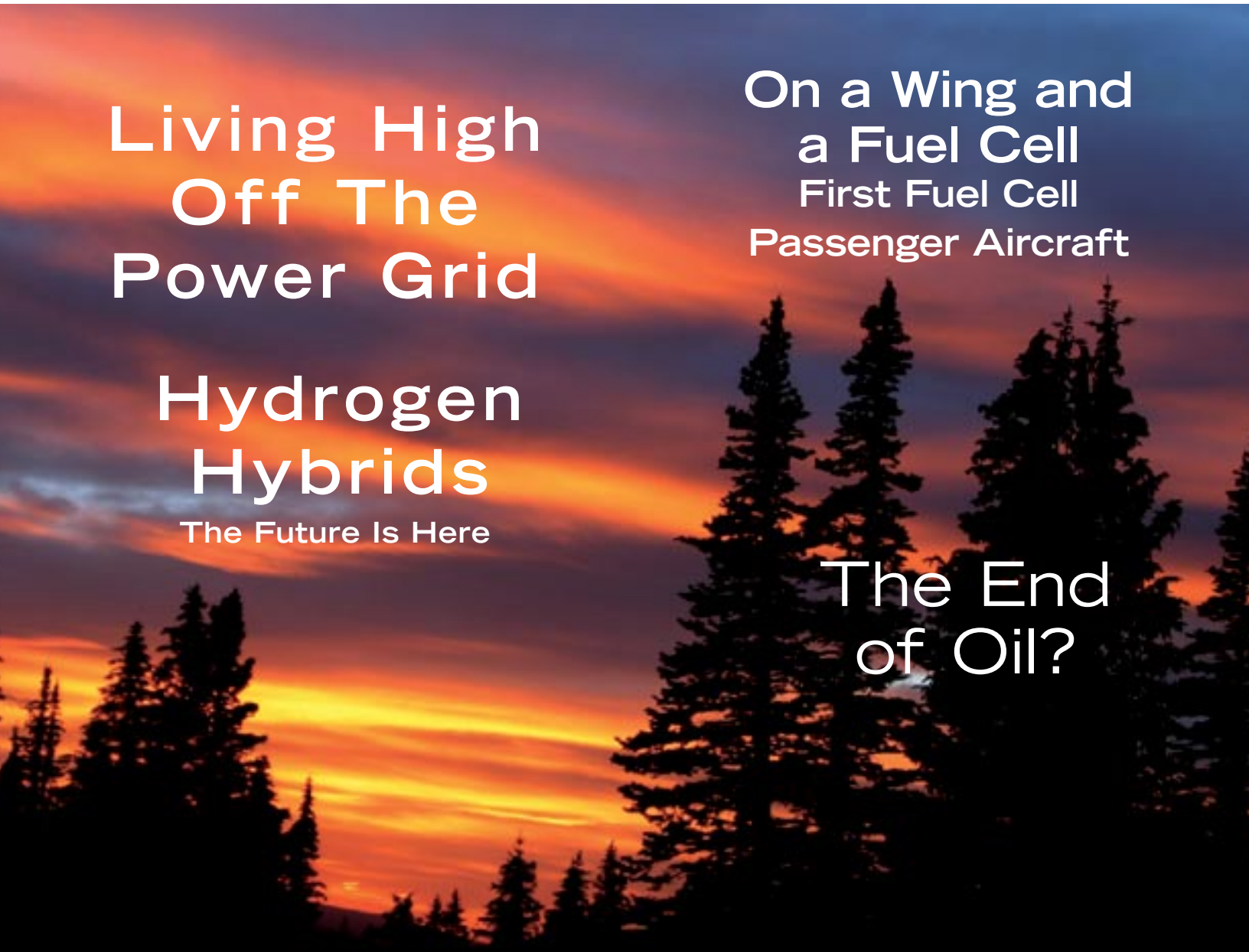
SPECIAL REPORT: 2004 Green Car Buyers Guide

YOUR GUIDE TO THE HYDROGEN ECONOMY

H2Nation

Hydrogen / Solar / Wind Energy

Vol. 1 Issue 2 March/April 2004



Living High Off The Power Grid

On a Wing and a Fuel Cell
First Fuel Cell Passenger Aircraft

Hydrogen Hybrids
The Future Is Here

The End of Oil?

Renewable Energies The Road to the Hydrogen Economy

$5.95 US $7.95 Canada
ISSN 1545-7036
03>
9 771545 703008

www.h2nation.com


...Will Have A Profound
Effect Tomorrow
The Actions We Take Today....
IONTECHCORP
Designing for the future TODAY
www.iontechcorp.com

THE HOUSE OF SPIRES
A house on top of the mountains. Life at 11,000 ft. has its challenges. We went to the home of Chuck and Theresa Burr to see this magnificent off-grid home.
Page 36.

When Power Came to Telluride
The story of the world's first AC Hydro-Electric power plant.
Page 48

Brewing a Better Tomorrow
New Belgium Brewery uses the latest in renewable energy to brew their suds.
Page 30

The End of Oil
An in-depth review of tomorrow's issues.
Page 54

Renewable Road to Hydrogen
Living off-grid
Three families and their off-grid homes.
Page 78

ON A WING AND A FUEL CELL

The First Fuel Cell Powered Passenger Aircraft.
Page 58

Green Car Buyers Guide

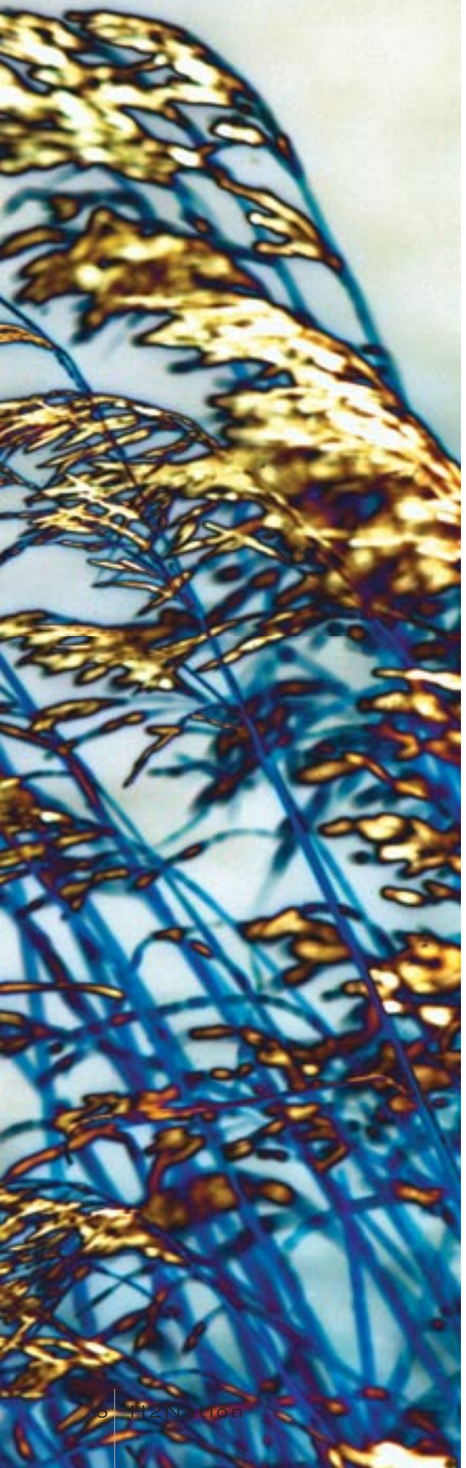
With the high cost of fuel, these cars are worth a look!
Page 20

departments

Publisher Judd Boyer
Editor Patricia Boyer
Senior Science Editor Larry Elliott
Director of Marketing Clyde Boyer
Photography Greg Boyer
Public Relations Abigail Martinez
Editorial Submissions
articles@h2nation.com
Advertising
partners@h2nation.com
H2Nation Publishing,Inc.
PO Box 52080
Sparks, NV 89435-2080
Ph. 775-356-8411 Fax.775.358.2168

H2Nation is published bi-monthly by H2Nation Publishing, Inc.
Single copy price:$5.95 U.S.A.;$7.95 in Canada.
Submissions of manuscripts, illustrations and or photographs must be accompanied by a stamped, self-addressed envelope.The publisher assumes no responsiblity for unsolicited material.
Printed in the U.S.A.by St.Croix Press
St.Croix Press,Inc.
1185 S.Knowles Ave.
New Richmond,Wisconsin 54017

Letter From the Publisher



Four Score and Seven Years

Corruption was rampant. The people had lost faith in the leadership. A disastrous involvement in a war left the economy in a hopelessly disrupted state. Much of the populace depended on others to supply them with their basic needs, and jobs were scarce or non-existent. And so, in March of 1917, the Russian Revolution began, a revolution that eventually destroyed millions of lives.

Today, four score and seven years later, a new revolution is beginning – the Hydrogen Revolution, a revolution that will save mankind.

Though it may seem that the same old story is unfolding; that corruption is rampant and many have lost faith in the leadership; the economy appears to falter; jobs are scarce or non-existent; and we are in manacles because of our dependence on foreign oil; nevertheless, there is yet a great hope for the future.

Technology advances at an astounding rate. What once took years to conceive and develop is now created with a stroke of a mouse, or a new algorithm. We are taken from concept, to design, to market faster than at any time in history. Yet, when it comes to the use of hydrogen for fuel, many cling to the old fear of change.

We hear: "It will take too long and cost too much and can only be produced with fossil fuel or nuclear energy." But that is not the truth of the matter. Hydrogen produced from wind and solar will bring the quiet power of the sun and wind into our noisy, cluttered, toxin-filled lives and the source of that quiet power may never end.

As our weather change becomes more dramatic, and the depletion of oil continues, we must encourage new technologies, embrace new ideas and welcome the change they bring to our lives, change for the betterment of all mankind.

Now is the time to make the change, to make the history, so that four score and seven years hence our descendants can say, "What a wonderful revolution it was!"

Judd Boyer

Contributing Writers

END OF OIL P.58
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."

On a Wing and a Fuel Cell P.50
Vicki Sanders is the award-winning editor in chief of the Boston College Law School Magazine. She has written for numerous publications, including the Boston Globe Magazine, The Miami Herald, the Providence Journal, Rhode Island Monthly, Natural Health, the Boston Herald and Radcliffe Quarterly.

***Natural Gas is the Problem: Not the Solution* P.18**
Harry Braun has worked as an energy analyst for the past 20 years. He is Chairman and CEO of Sustainable Partners, Inc., a systems integration company that is involved in a number of renewable energy projects including the development of a 180 megawatt Mesa Wind project in New Mexico.

He is a graduate of Arizona State University where his undergraduate interests evolved from anthropology, history and general science. His postgraduate research has focused on energy technologies and resources, as well as molecular biology, protein evolution and nanotechnology. He has been an advisory board member of the International Association for Hydrogen Energy (Coral Gables, Florida) since 1981.

When Power Came To Tulluride P. 48

Ernest Eich lives and breathes in southwest Colorado where he tackles a variety of social problems, including the best way down Telluride's Double Black Diamond Trails and the shortest path to the local's coffeeshop. When he isn't thinking about alternative energy solutions, he takes part in San Miguel County's Open Space Commission and helps knit together the annual Telluride Technology Festival, among other odd facets of a crystalline life in one of America's most beautiful mountain ranges. After studying civil and mechanical engineering to the point of exhaustion (but not academic recognition), he graduated from North Carolina State University with departmental honors from the forestry school and a tourism planning degree. His favorite color is oxymoron.

The Road To Renewable Hydrogen P. 78
Larry Elliott has been 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

Brewing a Better Tomorrow P. 30
Chris Meehan is currently an editorial assistant at Atlantic Information Services, Inc. He is a recent graduate of Colorado State University, and is dedicated to bringing about a brighter tomorrow through what we can do today. His hair is currently much shorter.

LETTERS

Dear Editor,

As an average frustrated civilian languishing in the muck of fossil fuel dependence, I thank you for your intelligent new magazine. The first issue of H2Nation is excellent, with the right blend of technical discussion and essays. I was particularly moved by Patricia Boyer's essay on the vision of Clyde Boyer, and commend the entire Boyer family and their colleagues for bringing much-needed news about hydrogen to the world. And wouldn't you know it, the week after I read the magazine the topic of the Hindenburg came up repeatedly; each time I was able to show my colleagues the Hindenburg article, and their gut dread of hydrogen turned into suprise, and then hope.

I was also delighted to read the advertisements, which were almost as interesting as the articles! As someone who has not had the good fortune to work in the field, I am unfamiliar with the people and companies who are doing this good work. It's great to get the "lay of the land," and read not only about the advertisers' products, but also their philosophy and determination to create a cleaner, safer future.

I hope that you will have room in an upcoming issue for an intelligent discussion of importation of Liquefied Natural Gas (LNG), the subject of a current feeding frenzy in the oil and gas industry as oil imports become more tenuous and local gas supplies allegedly dwindle. Many communities around the United States now face the prospect of hosting these massive, billion-plus dollar, concentrated fossil fuel receiving stations, which will take as long as a decade to be up and running. There is significant debate as to whether LNG is a necessary "bridge fuel" which will tide us through to the hydrogen economy, or whether it will chain us to fossil fuel decades longer than necessary and delay the rise of hydrogen and renewables. This important and thorny topic needs to be hashed out in arenas beyond government regulatory agencies and oil and gas conferences, and I think H2Nation would be an excellent venue.

My friends and I look forward to more fascinating and inspiring discussions of the myths, realities and potentials of hydrogen.
Best of luck in your endeavor.

Elena Haskins DuCharme
Vallejo, California

Sirs,
Thank you for your magazine. It is the information/communication source I want. It is hard to glean the bits and pieces of technical, business, and political information about hydrogen technology on my own. I hope to rely on your publication for timely and accurate information. I read the issue cover to cover and eagerly await the next issue.

Mike Caldwell
Scotts Valley, CA

Over the holidays I got the chance to read your new mag. It is great, answered many of my questions and sets a wonderful tone for the use of hydrogen in our society, produced by renewable sources. What I had thought was overly technical from a paging through without reading, was not accurate. All the articles were easy to read. What a huge task to take on publishing of something like this. I wish you well. There is a real need for something like this. Thanks
All the best in the new year,
Todd Cory
Mt. Shasta ,CA

Regarding the magazine content, I would like to see articles of the cutting edge of hydrogen production, far beyond electrolyzers. Particularly mechanisms that can capitalize on heat and light energy from concentrated solar collectors. Also, mechanisms that exploit biological processes like algae ponds, and perhaps custom bacteria and yeast cells. Or the chemical reactions they would use, in vitro-style.

I really liked your article at the end of the first issue.
Best Regards,
David Roth

I absolutely love how in the first issue alone you have worked to dispel so many myths while also demonstrating how the technology can be used. It answers a lot of peoples' questions quickly and accurately.
Ryan Dela
Keizer,OR

Yesterday I acquired a copy of H2Nation. After skimming through it I could not put it down. Needless to say I was elated ... it has been long overdue!

I hate to admit this, however during high school, either my Jr. or Sr. year (1960 or 1961) I built a model of a fuel cell for a science project. At that time most people had no concept of what a fuel cell was, including my science teacher. Basically I can say I have been a proponent of hydrogen technology most of my life.

Your publication H2Nation is very much appreciated.

Respectfully yours,
Art Matson
John Day, Oregon

Q&A

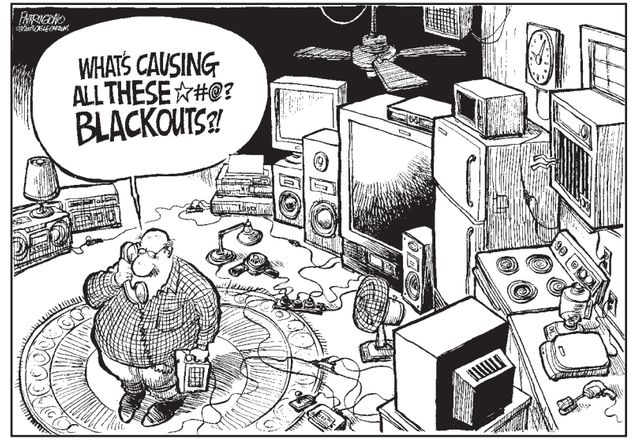
Hello. My friends tell me that fuel cell vehicles are just an electric vehicle with a small bank of batteries or some capacitors and that just adding more batteries like new high tech ones is better and would cost less. Aren't batteries more efficient than fuel cells? Why would I need to put in a fuel cell? Gupta Jahas .

Thanks for your question, Gupta.
Your friends are right in that fuel cell vehicles are electric vehicles. Just like other electric vehicles they use batteries or capacitors for storage. On the surface it may appear to be an easy thing to increase the storage capacity with more batteries and solve allot of problems but this is where things get a little more complicated.
One of the shortcomings for battery vehicles is something called specific power. This is a figure that describes the total amount of power that a device can deliver, usually based on total kilowatts at a certain voltage and current. This is just like horsepower for acceleration and load hauling. Fuel cells in vehicles have been getting smaller and lighter with higher specific power levels and will continue to get better with more research. They could eventually achieve power densities as high as internal combustion engines. Batteries, especially the new lithium ion designs have also been getting smaller and lighter with increased power densities. Unfortunately even these batteries are still far short of matching the power densities of existing fuel cell designs in terms of specific power, weight and volume. In addition, even though both the fuel cell and batteries are electrochemical devices, the fuel cell can easily deliver full power right up to the point where the hydrogen tank is nearly empty. Batteries, on the other hand, have a discharge curve. Their ability to deliver voltage and current goes down as charge levels deplete. This not only reduces performance but also helps to decrease their rated specific energy or overall storage capacity. Another short coming is an inability to recharge as fast as the refilling of a hydrogen tank. There are other battery shortcomings but, these are the most dramatic. The success or failure of both battery and fuel cell vehicles will be based on marketability and technology. acceptance. Hope this helps you make a decision on this issue.

I spotted your web site and thought I would send you a question. Why is there so much effort and money being invested in producing hydrogen? I guess part of it is that we need to have something better than Middle East oil but why not look at such things as bio diesel or battery powered cars. If you don't have time to answer I understand. Thanks. Dale P.

Hello Dale.
Your question is a good one and is at the center of debate on our nation's energy future.
All bio fuels are dependent in one way or another on the availability of open, arable land. To supply a sizeable portion of our transportation fuel from cultivated land or perhaps a rapid growing forest resource would heavily tax the limits of our existing agriculture base and these bio fuels will still have significant fossil energies embedded in them as a result of the fuel process cycle. Battery vehicles have limitations in supplying transportation solutions beyond light duty and short range needs. Hydrogen on the other hand can be produced from water and a source of electrical energy, in addition to many other methods. The electrolysis method of hydrogen production insures that literally anywhere water and electricity are available hydrogen can be produced. This is a major advantage with which bio fuels cannot compete In the foreseeable future, hydrogen has the edge in supplying a viable alternative to gasoline and diesel fuel.

I saw the Geo Tracker you guys are converting to hydrogen. Aren't you afraid that in a crash those two tanks will be just like big bombs?
This is a question I hear all the time. And no, I have no fear of an explosion. Here are some interesting points to consider. First of all, these tanks cannot explode like a bomb. Oxygen is necessary to produce an explosion. When properly filled there is no oxygen in the tank and even if the tank were ruptured, and there was a source of ignition, the hydrogen would simply rapidly burn without explosion. The second point is possibly the most revealing. Immediately beneath the hydrogen tanks is a ten gallon gasoline tank. This tank is made of very thin plastic and would fold up and burst in a rear end collision. In this case there would most likely be oxygen in the tank and yes there would be a huge fireball when ignited. On the other hand, the hydrogen tanks are made with aluminum shells and an overwrap of extremely strong fiber and resin. The possibility of a rupture of these tanks in a collision is very unlikely and even if severely damaged they are designed to withstand the high gas storage pressures. So no I have no fear in driving this vehicle. Thanks for a good question.



Hydrogen and Its Many Forms

Hydrogen as an energy carrier comes in many forms: liquid, gaseous and solid forms (metal hydrides). Which is best?

In our last issue we covered some of the basics for storing gaseous hydrogen at high pressures and some of the calculations needed to determine tank volumes and energy content.

In this issue we are going to take a look at storing gaseous hydrogen at lower pressures in the form of metal hydrides. Although there are several other methods now being researched, such as carbon nanotubes, glass spheres and even chemical forms, they are not sufficiently developed to be commercial products.

There are several companies now supplying metal hydride storage systems and materials used to store hydrogen. We have them listed at the end of this article. Metal hydride alloys come in various types for lower or higher temperatures, different levels of absorption qualities, or specific pressures, and are commonly made up of alloys of Nickel, Aluminum, Lanthanum, Titanium, Iron, or Magnesium.

A good analogy for how metal hydrides store hydrogen is to compare the process to a sponge absorbing water. The metal hydride materials are usually found in a powdered form of very fine particles. This creates a large surface area for a given volume of material. As the hydrogen gas is introduced to the metal (a process known as absorption) the molecules break down into atoms to a point where the hydrogen's electrons are actually shared within the metal matrix to form a solid substance known as a hydride. The metal crystals are actually stretched apart to accommodate the hydrogen.

Just as a sponge can absorb only so much water, the hydride reaches a point known as equilibrium and no additional hydrogen can be absorbed. But, unlike a sponge, a hydride's ability to absorb or release hydrogen depends on pressure and temperature. As the absorption process takes place, heat is generated. In chemical terms, this is known as an exothermic reaction. The faster the hydrogen is absorbed, the more heat is generated. In order to allow maximum absorption, some form of heat exchanger must be provided to reduce temperatures.

Conversely, as hydrogen is removed from a hydride in a process known as desorption, a cooling or endothermic reaction takes place, and some form of outside additional heat source must be supplied in order for the full content of the hydride to be delivered. Various hydride alloys also have different pressure characteristics known as equilibrium pressures. If a certain alloy has an equilibrium pressure of five bars (or atmospheres) and it is filled at seven or eight bars, it will fill until it reaches five bars of pressure. At higher fill pressures, it will fill faster but when filling is complete the equilibrium pressure will still be five bars. This characteristic means that in order to deliver hydrogen at useable pressures and flow rates, the hydride temperatures must be raised well above ambient levels. The higher the temperature the higher the pressures and flow rates. Most hydrides used

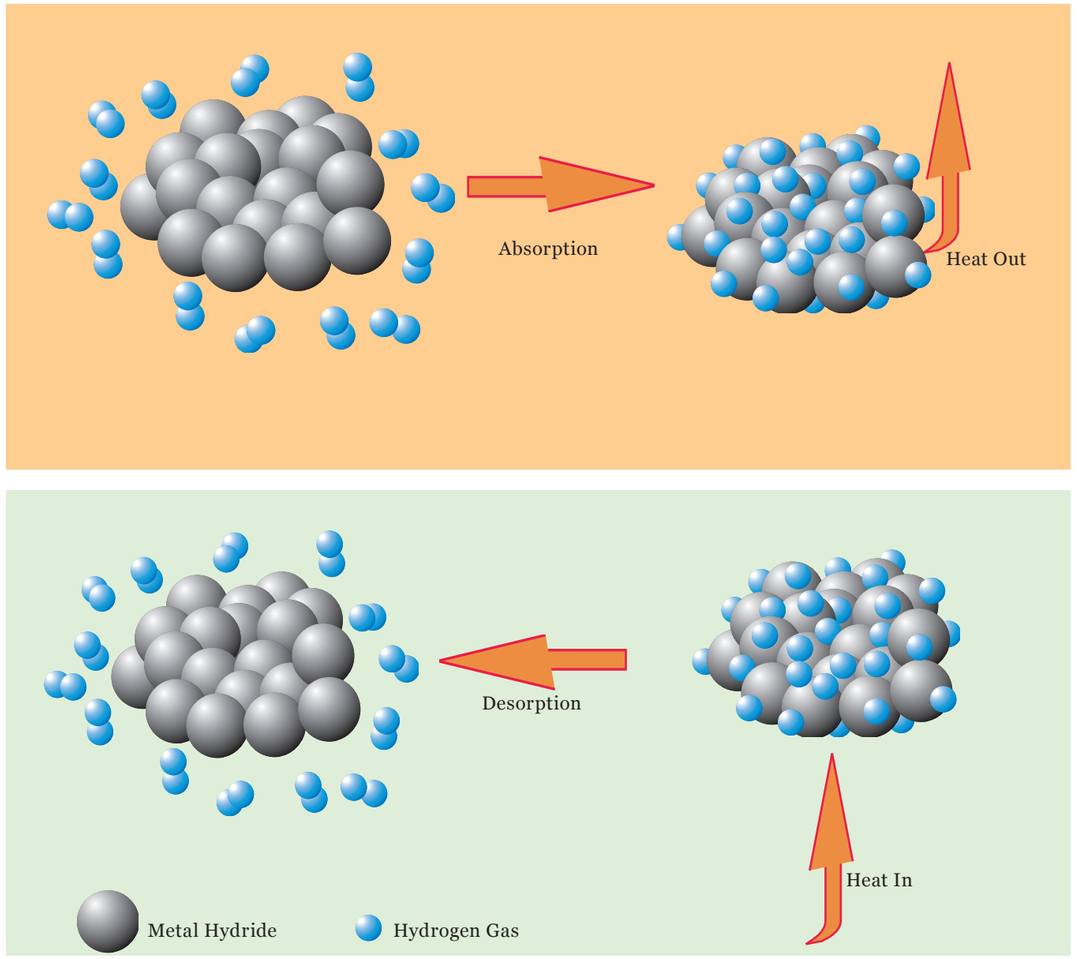


Fig. 1 describes the hydrogen molocule attaching to the Metal Hydride through the cooling of the metal. Fig. 2 describes the release of the Hydrogen molocule from the Metal Hydride through the process of introducing heat to the metal hydride.

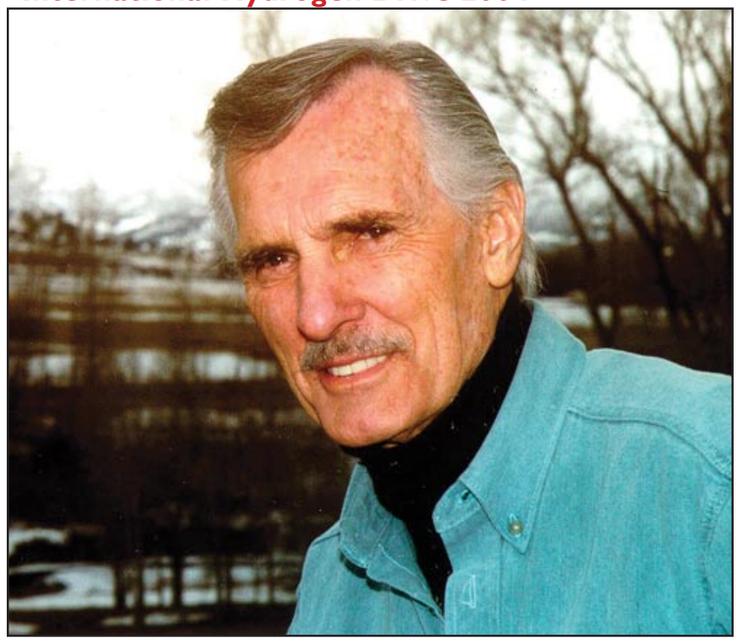
in vehicular applications have somewhat low temperature ranges from 140° F (60° C) to 200° F (93° C). This unique characteristic can be put to use in the compression of hydrogen.

When one is using a series of hydride tanks, heat is used to increase pressures from one tank to another until the desired pressures are reached. Although hydrides can store hydrogen at lower pressures, the additional weight of the metal and temperature conditioning equipment becomes a trade-off. One of the more promising hydrides is MgNiH2 which is a Magnesium/Nickel alloy. It can store hydrogen at a rate of 7.3% by weight. In other words 15 kg (33 lbs) of hydrogen can be stored in hydrides weighing 206 kg (453 lbs). Typically most hydrides are less than 2% hydrogen to hydride by weight.

The hydrides ability to absorb hydrogen also makes it susceptible to poisoning or contamination. Great care must be taken to assure that the gas going into the hydride is very pure. Hydrocarbons and even oxygen can contaminate the hydride. Some impurities (such as oxygen) can be flushed out when hydrogen is released, because only hydrogen atoms can enter the crystal matrix of a hydride. Still, this need for purity can increase the expense of using a hydride, especially in vehicle applications.

On The Horizon

International Hydrogen Drive 2004



Dennis Weaver, founder of the Institute of Ecolonomics, is one of the most respected actors working in filmed entertainment. Building upon the resounding success and high visibility achieved by the *Drive to Survive 2003* last May, IOE has begun planning an encore on a grand scale. In its most ambitious undertaking to date, IOE is very pleased to announce Dennis Weaver's International Hydrogen Drive 2004. IHD2004 is scheduled to take place from June 28 through July 12 visiting five state or provincial capitals, as well as several major cities, en route from Mexico to Canada. Hydrogen fuel cell vehicles and hydrogen internal combustion engine vehicles will be featured, while a variety of other alternative fuel vehicles will serve in supporting roles.

IHD2004 is planned to launch in Los Angeles with a major media event at the Petersen Automotive Museum and then travel to Mexicali, Mexico, the capital of Baja California. It will then head north, continuing through the three state capitals of Sacramento (CA), Salem (OR) and Olympia (WA). Once crossing the Canadian border and traveling through Vancouver, the vehicles will board a ferry for a short journey to Victoria, the provincial capital of British Columbia on Vancouver Island, for a grand finale.

The purpose of the drive is to raise awareness of the viability of hydrogen powered vehicles fueled with renewably sourced hydrogen, build momentum for the creation of hydrogen highways and promote a broad range of sustainable societal benefits that will occur by ending our dependence upon oil and other fossil fuels.

IOE considers itself fortunate to have Santa Monica, CA-based *Energy Independence Now*, and Daniel Emmett, Energy Independence Now Campaign Director, as our strategic partner in the planning and logistics for IHD2004. Bert Kronmiller is another notable early addition to our planning team. Clean Cities Coordinator for the Coachella Valley, CA (Palm Springs). Bert will serve as the Clean Cities Liaison for IHD2004, providing outreach and coordination with Clean Cities Coordinators along our entire route. Hydrogen fueling along the route may prove to be one of the most daunting challenges of IHD2004. We have already begun stitching together a patchwork quilt of stationary and mobile fueling stations along the route and are very appreciative of Stuart Energy's early commitment of support.

IOE is intent on supporting the creation of hydrogen highways from Mexico to Canada. These will initially be virtual hydrogen highways, but over the remaining years of this decade, through the passion and commitment of extraordinary individuals and champions from both the private and public sectors, a veritable International Hydrogen Corridor will be built.

It will require creative teamwork between industry partners and competitors, but most importantly it will require a groundswell of support at the grassroots level from ordinary citizens.

This can best be achieved through outreach, education and especially public involvement. Individuals will be invited to contribute their support to IHD2004 by being given the opportunity to sponsor a mile of the hydrogen highway as we continue building momentum to "Drive Hydrogen Home."
http://www.hydrogendrive.com/

GM and DOW Collaborate on Fuel Cell Project

The world's largest fuel cell transaction between Dow and GM is now a reality. With the pull of a lever by Secretary of Energy, Spencer Abraham, and Texas Governor, Rick Perry,

The Dow Chemical Company and General Motors Corp. began the Phase 1 installation operations of a single fuel cell that will convert hydrogen into electricity.

Dow and GM intend to prove the viability of hydrogen fuel cells for a large industrial power system. Operation of the first cell will last four to six months

with more fuel cells and electrical generating capacity added during the summer months.

Freeport, TX is the home of Dow's largest chemical manufacturing installation in the world.

Fuel Cell Unit Capacity
The initial GM fuel cell will generate 75 kilowatts of power. This is enough electricity for sixty average homes for one year. Dow and GM plan to ultimately install 400 fuel cells to generate 35 megawatts of electricity. That would be enough power for 25,000 average sized American homes. While this is a lot of electrical capacity, it represents only two percent of the total Dow needs at its Texas Operations site.

"This is a significant milestone from a business, technology, and environmental perspective," said Theo Walthie, Business Group President, Dow Hydrocarbons & Energy and Ethylene Oxide/Ethylene Glycol. "It is an important step that will make us less dependent on fossil fuels and help usher in a more sustainable future."

MidWest Net Metering

Although the Midwestern States are usually not thought of as "hotbeds" of renewable energy development, a bill just passed by the Indiana House of Representatives, HB1212, could give entrepreneurs and developers of renewable energy projects a big boost. The bill literally will allow individuals to be their own power company and sell their excess power on the power grid. This has been done for several years in states such as California; however, in the case of the Indiana bill there is real incentive, because the projects can be as large as 2 megawatts or two million watts. That's enough power for more than 800 homes. The utility companies in Indiana appear to oppose this bill, but the legislature passed it by a margin of 91 to 1. Perhaps, if other states adopt similar policies, we can hope for a cleaner and more evenly-distributed energy supply than now exists throughout the United States.

ON THE ROCKS

"It's all about torque," says Tony Kascbaisch of Rock Equipment. "This is the first Electric Rock Crawler." Over the years, rock crawling has grown into a sport that has big paydays. "Electric Rock Crawlers are 'a natural' for this sport. You won't be able to touch us in competition." The concept is really very simple; making it work has proved to be a bit more challenging. The Rock Equipment Team started with a handbuilt frame from Pep Daddy's of Auburn, California. "We had the frame built to hold a bank of Hawker Genesis batteries instead of an engine. Other than that, it is essentially the same frame as other competition rigs," states Marvin Pepper (Pep Daddy). Their design uses twelve 40 amp-hour sealed Hawker batteries. They

used the sealed gel battery because of time spent upside down in these competitions. As for the motor, they dropped in an advanced DC series wound motor rated at 20 hp. The Curtis 1224B controls the load to the electric motor. "The biggest problem we could have with this vehicle is twisting and breaking parts," said Tony Kascbaisch. The goal of the Rock Equipment Team is to install a hydrogen fuel cell to power the rig. Right now, they have about ninety minutes of run time before recharging is needed. H2Nation will keep you posted on their progress.

For more info:
www.rockequipment.com

On The Horizon

A new ICE Age is on its way

The Hydrogen Car Company (HCC) produces hydrogen internal combustion engine vehicles that deliver critical energy security, public health, environmental benefits and allow the customer to "Drive the Revolution."

HCC's vehicles are based not on an experimental technology, but rather on the highly developed one-hundred-year-old internal combustion engine. Common automotive platforms are configured either as basic fleet vehicles, standard personal vehicles, or uniquely personalized high-performance vehicles, and have all of the power and drivability of their gasoline-powered counterparts.

The Ford Ranger pickup, Ford Explorer and Lincoln Aviator SUV's are immediately available to fleets and individual consumers. This summer HCC will add to its line the Ford F-150 pickup, Ford Expedition and Lincoln Navigator SUV's. HCC also offers a line of high-performance Hydrogen Shelby vehicles, including the Hydrogen Shelby Cobra for which they have a waiting list. The Hydrogen Shelby Series 1 will be available in the late summer/early fall.

All of HCC's vehicles run on compressed hydrogen. HCC works with the customer to match the tank configuration, and thus the range, to their individual needs. Typically, HCC's trucks and SUV's can travel one hundred fifty to one hundred eighty miles per fill; and the range of the Hydrogen Shelby vehicles is eighty to one hundred miles. The vehicles perform similarly to their gasoline counterparts. The Hydrogen Shelby Cobra, for example, has a maximum speed of 140 mph, goes from zero to sixty in four seconds, and has a twelve-second quarter-mile performance. Vehicle prices, other than the Hydrogen Shelby Cobra and Series 1, range in price from $35,000 to $80,000.

To learn more about HCC, please see their website www.h2carco.com , or contact them by mail at 5700 Wilshire Boulevard, Suite 330, Los Angeles, CA 90036; by telephone at 323.936.9303; or by email at cars@h2carco.com.

National AFV Day Odyssey Experience the Excitement

The National Alternative Fuels Training Consortium (NAFTC) at West Virginia University announced National Alternative Fuel Vehicle Day Odyssey to be held April 2, 2004. At more than 50 sites across the country. Nearly 80 organizations have signed on to spread the word about the variety of alternatives to gasoline-powered vehicles available for consumers today.

Attendees will participate in an array of interesting activities that will include "ride and drive" demonstrations of vehicles from major manufacturers, as well as presentations on the many alternative fuels and advanced technologies that make them a smart choice in transportation.
"AFVs run on all kinds of fuels. There are CNG, propane, ethanol, electric and hydrogen powered vehicles. On April 2, 2004, every Odyssey site across the country will have information about alternative fuels and the cars, trucks and buses that run on them," said Al Ebron, NAFTC Executive Director. "The NAFTC and its Training Centers teach classes on all of these vehicles, no matter what fuel they use, and our message remains the same--AFVs are one solution for meeting America's energy needs for transportation."
"National AFV Day Odyssey events have proven to be a great way to get the word out that there's a growing market for AFVs and the fuels they run on," said Meg Baughman, co-coordinator of National AFV Day Odyssey. "Odyssey offers alt fuels professionals a way and a place to get together. They can present information to participants, meet other experts in the alternative fuels industry, and find out more about services offered by the NAFTC and its National Training Centers," Baughman added. "Alt fuels insiders, driving consumers, and AFV technicians all come together at Odyssey, because there's something for everyone, no matter what their involvement is in the alternative fuels industry."
Baughman reported that more than 17,000 people attended an Odyssey event in 2002. "We're getting the message out—thousands of people will learn about alternative fuels and AFVs at an Odyssey event this year, and many more will hear the AFV message through media broadcasts across the country," said Baughman. For more information about local Odyssey events, contact the NAFTC at **odyssey2004@mail.wvu.edu** or visit:
www.NationalAFVDayOdyssey.org on the web.

Star Shines Bright with Photovoltaics.

Film star Edward Norton has teamed up with BP Solar in what they call the Solar Neighbors™ program. Every time a celebrity joins the BP Solar Neighbors™ Program by purchasing a BP Solar Home Solution™, BP donates a solar system to a low income family in California. (Since solar systems are modular and so can come in almost any size, every 6 kW qualifies for a matching system Lead by Edward Norton, who proposed the concept to BP Solar while purchasing his own system, Celebrities Danny DeVito & Rhea Pearlman, Larry Hagman, Don Cheadle, Daryl Hannah and Alicia Silverstone all bought BP Solar systems for their homes as part of BP Solar Neighbors™ in 2003. This qualified 12 low income families who will be receiving matching systems. 2004 promises to be even more exciting.

HY-Seas

HaveBlue LLC.
There was hardly a sound when the X/V-1 technology demonstrator vessel, a Catalina 42 Mk. II, was first lowered into the cool waters of California this September. Yet the impact of the X/V-1 program, the first of its kind, and the impact of the hydrogen-based power and propulsion revolution it represents... will undoubtedly be heard around the world.

Through the X/V-1 program, HaveBlue's technical team is proving that vessels can effectively utilize the hydrogen in water (H2O) in conjunction with renewable technologies such as photovoltaic (solar), wind, and hydroelectric to renew a significant portion of the energy required for that vessel's operation. While shore-power and alternate forms of processed energy renewal can also be used, the marine operating environment is ideally suited for the use of sustainable, naturally renewable energy systems.

The X/V-1 technology demonstrator sailboat will obtain water from where it happens to be afloat (if necessary, it can also obtain water from a public utility) and an onboard "water-maker" device will process this H2O to the required level of purity. Then, an onboard electrolysis unit produces hydrogen and oxygen from the water. The hydrogen is stored onboard the X/V-1 for use by the fuel cell.

The electricity produced by the hydrogen-consuming fuel cell stack will power the electric motor for propulsion as well as supply the vessel's onboard energy needs. Its motor is regenerative (meaning it can function as a generator while under sail) and will provide another renewable energy source for the HaveBlue system.

The X/V-1 will be virtually energy independent from shore-power and fuel docks. HaveBlue's patented technology utilizes only proven systems and equipment already widely used in the marine industry — to separate the "H" from H2O in a practical, cost-effective way and use it as fuel.
http:www.haveblue.com

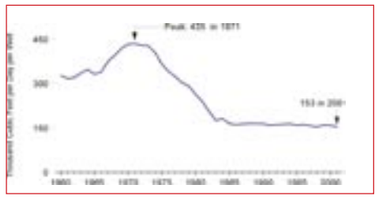
Most presidential candidates expend a lot of energy. Yet, their views on what should or could be accomplished to achieve energy independence in America, differ greatly. At least some of the candidates recognize that our dependence on foreign oil is the Achilles heel to national security. Only a few have a call to action for energy independence. But for one candidate, clean renewable energy is more than just an idea, it is a way of life.

Natural Gas is the Problem: Not the Solution

By Harry Braun

Virtually all of the new power plants under construction in the U.S. will be fueled by natural gas, a rapidly diminishing non-renewable resource that causes long-term environmental damage in its extraction process. According to the U.S. Energy Information Administration, U.S. natural gas production peaked at 435 thousand cubic feet per well per day in 1971, then fell steeply through the mid-1980s. Productivity in 1998 was only 146 thousand cubic feet per well per day. According to a March 19, 2001 article in The Wall Street Journal on natural gas reserves in the U.S., "Drilling is up, inventories are low and demand is strong." Moreover, the demand for natural gas is expected to increase 30% by the year 2010. Even Federal Reserve Chairman Alan Greenspan has warned that the natural gas shortages are real, and they threaten the economy recovery.

U.S. Natural Gas Well Productivity
(Source: U.S. Energy Information Administration)



One of the largest natural gas reserves is located in the Powder River Basin in Wyoming and Montana, where the Bush Administration has pledged to have natural gas producers drill over 75,000 coal bed methane wells over the next 10 years. If all goes well, an estimated 25 trillion cubic feed of natural gas will be recovered – which is what the U.S. consumes each year.

Temporary Gas Production Results in Long-term Devastating Environmental Costs

The most formidable obstacles in the Powder River Basin are not environmental groups, but Republican ranchers who are already being devastated by the billions of gallons of what is referred to as "product water." According an article in U.S. News & World Report (March 12, 2001), each natural gas well will typically produce about 12,000 gallons of this byproduct water daily -- or roughly 4.4 million gallons per year. Normally, water is a good thing, but in this case, the product water has such a high salt content that kills the crops and native grasses in the area. As Dennis Hemmer of the Wyoming Department of Environmental Quality indicated, the salty water seals the soil so crops are simply unable to grow. The 12,000 existing wells developed in the basin area have already left ugly scars on the landscape. An additional 77,000 wells would be potentially devastating. The pumping depletes the underground aquifers and threatens the long-term viability of agriculture in the region.

Other Environmental Costs

In addition to the problems of water contamination, ranchers in the area are forced to put up with the deafening noise coming from the natural gas compressor stations on the surface that roar like jet engines 24 hours a day, 7-days a week. In addition, the Bush Administration's natural gas plan in the basin will require building over 17,000 miles of new roads for the 18-wheeler trucks that will rumble through the area 24-hours a day; 20,000 miles of pipelines; 200 compressor stations and approximately 5,000 containment pits for the product water. The ranchers, who typically do not own the mineral rights under their property, now realize that they are helpless as they watch the daily destruction of their way of life.

All of this unnecessary and long-term environmental damage is part of the "external costs" for only one year's supply of natural gas. If that were not bad enough, there are also serious environmental problems associated with the emissions that will come from operating the natural gas-fueled power plants. Each power plant will emit thousands of tons of nitrogen oxides, carbon monoxide, carbon dioxide, volatile organic compounds and particulates annually. In addition, these 30-year design life power plants will consume roughly 100,000 acre feet of water annually, and much of that water is intended to come from already seriously depleted groundwater supplies.

Mass-Produce Wind-Powered Hydrogen Production Systems

Wind machines have been used for pumping water for over a thousand years, and they can now be mass-produced like automobiles to make the U.S. energy independent. Approximately 10 to 12 million one-megawatt wind-powered electrolyzers would make the U.S. independent of its current dependence on natural gas, coal, oil and nuclear fuels. Moreover, given that over 17 million cars and trucks are manufactured in the U.S. each year, the 12 million wind systems could easily be built and installed within a five or ten year period. It is important to understand that the primary obstacles to large scale use of wind power is the fact that winds are unpredictable, and even at a good wind site, the wind typically only blows about one-third of the time. The other major limitation is that most of the existing high-voltage transmission lines needed to transport the wind-generated electricity, are already full. However, both of these obstacles are eliminated if the wind machines produce hydrogen as their primary product, instead of just electricity.

Unlike electricity, hydrogen can be stored and transported to world markets just like oil or gasoline, and it can be used as a pollution-free "universal fuel" that can be used for the transportation sector as well as homes and power plants. As such, hydrogen is the critical element needed to make wind and other solar technologies practical, and if wind systems are mass-produced for large-scale hydrogen production, their contribution can be increased from less than 1% -- to over 100% of the U.S. energy requirements! Millions of jobs will be created as the U.S. is transformed from the world's largest energy importer, to a Saudi Arabia-class energy exporter, with a pollution-free fuel that is inexhaustible.

The necessary land exists in abundance in the U.S., where most ranchers and farmers will be able to earn more income from wind farming than they do with cattle or crops. However, the best areas to place most of the wind systems would be at sea where such "Windship" systems (which can be seen on the BraunforPresident.US website), could not only make America energy independent of natural gas, oil and nuclear power, but simultaneously provide a critical sanctuary for the ocean ecosystems that are rapidly being exterminated by oil spills and destructive fishing practices.

For more information on how to have "prosperity without pollution."

The Phoenix Project

initially requires Congressional Hearings that will lead to the passage of Fair Accounting Act legislation, which will eliminate subsidies to fossil and nuclear fuels and technologies and factor in the military and environmental costs of fossil and nuclear fuels. If a fair accounting system is used, solar-sourced hydrogen will be the least expensive fuel. As such, oil and other energy companies will rapidly shift their primary investments to building the fleets of Windships and OTEC ships, which are similar to oil tankers from a manufacturing perspective. Given that 90% of the global ocean ecosystem has been destroyed over the past 50 years, that means the remaining 10% of the fish and other marine organisms will be virtually exterminated within 5 years. This does not need to happen, but we are all like passengers on the Titanic, and we only have a limited amount of time to change course.☼
http://www.phoenixproject.com

2004 Green Car Buyers Guide

Beginning in the 2004 model year, new EPA emission requirements, known as “Tier 2”, have officially taken effect.

The requirements include the most stringent Federal emission standards ever. In 2004, manufacturers of cars and the smaller trucks are required to certify 25% of their fleet to meet Tier 2 standards. In fact, for Model Year 2004, more clean vehicles will be sold than the EPA program requires, thanks to the efforts of the automotive industry. The phase-in continues over the next few years, and by 2009, 100% of all cars and light trucks must meet the standards. Along with the Tier 2 standards, California’s strict “LEV II” standards are also taking effect. The new Federal and California standards are having a large effect on the emissions scores for 2004 models. For instance, the Green Vehicle Guide Scores for all vehicles have increased on average from 4 in 2003 to 6 in 2004.

#1 2004 HONDA INSIGHT

The first gasoline/electric hybrid on U.S. roads continues with only minor changes for 2004. Insight is a 2-seat hatchback coupe with a 3-cyl gasoline engine assisted by a battery-powered electric motor. The car recharges the batteries when coasting or decelerating, so no plug-in charging is required. Total horsepower is 73. Aerodynamic styling and aluminum-intensive construction contribute to industry-leading EPA fuel economy. Insight offers manual transmission and an optional continuously variable automatic transmission (CVT). The CVT lacks conventional gears, using a belt-and-pulley system to vary drive ratios as needed, but has steering-wheel “D” and “S” buttons to select normal and higher-performance ranges.

#2 2004 TOYOTA PRIUS

Toyota’s hybrid-power car is redesigned for 2004 and grows in size, power, and features, but not in base price. Prius is now a 4-dr hatchback rather than a 4-dr sedan. It’s 6.9 inches longer in wheelbase, 6.3 inches longer overall, 1.2 inches taller, nearly 2 inches wider, and 125 lb heavier. It continues with a special 4-cyl engine and an electric motor/battery pack. The two supply power separately or together, with sensors determining the most efficient method in terms of fuel consumption and power requirement. Plug-in charging is not required. For ‘04, the gas engine gains 6 hp, the motor 23, for a total of 133 hp, up from 114. Despite these gains, EPA-rated fuel economy improves, helped by a power-steering pump and air-conditioning compressor driven by electric motors instead of belts.

#3 2004 HONDA CIVIC

The 2004 Civic Hybrid is a 4-door, up to 5-passenger family sedan, available in 4 trims, ranging from the 5-spd MT to the CVT PZEV. Upon introduction, the 5-spd MT is equipped with a standard 1.3-liter, I4, 85-horsepower engine that achieves 46-mpg in the city and 51-mpg on the highway. A 5-speed manual transmission with overdrive is standard. The CVT PZEV is equipped with a standard 1.3-liter, I4, 85-horsepower engine that achieves 48-mpg in the city and 47-mpg on the highway. A variablespeed automatic transmission with overdrive is standard.

2004 HONDA INSIGHT

Honda's other gasoline/electric hybrid car is the Insight, a model with ridiculous fuel ratings that will basically go for a full day's drive without needing to refuel. That helps everyone—the environment, your pocketbook and future generations of children.

The other fuel saver in the Honda stable is the Civic Hybrid, which gets its design and many of its features from the family of the same name. With the Honda Insight, however, the style is as unique as the engine under the hood.

Just as you won't find automobiles on the road using hybrid engines, you won't find them looking like the Insight either. 2004 sees the Insight's distinctive aerodynamic rear fender skirts remain. In addition to those distinct skirts, the Insight has a whole page full of design features that help cut down wind drag, thereby making it as fuel efficient as possible.

Under the Hood

The unique engine under the hood is a 1.0-liter, 3-cylinder gasoline model assisted by a battery-powered electric motor. This unique configuration allows the car to recharge the batteries when coasting or decelerating, so no plug-in charging is required.

The Insight is offered with a traditional 5-speed manual transmission or a continuously variable automatic transmission (CVT). The latter is found on a few other Honda models, the Civic Hybrid being one of them. It uses a belt-and-pulley system to vary drive ratios as needed instead of conventional gears.

The 2004 Insight is a front-wheel drive model. If you're a speed-junkie, you're in the wrong place. The Insight produces 73 horsepower and 89 lb-ft of torque (79 lb-ft of torque with CVT).

Besides low emissions, the other main purpose of the Insight is an industry-leading EPA fuel economy. Insight models with manual transmission get 60/66 mpg (city/highway), while those with CVT get 57/56 mpg (city/highway).

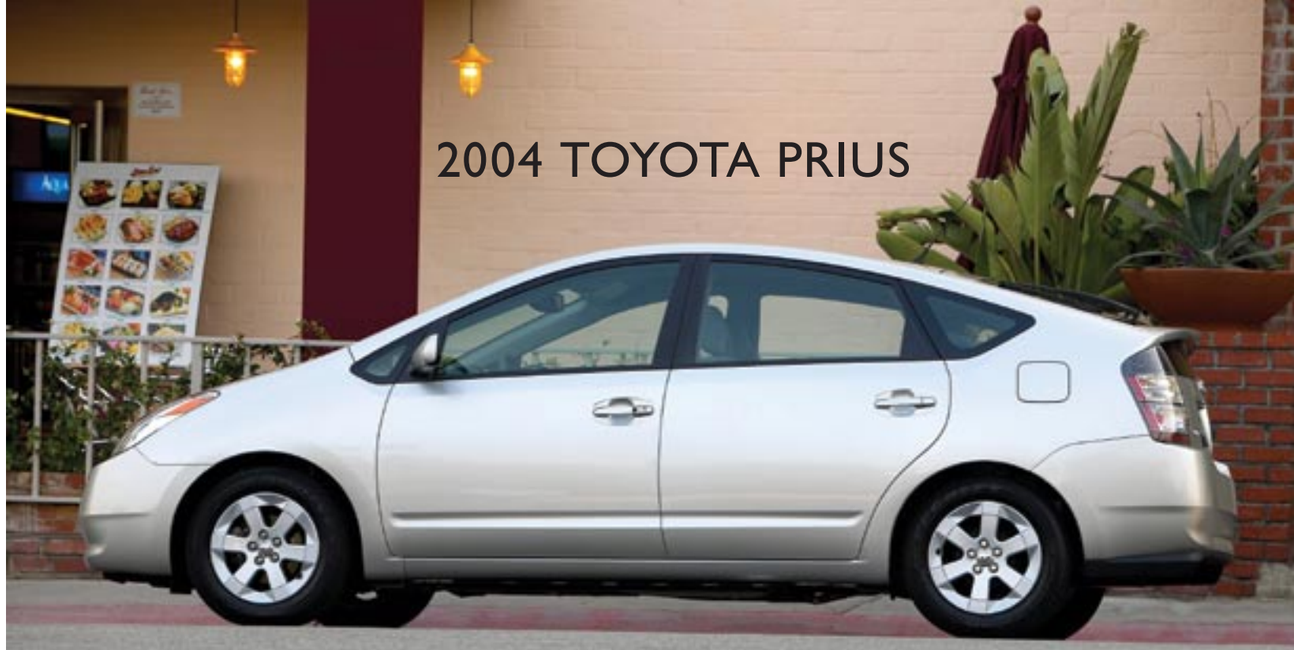
Standard Features, Options Packages and Style

The interior isn't like a desert, but it isn't in the luxury class either. Decadence isn't exactly the Insight's style.

All models receive power mirrors, windows and door locks, an AM/FM/CD player, a trip computer, a rear defogger, a rear wiper/washer and a driver's storage compartment.

For a few extra dollars, you can fit the 2004 Insight with air conditioning. It has automatic climate control so you can keep your eyes on the road.

2004 TOYOTA PRIUS



If you thought the Prius hybrid car was just a fad, you'd better think again. Toyota's revolutionary fuel-saver enters 2004 with nothing short of a full redesign. The new Prius is not only bigger, it's also more powerful and more fuel efficient. That's right: more powerful and more fuel efficient.

How did Toyota make the new Prius beefier but at the same time more fuel efficient? The short answer is advanced engineering. The technical answer is that the 2004 Prius uses electrical components rather than gasoline ones to run some vehicle functions: the power-steering pump and air-conditioning compressor are driven by electric motors instead of belts. But that is just the tip of the iceberg when it comes to the amount of changes this year's Prius receives. One of the most immediately noticeable alterations is the sheer size of the hybrid car. It's 6.9 inches longer in wheelbase, 6.3 inches longer overall, 1.2 inches taller, nearly 2 inches wider and 125 lbs heavier.

Under the Hood

Though the Prius is stronger than ever, it didn't go on steroids in the off-season. It continues with a special 1.5-liter inline 4-cylinder engine coupled with an electric motor/battery pack. The two supply power separately or together, with sensors determining the most-efficient method in terms of fuel consumption and power requirement.

Plug-in charging is not required with the Prius. For 2004, the gas engine gains 6 horsepower, pushing the total to 133. The engine has 76 horsepower at 4500 rpm and 82 lb-ft of torque at 4200 rpm, while the electric motor gets 67 horsepower at 1200 rpm and 295 lb-ft of torque at 0-1200 rpm.

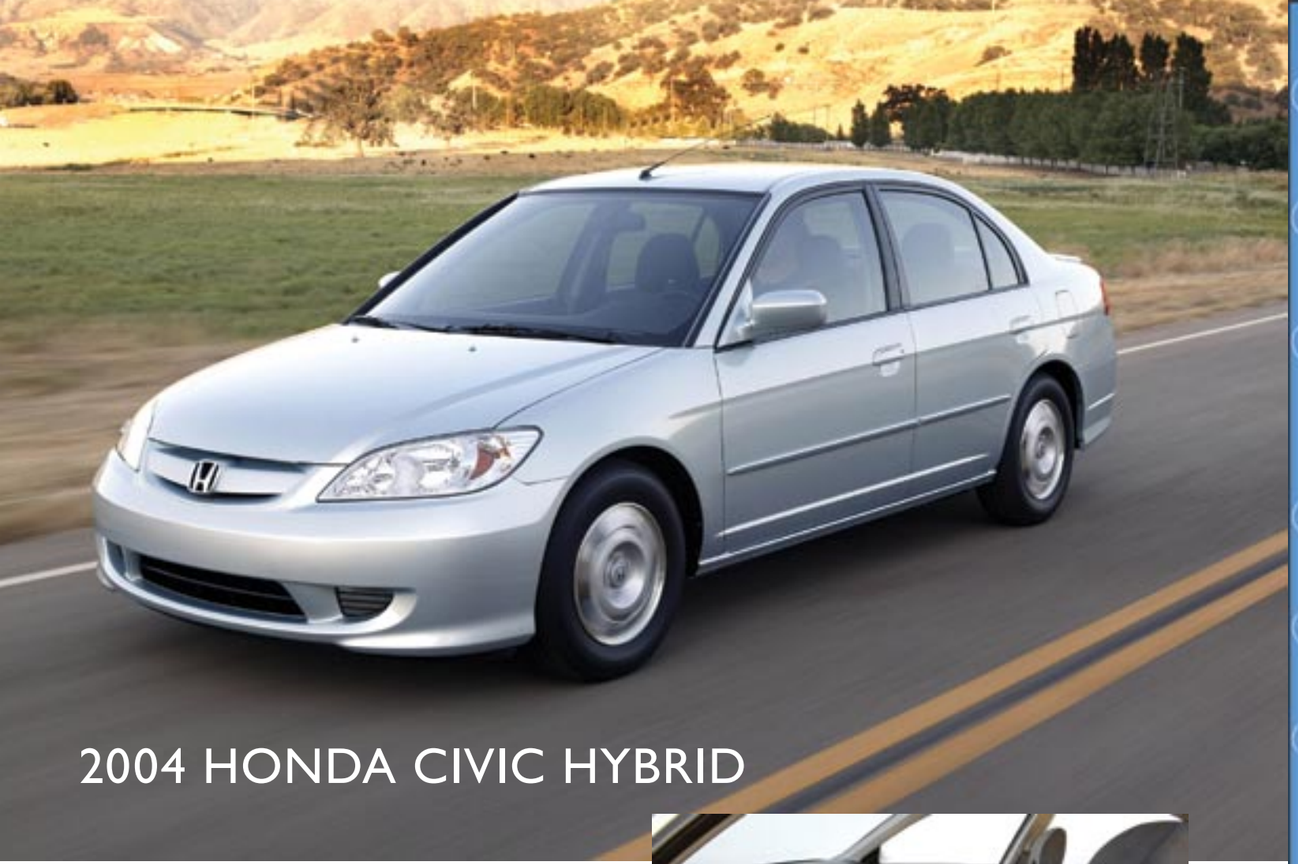
The Prius uses a continuously variable automatic transmission (CVT), with near-infinite gear ratios rather than traditional gears. In addition, new "by-wire" electronics replace the mechanical linkages for the accelerator and shifter.

Also newly standard with this year's Prius is a hill acceleration control. It is designed to maintain a steady speed up and down steep slopes.

Standard Features, Options Packages and Style

In another of the countless 2004 upgrades, the optional navigation system adds voice recognition and a larger dashboard touchscreen. Brand-new options include an antiskid system, xenon headlamps and a "smart" keyless entry/starting system with carry-along transmitter.

The standard features list includes alloy wheels, air conditioning with automatic climate control, a tilt steering wheel with radio and climate controls and an AM/FM/CD player.



2004 HONDA CIVIC HYBRID

Imagine being able to go up to 650 miles on a single tank of fuel. And no, it wouldn't be in a fully electric car that can only get up to speeds of a bicycle. It is only possible with the Honda Civic Hybrid, a model leading the way in environmentally friendly driving.

Joining the Hybrid in the highly fuel-conscious department is the Civic HX. It doesn't boast the same engine as the Hybrid, but it can still run for a long time on a single tank of fuel. The HX uses a similar engine as many other Civic models, but adapts it to get an estimated fuel rating of 36/44 mpg (with automatic transmission).

While these models will never win any speed events versus regular gasoline-powered cars, they do conserve fuel, thereby reducing the harmful emissions that enter our atmosphere. If more companies would pave the way with cleaner-burning cars like Honda, the world would undoubtedly be a better place to live in—now and in the future.

Under the Hood

The aforementioned engine under the hood of the Civic HX is a 1.7-liter inline 4-cylinder model. It generates 117 horsepower and 110 lb-ft of torque.

The Hybrid is so named because it uses gasoline-electric hybrid technology. The sedan's electric motor assists a special 1.3-liter gasoline engine, recharging the batteries when coasting or decelerating.

Both the HX and the Hybrid offer a continuously variable transmission (CVT). Unlike traditional automatic systems, it provides a near-infinite number of ratios. This gives Hybrid models with CVT a fuel rating of 48/47 mpg.

Civic HX models with 5-speed manual get an estimated 32/38 mpg. Hybrids with manual transmission have a rating of 46/51 mpg.

Standard Features, Options Packages and Style

The Civic HX is a two-door coupe, while the Civic Hybrid is a four-door sedan. Both can seat up to five people inside.

Just because it's fuel-efficient doesn't mean the Civic Hybrid has to skimp on the features. The innovative car includes air conditioning, power windows, mirrors and door locks, cruise control and an AM/FM/CD audio system. Advanced safety technology like antilock brakes, front side airbags and an immobilizer theft-deterrent system are also standard.

A leather-wrapped steering wheel, a trunk apron and a cargo net are some of the options for 2004.

Make and Model	 2004 Honda Insight	 2004 Toyota Prius	 2004 Honda Civic
Base Price	$19,180.00	$20,510.00	$19,650.00
EPA MPG (City/Highway)	60/66	60/51	48/47
Annual Greenhouse Gas	3.5 tons	3.5 tons	4.1 tons
Emission Rating	ULEV	ULEV	ULEV
Fuel Capacity	10.6 gal	11.9 gal	13.2 gal
Range, Miles City/Highway	699.6/636	714/606.9	633.6/620.4
Electric Motor	14 HP@3000 RPM	67 HP @1200-1500 RPM	13.4 @4000 RPM
Engine	Inline 3 cyl.	4 cyl. 1.5 liters	4 cyl. Inline 1.3 Litter
Horsepower	67 hp @5700	76 hp @5000 RPM	85 hp @5700 RPM
Battery type	NiMH	NiMH	NiMH
Battery Warranty	NA	8yr 100,000 Mile	NA
Voltage	144V	201V	144V
Battery Capacity	6.5 AH	6.5 AH	6.0 AH
Recommended fuel	Regular Unleaded	Regular Unleaded	Regular Unleaded
Dimensions and weight			
Length, in.	155.1”	175”	175”
Width, in.	66.7”	67.9”	67.9”
Wheelbase, in.	94.5”	106.3”	103”
Curb weight, lb.	1850 lbs.	2890 lbs.	2736 lbs.

Your choice of vehicle makes a difference for the environment. Use this guide to choose the cleanest vehicle that meets your needs. Be responsible about using and caring for your vehicle and it will reward you by polluting less and lasting longer!

Choose a cleaner vehicle

Using the information in this guide, you can choose the cleanest vehicle available that meets your needs. The choice you make will affect the quality of the air we breathe, because passenger cars and trucks are major contributors to air pollution. Even with continued improvements in air quality, almost 100 million people still live in areas with unhealthy levels of air pollution, much of which can be attributed to the increased use of passenger cars and trucks. Children and the elderly are the most at risk from air pollution.

Choose a more fuel efficient vehicle

The better gas mileage a vehicle gets, the less fuel it burns. Less fuel burned means fewer natural resources are used and less pollution is created from the extraction and processing of the fuel. Less fuel burned also means that less carbon dioxide, a greenhouse gas, is added to the atmosphere.

Drive fewer miles

Vehicles make up almost one-third of smog-forming emissions nationally, and because we are driving more and more miles every year (up 127% since 1970), vehicles continue to be a significant contributor to air pollution. Whenever possible, take public transportation, car pool, and combine activities into one trip (such as shopping trips).

FUEL CELLS: STATE OF THE INDUSTRY FOR ON-SITE POWER APPLICATION

By BERNADETTE GEYER
Director of Outreach Programs
for the US Fuel Cell Council

Distributed generation technologies, including fuel cells, renewables, microturbines and other ancillary services, can be located closer to where the power is needed, reducing traffic on the already "gridlocked" superhighways of the electrical distribution system. Distributed generation technologies can help states begin to address the challenge of satisfying electrical demand for such critical loads, by providing flexibility in siting these technologies where they do not require additional high voltage transmission lines.

To encourage a strengthening of the electric grid with distributed power, the U.S. Federal Energy Regulatory Commission (FERC) has issued standard procedures and a standard agreement for the interconnection of generators larger than 20 MW. FERC has also proposed expedited procedures for small generators no larger than 20 MW, and "super-expedited" procedures for interconnecting even smaller generators. The FERC actions only cover a portion of the electric utility industry. On the technical side, the Institute of Electrical and Electronics Engineers (IEEE) has approved the IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems, which provides requirements relevant to performance, safety, testing, operation and maintenance. The US Fuel Cell Council supports nationwide adoption of the IEEE standard.

The use of fuel cells for stationary power was highlighted following the extensive North American blackouts of mid-August 2003. Post-blackout stories reported that businesses using fuel cells, including New York City's Central Park Police Precinct, kept their lights on during the blackout. The incorporation of distributed generation technologies into our energy infrastructure is gaining converts as a more sensible approach than traditional grid systems in the United States. Fuel cells are considered an important emerging distributed generation technology because they can provide not only on-site power, reducing the amount of power lost traveling long distances on utility lines, but can also be used in efficient combined heat and power (CHP) applications.

The August blackouts also reinforced the view that the grid is not meeting the high-reliability needs of many industries for which even a minor grid fluctuation can cause millions of dollars in losses. According to Contingency Planning Research (1996), the average cost of downtime for Credit Card Operations is $6.48 million per hour. Fuel cells are an attractive option for businesses that are willing to pay a premium for power because the costs of losing power are great. An Alaska mail-processing center installed a 1 MW fuel cell system as the primary source of power. If there is a grid outage, the installation will automatically operate as an independent system, continuing to power the facility.

Fuel cells are environmentally preferable to traditional power generation technologies. The first commercially available fuel cell power plants produced by International Fuel Cells (now UTC Fuel Cells), create less than one ounce of pollution per 1,000 kilowatt hours of electricity produced, compared to the 25 pounds of pollutants for conventional combustion generating systems. Fuel cell power plants are so clean, some areas of the United States have exempted them from air permit requirements.

Because of their fuel flexibility, fuel cells can operate on renewable fuels like biomass and landfill gas. Several fuel cells are operating using gas from wastewater treatment plants and, in an application that gets the most notice, on waste gases at breweries. The fuel cells operating at the Sapporo, Asahi and Kirin breweries in Japan produce power for their facilities using waste gases from the brewing process as "fuel" for their fuel cells.

Status of Development

Fuel cell power plants, built by UTC Fuel Cells, are currently available in a modular 200-kW size that is "stackable" depending on load, and can run on natural gas or waste methane gas, such as from landfills. UTC Fuel Cells has delivered more than 250 fuel cell power plants around the world, including the fuel cell that kept the lights on at the Central Park Police Precinct during the August blackout, and the fuel cells at the Alaska mail processing center.

FuelCell Energy installed a DFC300A fuel cell power plant, which is providing power to the Los Angeles Department of Water and Power. Based on annual usage, the 250-kW power plant should displace about 1.2 million pounds of carbon dioxide and 25,000 pounds of sulfur dioxide. FuelCell Energy also offers 1.5-MW and 3-MW sized fuel cells for use in stationary applications, utilizing natural gas or waste methane gas as fuels. FuelCell Energy recently dedicated a Direct FuelCell® power plant at the AEP Ohio Coal LLC Rose Valley Site, in Ohio, where it will operate on coal mine methane gas.

Siemens Westinghouse delivered the first hybrid fuel cell/gas turbine power plant to Southern California Edison in May 2000. The power plant is being tested at the National Fuel Cell Research Center in Irvine, California. Siemens Westinghouse is in the process of building a fuel cell manufacturing facility near Pittsburgh, Pennsylvania, with a 250-kW solid oxide fuel cell (SOFC) power plant expected to be its first commercial product.

Fuel cell units for homes and small commercial applications are in the initial stages of commercialization in the United States. IdaTech has introduced two products, the FPM 20 fuel processor and the FCS 1200 fuel cell system, for commercial and defense markets. IdaTech's system can utilize both natural gas and propane as fuel, as well as liquid hydrocarbons such as methanol.

Long Island Power Authority is demonstrating 5-kW fuel cell systems built by Plug Power, and recently announced it will purchase an additional 45 systems for installation across Long Island; 20 of the systems will generate on-site heat and power for single or multi-family residential sites. Plug Power's GenSys 5C fuel cell system features standby capability for critical loads.

Avista Labs is marketing three Independence fuel cell systems, with capacities of 100-5000 watts. The company received CSA International certification for both its 500-watt and its 1-kW systems, meaning that they comply with applicable standards for safety and performance. Avista also recently received approval from CE for its 1-kW system, indicating that it has met all applicable performance and safety requirements for the European Union.

Proton Energy Systems recently announced successful testing of fuel cell prototypes in the 1 to 5-kW range that can generate their own hydrogen and provide electricity for 12 to 24 hours or longer.

Canadian developer, Hydrogenics, has standardized the commercial design of its 10-kW HyPM fuel cell power module, which will drive pilot production of the company's product line. The unit can be used for back-up, auxiliary or standby power, or for propulsion for light mobility electric vehicles.

Conclusion

Today, there are markets where consumers are willing to pay a premium for high-quality, reliable, and highly efficient energy production technologies in the technology and manufacturing sectors, as well as in the telecommunications industry. These are the markets that are adopting fuel cells today, and will enable economies of scale in manufacturing for future fuel cell products.

While hurdles such as capital cost and fuel cell life span still remain to be addressed, developers are making progress on these issues. The federal government and states are putting money not only into research and development, but also into demonstration projects that will ultimately prove the market-readiness of the technology.

Author Bio: Bernadette Geyer is Director of Outreach Programs for the US Fuel Cell Council. Her articles on fuel cell technology have appeared in numerous publications including "World Energy Review," "Sustainable Development International" and "Cogeneration and On-Site Power Production."

Contacts
U.S Fuel Cell Council :http://www.usfcc.com

BREWING A BETTER TOMORROW

by CHRIS MEEHAN

North of Old Town Fort Collins, beyond the rusty train tracks, beyond the Poudre River and a sun-scorched field of Colorado scrub, a silver-roofed building rises from the arid land like a ski lodge built on the plains. An oasis of native plants and grass welcomes visitors. The bike racks beside the entrance are full, while few cars litter the parking lot. This is the home of Fat Tire Ale, the award-winning hand-crafted brew offered by the New Belgium Brewing Company, a socially-responsible business, championing innovations in appropriate technologies, that started a mere thirteen years ago as America's smallest brewery. Today it is the country's fifth largest craft brewer.

In the late 80's as Jeff Lebesch rode his bicycle through the Belgian countryside, he dreamed of starting his own business, a business that provided not only a good living for its employees, but created a product that could be enjoyed by all. When he returned to Colorado, that dream became a reality. With his soon-to-be wife/business partner, Kim Jordan, he began brewing beer in his basement. Friends raved about the sophisticated tastes of the fledgling brews and soon Jeff and Kim began selling their beer locally. Their former neighbor, Anne Fitch, is the watercolor artist who has designed all their beer labels. From those small beginnings, New Belgium has grown to become one of the largest craft breweries in the United States, producing more than 250,000 barrels of beer a year.

While it is best known for its line of award-winning brews, having received the "Midsize Brewery" and "Brewmaster of the Year" awards at the 2000 and 2001 Great American Beer Festivals, New Belgium is gaining national recognition as an ethical and environmental business model. In this regard, the greatest achievement to date has been the brewery's decision (reached unanimously at a staff meeting) to purchase grid-supplied wind power at a premium price in order to reduce its production of carbon dioxide by approximately 1800 metric tons a year.

In addition to purchasing wind power, the company's wastewater treatment plant utilizes the digestion of aerobic and anaerobic bacteria to clean the water used in the brewing process before it is reused on-site for evaporative cooling, cleaning and landscape purposes. The process releases a biogas, 85% of which is methane. The methane is captured and used to generate electricity and heat onsite. The methane generator runs up to ten hours a day and off sets the peak demands on the Fort Collins electric grid. This is a new program undergoing its final stages, and when fully operational the company expects a return on the investment in 2004.

A walk through the brewery reveals other subtleties that work to save energy and reduce waste. Large windows provide more than a great view of Colorado's landscape, they also allow the influx of natural daylight throughout the brewery. In the warehouse, light tubes or suntubes (similar to skylights) are used to take advantage of Colorado's sunny skies. When lights are needed, the brewery uses efficient, compact-fluorescent bulbs operated by light sensors and motion detectors to prevent the overnight light syndrome.

JEFF AND KIM LEBESCH

NEW BELGIUM BREWING COMPANY'S PRAGMATIC APPROACH TO BUSINESS AND HUMAN AFFAIRS IS BEING RECOGNIZED THROUGHOUT THE BUSINESS WORLD AND THE ENVIRONMENTAL COMMUNITY.

The installation of an innovative, vapor coil, water-preheating system developed by Jeff Lebesch has also reduced overall energy use in the brewing process. In this method, a series of coils captures heat normally wasted in the brewing process and transfers it to the incoming cold city water prior to its use in a wide variety of process applications.

New Belgium is the first American brewery to employ the new Merlin Brewing System from Europe's Steinecker Company, a system 75% more efficient than traditional brewing methods. New Belgium anticipates using the Merlin to triple their brewing capacity over the next few years to reach a goal of 750,000 barrels annually. This will result in much more beer produced with far less energy use, less water use, and less time consumed.

The commitment to the environment through the use of new and appropriate technologies will ultimately result in an efficient work environment that will save resources and reduce expenditures. In the brewing process itself, New Belgium has reduced the amount of water used to produce a barrel of beer. Their representative stated: "For every barrel of beer that a typical American brewery produces, an average of eight to ten barrels of water are consumed. At New Belgium we actually are able to produce one barrel of beer using about four barrels of water." The goal eventually is to reduce the amount of water used in producing each barrel of beer to a three-to-one ratio, thus reducing waste, conserving energy, and saving production time, all the while producing a quality product.

In addition to their environmental efforts, New Belgium Brewing is a community-minded business that purchases from more than 300 local and regional companies. One dollar from every barrel of beer sold is donated to charities throughout the states where New Belgium distributes in accordance with localized sales, thereby insuring that money spent in the community contributes to the community.

The Tour de Fat is a traveling event that visits cities where New Belgium distributes. The Tour hosts morning bike rides and showcases local food and music, while promoting a sustainable environment; and it gives the company a chance to publicize their brews in a fun setting while raising funds for local charities. The profits made at a Tour de Fat are donated to local biking organizations.

In addition to promoting a cleaner environment, this remarkable company also sustains its employees. A progressive employee-ownership program introduced early in the life of the company was designed to empower the employees and include them in the decision-making process. Employees currently own 32% of the company. Because Fat Tire Ale was named to commemorate LeBesch's bike trip through Belgium, each staff member is awarded their own Fat Tire cruiser after a year of work with the New Belgium Brewing Company, a nice perk that promotes biking to work over driving. After five years of employment, each employee is offered a free trip to Belgium to become acquainted with the country and the breweries that inspired the building of their own brewery. These great extras are offered in addition to the ownership plan, full health and dental coverage, a 401K retirement plan, and the kid-and-dog-friendly atmosphere. The workplace has a full kitchen for employees who want to prepare their own lunch; and every other Tuesday, New Belgium buys lunch for the entire staff to celebrate birthdays and anniversaries. Other staff benefits include a free case of beer a week, ten paid holidays a year, and ongoing training in tasting and appreciation of beer.

New Belgium Brewing Company's pragmatic approach to business and human affairs is being recognized throughout the business world and the environmental community. In addition to awards won at the Great American Beer Festival, Business Ethics magazine gave New Belgium Brewing Company its Environmental Excellence Award.

While providing a proving ground for new technologies in a successful business atmosphere, the company has absorbed the cost of any failures, experienced benefits from all successes, and provided an important voice in the development process of appropriate environmental technologies for the 21st century.

ION BUSINESS

Technical highlights by Larry Elliott.

New Belgium Brewery's efforts to reduce waste and improve overall efficiency.
Anaerobic digestion of wirt (spent grain).
Using anaerobic digestion (fermentation in absence of air) the bacteria in the wirt breaks down simple sugars and starches and converts them to methane and CO2 gas. In New Belgium Brewery's system captures these gases beneath the plastic covers placed over the fermentation ponds.

Wirt and process water are delivered in and out of these ponds on a continuous basis. Because of the need to closely control PH, temperature and the solids to liquid ratios, a computerized system of control is employed. When all of the available gases have been extracted from the remaining sludge, it is removed for further composting and the waste water is treated and discharged to the city wastewater treatment plant. In the future, up to 90% of this water will be further used for evaporative cooling, cleaning and landscaping, This will require micro-filtration and reverse osmosis.

Power generation
On average, digester gas has a heating value or BTU content of 500 to 700 BTU's per cubic foot. As a comparison, natural gas has 1000 BTU's per cubic foot (.0283 m3) and at an average retail cost of about $1 per therm (100 cubic feet). Based on this the digester generates the equivalent of $294 per day. Another way to look at it is this; it generates the energy equivalent of 142 gallons of gasoline, 1180 lbs of coal, 16,046 cubic feet of natural gas, 5022 kwh's of electricity, or 55,646 cubic feet (1464 Nm3) of hydrogen, all from a resource that would normally be wasted.

Most of the methane gas generated is used to power an engine generator. A straight-eight Guascor engine is coupled to a 380 kw Stanford three phase generator. It is derated to 292 kw due to altitude and gas quality. The generator is intertied to the grid to allow shaving or reduction of peak loads at the brewery. No excess electricity at this time is sold back to the utility. The waste heat from the engine is used to keep the digesters heated. In addition, premium efficiency motors are used in the brewery along with efficient lighting, most of which use motion sensors so that they are off unless needed. They use variable frequency drives on motors that power bottling devices and other process equipment. ❁

The House of Spires

By Judd Boyer

The Paiute Indians called these mountains sacred. The miners found treasures of gold and vast riches. Today a new treasure sits at 11,000 feet above sea level.

Alex Markels of Newsweek Magazine said it best: “The beauty of doing a Telluride story is that you get to go there.” No truer words have ever been spoken.

One afternoon, sitting at my desk in the home office of H2Nation Magazine, I received a phone call from a gentleman asking a question we have heard many times before:

“Where can I buy a fuel cell system for my off-grid home?”

As we talked, a story began to unfold -- a story not only about a young couple building their off-grid dream home, but a story rich in history and adventure—a story of a home that sits at the top of the world. We had to go there. We had to visit the home of Chuck and Theresa Burr.

Larry, the science editor, and I left our office in Sparks, Nevada, early on a warm fall day this last September and drove eastward across the desert on I-80. Along this route, we encountered numerous geothermal power plants and all too many coal plants. By sundown, we arrived in Salt Lake City, only halfway to our destination. With an early start next morning, we reached the town of Telluride by midday. Right from the start, you could tell that this was a town of history; the storefronts looked as if they were right out of an old western movie. This was a town that held many stories, both sweet and sad.

After a quick tour of the town, we headed for the Burr home. With our GPS in hand, we set out for our final destination. After turning off the main road, we followed a dirt road that lead past the remains of what was once a mining camp. We read the instructions again, laughing at “If you come to two lakes, you‘ve gone too far.”

When we pulled into the driveway of a beautiful home high in the Colorado mountains (with a view that is beyond words), we checked our GPS -- and sure enough, it read 11,074 ft. The only time I had ever been at 11,000 feet in my life was in an aircraft -- with oxygen!

The site on which the home was built was a working gold mine in the early days of Colorado. It had served as a test bed for the new AC electric transmission systems being developed at the time by Nicola Tesla and the Westinghouse Company for use in the mining operations. Today, the house sits at the base of a rugged, snow-covered peak and is built right into the bedrock with no sign whatever of the ancient gold mine that once operated there.

We were graciously welcomed by our host and hostess and made to feel at home in this house with splendorous and breathtaking views of snow covered mountains. The craftsmanship of this home was apparent.

(Left) The road to the Burr Home. (top) The colors of the house blend into the surrounding area. (Above) The surrounding view is remarkable from any point on the property.

The exterior colors blended easily into the surrounding area, making this new home look as if it had always been there.

Chuck Burr took us around his property and as we walked he explained the history of the land and the mine, and how it was the first mining operation to use AC power.

We enjoyed a delicious evening meal, and talked about incorporating an electrolyzer and fuel cell as a backup for power to the house. We were surprised to learn that a team from Plug Power was to be there in the morning to discuss that very issue. After a delightful conversation, we retired for the night. We had never seen sky as black and vast, or stars as bright as we saw from the great bedroom windows that night. Made us feel we were part of the heavens we were viewing.

The powerhouse. The heart of the Burr residence energy station. Shown are the 16 BP 150 watt solar electric panels.

Bright and early next morning, we began the job we went there to do: that is, to investigate every aspect of this magnificent structure and find out how its inhabitants live and enjoy the home and its surroundings. Chuck explained that before the building began, he and Theresa, along with the aid of Leif Juell (Alternative Power Enterprises) mapped out what they felt would be needed in the way of power, not only to amply supply the finished home, but for use in the construction of the home. They decided that sixteen BP 150 photovoltaics, and two Xantrex 4024 inverters with an Outback Power distribution system, was the path to take. With the basic system in place, construction could begin. The home was completed in July of 2003.

The generous use of windows with a southern exposure help to warm the home in the winter.

Every aspect of this home was designed to maximize energy efficiencies. A generous but balanced window layout on the southern exposure allows passive heating anytime the sun is shining. The heat collected during the day in the second floor concrete slab slowly reradiates throughout the home in the evening, keeping it very comfortable. A fan installed in the high ceilings directs warm air down under the slab to keep temperatures regulated. Use of SIP or Structural Integrated Panels for most of the exterior walls as well as the roof insures a more than adequate insulation barrier to severe temperatures. The SIP panel is a lamination of polystyrene or Styrofoam between two layers of plywood or oriented strand board. The home is built directly on bedrock so a generous use of steel beams and concrete for most of the main structure disallowed the use of conventional batt type insulation. The SIP panels allowed nearly perfect sealing and high R value insulation without creating thermal bridges.

When temperatures stay severe for long periods of time and are then accompanied by cloudy weather, a unique supplemental heating system is employed. Plastic tubing was embedded into the floor slabs during construction.
A propane-fired boiler heats water that is then circulated

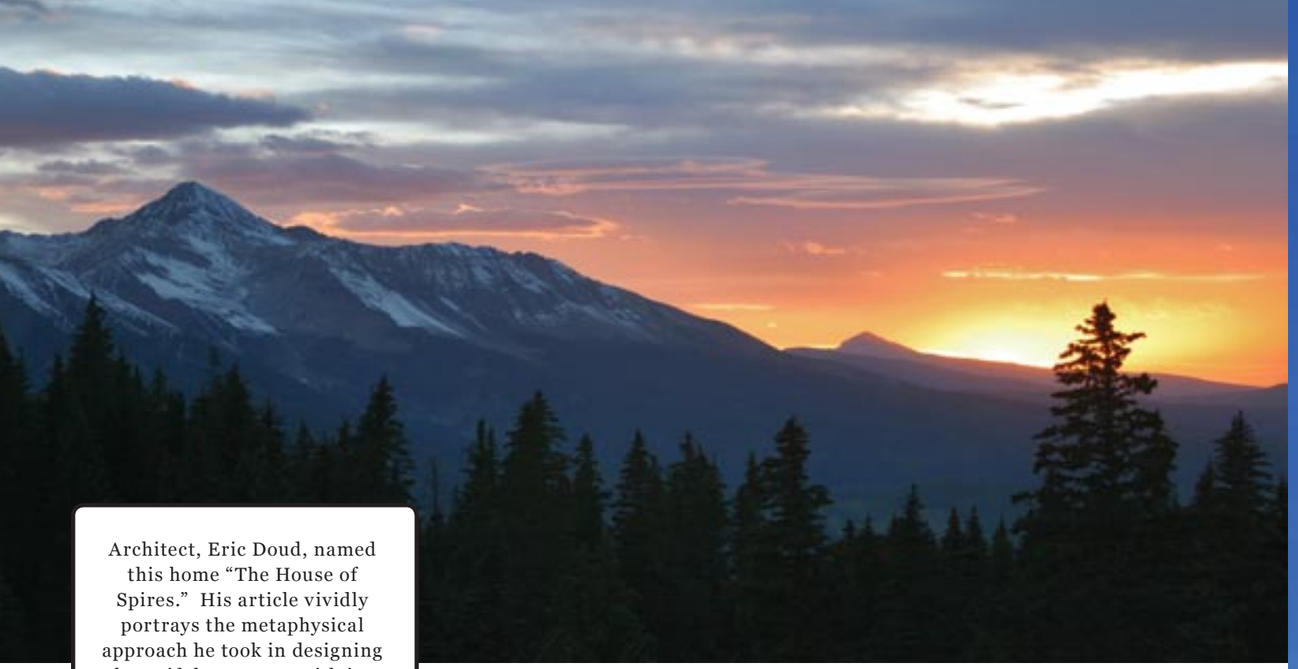
The office is equipped with the latest high tech gear, including high speed internet.

The kitchen is warm and airy. Built-in storage and an oversized commercial refrigerator/freezer keeps them well stocked for long winter days and nights.

through tubing embedded in the floors. Four one thousand gallon propane tanks are buried in solid bedrock in front of the house. Although this propane is used mainly for heating hot water and for cooking, it is unlikely that a large quantity of propane will be used each season for general heating purposes, because the heavy insulation of the house and passive solar heating should be adequate for all warming needs.

Another addition made as the home was being built consisted of a set of insulated tubes from the powerhouse to the boiler located in the basement. The powerhouse roof has adequate space for additional thermal solar collectors to be added in the future.

The Burr home has all of the comforts you could ask for through use of renewable energy. Every energy need -- from the deep well pump, to the dishwasher, to a large commercial-sized refrigerator and all of the lighting -- is met by using only the sun and an occasional backup from a propane generator. Leif Juell, the contractor who installed the Burr energy system, commented he was pleased that the home included radiant in-floor heating. The relatively tiny amount of power consumed by this type of system when compared to a forced air heating system means lower power system costs and better wintertime performance with very little need for backup charging.



Architect, Eric Doud, named this home “The House of Spires.” His article vividly portrays the metaphysical approach he took in designing a beautiful structure with jewel-like appointments. He succeeded in blending the house with the surroundings so that the aesthetics and the ecology merged in a symphony of order and beauty.

“HOUSE OF SPIRES” THE BURR RESIDENCE

Eric Doud: Architect’s Statement

The Nature of Response

The effect of architecture is always beyond the purely visible. Response to architecture does not occur as an association in the mind alone; but, of necessity, space is experienced directly and becomes tactile knowledge held in the memory of the body.

A deeper comprehension occurs when the dominant sense of sight is mediated by the body’s sensual understanding through this tactile experience. Architecture derives its fuller meaning from this understanding and it becomes powerful through the appropriate selection of form. Its visual response then (coupled with the choice of materials) evokes the deeper, sympathetic, sensual response.

Power of Place

The environmental setting of Gold King Basin poses a psychological dichotomy: the qualities of a fragile, high altitude environment with its subtlety of color and tenuous existence of high altitude flora; and the combined beauty of overpowering towers of rock and an eternal expanse of vista beyond.

In such a powerful location, the term “house site” cannot be used in the ordinary sense; for here, one is confronted with the power of place. Located at the very limit of the timberline, this site is extreme -- and the dwelling becomes the ultimate definition of shelter.

Building Structure & Materials

Selection of a faceted geometry that reflected the prismatic and crystalline high altitude minerals for which the land was originally claimed was the approach taken in finding an appropriate architectural form. Exterior building materials were chosen from a limited palette that consisted of unfinished metal, massive abutments of site-quarried stone and heavy timber, all used in a direct and immediate way.

Interior spaces of the dwelling are held in dynamic balance between the battered stone walls grounding the north, and the transparency of glass in the south that provides an expansive view of the upper basin.

Reflective of the site’s fragile beauty coupled with its massive ruggedness, inside finishes are jewel box-like in detailing that consists of sheets of alder paneling set with ribbons of metal trim. Built-in furniture and cabinetry throughout combine

with freestanding furniture of quartersawn white oak, detailed with black walnut accents, built specifically for this house. Metal spire sculpture and the artistry of high altitude flowers depicted on stained glass panels add to the richness of materials and images.

Systems

State of the art building and mechanical systems provide for a largely energy independent structure. The building envelope is constructed of stressed skin panels separate from the structural frame, creating great thermal efficiency. Low E triple-glazed windows minimize heat loss and provide panoramic views with passive solar gain. Concrete floors thermally stabilize interior spaces by creating a heat sink for the passive gains. This functions as a thermal flywheel between the day and night cycles. Additionally, direct gain heat is captured with the use of a destratification fan that delivers solar-heated air from the top of the building envelope to the crawl space where it is absorbed, thus contributing to the thermal flywheel. Passive solar gains are also developed through Trombe Walls constructed in this case by painting southern-facing, concrete, foundation walls black and simply glazing their exterior surface. Electrical energy is supplied through photovoltaic power production. This is matched with energy efficient lighting and appliances. Any additional demand is supplied by a propane-fired, backup generator and house boiler.

Conclusion

The power of architecture is in its ability to evoke a primal response. It is the intent that through the articulation of built form, the selection of natural material and appropriate environmental systems, the result touches our deeper sensibilities and questions the origins of meaning. We, who come to such a powerful place, cannot equal anything so magnificent as that originally before us. We can only hope that our effort, in some small way, becomes a worthy offering to the surrounding grandeur. This is the House of Spires.☼

Total array rated power 2.4 kw consisting of 16 BP 150-S photovoltaic panels, nominal voltage of 24 vdc.
Storage 12-4 volt Rolls Surrette 4ks25PS batteries 1347 amp hours each for total of 2694 amp hours.
Two Trace (Xantrex) SW4024 inverters wired for 110/220 vac split phase, includes Outback AC and DC power distribution panels.
Two Trace C40 charge controllers.
One 20kw Onan propane fired generator for backup derated to 10kw due to altitude of 11,000 feet.
4 in-ground Propane tanks holding 1000 gallons each.

Contractor Leif Juell (Left) talks to Plug Power senior board member, John Elter (center), about a future fuel cell upgrade.

12 Rolls Surrette 4ks25ps Series 5000 Batteries

Two Xantrex 4024, (Center) Outback DC (left) and AC (right)

Onan 20kw Propane generator

Buried in the bedrock are four one thousand gallon propane tanks

When Power Came to Colorado

By Ernest Eich

Something happened near Telluride, Colorado, in the late nineteenth century that is forgotten to all but a few of the most committed seekers of historical fact, an event of such magnitude it would change the society of our world forever; and it was brought about by a simple need for a better and less expensive way to do business. Oh, I'm not talking about the Hole in the Wall Gang and Butch Cassidy's first heist of $24,580 from the local bank, I'm talking about the advent of commercial Alternating Current power that took place high in the Rocky Mountains of Southwestern Colorado. In 1891, from a wooden shack in the short-lived mining camp at a place called Ames, high above Telluride, modern electrical Alternating Current was first generated and transmitted for commercial use.

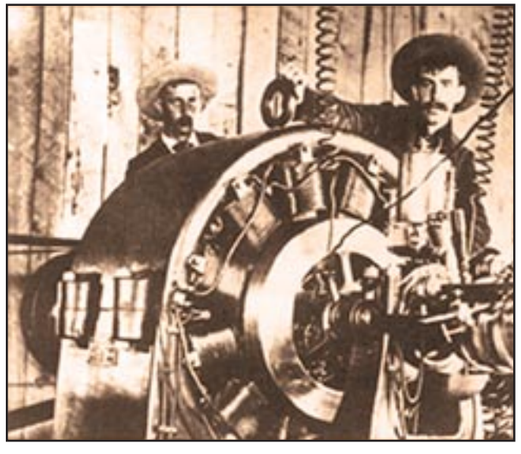
By the 1880's, Colorado's mining boom was in full swing. Fortunes were made and backs were broken mining the rich veins of gold, silver, lead, copper and zinc from deep within the hard-rock mountains. Light, air and water were provided to the mines by Direct Current generators that burned wood as fuel; and for this fuel, men had cleared the land of trees for fifteen miles around Telluride. With the wood gone, the only other option was coal, which soon cost $75 ton. This dirty fuel caused a smog that we in this present-day, slowly-heating world of massive pollution could scarcely imagine.

The coal, brought in by rail to a siding several miles from Telluride, was then hauled on the backs of mules up to the mines to fuel the generators. It wasn't long until the combined railroad freight, the mule skinners and the mules doing the hauling, cost each mine owner upwards of $2,500 a month and many could not pay the price to keep the generators going. Without the generators to provide lighting, air and water, the mines soon shut down.

In 1881, a lawyer named Lucien L. Nunn walked into Telluride, and not long after that inauspicious beginning built a fortune. By the time the mines shut down, he had accumulated an enormous amount of raw gold, owned a copper mine, and also owned the local bank that held loans

(left) Telluride 1867 (Right) The San Miguel river (Below) Miners on the Gold King claim.

Bridal Veil Falls



Pinheads working on the first AC induction generator.

to several of the largest mines. If the mine owners couldn't pay their debts, Nunn would lose everything he had built; however, he was not a man to stand idly by and let his fortune dwindle to nothing.

He formulated a plan to harness the energy of falling water of South Turkey Creek to power the mines. The only way to use electricity at that time was with Direct Current, a system that required a generating plant every two miles or less in order to overcome transmission losses. The system also required lots of copper for the many circuits required to loop back to the generating station.

To power a mine's generators with DC current, at the distance and at the voltage Nunn proposed, would require cables eight inches in diameter that stretched more than three miles across the most rugged mountains in Colorado. Even though he owned a copper mine, the stuff wasn't free.

He had heard of a new technology called Alternating Current that just might solve his problem. George Westinghouse, who invented air brakes for trains, had in his employ the brilliant Croatian engineer, Nikola Tesla. Tesla had designed a complete Alternating Current system that could easily meet the needs of Lucien Nunn for the Gold King mine. In theory, a generator could be built that would enable electric current to move rapidly from positive to negative in a balanced oscillation that would send enormous amounts of power through small, aluminum conductors with comparatively low losses.

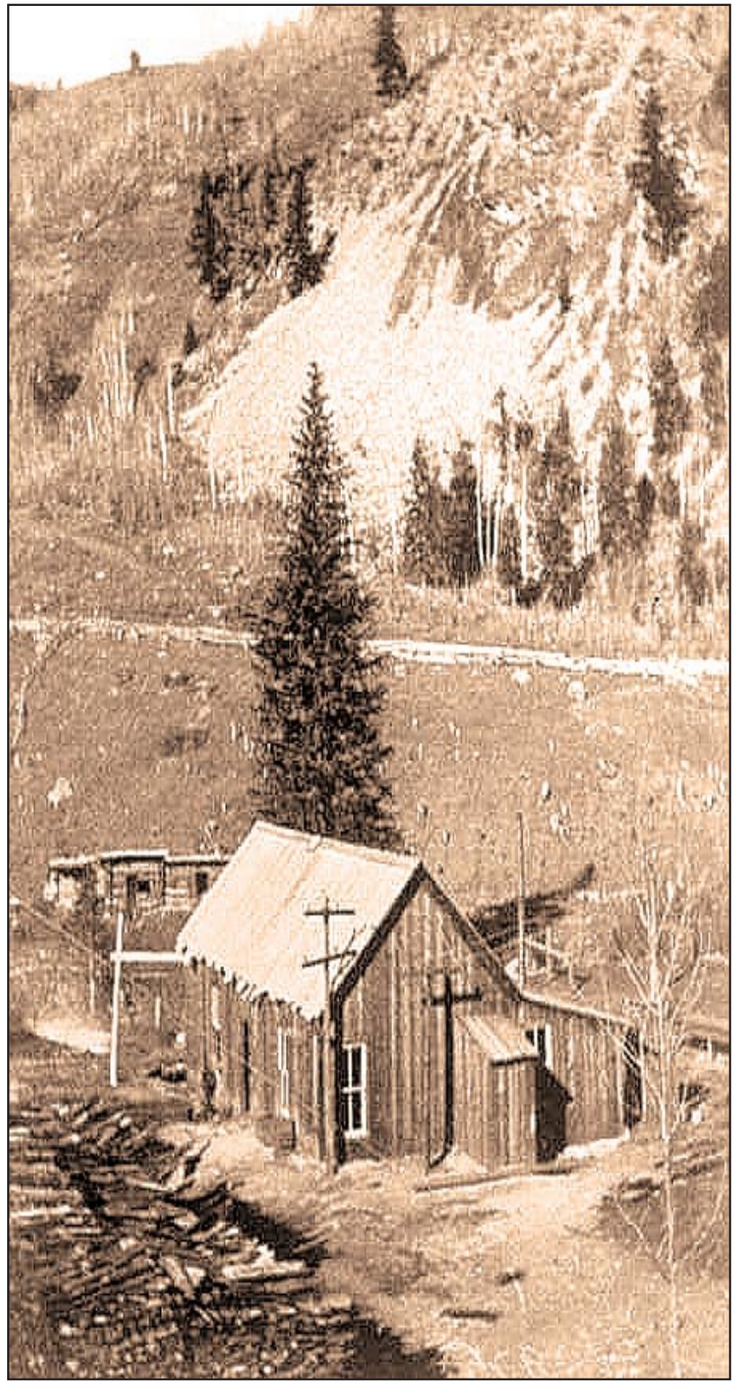
Lucien Nunn asked his brother, Paul, a trained engineer, to learn as much as he could about this new system and gather together some men to help with design work. Lucien himself would do the surveying for transmission lines. The young men they gathered together for this monumental task (some of them from way back East) called themselves "The Pinheads" and they are honored to this day by the Smithsonian/Telluride affiliation known as "The Pinhead Institute." The cost of building a prototype of Tesla's AC system and the task of approaching Westinghouse's Board of Directors were then the only obstacles remaining to Nunn's plans for regaining his fortune. So, he set out for Chicago by train. Upon arrival at the Westinghouse offices he was forced to sit in the waiting room for several days before being admitted to the boardroom for a hearing. He was a persuasive speaker and to add drama to the end of his presentation, he spilled out upon the conference table a bag of gold nuggets and spread them before the amazed directors.

"Gentlemen, I am prepared to wager one million dollars on the venture. What do you say?" The board agreed to the project and in 1891 Nunn built the world's first commercial Alternating Current power plant at Ames, Colorado. The Pinheads, pioneers in this technical field, had to devise ways and means of safely operating the system. Without the benefit of modern switches and clutches, they had to bring the drive motor up to the correct speed using a Tesla induction motor, then couple the stamp mill (a giant, piston-type rock crusher) to the motor shaft across the miles to the generator, all the while keeping everything in synchrony.

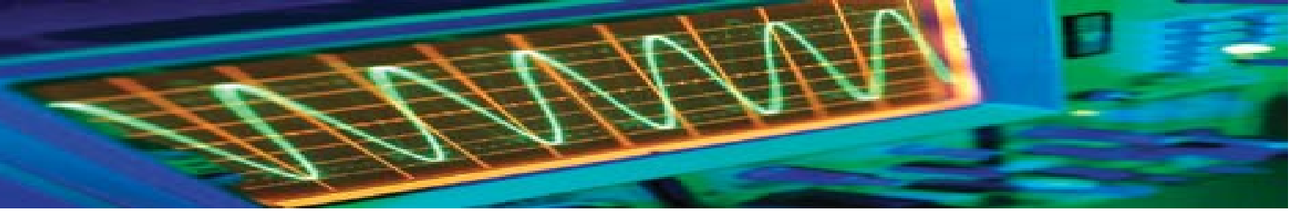
Tesla designed a simple, matched system for the Gold King Mine. A 3,000 volt, single-phase circuit connected the generator to a motor at the mine. Today, this type of thing is in general use around the world, but for the Pinheads it was a monumental challenge. In the first matched, dual-speed system, the motor spun at the same speed as the generator, based upon the transmission frequency used. Tesla's choice was 8,000 to 10,000 cycles per minute (133 1/3 Hz to 166 2/3 Hz) compared to today's common system using 3,600 cycles per minute, or 60Hz.

Shortly thereafter, Telluride became the first town in the world to become electrified with Alternating Current generated by falling water. Each room in the local hospital boasted a fifty-watt light bulb. Streetlights were free.

Nunn's project in the San Juan Mountains was the first application of what would become the global paradigm for power across the next century and beyond. Lucien L. Nunn, Paul N. Nunn and the Pinheads, utilizing the brilliance of Nikola Tesla, the unsung hero of the world of electricity, brought Telluride into the modern world.☼



Exterior view of the L.L. Nunn power station, Ames, San Miguel County, Colorado, shows a side gable structure with lean-to additions, board and batten construction and uneven board roofline. A large stack of lumber is piled in front of the power station below the Gold King mine.



Benchmark Review

This article is an update on our efforts to date to develop a solar/hydrogen/fuel cell energy system for our office/shop. As we gather more equipment and do more detailed testing, we will have additional updates in future issues; but here is where we stand so far.

We have acquired a battery bank that consists of four 12-volt batteries of 26 amp/hour capacity. This is quite small in comparison to a 4 kW solar array, but limited space requires a compromise. It is very difficult for small battery banks, such as this one, to supply the large amounts of current necessary to start electric motors. (We plan for many more for our shop in the future.) To overcome this limitation, batteries with very low internal resistance were selected. They are connected in parallel to a bank of UltraCapacitors that have an even lower internal resistance. This arrangement allows the batteries to supply continuous energy while the capacitors supply the large amounts of current in the short intervals normally found in motor starting. Our small battery bank translates into a limited amount of energy storage. On cloudy days, or during periods of heavy and continuous loads, a backup source of power is therefore a necessity; so this is when we use the fuel cell and the hydrogen electrolyzer.

We had hoped that our new AC-DC inverter (one of the critical pieces of equipment needed to complete our setup and testing) would have been delivered by now; but it looks as though we will have to wait a few more weeks.

In a future article we will have a more complete and detailed summary of how this inverter performs, and we will have the results of our detailed testing of the batteries, capacitors and fuel cell; but, for now we will describe some of the things we've already learned.

Our system is based on a DC buss of 48 volts. This includes our fuel cell, battery/capacitor bank, and the soon-to-arrive inverter.

All of our load testing was done with AC power supplied by an inverter.

With the more versatile and powerful Outback GVFX3648 still on backorder, we overcame this problem by using one of our Outback FX2024's for initial testing. The main drawback was that this inverter needed a 24-volt input. We overcame this problem by rewiring the capacitors and batteries to 24 volts. Normally this would pose a problem because our fuel cell and regulated voltage from the array are both 48 volts. We solved this problem by using another Outback Power product. The model MX60 solar charge controller used to regulate the photovoltaics proved quite versatile. It is easily programmed to accept an input voltage as high as 140 volts and then efficiently step that down to as little as 10 volts with a current limit of 60 amps. Additionally, very sophisticated MPPT or Maximum Power Point Tracking is provided that increases overall efficiency by as much as 30% when compared to the simple DC-DC regulation found in most common solar controllers. This function and user programmable voltage and current set points and an auxiliary output based on these set points proved their value in our system design. We also found its current limit feature especially handy when recharging heavily drained capacitors from power supplied by our first generation Avista fuel cell. The low internal resistance and state of charge of the capacitors would easily cause a breaker trip had we not first sent the power through the MX60 controller.

Tests began with the initial charging of 22 PC2500 2700 farad Maxwell UltraCapacitors wired as two parallel sets of 11 in series. Maximum voltage was set at 27.5 volts.
The capacitors were connected in parallel to four Hawker Genesis G26EP 26 amp hour batteries also wired in series/parallel to a nominal 24 volts. Using the Outback FX2024 inverter, 110 volt AC motor loads were repeatedly started while recording maximum currents and minimum voltages. Heavier loads such as 220-volt air compressors were tested using a step-up transformer. We can eliminate this transformer in the future since as many as ten Outback inverters can be stacked to provide 110/220 volt split phase or even 208 volt three phase.

A Fluke 87-III with a very fast sampling rate and min/max recording function was used for most of the tests, along with a TriMetric amp hour meter for recording overall input/output power.

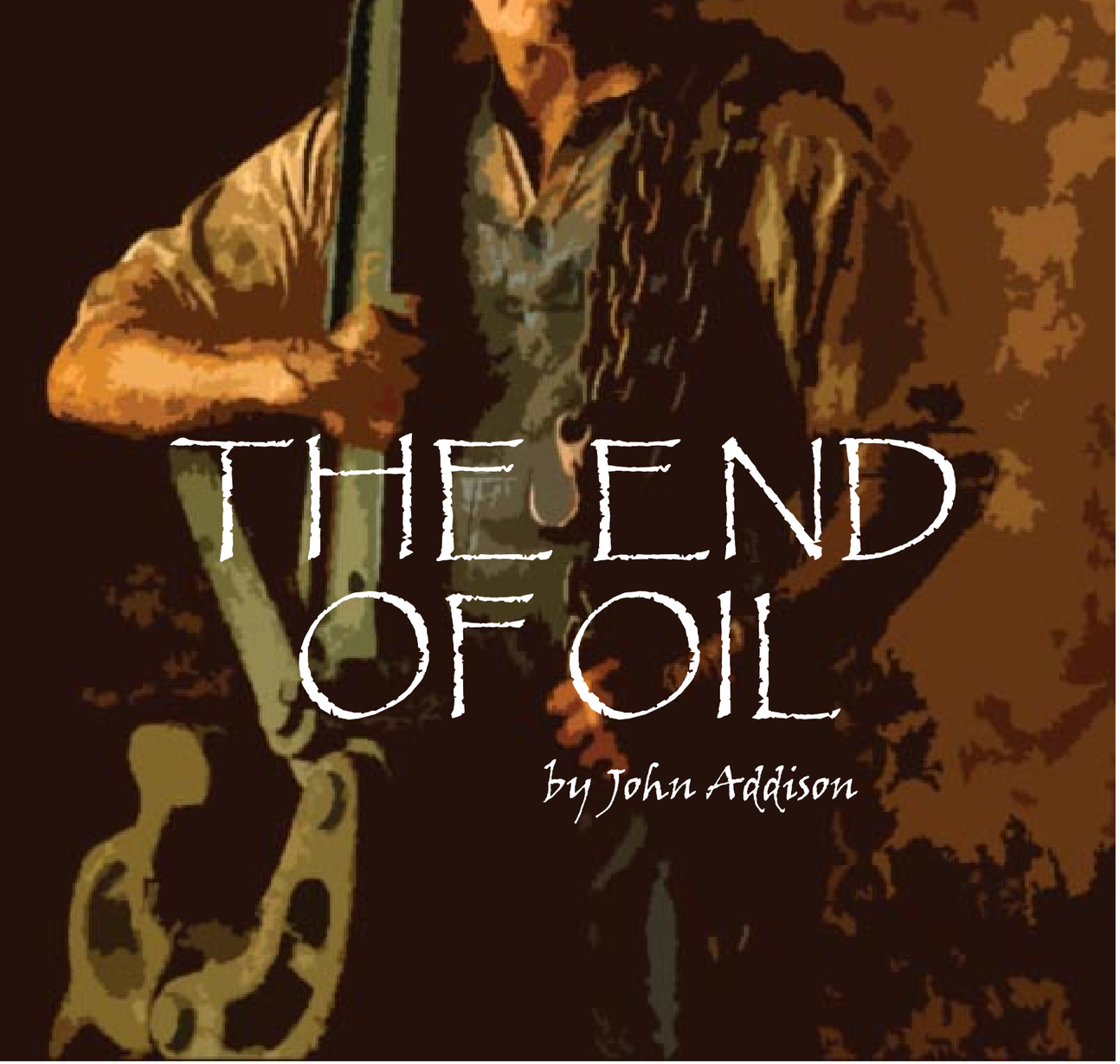
The Outback FX2024 inverter is rated at 2000 watts continuous and 3800 VA for 5 seconds. These limitations kept us from testing compressor loads in the multi-horsepower range, but we easily supplied required peak currents at no lower than 22 volts in our surge tests. This current was delivered from fully charged capacitors and batteries without connection to a solar array and shop temperatures were about 65 degrees Fahrenheit. We used a high current EV200 Kilovac contactor to electrically disconnect the batteries from the capacitors to allow comparison of their ability to deliver current as a parallel set and individually. As expected, they performed better as a parallel set. The capacitors appeared to contribute more and more motor starting benefit as the batteries reached lower and lower charge levels. At higher charge levels the batteries appeared to be almost equal in their ability to deliver surge current. In fairness, the capacitor bank is only about half the size it should be and our new inverter will draw far more power; but the batteries' low internal resistance still allows impressive current levels. Only further testing with the larger inverter will provide a more detailed picture of how beneficial this capacitor/battery arrangement will be.

Two of the components in this system, with technology far more on the cutting edge than simple batteries, proved interesting in testing. The PEM electrolyzer was built in-house. It is a seven-cell design capable of producing a little over 700 cc's of hydrogen per minute at a maximum pressure of about 150 psi while consuming about 140 watts of power. A future design will allow greater pressures with reduced parasitic power losses for additional compression. The Outback MX60 controller again proved its value and versatility as the electrolyzer's voltage is limited to 13.2 volts. The controller easily supplied this from our 48-volt buss. The electrolyzer works fine; but the addition of cold start controls and cell stack monitoring as part of controller programming will be sought in future configurations. The system photo shows the electrolyzer with the original vernier displacement cylinders used for accurate but inexpensive gas volume flow rate measurements. Not shown is the very inexpensive AquaPure deionizer and reverse osmosis water conditioner that supplies extremely pure water used in the electrolyzer. Also much larger storage tanks and a gas dryer will be used in future designs.

The fuel cell we use is an older model of Avista Labs Independence 1000. Its eight plug-in air cooled PEM cell stacks allow exchange of damaged stacks even while in operation. This fuel cell has a little over 200 hours of operation on it and has been very reliable and easy to use. The low hydrogen pressures supplied by the electrolyzer and our small tank proved a limiting factor in tests. Presently we are using a tank of compressed hydrogen obtained locally. We anticipate this fuel cell will prove to be a good choice in our overall system design. Something we are working on is a better automatic control necessary for the start and stop of the fuel cell when backup is called for. Although we can easily wire the auxiliary output from the MX60 controller or the inverter to the fuel cell's remote start/stop connection and precisely set up our on/off levels complete with hysteresis control, automatic starting of the fuel cell still has severe limitations when the set points are based on simple high or low voltages. The precious hydrogen supply should not be used to supply backup power when the voltage condition may be only a transient and short-lived condition based on either peak load or low solar input. We are looking at incorporating controls based on voltage and current levels as well as recorded amp hours removed or remaining in the batteries. This will prove interesting and challenging and if successful will greatly improve overall system efficiency.

Look for a more detailed summary of our testing and progress in the next issue of H2Nation Magazine

1. Maxwell PC2500 Boostcaps enclosed in a Outback PSDC **2.**Outback FX2024 Inverter. **3.** Outback Mate and MX60 Controller **4.** PEM Electrolizer **5.** Hydrogen K tank. **6.** Four Hawker Batteries **7.** Photovoltaic panel **8.** Avista Independence 1000w fuel cell. **9.** Plug-in fuel cell stack.



THE END OF OIL

by John Addison

If your best friends spent 30 years making less every year while spending more, would you say anything? If you loved these friends and they were destroying their health and the lives of their children, would you want to help? Of course you would.

Now, liken this to our problem with oil.

For over thirty years, we have been finding less oil and burning it faster. The United States continues to consume 25% of the world's oil, even though it now has only 3% of the world's oil reserves.[1] This is the debilitating problem of oil.

Oil is increasingly difficult to defend, recover, transport, or refine into gasoline, diesel fuel, jet fuel, heating oil, and plastic.

In 1970, oil production peaked in the United States. In 2001, the global production of oil peaked. [2] Easy oil is disappearing. Oil giants must now invest more in secondary and tertiary recovery. Mining of tar-sands oil is an increasing necessity. For these reasons, oil is becoming more expensive. Oil that once cost $3.00 a barrel now costs $30.00 a barrel.

The question is: How will we bring the use of oil to an end?

The current path of the United States is to prolong oil's use for as long as possible; thus contributing to global warming, and putting national security at risk. This article will consider alternatives, including a rapid transition to clean energy.

GLOBAL WARMING

All atmospheric scientists agree on two facts: the atmospheric concentration of carbon dioxide (CO_2) has increased and the earth's average temperature has increased. Most scientists agree with some certainty that the increases in CO_2 concentration and global warming are primarily caused by burning fossil fuels. CO_2 is the greenhouse gas responsible for most climate change, followed by methane (CH_4), then nitrous oxide (N_2O).[3]

For more than 400,000 years, atmospheric CO_2 concentration ranged from 170 ppm to 280 ppm, explains Dr. Ralph Cicerone, Professor of Earth System Science, Professor of Chemistry, and Chancellor of the University of California at Irvine. Scientists measure historic concentration by taking ice cores from the Antarctic that are 3,600 meters in thickness, carbon dating the ice at various levels, and measuring CO_2 concentration. By 1955, CO_2 concentration had increased to 310 ppm, breaking out of its historical pattern. Since then, concentration has rapidly increased to the current 370 ppm.[4]

Every time anyone burns a gallon of gasoline, 20 pounds of carbon dioxide emissions are added to the atmosphere. The atmospheric heat trap gets thicker. If we continue on our current path of consuming oil and coal, CO_2 concentration will be at least 600 ppm by 2100, and dangerously increasing.[5]

A United Nations report predicts that average temperatures will increase 2.5° to 10.4° by 2100. Even taking the most conservative 2.5° increase implies the massive melting of ice-covered land, a sea that may rise 5 meters, the displacement of hundreds of millions of people, and drought conditions in parts of the world resulting from climate change.[6]

> "The scientific consensus presented in this comprehensive report about human-induced climate change should sound alarm bells in every national capital and in every local community."
>
> Klaus Topfer
> United Nations
> Environment Program

Variations of the following three scenarios are debated in global meetings, the U.S. Senate, conference boardrooms, town halls, and living rooms. Consider the alternative choices that the human race has along with the consequences.

THREE CHOICES

CHOICE #1:From Denial to Destruction

Choice #1 involves the increasing consumption of oil by the people of the world. The U.S. consumes 19,700,000 barrels of oil per day – three and a half times as much as any other country. We must import 10,600,000 barrels of oil per day. China has now emerged as the second largest consumer of oil. Choice #1 continues a vicious cycle of bidding up the price by those desperately addicted to oil.

As prices increase, more expensive means of oil discovery and recovery will be deployed. Oil that never would be recovered at $30 per barrel will be financially feasible at $100 per barrel. The total proven reserves of oil will increase. Exploration will increase, aided by sophisticated 4D seismic modeling. Difficult and environmentally damaging mining of sand-tar oil will become financially viable. New technology will lift average oil recovery. If we choose to continue to subsidize oil, it will continue as our leading source of global energy for another 40 years.

Powerful oil, coal, and automotive interests will lobby for new energy bills loaded with tax breaks, shields from liability suits, and government subsidies. Continued subsidizing and protection of inefficient coal, oil, and vehicle manufacturers will lead to their ultimate demise as short-term protection insures long-term inability to meet the clean energy needs of global customers.

With increasing oil consumption, more offshore drilling will cover beaches with black tar. United States taxpayers will repeatedly sacrifice another $87 billion for yet another war. More sands will be covered with red blood.

"Such miracles will not come cheap, however, since much of the world's oil is now produced in ageing fields that are rapidly declining. The IEA concludes that global oil production need not peak in the next two decades if the necessary investments are made. So, how much is necessary? If oil companies are to replace the output lost at those ageing fields and meet the world's ever-rising demand for oil, the agency reckons they must invest $1 trillion in non-OPEC countries over the next decade alone. Ouch."

The Economist

Consider this irony. Fuel from oil constitutes 70% of the Army's total weight that must be transported into battle for transportation and stationary power. Our battles are increasingly about the oil that is converted into that fuel. We now have an opportunity to make a transition to hydrogen that is lighter to transport, does not make us vulnerable to foreign suppliers, and is not a cause of war.

If we continue our current consumption of oil, CO2 concentration will increase to 600 ppm from our already dangerous level of 370 ppm. Global warming will accelerate and oceans will rise by meters. Choice #1 is the current choice of the United States. With your influence as consumers and voters, it can be abandoned. It must be abandoned.

CHOICE #2:
Natural Gas and Fossil Hydrogen

Natural gas is 85% to 95% methane (CH4), a fuel gas that has 4 hydrogen atoms bound to one carbon atom. More than 80% of all commercial hydrogen is reformed from natural gas. Shell forecasts that in 2025 it will earn more from natural gas than from oil.

Natural gas has proven reserves to meet over 100 years of current consumption. It is more evenly distributed globally than oil, thus lowering the likelihood that war will be waged over it.

In modern times, energy sources have had their periods of global leadership, and have then been replaced by a new leader. Around 1850, coal replaced wood as the number one source of energy. Around 1950, oil replaced coal as the energy leader when vehicles proliferated. With each change of leadership, the percentage of hydrogen in the fuel has increased. Natural gas will likely replace oil within 20 years as the world's leading source of energy. Indeed, this is close to the forecast of the U.S. DOE Energy Information Agency, Shell and BP. If all major nations agree to the Kyoto Protocol, the transition is certain.

With Choice #2, the fuel and transportation industries will steadily migrate to customers' needs for cleaner transportation and energy.

An expanded role for natural gas does not sit well with many environmentalists. Natural gas is a fossil fuel. It contributes to over 20% of global warming. Many fear that building a major infrastructure around it will prolong our dependence on fossil fuel, foreign suppliers, and the power of current energy suppliers. Some point to the rising price of natural gas as evidence that most proven reserves are too difficult and costly to extract. With Choice #2, global warming will increase, but at a less alarming rate than with Choice #1.

CH4 allows large-scale economic production of hydrogen. Hydrogen can be blended with natural gas, improving efficiency, lowering NOx emissions, and accelerating the hydrogen infrastructure. Natural gas represents a transitional strategy to the large-scale adoption of hydrogen as an energy carrier.

CHOICE #3:
Clean Energy and Renewable Hydrogen

Clean energy could displace oil as our number one global energy source in twenty years. A twenty-year transition would be remarkable. Conventional forecasts place the transition to clean energy at least fifty years away.

THE U.S. GOVERNMENT SHOULD ACT NOW

"...A transformation from gasoline to hydrogen would reap huge benefits for our security, economy and environment. Our reliance on imported oil is a serious security concern. The U.S. today imports 54 percent of its oil from foreign sources, and that dependency is expected to increase to 68 percent over the next 25 years."

Spencer Abraham
United States Secretary of Energy

Because CO2 remains trapped in the atmosphere for as long as 200 years, stabilizing the earth's atmosphere requires that we reduce our CO2 emissions by 60%.

Greenhouse emissions can be reduced 60% in twenty years by improving global efficiency 4.5% annually (check the math by taking .955 to the 20th power). Improvements from efficiency, conservation, and renewable energy must outweigh the energy cost of a growing population desiring increasing consumption.

Many nations are encouraging efficiency with tax credits, education and funding research. We should start with conservation. Double transportation efficiency and demand will be cut in half. Run vehicles on hydrogen, and we will have unlimited reserves. Tax and subsidy policy should shift from billions for oil and coal to billions for efficiency and renewable energy.

A twenty-year transition would take political will and global cooperation. History shows this is possible. Nations agreed to the Montreal Treaty and stopped the production of greenhouse gas CFC. The dangerous expansion of the ozone hole already appears to be reversed. In 1990, Germany appeared to be paralyzed by the political power of their coal and auto industries. Now they are the world leader in wind power, and they have lowered their annual greenhouse emissions. In the United States, during World War II, Detroit dramatically transformed its production from autos to new defense equipment in a matter of months.

California has a long history of innovation. It may now lead the United States in a fast transition to clean energy. Governor Schwarzenegger has declared that by 2010 there will be a hydrogen fueling station every twenty miles on major highways. The state already has ten H2 stations in daily use. Twelve more are in development. A growing number of hydrogen fuel cell and H2ICE cars, buses, and trucks are using these stations.

California is the nation's leader in the use of wind, geothermal and solar power. Some existing hydrogen fueling stations use solar or wind power to create hydrogen by electrolysis. This is renewable hydrogen, not fossil hydrogen.

Unfortunately, California is also a leader in SUVs per capita, each contributing a disproportionate share of greenhouse gas emissions. South Coast Air Quality Management District and five cities are using their financial clout to buy hydrogen-fueled vehicles to replace their aging fleets and accelerate the shift to clean transportation.

We need a President who listens to his people. We need representatives who care more about the next generation than the next election. A United States President once created the vision that there would be a man on the moon within ten years, and there was.

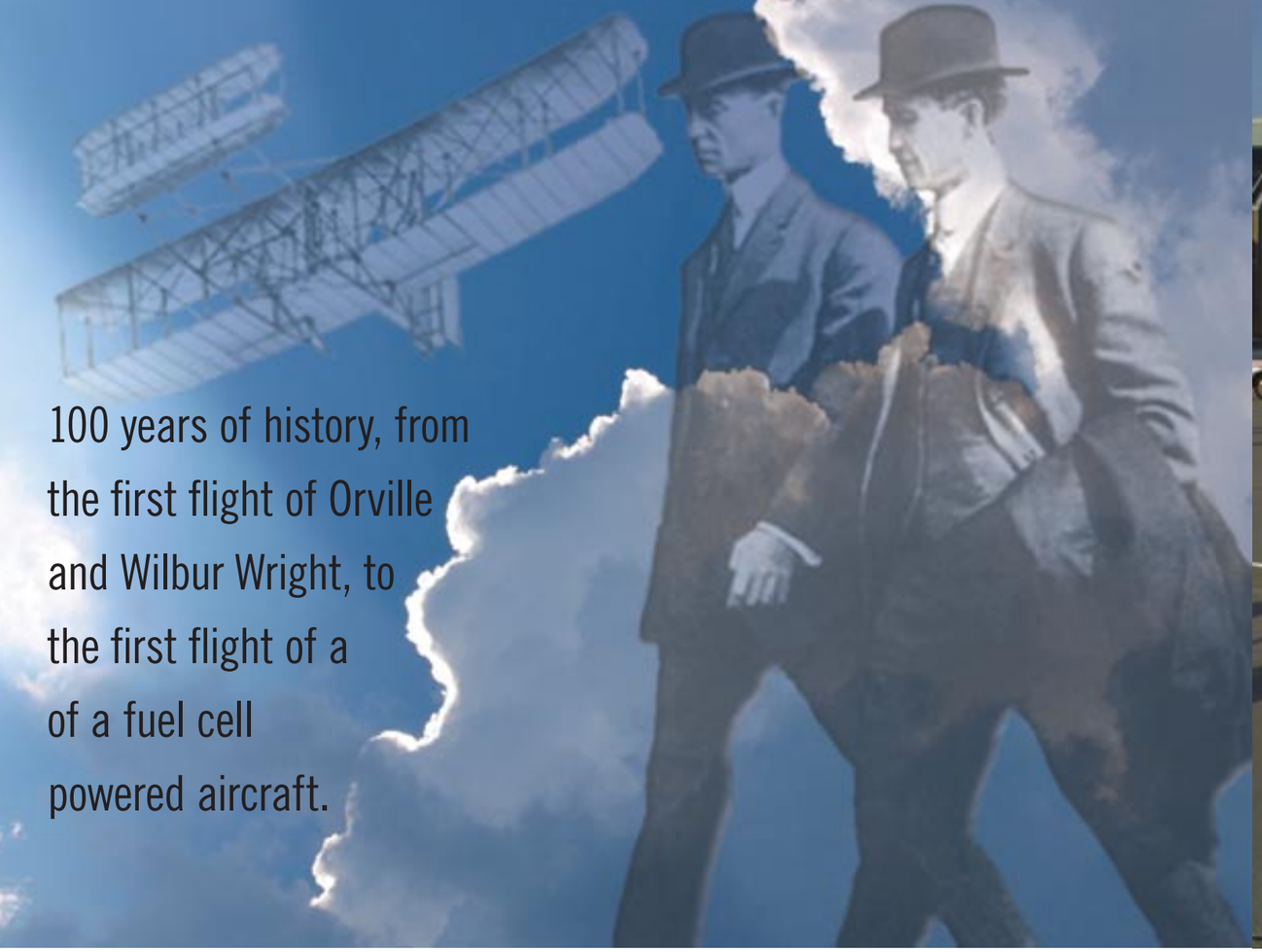
The U.S. Government is the world's largest consumer of energy, vehicles and fuel. New vehicles purchased by the U.S. Government should run on either natural gas or hydrogen. The U.S. should follow the California example of a phased implementation of hydrogen stations and hydrogen fleets.

As a reader of H2Nation, you lead by example in your energy usage, your transportation sources, your voting power, and your voice. May your voice be heard around the world.

 John Addison is president of OPTIMARK Inc., and a board member of the California Hydrogen Business Council. Special thanks go to John Williams and Jerald Cole for their insightful reviews of this article. The positions in this article are Mr. Addison's, not necessarily those of H2Nation or the organizations in which he is a member. Mr. Addison is considered an expert about how businesses succeed with disruptive technology. He is the author of the book, Revenue Rocket. A free 15-page book summary is at :www.optimarkworks.com/books

(Endnotes)

[1] Apollo Alliance, 11/03 http://www.apolloalliance.org/strategy_center/energy_independence_facts/index.cfm.
[2] BP Statistical Review of World Energy 6/03
[3] "Stormy Weather" Guy Dauncey with Patrick Mazza, New Society Publishers 2001
[4] Dr. Cicerone's lecture to the Academy of Sciences and interview with the author 11/18/03
[5] IPCC Third Assessment Report: Climate Change 2001 http://www.ipcc.ch/pub/reports.htm
[6] IPCC Third Assessment Report: Climate Change 2001 http://www.ipcc.ch/pub/reports.htm
[7] "Sunset for the Oil Business?" The Economist 11/01



On a Wing and a Fuel Cell

by Vicki Sanders

Weighing just eight hundred seventy pounds, the all-carbon DynAero Lafayette III is a lightweight among airplanes, but it's about to carry aloft a weighty dream. Soon the plane will take a critical step toward becoming the first piloted plane to be powered by fuel cells. The event will be an important first in the next century of flight, following the yearlong celebration of the 100th anniversary of the Wright Brothers' first flight on December 17, 1903.

"One reason we're doing this is -- that everyone thought it would be impossible," says James P. Dunn, president of Advanced Technology Products, Inc (ATP) of Worcester, Massachusetts, the corporate entity behind the plane. Dunn is also the executive director of the Foundation for Advancing Science and Technology Education (FASTec), the non-profit arm of the project. This alternative energy expert and experimental pilot is also chief executive officer of the Center for Technology Commercialization (CTC), his "day job."

A tall, energetic man who loves a good challenge ("Who'd want one of those?" his detractors asked in 1981 when he invented the first battery-powered laptop computer), Dunn has used his powers of persuasion to engage a number of partners in the creation of the e-plane. They include Worcester Polytechnic Institute's (WPI) Fuel Cell Center, NASA, American Ghiles Aircraft, Inc., Giner Electrochemical Systems, UQM Technologies, Diamond Aircraft and W.L. Gore & Associates, Inc., along with a band of more than one hundred volunteer professionals, aviation enthusiasts and WPI alumnae, faculty and students.

In September, Dunn, an alumnus of WPI, and some seventy others from the school, formed teams to work on eight tasks critical to preparing the e-plane for its first flight. They're studying everything from the weight and balance trade-off to the electric throttle and the cooling system

Dunn is developing the plane in three phases. The first flight (scheduled for this spring from Worcester Regional Airport) will be powered solely by rechargeable batteries. Flying alongside the e-plane on its maiden voyage will be a replica of the Wright (B) Flyer used by the Wright Brothers. The e-plane will then be transported to Lakeland, Florida, where it will be on display at the EAA Sun'n'Fun celebration. It will not fly at the event.

In Phase II, the batteries will be augmented by a 15- to 25 kW proton exchange membrane (PEM) fuel cell that will extend the plane's flying range from about one hundred miles to more than two hundred fifty miles. The target date for the flight is December 2004.

During the year 2005, Dunn expects to fly the DynAero in cruise mode with only a 25- to 75 kW fuel cell. He hopes to have it compete with another fuel-cell-powered plane that Boeing originated and that is undergoing further development in Worcester.

Dunn says that recent advances in fuel cell technology, the development of lighter and more powerful electric motors and new lithium-ion batteries that are six times more powerful per pound than lead-cell batteries, are among the reasons the e-plane is viable today. Another is the growing demand for sustainable energy.

Fuel Cells are sustainable and essentially emission free, but are expensive to build (requiring platinum and other precious metals). On a per-kilowatt basis, Dunn calculates, fuel cells cost ten to fifty times as much as internal combustion engines; one reason it may be another decade before fuel cells are commonly used in general aviation aircraft and even longer for commercial planes.

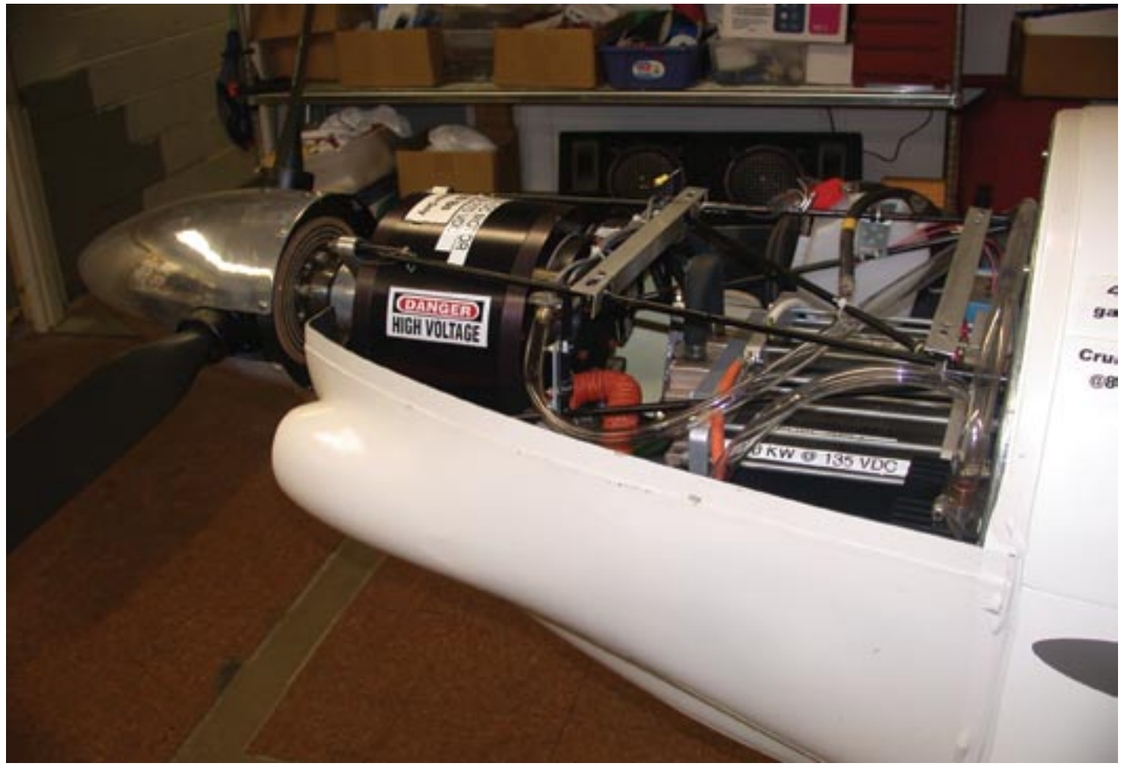
The more immediate concerns for ATP's e-plane – and this is where WPI's Fuel Cell Center comes in – are how to provide a fuel cell sized to the plane's requirements and how to generate and store the hydrogen fuel. Hydrogen is customarily stored under pressure in heavy metal bottles or at low temperatures in Dewar flasks. For space and weight reasons, neither set-up is workable in a small aircraft; so the WPI researchers are looking for ways to produce hydrogen on-board. One option is to start with hydrocarbons that can be reformed into hydrogen during flight. Another possibility is to break down ammonia, which has three hydrogen atoms per molecule.

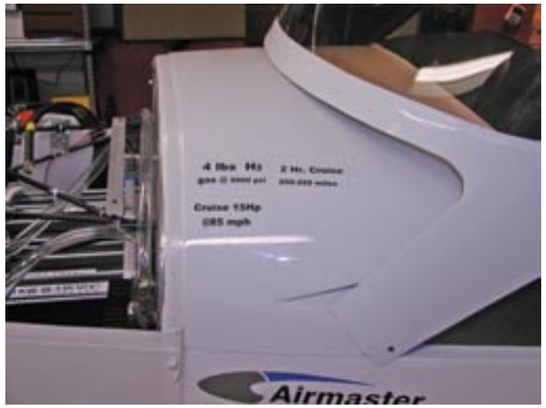
The project is important to WPI because it involves the students in leading edge research, says Associate Provost William W. Durgin. "Fuel cells have been around for a long time, but nobody has tried this application before. It's very challenging."

Dunn has attracted numerous backers, among them NASA, the U.S.Army and W. L. Gore, who've supplied everything from the aircraft itself to fuel cell analysis to batteries. He says he will need more funding to complete the plane. "We've got a project that's got a lot of sizzle," he says,"and we need to get more sponsorship to enhance our success and educate more people on emission-free, sustainable energy sources like hydrogen."

As word of the e-plane has spread, the project has won the response of a widening circle. Last year, Aviation Week bestowed on ATP its Outstanding Technical Innovation Award. The three volunteer test pilots are aerospace heavyweights: international air racer, Robert "Hoot" Gibson, the first American astronaut on the Mir space station and former head of the Navy's "Top Gun" school, is the chief test pilot. He is joined by aerobatics champion and former Naval aviator, Wayne Handley, and Formula One air racer and Exxon Flying Tiger, Bruce Bohannon.

Scientific American reports that "the connections Dunn has made for systems and component elements within the fuel cell





industry represent as much of a Who's Who as his test pilots. Also on the team is Paul McCready, CEO of AeroVironment Corp., the company developing the Helios unpiloted flying wing, and Jay Carter Jr., developer of the revolutionary Carter-Copter gyroplane."

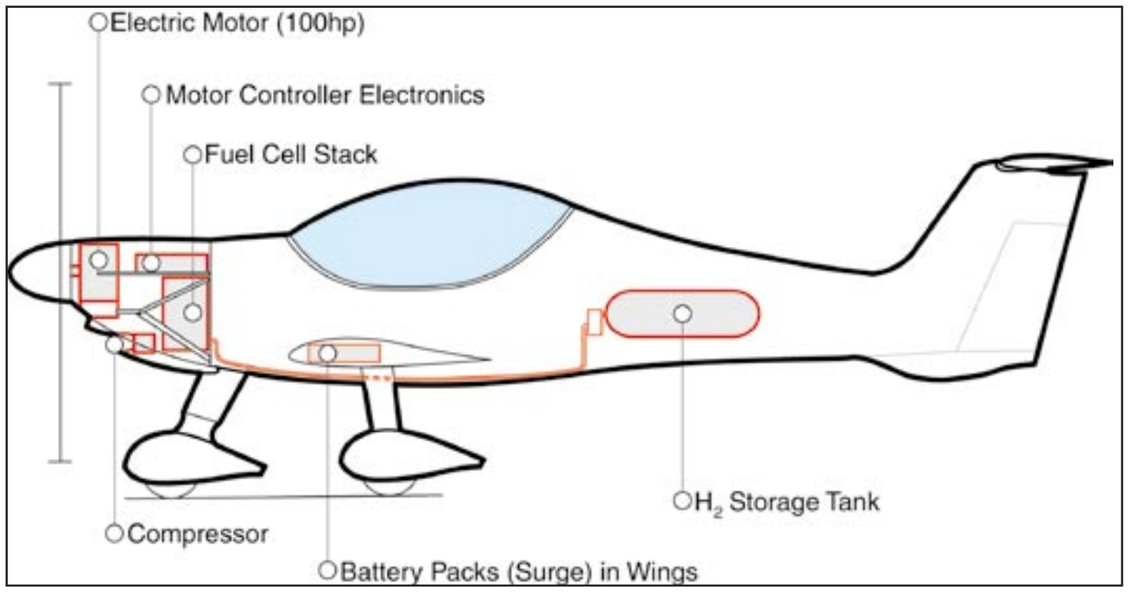
For Dunn, who washed and waxed planes at the Worcester airport during his student years at WPI to earn flying time, loyalties run deep. He is a co-founder of the WPI Venture Forum. Along with many other WPI alumnae involved with key areas of the program, two among his colleagues at ATP include Peter T. Launie, who tackled the problem of how much weight (including batteries and fuel cells) the DynAero could bear; and Bob Duris, who is helping develop the data acquisition system.

Dunn hopes that his e-plane will lay the foundation for further innovations. "If we can make a fuel cell work on an airplane – if we can solve the hydrogen generation problems and demonstrate that it's a sustainable and renewable fuel," he says, "we can get people excited about the future and about being independent of the petroleum-based economy."

For more information about the electric plane, visit the project's web site aviationtomorrow.com.

This story has been reprinted with permission from Transformations, a publication of the Worcester Polytechnic Institute.

Robert "Hoot" Gibson is a retired astronaut, decorated Naval pilot and Vietnam veteran. He flew five NASA missions between 1979 and 1995 for a total of 36 1/2 days in space. He is a graduate of the Naval Fighter Weapons School, or "Top Gun", and his numerous honors include the Distinguished Flying Cross and the Vietnam Campaign Medal. Gibson's first three NASA missions included launching satellites, conducting astrophysics experiments and carrying cargo for the Department of Defense. On his forth space flight, the 50th Space Shuttle mission, he served as spacecraft commander aboard the Orbiter Endeavour. Most recently he commanded a crew of 15 on Space Shuttle Mission STS-71, the first to dock with the Russian Space Station Mir. While with NASA, Gibson served as Chief of the Astronaut Office, as deputy director of Flight Crew Operations and as a team investigator into the Space Shuttle Challenger accident. Now 54, he lives in Lakewood, California with his wife Rhea.



So just where IS the electric vehicle?

By Larry Elliott

It's now twenty years since a group of electric vehicle enthusiasts created an organization known as EDTA or Electric Drive Transportation Association. Each year since then, they have held an Electric Vehicle Symposium or EVS. Manufacturers, engineers and electric drive developers have come together at each symposium to share technology, new ideas and designs, and refine electric drive technology that will compete with the internal combustion engine and become more commonplace on our highways.

EVS20 was recently held at California's Long Beach Convention Center. Several H2Nation staff members attended to gather the latest information on new technology; to get a sense of where "state of the art" electric drive technology is now, and to find out where it is going in the future.

When the first EVS event was held in Phoenix, Arizona, in 1969, no major automobile manufacturers exhibited. For at least the first ten symposia the most common vehicles on display were standard, internal combustion engine vehicles converted to electric drive. The idea at the time was to take an inexpensive, small and lightweight vehicle, remove the engine and all components no longer needed, and proceed to stuff heavy, messy, lead acid batteries anywhere room was available. If the vehicle owner could afford it, heavy series, wound electric traction motors were then coupled to the existing transmission and controlled by rather crude and inefficient electronic controllers. For those on tight budgets, even heavier, less efficient and unreliable aircraft starter motors were employed, along with control supplied by a series/parallel arrangement of resistors. These vehicles had poor range, usually not exceeding 40 to 50 miles, and had a hard time keeping up with traffic due to poor acceleration and the weight penalty of lead acid batteries. Handling (especially braking) was severely compromised because of the battery weight. A common comment at the time was that these vehicles were designed as a means to haul around the batteries rather than the passengers.

In spite of the limitations, inventors and engineers continued to refine the designs with more advanced DC traction motors and better electronic controls. In spite of these advances, pure electric vehicles still had severe shortcomings and a customer base could not be found. It seemed that the real limitation was in the batteries. In 1991, the federal government allocated several millions of dollars to what became known as the ABC, or Advanced Battery Consortium, an organization of battery manufacturers and researchers, funded privately and through government grants, with a goal of research and development of state of the art battery designs that could be brought to commercial production and solve the electric vehicle battery problem. Millions of dollars and thousands of research hours later one might ask if we are any closer to seeing pure battery electric vehicles on showroom floors. The answer is: We probably never will see pure battery electric vehicles any time soon from major manufacturers.

EVS-1 Phoenix, Arizona, USA 1969
EVS-2 Atlantic City, New Jersey, USA 1971
EVS-3 Washington, D.C., USA 1974
EVS-4 Düsseldorf, Germany 1976
EVS-5 Philadelphia, PA,USA 1978
EVS-6 Baltimore, Maryland, USA 1981
EVS-7 Versailles, France 1984
EVS-8 Washington, D.C., USA 1986
EVS-9 Toronto, Ontario, Canada 1988
EVS-10 Hong Kong 1990
EVS-11 Florence, Italy 1992
EVS-12 Anaheim, California, USA 1994
EVS-13 Osaka, Japan 1996
EVS-14 Orlando, Florida, USA 1997
EVS-15 Brussels, Belgium 1998
EVS-16 Beijing, China 1999
EVS-17 Montreal, Quebec, Canada 2000
EVS-18 Berlin, Germany 2001
EVS-19 Busan, Korea (South) 2002
EVS-20 Longbeach,California 2003

Nickle Metal Hydride Battery Module that is installed in the Toyota Prius. Each Module contains six-1.2 volt cells at 6.5 Amp-hours. There are 28 modules for a total of 201.6 VOC in the 2004 Toyota Prius

A casual walk around the exhibit hall at EVS20 would have easily confirmed this question. Not a single major automobile manufacturer displayed or even planned for future production of a pure battery electric vehicle. That is not to say that battery technology has not advanced in the last twenty years. Nickel Metal Hydride's from Texaco Ovonics and Panasonic as well as Lithium Ion batteries from Gaia were on display. Both of these technologies show greater promise in higher energy densities, specific energy and cycle life than the more common lead acid or even the advanced Nickel Cadmium designs.

In spite of advances, both battery technologies have failed to deliver a practical electric vehicle. General Motors has now dropped production of the EV1, a two-seat, sports type car. Lack of sufficient demand was given as reason for its failure in the market. With only two seats and limited cargo space, this ultralight vehicle failed to exceed a range of 150 miles, even while using advanced Nickel Metal Hydride batteries.

Toyota has decided to drop production of its RAV4EV. Low demand and high battery costs as well as the inconvenient and lengthy recharge times were the primary reasons given.

Southern California Edison, a sponsor of EVS20 and owner of a fleet of over 100 RAV4EV's has over 100,000 miles on some of these vehicles and likes the lower cost of operation. Perhaps they can fill a niche market such as use in meter reading or intercity package delivery, but the market is still too small for a major manufacturer to pursue further production.

The two technologies that were most commonly displayed by both major manufacturers (and even some small R&D companies) were hybrid drive and hydrogen fuel cells. The hybrid drive uses an internal combustion engine coupled to an electric motor and batteries, or in some cases ultracapacitors. The fuel cell vehicles use a hybrid arrangement of electric drive, batteries or ultracapacitors, and a fuel cell that is fueled in most cases by gaseous hydrogen that supplies constant power to the electric motor.

So far, only Toyota and Honda have produced hybrids that are available on showroom floors. Toyota's Prius uses a system called Hybrid Synergy Drive to power a vehicle that is similar in size to a Camry, yet gets more than 55 miles per gallon on a 1.5 liter engine, while delivering acceleration comparable to engines twice the size.

Toyota was well represented at EVS20 by having several new 2004 Prius models on display and available for the Ride and Drive portion of the event in which journalists as well as potential buyers had an opportunity to drive the latest vehicle designs in real world urban traffic and in some cases on a test track.

GM's EV-1 Grave Yard

Hybrid drives for large buses and trucks were on display, such as those from Enova, a California developer of large electric drives in excess of 300 hp.

General Motors brought an item to the show called a “mild hybrid” that will soon be an option on its light and medium duty trucks. In this option, a motor that replaces the conventional starter is integrated into the bell housing along with the torque converter or clutch. It serves additionally as a generator to recharge a 42 volt bank of batteries placed under the seats. This allows the engine to be shut off when the vehicle stops, then restarts the engine and adds about 13 hp when accelerating. It also recharges the batteries when supplying power to a standard 110 volt auxiliary power outlet. Twenty-five hundred dollars was the cost of this option.

In addition to the Hybrids, several manufacturers displayed their latest fuel cell vehicles. Perhaps the most advanced and certainly the most futuristic model on display came from GM, where a radical approach to future fuel cell vehicle design has been taken. Starting with a clean sheet approach, they have “leap frogged” current chassis and vehicle drive technology. The Autonomy and the HyWire are based on what is known as a”skateboard” chassis. This is a

design in which all of the major drive, fuel storage, control and suspension components are contained in a frame only 12 inches thick that resembles a skateboard. It is essentially a flat platform with four wheels attached.

GM did not stop there. They also designed the chassis to accept an entire series of body designs from pickup and SUV, to sports car or utility vehicle. These bodies can be removed easily and interchanged because the vehicle uses drive-by-wire technology. Originally developed for aircraft, the drive-by-wire design eliminates the common steering wheel, brake and throttle pedal. All of these functions are organized within a yoke in which simple hand movements are translated electronically to control steering, braking and throttle control. The yoke can even be moved from left to right or set anywhere in-between. In future designs, GM has plans to mount hub motors (or motors that also serve as the vehicles wheels) at all four corners, thus allowing true four-wheel drive with infinite traction control. This will eliminate the need for a transmission and reduce weight. It is truly a radical design departure for GM. Only time will tell if it is a commercial success.

Toyota displayed its fuel cell vehicle and also made it available for test driving. Based on the standard production Highlander chassis, the FCHV is a true fuel cell hybrid. A 90 kw (130 hp) PEM (proton exchange membrane) fuel cell is placed where an engine normally would sit. This supplies DC power to a controller that converts the DC to three phase AC to power the 50 kw motor coupled to the front wheel drive. Just as in most of the fuel cell vehicles currently being developed, hydrogen is stored in high-pressure carbon fiber tanks. Five thousand pounds per square inch or 350 bar is the common pressure range, but tanks with as high as ten thousand pounds per square inch are being developed and tested by most major auto manufacturers.

Currently, several Toyota and Honda fuel cell vehicles are leased to universities and government fleets in California for real world testing and so far they have proven very reliable and practical. Toyota is developing fuel cell vehicles concurrently with their hybrid drive systems, since they see the coupling of hybrid drive with fuel cell technology as being necessary in most practical designs. Already much of the technology developed for the Prius is being used in the new fuel cell vehicles. The batteries are the same nickel metal hydrides found in the Prius and much of the inverter and computer control in the fuel cell vehicle is similar to that found in the hybrid drive.

So far, skeptics of Toyota’s hybrid drive marketability are being proved wrong because of the greater than expected sales of the Prius. Most dealers have long waiting lists. So far in 2004, more Priuses have been sold than in all combined sales during the six years since its original introduction. Additionally Toyota has plans for a series of hybrids from the Lexus LS 430 to the Highlander, and even pickups in the next few years. Perhaps their fuel cell designs will have similar positive impact on electric drive technology in the near future.

Other companies are making contributions to hybrid drive and fuel cell technology as well. Anuvu, based in Sacramento, California, probably has developed the least expensive fuel cell hybrid vehicle now available. It has a price tag of $99,995 which is many time less than fuel cell vehicles offered by the major auto manufacturers. Rex Hodge, President and CEO, states that with economies of scale this price can be reduced substantially by mass production. Anuvu has been developing PEM fuel cells for several years and has made some breakthroughs in cost reduction and increased reliability. Using their standard platform 1.5 kw PEM fuel cell stacks, they have assembled a hybrid fuel cell vehicle using Nissan Frontier pickups. Four stacks are assembled in series to deliver a nominal 48 volts which is then increased to 120 volts through the use of a DC-DC converter. This power is used to establish a maintenance charge on the standard lead acid Optima batteries. Designed primarily as an urban vehicle used for commuting, it has a speed limit of 70 mph, but still has good cargo capacity. In addition, the fuel cells allow a range in excess of 250 miles.

Another very interesting feature of the EVS20 seminar for many attendees was a series of breakout sessions where attendees could participate in power point presentations given by manufacturers and government policy makers. Unlike past EVS events where battery and electric drive technologies took center stage, this year’s event illustrated the significant inroads that hydrogen and fuel cell technologies are making in the development of electric vehicles.

One presentation of particular interest to renewable hydrogen advocates was given by Honda Motors. Honda has been exploring the zero emission fuel cycle for several years now. At their facilities in Torrance, California, they installed a hydrogen electrolyzer coupled to a large photovoltaic array. This equipment supplies compressed hydrogen which is then used in their experimental fleet of fuel cell vehicles. In addition, Honda has been performing research on advanced electrolyzer designs that has increased efficiency over current designs without increasing cell temperatures. They are also developing photovoltaic technology that greatly decreases the CO_2 produced in the manufacturing process and increases overall efficiency.

Their latest press release announced a breakthrough in PEM fuel cell design that allows operation at lower temperatures than in currently available fuel cells, and increases the power density significantly. Judging from these developments, it seems clear that both Honda and Toyota see a promising future for hydrogen and fuel cells in vehicle designs yet to come, and that the hydrogen fuel will most likely be derived from renewable sources.

The roundtable discussion that took place on Tuesday was the event that best illustrated the direction in which electric vehicle technology is headed. A representative from each of the six leading automobile manufacturers was given an opportunity to give a fifteen minute presentation setting forth their vision for the automotive future and illustrating the focus of their current R&D. Toyota, Daimler Chrysler, Honda, Ford, Nissan, and General Motors were represented. Each company’s approach to developing the next generation of vehicles was different in many aspects. Notable was Daimler Chrysler’s emphasis on advanced diesel technology. This probably reflects their European market demands that heavily favor the diesel engine.

Ford on the other hand sees promise in hybrid technology as well as fuel cells, although they have yet to get their Escape Hybrid to market. Originally their approach was to borrow hybrid technology developed by others. It was later decided to do all development in-house in order to protect intellectual properties and have greater control over the technology. This meant greater lead time in bringing the product to market. From all accounts, the performance and fuel efficiency of the Escape Hybrid should make it a winner in the marketplace. It will have the performance of a V6 with its large electric drive (even though it has a four-cylinder engine) and it should retain the towing capability of the original V6 Escape. Ford is also working on advancing hydrogen use in internal combustion engines as displayed in their Model U concept vehicle and the Vortec four cylinder engines used in their H2 Focus.

General Motors has always had a heavy presence in the bus and truck market. Much of their effort goes into hybrid drive technology in their Allison division. In addition, they too are making a heavy investment in fuel cell technology and see a large future market in stationary fuel cells. They have a partnership with Dow in developing a lower cost, high-power PEM fuel cell for both stationary and vehicle use. They plan to lower costs through a number of innovations, and achieve cost reductions by volume production of both automotive and vehicle fuel cells using many of the same production methods and parts.

Three standouts among the group of manufacturers attending EVS 20 were Nissan, Honda and Toyota. Both Nissan and Honda delineated the developments and advances they are making in hybrid and fuel cell technology. Both are committed to future development of both of these technologies. Toyota perhaps took the strongest stand in favor of a gradual transition from the fossil-fuel-internal-combustion-engine present, to a hybrid-and-fuel-cell future. They stressed the fact that hybrids alone will not solve the greenhouse gas problem and will not significantly reduce dependence on fossil fuels. The innovations to date and expected future advances were clearly explained.

Perhaps the most telling concept of EVS20 was the clear signal that the future of advanced transportation is in hybrids and hydrogen fuel cells. It is apparent that the major manufacturers have given up promoting pure battery electrics and have decided that the fuel to drive advanced transportation in the future is hydrogen. Clearly they see hydrogen as the “end game.”

We have no way of knowing exactly how all this will evolve, but it is evident we are making progress on the road to a hydrogen-based transportation system. With events like EVS20 and those still to come, perhaps electric drive transportation is closer than we think. Only time will tell. ☼

Hydrogen Hybrid

ECD's Toyota Prius Hydrogen Hybrid

By Larry Elliott

Those hoping to advance the hydrogen economy have been talking lately about converting existing internal combustion engines to operate on hydrogen. Some believe that development now of a hydrogen fueling infrastructure, using existing technology, will accelerate an early adoption of fuel cell vehicles. To date, no major auto manufacturer has taken the lead in producing an advanced hydrogen ICE vehicle for the general public; and many in the industry believe that a practical hydrogen vehicle will not be available for many years.

However, one company involved in a variety of technologies well-adapted to advancing early adoption of hydrogen (and specifically renewable hydrogen) has come very close to making a reality of advanced hydrogen transportation for the general public. ECD (Energy Conversion Devices) of Rochester Hills, Michigan, has been involved in the research, development and manufacture of advanced battery, solar photovoltaic, and hydrogen storage products since the early 1960's. Today, ECD has developed all of these technologies so that they require only adaptation to an advanced vehicle design and refinement in order to make hydrogen vehicle fueling a near term proposition.

Advanced hydrogen vehicle technology should be applied only to an equally advanced, commercially available vehicle; and another innovative company with a track record for great engineering and environmental awareness had just what ECD was looking for. Toyota Motor Company has produced the Prius Hybrid since 1997. Its sales to date have exceeded Toyota's own projections. Sales of the latest 2004 improved model may be even more dramatic.

ECD capitalized on the already clean engine emissions and high efficiency of the Prius.

Several modifications were made to the existing vehicle systems of the 2002 model. The Prius has a 1.5 liter naturally aspirated (nonturbo supercharged) engine with port injection (individual fuel injectors on each cylinder). Because the hydrogen is introduced as a gas and not a liquid like the original gasoline design, it was necessary to install new injectors. Fortunately, for some time now, Quantum Technology of Irvine, California, has been producing injectors designed specifically for hydrogen. These injectors are driven from the original engine control module, but a new "map" (ignition and injection program) had to be developed to optimize performance with hydrogen.

Anyone who has attempted to convert an existing internal combustion engine to hydrogen, knows full well the dramatic loss of power (relative to gasoline) due to the lower energy density of the hydrogen gas compared to gasoline. One way to overcome this problem is to install a turbo supercharger (driven from waste exhaust energy) or a supercharger (mechanically driven). Especially when the engine is quite small, a turbocharger is preferred over a supercharger due to the lower parasitic power demands. This is the approach used in the ECD conversion.

Dr. Stanford Ovshinsky,
the Founder, Chief Executive Officer, and
President of ECD,

Another problem that can develop when fueling with hydrogen is the increase in NOx (Nitrous Oxide). Nearly 75% of our air is composed of nitrogen gas and the remainder consists of oxygen and some trace elements. When this combination is compressed and heated, it converts to NOx, a contributor to smog formation.

Engine Specifications
4 cylinder inline, aluminum block and head, 1497 cc displacement (75 mm x 84.7mm)
13.5 : 1 mechanical compression ratio (9.5 : 1 effective Atkinson CR)
16 valves, hydraulic lash adjusters, dual overhead camshafts, variable intake cam timing
Port hydrogen injection @ 30 psi (Quantum injectors, one per cylinder)
Power and Torque: 70 BHP (50 kw) @ 4000 RPM, 96 lb-ft (130 Nm) @ 3200 RPM

Emissions (g/mi) and Fuel Economy (miles/kg-hydrogen)

Cold 75 CVS:		HC	CO	NOx	CO2	MPK-city	MPK-hwy
Tailpipe (with Prius catalyst)		0.001	0.001	0.018	3.2	42.3	46.1
Tailpipe (without catalyst)	0.032	0.041	0.013	2.5			
SULEV / PZEV standard	0.010	1.0	0.020	na			
Gasoline Baseline		0.010	0.386	0.004	222.8	42.4	45.0

Vehicle Performance	Hydrogen @ 3250# curb wt.	Gasoline @ 2800# curb wt.
0 - 60 MPH	17.3 seconds	14.1 seconds
30 - 50 MPH	6.6 seconds	5.8 seconds
Distance @ 5 seconds	120 feet	145 feet
Distance @ 10 seconds	385 feet	460 feet
Gradeability @ 55 MPH	11.2%	13.4%

The higher air-to-fuel ratios and higher temperatures generated in a lean burn hydrogen engine also make this a bigger problem than in a gasoline engine. Fortunately there are several methods of controlling NOx, from exhaust gas recirculation, to lowering temperatures by injecting water into the cylinders. ECD engineers used a different method that uses the cooling properties of high ratios of air to fuel quantities controlled by the turbo supercharger and fuel injectors.

The relativly low energy density of hydrogen (compared to gasoline or other fossil fuels) presents not only a problem of reduced horsepower, but requires innovative design of the storage tanks to achieve sufficient range and smaller size. Most of the prototype fuel cell and hydrogen fuel vehicles on the road today use high pressures to gain range and lower the volume of the storage tank. Pressures as high as 10,000 psi have been proved safe and reliable with even greater pressures planned in the future. Some auto manufacturers (such as BMW) have been developing liquid hydrogen fueling systems. Both of these approaches have some limitations. Creating the high pressures for filling gaseous tanks requires energy that can reduce overall well-to-wheel (point of production to final use) efficiency by as much as 10%, and increase the cost of the tanks. Liquefying the hydrogen not only requires an even greater parasitic energy loss, it also poses the problem of dealing with extremely low temperatures (-423° F., -253° C.). Even the best liquid hydrogen tank designs require a continuous bleed-off of gas to keep pressures in balance as the hydrogen warms up and turns to a gas.

ECD has been developing metal hydrides for many years. These metal hydrides can absorb hydrogen at relatively low pressures. This is the approach used in ECD's conversion of the Prius. However, there are some disadvantages in the use of hydrides relative to gaseous or liquid hydrogen. The hydrides are an alloy of powdered nickel, aluminum and other metals. These metals present a weight penalty. Also, a hydride requires a temperature management system. When filling a tank, hydrides create heat, and as they heat a point is reached at which the metal can no longer absorb the hydrogen. A heat exchanger is needed inside the tank to remove the heat and allow greater capacity. Some of this cooling requirement may be reduced if a slow fill is employed, as when filling directly from an electrolyzer. When the gas is released from the hydride, it cools off and this then requires the application of heat to insure full release of the gas. In addition, very clean gas is required to prevent poisoning of the hydride.

Fortunately, the heat requirement is easily satisfied in the ECD hydride design because temperatures as low as 160° F. (71° C.) can be used.
Both internal combustion engines and fuel cells generate enough heat to meet the requirement. In regard to the weight penalty, the ability of the hydride to absorb a given quantity of hydrogen at one-sixth the volume of an equivalent capacity at 5,000 psi is an advantage. In addition, the lower charge pressure of 1,500 psi (100 bar) helps decrease the tank's structural requirements. Even so, the hydride tank has a weight penalty of 150% compared to equivalent capacity in a 5,000 psi (350 bar) tank. Hydrogen derived from electrolysis (when properly dried) should pose little, if any, poisoning problem.

As it is presently configured, ECD's Prius has a capacity of 3 kg of hydrogen, or the equivalent energy of 3 gallons of gasoline, which allows a driving range of more than 130 miles. Further refinement of the alloys could contribute to longer range with the same tank volume and similar weight.

The 2002 Prius used in the ECD conversion originally came equipped with a nickel metal hydride (NiMh) battery bank of 276 volts. The new 2004 Prius uses a DC-DC converter to increase the battery pack voltage to more than 500 volts. This allows an increase in the kw (hp) capacity of the electric motor and helps decrease the number of individual cells. ECD engineers also have increased the voltage of the battery pack in their conversion and this has helped boost the torque and overall performance of the hybrid drive.

As someone who has driven the original gasoline Prius several times in both city and freeway traffic, I was impressed with the performance of ECD's conversion when I got a chance to drive it at the 2003 Michelin Challenge Bibendum at Sonoma, California. Except for a small additional increase in the sound level due to the addition of the turbo supercharger, the performance was equal to or better than the original.

Although it is unlikely that Toyota will offer a conversion of this type anytime soon, it is still exciting to see the near term possibilities of the advancement of the hydrogen economy through efforts such as those from ECD.

At a recent meeting of the California Hydrogen Business Council, a display was set up in the parking lot of Toyota's

facility at Torrance, California. A hydrogen electrolyzer from Stuart Energy of Canada was directly connected to an array of photovoltaic panels supplied by ECD's subsidiary, UniSolar. Everything, including a compressor and a backup fuel cell from Avista, was

installed on a trailer that supplied compressed hydrogen to Toyota's new FCHV Highlander Fuel Cell SUV, and to the ECD Prius.

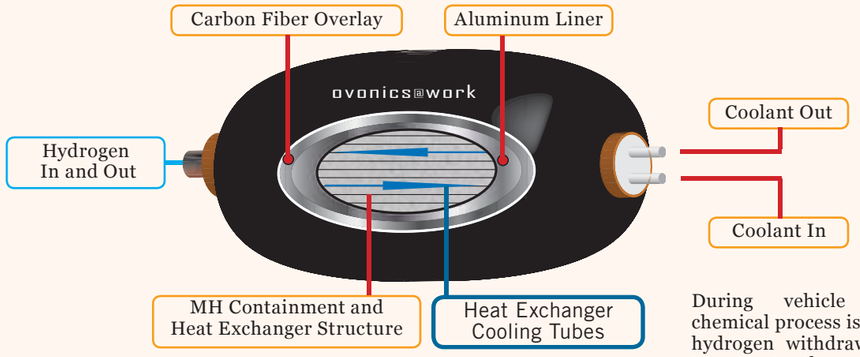
With increased demand from the car-buying public, and the hardware already available from these and other manufacturers, the road to the hydrogen economy could be shorter and less filled with potholes and bumps than some skeptics now proclaim.☼

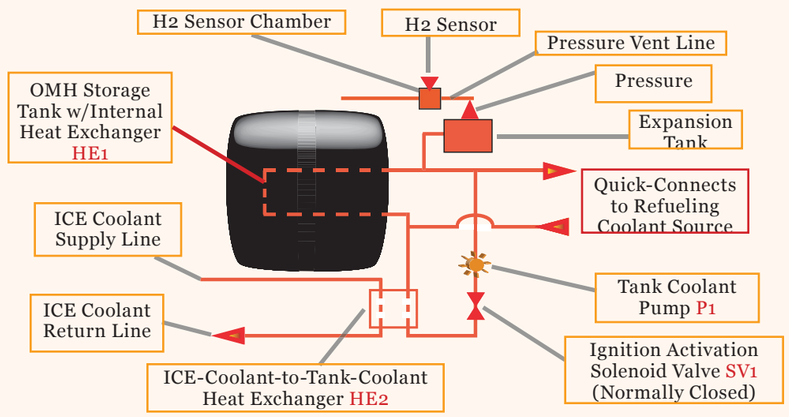
Energy Conversion Devices
2956 Waterview Drive
Rochester Hills, Michigan 48309
Tel.: 248-293-0440 Fax: 248-844-1214
Toll Free U.S.A. 1-800-528-0617

ECD's Toyota Prius

In the OVONIC Solid Hydrogen Storage system, atomic hydrogen is chemically bonded to a proprietary host metal alloy that is contained in powder form within the storage tank. When gaseous hydrogen is introduced to the tank, it is chemically absorbed by the host metal, which is transformed into a metal hydride (MH) during this process. This transformation reaction is exothermic, meaning that heat is released during the absorption process. The process is self-regulating. Unless process heat is removed, absorption of hydrogen will automatically stop.

To permit fast refueling, the OVONIC tank incorporates a proprietary integral heat exchanger (HE1) capable of quickly removing this process heat. The heat exchanger also serves as a containment structure for the host metal powder. Cooling is provided by a network of stainless steel tubes within the tank. Liquid coolant from an external source is circulated through the tubes during refueling to remove heat released by the absorption process.





During vehicle operation, the chemical process is reversed. Gaseous hydrogen withdrawn from the tank to operate the engine or fuel cell must be replenished with hydrogen desorbed from the MH powder. The desorption process is endothermic (absorbs heat), causing the MH temperature to drop. Unless makeup heat is provided, the MH powder will cool to a point at which hydrogen desorption will stop. The integral heat exchanger (HE1) delivers the heat required to sustain the desorption process. A small electric pump (P1) circulates tank coolant through an external heat exchanger (HE2) where it is warmed by waste heat from the engine or fuel cell. The warmed tank coolant then flows through the tubes within the OVONIC tank, delivering the heat required to sustain hydrogen desorption.

Unlike high-pressure storage systems that require fueling pressures of over 6000 psi, the OVONIC Solid Hydrogen Storage system is refueled at a pressure of only 1500 psi. Reduced fueling pressure enables savings in hydrogen compression costs, resulting in a lower delivered fuel cost.

Shortly after refueling, vehicle operation causes pressure in the OVONIC tank to drop from 1500 to about 250 psi, where it remains until the next refueling. Lower onboard storage pressure enhances vehicle safety.

The OVONIC Solid Hydrogen Storage system weighs about 150% more than a 5000 psi system with identical storage capacity. New alloys currently under development are expected to improve the weight ratio. However, in the same physical space, a current OVONIC tank will store almost three times as much hydrogen as a 5000 psi tank.

HYGEAR

RE / HYDROGEN PRODUCT REVIEW

1.5kw Fuel Cell Put it to work

The media often portrays the Hydrogen Economy and the fuel cell as being at best "pipe dreams," and at worst -- far off in some undefined future.

Now a California company is helping to bring the fuel cell a little closer to a near term commercial possibility. Anuvu (*that's a-new-view*) is a group of engineers and entrepreneurs working out of a small facility in Sacramento. Their goal is to bring the cost and complexity of fuel cells down and place them in a broader range of practical applications.

Rather than developing fuel cells of various voltages and power ranges, they have decided instead to concentrate on refining one smaller modular stack that can be assembled into as large or as small a power system as needed by the end user.

Much design effort has gone into reducing the overall size and weight of the stack and they have already met the DOE goals for mobile applications.

In addition, effort has gone into increasing cell life by developing a stronger membrane and increasing the cooling capacity to reduce membrane dehydration.

From the start, one of the designers' key goals was to insure that the stack was more easily manufactured with lower production and tooling costs than competitors' designs.

With a cost per watt of under $4 they are coming close to the costs for photovoltaics in spite of the fact that the cost for the balance of systems such as air compressors, humidification controls and power regulation may add another $2/watt.

The stacks are available as raw tested stacks or they can be ordered as complete plug and play assemblies meeting customer specifications.

Also, Anuvu at this time is using these stacks in converted Nissan Frontier pickup truck conversions that are the lowest cost fuel cell vehicles now commercially available.

You can contact them directly at Anuvu 3980 Research Drive Sacramento Cal. 9588 info@anuvu.com or contact www.fuelcellstore.com

TECHNICAL SPECIFICATIONS
Peak Power: 1.5 kW @ 10 V 2.0 hp @ 10 V
Typical Operating Point: 1.0 kW @ 12 V 1.3 hp @ 12 V
Output Voltage Range: 10 – 15 V
Dimensions: 18cm x 18cm x 12cm 7in x 7in x 4.75 in
Weight: 6.8 kg 15 lb
Operating Temperature : (at full power output) 600 C 1400 F
Hydrogen Purity: Minimum 99.5 % - Oil and Sulfur Free - Maximum 5 ppm CO *
Hydrogen Humidification: 70 - 100 %
Hydrogen Pressure **: 2.4 - 4.4 atm 20 - 50 psig
Air Purity: Oil Free and 0.1 µm Particle Filtered
Air Humidification: 70 - 100 %
Air Pressure **: 2.4 - 4.4 atm 20 - 50 psig
Coolant Water Purity: Triple Distilled Deionized
Min. Coolant Flow at Peak kW / Max. Inlet Temperature: 3.4 lpm / 48.5 o C 0.9 gpm / 119 o F
Coolant Water Pressure **: 2.4 - 4.4 atm 20 - 50 psig
Gas and Coolant Connections Hydrogen - 1/8 in. FPT; Air - 1/4 in. FPT; Coolant - 1/4 in. FPT
Recommended Wire Size: 000 Gauge at Peak Power / 4 Gauge at 1.0 kW
Acceptable Ambient Temperature Range: 30 – 490 C 380 – 1200 F

Power "for those on the go"

This next-generation solar device is the ultimate means of powering your equipment in the field. Even though the SolarRoll weighs just 17 ounces, it's capable of producing 14 Watts of power--enough juice to run a satellite phone, digital camera, and many other electronic appliances. It can also charge larger items like laptop computers or car batteries, and the SolarRoll quickly rolls up into an included tube for easy packing and storage. Simply stated, this is the item to bring along if you need ample, reliable power without extra weight or bulk.

- 12" x 57" / 17 oz.
- Max. Output = 14 Watts (15.1 volts at 900 mAh)
- Includes several adapter cables for different devices
- Only 3" in diameter when stored in the included tube
- Tefzel® floropolymer construction for extreme durability
- Waterproof
- UV transparent
- Link multiple units together for increased power
- Custom lengths with varying power output are available
- One-year warranty

Brunton
620 East Monroe Avenue
Riverton, WY 82501 USA
Phone: 307.856.6559
Fax: 307.856.1840
Orders: 800.443.4871

HYGEAR

RE / HYDROGEN PRODUCT REVIEW

SUNSLATES® are secured with stainless steel storm anchor hooks and anchored to 1x4 nailers resting on 2x2 sleepers. Each SUNSLATES® tile comes with a proprietary gas-tight connector that wires each tile to the adjacent tile. With a simple twist of a special screwdriver-like tool (provided), locks and secures the SUNSLATES® tile within its circuit.

Atlantis Energy

Phone Number: 916-438-2930
Email: jomo13@atlantisenergy.com 9275
Beatty Dr. Suite B
Sacramento, CA 95820

With SUNSLATES® solar electric roofing tiles, you get more than a roof over your head. A technologically advanced roofing solution dramatically reduces electricity demand. Atlantis Energy's stringent standards and insistence on using superior building materials, results in a product that will last for decades. Each SUNSLATES® tile begins as an Eternit roofing slate. These slates dominate the European roofing world. We then glue the low glare tempered glass power panel to the exposed surface. Because it is a roofing product, it is installed using onsite electrical or roofing subs. Ideal for both new construction or re-roofing, the complete SUNSLATES® system is delivered to the job site. No special trades are necessary. Once trained, the roofer and electrician can handle the installation themselves:

The typical size of an energy roof uses about 300 ft. square of SUNSLATES®. (17' x 17'). This size dimension requires one inverter. (Note) Each 100 sq feet of SUNSLATESâ installed is 750 pounds of roofing. This compares to 1100-1300 pounds per square for concrete tile and 300 pounds for composition shingles.

Cool New Glass That Heats

Nearly everyone has experienced that feeling of warmth and additional comfort when outside temperatures are low and they stand in a bright ray of sunshine. This warm feeling is caused by radiated energy. Most people also have experienced that cold, drafty feeling inside a warm building when they stand close to a window or large area of glass. This is because of the heat radiating from your body to the cold glass.

Now a company has developed a window that puts radiant energy to work, not only to eliminate that feeling of cold and drafts; but also to supply supplemental heating in a home or commercial building. IQGlas is the manufacturer with offices in the US and Europe.

In their design, two panes of glass enclose an insulating, non-toxic gas. The inner pane has a clear metallic oxide layer that, when supplied with electric current, radiates heat into the building while blocking radiant heat to the outside. A ten square foot (approximately one square meter) window could supply close to 800 BTU's of heating energy. Homes with radiant in-floor heating systems would especially benefit from the use of this type of window, because thermostats could be set many degrees lower without losing any level of heating comfort. This would automatically result in lower overall heating bills, even with the additional electricity for the windows. http://wwwiqglas.com
1024 N. Utah Street # 222 Arlington, VA 22201 U.S.A. Tel: +1 703 589 7771 Fax: +1 270 626 9217

TIDALFORCE

Powered by a 750-watt WaveCrest Adaptive Motor® system in its rear wheel hub, the M-750 is ideal for many different transportation and recreational uses. Riders can pedal without assistance for exercise, ride easily past congested traffic to run errands, and add as much power as they need to level hills and cover long distances. The M-750 is very reliable and durable, extremely comfortable and easy to operate, and incredibly fun to ride. With low noise, heat and no pollution, it's also good for the environment.

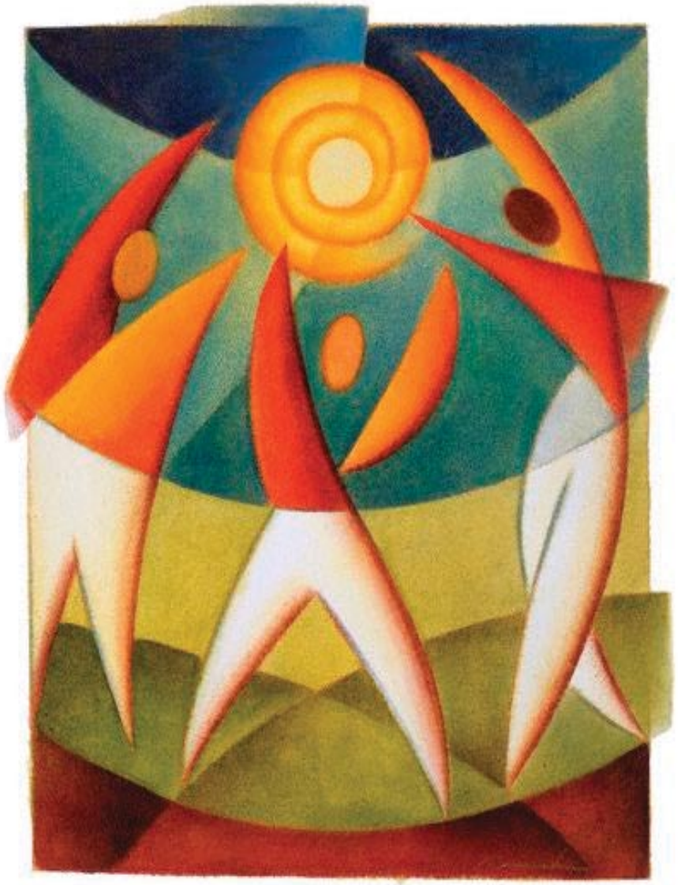
PERFORMANCE
- Maximum speed: 20 mph (32 km/h)
- Range : 20 miles (32 km)
- Weight (with front hub battery): 64 lbs (30 kg)
- Gross payload: 350 lbs (160 kg)

BATTERIES
- Front hub battery: 36V NiMH
- Charging time: 3-6 hours

MOTOR
- 750-watt WaveCrest Adaptive Motor system provides exceptional power.
- Unique WaveCrest DSP controller delivers high torque across all speeds.

BICYCLE
- Rider can add power with pedals or propel vehicle on human power alone using seven-speed gears.
- Strong, light aluminum frame.
- Comfortable, adjustable gel-padded seat.
- Double Crown Suspension Front Fork, 26" wheels, linear pull brakes.

MSRP: $2499
Contact : www.wavecrestlabs.com



Renewable Road to Hydrogen

When Jules Verne, in his wonderful book, *Mysterious Island*, first suggested that hydrogen or "fuel made from water" would be a replacement for coal and other popular fuels of his era, even his fertile imagination would have been hardpressed to imagine the many options we now have for using hydrogen and especially renewable sources of energy.

Just as the steam engines, sailing ships and whale oil lamps of his time evolved into the advanced technologies of today; the new hydrogen age will require changes in many of the things we now take for granted. Continued use of fossil fuels and the inefficient and wasteful habits its use fosters, must be set aside if we are to advance into the hydrogen era.

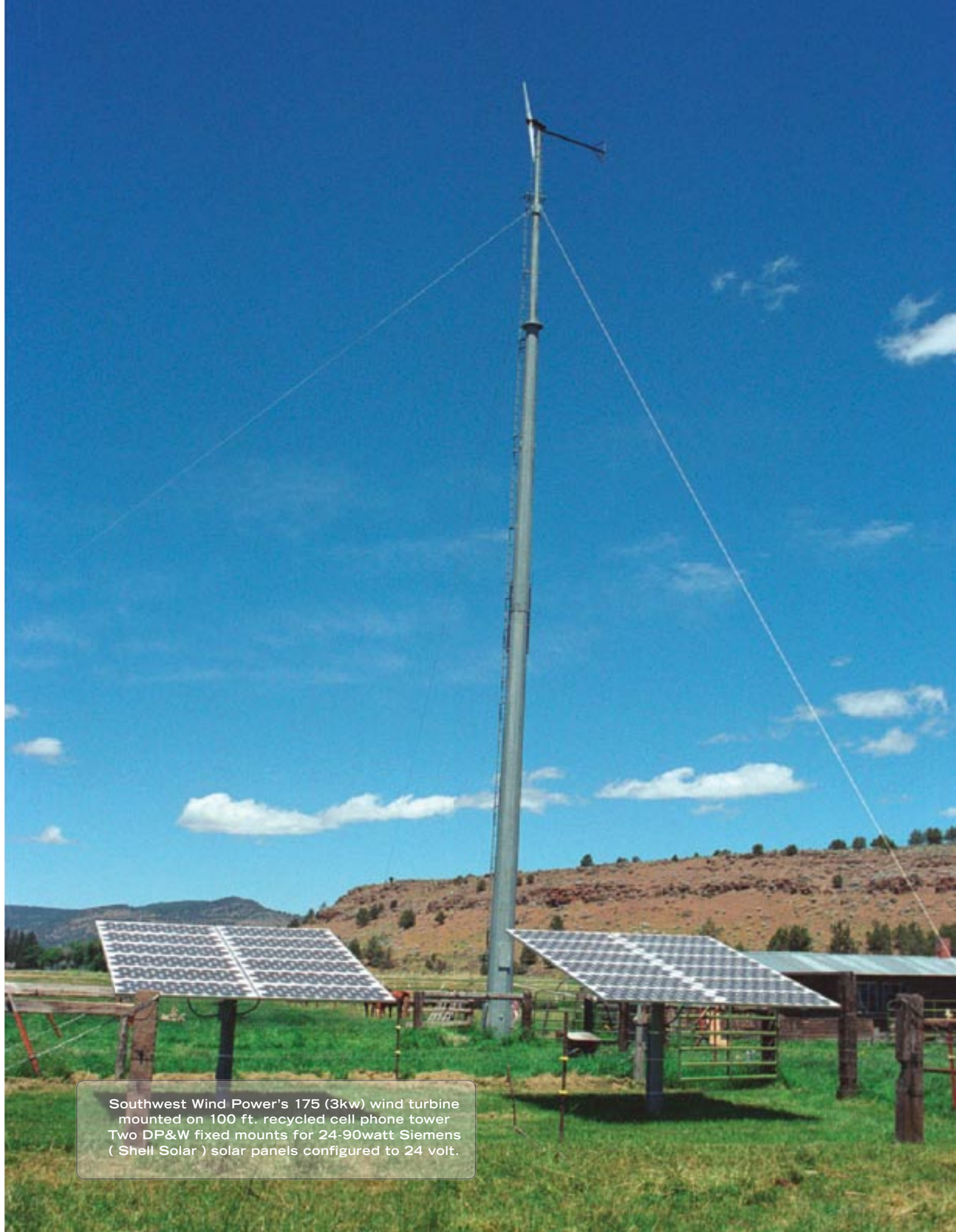
The purpose of this article is to illustrate some of the early steps modern day pioneers are taking to adapt renewable energy sources into their daily lives. In so doing, they reduce their living expenses and improve their homes' efficiency. There are actually three separate but similar systems detailed in this article. Each system uses one or more renewable energy sources such as wind, solar electric and solar thermal. Each may be transferred easily to hydrogen use as electrolyzers and/or fuel cells become available.

The Ames System

This first-described system is installed on a farm in Southern Oregon. Ron and Carrie Ames made the switch to renewable energy during the water crisis Klamath Basin farmers experienced when the Bureau of Reclamation turned off their irrigation water to help save fish habitats in the Klamath River. The Ames, at this point, felt that if their water could be turned off, perhaps their electricity and heating oil would be next.

Their system is a true hybrid because they have both a wind generator and a solar array delivering power to a common set of batteries and then to the grid. This is known as a grid tie with backup system. Under normal operating conditions the wind and solar are used to power both the home and farm. Any excess generation goes to the utility grid to offset their monthly bill. If at any time the grid were to fail, (and in their rural setting this happens quite often) the inverter automatically switches from the grid to producing power from the storage batteries.

Even though the Klamath Basin gets only average winds, the wind generator installed two years ago has been doing better than expected; due, in part, to the very tall tower chosen for mounting the turbine. A 100-foot, hot-dipped galvanized tower was purchased at a surplus yard for under $900. Originally designed as a cell phone tower it required no guy wires. With a large turbine installed on top, the wind loads required that a set of four guys be placed at the top of the tower and at the midpoint. The generator is a Model 175 from Southwest Windpower. It is a two-bladed turbine rated for 3200 watts at 27 mph (12m/s). In an average wind speed of 12 mph (5.2 ms) it can generate up to 500 kwh's/month. This power is generated as three-phase AC variable frequency and then converted to either 24 or 48 volt DC in the control panel. In this particular installation it is wired as 24 volts.



Southwest Wind Power's 175 (3kw) wind turbine mounted on 100 ft. recycled cell phone tower
Two DP&W fixed mounts for 24-90watt Siemens (Shell Solar) solar panels configured to 24 volt.

The generator is self-governing in high winds since the blades turn horizontally, similar to those of a helicopter. This helps slow the turbine and unloads the high wind pressures experienced in storms. In addition, since the turbine is a permanent magnet design, a switch in the powerhouse can be set to apply a braking action that keeps the blades from turning. Mr. Ames has enjoyed watching his turbine in 70 and 80 mile per hour wind gusts when winter storms come roaring out of the southwest. Although the turbine has done quite well in these storms, he still prefers to use the brake to shut it down overnight.

Installed just south of the turbine is an array of solar electric panels. Twenty-four panels are installed on two fixed mounts from DP&W. These mounts allow seasonal changes in elevation angles. Each panel is rated at 90 watts for a total of 2160 watts peak in full sun. They are manufactured by Siemens Solar (now Shell Solar) and are wired at 24 volts.

An underground conduit sends the power from the wind turbine and the solar panels to a powerhouse attached to the side of the Ames shop. The wind turbines' factory control panel controls the charge rate to the batteries. It does this by diverting power not needed by the loads or the batteries to a large heating element that serves the dual purpose of keeping the powerhouse heated in winter. In addition, a charge controller is wired to each solar array. These controllers from RV Power Products (now Blue Sky) not only regulate the power to the batteries, but they also electronically maximize the available current from the panels, especially when it is sunny and cool.

24 Siemens SR-90 panels mounted on DP&W Racks

The batteries used in this system are not large. Most of the time any excess power is sold back to the utility. It is only when the utility fails that the batteries are used, so they are only sized to provide power for two days.

Mr. Ames uses his shop quite often in the winter. He always dreamed of having a warm place to do his wood and gunsmith projects. When he decided to install his renewable energy system, he also decided to install the most efficient and effective heating system he could find.

He had heard many times from folks who visited Europe that hydronic (water or steam based) heating systems were used there almost exclusively, and in recent years a system known as radiant floor heating was being used. This is a system that employs coils of plastic tubing embedded in a concrete floor or attached to a wooden subfloor that circulates heated water, and thereby heats a room or building. This seemed like an ideal system to Mr. Ames, since he eventually wanted to add solar collectors to his shop for heating and he also could use the excess power from his wind turbine to heat some of this water.

A very small wall-mounted "instant hot water heater" using propane gas was installed in the powerhouse. This supplied enough hot water to heat his 800 square foot (79 m2) shop even on the coldest days. Anytime that the shop calls for heat, a small 18 watt 24 volt DC pump circulates water to the heater. This automatically lights the flame. As this water circulates, another smaller DC pump takes only enough of this hot water to keep the embedded floor coils at 110 degrees. This is a simple system that

Millers' 150 tube THERMOMAX solar heating system. They are mounted vertically on south wall to help eliminate summer over- heating

has worked flawlessly since being installed. There are times, Mr. Ames says, when he is lying on his back doing auto service work in the shop, that he actually prefers to do any conversing from this position because he loves the heat the floor supplies to his bad back. In the future, solar collectors will supply most of the hot water needed for this system.

The Miller System

This is another renewable energy system, installed in a different setting, that works just as well as the one on the Ames farm.

Joe Miller is a stockbroker and financial analyst. He knows quite well the value of money, return on investment and the cost benefit ratio. When he had his architect design a home for him, all went well until it came to deciding what sources he would use to heat, cool and supply electricity to his new home. Joe was looking toward his future as a retired person and wondering if he could afford ever-increasing utility bills.

Mr. Miller's home contains 5200 square feet, has three floors, a lot of open space, and large expanses of glass on the west side facing Klamath Lake. Heating this home with natural gas or oil would mean high fuel costs that would only continue to escalate. In addition, supplying the electrical energy required by common forced air heating systems would be costly. Mr. Miller felt that (based on his past experience) a forced air heating system would still leave his home cold and drafty.

Since Joe advises his clients to seek out expert advice when investing, he followed his own rule in regard to energy use. A local dealer/installer of renewable energy systems was contacted. After the installer looked at the builder's blueprints, he decided that the most cost effective and efficient method to heat the home while still providing superior comfort, was to use radiant floor heating coupled to an appropriately-sized solar collector and a backup, oil-fired boiler. The abundant sunshine of the Oregon High Desert climate also dictated that solar electricity was a perfect choice for supplying a more stable and cost-effective source of electricity.

Two 120 gal. storage tanks showing solar heat exchanger and injection loop for Warmboard heating system

When the general contractor for the project submitted the plans to the county for approval, a problem emerged. Because of a recent earthquake, the county had made changes in the code. Most common in-floor heating systems are installed by setting loops of flexible plastic tubing in concrete slabs or embedding them in a thin layer of gypcrete (a mixture of gypsum and concrete) placed over the existing subfloor. Unfortunately, this layer would add substantial weight to the floor and act as a potential destructive load in an earthquake, especially on the second and third floor levels. Approval of this system would cost many thousands of dollars for structural and engineering changes.

In addition, the general contractor was reluctant to deal with all of the mess and bother of spreading concrete throughout the house, and then having to deal with the costly delay of the drying and hardening process. Another issue to face was the overheating of a home when the heavy concrete slab was quite warm and it suddenly became sunny outside. There can be quite a lag between the time a home calls for heat and the time the floor actually gets warm enough to begin heating. Mr. Miller insisted on in-floor heating for its comfort and efficiency, and the solar designer also advised that adapting solar heating to a forced air system was neither practical nor cost effective.

At this point in the building process, the solar contractor discovered a commercial product known as "Warmboard" that not only allowed radiant floor heating without structural changes, but substituted as subfloor as well, and would deliver effective and well-distributed heating throughout all three floors of the Miller home.

Warmboard comes in the form of a 4 x 8 sheet of plywood, 1- 1/8 inches thick, structurally rated by UBC for use as a subfloor; and all of the grooves for insertion of plastic tubing (known as PEX or cross linked polyethylene) are already in place. What makes this product truly unique is the .025 inch sheet of aluminum bonded across the entire surface.

The use of an aluminum sheet in the Warmboard product insures an even transfer of heat across all surface areas of a floor. The low overall mass of the Warmboard sheet also allows very rapid warm-up when heat is required and a fairly rapid cool down when outside temperatures rise. The lack of thermal mass and the use of aluminum for heat transfer in the Warmboard system eliminates many of the problems encountered in less sophisticated systems such as poured-in slab or gypcrete.

The Warmboard product allows effective heating even when using the lower temperatures supplied by solar collectors in less than ideal weather conditions or when the tank storage temperature begins to drop when supplying heat at night.

As a side benefit in the unlikely event of tubing leaks, repairs can be made quite easily. Leaks in poured concrete can be a nightmare.

Over 75% of this home's yearly heating load is supplied by hot water generated in the collectors mounted on the south side of the garage wall. These are no ordinary collectors. They are known as evacuated tube collectors.

The collectors installed on the Miller home are made in the UK by Thermomax. Germany and England make great use of this less common type of collector because of its excellent performance during cloudy or cold weather.

The technology employed in these collectors is basic, but very effective. A long narrow sheet of aluminum, covered with a nonreflective coating, is bonded to a thin copper tube using a laser welder. The tube is partially filled with water, or in some cases water and methanol. A vacuum is created inside the tube as both ends are crimped and sealed. This assembly is placed inside a clear glass tube with a short section sticking out of the top. A vacuum is then pulled in the glass tube as both ends are sealed. A vacuum is a very effective insulator. As solar energy passes through the glass tube, it is absorbed by the collector and whatever remains cannot pass back out of the tube. This causes the fluid-filled tube to warm and this, in turn, causes the fluid to boil and turn to a vapor. As the vapor flows to the top of the tube, a larger copper tube attached at the upper end serves as a condenser where heat is released, the vapor returns to liquid form, and falls back down the tube to be reheated. This mechanism is known as a heat pipe.

The installation of Warmboard, in floor heating

The tubes are then inserted and clamped into a manifold where a mixture of water and nontoxic glycol flows around the condenser and carries off the heat. This heated mixture of water and nontoxic glycol are then pumped to a heat exchanger. Two 120 gallon insulated electric water heaters are used to store the heated water, which is then distributed to the floor as well as to hot water faucets. At any time that there is more heat demanded than supplied by the solar collectors, a small fuel oil boiler supplies additional hot water.

The primary difference between vacuum tube technology and the more common flat plate collector is the use of a vacuum for insulation rather than the less effective foam or bat type. This primary characteristic ensures that very little of the energy coming from the sun re-radiates or is conducted out through the frame or glass cover and helps provide far higher temperatures, utilize more diffuse and reflected energy, and allow excellent performance in very low ambient temperatures. Tests performed by a Canadian utility found that collector tube efficiencies as high as 95% were possible.

The solar electric system installed in the Miller home is similar to that installed in the Ames home. Twenty-four 100 watt photovoltaic panels supply 2400 watts peak to an inverter that converts the DC supplied by the panels to AC power that can be used in the home and delivered to the utility as excess power. Batteries are employed in this installation to supply backup power in case of a power outage.

Two 30 tube THERMOMAX evacuated tubes with manifolds

The Adler System

The Adler family of Ashland, Oregon, found their ideal piece of property on the side of a mountain. It was many miles and thousands of dollars away from a source of utility power. Jim Adler was determined that his wife, Vicky, and their two small children would live in a comfortable home without all the expense and hassle of hooking up to the utility grid.

Their home is very similar in total design to the Miller home, using the same state of the art Warmboard system coupled to about 500 square feet of evacuated tube solar collectors. The primary difference is the fact that they are not connected to a utility grid. All of their power is supplied using an array of solar electric panels.

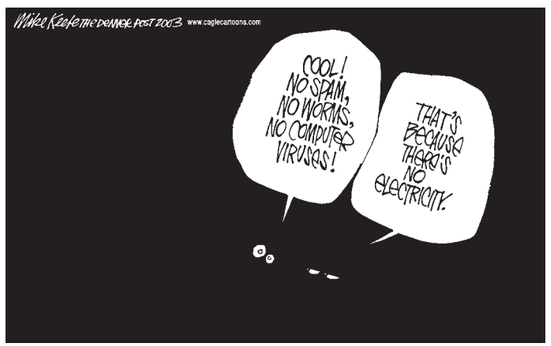
Located south of and just down-slope from the home are two DP&W panel mounts. One has ten 165 watt Sharp solar photovoltaics and the other has twelve for a total power output of 3630 watts. This power is delivered to the basement power panel at 48 volts DC. The DC power is then converted to AC at 110/220 volts using Outback inverters and power control equipment assembled and tested by Energy Outfitters of Grants Pass, Oregon. A total of 7200 watts of power is available at the main breaker panel. With water and space heating loads supplied by solar and a minimal amount of propane used as backup and for cooking needs, this amount of power is more than enough for all of the Adler's needs, which include a 220 volt AC deep well pump, all of the pumps and controls used to operate the heating system and hot water supply, a full time office in the heated basement, in addition to all other common loads such as refrigerator, lights and entertainment centers.

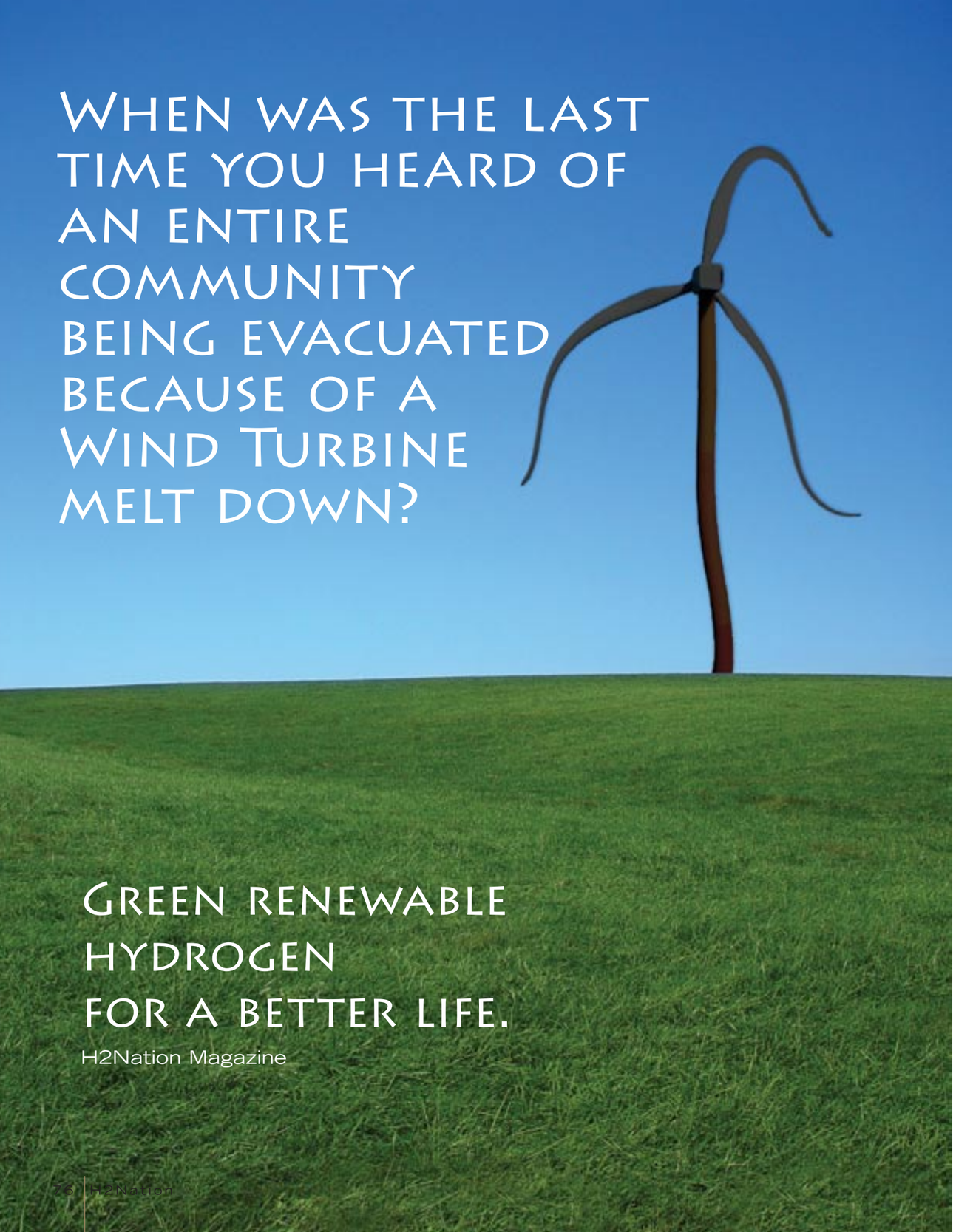
The energy demands from fossil fuels for the Adler home are a fraction of those used in the average home. Even with the addition of a propane generator for backup power, demands are still extremely low due to good, whole-house design and efficient appliances.

Mark has expressed his desire many times to purchase equipment that would allow him to utilize his excess summer power production in the winter when he needs it most. A good choice would be hydrogen fuel produced using an electrolyzer and water. He has confidence that industry will eventually supply this type of system so that he can completely remove himself from the fossil fuel treadmill. ☼

Company Contact Information

DP&W 4000-B Vasser Dr NE Albuquerque NM 87107
800-260-3792 Fax 505-889-3548 www.directpower.com
Thermomax 5560 Sterrett Place Suite 115 Columbia Maryland 21055
410-997-0778 Fax 410-997-0779 www.thermomax.com
Warmboard 800.338.5493 info@warmboard.com www.warmboard.com
Southwest WindPower 2131 N. First Street Flagstaff, Arizona 86004 USA
928.779.9463 fax 928.775.1485 www.windenergy.com





Is The World Still Flat?

by Patricia Boyer

We hear, "Do you folks really anticipate the general public use of hydrogen for fuel?"

"Why, yes we do! And much sooner than you think."

We, at H2Nation, believe that within ten years there will be available to the general public affordable vehicles running on hydrogen fuel and hydrogen fueling stations placed across the country. We believe that homes and places of business will be heated and cooled by renewable energy, wind, solar, and green hydrogen; and the only use we will have for oil will be for lubricating machinery. That's what we believe. And we believe the world will be a better, cleaner, healthier place because of the use of green hydrogen.

There are many naysayers in the world today shouting: "It will never work – and even if it does work it will cost more than we can pay – we can never do without oil – and if we do produce hydrogen, it will have to be with coal and nuclear power." We hear these voices of negativity and remember that there were once people who believed so strongly that the world was flat, that the sun and stars revolved around the earth and that the moon was a flat, smooth disc, that they refused to look through a telescope to see the truth, and were willing to burn scientists of the time at the stake. When Columbus sailed westward the same mindset believed he would fall off the edge into eternity, because the world was flat.

Even in this century there were those with the same mind-set who said, "What in the world makes those boys think that contraption of theirs will fly if they take it to Kitty Hawk? It'll never work. If we were meant to fly, we'd have been born with wings "

And in our time, I remember my husband saying, "I'm going to buy a KayPro. It is going to make it so easy to keep track of the cows and calves, and the tonnage of hay. You are going to love it."

"What in the world is a KayPro?" I asked incredulously.

And so he brought one home and I found out what a KayPro was. That was in 1982. We remembered then that it had not been too many years since a computer filling up a very large room did less work than this little KayPro now sitting three by three on our kitchen table. Within the next ten short years we would be introduced to the World Wide Web with interconnectedness and speed of information like we had never known.

And now, even though we sometimes feel that we are a voice crying from the wilderness, we at H2Nation believe that the time has come for all of us to accept the infinite gift of hydrogen that the universe has given us and move forward swiftly. We believe that the progression will not come by producing hydrogen with coal or nuclear power that will only produce more toxins and waste so enormous there will be no place left to store it; waste that will not dissolve for thousands of years. We believe that we must produce hydrogen by utilizing wind, solar and fuel cells. And we definitely believe that the world is not flat.

THE NEW VALUE FRONTIER

KYOCERA

KYOCERA Solar, Inc.

Wildlife. All life.

Every solar cell we put into circulation today helps reduce carbon dioxide emissions and perhaps the effects of global warming. Such issues never made the news when Kyocera began developing solar energy technology in 1975. Today, we are among the world leaders in multi-crystal silicon solar-cell production. our mission is to make the sun a practical energy source for people everywhere. And won't that make life a little better for everyone on the planet?

KYOCERA d.Blue Photovoltaic Module

Because ENERGY is essential and LIFE is precious

7812 E. Acoma Dr.
Scottsdale, AZ 85260
tel: 480.948.8003
fax: 480.483.6431
info@kyocerasolar.com
www.kyocerasolar.com