Potential Barrett Scholars 2025 Projects

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The handshake job posting is at the following URL or QR code:

https://uvm.joinhandshake.com/stu/jobs/9616377

You can read more about the program at the following URL or QR code:

https://www.uvm.edu/cems/richard-barrett-scholars-program

This program is **ONLY** open to engineering students at UVM who are NOT graduating in Calendar year 2025 (Soph, Junior, Seniors)

1. **<u>Project title:</u> Exploring the Role of Underwater Soundscapes (a.k.a. Hydroacoustic) in Facilitating Coral Reef Restoration**

Project Description: Coral reef organisms (i.e., shrimp, fish) emit sounds that intermingle with background "noise" (i.e., bubbles, sand movement) that have been shown to attract fish, invertebrates and coral larvae. By playing back the sounds of healthy reefs, larvae can be attracted to degraded sites, "kick starting" restoration. Yet we know extremely little of who, how, and when these sounds are created. Northeastern University (NU) is deploying a series of acoustic sensors at both healthy and degraded reef sites to record acoustic signatures. This project will also help connect UVM with Jacques Cousteau's grandson's nonprofit which will be building a very impressive underwater lab called Proteus. https://news.northeastern.edu/2023/05/19/underwater-labs-co-op-experience/

Barrett scholar's role: Collaborate with NU on data analysis. Specifically, use programming skills to explore how the acoustic signatures collected by NU personnel vary over the course of a day or season, or how sounds change with varying degrees of reef decline.

Other details: This will be the second year of this project in collaboration with NU. The project will include one undergraduate researcher from NU, who will participate in the field capture of sound data and in analyses of the large amounts of sensor data, as well as faculty at NU, Mark Patterson with expertise in machine learning and AI approaches.

Proposing faculty: Kathryn Hinkelman (Civil and Environmental Engineering) and Brian Helmuth (Department of Marine and Environmental Sciences and School of Public Policy and Urban Affairs at Northeastern University). Email: kathryn.hinkelman@uvm.edu

2. **<u>Project title:</u> Assess Climate Vulnerability at Quarai Spanish Mission Complex**

Project description: This project will result in the development of a climate vulnerability assessment of the 17th Century Quarai Spanish Mission Church in New Mexico, a stone masonry structure constructed c.1626. Quarai is located in the Salinas Missions National Monument and includes architecture associated with the mission period, cultural landscape features, and archeological deposits associated with the mission and the ancient Indigenous communities living on the site. It retains connections to living descendent communities. The site is located in a region where future climate impacts are expected to include more prolonged and more severe periods of drought, increased risk of wildland fire, more

frequent extreme precipitation events, and reductions in current groundwater levels. This project will create essential baseline data needed to assess and monitor the mission church, will identify vulnerabilities associated with climate change, and will make recommendations that can be used to develop mitigation/adaptation strategies to be implemented by the Park. The Salinas project is part of a pilot conducted by the Vanishing Treasures Program of the National Park Service, intended to develop options for climate change preparedness that will apply to other southwest parks.

Barrett scholar's role: Participate in a site visit to archaeological sites in the park by the project team, acquire climate data for the region, conduct statistical analyses of changes in rainfall extremes over time, and assist in deploying sensors to acquire site-specific data.

Other details: This project will be conducted in partnership with the Department of Anthropology at the University of New Mexico (UNM), which is in the first year of a 3-year project in the Monument. In addition to the Barrett Scholar, the project will involve students (undergraduate and graduate) from UNM.

The Quarai mission church (tall structure) with a portion of the mission Convento overlaid on ancient Pueblo construction in the foreground. This site in New Mexico, south of Albuquerque, is at an altitude of approximately 7,000 feet.

Proposing faculty: Doug Porter, Arne Bomblies, Donna Rizzo. Emails: douglas.porter@uvm.edu; abomblie@uvm.edu; drizzo@uvm.edu

3. Project title: Climate Vulnerability and the Preservation of Archaeological Sites and Landscapes in Canyon de Chelly National Monument, Part II

Project description: Canyon de Chelly National Monument, an area co-managed by the Navajo Nation and the National Park Service, encompasses one of North America's longest continuously inhabited landscapes. In this arid environment, population density varied over time, often in response to drought conditions; these were especially severe in the 13th century and may have resulted in a hiatus in the construction and use of the stone and earthen masonry alcove villages that proliferated in the canyon by the 11th century. The Navajo farmers and ranchers living in the canyon today, as well as the numerous archaeological and historical sites preserved there, are again threatened by extreme drought conditions that affect the surrounding Chuska Mountains and the potential for

flash floods in the narrow canyons that make up the Monument. A Barrett scholar working on this project in 2023 deployed sensors to log changes in the water flows in the canyon and developed a 2-D Hec-RAS model for the site.

Barrett scholar's role: Participate in site visits to archaeological sites in the park by the project team, acquire climate data for the Chuska Mountains and canyon region, retrieve data from the sensors deployed in 2023, and begin to populate the hydraulic model.

Other details: This project will be conducted in partnership with the Department of Anthropology at the University of New Mexico, which is in the fourth year of an 8-year project in the Monument. In addition to the Barrett Scholar, the project will involve Anthropology students (undergraduate and graduate) from UNM, an engineering student from UC Berkeley, and interning Indigenous artists.

The Tower Complex and East Alcove of Mummy Cave (c.300-1300 C.E.), the largest of the alcove villages in Canyon de Chelly National Monument. This Barrett scholarship is focused on determining the likely impacts of climate change on this and other alcove sites in the canyon complex that comprises the Monument.

Proposing faculty: Doug Porter, Arne Bomblies, Donna Rizzo. Emails: douglas.porter@uvm.edu; abomblie@uvm.edu; drizzo@uvm.edu

4. Project title: Space Weather Monitoring and Prediction for Planetary Health

Project Description: Modern society is increasingly reliant on electrical and communications infrastructure that is vulnerable to disruptions caused by adverse space weather. Additionally, earth-based weather and radiation depend on space weather. This study would have the student study space weather, link into available databases, and possibly build earth-based sensors that detect the effects of space weather.

Barrett scholar's role: Data analysis, computer modeling, possible sensor fabrication, and networking.

Proposing faculty: Dryver Huston. Email: Dryver.Huston@uvm.edu

5. Project title: Computer Chip Packaging for Reduced Environmental Impact

Project Description: Microelectronics, i.e. computer chips, continue to play an important role in modern society. The advancement and demand for AI systems is driving an extraordinary growth in computer hardware and the associated environmental impact, including heat generation, energy consumption and the use of deleterious materials. This project would be to examine computer chip packaging architectures for reduced energy and environmental impact. A focus may be on 3-D heterogeneous packaging as it increases performance, increases heating issues, and offers potential opportunities for environmental mitigation. The project would involve numerical modeling, experiments and possibly interaction with the semiconductor industry.

Barrett scholar's role: Data analysis, computer modeling, possible experiments.

Proposing faculty: Dryver Huston. Email: Dryver.Huston@uvm.edu

6. Project title: Low-Carbon Concrete with Advanced Admixtures

Project Description: The use of concrete is one of the biggest generators of carbon released into the atmosphere, 8% of annual worldwide output. A multi-year research effort at UVM has investigated concrete mixes with low-carbon footprints that have durability and cost comparable to conventional Portland Cement concrete. This research would examine the use of advanced admixtures that control shrinkage, stress, microstructure and durability of cement. Active yarn fibers, ground glass pozzolans, and Portland Limestone Cements are among the possibilities.

Barrett scholar's role: This project involves experiments, possibly numerical modeling, and interactions with the concrete industry

Proposing faculty: Dryver Huston. Email: Dryver.Huston@uvm.edu

7. Project title: In Silico Quantum Material Structural Characterization for Solar Energy Harvesting

Project Description: Quantum dots (QDs), such as lead chalcogenide QDs, are excellent candidates for solar **energy** harvesting due to their ability to absorb a broad spectrum of sunlight, including infrared, typically wasted in conventional solar cells. In our recent study, conducted in collaboration with scattering scientists at Argonne National Laboratory, we demonstrated that lead chalcogenide QDs exhibit fast and reversible symmetry variation upon photoexcitation, which affects their absorption wavelength. Additionally, we discovered that the ligand materials capping the QDs also influence this symmetry variation. In this project, we will use ab initio calculations to elucidate how ligands affect the QD symmetry response to photoexcitation at different temperatures. Understanding this symmetry variation mechanism will help identify the optimal conditions, including ligand species, density, and temperature, for efficient solar energy harvesting.

Barrett scholar's role: Construct interfacial structures between quantum dots (QDs) and ligands, and perform ab initio calculations to relax these structures and determine their bandgaps.

Other details: This project will be conducted in collaboration with scattering scientists at Argonne National Laboratory, Middlebury College, and Northwestern University, as well as synthetic chemists at the University of Chicago. At the University of Vermont (UVM), a PhD student will mentor the undergraduate student on ab initio calculations.

Proposing faculty: Jihong Ma (Department of Mechanical Engineering & Department of Physics). Email: Jihong.Ma@uvm.edu

8. Project title: Methane Degradation in Landfill Cover Soils

Project Description: Methane is a potent greenhouse gas, and landfills are major methane emitters. Methane-eating (aka methanotrophic) bacteria present in cover soils above landfills can help combat climate change by converting methane to CO2. To understand environmental conditions that promote methane degradation, the EMERG lab has constructed a bench-scale bioreactor system with real-time monitoring of environmental parameters (e.g., moisture content, methane composition of off-gas) to simulate landfill cover soils. This reactor will be seeded with real landfill cover soil and operated to identify conditions that promote or inhibit methane degradation.

Barrett scholar's role: The Barrett scholar will be responsible for operating and maintaining the bioreactor to test multiple conditions throughout the summer. The student will be mentored by Dr. Scarborough and Ph.D. student Silas Decker. The student will work alongside other undergraduate and graduate students.

Other details: The student will be required to work in a BSL2 laboratory environment and meet the rigorous requirements set forth by BSL2 protocols.

Proposing faculty: Matthew Scarborough. Email: Matthew.Scarborough@uvm.edu

9. Project title: Isolating Methane-Degrading Bacteria

Project Description: Methane-degrading bacteria (aka methanotrophs) play a crucial role in carbon cycling in the natural world. These organisms have evolved to harness the energy and carbon in methane and are found throughout nature – in bogs, permafrost, sediments, soils, and elsewhere. They can also be harnessed for environmental biotechnology applications to degrade methane, which is a potent greenhouse gas. The EMERG lab is developing protocols to isolate methanotrophs – meaning, we are trying to enrich pure cultures of methanotrophs—so that we can study their metabolic features outside of their native environment and do other fun things—like name them.

Barrett scholar's role: The Barret scholar will be responsible for assisting a Ph.D. student (Silas Decker) with isolating methanotrophs from soils. The student will work on media preparation and maintaining enrichment cultures. The student will use microbiology

techniques to isolate and maintain methanotrophs. If successful, the student will also characterize the DNA and metabolism of the isolated strains.

Other details: The student will be required to work in a BSL2 laboratory environment and meet the rigorous requirements set forth by BSL2 protocols.

Proposing faculty: Matthew Scarborough. Email: Matthew.Scarborough@uvm.edu

10. Project title: Evaluating Real-World Efficiency of Electric Vehicles in the Vermont Context

Project Description: There is a need to develop a place-specific understanding of the factors that affect GHG emissions of vehicle electrification to inform programs that seek to effectively advance GHG reductions. Reducing greenhouse gas emissions from the transportation sector will be critical to meet GHG reduction targets in Vermont and across the US. Advancing the adoption and use of electric vehicles will be critical to achieving GHG reduction targets, particularly in rural contexts where people are more vehicle reliant. The GHG reductions that result from vehicle electrification depend on vehicle use and efficiency, which are likely to vary in rural, mountainous, and cold weather conditions. This study will use real-world driving data in Vermont to determine how plug-in electric vehicle use and efficiency differ in rural, mountainous, and cold weather conditions. Findings from this research can inform the effectiveness of vehicle electrification strategies such as vehicle incentive programs and electric vehicle charging investments in the Vermont context.

Barrett scholar's role: The Barrett scholar will use spatial analysis and computer programming to evaluate real-world driving and fueling data to determine the efficiency of electric vehicles in Vermont. Pilot data collection has been underway since Fall 2024, with research data collection planned to start in Spring 2025. The Barrett scholar will use the pilot data to evaluate the accuracy of different analysis methods for estimating vehicle efficiency. They will then evaluate the pilot data to determine the vehicle efficiency of real-world driving in Vermont's rural, mountainous winter conditions.

Other details: The Barrett scholar will collaborate with two PhD students.

Proposing faculty: Dana Rowangould, Transportation Research Center. Email: drowango@uvm.edu

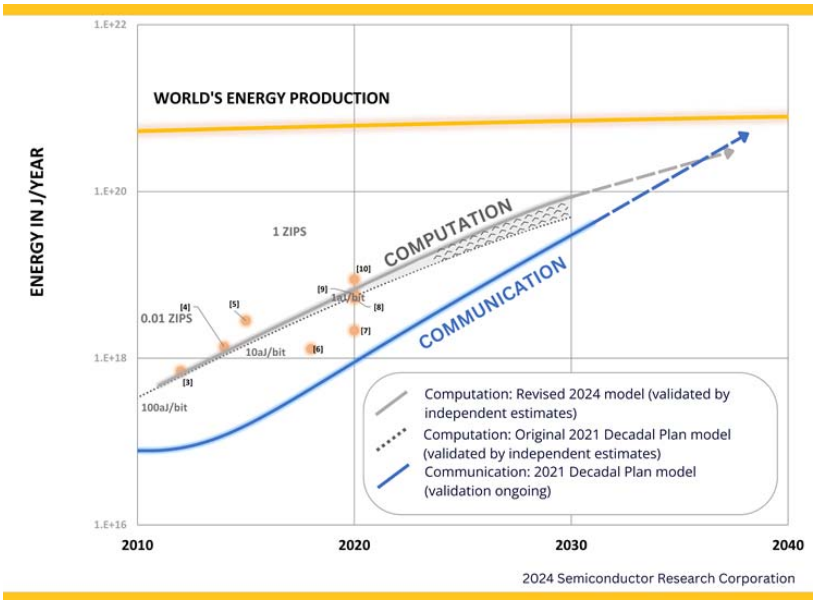
11. Project title: Assessing Post-Wildfire Soil Recovery

Project Description: This project researches how forested hillslopes recover after destructive wildfires by leveraging advanced modeling informed by a low-cost and long-term sensing platform for in situ soil measurements. Barrett scholar's role: The Barrett scholar will work directly with a PhD student to conduct tests to ascertain a soil's pre-/post-burn stability and ability to hold moisture. In addition, the scholar will gain experience with a wireless moisture-sensing approach that leverages an embedded, passive transponder. The student will thus gain experience that crosses disciplinary boundaries.

Other details: This is an ongoing project supported by the National Institute of Food and Agriculture and is a collaboration with Oregon State University and the University of South Florida. The work has already involved CEMS REUs from electrical, environmental and mechanical engineering, so we feel confident that we can set appropriate expectations and provide quality mentoring to the Barrett scholar. The Barrett scholar will work directly with a PhD student completing their second year on the project.

Proposing faculty: Jeff Frolik and Mandar Dewoolkar. Email: jfrolik@uvm.edu / mdewoolk@uvm.edu

12. Project title: CMOS-Integrated Acoustic Systems to Support Grid Decarbonization



Project Description: In recent years, the growth of global energy consumption has far outpaced the addition of energy production to the grid. This trend has accelerated over the last several years with the emergence of large language models, leading to the delayed closure of several coal power plants and a forecast energy shortfall in parts of the United States, threatening decarbonization goals. The integrated circuits powering AI and general computing *must* be made orders of magnitude more efficient to avoid this energy shortfall and support expedient transition away from the most polluting generation sources.

In modern integrated circuits, roughly 90% of energy consumed is due to the finite electrical conductance of small metal wires when moving both data and the reference clock across the chip. This project will look at the feasibility of generating and propagating a solid-solid (Stonely) interface wave using CMOS-compatible materials as a potential path towards long-distance acoustic signaling to reduce these wiring losses.

Barrett scholar's role: The Barrett scholar will utilize the Materials Project API to query and explore systems that could support propagation of Stoneley waves in CMOS-compatible materials. Familiarity with Python and basic mechanics of materials is recommended.

Other details: This is an exploratory project with potential to lead to future experimental work based on the student's findings. The student will primarily work with Dr. Anderson, but will have the opportunity to interact with other students working in the area of micro-electro-mechanical systems and semiconductor devices.

Proposing faculty: Jackson Anderson, Electrical and Computer Engineering. Email: Jackson.anderson@uvm.edu

13. Project title: International Comparison of Transportation Planning Practices and Sustainability Outcomes

Project Description: How people travel varies considerably around the United States and the world; however, the United States stands out as one of the most automobile dependent countries. A larger share of people in the United States rely on driving a personal vehicle to meet their daily needs and drive their vehicles longer distances than people do anywhere else on the planet. This level of automobile dependance has significant consequences on sustainability, safety and household finances. While there are many factors that contribute to the high level of automobile dependance and use in the United States, how we make decision about the design of our transportation system and how we plan our cities and communities is an important factor. The goal of this research project is to understand how transportation planning and design decisions are made in cities outside the United States that achieve significantly more sustainable transportation outcomes. For example, how are planning and design decisions that support greater amounts of walking, bicycling and transit use or less vehicle travel made? What are the commonalities and where do the methods, data, design standards and modeling tools diverge? What share of the differences in outcomes can be attributed to differences in planning and design processes? What changes can be made to create more sustainable outcomes in the United States?

Barrett scholar's role: Conduct an international comparison of transportation and urban planning practices. This will likely involve a literature review, review of technical and planning documents using AI tools, and interviews with transportation planners. The Barrett scholar will work with a team of undergraduate and graduate students working on related transportation planning research at the UVM Transportation Research Center.

Other details: The focus of the above research can be tailored to the student's specific sustainable transportation interests. For example, a focus on a particular mode of travel or a specific part of the planning or design process.

Proposing faculty: Gregory Rowangould. Email: Gregory.Rowangould@uvm.edu

14. Project title: Investigating the Use of Xanthan Gum in Roadway Subbase Stabilization

Project Description: In roadway subbase applications, biopolymers are being explored as environmentally friendly alternatives to traditional stabilizers such as cement, calcium chloride, or asphalt emulsion. This study investigated the effects of the biopolymer Xanthan Gum on the strength and stiffness of roadway subbase materials. Laboratory Unconfined Compressive Strength (UCS) experiments will be conducted on specimens treated with different amounts of Xanthan Gum and subjected to different curing times.

Barrett scholar's role: The Barrett scholar will work with a graduate student under the supervision of two faculty members. This individual is responsible for: 1) acquiring aggregates for testing, 2) preparing and curing specimens, 3) performing UCS tests, 4) collecting and analyzing the data, and 5) writing the report. Some knowledge of statistical analysis is preferred, but the scholar can also learn these skills during the program.

Other details: The project is funded by the Transportation Infrastructure Durability Center, and the scholar will work along with other students working on similar topics in the research group.

Proposing faculty: Ehsan Ghazanfari and Mandar Dewoolkar. Email: Ehsan.Ghazanfari@uvm.edu

15. Project title: Fracture Modeling in Rocks for Carbon Storage Applications

Project Description: The objective of carbon capture and storage (CCS) is to mitigate the impacts of climate change by reducing the concentration of carbon dioxide in our atmosphere. Geological storage involves injecting carbon dioxide emitted from industrial activities into underground rock formations. In such applications, fracture analysis is necessary to ensure the structural integrity and safety of underground storage reservoirs. Accurate modeling of crack propagation in CCS applications is crucial for predicting failure modes and preventing carbon leakage. This research project includes the development of fracture models for anisotropic materials, such as sedimentary rocks, and the assessment of their predictive capabilities based on experimental data.

Barret scholar's role: Conducting numerical simulations on supercomputers and comparing results against experimental data for anisotropic materials

Other details: This interdisciplinary project will provide the scholar with knowledge in fracture mechanics and high-performance computing, utilizing resources from the Vermont Advanced Computing Center.

Proposing Faculty: Lampros Svolos. Email: Lampros.Svolos@uvm.edu

16. Project title: Accelerating Fracture Simulations through Machine Learning

Project Description: Fracture is the ultimate failure mode in engineering materials, potentially leading to the collapse of structures (e.g., bridges, pipelines). Modeling fracture

propagation is computationally demanding due to the multiscale nature of structural materials and the need to capture complex crack patterns. Data-driven approaches that leverage machine learning techniques have shown promising results in reducing simulation times by coupling traditional numerical solvers with pre-trained neural networks. Despite the advent of scientific machine learning, the development of reliable data-driven methods for modeling coupled physical phenomena remains an active research area. This research project involves the application of machine learning techniques to fracture mechanics problems and the assessment of their efficiency in accelerating simulations of failure mechanisms.

Barret scholar's role: Applying machine learning techniques to fracture mechanics problems and optimizing data-driven models that can reduce the computational cost of simulations.

Other details: This interdisciplinary project will provide the scholar with knowledge in machine learning and fracture mechanics, utilizing resources from the Vermont Advanced Computing Center.

Proposing Faculty: Lampros Svolos. Email: Lampros.Svolos@uvm.edu

17. Project title: Characterizing River Erosion in Response to Flood Events of 2023 and 2024

Project Description: During the July floods of 2023 and 2024, Vermont communities suffered impacts from both inundation and erosion flooding. In steep mountainous settings, erosion hazards pose a great, if not a greater, risk to people and infrastructure than inundation hazards. Yet erosion hazards are not well captured by existing flood risk maps. Research is needed to understand better which river reaches are most vulnerable to erosion to inform hazard mitigation plans and design restoration and conservation projects for improved community flood resilience. This Barrett project will examine existing remotely sensed data sets to estimate reach-scale channel erosion and deposition and apply statistical techniques to explore the various factors that influence the spatial and temporal patterns of erosion/deposition throughout a river network.

Barrett scholar's role: compiling and analyzing aerial and oblique imagery and high-water-mark data to evaluate the magnitude and extent of flooding impacts from 2023 and 2024

events; differencing Digital Elevation Maps from before and after flood events to quantify areas and volumes of sediment erosion and deposition; digitizing channel positions from aerial images spanning flood events to visualize lateral channel change; field verifying GIS estimates of erosion/deposition. Some experience with GIS and programming languages is desired, and the Barrett intern will build their proficiency during this role, including learning statistical analyses and data visualization skills.

Other details: The Barrett intern will have opportunities to cohort with an interdisciplinary team of graduate students, post-docs, and faculty with specialties in river science, engineering, and machine learning (CIROH at UVM).

Proposing faculty: Kristen Underwood, PhD, Civil & Environmental Engineering. Email: Kristen.Underwood@uvm.edu

18. Project title: Predictive Analytics for Renewable Energy Projects: Meteorological Events, Sensor Faults, and Plant Operations Decision Support.

Project Description: At the early stages of wind and solar energy project development, a resource assessment campaign is conducted to understand the meteorological characteristics of a potential site. Central to this data collection phase are local surface measurements obtained by a suite of sensor systems at the site under study. In addition to these pre-construction observations, many project owners will continue to monitor meteorological conditions throughout the life cycle of the wind or solar plant as part of a post-construction measurement plan. Together, pre-construction along with post-construction observations create valuable data sets for the owners and operators of renewable energy generation assets.

As the provider of meteorological observation systems for wind a solar measurement campaigns conducted by the world's largest utility scale renewable energy providers, NRG Systems is uniquely positioned help our customers extract the highest impact insights from pre- and post-construction data. This project will utilize real customer data to evaluate the most promising avenues for value-add predictive analytics for optimizing wind and solar plant operations and yield.

Some examples of predictive analytics with meteorological data set components:

- Measuring and predicting energy generation loss from particulate deposits on top of PV modules
- Predicting hail with hail sensors and hail prediction models
- Classifying sensor faults to reduce measurement uncertainty
- Characterizing wind turbine under-performance with lidar remote sensors optically measuring wind characteristics from the ground and from wind turbine nacelles.

Barrett Scholar's Role: The Barrett scholar chosen for this position will work with a team comprised of data science, analytics engineering, software engineering, and product

management disciplines to investigate the capacity for high-performing predictive models and classification models with customer data. The individual will be responsible for 1) aggregating, data sets and performing exploratory analysis, 2) testing predictive and classification methodologies 3) working towards improvement and verification of these methodologies with collaboration from teammates.

Other Details:

- This position will be supported through the Fall 2025 semester at 8 hours per week after the conclusion of the summer commitment
- Potential to result in an abstract submission and poster presentation for a prominent renewable energy industry conference in Spring 2026
- Hybrid location arrangement with available workspace and team collaboration on-site at NRG's Hinesburg, VT headquarters
- Unique experience to do industry-applied research with the opportunity to learn more broadly about how a multi-disciplinary driven engineering department, within an internationally relevant renewable energy technology company, operates

Proposing Project Advisor: Alexandra Arntsen, Ph.D. NRG Systems (aea@nrgsystems.com)