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Features

In Every Issue

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HUMBOLDT STATE UNIVERSITY

SERC Completes Siting Analysis for Electric Vehicle Infrastructure on the North Coast

Colin Sheppard

Over half of Humboldt County's energy-related greenhouse gas emissions come from transportation. Nationwide, the transportation sector contributes 28% of all greenhouse gas emissions. Plug-in electric vehicle (PEVs) present a compelling opportunity for communities to dramatically reduce these emissions along with air pollutants responsible for a wide range of adverse health impacts.

To support the successful introduction of PEVs to the North Coast, SERC is serving as the technical lead on the North Coast Plug-in Electric Vehicle Readiness Study. Funded by the California Energy Commission, this work is being done in partnership with the Redwood Coast Energy Authority and local engineering firm GHD.

One of the key questions we have addressed is how to deploy PEV chargers throughout the region in a cost-effective manner. This is a complex question. Where will PEV drivers live? Where will they drive? How long will they spend at their destinations? How will drivers adapt when they need a charge but no station is available?

Our approach to answering these questions was to develop an "agent-based" simulation model of PEV drivers in Humboldt County. Individual PEV drivers (or agents) are simulated as they conduct their daily travel throughout the county and interact with a hypothetical charging network. Drivers begin a day with a vehicle, an itinerary of trips, and a set of rules for how to behave. An example of a rule would be that drivers seek out a charger if their battery doesn't have sufficient energy to make their next trip. Another example would be that some drivers elect to charge their vehicle even if it's not necessary.

The simulation evolves over the course of the day as drivers follow their rule sets, interact with the charger network, and respond to changing circumstances. At the end of a simulation run, we can summarize the day's events in a multitude of ways. Where, when, and how often did drivers charge? How many drivers experienced inconvenience of some kind (e.g., experienced a delay while waiting for a charger)? By repeatedly running the simulation with different charger locations, we can use the model to evaluate the impact of any hypothetical infrastructure scenario on driver inconvenience.

For a given penetration of PEVs into Humboldt County, we used optimization to find the infrastructure scenario that provided the greatest benefit to drivers for the least cost. See the map of Eureka on page three for an example of the recommended infrastructure for 2% penetration of PEVs, or roughly 3000 vehicles. Maps of the whole county can be downloaded at www.schatzlab.org/projects/policyanalysis/pev.html.

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A Message from the Director

Activities on the Humboldt State campus have slowed down for the summer, but we are still very busy here at SERC. The articles in this newsletter highlight some of our current activity. As Colin Sheppard's article indicates, we have been engaged in analysis related to planning for plug-in electric vehicle (PEV) infrastructure development in Humboldt County. We are also working on a similar analysis for three other northern California counties and are exploring other project possibilities. All of this work fits into SERC's longstanding tradition of enabling expanded use of clean transportation technology in the U.S. and beyond.

In this issue we also describe two new biomass energy efforts at SERC. One of these projects, involving torrefaction technology, is motivated by a desire to reduce the cost of transporting biomass fuel from the forest to end-use sites. The second effort explores conversion of biomass-derived sugars into hydrogen, which can then be injected into engines to improve efficiency and reduce emissions. These projects represent important progress in SERC's bio-energy research, and, in both cases, we are grateful for funding support from the California Energy Commission (CEC). We will start additional bio-energy work soon on a $1.75M CEC-funded project involving collaboration with the Blue Lake Rancheria, Redwood Coast Energy Authority, and Ballard Power Systems.

We also remain busy on the international front. Our work with the World Bank Group's Lighting Africa and Lighting Asia programs continues to involve laboratory, field, and policy activities. In the lab this summer, we are grateful to have participation by student assistants Melissa Lancaster and John Hunter. Recent activities have taken team members to Kenya, Tanzania, India, and Bangladesh. Additionally, last month I attended meetings hosted by the Global Off-Grid Lighting Association (GOGLA) in Munich, Germany on the sidelines of Intersolar-Europe. As reported in our last newsletter, we are also working on a feasibility analysis and design for solar powered mini-grids in India. Two members of our team, Richard Engel and Brendon Mendonça, traveled to India last month as part of this effort.

Last but not least, we recently received good news related to the cost of education for some of our graduate students. Over the years, a number of graduate students from the Energy Technology and Policy (ETaP) and Environmental Resources Engineering (ERE) options of the Environmental Systems (ES) Graduate Program have worked at SERC. The ES Graduate

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SERC Receives Funding for Bio-Energy Research

A $95,000 California Energy Commission (CEC) grant enables SERC, in partnership with Renewable Fuel Technologies (RFT) of San Mateo, to continue experiments aimed at converting slash from logging and fuel reduction efforts into energy dense bio-coal. RFT has developed a pilot-scale, one ton per day torrefier which produces bio-coal from timber waste by heating biomass to 300°C in the absence of air. Bio-coal can be co-fired in a power plant with standard fuels such as coal or wood chips to generate renewable electricity.

This new project involves measuring the energy and mass balances in RFT's pilot-scale unit. These measurements will aid in designing the torrefier for mobile, stand-alone operation and optimizing the technology for commercial use. Mobility is considered crucial if torrefier technology is to become commercially viable. A good deal of forest debris lies in remote, difficult to reach locations, generating high logistics overhead. By making biomass three times as energy dense, the mobile torrefier would provide a far more economical approach as well as a major incentive to commercial conversion of timber waste into very low carbon renewable energy.

The CEC also awarded SERC Faculty Research Associate Dr. David Vernon $94,993 to examine the use of sugars from biomass to offset fossil fuel use, increase efficiency and reduce emissions in combustion processes. This work uses plant-derived sugars in chemical reactions that consume waste heat to produce a hydrogen-rich gas that can be mixed with traditional fuels to promote more complete combustion. This process has the potential to replace up to 50% of the fossil fuel and to increase efficiency by as much as 25%. It could also reduce emissions of NOx by over 95% while maintaining or reducing emission levels of other pollutants. If successful, the technology developed from this work could be retrofit onto existing gas turbines and engines in power plants and gas pipeline compressor stations without requiring costly modifications to the existing systems.

Graduate Student Assistants Mark Severy and Billy Karis (*left*) and Faculty Research Associate David Vernon test aqueous phase reformation reactions.

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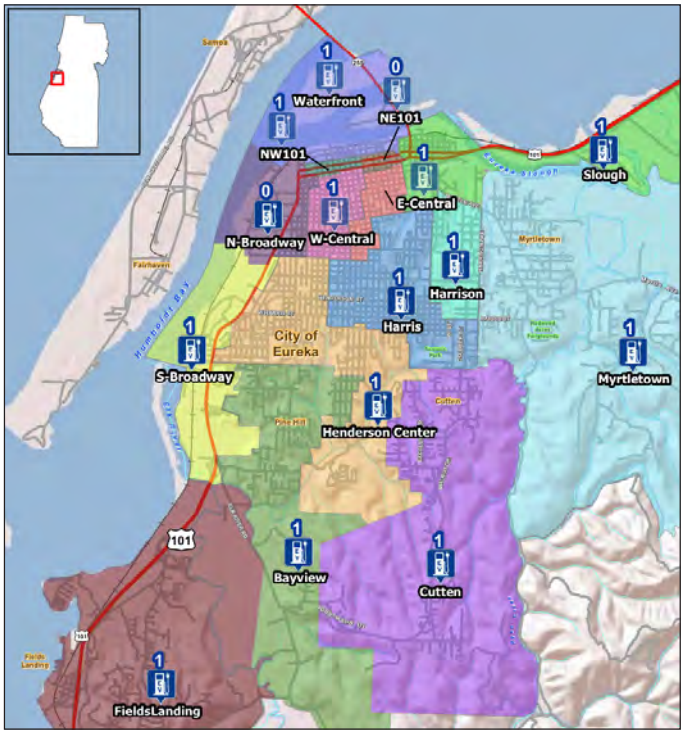
We also developed some general conclusions about the optimal siting of PEV chargers in Humboldt, which are likely transferable to other rural communities:

- Overall, relatively few chargers are needed to support a large number of PEV drivers. Approximately 45 public chargers were sufficient to support about 3000 drivers in the 2% penetration scenario. Drivers will be able to accomplish most of their travel needs (~90%) just by charging at home.

- Chargers tend to be sited in and around population centers and major regional corridors.

- Level 2 chargers (which can charge a Nissan Leaf in ~5-6 hours) provide a more cost-effective means of supporting PEV drivers than DC fast chargers (which can charge a Leaf in less than 1 hour). This is primarily because DC fast chargers are about 10 times more expensive to install and only charge batteries to 80% of full capacity.

- Exact siting of chargers is flexible. Chargers can be sited in one zone or a neighboring one and the overall impact on PEV drivers will be about the same as long as the total need for chargers in that region is satisfied.



The recommended PEV charging infrastructure for the City of Eureka for 2% penetration of PEVs, or roughly 3000 vehicles. The estimated cost of this scenario is $130k.

Our deployment guidelines wouldn't be complete without an estimate for when the infrastructure should be in place. To answer this question, we looked at the historic adoption of the Toyota Prius and other hybrids in Humboldt. If we assume that drivers will adopt PEVs at the same rate as hybrids, then we would expect that 1% of the light duty vehicles in Humboldt will be PEVs by approximately 2018 and 2% by 2025. In other words, there's little time to spare in rolling out PEV chargers.

Fortunately, the North Coast PEV Readiness team is already working on a near-term implementation plan. Critical to this plan is identifying specific sites where the first wave of PEV chargers might be installed. This process involves soliciting input and feedback from a variety of municipalities and local stakeholders to ensure that the final sites reflect the needs and priorities of the whole community. If you'd like more information, or want to participate in this process, contact the Redwood Coast Energy Authority.

Project Updates

Renewable Energy Mini-Grids

Over the past year, SERC has been collaborating on the Renewable Energy Mini-Grids for Improved Energy Access project with researchers from Lawrence Berkeley National Laboratory (LBNL), Energy and Resources Group (ERG) at University of California at Berkeley, Prayas Energy Group and Palang Thai. These efforts are in support of the Global Lighting and Energy Access Partnership (Global LEAP) initiative associated with the Clean Energy Ministerial.

Renewable energy-based mini-grids offer a significant opportunity to increase access to reliable electricity services for rural populations throughout the developing world. A mini-grid is a village-scale electrical distribution system served by an isolated generator of up to a few hundred kW in capacity. Power on these grids is often provided by diesel generators, but can be supplied by local, renewable resources such as microhydro, solar, biomass or wind. Mini-grids offer an intermediate solution between stand-alone individual home power systems and main grid connection, and often prove to be more cost-effective and beneficial to the community than either of those alternatives.

Top to bottom: A biomass gasifier mini-grid and solar mini-grid in India.

Our team recently produced three documents to help inform delegates participating in

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Project Updates *(continued from page 3)*

the Mini-Grid Development roundtable discussion at the fourth Clean Energy Ministerial (CEM4) in New Delhi in April. CEM4 brought together energy ministers from 23 of the world's leading economies, along with business leaders, NGOs and academia to discuss policies, technologies, investment, and skills needed to achieve the CEM's goal of "accelerating the transition to a global clean energy economy." Our team's contributions included:

- **Sustainable Development of Renewable Energy Mini-Grids for Energy Access: A Framework for Policy Design**, which provides a review and critique of mini-grid policies from several countries and offers recommendations for national policy design to support the development of mini-grids.

- **A Guidebook on Grid Interconnection and Islanded Operation of Mini-Grid Power Systems Up to 200 kW**, which is intended to help meet the widespread need for guidance, standards, and procedures for interconnecting mini-grids with the central electric grid as rural electrification advances in developing countries.

- **Review of Strategies and Technologies for Demand-Side Management on Isolated Mini-Grids**, which discusses different measures available to help with load management on isolated mini-grids.

These documents are available on the SERC website at www.schatzlab.org/projects/developingworld/minigrids.html.

Lighting Lab Welcomes New Student Assistants

We are pleased to have two undergraduate Environmental Resources Engineering students, John Hunter and Melissa Lancaster, working in the lighting laboratory this summer. John and Melissa will conduct various testing procedures to assess the quality of solar off-grid lighting products. The tests include checking product ratings, measuring product parameters such as run time and solar power, testing product durability, and examining a product's lighting service in terms of longevity and total light output. The test results support the Lighting Global Quality Assurance Program, which is closely associated with the Lighting Africa and Lighting Asia programs. The goal of Lighting Global is to support the entry of quality solar off-grid lighting products into rural markets around the world. It is a joint initiative of the International Finance Corporation (IFC) and World Bank.

Research Engineer Kristen Radecsky *(right)* explains to John Hunter and Melissa Lancaster how to measure a solar module's IV curve to capture its maximum power point.

From the Director *(continued from page 2)*

Program was recently accepted by the Western Regional Graduate Program (WRGP), which means that students from eligible states will be able to attend HSU at a cost equivalent to the rate for California residents. This makes the ETaP and ERE graduate program options much more affordable for students from these states. This is great for SERC, as it will help us recruit talented students from western states such as Oregon, Washington, Colorado, Alaska, Hawaii, and others. More information is available on the ETaP and ERE graduate program websites. Goodbye until next time.

Bio-Energy Research *(continued from page 2)*

Specifically, this project explores the use of aqueous phase reformation reactions that directly process sugars and operate at lower temperatures than the gas phase reformation reactions that are being investigated for waste heat recovery elsewhere. Sugars can be produced from virtually any cellulosic biomass, including waste resources such as forestry slash, lumber mill waste, crop residues, portions of municipal solid waste, yard waste, etc. By operating at lower temperatures, aqueous phase reformation has the potential to recover significantly more waste heat compared to gas phase reformation reactions.

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.

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