SERC
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Features

In Every Issue

The quarterly newsletter of the Schatz Energy Research Center

HUMBOLDT STATE UNIVERSITY

Solar Mini-Grids Put India's Villages in a New Light

Richard Engel

As we reported in our spring issue, SERC is part of an international team assessing opportunities to use solar power for rural electrification in India. Providing solar power via a central PV array and a village distribution system, or mini-grid, can be more cost-effective and durable than providing independent solar electric systems for each household.

This approach is already being used widely in rural India, but in most cases implemented by government agencies that provide heavy subsidies. Recent financial turmoil and growing public sector deficits in India demonstrate that these subsidies are not sustainable for the long term. Our team's client, Indian company Azure Power, is interested in learning whether a for-profit firm can provide mini-grid service at a price that even lower income villagers can afford. Financial assistance for the study comes from the U.S. Trade and Development Agency.

We have now completed nearly all of our work on the three tasks we led:

- a literature survey of similar projects in other developing countries,
- an assessment of how Indian energy policy and regulations might affect such projects, and
- field studies to estimate energy demand and willingness to pay for electricity in candidate villages Azure Power has selected.

SERC staff including Tom Quetchenbach and Meg Harper made important contributions to the first two tasks. For the third task, I traveled to India for two weeks in June, accompanied by the project lead, Priya Sreedharan, from the San Francisco energy consulting firm Energy and Environmental Economics (E3) and former HSU graduate student/SERC student assistant Brendon Mendonça. In New Delhi, we met up with principals and staff of India-based consultant Varesh Energy, completing our field team. After a meeting with Azure Power staff, the team headed out to the two field sites in Eastern and Northern India.

Project team member Brendon Mendonça leads a focus group discussion with villagers.

After orienting ourselves and meeting with village leaders, we set to work conducting house-by-

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A Message from the Director

We have completed the transition from summer to fall here in far northern California, and – while it has been clear and sunny for the past few days – we recently had the first heavy rainstorm of the season. As the seasons change, we remain busy at SERC with a diverse portfolio of clean energy projects. The selection of articles in this newsletter reflects this diversity.

In the lead article, Richard Engel reports on a project that is in line with our broader work aimed at enabling energy access in off-grid areas ranging from South Asia to East Africa. We are also happy to report on recent progress in our biomass energy collaboration with Renewable Fuel Technologies (RFT). We look forward to deepening our work with RFT and others in the field as we expand our efforts in this arena.

Several other articles reflect our long tradition of work related to clean transportation. We were pleased to be in a position to fuel the hydrogen fuel cell vehicle that SERC alum Anand Gopal and his wife Liz Pimentel drove up from the Bay Area. We hope this event will be the first of many such occurrences made possible by our hydrogen vehicle fueling station.

We are also pleased to extend our plug-in electric vehicle (PEV) charging infrastructure planning work from California to India. The work in New Delhi, which involves collaboration with Anand Gopal and colleagues from Lawrence Berkeley National Laboratory, will require analysis in a new and complex setting involving very different driving patterns and electricity infrastructure. We at SERC always like to get involved in new and challenging work, and we hope to contribute meaningfully to the wider effort to enable cleaner transportation systems in New Delhi and beyond.

I will close by welcoming several new members to the SERC team. This August, Nick Bryant of Washington state and Amit Khare of New Delhi, India started work at SERC. They are also pursuing master's degrees in the Energy Technology and Policy (ETaP) program here at HSU. We also have three additions to our docent team, including Yaad Rana, Onomewerike "Robo" Okumo, and Jake Coniglione. All are undergraduate students in the Environmental Resources Engineering program. It is great to have these students on board.

Blue Energy in the Humboldt Bay

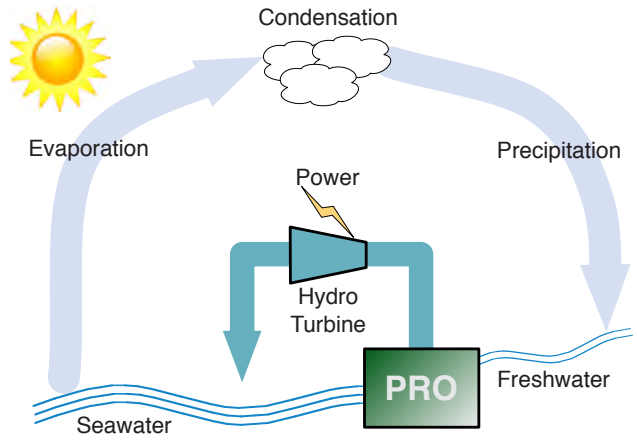
Andrea Achilli

Blue Energy, a potential source of renewable and sustainable energy, is the energy released from the salination of water when freshwater mixes with saltwater. One process for capturing this energy is pressure-retarded osmosis (PRO). In PRO, a semi-permeable membrane separates a pressurized high-salinity solution from a low-salinity solution. Because the osmotic pressure across the membrane exceeds the hydraulic pressure of the high-salinity solution, water from the low-salinity solution permeates across the membrane through osmosis and dilutes the high-salinity solution. In this way, the chemical potential (osmotic pressure) is transformed into hydraulic potential and power is obtained by depressurizing the excess water through a hydroturbine.

One category of PRO systems is referred to as open-loop. Open-loop PRO systems take advantage of naturally occurring salinity gradients in "river-to-sea PRO" scenarios. In these systems, the solar energy that evaporates water from the sea is recovered by a PRO system in the estuary where the river water mixes with the seawater. Open-loop systems can also be used with engineered salinity gradients (e.g. in the disposal/dilution of the concentrate stream at reverse osmosis (RO) desalination facilities) in a "RO-PRO" scenario.

I have investigated PRO experimentally and theoretically in both river-to-sea and engineered configurations. Currently, I am exploring the potential of Humboldt Bay as a site for PRO through experimental investigations in my research lab in the Environmental Resources Engineering (ERE) department at HSU. I am also involving ERE seniors in the design of a PRO facility for the Humboldt Bay in their Capstone Design course this semester.

Results from the Capstone Design course will give insight into whether the available fresh water at Humboldt Bay will make it possible to locally house the first prototype river-to-sea PRO facility in the U.S. and to shorten time-to-market of PRO technology by attracting institutional and industry funds. Because of the exciting potential of PRO technology to provide large amounts of renewable energy, pressure retarded osmosis is an area of active and promising research. Stay tuned for future reports on this effort.



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SERC Continues Electric Vehicle Planning Work in Two New Regions Colin Sheppard

Earlier this year we reported on our plug-in electric vehicle (PEV) readiness planning work for Humboldt County. Building on this effort, SERC is now engaged in similar studies for New Delhi, India as well as the Upstate Region of California (covering the counties of Siskiyou, Shasta, and Tehama).

In partnership with Lawrence Berkeley National Laboratory, SERC will be adapting our agent-based PEV model to simulate vehicle adoption and the need for public charging infrastructure in New Delhi, India. Among the many new challenges presented by this opportunity are capturing the impact of congestion on electric vehicle performance and simulating battery-swapping as an alternative to conventional charging. Like the Humboldt project, the Upstate Region readiness effort will involve a range of activities intended to prepare the region for the ongoing roll-out of plug-in electric vehicles. These tasks include adapting the infrastructure deployment model to evaluate the Upstate Region, streamlining permitting in the region, increasing public awareness about PEVs, and evaluating the challenges and opportunities associated with PEV adoption.

Solar Mini-Grids *(continued from page 1)*

house surveys and holding focus group meetings. We collected demographic data, inquired about people's expectations and desires for household electrification, and asked the villagers to respond to hypothetical electrification scenarios and associated costs. The two villages we focused on are not "greenfield" sites without previous electrification experience. One of them had previously been electrified with a mini-grid that was later removed, while the other village has partial grid electrification. The desire for electricity and willingness to pay were encouraging in both cases although the details and conditions varied between the villages. These field findings will be integrated into the engineering and economic analysis that remains to be conducted in the project to thoroughly assess the feasibility of solar minigrids for these two sites.

We have delivered our task completion reports to Azure Power, and they have responded with special enthusiasm to the field study, calling it "useful, thorough, well-done, and enjoyable." In the coming months, SERC will continue to provide support to other project partners as they complete the remaining tasks on this important feasibility study. Upon completion of the entire project, the USTDA will make the main findings of this field study and the overall feasibility project accessible to the public through a publicly available report.

Project Updates

HSU Hydrogen Fueling Station Hosts First Hydrogen Fuel Cell Commute from the Bay Area Meg Harper

Anand Gopal, research scientist at Lawrence Berkeley National Labs (LBNL) and former Schatz Energy Fellow, and Elizabeth Pimentel-Gopal, former HSU Assistant Director of Admissions, drove from Berkeley to Arcata to visit friends and family over the second weekend of September. Rather than a mundane weekend trip, theirs was a precedent-setting event; their entire trip was powered by hydrogen fuel.

Their trip represents the first time the HSU Hydrogen Fueling Station has been used to fuel a vehicle commuting to and from the Bay Area aside from the vehicles under test at SERC. Filling the Toyota Fuel Cell Hybrid vehicle (FCHV-adv) with hydrogen at 700-bar (10,000 psi) gave the vehicle a range of over 285 miles and enabled Anand and Elizabeth to complete their return trip to one of the nearest hydrogen stations (located in Richmond and Emeryville). For Anand the event was especially meaningful. During his time at SERC, the HSU student team that he advised won an international hydrogen energy design competition in 2005, which inspired the development of the HSU hydrogen station.

Anand Gopal poses with the Toyota Fuel Cell Hybrid vehicle (FCHV-adv) that he drove from the Bay Area.

SERC Completes Instrumentation of RFT Torrefier Marc Marshall

In September, Greg Chapman and I made our second trip to Renewable Fuel Technologies (RFT) to continue work on measuring the energy and mass balances of RFT's pilot-scale torrefier. The one-ton-per-day torrefier produces a charcoal-like product called bio-coal from wood waste by heating biomass to 300°C in the absence of air. The bio-coal can then be co-fired in a power plant with standard fuels such as coal or wood chips to generate renewable electricity. SERC's measurements of the device will aid in designing the torrefier for mobile, stand-alone

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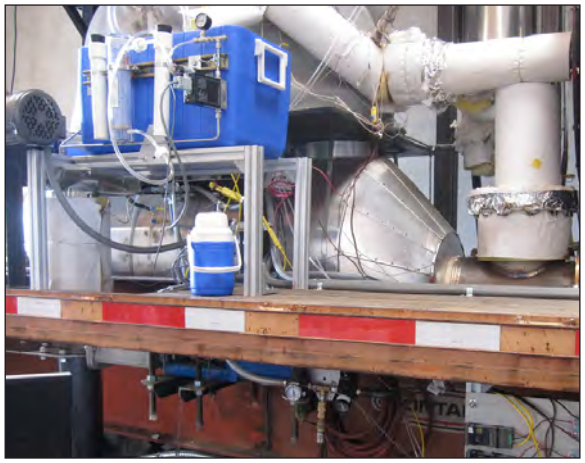
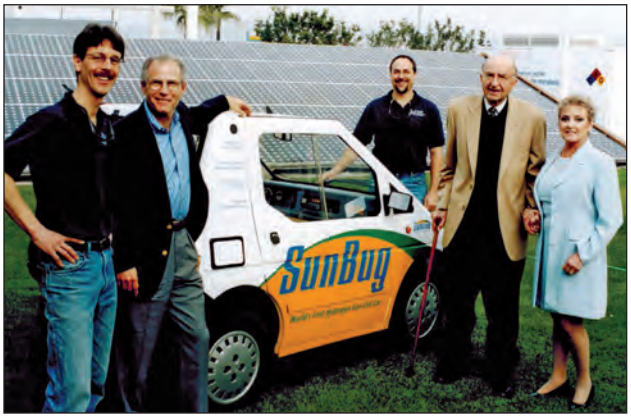
Project Updates *(continued from page 3)*

operation and optimizing the technology for commercial use in converting timber waste into very low carbon renewable energy. This work is funded by the California Energy Commission.

During this visit, we installed new instrumentation on the pilot-scale torrefier to measure power, air and gas flows. Greg also designed, built, and installed a condenser to sample the condensable portion of the gas by-product of the torrefaction process, called torrgas, which is used to generate heat as a key part of RFT's efficient design. An initial test run of the system using the new instrumentation was successful, and planning is now underway to procure and transport several tons of wood chips to RFT, which will be used in a series of torrefaction experiments under varying conditions to collect detailed data on the operating characteristics of the system.

Top to bottom: The newly-installed air-measurement devices and torrgas sample condenser.





We have sad news to report. Betty Schatz, wife of the late Dr. Louis Schatz, passed away on April 27, 2013. Shown above are Betty and Louis Schatz celebrating Dr. Schatz's 88th birthday at SunLine Transit Agency in January 2000. Also shown around our pioneering fuel cell car are SERC team members *(left to right)* Jim Zoellick, Peter Lehman, and Greg Chapman.

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. 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 advisory board members are Rick Duke, Shannon Graham, Dan Kammen, David Katz, Jaimie Levin, David Rubin, Jeff Serfass, and Andrea Tuttle.

SERC co-directors are Arne Jacobson, Peter Lehman, and Charles Chamberlin. Faculty research associates are Andrea Achilli, Kevin Fingerman, and David Vernon. Research and administrative staff include Nick Bryant, Allison Campbell, Greg Chapman, Richard Engel, Meg Harper, Andy Harris, Robert Hosbach, John Hunter, Billy Karis, Amit Khare, Patricia Lai, Melissa Lancaster, Marc Marshall, Allison Oakland, Carolyn Ortenburger, Tom Quetchenbach, Kristen Radecsky, Mark Rocheleau, Mark Severy, Colin Sheppard and Jim Zoellick. SERC docents are Jake Coniglione, Chet Jamgochian, Onomewerike "Robo" Okumo, Greg Pfotenhauer, Yaad Rana, and Max Tanti.

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