Schatz Energy NEWS Fall 2018

Anh Bui and Greg Ball leverage a module into position

The Schatz Center roof goes solar

On the last weekend of September, Schatz Center alumnus Nate Coleman returned to Humboldt State with a team of solar professionals to lead the installation of a photovoltaic array on the roof of the Schatz Center. Dodging between downpours, and assisted by Center staff, students, and HSU Facilities Management personnel, the team heroically completed the installation in two days.

The 20 kilowatt (DC) array will produce an average of 57 kilowatt-hours per day, enough to completely power the Center's new West Wing and electric vehicle charging station.

The eighty modules of the solar array and the proprietary mounting hardware and connectors were donated to Humboldt State from Zep Solar through the efforts of Coleman and Jack West — a member of the Center's Advisory Board and also an alumnus of the university.

Later this year, an array display will be installed outside the Center. Visitors will be able to see a live report of energy generated by the array, plus rooftop weather data that directly impacts array efficiency: solar radiation, air temperature and relative humidity, wind speed and direction, and the temperature of the modules. The monitor will also feature project news from the Schatz Center and data from the onsite EV charging station.

The interpretive display has been funded by HEIF, the student-run Humboldt Energy Independence Fund, and NorthCAT, the Northern California Center for Alternative Transportation Fuels and Advanced Vehicle Technologies. HEIF also provided the instrumentation for the data acquisition system.

Many thanks to our solar installation team — especially Brian Atchley, Greg Ball, Nate Coleman, Marcelo Macedo, and Ryan Woodward for bringing their installation expertise to Humboldt!

Features

The twice annual newsletter of the Schatz Energy Research Center

HUMBOLDT STATE UNIVERSITY

A message from the Director *Arne Jacobson*

The Camp Fire in Butte County has been the most damaging wildfire in California history. Hurricanes, wildfires, cyclones, floods, and heat waves are taking a heavy toll on communities around the globe. While no single weather event can be linked directly to climate change, weather disasters as a whole are expected to become increasingly common and destructive as climate change progresses.

The Intergovernmental Panel on Climate Change's (IPCC) recent special report on the prospect of limiting climate change to a 1.5°C global average temperature rise relative to pre-industrial conditions indicates that global net human-caused greenhouse gas emissions need to decline before 2030 by about 45% relative to 2010 levels. It is imperative that we do all we can to make progress toward this goal given the expected damages associated with a failure to do so. Simultaneously, given the climate disruption that is already baked into the system, actions to reduce vulnerability and increase resilience to climate damages are also needed.

Our work at the Schatz Center is strongly motivated by these challenges. Our renewable energy microgrid work combines efforts to integrate more solar power into the electrical grid while increasing resilience for critical infrastructure including emergency response centers, fuel stations, airports, and Coast Guard facilities. Likewise, our upcoming feasibility analysis of offshore wind development along California's northern coast will explore a large potential new clean energy resource for our state. Through these and other efforts, we continue to promote clean and renewable energy and to otherwise take measures to address global climate change.

Measures to address climate change will be most effective if they are crafted by diverse teams from all walks of life. With this in mind, we have also been doing some introspective work at the Center related to staff diversity and an inclusive work environment. We held an all-day retreat in August that focused on these topics, and we have begun implementing measures identified at the retreat and subsequent staff and subcommittee meetings. As we work to make progress, I appreciate the thoughtfulness and initiative that our team has brought to the table. We are committed for the long haul when it comes to making a positive difference regarding diversity and inclusion. The successes that we achieve will make us a stronger and more effective organization.

I will close by welcoming Carisse Geronimo and Grishma Raj Dahal to the Schatz Center. Both are graduate students in the Energy Technology and Policy (ETaP) master's program. Carisse is the first recipient of the Donald and Andrea Tuttle Fellowship for Clean Energy Studies. She is working with Dr. Sintana Vergara and other Schatz Center colleagues on biomass energy, waste management, and associated opportunities to reduce greenhouse gas pollution. Grishma, who received the Schatz Energy Fellowship, is working with our off-grid energy access team on research related to off-grid solar power. We are very glad to have them on our team.

Happy winter holidays, and goodbye until next time.

New Projects

ARI Biochar *Mark Severy*

Biochar has the potential to provide environmental and economic benefits to California's agricultural sector through improved water retention (Abel 2013), carbon sequestration (Brassard 2016), and reduced nutrient leaching (Laird 2010), but realization of this potential is currently impeded by an information market failure (Groot 2017). In August, we were awarded a new project from the Agricultural Research Institute (ARI) to study the biochar market and evaluate how physical characteristics of different biochars relate to their market price. The outcomes from this project will help biochar producers understand how to price their product based on its characteristics, and will help consumers identify the quality of different biochars using informed knowledge and price signals.

The current market size for biochar is estimated around 400,000 tons per year for gardening and landscaping — but it is poised to quickly grow into much larger agricultural sector opportunities where biochar could gain an estimated 2% of the soil amendment market (Sasatani 2018). To achieve this growth, improved information about available biochar products is needed. Currently, many sellers may not receive the full value for their product, and consumers do not know the characteristics of the biochar they are considering for purchase because quality assessment protocols have not been widely adopted. This project aims to understand this market failure and help close the information gap between producers, distributors, and buyers by measuring the characteristics of a dozen biochar products and interviewing stakeholders about desirable properties. By improving the maturity of the biochar market, this project will help California farmers save water and improve crop yield by appropriate, context-specific biochar applications.

Woody biomass before and after biochar conversion

As the first step in this project, Mark Severy attended the U.S. Biochar Initiative 2018 Conference in Wilmington, Delaware to deliver a presentation and connect with key stakeholders. The presentation, *Biochar Quality and Market Assessment: Comparing Physical Properties to Market Value*, provided an overview of the current state of the biochar market and demonstrated how price is not always reflective of quantitative, measured physical characteristics. Mark connected with many biochar producers who are willing to participate in interviews and contribute samples for testing and analysis.

This work will continue by collecting samples of biochar and conducting measurements to quantify their chemical, physical, and agricultural properties. Before and after the tests, interviews with biochar suppliers and end users will be used to understand how they evaluate the use value of biochar in each context. Results will be disseminated through a webinar and technical report when the project concludes in early 2020.

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Groot, Harry, Jeff Howe, Jim Bowyer, Ed Pepke, Richard, A. Levins, and Kathryn Fernholz. (2017). "Biochar as an innovative wood product: A look at barriers to realization of its full potential." Dovetails Partners, Inc.

Sasatani, Daisuke and Ivan Eastin. (2018). "Demand curve estimation of locally produced woody biomass products." Applied Engineering in Agriculture 34, no. 1: 145-155. doi: 10.13031/aea.12392

New projects, continued from page 3

Energy Paths for the Yurok People *Jim Zoellick*

We recently helped the Yurok Tribe secure a $180,000 contract from the U.S. Department of Energy and we are now working together to develop a Yurok Tribe Strategic Energy Action Plan. This plan will support the tribe's efforts to increase energy efficiency, develop local renewable energy resources, reduce energy costs, and meet energy needs on the reservation. First we will identify potential energy projects that can help achieve these goals. This list will then be screened and prioritized based on technical feasibility, cost, likelihood of being funded, and other criteria. Finally, we will work with the Tribe to select a few key projects where we will develop preliminary design and cost information sufficient to "queue them up" for future funding and deployment.

Our work will be split between two key regions of the Reservation – the Klamath region at the mouth of the Klamath River (served by Pacific Power), and the upriver region near Weitchpec (served by Pacific Gas & Electric). Projects will be identified in these two regions that can provide economic, environmental, resilience, and energy security benefits. These may include community solar installations with energy storage, micro-hydropower, microgrid technologies, and participation in aggregate net metering programs. The Yurok Tribe has been working for years to make sure all tribal members on the reservation have access to reliable, affordable, modern, cost-effective energy services. This project aims to outline a clear path to achieving these goals.

Project Updates

Solar+ project continues in Blue Lake *Peter Alstone*

The Solar+ project at the Blue Lake Rancheria (BLR) hit high gear this summer, with activity across our research and design areas — from engineering to market assessment. Our project is at the halfway point, with construction underway and plans afoot for experiments to run once we are operational next year. It has been rewarding to see progress towards a standardized package for microgrids at the individual building scale.

Over the summer, our engineering designs came into form as the PV array was installed at the Rancheria's "Playstation 777" fueling station and convenience store. Our partners at BLR have been working closely with us to coordinate the construction and installation of a 60 kW array of high efficiency SunPower modules on the fueling area canopy. Later this year we will install control devices, switchgear, and other microgrid components.

In parallel to our work designing and installing the microgrid hardware, project partners at Lawrence Berkeley National Lab (LBNL) have been developing the control software that will eventually manage the microgrid. Building off the open source XBOS ("Extensible Building Operating System") framework, the LBNL team has been adding model-predictive control and communications features needed to optimize the operation of our energy systems. We are in the testing phase for this software now, and look forward to its installation and operation in 2019.

Completed PV module installation at the Solar+ site

Along with our progress on the prototype installation for our Solar+ microgrid design, we have been synthesizing our overall experience in microgrid design and development. Our cross-site analysis is helping us model the current costs and benefits of microgrids based on the characteristics of a site — and we are looking ahead to future prices for PV, storage, and integration technology to understand possible deployment pathways for microgrids at scale.

We made a lot of progress this summer, thanks in great part to a crew of excellent summer research assistants. René DeWees and Ellen Thompson joined our market and data analysis team, and helped model the costs of microgrids (along with big contributions from Jo Caminiti and Thalia Quinn). Craig Mitchell joined the hardware design and construction team, and provided important on-site research observation and engineering support as we worked on building the PV array.

Fuel Cell Vehicle Readiness *Jerome Carman*

Over the last three years, we have been a technical lead for the North Coast and Upstate Fuel Cell Vehicle Readiness Project, in partnership with the Redwood Coast Energy Authority and six local government agencies across eight counties in Northern California. Funded by the California Energy Commission (PON-14-607), this project seeks to support the successful introduction of fuel cell electric vehicles (FCEVs), reduce barriers to the effective deployment of hydrogen fueling infrastructure, and help catalyze a robust regional market for FCEVs. This

project is catalyzed by aggressive California targets to transition the on-road vehicle fleet to zero emission vehicles (ZEVs).

This year, the Center has led the completion of two key project deliverables. The first is a Site Readiness Report that provides recommendations for public fueling infrastructure, focusing on the cities of Eureka and Redding. Led by Greg Chapman, P.E. with support from Jerome Carman, this report provides an overview of:

- state of the art of hydrogen fueling station design,
- current code and safety requirements,
- station design recommendations, and
- a list of recommended locations for the installation of hydrogen fueling infrastructure.

The second is a Micrositing Summary Report which documents past efforts and recommends next steps regarding potential station development locations and stakeholder engagement. Going forward, this report will be used to continue engagement with key stakeholders and catalyze momentum towards the development of fueling stations in the North State.

Currently the project team is engaging with state government fleet managers to leverage aggressive mandates (DGS Memo 16-07, SAM 4121, SAM 4126, EO-18-12) as a way to catalyze FCEV adoption in rural areas.

Student Research 2018

This summer, thirteen students contributed to Schatz Center research projects in smart grids, bioenergy, wind, and off-grid energy access.

SMART GRIDS

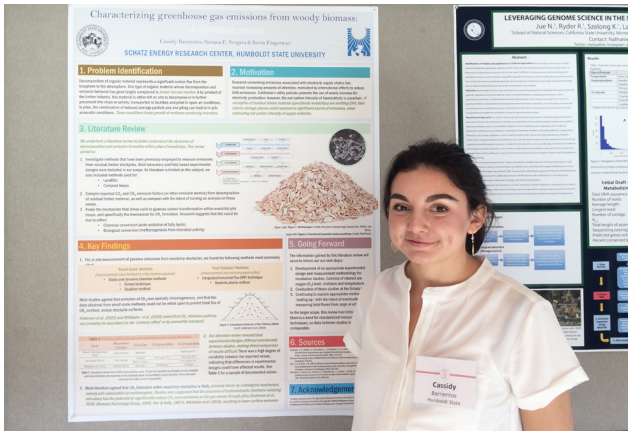
Craig Mitchell provided construction observation at the Solar+ installation, tracking the canopy weight in real-time and serving as an onsite liaison between contractors and the Schatz microgrid team. As part of his observation, Craig recorded the installation's actual daily labor and equipment requirements, to better define the needs for similar projects in the future. He is currently developing a hardware design toolkit that documents lessons learned in the Solar+ installation.

Thalia Quinn, Ellen Thompson, and René DeWees have been developing a model to assess the current and future costs of building microgrids that integrate solar, battery storage, and fast EV charging. This model will help define which sites are good candidates for investment, and identify future research and development opportunities. This summer, the team conducted a detailed literature review to assess current and forecasted cost data: Thalia focused on battery storage, Ellen on electric vehicle charging infrastructure, and René on solar PV. They are now refining their cost model and generating a convenience store survey, to understand how current site owners view microgrids and to better assess installation opportunities.

Smart grid design is also evolving to take advantage of demand response technologies. As part of a collaboration with GE & Southern California Edison, Anh Bui developed an algorithm using Python code for estimating the tension between shifting a customer load to benefit the grid versus shifting a load to reduce their bill. Anh also helped with the installation of our new Schatz Solar Array in September.

BIOENERGY

This summer, Sabrinna Rios Romero quantified decay rates for the post-harvest residues of seven agricultural crops: corn, wheat, rice, cotton, almond, walnut, and grape. These decay rates will allow us to better assess the greenhouse gas (GHG) emission implications of leaving residues in the field versus converting them into electricity. This fall, Sabrinna is surveying state foresters to clarify the fate of forest residues — i.e. whether they are piled, burned, or scattered in the field — information which will allow us to more accurately assess emissions following forest harvest. She has also been analyzing biomass samples using a bomb calorimeter and a thermogravimetric analyzer, to measure the performance of a gasifier system.



Cassidy Barrientos (*above*) conducted a literature review that characterized GHG emissions from wood chip storage (e.g. chip piles at a power plant). Decomposition during storage and the resulting emissions have not been well-quantified, and may represent an important source of greenhouse gases. In September, Cassidy and Schatz Faculty Research Associate Sintana Vergara presented a poster, *Characterizing greenhouse gas emissions from wood chip storage*, and gave an oral presentation *Waste not: Improving the efficiency of using forestry residues as an energy resource* at the ARI Principal Investigator's Meeting in Sacramento.

Continued on reverse...

Student Research 2018, continued from page 5

Max Blasdel continued his ongoing work for the California Biopower Impacts Project. Max is characterizing the field decomposition of woody biomass residues left behind by forestry operations. His efforts comprise a key component of the business-as-usual case used to evaluate the net climate impacts of biomass removal for electricity generation. Max's project research will form the basis for his master's thesis in the Natural Resources program here at Humboldt State.

WIND ENERGY

Karsten Hayes developed an initial cost model (using Python and R) for north coast California offshore wind energy. The model includes associated storage needs, and integrates high-resolution offshore wind resource data from the National Renewable Energy Laboratory with load data for Humboldt County and California, drawn from Pacific Gas & Electric and the California Independent System Operator (CAISO).

OFF-GRID ENERGY ACCESS

Tanya Garcia (*below*) worked in the Schatz Center's off-grid solar lab this summer, conducting solar product tests — including durability (drop and ingress), safety, and truth in advertising (light output, max power, full battery run time, etc.). She developed communications templates for the test lab network and edited specifications sheets to clarify product test policies. Tanya also helped test an open source electricity monitor, the EmonPi, and provided energy outreach activities for university and K-12 groups. Tanya is continuing her work in the off-grid solar lab this fall.

Eli Wallach and Chih-Wei Hsu developed a method to estimate the number of fossil fuel generators used in low- and middle-income countries, how much electricity they generate, and how much fuel they consume. Their work supports a larger effort to estimate the economic, environmental, and health impacts of fossil fuel generator systems used as a primary or backup source of electricity. To inform their assumptions and approach, they drew from multiple sources of data, including dozens of nationally representative household and business surveys. These data helped them understand the intensity of generator use at the country level, and in which sectors they are being utilized (i.e. commercial, residential). Eli and Chih-Wei's fuel consumption estimates for over 130 countries are currently being utilized to update a widely used air quality and climate impacts model maintained by project collaborators at the International Institute of Applied Systems Analysis.

Schatz fellow Anamika Singh worked this summer with a team led by Dr. Amol Phadke at Lawrence Berkeley National Laboratory. Her research, which included collaboration with Dr. Phadke and Dr. Nikit Abhyankar, focused on identifying the parity price at which renewable energy technologies become feasible for heavy industries in India. Chih-Wei and Anamika also helped with our Schatz Solar Array installation in September.

From the Fellows *Anamika Singh*

I am a second year graduate student in the Energy, Technology and Policy program here at HSU. I am also a recipient of the Blue Lake Rancheria fellowship for clean energy studies and a graduate research assistant at the Schatz Center. My primary interest lies in providing electricity access to rural communities through renewable energy technologies. I am writing my thesis on identifying the techno-economic feasibility of solar water pumping for public facilities in rural parts of Nigeria. At the Center, I am working on the development of a quality assurance framework for these systems, to provide guidance for gathering necessary data, assessing the hydro-geologic conditions, and designing an off-grid groundwater extraction and delivery system.

Before coming to HSU, I worked as a project engineer with the Bureau of Energy Efficiency, Government of India. My work primarily revolved around promoting energy efficiency in small and large industries and appliances. This summer, I began research at the Lawrence Berkeley National Laboratory focused on identifying the electrification potential for heavy industries, including cement, iron, and steel, in India. The project aims to identify the parity price at which electrification via renewable energy technologies can become feasible – with the end goal of reducing coal demand and mitigating CO_2 emissions.

Lighting Global Quality Assurance: Project Updates

Updates to test method and standards

Scott Toyama

As a growing and dynamic industry, the off-grid solar market encompasses a wide diversity of product quality. Some products are designed and manufactured well, while others fall short of expectations for safety, durability, or performance. In many households, purchasing an off-grid solar product is a major financial decision. Poor quality products can lead to market spoilage — in which consumers lose trust in an entire technology. Product standards and testing provide quality assurance for consumers, and support those companies who follow best practices in manufacturing and design.

Starting in 2007, the Schatz Center, working in collaboration with the Fraunhofer Institute for Solar Energy Systems in Germany, helped develop a set of test methods for evaluating off-grid solar product quality. In 2013, a revised version of these test methods was published by the International Electrotechnical Commission (IEC) under IEC TS 62257-9-5. Since 2009, we have worked closely with Lighting Africa, Lighting Asia, and Lighting Global World Bank Group initiatives to develop an international program for quality assurance and consumer protection for LED-based off-grid lighting and power systems.

Recent developments:

- In 2018, we updated the test methods to include a more robust analysis of ports and appliances. This new version of the IEC TS 62257-9-5 was published in June.
- The Schatz Center renewed and expanded our ISO 17025 accreditation through the ANSI-ASQ National Accreditation Board (ANAB). We are one of three off-grid solar testing labs internationally accredited to conduct testing according to the new version of IEC TS 62257-9-5.
- We recently submitted the Lighting Global Quality Standards to the IEC for adoption. Having these standards published by the IEC will create an easier path for government adoption and will help limit the sale of poor quality products in the market.

Quality Matters: a new report

The Lighting Global Quality Assurance Program works to ensure that solar products sold around the globe meet established quality standards for product durability, representation of product performance, and warranty. To obtain quality verification, manufacturers may submit products for testing at laboratories in the Lighting Global network.

Pico-solar products include lanterns and simple systems with a peak PV module power up to 10 watts. These small systems encompass 85% of the global cumulative sales of off-grid solar devices. Although more than 30 million quality assured off-grid solar products have been sold globally over the past eight years, the sales numbers for products that do not undergo quality verification (hence are "non-QV") is even higher. Field observations and customer experiences indicate that non-QV products typically underperform compared to the standards established by Lighting Global.

In order to ascertain the actual performance of these devices, Lighting Global laboratories recently tested 17 pico-solar non-QV products that are top-sellers in Ethiopia, Kenya, Myanmar, Nigeria and Tanzania. Products were purchased direct from market retailers.

Key results:

- All 17 evaluated products failed to meet the Lighting Global Quality Standards for pico-PV products.
- 94% of the tested products failed to meet the Standards due to one or more deficiencies that affects product durability.
- 88% of the tested products inaccurately advertised product performance.
- 88% of the tested products did not include a consumer-facing warranty.
- 76% of the tested products would require significant changes to product design and components to meet the Quality Standards.

The Lighting Global Quality Assurance team issued the report this August as part of the Technical Notes series. Chris Carlsen (a Schatz Center alumnus) led the effort in collaboration with team members from CLASP, the Schatz Center, World Bank Group regional lighting programs, and the Lighting Global network of test labs.

Northern CA coast offshore wind feasibility study

Mark Severy

On October 25, we were awarded a grant from the California Ocean Protection Council (a division of the California Department of Natural Resources), to study the feasibility of offshore wind generation for the Northern California coast. The $623k grant will assess the environmental impacts, determine the required modifications of coastal infrastructure, examine stakeholder benefits and impacts, and evaluate local, state, and federal policies as they relate to offshore wind development.

Offshore wind energy is likely to play an important role in meeting California's targets for carbon neutrality by 2045. The offshore wind resource near Humboldt Bay is among the best in the nation, with wind speeds often exceeding 10 meters per second at 90 meters above the ocean's surface (Schwartz 2010), which is the approximate height of wind turbines. The National Renewable Energy Laboratory estimates that the state's offshore winds have the technical potential to produce 392 TWh per year, about 150% of California's annual electricity load (Musial 2016).

Analysis of north coast wind speed data has shown that the wind power is fairly consistent throughout the day (Musial 2016) when compared to other renewable resources such as land-based wind or solar. Offshore wind could provide a more consistent power flow to the grid, which in turn would support increased integration of technologies with highly variable generation throughout the day, such as solar. But California's deep ocean floor, sensitive ecosystems, seismic activity, and protected coastlines, will require careful research and development in order to responsibly develop offshore wind projects. Engaging California's coastal communities — who have the most to lose from sea level rise due to climate change — in early research and planning is critical for successful future development efforts.

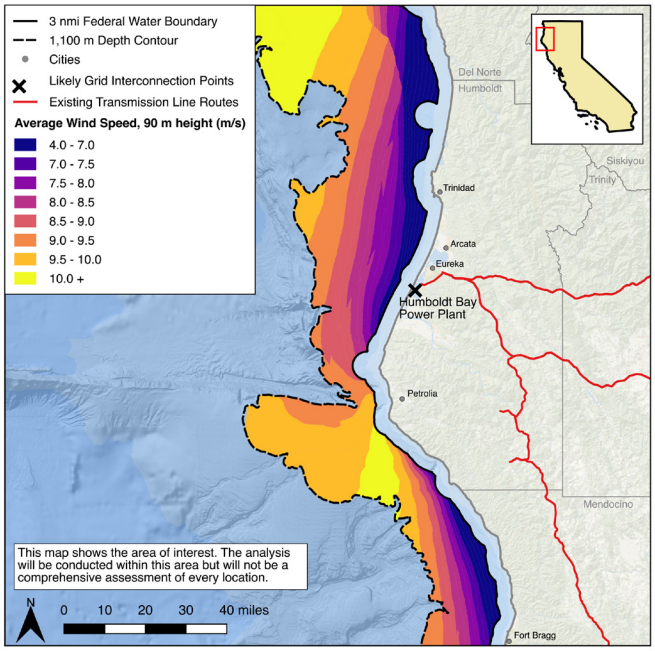
The project is expected to kickoff in early 2019. For this project, we are collaborating with ecological consultants from H.T. Harvey and Associates, coastal engineering specialists from Mott MacDonald, and faculty in the Economics and Environmental Science & Management departments at Humboldt State.

References:

Musial, Walter, Philipp Beiter, Suzanne Tegen, and Aaron Smith. (2016). Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs. No. NREL/TP-5000-67414. National Renewable Energy Laboratory, Golden, CO.

Schwartz, Marc, Donna Heimiller, Steve Haymes, and Walter Musial. (2010). Assessment of Offshore Wind Energy Resources for the United States. No. NREL/TP-500-45889. National Renewable Energy Laboratory, Golden, CO.

The feasibility analysis will cover selected areas in this region



For the latest project announcements and updates, subscribe to our online newsletter at

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The mission of the Schatz Energy Research Center is to promote the use of clean and renewable energy.

The Schatz Center is led by Arne Jacobson (Director), Peter Lehman, (Founding Director), and Charles Chamberlin (Co-Director). Our team of approximately 40 people includes faculty and research associates, engineers and professional staff, student research assistants, and volunteer docents. Our expertise includes design, deployment, research, and policy development in off-grid energy access, renewable energy systems, smart grids, bioenergy, and clean transportation.

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