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ERE MESSENGER

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ERE Program Strength: Energy Resources

by Peter Alstone, PhD (MS ES-ERE 2009), ERE Assistant Professor

In ERE, our energy resources focus area is unique among environmental engineering programs. The learning and research we do on energy systems spans a range of topics and techniques from multiple disciplines: building energy systems, solar photovoltaic generation systems, hydrogen fuel cells, biomass energy, microgrids, applied thermodynamics, rural energy access, and more. The threads that tie all of this work together are equitable access to clean and renewable energy, and reducing the environmental impacts related to energy use. That is why we do this important work as environmental engineers!

The ERE energy topic includes an evolving set of course offerings and a growing portfolio of research that focuses on the most important topics in this fast-changing area. The courses include fundamentals that every student needs, along with opportunities to learn about the design of cutting edge systems. Many of those design projects are influenced by work that goes on at the Schatz Energy Research Center, the hub of clean energy research at Humboldt State. The close connection between the classroom and the Schatz Lab is a mutually beneficial process. Students and faculty learning and working in this area continue to push the cutting edge, as the world's energy systems are transitioning from dirty fossil fuels to clean energy.

ERE undergraduate (left) and ETaP graduate student researchers on site during construction of the Blue Lake Rancheria Community Microgrid in the summer of 2016. Photo by K.J. Brown

This is the second in a series of articles about ERE Program Strengths. Next up: Water Resources

History of ERE Energy Resources

At HSU, we have known for a long time that energy resources are critically important pieces of the sustainability puzzle, but it has taken a while for the rest of the world to catch up. The focus on energy systems in ERE began in the late 1970's, in the wake of the oil and energy crisis from earlier in that decade. Finally realizing that

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FROM THE EDITORS

Hello from the Messenger staff! We hope you enjoy this Spring 2020 edition.

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"The society that scorns excellence in plumbing because plumbing is a humble activity, and tolerates shoddiness in philosophy because it is an exalted activity, will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water."

John W. Gardner
author and statesman
(1912-2002)

Alumni Profiles

Dave Roberts, PE

BS ERE 1989
Manager
Residential Buildings Research Group
Buildings and Thermal Sciences Ctr
Nat'l Renewable Energy Lab (NREL)
Golden, CO

I always enjoyed word problems in math classes, and I think it was that and high school physics that led me into engineering. After trying electrical engineering at San Jose State University and solar architecture at U.C. Berkley, I found HSU ERE and was intrigued by the energy emphasis, particularly the solar and wind energy courses. I enrolled in the program in 1985.

In support of the cover story
ERE Program Strength: Energy Resources
the three alumni profiles in this Messenger edition are all in the area of Energy Resources

I was immediately impressed with the learning environment in ERE. With smaller classes, and professors who were there to teach, it contrasted sharply with SJSU and Cal. Mike Anderson, Peter Lehman, Mac McKee, and Charles Chamberlin were all challenging and inspirational. I finished my degree in 1989, intent on obtaining a PhD and teaching the next generation of solar engineers. I was accepted as a PhD candidate at the University of Colorado (CU) and continued studying solar energy and building science. Arriving at CU, I soon started working for Architectural Energy Corporation (AEC), a small consulting firm in Boulder. My primary job there was running building energy simulations in support of designing new commercial buildings. By 1991, I had finished my Master of Science and decided not to pursue the PhD. Instead, I went to work full time for AEC.

During my 19 years at AEC, I had three mini-careers. The first was modeling commercial buildings to provide energy-related guidance to the design process. One high-profile building I modeled is the Denver International Airport landside terminal. My second position involved writing software to automate building energy modeling in support of utility demand-side management (DSM) programs, particularly the California investor-owned utilities. My final position at AEC was managing the REM/Rate home energy rating system (HERS) software product and working closely with the HERS industry organization, RESNET, to develop standards for the newly emerging industry. By the time I left AEC in 2008, approximately 200,000 new homes per year were being rated using REM/Rate and RESNET standards. During that time, I worked with fellow HSU ERE grad Rob Salcido ('90), who took over management of REM/Rate when I left.

In 2008 I joined the National Renewable Energy Laboratory (NREL) in Golden, Colorado to continue developing residential building energy modeling software. NREL is the only USDOE national laboratory focused exclusively on energy efficiency and

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renewable energy. I currently serve as Manager of the Residential Buildings Research Group, which consists of 30+ talented engineers and scientists working to develop new innovations and solutions aimed at improving the efficiency and flexibility of new and existing residential buildings. Results of the research being conducted in our group include BEopt building energy optimization software, ResStock building stock modeling software, the Foresee™ home energy management system, and Eco-Snap AC (the last three all being R&D 100 Award winners). We also host the Solar Decathlon Design Challenge (formally the Race to Zero Student Design Competition). HSU has had several teams compete as finalists in the past few years.

The current overarching focus of our group's research, and much of NREL's, is modernizing the U.S. power grid to accommodate higher penetrations of variable, renewable generation. Buildings in the U.S. consume 75% of the electricity produced by the grid, and thus can play a significant role in accommodating renewables. Much of our current research is focused on load flexibility – optimally integrating energy efficiency, power generation, thermal and battery storage, and control into homes to optimize *when* energy is used. We are striving to create homes that can maximize energy usage from clean energy sources and minimize energy usage from fossil sources while maintaining comfort and convenience for occupants.

I look back fondly on my days at HSU, and I've always appreciated the close relationships and intimate learning environment provided by the professors there. I've been traveling down memory lane lately as my oldest daughter, Emma, started at HSU last fall, double majoring in International Studies and French. She's sending pictures from all my favorite beaches and redwood groves. Those were grand times! Ω

Andrea Alstone

MS ES-ERE 2009
Energy Planner and Analyst
Office of Sustainability
Facilities Management
Humboldt State University
Arcata, CA

I graduated from UC Santa Barbara with a degree in physics, and was lucky to land a job working as a technician in the high energy physics group helping to construct the CMS experiment that was going to be installed on the Large Hadron Collider at CERN, the world's premiere particle accelerator located near Geneva, Switzerland. I enjoyed my time in Santa Barbara, but I wanted to do something to address climate change and advance renewable energy, and this led me to investigate the ERE program at HSU. On my first visit I found myself in the community forest, and I knew this was a place I would enjoy.

I arrived at HSU in the fall of 2005 to start the ERE master's program, and at the end of my first year was fortunate to land a position as a research assistant at the Schatz Energy Research Center (SERC). There I got more hands-on experience building fuel cell testing equipment, working to modernize the solar powered fuel cell system at the Telonicher Marine Lab, and managing HSU's hydrogen fueling station. Shortly before completing my degree, I married Peter Alstone, a fellow ERE grad student and research assistant at SERC.

After a few years at SERC, Peter decided to pursue a PhD at UC Berkeley, and we headed for the Bay Area. My job search landed me at Lawrence Berkeley National Lab (LBNL), working in the appliance standards group which supports the Department of Energy's energy efficiency standards work. My work there involved looking at the national economic impacts of setting efficiency standards for lighting products at various levels. It was an interesting time to be watching the national market for lighting products, because LED lights had just started to find their way into the general market in earnest, and prices were dropping rapidly. The last standard I worked on was for general service lamps, the kind that probably comes to mind when you think about a light bulb. One of my biggest lessons from my time at LBNL is that people have passionate feelings about their appliances, including even light bulbs.

After 4 years and a PhD from UC Berkeley's Energy and Resources Group, Peter accepted a position in the Environmental Resources Engineering program at HSU. We were moving back to Humboldt! I took a position at the Redwood Coast Energy Authority, working to launch the Community Choice Energy program for Humboldt County. This position brought me down from the ivory tower of national policy and into the public trenches. In this role, I was surprised to find customer services skills I didn't know I had. For many weeks prior to and after the program launch, I found myself on the phone explaining the program to affected customers, ranging from senior citizens to some of the largest energy consumers in the county. I

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also now understand every line on my electricity bill, no small feat if you've ever looked closely at one.

After about a year and half at RCEA, I came full circle and took a position as Energy Planner and Analyst in Facilities Management at HSU. In this role, I monitor campus energy use, work to find ways to reduce it, and help in planning for a more sustainable energy future. I really enjoy putting into practice so many of the skills I learned from my previous work.

Another thing I really enjoy is working with students, especially because many of them are much like I was when I started at HSU. It feels good to pass on some of the knowledge I've gained over the years, and it is a source of inspiration for me to see the enthusiasm and passion that students bring to their work. Ω

Ryan Mayfield
BS ERE 1998
Founder & CEO
Mayfield Renewables
Corvallis, OR

I found myself at HSU through a bit of teenage naïveté and good luck. I applied to HSU primarily because it was as far away as possible from my home in the San Joaquin Valley, while still allowing in-state tuition. I didn't know anything about ERE at the time, and I started as a forestry major. However, luck was with me and I was introduced indirectly to ERE by a friend, and talked with her father who was an environmental engineer in the Bay Area. Hearing about his work and projects sold me on switching majors.

During my time in ERE, the energy resources focus was what really interested me. Photovoltaics (PV) wasn't commonplace yet, but the ERE program gave me good exposure, and I was hooked. Shortly after graduation, I began my career in solar as an installer. It wasn't engineering, but it gave me great hands-on experience. This grew into other industry positions where I really got to dive into PV system design and engineering.

In 2006, I began teaching a three-term PV-specific course at Lane Community College in Eugene, OR. This was a new experience for me, and threw me headfirst into a love for teaching and PV training. In 2007, I decided I was ready to venture out on my own, and I started Mayfield Renewables. Thirteen years later, I have been able to build a company with 11 employees and growing.

One of our two core missions at Mayfield Renewables is promoting the advancement of PV technologies, and I've been able to do that partly through educational projects. I've written numerous articles for SolarPro and Home Power magazines. I also wrote PV Design and Installation for Dummies. I continue to teach courses on PV-specific topics for industry professionals across the country.

Our other focus is PV system design. Our core clients are electrical and PV contractors who need help with PV system design, permitting and construction packages. We've been involved in small residential projects all the way up to multi-megawatt commercial systems.

The PV industry is changing rapidly, and advancements occur often. One area the business has grown into recently is resiliency projects and micro-grids. We work across the country, helping clients to understand their concerns and goals when designing micro-grid projects. It's especially rewarding to work with agencies charged with supporting the public in times of emergencies, and helping them meet their objectives.

In late 2019, I expanded my company to include technical content development. We now work with manufacturers of PV and clean tech equipment to educate the industry and their customers on specific products. This includes technical writing, presentations, and creating content for use in social media platforms. It's an exciting way to help bring to life the engineering and technical side of the industry for industry professionals.

You shouldn't be surprised to learn that the solar industry is full of ERE graduates. I've reconnected with former classmates at industry events and through social media. We are spread out in various segments of the industry, and we all seem to hold a special place in our hearts for our time at HSU and the ERE program.

I am fortunate to have been able to spend my entire professional career in solar, and am very thankful for my time at HSU, especially for ERE giving me the encouragement and desire to be in such a fun and dynamic industry.

My family has an annual tradition of camping in the redwoods, and I return to Arcata with them each summer and visit campus and Los Bagels, and find new favorite Humboldt spots. Ω

Anticipate and Avoid

Meet ERE Lecturer Bob Brown

by Bob Brown, AICP, ERE Lecturer, and Planning Principal, SHN, Eureka, CA

Spring 2020 marks my eigth year co-teaching ENGR 410, Environmental Health and Impact Assessment. I am responsible for the Environmental Impact Assessment (CEQA/NEPA) portion of the class. For four years prior to this, I taught the similar EMP 410 class for the Natural Resources Department.

How did I get started in CEQA/ NEPA? I first arrived at Humboldt State University in 1979 as a student in the Natural Resources Planning program. Shortly after graduating in 1981, I remember asking about employment opportunities at a local engineering firm. I was pulled into an office and the first (and only) question I was asked was "What do you know about CEQA?" At the time I knew nothing of the then 12-year old legislation, and I didn't get hired. After that I learned what I could, and several years later I started to practice CEQA.

The Einstein Quote "We cannot solve our problems with the same level of thinking that created them" is especially relevant to ENGR 410. What is stressed in this class is getting away from the 'assessing and fixing' mentality that so much of engineering seems focused on these days, to developing thought processes necessary to 'anticipate and avoid' environmental problems. While CEQA/NEPA is focused on fixing problems on existing projects, the intent of the legislation was to incorporate design elements that anticipate and avoid environmental risks (and thereby minimize the CEQA/ NEPA process).

I recently pondered the question: "how on earth did I end up doing CEQA/ NEPA?" I could see early evidence. 'Anticipating and avoiding' has long been a part of my life. My parents emigrated to the United States post World War II from Scotland and Ireland, and much of my childhood in Oak Park, a village outside Chicago, Illinois, was spent combing the surrounding forest preserves, capturing critters in the ponds and prairies, and monthly camping with my Boy Scout troop. This not only gave me an appreciation for the outdoors, it also got me out of the house, avoiding chores and family drama.

Starting in high school, I worked several years at the Art Institute of Chicago in downtown Chicago. While I received an informal education in art history during that time, I mostly remember taking public transit past the housing projects and learning about Chicago's rich history in urban landscapes. While impressed, I realized early on that city life was not for me. While at the University of Illinois, I was preparing to go into Oceanography with the intent of getting into UCSD Scripps Institute of Oceanography. What became apparent to me in that process was that people were pretty much still 'studying' the ocean and nobody was actually 'living' in this vast region. I realized then that I wanted to be in a field of applied knowledge, and I switched my direction. However, I was still drawn toward the Pacific Ocean.

And so my journey west began. In 1976, I bought a '68 Chevy van, fixed it up to live in, and headed west on a six-month journey. While picking pears in Brewster, WA in October, my intent was to turn right and head north to Alaska. I was persuaded by people who spent the summer in Alaska (and were heading south) to avoid the winter there, and so instead I turned left. I reached California, spent a week in the

Made it to the top! Bob Brown (right) with his two sons on Half Dome, Yosemite National Park, in July 2016.

redwoods and on the Smith River, and then drove along the coast and, for the first time, through Humboldt County.

When I returned to Humboldt in 1979 to finish college at HSU, my intent for my selected coursework was to eventually move someplace off the grid. My years at Humboldt began with living in my Chevy van (today it is considered being homeless; then it was an adventure). I got kicked out of some of the best of places in town, including the Arcata Marsh, but finally found places to park and reside in my van for the next two years. At times, I did 'live in a van down by the river.' While at Humboldt, I also had an opportunity to spend two summers doing conservation work on Prince of Wales Island, near Ketchikan, Alaska, thereby fulfilling a long-term goal.

In my senior year I received an internship with Arcata Public Works Department developing the recreational portion of the then newly-constructed Arcata Marsh and Wildlife Sanctuary. I was responsible for developing the original signage, including painting the original entrance mural and map, developing the regulations, constructing the trails with a front-end loader and dump trucks, and designing the upland planting plan. Since then (for the last 40 years), I have volunteered for the City of Arcata on what is currently called the Arcata Wetlands and Creeks Committee.

With graduation and a degree in Natural Resources Planning around the corner, I began to wonder (a bit late in the game!) what planners actually do. I had school debt and was tired of having no money, plus I actually started to like people and wasn't so interested in going off grid anymore. And so the job search started. Having had so many jobs out of college, I realized I had become 'stuck' in Humboldt County, but then that was by choice.

Eventually, I began working as a planner for Omsberg & Company, a local engineering company, and that is when I bumped into CEQA/NEPA, which became a necessary survival skill that has kept me employed these last 35 years. Ten years later, I started Streamline Planning Consultants, which primarily focused on rural planning and CEQA projects, and for the next twenty years I maintained a staff of 7-10 people in Arcata. While I provided municipal planning for the cities of Blue Lake and Trinidad, I also completed the permitting for many in-stream gravel and rock quarry projects and became involved in river monitoring, environmental assessments, and designing restoration projects on the Mad, Eel, Trinity, Smith and Klamath Rivers. While at Streamline Planning, I also had an opportunity to travel to China with a planner's group, and twice visited Haiti (first time right after the January 2010 earthquake), looking at how a children's ministry could become more sustainable.

In 2016, Streamline Planning merged with SHN to become the planning and biological arm of that firm. SHN is well equipped to take projects from the initial designs, through permitting, and finishing with construction management and monitoring. The merger has opened the door to working on many diverse projects in Northern California and Southern Oregon, and with a team of more than 100 people, can provide for the needs of just about any project. I have been part of a team writing the EIR for the removal of the Klamath Dams and working with municipalities in responding to the State's housing crisis. SHN is currently part of a team begining to assess impacts related to the Last Chance Grade realignment, and is finishing biological monitoring of the Willits Bypass.

It has always been important to me to be involved in the projects near where I live and work, to make a difference. During my career, I completed the environmental assessments for numerous local businesses, subdivisions and housing developments. Arcata projects include Cypress Grove Chevre, Plaza Point, Footprint Recycling, Goodman Winery, Arcata Theater Lounge, McKinley Statue Removal, Village Student Housing, and Creekside Homes.

So why ENGR 410? I ask my students each semester why they think environmental impact assessment is important for someone in Environmental Resources Engineering. The most rewarding part of knowing the class material is that one has an opportunity to apply the information to redesign or new projects in a manner that will have minimal environmental impact, by anticipating and avoiding. Ω

Children in Bon Repos, outside Port au Prince, Haiti, in 2011 during Bob Brown's visit to a children's ministry.

ERE Enery Resources

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oil, coal, and gas were not going to be cheap and abundant forever, people all over the world were taking action to better understand and plan our energy systems. Unfortunately, much of this focus was lost in the 1980's, and has only recently been recovered in the face of undeniable climate change. Over the whole period, however, ERE has remained focused on the topic.

Many of the courses and research topics we work on today were started more than 30 years ago. Dr. Peter Lehman was the first professor hired in ERE specifically to focus on energy, and he developed courses in the early days of the program including Thermodynamics II and Solar Thermal (Hot Water) Engineering. Later, he collaborated with Dr. Charles Chamberlin and others to found and direct the Schatz Energy Research Center (http://www.schatzcenter.org).

The ERE energy area also had significant early contributions from HSU Chemistry Professor Dr. Tom Borgers, a physical chemist who worked with researchers at Lawrence Berkeley National Laboratory (LBNL) to develop first-of-its-kind software for analyzing energy use in buildings. This software was was named "DOE" after the sponsor of LBNL, the U.S. Department of Energy. Today, people are using "DOE 2, the second generation of that simulation engine, to help save energy in buildings across the world. Based on this earlier work, Dr. Borgers developed a course on Building Energy Analysis that is still taught in ERE.

The Campus Center for Appropriate Technology (CCAT) was founded in 1978 by students who were focused on appropriate technology, and wanted to create a bridge between academic work and practical applications. The CCAT house and grounds are still active hubs for this activity today. ERE Professor Peter Lehman was the founding CCAT faculty advisor, and many of the early student leaders were ERE students. Over the years the organization has grown to encompass a broad range of sustainability topics, which is emblematic of the way energy touches so many aspects of society.

Through the 1980's and 90's and the turn of the 21st century, the energy aspects of ERE grew to include solar photovoltaics (PV), appropriate technology, fuel cells, and other energy technology systems. Building on that foundation, the energy topics in ERE have evolved to meet the new challenges of climate change, as well as opportunities associated with rapidly improving clean energy technology.

A pair of thermal images captured during a Building Energy Analysis lab exercise involving heat transfer in buildings. TOP: a student operating a blower door that allows measurements of air leaks in a building. BOTTOM: a smiling student illustrates how infrared light does not pass through eyeglasses, but can reflect like a mirror off of a nearby window. Photos by P. Alstone

When the ERE energy program was founded (late 1970s), the cost of solar PV modules was about $70 per watt. It would have cost $300,000 or more to buy enough modules to cover the energy needs of a typical household (and in those days it wasn't allowed to connect them to the grid in any case). Today, the cost of solar is less than $1 per watt and falling, making it cost competitive with conventional generation. These changes didn't happen overnight or steadily, but instead have been the result of many innovations that have accelerated in the last decade. The result is that today we live in a world where clean energy is actually both cheap AND a good idea.

ERE Energy Courses

Today, ERE undergraduates can take a number of courses that delve into topics that are important for careers in the area. First, everyone in the major takes ENGR 331 (Thermodynamics and Energy Systems I). This foundational course is critical for every engineer, since the "laws of thermodynamics" are fundamental to solving any problem that has to do with heat and work. You remember these laws, right? Energy must be conserved (First Law). Two objects in equilibrium are at the same temperature (Zeroth Law). Things tend toward disorder without effort toward order (Second Law).

And, of course, we don't stop with the fundamentals. There are also four design electives that cover a range of energy topics:

ENGR 471: Thermodynamics and Energy Systems II. Learn about power plants, engines, and other machines.
ENGR 473: Building Energy Analysis. Learn to design low-energy buildings.
ENGR 475: Renewable Energy Power Systems. Learn about clean energy generation.
ENGR 478: Electricity Grids and Distributed Renewable Energy. Learn about clean energy and the grid.

Another key course for energy-interested students is PHYX 315: Electronics. This fulfills the science elective in the ERE major, and is a prerequisite for two of the four design electives.

The graduate program for students interested in energy has two pathways to a master's degree in Environmental Systems. The "Engineering" option has a foundation similar to the upper division ERE undergraduate program, and requires additional courses and completion of a project or thesis. The other pathway is the "Energy Technology and Policy" (ETaP) option, an interdisciplinary program focusing on exactly what it sounds like. ETaP students develop skills in considering the broader environmental, economic, and social dynamics at play when people develop and deploy new energy technology. There are some additional course offerings as well: ENGR 532: Energy, Environment, and Society; ENGR 535: Development Technology; and ENGR 533: Energy and Climate. These courses delve deeply into the intertwined systems of technology, ecosystems, industrial policy, and social science.

The world faces a wicked problem in replacing conventional energy systems quickly enough to stem the tide of climate change. Here at HSU, ERE students are preparing to contribute, using tools ranging from the foundations of thermodynamics to advanced design elective applications and graduate program courses.

ERE Energy Research

The courses we teach in ERE are directly shaped by the vibrant energy research community we have built here at HSU and on the North Coast.

Almost all of the research on energy systems by ERE faculty is done through the Schatz Energy Research Center. At the Schatz Center there are currently active research programs in Off-grid Energy Access, Microgrids, Bioenergy, Transportation, and Offshore Wind. In these topic areas, there are a number of projects that bring together faculty, staff, and students to answer scientific questions and drive the state-of-the-art forward in engineering and systems integration. Over the years, the Schatz Center has developed a reputation as a place where policy analysis, lab work, systems engineering, and field testing are done under the same roof to high standards of quality. This broad skillset is critical for us to continue making significant advances.

One of the emerging areas of research is Offshore Wind power. This is particularly exciting because of the potential for our region if the resource turns out to be favorable for development. There is a world-class wind resource off the coast of Northern California, and Eureka is the only working port for hundreds of miles that could support developing the floating offshore wind platforms that are being considered. There are current projects at the Schatz Center focused on better understanding the scale of the opportunity, the costs, and potential environmental impacts. This work will support decisions being made in the near future that will determine if large-scale wind will be built and supported out of Humboldt Bay. Participating students are doing work that is critical for success of the project: environmental mapping, working to understand the floating wind technology, and assessing the quality of the wind resource.

Offshore wind is just one example of the impactful energy research being done by ERE faculty, students, and alumni. ERE faculty members currently involved in energy-related research (and teaching focus) are: Peter Lehman, Charles Chamberlin, Arne Jacobson, Peter Alstone, Liza Boyle, and Sintana Vergara.

The energy research at HSU doesn't stop at the campus boundary. Our projects often include local partners and field deployment. Working with the Blue Lake Rancheria tribe, researchers from the Schatz Center have designed and built innovative microgrids that are advancing the standard for resilient clean energy sys-

tems. Redwood Coast Energy Authority is a common partner on projects, ranging from biomass power to electricity planning. Next time you ride the bus in Humboldt county, check to see if it is electric. The Humboldt Transit Authority has been working with ERE researchers to understand and manage the transition from diesel to a clean energy fleet.

ERE Energy Clubs and Activities

There are five HSU student clubs associated with ERE, and all have their own special interests and verve. One of these clubs has a focus on energy systems technology topics. The Renewable Energy Student Union (RESU) was started by students in 2004 to make sure energy systems remained a focus for ERE, and also to support more opportunities for student involvement at the Schatz Center. I was a student member in those early days, and proudly helped write the original club constitution. Over the years, RESU has participated in many regional and national energy-based competitions, and notably won first prize in the 2005 National Hydrogen Association Student Design Competition. This achievement indirectly led to construction of a hydrogen vehicle fueling station on the HSU campus. RESU has continued to be a place where students come together to work on energy-related projects and ideas.

A look back at historical RESU activities circa 2006: RESU Faculty Advisor Professor Arne Jacobson (front row, center) with student members and supporters at a wind monitoring tower they installed in Kneeland, CA. Fun fact: James Apple (back row, second from right) has made a career of wind monitoring and assessment at DNV GL in San Diego, and now manages a team of programmers developing new tools for assessing large-scale wind and solar projects all over the world.

Another outgrowth of the energy topic area in ERE is HSU's Humboldt Energy Independence Fund (HEIF). This fund is paid for by student fees and provides support for projects on campus that promote and take action toward reducing the impacts of energy use. ERE students were among those who helped get HEIF on the ballot and passed, and have been instrumental throughout its history as proposal writers and student employees. Did you know that you can write a proposal for a clean energy project, then get paid by HEIF to develop the idea and figure out if it can work on campus?

Closing

Between a unique set of courses, world class research, clubs, and broader campus activities, Humboldt State is a great place to be for learning about the engineering of clean energy systems. Looking forward, the transition to electric transportation, continued deployment of cheap renewable energy, and other "megatrends" are tending toward topics where ERE students and faculty will be well-prepared to contribute.

What new courses will we be teaching in the coming years? Will CCAT or HEIF change? How can the research projects we do accelerate a just transition to clean energy both locally and across the world? It will be exciting to find out, and you can participate. Ω

Look Under Your Feet

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sor Whendee Silver's lab at UC Berkeley to measure real-time greenhouse gas emissions from commercial-scale windrow composting piles. ERE students reading this article will be pleased to know that the mass balance approach that we talk so much about in class is quite useful – we used this approach to measure emissions from composting. We essentially drew a box around the large composting pile (our control volume), and measured mass flow rates upwind and downwind of the windrow throughout the composting process. The difference between upwind and downwind mass flow rates could be attributed to emissions coming from the pile itself.

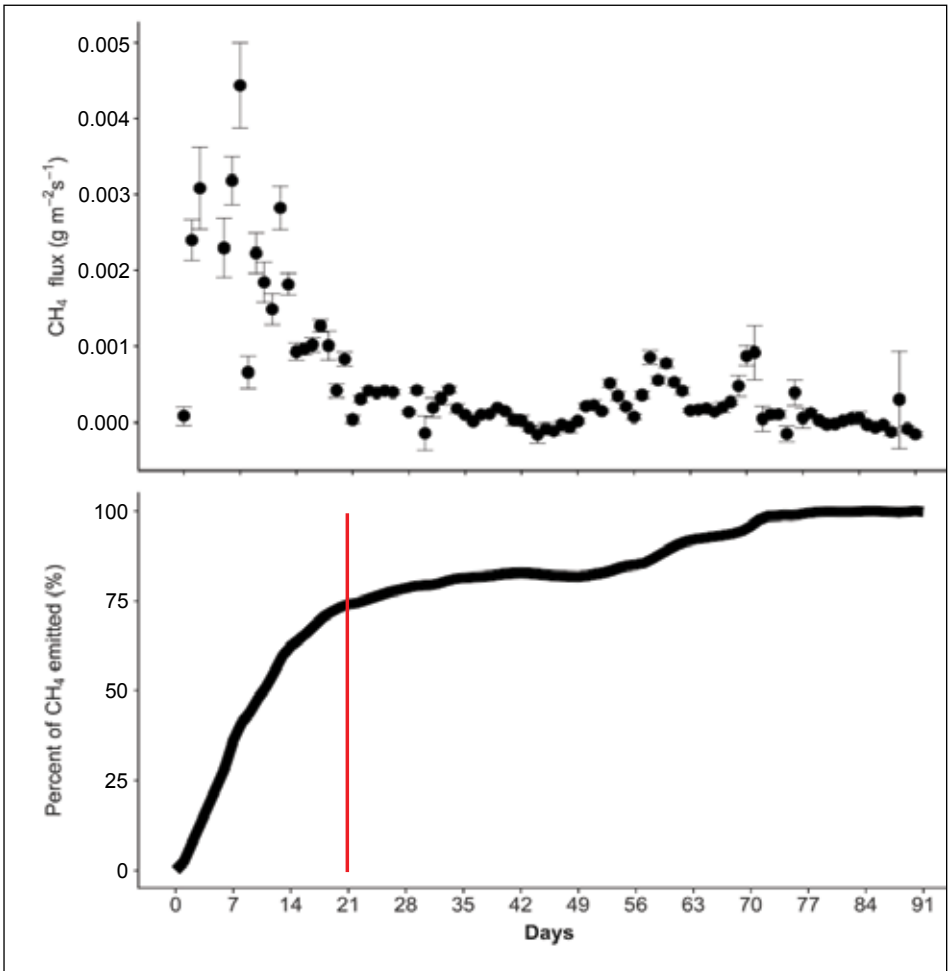
To study this low-tech process of microbes decomposing organic matter, and heating up the composting pile in the process, we used a decidedly high-tech system. We surrounded the pile with towers that we built ourselves. Four towers housed gas intakes, which continuously pulled in ambient air and sent the samples to a greenhouse gas analyzer, and two towers housed 3D sonic anemometers, which measured wind speed and direction. We also placed a system of 27 sensors inside the pile. These sensors measured moisture, temperature, and oxygen concentration.

We ran two 100-day composting experiments at a commercial composting facility in Marin County, CA. The field work was fun, but not glamorous – we were composting mostly cattle manure! – and I got to work with a lot of wonderful students. A lab technician (now PhD student) came to the field with me each week, to move all of our towers, take compost samples, dig up our probes (in a pile of mostly manure!), turn the pile, replace all of our equipment again, and download our data. Over the summer, we had a group of interns (high school and college students) help out. We brought our compost samples back to the lab at UC Berkeley, where undergraduate research assistants analyzed them for a range of chemical and physical properties (pH, C:N, moisture, porosity). We were taking measurements every second (!), and I learned to program in R to help us analyze the massive dataset we were building.

So what were the results of this effort? In our experiments – the first to continuously measure greenhouse gas emissions from commercial-scale composting – we calculated the total carbon emitted as CH_4 (methane), a powerful greenhouse gas, versus CO_2 (carbon dioxide). (We were not able to detect any N_2O, an even more powerful greenhouse gas.) We found that most CH_4 (and CO_2) is emitted during the first three weeks of composting, at a time when: (a) the material is most available to microbes, (b) decomposition occurs the fastest, and (c) the pile is hottest. So, if we want composting to emit even less than it does, we should focus on the first three weeks of composting, making sure that the feedstock is well aerated, thus reducing anaerobic pockets and the production of methane.

Compost, over its lifecycle, is a net sink for carbon. Specifically, composting yields: (a) big avoided (negative) emissions (because without composting, manure would emit far more), (b) small positive emissions from the process itself (this is what our experiments measured), and (c) modest negative emissions from land application (enhancing the plants' work of pulling carbon into the soil).

So composting is a low-tech innovation that can combat climate change, and microbes have been at it for thousands of years. Ω



Data plots showing that most CH_4 (roughly 75%) is emitted during the first three weeks of composting. (Vergara and Silver, 2019)

ERE Clubs Information Board

Club / Organization	Club Mission / Purpose / Activities
ERE Student Association (ERESA) **Email:** *eresa@humboldt.edu* **Webpage: Go to** *ERE web pages > Student Life > Clubs*	The Environmental Resources Engineering Student Association raises funds for student events, organizes student social activities, and works with all other engineering clubs. All ERE students are members of ERESA. ERESA members may become student members of the American Society of Civil Engineers.
Engineers Without Borders (EWB) **Email:** *humboldtewb@gmail.com* **Webpage:** *https://www.facebook.com/HSUEWB/*	The Engineers Without Borders mission is to provide technical assistance to communities worldwide who have self-identified needs associated with improving their quality of life. These projects are conducted through implementation of environmentally and economically sustainable engineering projects that fulfill basic human needs and develop internationally responsible engineering students. EWB works on both local and international projects. ERE students and non-engineers are encouraged to join EWB.
Renewable Energy Student Union (RESU) **Email:** *resu@humboldt.edu* **Webpage:** *https://www.facebook.com/HsuRenewableEnergyStudentUnion/*	The purpose of the Renewable Energy Student Union is to facilitate more renewable energy related activities for the Environmental Resources Engineering program. RESU students have worked with the Schatz Energy Research Center to develop a docent program where ERE students teach local school children about renewable energy and installed a solar radiation monitoring station on the library roof. RESU draws members from the both undergraduate ERE students and Environmental Systems graduate students.
Society of Women Engineers (SWE) **Email:** *swe@humboldt.edu* **Webpage:** *http://hsu.swe.org*	The Society of Women Engineers mission is to stimulate women to achieve full potential in careers as engineers and leaders, expand the image of the engineering profession as a positive force in improving the quality of life, and demonstrate the value of diversity. SWE plans events that inspire young girls to become involved in science and math. Women, men and non-engineers are encouraged to become members of SWE.
Society of Hispanic Professional Engineers (SHPE) **Email:** *shpe@humboldt.edu* **Webpage:** *https://www.facebook.com/shpe.hsu/*	The Society of Hispanic Professional Engineers is a national organization at the forefront of advancing Hispanic individuals in the STEM fields: Science, Technology, Engineering, and Math. The SHPE-HSU club focuses on academic excellence and professional development. Other activities include community outreach and cooperating with other clubs. SHPE-HSU is not exclusive to Hispanic people and welcomes individuals of all backgrounds to join.

Searching for climate change solutions? Look under your feet!

by Sintana E. Vergara, PhD, ERE Assistant Professor

What comes to mind when you think of possible solutions to climate change? Perhaps solar panels or wind turbines or electric vehicles – all wonderful modern technologies that are capable of greatly reducing our greenhouse gas emissions. Or, maybe large-scale, futuristic experiments like blocking incoming solar radiation. You are probably not thinking of the soil under your feet or the plants in your backyard.

In fact, to avert climate change, it will not be enough to reduce emissions of greenhouse gases. The Intergovernmental Panel on Climate Change has warned that we must also find ways to pull carbon out of the atmosphere and store it elsewhere.

Luckily, ancient technologies have been doing this for millennia, via photosynthesis. Plants take carbon (as CO_2) out of the atmosphere and turn it into biomass. Some plants, grasses in particular, move much of their carbon into their root mass, where it makes its way into the soil. So, the question is, if plants have already found a way to pull carbon out of the atmosphere, what can we do to enhance their work?

Commercial composting facility in Marin County, California, during one of two 100-day composting experiments. Photo by S. Vergara

Recent research has verified what farmers have known for a long time: compost – decomposed organic matter – helps plants grow. And it does more than this. Research in California shows that applying compost to grasslands leads to more grass growth, and as I said previously, grasses pull most of the carbon into their root systems, where it becomes part of the soil. So, using compost enhances this natural carbon chute, moving carbon from the atmosphere (where we don't want it) to the soil (where we do). This is great news for soil fertility, and great news for the climate.

But to fully understand the potential of compost to sequester (store) carbon, we need to look at the full life cycle of composting, including any emissions from the composting process itself. It turns out that emissions from composting are fairly uncertain, in part because measuring these emissions is challenging. Does the process release more carbon to the atmosphere than it pulls down from the atmosphere?

To answer this question, I led a study as a Postdoctoral Scientist in Profes-

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