



# SERC ENERGY NEWS

## Humboldt County Clean Energy Futures

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### Features

Humboldt County Clean Energy Futures

Helping Frostburg State with Hydrogen Technology

The Schatz PV Array - Twenty Years and Counting

### In Every Issue

A Message From the Director

Project Updates

Looking Back

The quarterly newsletter of the Schatz Energy Research Center

**HUMBOLDT**  
STATE UNIVERSITY

The Humboldt County Renewable Energy Secure Community (RESCO) project gives all of us at SERC a welcome opportunity to focus our effort on the community where we live, work, and play. The goal of the RESCO project is to forge a strategic plan for Humboldt County to develop clean and renewable energy resources that meet at least 75% of our electricity needs and a significant fraction of our heating and transportation needs. Our main project partner is the Redwood Coast Energy Authority (RCEA). RCEA is focused on political and strategic issues; SERC is doing the technical and economic work.

California continues to be a national leader in addressing climate change; our goal of returning to 1990 greenhouse gas emission levels by 2020 (set in Assembly Bill 32) was recently upheld by the voters when we defeated Proposition 23. We hope the RESCO project can help Humboldt County be a model for clean energy development and that California can continue its role as a national trendsetter in addressing air pollution issues.

The main technical analysis tool we are using to explore clean energy futures in Humboldt County is a computer model developed at SERC that integrates energy supply and demand. It uses an optimization algorithm called "Differential Evolution" to find a suitable portfolio of energy generation and conservation technologies given a set of priorities and constraints that we provide. For instance, we can use the model to answer questions like "What is the energy portfolio with the lowest carbon emissions if we want to hold overall energy costs at current-day levels?" We completed the model in December 2010 and have put it through its paces in the first round of validation runs. Once we make a few improvements it will be ready to be used as a tool to help guide the discussion we've started with our community stakeholder group on energy development in the county. The stakeholder group had their first meeting December 4, 2010 and will continue working to frame a strategic energy plan throughout 2011.

We knew all along that Humboldt County has bountiful renewable energy resources but through the lens of our RESCO model, we have developed a deeper appreciation for how these resources might fit together both with each other and with demand side technology.



RESCO Project Manager Jim Zoellick stands next to a 10 MW Natural Gas generator, one of sixteen that were recently installed by PG&E to replace the aging power plant at King Salmon south of Eureka. The generators will be a good match to intermittent renewable energy like wind and wave power.

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## A Message from the Director Peter Lehman

As I wrote in this column last time, the November election in California was crucial to our progress to address climate change. Whatever else resulted from that election, one thing was clear - Californians are solidly behind their state's efforts to limit our effect on climate. Voters soundly defeated Proposition 23, which would have undermined the Global Warming Solutions Act, California's landmark bill to tackle the difficult climate change issues facing us.



The California Air Resources Board lost no time. It recently approved a cap and trade program to limit our emissions of greenhouse gases. Though many details are still to be worked out, this is the first effort in the U.S. to set a meaningful price on emitting carbon and start us on the path to repairing our atmosphere. Once again, I'm proud to be a Californian.

At the Schatz lab, we've made significant progress in our efforts locally in Humboldt County to decrease our reliance on fossil fuels and switch to renewables. As Peter Alstone reports, our RESCO project is humming along, providing us with interesting energy modeling results. Richard Engel describes the new developments in our hydrogen education project, including our first video productions. Co-director Charles Chamberlin writes about our continued testing of the Trinidad photovoltaic array and our new plan to test SolarMagic™, a device to limit mismatch loss in solar arrays. We now have 20 years of detailed performance data, one of the most careful and complete PV data sets in the world. And Andrea Alstone reports about our collaboration with Frostburg State University in Maryland to build their own solar hydrogen system.

As I write this, the boxes are piling up at our old lab as we prepare for our big move into our wonderful new lab and office building. In our next issue (I promise this time!), we'll have pictures of us working happily in our new digs.

Best wishes to all our readers for a healthy and happy new year.

## Helping Frostburg State with Hydrogen Technology Andrea Alstone

SERC has recently begun working with Frostburg State University (FSU) and Instant Access Networks to design and build an off-grid hydrogen storage and power system. FSU, located in Western Maryland in the city of Frostburg, is looking to create a backup power system for important equipment in the case of a long-term power outage caused by natural or manmade disasters. They plan to generate hydrogen via electrolysis and renewable energy and store it on site; a fuel cell will provide power when needed. The system will be housed at FSU's Sustainable Energy Research Facility, an off-grid and renewable energy powered building currently under construction.

Currently SERC research engineer Andrea Alstone and graduate research assistant Meg Harper are looking into commercially available hydrogen storage technologies to determine the least cost option. The type of storage chosen will help determine what other kinds of equipment are necessary, such as a compressor. Once the final storage option is chosen, SERC will complete the design of the hydrogen power system. We expect to finish our work by July 2011.

### Clean Energy Futures *(continued from page 1)*

Biomass power generation is a recurrent key player in the RESCO model runs we've completed so far. Biomass power already accounts for 33% of the locally generated electricity in Humboldt County. It comes from three plants that total about 60 megawatts (MW) and counts as a renewable electricity source towards California's greenhouse gas reduction targets. Unlike many renewable energy sources, biomass power plants provide stable, base load power by burning wood waste to turn a conventional generator, and they can be ramped up or down to meet our variable demand for electricity. There is ongoing debate about what level of biomass power generation is sustainable and carbon neutral, and the best estimate we've found so far is that Humboldt County could develop up to 250 MW of capacity. As we move forward with the stakeholder engagement process we hope to have a productive dialogue about the future of biomass power in Humboldt County.

Nearly 60% of our current-day, energy related greenhouse gas emissions result from our use of gasoline and diesel fuel for transportation. Every year we burn over sixty million gallons of gasoline and diesel fuel in Humboldt County to run our cars and trucks and all of it has to be barged into the county. We found that electrification of our vehicles complements renewable energy development and is key to reducing greenhouse gas pollution in the county. As we bring renewable power online we expect periods when there is a surplus of clean electricity available - particularly from wind and wave power, which are intermittent by nature. Because our ability to export renewable energy out of the county is limited, building smart, responsive loads like electric vehicles can help to keep our renewable generators humming

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# The Schatz PV Array - Twenty Years and Counting

Charles Chamberlin

Twenty years ago Jim Zoellick measured the performance of every one of the 192 photovoltaic modules just before they were installed in the Schatz Solar Hydrogen Project array. Nine years ago Antonio Reis and Nate Coleman retested every module after it had been in service for eleven years. This year Mark Rocheleau, Marc Marshall, and Scott Rommel tested every module for the third time after twenty years of service.

These painstaking measurements provide a unique opportunity to track the degradation of the performance of individual modules over twenty years of service in the cool, coastal, marine environment 150 meters from the Pacific Ocean at HSU's Telonicher Marine Laboratory in Trinidad, CA.

In 1990 when the modules were brand new, right out of the box, Jim determined the current versus voltage (I-V) curves, the maximum power output, and other performance parameters for each of these ARCO M75 modules. Even then the average peak power under full solar illumination at normal operating cell temperature was 39.88 W, 14.1% below the 46.4 W nameplate rating; the power ranged from 37.79 W to 42.61 W.

Eleven years later in 2001, Antonio and Nate found that the average peak power had fallen by 4.3% to 38.13 W and ranged from 31.4 W to 41.55 W. They attributed the drop in performance to the visually observable physical defects in the modules. The modules' ethylene vinyl acetate encapsulant had delaminated, leading both to corrosion of the cells and to the occurrence of localized hot spots.

These degradation processes continued and appear to have accelerated over the intervening nine years. When Mark, Marc, and Scott retested every module again this year, the average peak power had declined from the 2001 levels by an additional 12.4% to 33.43 W and ranged from 9.64 W to 37.95 W. Not only is the average peak power steadily falling, but the variation among the modules is also dramatically increasing. The impact of increased variation is to accentuate the mismatch among the modules, which in turn reduces the peak power output of the array as a whole.

Though the mismatch among our modules diminishes the array power, it caught the attention of National Semiconductor. National has developed a product they call SolarMagic™ power optimizer, a technology specifically designed to reduce power loss in mismatched photovoltaic arrays. Chris Goeltner of National contacted SERC and said our array is just what National is looking for to test their product. After some discussion National decided to fund a project and next month, we will begin modifying the array in preparation for the installation of SolarMagic in half of the array. We will then compare the performance of the unmodified half to the half outfitted with SolarMagic. The testing will continue for about one year; we'll let you know how things are going in future newsletters.

## Project Updates

H<sub>2</sub> Education Project Goes Public Richard Engel

Our Hydrogen Energy in Engineering Education (H<sub>2</sub>E<sup>3</sup>) project continues to grow as it enters its third year. This semester we brought hydrogen-related curriculum to five engineering and environmental science courses at Humboldt State, including new activities for a probability and statistics class, an upper-division renewable energy course, and a new thermodynamics class for non-engineering students.

As we reach out to other campuses interested in using our curriculum, one message we have heard is that faculty would like extra help in learning to use the lab hardware. Given the cost of visiting distant campuses in person to provide training and support, we instead got creative and made a series of instructional videos aimed at faculty and engineering lab technicians. The videos provide an orientation and detailed guidance for new users of our benchtop fuel cell/electrolyzer kits and fuel cell test stations.

We have also been developing our project website to provide curriculum content and links to the instructional videos. Please have a look at our work in progress at [www.hydrogencurriculum.org](http://www.hydrogencurriculum.org) and let us know what you think.



Top: SERC outreach coordinator Allison Oakland and HSU engineering lab instructor Annie Yaberry shoot an instructional video. Bottom: Still from an instructional video.



while reducing our consumption of conventional fuels.

In our initial model runs we found that for about the same costs we pay today, we could cut our countywide energy-related greenhouse gas emissions in half. We are working with PG&E to understand how the local electric grid would respond to the additional stress and with RCEA and the stakeholder group to identify community priorities and preferences concerning changes in our energy sector.

In 2011, we will finish our modeling work, create a strategic plan, and submit our final project report to the California Energy Commission. As we continue our RESCO work, California and the world are moving forward to reduce greenhouse gas emissions and to address global climate change. We are poised in Humboldt County to not only do our part but also become a model community for encouraging clean energy development.



Wind turbines like these may soon be atop Bear River Ridge south of Ferndale. Shell Wind is currently planning a 50 MW project there.

Photo courtesy of Sam Camp.

SERC Energy News is published quarterly by the Schatz Energy Research Center at Humboldt State University.

The mission of SERC is to promote the use of clean and renewable energy in our society. SERC meets its mission by performing research and developing new technology; designing, building, operating, and demonstrating clean and renewable energy systems; providing training for professionals; and educating the public about a sustainable energy future. SERC's affiliation with the Environmental Resources Engineering program at HSU provides a rare opportunity for undergraduate and graduate engineering students to acquire hands-on experience with cutting-edge energy technologies.

SERC is a member of the Fuel Cell and Hydrogen Energy Association, the International Association for Hydrogen Energy, the International Solar Energy Society, and the American Solar Energy Society.

SERC co-directors are Peter Lehman, Charles Chamberlin, and Arne Jacobson. Faculty Research Associates are Eileen Cashman and Steven Hackett. Research and administrative staff include

## Looking Back

**11 years ago...**we received our first patent for "Proton Exchange Membrane Fuel Cell" technology. In a nutshell, this patent provides a fuel cell that maximizes the net power from the fuel cell system. Our method to do this includes reducing the overall pressure of the fuel cell system to minimize parasitic losses while still maintaining adequate airflow through the flow channels to remove water, and minimizing the pressure drop across a fuel cell and through the fuel cell stack to reduce the parasitic losses.

Our second patent, "Humidification of a PEM Fuel Cell by Air-Air Moisture Exchange," was received in 2002. This patent prevents fuel cell components that require humidification from becoming dehydrated and inoperable. Currently, we license our technology to two leading fuel cell companies. For more information about our intellectual property visit [www.schatzlab.org/about/capabilities/ip.html](http://www.schatzlab.org/about/capabilities/ip.html).

US005879826A

**United States Patent** [19] [111] **Patent Number:** **5,879,826**  
**Lehman et al.** [45] **Date of Patent:** **Mar. 9, 1999**

[54] **PROTON EXCHANGE MEMBRANE FUEL CELL** 4,364,805 12/1982 Rogers ..... 429/13 X  
 5,470,671 11/1995 Fletcher et al. .... 429/34 X  
 5,589,285 12/1996 Cable et al. .... 429/13

[75] **Inventors:** Peter A. Lehman; Charles E. Chamberlin, both of Arcata; Ronald M. Reid, McKinleyville; Thomas G. Herron, Eureka, all of Calif.

[73] **Assignee:** Humboldt State University Foundation

[21] **Appl. No.:** 669,861  
 [22] **Filed:** Jun. 24, 1996

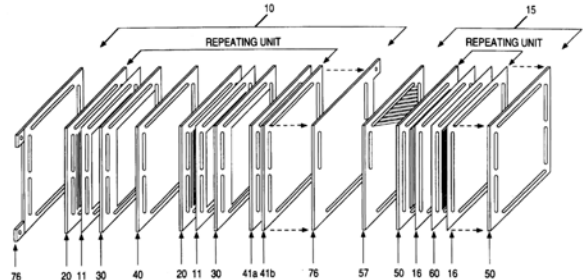
**Related U.S. Application Data**

[60] Provisional application No. 60000,798 Jul. 5, 1995.  
 [51] **Int. Cl. 5** ..... H01M 8/04  
 [52] **U.S. Cl.** ..... 429/13; 429/34  
 [58] **Field of Search** ..... 429/13, 34, 25

[56] **References Cited**  
 U.S. PATENT DOCUMENTS  
 3,770,508 11/1973 Sandler ..... 429/13

[57] **ABSTRACT**  
 A polymer electrolyte membrane fuel cell using hydrogen as the fuel and oxygen containing air as the oxidant. The fuel cell including a hydrogen side electrode; an air side electrode; an electrolyte positioned between the electrodes; a hydrogen diffuser/collector plate including hydrogen channels; and an air diffuser/collector plate including air channels. A method of operation of the fuel cell including introducing hydrogen into the hydrogen channels and introducing air into the air channels at a pressure of less than 5 psig and with a channel velocity of between about 0.15 and 7.0 meters/second.

**12 Claims, 11 Drawing Sheets**



Andrea Alstone, Peter Alstone, Nir Berezovsky, Christopher Carlsen, Greg Chapman, Richard Engel, Ruben Garcia, Meg Harper, Patricia Lai, Marc Marshall, Brendon Mendonca, Tirian Mink, Allison Oakland, Tom Quetchenbach, Mark Rocheleau, Lucas Scheidler, Charlie Sharpsteen, Colin Sheppard, Alina Taalman, and Jim Zoellick.

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