



SERC

ENERGY NEWS

GridShare Success in Bhutan *Meg Harper and Tom Quetchenbach*

Fall 2012
Volume 7, Number 3

Features

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We're excited to report on the successful installation of GridShares on a small microhydro mini-grid in Bhutan. In our Summer 2011 newsletter, we wrote about our upcoming fieldwork in the Bhutanese village of Rukubji, and we can now share our results and the feedback we've received from the village. The GridShare is a demand-side management device designed by our group of HSU students and advisors and is intended to reduce the occurrence of brownouts on power-limited mini-grids. The GridShare device encourages load-shifting in two ways: by using red and green LED lights to indicate the state of the grid to the user and by preventing residents from using large appliances, like rice cookers and water boilers, during brownouts. After winning a grant to support the project through the EPA's People, Prosperity and the Planet (P3) Student Design Contest in 2010, we improved upon our original prototype and tested the GridShare devices in a village-scale pilot installation in Rukubji, Bhutan.

Rukubji, a village of approximately 90 households connected to a 40 kW-rated microhydro system, suffered from daily brownouts and served as an excellent location to evaluate the potential of the GridShare technology to reduce brownouts in village scale renewable energy systems. To perform the pilot installation, our team, with the help of many volunteers, designed, tested and manufactured 120 GridShare devices here at SERC. In collaboration with the Bhutan Power Corporation and the Department of Energy of Bhutan, we installed 90 devices in Rukubji and the surrounding villages of Sangdo, Tsenpokto and Bumiloo in June of 2011.

We assessed the GridShare installation with three main methods: electrical data logging, household surveys and community meetings. We have used HOBO data loggers to continuously monitor the current and voltage of the system since June of 2010, which provides us a year of data before and after the GridShare installation. Household surveys were conducted before the installation and again in January of 2012 to assess the effectiveness and reliability of the GridShares and the degree of user satisfaction. Community meetings before and after the



Left to right: The main village of Rukubji is located in the center of Bhutan in Himalayan Asia. BPC electrician Sangay Phuentsho installs a GridShare circuit near the electricity meter on the outside of a home near Rukubji, while the red and green indicator lights are installed inside the house near the cooking appliances.

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The quarterly newsletter of the Schatz Energy Research Center

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A Message from the Director

I am honored to write my first newsletter column as Director of the Schatz Energy Research Center. The faculty, staff, and students who work at SERC are a talented and dedicated group of people, and it is a privilege to work with such a fantastic team.



As I start in this new role, I am conscious of the large shoes I am attempting to fill. Peter Lehman has directed SERC boldly and effectively since it was founded in 1989. I feel fortunate to have the opportunity to collaborate closely with Peter over the years to come as he continues to play a leading role in his position as Founding Director.

Under the leadership of Peter and long time Co-Director Charles Chamberlin, SERC has built a reputation for taking on innovative and challenging renewable energy and energy efficiency projects that make a difference for the environment and society, carefully measuring and analyzing energy system performance, and building things that work. It was, in fact, these characteristics that attracted me to SERC, first as an Environmental Resources Engineering (ERE) master's student back in 1992 and later—after completing a PhD in Energy and Resources at UC Berkeley—as a faculty member in the ERE department in 2005. These traits are now deeply embedded into the culture of who we are at SERC, and we will, of course, strive to build on them.

Since becoming a Co-Director at SERC in 2007, I have worked with Peter, Charles, and the broader team to develop three key themes at the Center. First, we have worked to increase student involvement in SERC projects. Second, we have taken on interdisciplinary projects that combine technical rigor with policy and social science analysis. And third, we have diversified our portfolio of projects; for example, we now have a robust set of international efforts that complement our local, state, and nationally oriented projects. These will continue to be high priority themes going forward.

The lead story in this issue exemplifies the marriage between SERC's longstanding core capabilities and the emerging themes we have been working to add. The GridShare project involves the application of smart grid concepts to improve the quality of electrical service from a village scale renewable energy mini-grid in Bhutan. Successful implementation involved collaboration with international partners and an interdisciplinary approach that spanned technical, socio-economic, and educational activities. The project was also a student-led effort that provided significant opportunities for learning and professional

RePower Humboldt Plan Pivots on Local Renewable Resources Jim Zoellick

SERC and the Redwood Coast Energy Authority (RCEA) have unveiled their joint RePower Humboldt Strategic Plan, spelling out how local renewable resources can be used to meet the majority of Humboldt County's electricity needs and a large portion of its transportation and heating energy needs as well. The plan lays out an array of opportunities and recommends a set of actions that would create jobs, stimulate the local economy, reduce greenhouse gas emissions and increase local energy security.

The RePower Humboldt plan is the result of more than two years of research, analysis and community involvement. According to Matthew Marshall, Executive Director of RCEA, "renewable energy development has the potential to provide significant economic, environmental and energy security benefits to our region. We're excited to share the plan with the community and begin a dialog about our options moving forward."

SERC Director Arne Jacobson said, "If California is to meet its greenhouse gas reduction goals, which call for an 80% reduction below 1990 levels by 2050, we will need some regions to lead the way by scaling up clean energy use decades earlier. Humboldt County has the opportunity to serve as a positive example in this regard, and the RePower Humboldt plan can act as a road map to get us there."

Key recommendations in the plan include:

- Aggressively pursue cost-effective energy efficiency opportunities.
- Support responsible wind energy development.
- Expand the use of biomass energy that is consistent with forest restoration needs and priorities.
- Develop infrastructure for and encourage the use of electric vehicles.
- Encourage development of distributed energy installations.

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development for both graduate and undergraduate students.

Closer to home, in this issue we also report on an analysis of infrastructure needs for plug-in electric vehicle infrastructure for Humboldt County; the release of RePowering Humboldt, a strategic plan for scaling up renewable energy use over the next two decades here in Humboldt County; and progress on the HSU hydrogen fueling station upgrade. It is exciting to be involved in this diverse and meaningful set of projects. I look forward to many more in the years to come.

Bhutan GridShare (continued from page 1)

installation offered opportunities to discuss the GridShare and receive system feedback.

These comparative data indicate that the GridShares have effectively reduced the depth and duration of brownouts. The occurrence of severe brownouts, or times when the voltage dropped below 190 V for more than 10 minutes, was reduced by over 90% on all three phases of the grid. In household surveys and community meetings, residents stated that with the GridShares the electric grid was more predictable and they could more reliably cook their rice and light their homes.

We were thrilled when the community of Rukubji decided by consensus to keep the GridShares installed and the Bhutan Power Corporation agreed to continue to support the effort. Though several improvements to the design and implementation strategy would be useful before performing additional installations, this pilot project provides evidence that user-interactive demand-side management strategies, such as the GridShare, are effective at reducing brownouts on mini-grids.

To learn more about the GridShare project in Bhutan visit www.schatzlab.org/projects/developingworld/gridshare.html.



Top to bottom: The three main methods of evaluation of the GridShare project included electrical data logging, household surveys and community meetings.



Project Updates

Hydrogen Fueling Station Upgrade Greg Chapman

SERC engineers have completed the testing phase of the project's commissioning plan. Two critical and successful steps in the plan were the high pressure testing of the 700 bar dispensing system and hydrogen gas analysis. The gas analysis, performed by two independent laboratories, indicate that the station's gas quality meets the *Hydrogen Fuel Quality for Fuel Cell Vehicles (SAE J2719)* requirements set forth by the Society of Automotive Engineers (SAE).

The final task for project completion will be the initial 700 bar hydrogen fueling of one of the Toyota FCHV-adv vehicles. Toyota engineers will be on-site to monitor the fueling process and ensure that station operators follow proper vehicle fueling protocols.



The fueling station now serves two Toyota FCHV-adv; the second vehicle, also on loan from UC Berkeley, arrived at SERC in July.

North Coast Electric Vehicle Planning Study Colin Sheppard

As part of a plug-in electric vehicle (PEV) planning study for our North Coast community, SERC engineers have been busy developing a simulation model of PEV drivers and their experiences traveling through the county in electric vehicles. The model will allow us to investigate the demand for public charging stations and make recommendations for prioritizing which sites are the most critical to supporting the widespread adoption of PEVs in Humboldt County. We are working in collaboration with the Redwood Coast Energy Authority and GHD (formerly Winzler and Kelly) on this study funded by the California Energy Commission.

Meanwhile, there is recent good news for electric vehicle
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Project Updates *(continued from page 3)*

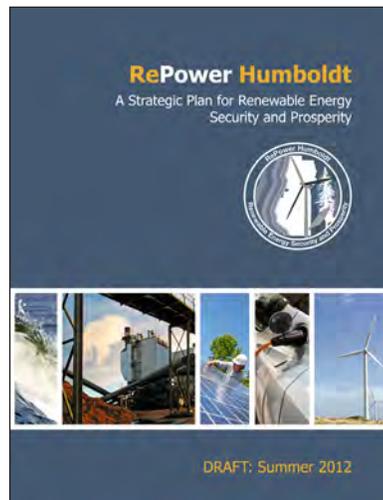
owners in the county. Ourevolution Energy & Engineering will receive funding from the California Energy Commission to install electric vehicle charging stations in Eureka and Arcata. The two stations, which could be installed by the beginning of 2013, will feature ChargePoint equipment by Coulomb Technologies. This project will increase the number of modern charging stations in Humboldt County from one to three and increase the total number of public stations from three to five.

RePower Humboldt *(continued from page 2)*

- Pursue options for local development and ownership of renewable energy projects, as well as local purchase of the power generated.
- Form an energy leadership group to move the plan forward.

A public draft of the plan is now available and the community is encouraged to review it and provide feedback, either on-line at www.redwoodenergy.org/programs/repower or www.schatzlab.org/repower or in-person at the RCEA, 517 5th Street, Eureka, 707-269-1700.

Public comment on the plan will be accepted through October 26th for incorporation in a final version.



Note: RePower Humboldt is the result of work conducted under the Humboldt County Renewable Energy Secure Community (RESCO) project. The RePower Humboldt name, rather than RESCO, will be used to refer to this effort in the future.

Looking Back

8 years ago... Faculty and students from HSU 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. The project made a very real difference, as sales of the lowest quality brands of solar modules in the Kenyan market have declined sharply. For more information visit www.schatzlab.org/projects/archive/pv_quality.html.



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 California Hydrogen Business Council, the International Association for Hydrogen Energy, the International Solar Energy Society, and the American Solar Energy Society.

SERC co-directors are Arne Jacobson, Peter Lehman, and Charles Chamberlin. Faculty research associates are Eileen Cashman, Elizabeth Eschenbach, Steven Hackett, and David Vernon. Research and administrative staff include Allison Campbell, Greg Chapman, Richard Engel, Meg Harper, Robert Hosbach, Billy Karis, Patricia Lai, Marc Marshall, Allison Oakland, Carolyn Ortenburger, Tom Quetchenbach, Kristen Radecsky, Mark Rocheleau, Colin Sheppard and Jim Zoellick. SERC docents are Joel Bautista, Dustin Fredricey, Chet Jamgochian, Steven Pearl, and Greg Pfothenauer.

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