



SERC

ENERGY NEWS

Summer 2011
Volume 6, Number 2

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The quarterly newsletter of the
Schatz Energy Research Center

HUMBOLDT
STATE UNIVERSITY

HSU Students Install GridShare Devices in Bhutan *Meg Harper*

For over two years, a dedicated group of HSU students and advisors has been working on the design of a "GridShare" device intended to reduce the occurrence of brownouts on power-limited mini-electric grids. Last year, after winning a grant through the EPA's People, Prosperity and the Planet (P3) Student Design Contest, three of us traveled to Bhutan to assess the village of Rukubji as a site to perform a pilot installation of our GridShares (see the [summer 2010](#) issue of our newsletter). After receiving enthusiastic support from the Bhutan Power Corporation, the Department of Energy of Bhutan, and the residents of Rukubji, the GridShare team (Nathan Chase, Chhimi Dorji, James Robinson, Tom Quetchenbach, Kirstin Mielke and I; SERC alum Rick Mayberry; and SERC advisors, Kyle Palmer, Arne Jacobson, Peter Lehman and Eileen Cashman) worked to refine the design of our GridShares and arrange the logistics for the installation.

Following two years of design work requiring multiple prototypes, the last few months yielded a frenzy of GridShare assembly, testing, and shipping. Sponsorships from local and regional businesses helped to reduce the cost of manufacture, while many volunteers helped the team finish the assembly and testing of each GridShare to ensure its success in the field. To accompany the GridShare installation, we've also created a series of colorful bilingual posters and pamphlets to help the residents of Rukubji learn how to interact with the GridShare and better manage their limited electric system.

We hope to see all of these preparations pay off in the next few weeks as we are thrilled to have just arrived safely in Bhutan, along with all of our luggage and 14 large boxes filled with 120 GridShares and equipment. We will begin installing the GridShares by the end of June. Stay tuned for our fall newsletter where we will describe our experience in Bhutan and the Rukubji residents' reactions to the GridShares.

Breaking news: Meg just emailed from Bhutan to say that aside from one house where the owner is away and one in which they are still working out some complications with some internal re-wiring,

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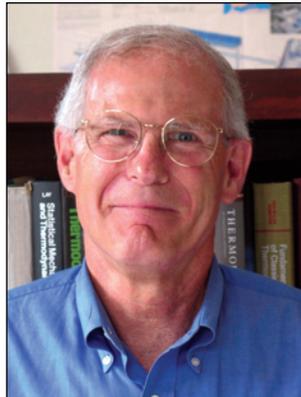


Top: Chhimi Dorji (left), Nathan Chase, and Meg Harper present GridShare education and outreach to Rukubji schoolchildren.

Bottom: Meg installs a GridShare device in Rukubji. *Photo credit Arne Jacobson.*

A Message from the Director Peter Lehman

I just returned from the Photovoltaic Specialists' Conference in Seattle; it was the 50th year anniversary of the conference. The first PVSC that I attended was in 1987 when Charles Chamberlin and I reported on PV module tests in Humboldt County.



What a difference! The conference is now huge, with thousands of attendees, and the PV industry is mature and sophisticated. Total worldwide installations of PVs have now reached 40 GW and as one speaker reported, if PV growth stays on the historical path that it has maintained for the last 30 years, total installed PVs will reach 1000 GW by 2020. At that level, PVs will contribute about 10-15% of the world's total electricity generation. That's amazing and heartening progress.

This time we reported on the 20-year performance of the PV array at the Schatz Solar Hydrogen Project at our marine lab in Trinidad. In 1990, Jim Zoellick measured the performance of each of our 192 modules for his senior project. In 2001, Nate Coleman and Antonio Reis remeasured them and reported the results at the 2002 PVSC. Last year, Mark Rocheleau and Marc Marshall repeated the measurements again so we now have a careful 20-year record. Our results, analyzed by Charles, were received enthusiastically. One attendee from PV manufacturer First Solar emailed me that our report was "very detailed, thorough and information/data packed." He went on to say, "I am working on PV cell/module long term reliability/degradation issues. That is why your talk was so interesting to me." It's rewarding to have gathered information so useful to the industry.

In this issue, Meg Harper reports on the great success that our student team is having installing GridShares in Rukubji, Bhutan. It's been a long road to this point with lots of red tape and engineering design work—kudos to the team for a job well done. Richard Engel reports on continuing success of our H₂E³ hydrogen fuel cell curriculum and on grad student Nick Riedel's work in El Salvador. Peter Alstone describes recent work on the Lighting Africa project; SERC is an essential player in this World Bank effort to replace fuel-based lighting in Africa. And Andrea Alstone reports on a project just starting to upgrade our hydrogen fueling station to 700 bar capability.

After an exceedingly rainy spring, summer has finally arrived on the North Coast. Best wishes to all for a sunny and relaxing summer.

HSU Grad Student Builds on SERC's Work in El Salvador

HSU engineering graduate student Nicholas Riedel is spending the summer in El Salvador, studying how energy is used on a university campus. Nicholas is conducting a broad-scale campus energy audit at Universidad Don Bosco and intends to compare and contrast energy efficiency opportunities in this tropical setting in a developing country with lessons previously learned about energy management at HSU. Mentoring for Nicholas's efforts comes from SERC senior research engineer Richard Engel, who served as a Fulbright scholar at UDB in 2010. Nicholas's visit to UDB is the first inter-campus exchange under an HSU-UDB cooperation agreement that grew out of Richard's stay at UDB.

Richard and Nicholas kicked off this year's project by traveling together to UDB, where they gave a day-long workshop on institutional energy auditing and energy efficiency. Twenty-one Salvadoran energy professionals participated in the workshop. Nicholas gave a hands-on tutorial on computer modeling of energy use in buildings, while Richard led a demonstration of energy auditing tools that have recently been acquired by UDB as part of a U.S. State Department-funded "Science Corner."

Nicholas will spend the remainder of the summer collecting and analyzing data on buildings at UDB and modeling the costs and savings associated with different energy efficiency options. He has found a number of UDB faculty and students eager to collaborate with him on his energy-saving work. UDB is contributing to the project by providing housing and meals for Nicholas and release time for faculty who are working with him.



He's still at it. Director Peter Lehman and guide Pete Keane on the summit of Mt. Hood.

Hydrogen Fueling Station to Receive Upgrade

Andrea Alstone

SERC has recently received a Caltrans grant to increase the delivery pressure capacity of the HSU hydrogen fueling station. Currently the station stores hydrogen gas at 420 bar (6,000 pounds per square inch), and can fill a vehicle's tank to 350 bar (5,000 psi). The upgrade will allow for fueling up to 700 bar (10,000 psi). Newer fuel cell vehicles, such as the Toyota FCHV-adv currently on loan at HSU from UC Berkeley, have storage tanks rated for 700 bar storage, which almost doubles the amount of hydrogen that can be stored onboard.

To get to hydrogen gas at 700 bar, an additional compressor will take hydrogen gas from storage at 420 bar and compress it directly into the vehicle's tank to 700 bar. This so called "slow-fill" method will eliminate the need for expensive new storage vessels. There will also be a dedicated 700 bar dispenser located inside HSU's Plant Operations corporation yard. Operation of the current 350 bar dispenser will remain unchanged. The high-pressure fill will increase the Toyota Highlander's driving range from 200 miles with a 350 bar fill to 400 miles with a 700 bar fill. This will enable the vehicle to drive from Arcata to other high-pressure fueling stations in Sacramento and the Bay Area, linking Arcata to the rest of California's Hydrogen Highway.

SERC to Provide Fuel Cell Kits to San Francisco State University

Richard Engel

Since 2009, SERC's Hydrogen Energy in Engineering Education (H_2E^3) project, with financial support from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, has produced over 50 hydrogen experiment kits that have been made available on loan to engineering departments at University of California and California State University campuses. Each kit includes an electrolyzer for generating hydrogen, a fuel cell for generating electricity with the hydrogen, and instruments for making measurements of system efficiency. SERC has developed a set of lab activities that incorporate the kit.

Mechanical engineering faculty at San Francisco State University, after trying out one of the kits, decided they would like to purchase a set for permanent inclusion in their undergraduate lab activities. SFSU recently placed an order for eight of the kits, set to be delivered in time for fall semester 2011 classes. In keeping with the H_2E^3 project's goal of incorporating fuel cell and hydrogen learning in existing engineering classes, the kits will be used for a course in engineering experimentation, ENGR 300. This course helps engineering students build fundamental skills, such as ability to make sound engineering assumptions and to set up and troubleshoot experiments.

Project Updates

LED Lighting Africa

Here at SERC we are continuing our work supporting the Lighting Africa program, a joint IFC-World Bank initiative to catalyze markets for good quality off-grid lighting in the developing world. Over the last year, SERC has played a key role coordinating the Quality Assurance portion of the program, including generating and interpreting product test results, writing test methods, meeting with international policy-makers, and too many other tasks to list here. Some key breakthroughs and activities over the last few months have been:

- Developing a new method for measuring total lumen output for lighting devices that only requires \$2,000 in equipment – compared to the \$30,000 often required for the necessary hardware. This will allow startup manufacturers and low-budget laboratories (like the ones in some developing countries) to measure the true light output of their devices without needing to send them out for expensive testing.
- Contributing to the United Nations Framework Convention of Climate Change "Small-scale methodology AMS-III.AR," which allows off-grid lighting systems to receive credit for reducing greenhouse gas emissions and helps reduce the up front cost of improved lighting to end-users.
- Traveling to Munich and Nairobi to meet with policymakers and representatives from other international programs and harmonize their activities with the Lighting Africa Quality Assurance framework, which is becoming a global model in the off-grid lighting world.

Student research assistant Patricia Lai demonstrates the "multiplane distribution" test method that was developed at SERC and allows low-cost measurement of luminous flux. *Photo credit Kellie Jo Brown.*



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Project Updates *(continued from page 3)*

As we enjoy these long summer days, our SERC Lighting Lab team is continuing our work to ensure that people in developing countries have cleaner, better, and more economical options for lighting up the night.

We also wish Chris Carlsen, a graduating masters student, a good journey; he is moving to Dakar, Senegal to work as a consultant to the Lighting Africa program in West Africa. He joins Jenny Tracy, another SERC alum, who is based in East Africa with the Lighting Africa program.



Educational posters help residents learn how to interact with the GridShare and better manage their limited electric system. *Photo credit Arne Jacobson.*

GridShare Installations *(continued from page 1)*

the P3 team has finished the installations (along with hundreds of cups of tea). They've also held a short education program with 4th, 5th and 6th graders about brownouts and load shifting and a community meeting with over 50 people where they discussed their work, responded to questions and concerns about the GridShares, and had people brainstorm on ways they could shift their loads.

Congratulations to the team for a job well done. - Peter Lehman

Chhimi Dorji (left), Nathan Chase, and Tom Quetchenbach prepare to cross a bridge built by the "Iron Master" in the 14th century. *Photo credit Meg Harper.*



Looking Back

5 years ago... SERC researchers and HSU staff and students played a central role in efforts to ensure the quality of solar modules sold in the Kenyan solar market. The work involved laboratory testing at HSU as well as field testing of solar equipment in Kenya, and the results have been published in academic journals as well as the Kenya based Solarnet magazine. The project made a very real difference, as Kenyan solar buyers have tended to purchase high quality solar modules and sales of the poorest quality brands have declined sharply. For more information visit www.schatzlab.org/projects/research/photovoltaic/pv_quality.html



Photo credit Kellie Jo Brown.

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 Andrea Alstone, Peter Alstone, Greg Chapman, Richard Engel, Ruben Garcia, Meg Harper, Robert Hosbach, Patricia Lai, Marc Marshall, Brendon Mendonca, Allison Oakland, Carolyn Ortenburger, Kyle Palmer, Tom Quetchenbach, Kristen Radecky, Mark Rocheleau, Lucas Scheidler, Colin Sheppard, Zak Stanko, and Jim Zoellick.

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