



SERC

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The quarterly newsletter of the
Schatz Energy Research Center

HUMBOLDT
STATE UNIVERSITY

LED Technology for Off-Grid Lighting in Africa

Arne Jacobson

Battery powered lanterns that use white LED technology are emerging as a potential substitute for kerosene lighting in unelectrified areas of Africa, Asia, and Latin America. Dozens of LED-based off-grid lighting products are now available, with most selling at prices ranging from \$2 to \$60 per unit.

Over the past two years, SERC has been involved in research related to the quality, performance, economics, and end-uses of LED lights. The effort, dubbed the Lumina Project, is a collaboration headed by Evan Mills of the Lawrence Berkeley National Laboratory (LBNL) and Arne Jacobson of SERC. The work is funded by Richard C. Blum Center for Developing Economies through a donation from Art Rosenfeld. To date, the research has included laboratory testing of existing LED lighting products, as well as fieldwork in Kenya.

Results from our laboratory tests indicate that product quality varies widely from one off-grid lighting product line to another. The measurements show that some brands perform at or near their rated specifications, while others perform well below advertised levels. In some cases, we also found considerable variation from one unit to another within a given brand. See reports by Mills and Jacobson (2007) for additional information (available at <http://light.lbl.gov> and <http://www.schatzlab.org/publications.html>).

These results confirm that market spoiling and consumer protection are major concerns for emerging markets for off-grid lighting. That is, while LED lanterns have the potential

to provide superior lighting services relative to kerosene lamps, there is a danger that some developing country markets for off-grid lighting products will be flooded with low quality goods. This would result in financial losses for those unfortunate enough to buy a poor performing light, and it could also reduce sales even of the best performing products. This is true because many disappointed customers may be hesitant to buy another LED lighting product.

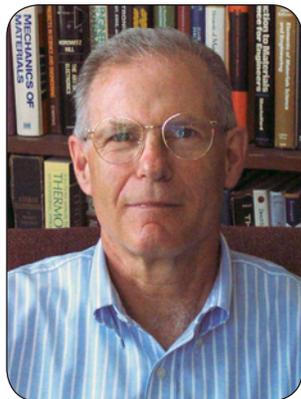
In the context of the Lumina Project collaboration, we are working to address issues
(continued on back page)



Graduate Students Ranjit Deshmukh and Stephen Kullmann and Professor Arne Jacobson measuring LED lighting performance at SERC. *Photo by Kellie Brown.*

A Message from the Director Peter Lehman

At a recent weekly staff meeting, we welcomed a couple of new graduate research assistants, Michael “Joe” Purdon and Colin Sheppard. You can read about them and their interests in this newsletter. The addition of Joe and Colin to our staff means that we’ve grown to 20 people, a milestone for the lab and the largest we’ve ever been. It’s heartening to see how far we’ve come since the early days when Charles Chamberlin and I and two undergrads were the entire staff.



It’s also heartening to see the progress we’ve made towards building a new SERC facility. We’ve decided on a design-build procurement process and we’re now working with Facilities Management staff at HSU to develop the Request for Proposals that will go out to contractor-architect teams. They will respond with proposals and we hope to have chosen the winning team by early summer. Groundbreaking is scheduled for late summer. We’ll keep you informed about our progress.

In this issue, Greg Chapman reports on progress with our hydrogen station. We’re nearing completion of the station and we’re celebrating getting word from the California Air Resources Board that we’re finally going to receive a hydrogen powered Prius that will refuel at the station. As described by Ranjit Deshmukh, we’re gearing up to receive an experimental gasifier from India. We’ll be using the gasifier for experimentation that we’ll be doing in collaboration with colleagues at UC Berkeley. Arne Jacobson writes about his continuing efforts to measure effectiveness and improve standards for LED lighting. Arne is working with colleagues at Lawrence Berkeley Lab and the World Bank; he’ll be traveling to Ghana in May to present this work at a lighting conference there. You can also read about our sixth and latest UNPEPP project, coming up this summer. This partnership with Redwood National Park has been gratifying and productive and we’ve had some wonderful summer interns over the years.

As I write this, the cost of oil has broken the \$100/bbl barrier and shows no signs of going lower. Evidence of global climate change and its disastrous consequences continue to mount. More than ever we need to reign in our consumption of energy and develop renewable sources. We at SERC are working to do our part.

Gearing Up for the Biomass Gasifier Ranjit Deshmukh

These are exciting times at SERC as we prepare for the arrival of the biomass gasifier system from India. The gasifier system is an air-fed downdraft gasifier coupled with a gas engine and generator, designed and constructed by Ankur Scientific Energy Technologies in India. The gasifier has a thermal output of 20kWth while the entire system has an electrical output of 11kWe. It will be housed behind our present premises in a new carport structure, which is near completion. We are also diligently working on the instrumentation and fuel drying aspects of the project.

SERC, in collaboration with the Renewable and Appropriate Energy Laboratory group at UC Berkeley, will perform various tests on the gasifier system. We will study the response of the gasifier in terms of its thermal efficiency over a range of fuel moisture contents. We will also make tar measurements in the gas, as tar is the biggest impediment to the use of the product gas in end-use applications. These experiments will help us better understand the gasification process and further our research in biomass energy technologies.

Biomass thermal gasification is the incomplete combustion of biomass that results in the production of combustible gases consisting mainly of carbon monoxide and hydrogen. These product gases, after being cleaned and filtered, can be fed into a gas turbine or an internal combustion engine to drive an electric generator or directly combusted for thermal applications. This technology has numerous end-use applications; SERC is currently pursuing two. The first is utilizing woody biomass from fuel reduction activities such as those in the forests of Humboldt County. The second is electric and thermal energy generation using sugarcane residue, called “bagasse,” from the sugar industry in Indonesia. Stay tuned for future updates on this project in subsequent newsletters.



SERC staff (left to right) Charles Chamberlin, Marc Marshall, Scott Rommel, Allison Oakland, Richard Engel, Kyle Palmer, Ray Glover, Peter Lehman, Michael Winkler, Jim Zoellick, Keith Glenn, Greg Chapman, Stephen Kullmann, Mark Rocheleau, Peter Johnstone, Andrea Allen, Ranjit Deshmukh, and Arne Jacobson. *Photo by Kellie Brown.*

RNSP Headquarters to Become Sixth UNPEPP Project for SERC-RNSP Partnership

Peter Johnstone

With funding from the University-National Park Energy Partnership Program (UNPEPP), SERC will again partner with Redwood National and State Parks (RNSP) for a summer 2008 UNPEPP project. The UNPEPP 2008 project follows and builds upon the highly successful summer 2000, 2001, 2002, 2003, and 2006 SERC-RNSP internships sponsored by UNPEPP. The UNPEPP 2008 project will consist of auditing energy use, making recommendations for energy efficiency improvements, designing a grid-connected photovoltaic system for onsite energy production, and producing an interpretive sign to inform visitors about the work taking place at RNSP's Headquarters in Crescent City, CA. As with prior UNPEPP projects, the 2008 project will employ two student interns from Humboldt State University. SERC and RNSP will conduct day-to-day project oversight.



SERC staff and HSU Engineering students pose in front of the Wolf Creek Outdoor School photovoltaic array, the design of which originated from the SERC-RNSP UNPEPP 2001 partnership.

The RNSP Headquarters is a multi-use facility and was built in 1972. The primary use of the building is administrative office space. Additionally, there is some warehouse and maintenance space and a visitor center that is open to the public. The building has been identified by RNSP as a good target for energy efficiency and conservation upgrades.

In addition to identifying opportunities for energy conservation, the students will design a grid-connected photovoltaic system for the Park Headquarters. On-site generation of renewable energy could supplement the effort to reduce the overall electricity demand for the Headquarters, and would provide a high-visibility visual indication to the public of RNSP's commitment to renewable energy.

SERC looks forward to another successful project that helps UNPEPP meet its mission "to link university resources with national parks to provide energy services to the parks and real-world problem-solving opportunities to university students."

Project Updates

Hydrogen Technology and Education Curriculum Allison Oakland

Project partners Lawrence Hall of Science (LHS) at UC Berkeley, SERC, and AC Transit Authority were recently awarded an additional \$150,000 from the U.S. Department of Energy (DOE) to further develop the Hydrogen Technology and Education Curriculum (HyTEC). As subcontractor on this project, SERC's involvement to date includes curriculum development, teacher training, pilot testing in the classroom, and the development of hands-on laboratory kits that feature student operated fuel cells and electrolyzers.

HyTEC is a two-week module targeted for high school chemistry and environmental science students that features hands-on laboratory activities, readings and calculations, and issues based role-play activities. We recently completed revisions to the curriculum based on feedback from California classroom pilot tests and teacher workshops. The additional DOE funding will help meet the project's multi-year goal of national field testing and dissemination of the curriculum to a large, national audience of students and teachers.

HSU Hydrogen Fueling Station Greg Chapman

The construction and installation phases of the hydrogen fueling station are complete (see photo, below). Site inspections of the hydrogen piping and electrical system were conducted by a mechanical and electrical engineer with no major issues noted. SERC engineers are now beginning start-up testing of the station. Testing will include hydrogen generator, compressor, and dispenser operational checks, gas purging and pressure testing of the piping system, and safety and instrumentation system verification and operation testing.

Quantum Technologies's retrofit of the hydrogen-powered Toyota Prius is complete and the vehicle is scheduled for delivery in the next month. Look for information on the fueling station's grand opening on our homepage, www.schatzlab.org, or HSU's homepage, www.humboldt.edu.



related to the quality and performance of off-grid lighting products through several avenues. First, we provide manufacturers with feedback about their products. The information that we have delivered to date has been based on a combination of laboratory measurements and focus-group oriented fieldwork conducted in Kenya. The response that we have received from manufacturers has been positive, and several have re-designed their products upon receiving the information.

Second, we are working to perfect a rigorous, yet low-cost, set of tests for measuring the quality of off-grid lighting products. Here, our goal is to create an open source quality screening method that can be used by government agencies (e.g. the Bureaus of Standards of countries in Sub Saharan Africa), consumer protection groups, and manufacturers alike.

Third, we are serving as advisers to the World Bank's Lighting Africa project. This project aims to support the development of markets for off-grid lighting products in a number of African countries. Quality assurance and consumer protection is central to the overall mission of the effort. To this end, these issues will play a key role in the upcoming Lighting Africa 2008 Conference in Accra, Ghana (May 6-8, 2008). SERC Co-Director Arne Jacobson will lead a series of sessions at the conference on quality assurance for off-grid lighting products.

Looking Back

8 years ago SERC initiated a collaboration with the University-National Park Energy Partnership Program (UNPEPP). UNPEPP links national parks with university energy programs all over the United States. Students work as summer interns in the parks, identifying opportunities to improve energy efficiency or use renewable energy. To date we have completed five UNPEPP projects ranging in scope from energy audits to the design and installation of a hybrid solar electric system. Our sixth UNPEPP

collaboration will begin in May- see our newsletter article for more information about this exciting new project that will help turn our parks clean and green. For in-depth information about our prior projects visit www.schatzlab.org/unpepp.



Welcome New Graduate Research Assistants

SERC is pleased to welcome Michael "Joe" Purdon and Colin Sheppard as graduate research assistants.

Colin Sheppard (formerly Colin Ritter) is a graduate student in the Environmental Resources Engineering (ERE) Department at HSU and the president of RESU (the Renewable Energy Student Union). He is overjoyed to be working for SERC as a research assistant in the assessment of wind and micro-hydro resources on the Yurok Reservation. Colin's previous involvement with SERC includes conducting outreach and education as a docent. His current academic research involves developing and evaluating statistical tools for assessing wind resources in Humboldt County. He hopes to apply these techniques in his work with the Yurok Tribe and he looks forward to many more misty field visits to the Klamath.

Joe is a graduate student in ERE's Environmental Systems graduate program and is interested in all types of renewable energy. His research experience, which was gained while working on government contract research in Kansas, includes using microscopy and spectroscopy equipment for surface science as well as studying high temperature lubrication. At SERC, Joe will be running the new gas chromatograph which is part of the biomass gasification project. He is very excited to join the SERC team and this new research endeavor.

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 National Hydrogen 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. Research and administrative staff include Andrea Allen, Greg Chapman, Ranjit Deshmukh, Richard Engel, Keith Glenn, Ray Glover, Peter Johnstone, Marc Marshall, Allison Oakland, Kyle Palmer, Joe Purdon, Kristen Radecsky, Mark Rocheleau, Scott Rommel, Colin Sheppard, Michael Winkler, and Jim Zoellick.

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