equipment, mobile sensors, communications and computer equipment.

- 100 Watt continuous rating
- 120 Watt peak loading
- Dual Output 110 VAC + 12 VDC
- 230 VAC + 12 VDC optional
- Other DC & AC outputs available
- Self contained with Hydride canister or
- External hydrogen supply
- Hydrogen consumption is 1.3 l/min at 100% load
- IP65 rating
- Hydrogen supply pressure is 0.4 psig
- Approx dimensions (33cm wide,33cm high,16cm deep)
- Approx weight 10 Kg or 22 lbs

Contact: http://www.fuelcellstore.com

Defining The Hydrogen Economy

By Lawrence Elliott and Patricia W. Boyer

Recently, environmentalists, technologists, scientists, and now even the president, have so freely used the term Hydrogen Economy in their communications that it may soon become an integral part of our lexicon. On the other hand, many feel that by combining the word hydrogen with the word economy, no real interrelationship between the two is connoted.

In reality, Hydrogen Economy describes a now and future transition to a world-wide business and humanitarian state based on the use of the element hydrogen as fuel rather than the present economy based on fossil fuels alone. Environmentalists see it as "green" and freely promote hydrogen's virtues. Technologists see a chance to advance technology and "push the envelope." A reasoned and visionary definition of just what a switch to a hydrogen (and more specifically renewable hydrogen) economy would actually have on our present and future economies is rarely seen. Is it more than just "clean" and "green?" Is it possible that the use of renewable hydrogen to fuel the bulk of our energy needs could create "greenbacks" while being labeled "green?" There are many today who believe that this is well within the realm of possibility.

In the history of mankind, each discovery along the path led eventually to the creation of a more comfortable lifestyle, or wealth, or both. Historically, the pattern of adapting ever more sources of energy to daily activities to allow mankind time to pursue interests other than hard physical labor has been the rule rather than the exception. Wood, animal power, falling water, wind and even animal byproducts such as whale oil continued their use as fuel from earliest times until the industrial revolution began in the 18th century when coal began to fill growing energy needs. Yet even while the industrial revolution was emerging and coal was becoming king, the bulk of our energy still came essentially from the natural and renewable sources. In our own recent past history, coal use and the discovery of oil contributed to creating great wealth for some and a better lifestyle for many throughout the world. Colonel Drake's discovery of oil in Titusville, Pennsylvania, in 1859 set the stage for our modern day energy usage and wealth creation.

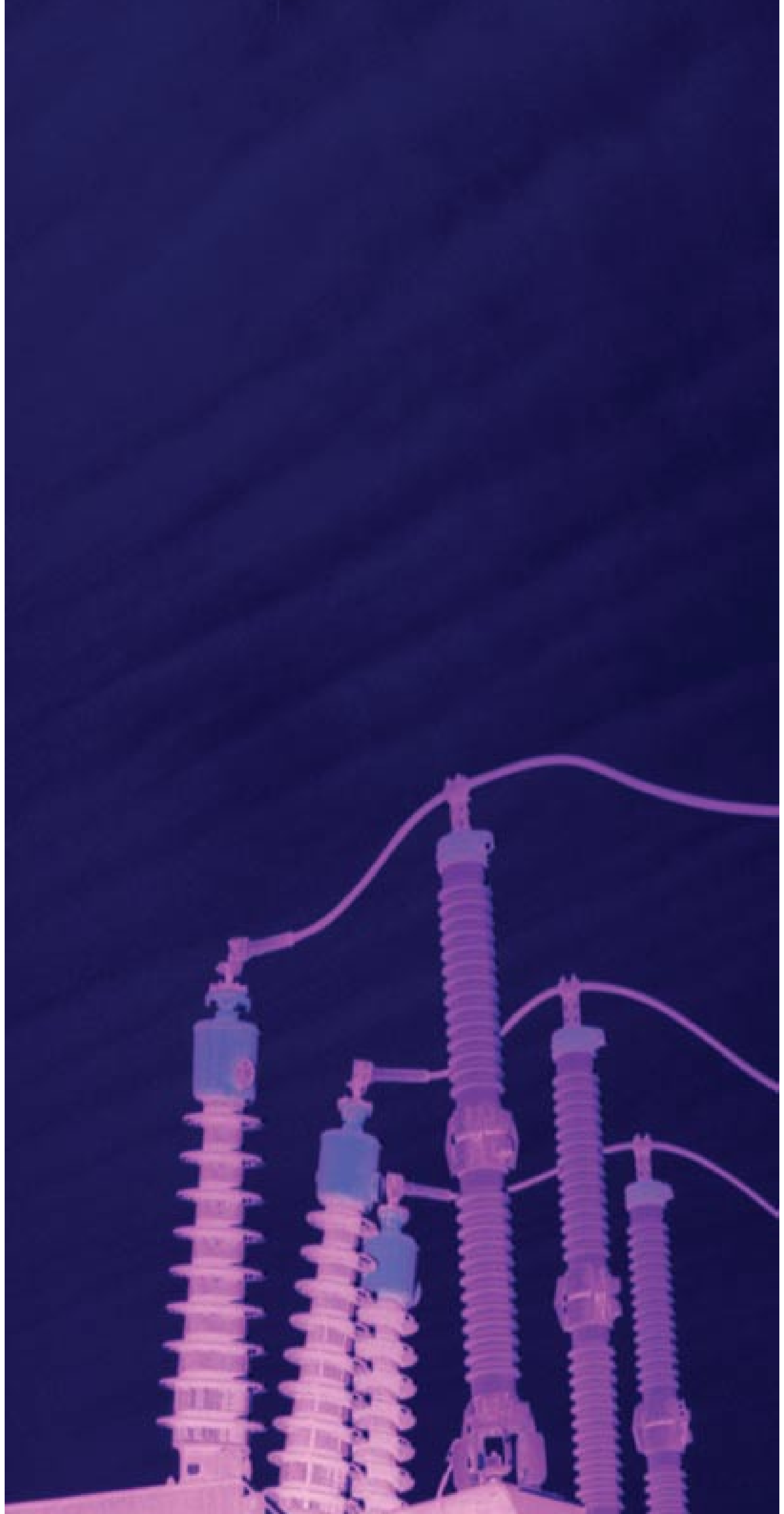
In less than four decades after the discovery of oil, man went from living a life of hard physical labor with limited free time and even more limited wealth to one of growing opportunity and leisure. Life was definitely getting easier. Although crude by today's standards, new labor saving devices that used oil were being created almost daily throughout most of the 20th century, with oil always central to the wealth created. Life quickly became bearable and in many cases quite enjoyable. The early 20th century saw the internal combustion engine refined and developed. Fueled primarily by oil, it helped create the auto age and the rest, as we say, is history.

The use of oil had a dramatic impact on every aspect of our daily lives and wealth was created quickly and in some cases easily. It was quite easy to see oil and its embedded energy as a direct substitute for our own human labor. Using the energy of oil we could do more in less time than we ever previously thought possible. We continued to find unlimited uses. It supplied more energy per unit weight or unit volume than coal or any other substitute available at the time. Applications for oil seemed without end. One hundred and fifty years of oil use has given us

the lifestyle and economy we now enjoy.
Unfortunately, in the 21st century, the negative aspects of continued oil use are rapidly becoming evident. The positive wealth creation in oil's past history may be coming to an end in what appears to be a rapid reversal. The wealth consumed in securing a continued oil supply through military involvement, air and water pollution, health costs, diminishing supply with increased demand that escalates oil prices, and a severe imbalance in our trade deficit are among the most obvious drawbacks to continued use of oil.

In economic terms, America and most of the western world have what is called a "mature economy." Our growth rates are, at best, on a continual decline and we struggle each day to keep our present economies on an even keel. Over two-thirds of our economy is now driven purely on the basis of consumption of manufactured goods, much of which is supplied by China, and so-called third world countries. The "dot com" revolution helped fuel the other third of our economy, but is now struggling because of market saturation.

By using less oil and relegating the remainder back to fossil status, we can create a new, dynamic and ever-growing economy simply by weaning ourselves from oil. By generating a hydrogen economy we can bring about an economic shift perhaps far greater than that created when we first began the use of oil.
Infusion of capital into a hydrogen infrastructure will immediately create wealth and



higher wages. It is simply the nature of any new and emerging industry. If the technology is sound and the products and systems are reliable, a customer base within the early adopters and environmentalists will be created immediately. The capital needed to fuel this new industry can come directly from the reduction in our balance of payments to foreign countries that now supply us oil. Economists will argue that a cheaper supply of energy is essential to economic growth; but, that applies only when the true cost of fossil fuels is externalized.

Initially, expecting hydrogen to be cost effective or competitive when compared to fossil fuels is unrealistic. Automobiles were not cost effective when compared to horse-drawn carriages, and word processors were not cost effective when compared to typewriters; yet vibrant industries were created as the new displaced the old. With economy of scale prices began to fall.

We do not have the luxury of waiting for fossil fuels to become expensive enough to make hydrogen production cost competitive. We need to start now to fund the hydrogen infrastructure, so that the transition to the hydrogen economy can be made in a gradual and orderly fashion. One thing is certain: we may never run out of oil; but, we definitely will run out of economically recoverable oil. Since we still need to inject wealth and capital into extracting oil from the earth, when the money needed for this extraction consumes a greater percentage of the profits than it generates, the oil well becomes an energy sink rather than an energy source. At such a time it will be more cost effective to simply leave the oil in the ground and look for other energy sources.

Crude oil is not only energy dense, it is also rich in hydrocarbons and should be used more in the production of plastics and other durable goods than in the transportation industry as we use it now. It is imperative that we invest in an alternate source of energy so that we can simply leave the oil for the production of goods that create greater wealth rather than simply burning it.

Just as the early adopters of oil could not realistically predict where its use would lead, it is equally difficult to predict where the hydrogen economy will take us. But there are some results that we can predict with accuracy and these results may be startling. If we adopt hydrogen as our primary transportation fuel, the reduction in air pollution and the resultant health benefits would be immediate. We can only speculate on the monetary benefits that would result; but one thing is sure, they would be substantial.

When horse and buggy was the transportation of choice, pollution and odors from animal wastes were major problems, especially in cities. The automobile seemed to solve this problem; but, in reality we simply reduced the obvious severity, and in many ways the pollution and odor were increased.

What would it be like to stand in a city center where the streets are filled with hydrogen fuel cell vehicles? First of all, there would be no smell, smog or odor emitted from the vehicles. That improvement alone would be worth any cost associated with a transition to hydrogen. The silence would be "deafening." No longer would city buses with their growling and belching be seen as part of the landscape. Clouds of black, diesel smoke would be only a memory.

Perhaps the less obvious benefits would be the most striking. All the hydrogen needed to accomplish this miracle, if produced renewably, would have immediate and far-reaching impacts on areas outside of the city. In such an ideal situation, farmers, who now depend heavily on subsidies to remain in farming, will be harvesting royalties by leasing their land to wind farm developers for production of electricity to be converted into hydrogen. Land that is normally unproductive could be put to the plow to harvest bio fuels to be used for hydrogen production. Deserts and millions of rooftops could be covered with solar panels to harvest the sunshine. Brownouts and blackouts will belong to the past when fuel cells can supply instant backup to the grid. Critical industries will no longer sustain the loss of billions of dollars because of any shut down during blackouts.

In the suburbs, commuters could fill up on hydrogen produced at home using their own solar electricity. Or, before their commute, they could be filling up at local filing stations that produce hydrogen on site from the electricity produced on wind farms or other renewable energy producers.

Each dollar spent on domestically produced hydrogen is a dollar that will stay in this country and will not be sent to foreign countries to purchase oil. For those who produce their own hydrogen from their own renewable sources, the dollars spent now on gas or diesel will be available to purchase other goods and services. There would be an immediate increase in consumption with an increase in economic activity.

Manufacturers, who now struggle with older technologies that are low profit and that already saturate the market, could begin to manufacture the equipment and systems needed for the new hydrogen economy. The increased prosperity generated in the emerging hydrogen economy will pay dividends that could then be reinvested in new technologies and new economic development. It is difficult to guess what new industries and technologies would be created to serve a new hydrogen economy. It is difficult for me to see any downside to a complete, gradual transition away from oil and fossil fuels to the use of hydrogen fuel based on renewable energy sources.

The benefits of a switch to a hydrogen economy based on renewable energy sources can far exceed our wildest dreams.

That day is close at hand.

Confused About Photovoltaic Systems?

Finally, people all over the world are taking a long, hard look at Renewable Energy. Photovoltaics, wind, hydro and other renewable forms of energy offer great sources of clean and sustainable power. However, just as in any new technology, there are always many questions consumers need answered before a purchase can be made.

Here is a representative sample of the most common questions along with answers that should offer enough basic information to allow the average consumer to make a wise choice.

"I live in a 2800 square foot home with all the usual loads. How much power do I need to get off of the grid?"

"Houses do not use power but people do." By that, we mean that the amount of power a home uses is not based on its square footage. Each home can have a load pattern as unique as the occupants who live in it.

The first step you must take when answering the "how much power do I need" question, is to contact a local renewable energy supplier to have them do a detailed load analysis. If that is not possible, then look at your current power bills to determine a load profile based on the number of kilowatt hours consumed each month. Many who decide to supply all or most of their power using renewable energy are pleasantly surprised to find that a few simple changes in lifestyle habits, major appliances and updated HVAC equipment can sometimes lower their energy consumption by as much as 50% and in some cases even more.

What type of system is right for me? Should I go "off the grid" or should I go "utility backup" or "grid-intertie?"

Each offers a different level of protection and a different level of expense. As a "rule of thumb," if your home is to be sited more than a quarter of a mile from a utility connection, economics will dictate an "off the grid" system. "Off the grid" simply means that your renewable source of energy will supply enough energy to make connection to the grid unnecessary. With ever-rising costs of connection, some utilities' charges for even a one-eighth mile extension of the lines could make an off-grid system cost competitive. If you want electricity protection during storms or rolling blackouts, then you can go with a "utility backup system." This type of system does not need to be big to keep lights and the microwave going, or a computer, or even a TV. Of course, the size of this system will depend on what you want to keep running in case of a blackout. This is something you have to consider. What are your priorities? The more items you think you need to have running during a blackout, the more expensive your system will be.

If you want simply to supplement your electricity and lower high energy cost, you can "grid intertie." The term "grid intertie" means a system that feeds power back to the power company, either supplementing your power cost or better yet, getting paid from the power company. **Note** Not all power companies will let you sell back to them. Remember, a "Grid Intertie" system offers NO backup power!

What are the components that make up a typical renewable energy system ?

An "**Off Grid**" or a"**Utility Backup**" system consists of the following basic components:

1. *Photovoltaic panels* (solar panels) or Wind generator or Hydro or a generator (gas/diesel/propane) or a combination of all of the above.

2. *Inverter.* This unit converts the energy (DC/Direct Current) to (AC/Alternating Current) or better know as Household current.

3. *Charge controller.* This unit controls and regulates the amount of current that goes to and from your batteries.

4. *Meter.* This is like a fuel gauge. It tells you how much energy you are using and how much you have left.

5. *Batteries.* Batteries are used to store the energy you create. These are not the little bunny type of batteries, these are like car batteries, but larger.

6. *Fuses. Fuses, Fuses, Fuses*.......DC current can be dangerous and damaging to expensive equipment. Did I mention Fuses, Fuses, Fuses!

7. *Wire*. The further you have to run wire from your panels to the batteries, the larger the wire (the more expensive also). Consider a higher voltage system to reduce cost.

8. *Mounting.* This is a way of mounting your panels. You can mount them on the ground, on your roof, or up high on a pole. Other more efficient mounting systems are called Trackers. They move along with the sun, giving your panels the most direct sun all day.

The type, size and amount of equipment depend on two things -- the size of your wallet and the amount of energy you wish to produce.

Utility Backup system

This system consists of the same components as above. The only difference between "Off Grid" and "Utility Backup" is in the way they are used.
A Utility Backup system can feed the energy it produces back to the power company; that is, your

power meter turns backwards, then when the power goes out, it kicks in and provides you with the energy you need. When the utility power comes back on, it goes back to work, first charging your batteries and then resuming delivery of power back to the grid.

For most people living on the grid in an area that experiences frequent power outages, especially those who have very critical loads such as computers or servers, this is a great way to go.

Grid Intertie

This system consists of solar electric panels and a utility interactive inverter. These allow bidirectional flow of power either from the panels to the grid when your loads are lower than the power available, or from the grid at night, or when loads exceed your level of production. In a state or local power district that allows net metering you quite simply "run your meter backwards." This is something that most people with large power bills have dreamed of for years. Now it is possible, and it is all legal.

How much does a system cost?

Determining the up-front cost for the purchase of a system is actually fairly simple. The initial cost is determined by the amount of power you feel you need. System costs have been falling since the initial introduction of the technology, and as the level of production and installation increases, the price will continue to fall. Because an off-the-grid system does not require batteries or other methods of storage, a given system size will in (most cases) be lower cost than a system that allows you to be off-the-grid.

Here are some ball park figures to use when calculating what a system might cost.

Off Grid" or "Utility Backup" will run right around $8.00 per installed peak watt. As an example, a 2500 watt system would cost about $20,000.00. A typical grid intertie system will cost less at about $6 per installed peak watt. That means for the same $20,000 you could purchase a system of a little over 3300 watts.

PV professionals install the lastest in Photovoltaic roof shingles

Another common question is: "What is the payback on my system?"

In very simple terms, one could calculate the amount of power that could be purchased for the equivalent amount spent on the solar system. This, of course, ignores an entire range of variables that come into play. You simply rent power from a utility, so you would need a crystal ball to know how much power will cost next year or next decade or beyond. However, if you have a renewable energy system you own your own utility. If power costs continue to escalate (which is almost a certainty), the dollar you spend on your system today may be worth two, three, or even four times more in energy value in the twenty or thirty year life of the system.

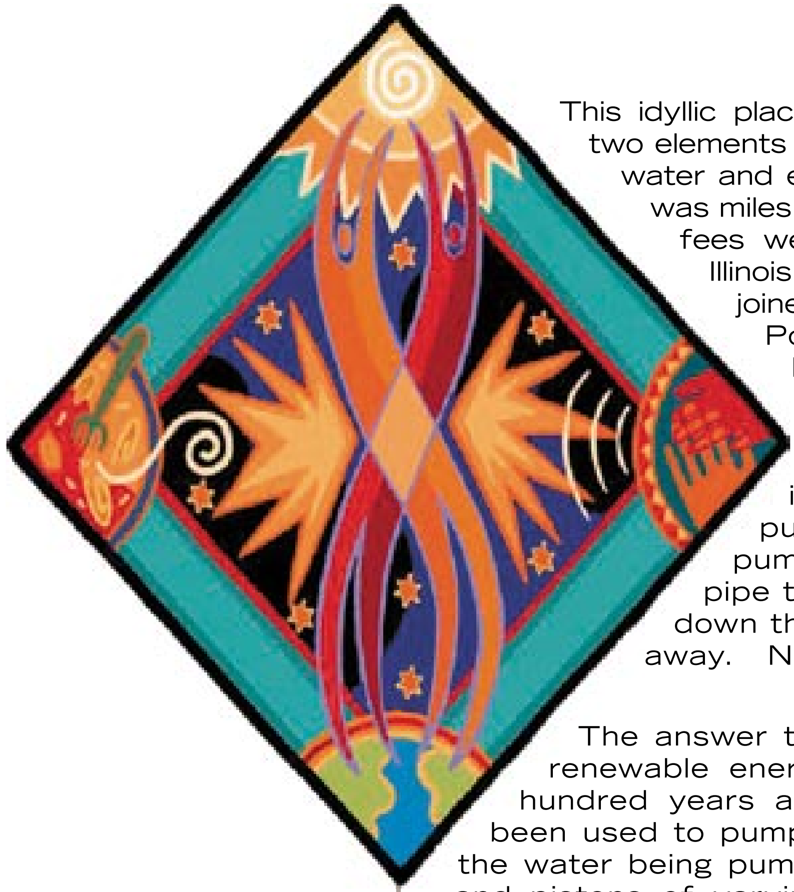
In addition, we have no way of knowing where the price of oil or natural gas is going; so if our system is used to provide a source of hydrogen for fueling vehicles sometime in the future, then the true value and thus the actual cost may be extremely low overall.✪

Off the Grid Meets On the Grid

A Grid Tied Story

By Patricia W. Boyer and Lawrence Elliott

In 1988 when Bob Maynard moved into a small cabin in the mountains above the Illinois River just a few miles west of Grants Pass, Oregon, he found that the daytime peace and quiet of the forest surrounding his new home was broken only by the sound of an occasional bird call and the gurgle of a small stream that tumbled down the mountain from high above to join the river below. At night a bear occasionally wandered through the clearing near the cabin.



This idyllic place had been Bob's dream, but it lacked two elements he had become accustomed to – running water and electricity. The nearest utility connection was miles away from his new home and connection fees were out of the question. Although the Illinois River and the many small streams that joined it were just just a stone's throw away. Potable drinking water was available to him only from a source several hundred feet down the mountain from the cabin. He had two options: either he could haul water up the mountain in a bucket to his cabin; or he could purchase a generator or gas-powered pump to move the water uphill through a pipe to his cabin and haul fuel for the pump down the canyon from the nearest town miles away. Neither option appealed to him.

The answer to his problem was his introduction to renewable energy. He knew that for at least one hundred years a mechanism called a ram pump had been used to pump water uphill, using only the force of the water being pumped through a series of check valves and pistons of varying diameter. From the Fleming Ram Company of Virginia, he purchased a modern-day ram pump, a simple, reliable, plastic device that solved his water problem, and is still running today. From this small success, he began to plan how he might use a renewable source of energy to supply electricity. In addition, he needed a source of income and both problems were solved after he approached Gene Hitney for a job. Hitney had opened a branch of Photocomm in the town nearest Bob's cabin, Cave Junction, Oregon, and needed a part-time salesperson for his solar equipment. Bob had a background in PBX and commercial phone installation and sales; so, Hitney agreed to hire him as an installer.

The forest product based economy of the State of Oregon was in decline so Bob was happy to have an interim job that provided not only cash for daily needs, but the opportunity to learn as much as possible about the emerging renewable energy field.

When Gene Hitney decided to move to Arizona, he left Bob to operate the business alone. Bob quickly cultivated friends in the solar industry who encouraged him to tough it out, to learn as much as he could, to persevere. He soon became regional manager for Photocomm, and, in addition, installed at his cabin an off-grid solar electric and micro-hydro power system. Success brought more success and in 1991 Bob left Photocomm to start his own business, Energy Outfitters. His first wholesale customer later became the Senior Science

Editor for H2Nation Magazine.

Success in business and comfort and convenience at home had been supplied by renewable energy. Bob, with his little dog, Daisy, for company, loved his life in his cozy cabin in the canyon. His life was almost perfect – almost, that is. It lacked only one thing – human companionship at home. And Bob solved this problem as well. With the help of power from the sun and a cell phone internet connection he met Barb, the woman to whom he is happily married today.

Barb lived in Portland, Oregon, about as far away from a mountain cabin as a professional businesswoman could get. Bob's business continued to expand, so it seemed only natural that when they married, it would be a new world for both of them and a compromise seemed in order. Barb would move from the big city with its hustle and bustle and Bob would move from his remote mountain cabin and together they would make their home at a place far different from that either had known before – in the small mountain town of Grants Pass, Oregon.

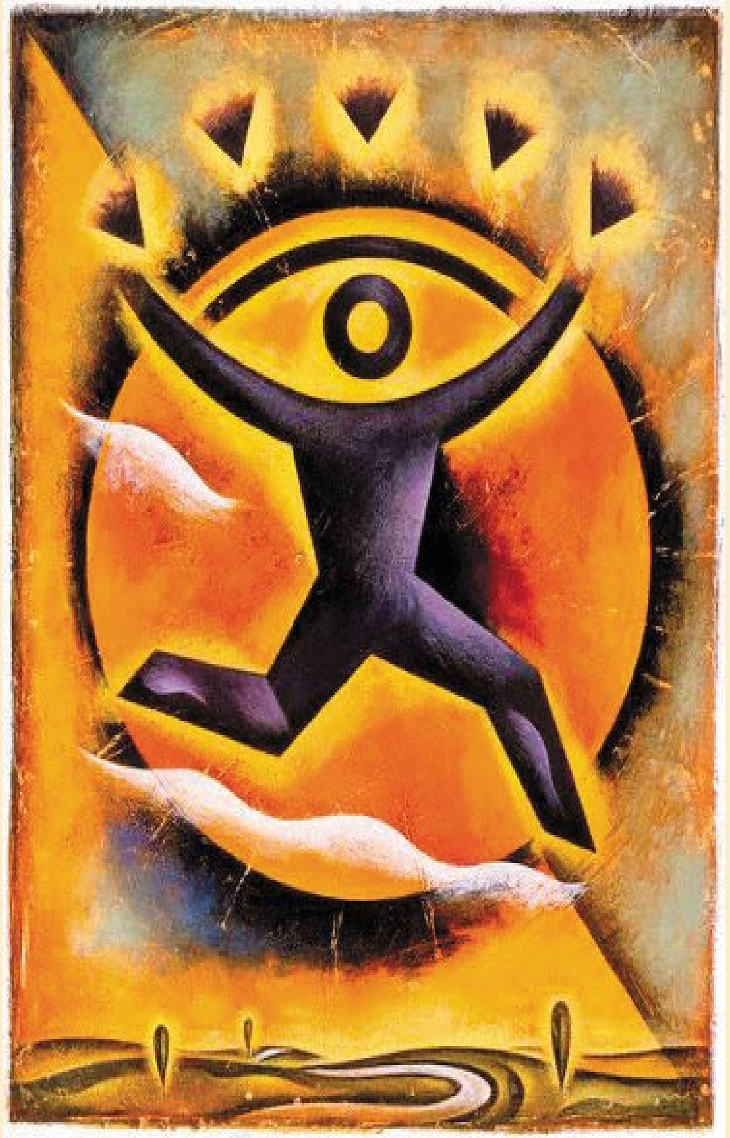
At about the same time Barb and Bob bought their new home, Energy Outfitters acquired the distributorship for Sharp Solar. Sharp was ready to introduce a new interactive line of solar equipment into the American market and Energy Outfitters had developed their new R-power line of solar electric systems.

Unlike the old system Bob had installed at his mountain cabin, the system for his new home would be much larger and have no need for batteries. Eighteen solar panels were installed on the Maynard home in May of 2003, with power production being closely monitored by a Sharp Solar remote display that records and displays kilowatt hours and peak power production; and, in addition, indicates the amount of CO_2 emissions the system avoids producing because of solar's zero production of pollution.

Even though the national average consumption of residential electrical power is 13,000 kilowatt hours per year, and usage is higher in homes using electric heat or air conditioning, the solar system on the Maynard home has been producing up to twenty kilowatt hours per day, more than sufficient to power the entire electric needs of the household. Though their home includes energy-saving devices such as compact fluorescent light bulbs, nevertheless, all their appliances are standard models. In addition, Bob's average twenty kilowatts per day usage saved him approximately $51.00 when he signed up for Oregon's Green Power option that costs $.085 per kilowatt.

The State of Oregon is a "net metering" state that allows you to literally run your electric meter backwards and have a direct reduction in your power bill and also provide incentives for installation of renewable energy systems.

The Energy Trust of Oregon uses revenue from small charges on the electric bills of two of the state's investor owned utility companies to make rebates available in the purchase of solar electric systems such as the one installed by Bob and Barb Maynard. The initial rebate is equal to $4.25 for each rated watt of installed capacity, and will soon drop to $3.90. The Maynard home qualified for the full rebate.



Other states are establishing rebate programs similar to those of California and Oregon and sales of renewable energy products are increasing over 30% per year. Energy Outfitters is doing its part to supply quality products and services to this market.

In the early years of his renewable energy experience, Bob could not have imagined that he would one day be happily married to Barb and living in the comfort supplied by renewable energy.

Energy Outfitters has opened a branch in New Jersey. As I finish writing this article, I have just learned of the entire shutdown of the northeast energy grid. When Grants Pass, Oregon, slid into economic decline because of the shutdown of the forest products industry, Bob made the transition into the emerging renewable energy industry. He and Barb prospered from that transition. Perhaps people on the east coast will now consider the electrical grid shutdown as a wake-up call and will make a transition to the renewables that will insure a safe, clean and reliable energy future for all of us.✪

Calendar of Events

Fuel Cell Seminar
This event takes place on 11/3/2003

The Fuel Cell Seminar, in conjunction with the National Fuel Cell Research Center (UC Irvine), is pleased to announce a One Day Fuel Cell Short Course that is designed to prepare and provide a foundation for participants of the Fuel Cell Seminar. Presented by university experts from around the nation, the intent is to provide an unbiased, balanced perspective of both the technical and market opportunities and challenges fuel cells face . Sponsored in part by the US Fuel Cell Council.

Registration required.

Location: Washington, , DC - United States

For more information about this event contact:
Fuel Cell Seminar Headquarters
c/o Courtesy Associates,
2025 M Street, Suite 800
Washington, DC 20036

Event Website: http://www.fuelcellseminar.com/shortCourse.asp
Contact Email: fuelcell@courtesyassoc.com
Contact Telephone: (202) 973-8671
Contact Fax: (202) 331-0111

EVS 20: 20th International Electric Vehicle Symposium and Exposition
This event starts on: 11/15/2003 and lasts 4 days

Organized by: Electric Drive Transportation Association

Celebrating its twentieth anniversary, this important gathering consistently draws thousands of industry, government, academic and environmental leaders from around the world to explore the latest in battery, hybrid and fuel cell electric transportation technologies

Location: Long Beech, CA, , CA - United States

For more information about this event contact:
EDTA, 701 Pennsylvania Avenue
NW, 3rd Floor
Washington, DC 20004,

Event Website: www.evs20.org
Contact Email: evaa@evaa.org.
Contact Telephone: 202-508-5995
Contact Fax: 202-508-5924

POWER-GEN Renewable Energy
This event starts on: 3/1/2004 and lasts 3 days

POWER-GEN Renewable Energy brings together the renewable energy (wind, solar, biomass, hydro and geothermal) and emerging technologies (fuel cells, microturbines, energy storage and energy efficiency) sectors of the energy industry to discuss the key technical, regulatory, structural, economic and market issues impacting their commercial future. With a conference program featuring multiple tracks of sessions covering technologies and business issues, plus an exhibit floor showcasing the latest products, systems and services, POWER-GEN Renewable Energy is the industryýs premier event covering all major aspects of the renewables market.

Location: Las Vegas , NV - United States

Directions: Flamingo Hilton - Las Vegas, NV

Cost: Register on-line at www.power-gengreen.com

For more information about this event contact:
Lisa Gasaway, Event Director

Event Website: www.power-gengreen.com
Contact Email: pgreconference@pennwell.com
Contact Telephone: 918-832-9245
Contact Fax: 918-831-9875


Clyde M. Boyer (1921-1997)

Past, Present and Future:
Thoughts from the Editor
by Patricia Boyer

In World War II during the D-Day campaign, squadrons of American planes continually flew sorties from England over Europe through a carpet of flak. After beachheads were secured, the Allies moved inland and one of those squadrons moved planes onto a small airfield wrested from the Germans at a location somewhere near the Ardennes in Belgium. Almost immediately, the enemy recaptured the airfield. Those American airmen lucky enough to escape with their lives made it to a place called Bastogne. There they spent a winter like no other before or after. My husband was one of those men. He came home from that war in the fall of 1945.

He finished his education, received his engineering degree, was called back to active duty during the Korean Conflict, then later became one of the crew that put our Vanguard Satellite into orbit, where it remains to this day. A stint as Project Engineer for Titan at Vandenberg Air Force Base was his last endeavor for his country. He left the space race and spent the rest of his life where he had dreamed of being since he was a boy: a place far away from so-called civilization; a place where the air was clean and pure, the silence broken only by the bawl of a calf, a bird song, or the occasional howl of a coyote at night; a place where he and his family could raise cattle and breathe clean air.
However, the pollution of this earth crept slowly into our idyllic place and even though we were miles from so-called civilization, the effects of fossil fuel emissions were beginning to take their toll. And neither could we, who lived far away from this so-called civilization, say we were blameless. Our ranch tractors and harvesters emitted the same noxious pollutants as the vehicles of the big cities.

My husband was one of those far-seeing ones who, because of his engineering background, knew there was a better way for mankind. Though he was no longer in a position to do anything about it personally, nevertheless he never ceased preaching to the family that "hydrogen, the never-ending element, is the fuel that we will be using some day, the fuel we must use some day."

So, my family grew up hearing this prophecy stated and re-stated over the years. Though their dad left this plane of existence a few years ago, the memory of his prophecy is burned indelibly in their minds. They, too, are sure that hydrogen is the fuel we must be using – not just some day – but here and now.

These days, although I see my family often, nevertheless, since their dad left this plane, I have much time to myself to reflect on our lives and to think about what the future holds for all of us. At the time of this writing, I live on the Oregon Coast, probably one of the most beautiful places on earth. A walk along the beach is my meditation. As I walk in the wet sand, the cold Pacific laps at my feet. I pick up a little piece of jade or sometimes I find an agate, and I lose all sense of daily life. A steady, cool wind blows from the sea. The gulls swoop around me, settle down and walk along beside me, just as though we had known one another for quite some time. As I walk, I am filled with gratitude for the beauty of this place and I hope that it will last forever; yet, I know that if we remain on the course mankind has set to date, it will not.

However, I also know in my heart that there is an answer. I, too, believe that the use of hydrogen for fuel will allay the damage already done to our beautiful, blue planet, and we will then retrieve for all time, what we have come very close to losing forever.

And so, my sons and I, along with an engineer friend, have embarked on a mission: a mission to help fulfill their dad's prophecy; a mission to tell the world that clean air, pure groundwater, clean oceans, green forests, immaculate snow in winter, and pure, clean rain in spring are all imminent possibilities. This magazine, H2Nation, they are bringing to the world is not just an entrepreneurial whim, it is the result of a deep inner conviction placed in their hearts from the time they were just boys: that there is only one way to save this world and that is through leaving fossil fuels where they belong – in primordial earth, and using the never-ending gift from the universe, *hydrogen.*