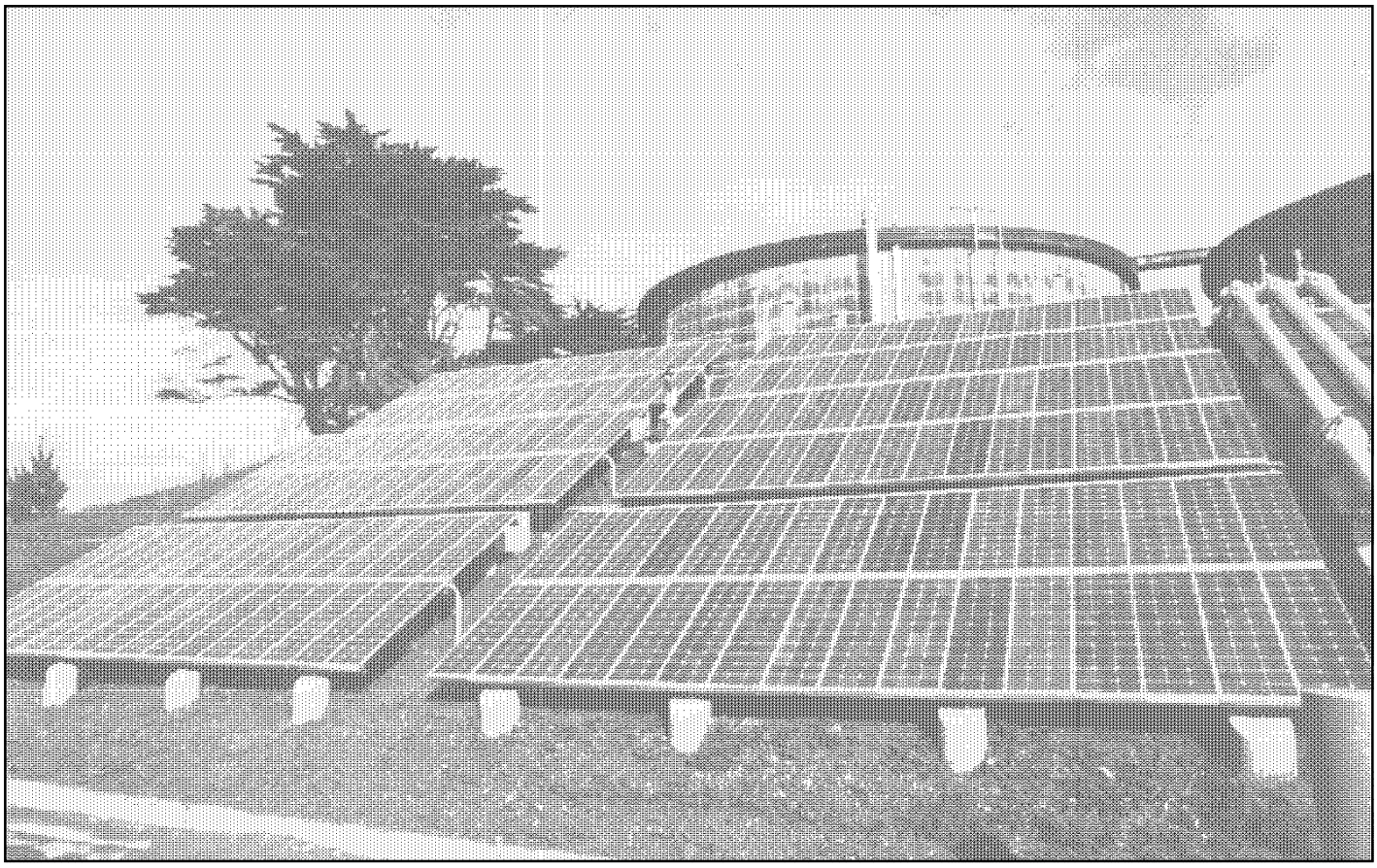


Above: 192 PV panels make electricity which is converted into hydrogen and then back to electricity by a fuel cell.

The Schatz PV Hydrogen Project

Richard Perez

Many of us dream of more efficient ways to store the power we make from renewable energy sources. Here's a system that uses sunlight to make hydrogen and oxygen gas. These stored gases are converted directly into electricity by a fuel cell. Sound futuristic and impossible? Well, it's happening at Humboldt State University in Arcata, California.

An opportunity we couldn't refuse…

I recently attended a conference on energy conservation at Humboldt State University. One of the conference's organizers, Michael Welch of the Redwood Alliance, suggested we visit an experimental PV/Hydrogen project at the school. It was an opportunity that we couldn't pass up. So, Bob-O Schultze and I saddled up and headed for the Humboldt Hydrogen.

The People

Renewable power systems are born because someone decides to build them. It is the interest and intelligence of the system's inventors/designers/users that makes it a reality. The hardware is secondary to the human desire to do it. We have technology coming out of our ears and we still fight wars over the oil that is slowly killing us. Renewable energy is worthless if we don't use it.

The PV/Hydrogen project is the work of Dr. Peter Lehman and the crew of the Environmental Resources Engineering Dept. at Humboldt State.

Bob-O and I were prepared for an ivory-tower tour focusing on the age encrusted ideas chiseled indelibly in stone. What we found was entirely alive, open, and growing. These folks' project is as real as a Physics book, but their feet are dangling over the edge of energy reality, just like those of every home power producer. We instantly found ourselves at home with folks that shared the same dreams, concepts, and fears that we have. It was enough to make me want to go back to college.

The Concept
Sunlight makes Hydrogen that makes Electricity.

The concept of the Schatz Solar Hydrogen Project is not very different from home power systems, with one exception. The power here is stored as hydrogen and oxygen gases rather than in a battery.

An 8,000 Watt photovoltaic array directly converts sunlight into electricity. The power of the array feeds an electrolyzer cell. The electrolyzer converts the array's power into hydrogen gas and oxygen gas by electrolysis of water. These gases are stored in tanks for use at night or on overcast days. The hydrogen and oxygen gases are fed into a fuel cell for direct conversion into DC electric power. The DC electricity, either from the array direct or from the fuel cell, is converted into 120 vac by an inverter. The load supplied by this system is the aeration compressor bubbling air into the Marine Lab's fish tanks. Talk about happy fish! They have an uninterruptible solar power supply to provide their air.

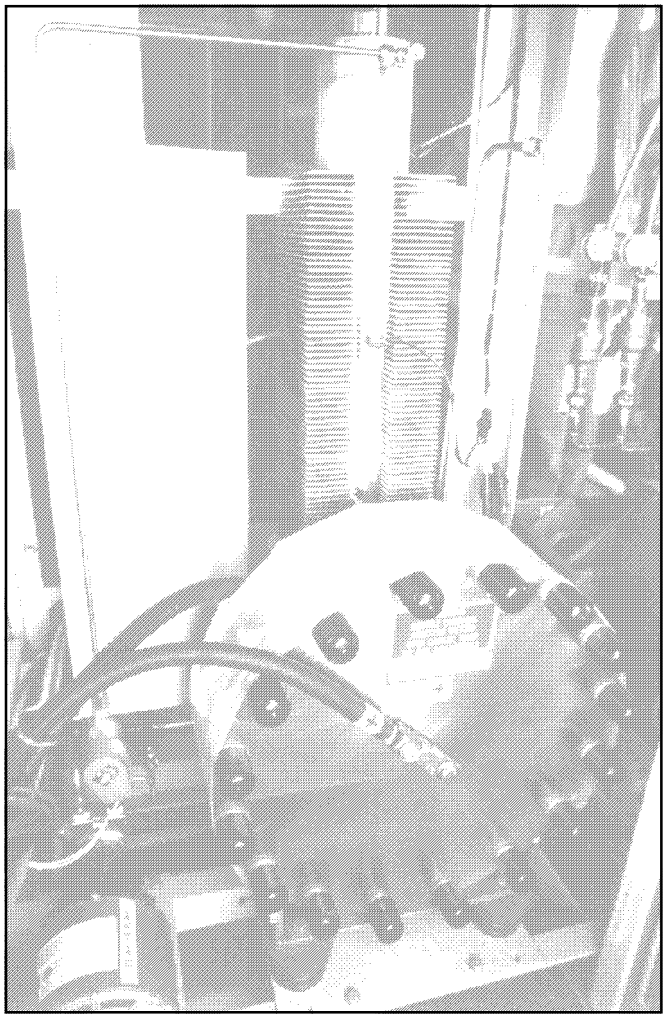
While the fish are happy, so are the folks working on this project. They are learning, hands-on, to apply hydrogen storage in a PV system. This learning experience is the real reason for the Schatz Solar Hydrogen Project. High-tech R&D projects and backwoods home power systems both learn about renewable energy the same way– by doing.

The PV Array
The photovoltaic array contains 192 ARCO M75 modules wired for 24 VDC use. The array is broken into sub-arrays that are each individually controlled. Each module in the array is grounded and wired with #10 gauge, USE insulated copper wire. The output of each sub-array connects to the main system by #2 wire. Each sub–array is isolated from the rest of the array by a 60 Ampere Schottky diode.

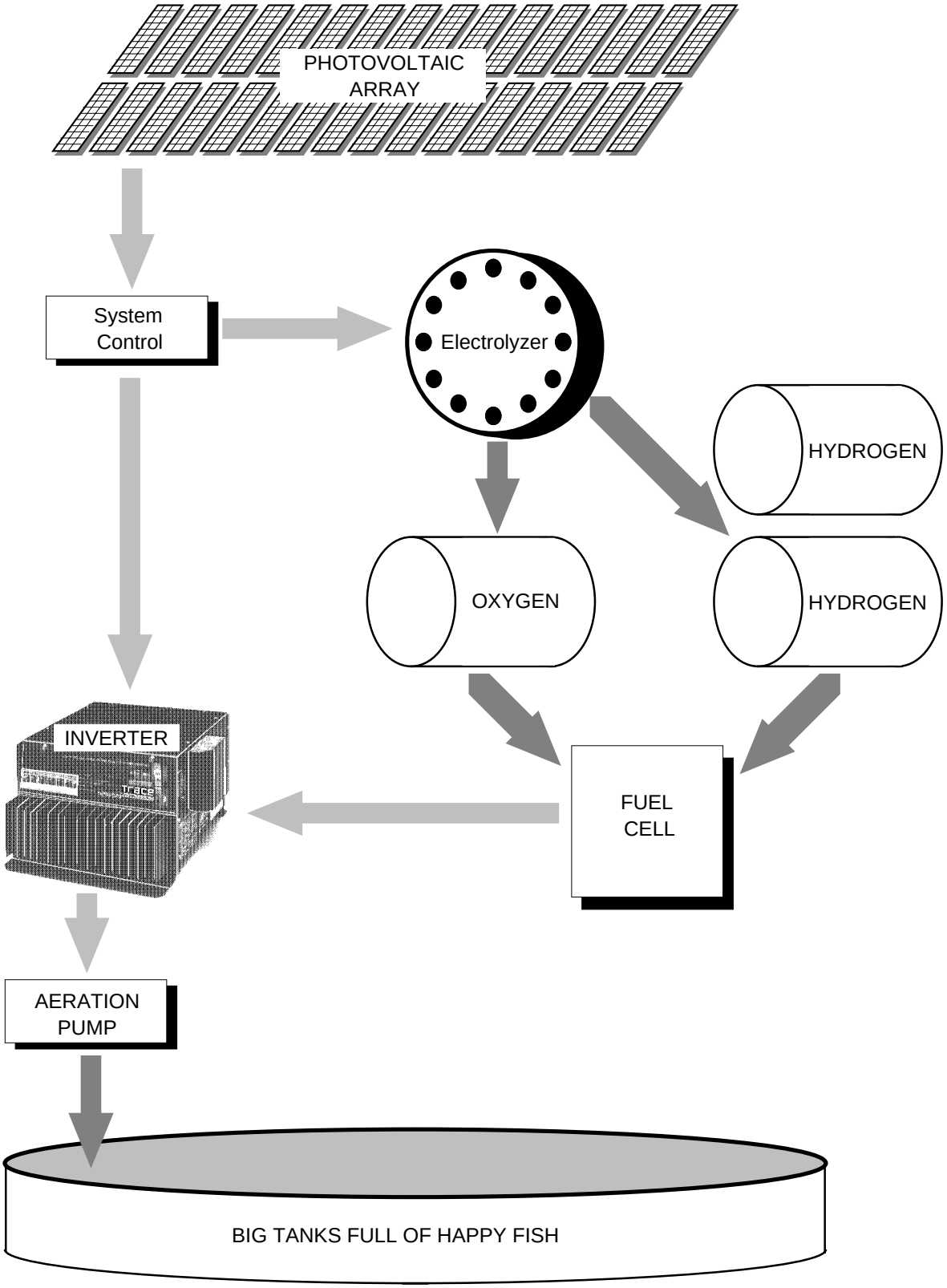
The Electrolyzer
The electrolyzer is a high pressure, bipolar, alkaline type. The electrolyzer contains 12 individual cells connected in series, each with a working voltage around 2 VDC. The electrolyzer cells use a 25% solution of potassium hydroxide (KOH) in water. The plates of the cells are made from stainless steel. This electrolyzer is made by Teledyne Energy for manufacturing processes that require pure hydrogen. It produces about 20 liters of hydrogen gas per minute and is between 75% and 80% efficient.

The gas output of the electrolyzer is metered by a mass flow calorimeter, a visual flow meter, and mechanical pressure gauges.

The oxygen gas is far from pure as it leaves the electrolyzer's cells. The oxygen output of the electrolyzer still contains small amounts of hydrogen gas and vast



Above: the Electrolyzer.

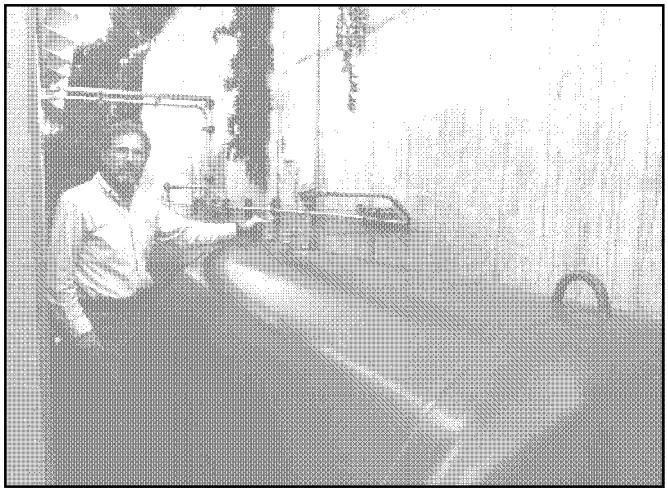

PHOTOVOLTAIC ARRAY
System Control
Electrolyzer
HYDROGEN
OXYGEN
HYDROGEN
INVERTER
FUEL CELL
AERATION PUMP
BIG TANKS FULL OF HAPPY FISH

amounts of water vapor. The oxygen gas is first run into a tube–in–tube condenser that turns the water vapor into a liquid that is removed. The dryer oxygen gas then passes into a catalytic scrubber that combines the minute amounts of remaining hydrogen gas with the oxygen gas and produces water. The water is drained off and then the whole process of condenser/catalytic scrubber is repeated. The net result is very pure, very dry oxygen gas that is stored in the tank.

The electrolyzer requires only minimal maintenance– the replenishment of its electrolyte about every six months of continuous operation.

The Storage System

Both the hydrogen and oxygen gases produced in the electrolyzer are stored for later use in the fuel cell. These gases are stored in three 500 gallon LPG tanks with a rated working pressure of 250 psi. Two red tanks hold the hydrogen and one green tank holds the pure oxygen. Working pressure in these tanks is 100 psi to 125 psi. These tanks use all the hydrogen accouterments of pressure relief valves, stainless steel piping and connectors, and thermocouples that act as "gas gauges" determining the amount of gas in the tank.



Above: Peter Lehman stands beside the oxygen storage tank. Behind him are two hydrogen tanks.

The Fuel Cell

The fuel cell reverses the process carried on in the electrolyzer and converts the stored hydrogen and oxygen gases back into water. This process also releases DC electricity at the same time. On the day we visited the Schatz project, the fuel cell had been returned to its manufacturer for testing. When installed in the system, the fuel cell will enable the stored gases to be directly and silently converted into electric power. The combination of the storage tanks and the fuel cell are roughly equivalent to the battery in a home power system. In contrast to batteries, fuel cells have no finite capacity. A fuel cell will produce power as long as it is fed hydrogen and oxygen. The storage capacity of the system is limited by the size of the hydrogen and oxygen tanks, not by the size of the fuel cell.

The outputs of the fuel cell are DC electricity and water. That's it. The entire system produces no polluting byproducts–no carbon dioxide, no sulfur dioxide, and no radioactive waste. The entire process is totally symmetrical. Water molecules are transformed into their elemental components of hydrogen and oxygen. The hydrogen and oxygen atoms are recombined into water molecules. The system's creators bank the solar energy in tanks and retrieve it when needed.

This particular fuel cell is made by Energenics of Ringwood, New Jersey. This fuel cell is a proton exchange membrane type that is capable of making effective use of the pure oxygen made by the electrolyzer. This fuel cell is an "instant–on" version that runs at lower temperatures (70°C.) than other versions (like the phosphoric acid version at 150°C. & the molten carbonate version at 800°C.). This Energenics version puts out 750 Watts continuously. The Energenics Company is working hand-in-hand with the Schatz project in research and development on retrieving energy stored in hydrogen.

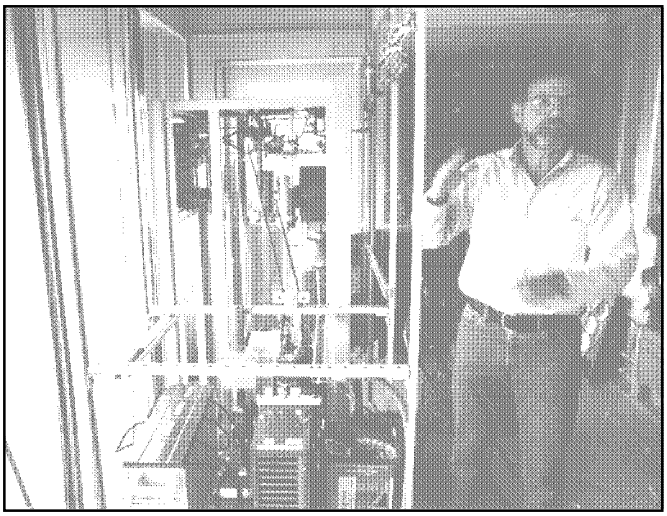
The Inverter

We expected to find a high-dollar, super inverter in such an advanced system. Instead, we found the same garden variety Trace Inverter used in thousands of home power households. A Trace 2032 Inverter hummed happily on the wall. It doesn't care if its DC power comes directly from the PV array during the day, or from the fuel cell at night. The Trace is very democratic, and very reliable; it keeps the fish alive & happy.

System Control and Instrumentation

The instrumentation and control on the Schatz project are extensive. After all, the major product here is information. The system is monitored by computers at every stage of the process. Seven optoisolated, analog to digital converter boards talk to the system's two Macintosh computers.

System control is accomplished by shorting out individual sub–arrays. This is accomplished by computers controlling 30 Ampere relays. A bank of NIFE Sunica nickel-cadmium cells is floated on the array to act as a



Above: Peter Lehman explains the system. The vacant space in the rack holds the fuel cell.

"flywheel" to prevent constant relay switching during power surges.

The System's Safety
A clear Lucite cage contains all hydrogen handling components. This cage vents outside and operates at less air pressure than the room in which it lives. Any hydrogen leaks are instantly detected by ultra sensitive hydrogen sniffers and the system is automatically shut down. All piping within the system is stainless steel. The electrical components are protected with every known fuse, breaker, and disconnect. The entire system will not only meet the NEC, but it will make the most paranoid electrical inspector feel safe. This PV/hydrogen installation is safer than your kitchen stove or hot water heater.

The Reasons Why
The first reason is to learn how to store PV produced power as hydrogen. The second reason is to learn how to retrieve this stored energy through a fuel cell. The Schatz project is research and development in the use of solar hydrogen.

The project is funded by Mr. L.W. Schatz, president of General Plastics Manufacturing Company of Tacoma, WA. My compliments to Mr. Schatz for looking far beyond the next quarter's profits and into an energy future we can all share.

Hydrogen Home Power?
Well, not yet. But, Peter Lehman and his compatriots are working on it. This system is far too costly and complex for basic home power right now. That's what Peter and the crew are working on. In the future, when we're using hydrogen for power storage, then it will be because folks like the Humboldt crew did their work right now.

Hopelessly Hi-Tech?
Not on your life. After a morning of sunshine hydrogen flowing through polished stainless steel, we visited another project at Humboldt State– the Campus Center for Appropriate Technology (CCAT). CCAT makes renewable energy real right now. The CCAT building uses PVs and wind for power (battery storage here), solar hot water, efficient appliances, a solar greenhouse providing space heat as well as fresh veggies, and even composting toilets. The CCAT building houses students in the Environmental Resources Engineering program and gives them the same hands-on experiences lived by home power producers. These students get to live on renewable power on a daily basis, learn about the systems involved, and create their own variations. They are an intense crew. I could see their commitment from the well–thumbed copies of Home Power on their bookshelves. The students at CCAT were not only learning new things, but are willing to share what they have learned. They have promised to write about their experiences in the next issue of Home Power.

Conclusion
Hydrogen storage is coming. The students and faculty at Humboldt State are joyously pushing the edge of the energy envelope. When I was in school the only things under discussion were building better bombs and nukes too cheap to meter. To find an established center of learning with a heart and an eye to our future gives me great hope. As I said, "It makes me want to go back to school."

Access
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