MINternship Program

Transatlantic Energy Research Experiment
(TE-REx)

Research opportunities available at UNC Charlotte
April 2023 – September 2023

General Contact
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<table>
<thead>
<tr>
<th>Research Opportunities</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project #1: Modeling a Wave Energy Converter Power Take Off</td>
<td>3</td>
</tr>
<tr>
<td>Project #2: Building Controls for Demand Flexibility</td>
<td>4</td>
</tr>
<tr>
<td>Project #3: Artificial Intelligence (AI) based Arc Fault Detection for PV Systems</td>
<td>5</td>
</tr>
<tr>
<td>Project #4: Intelligent battery health and safety status monitor</td>
<td>6</td>
</tr>
<tr>
<td>Project #5: Exploring location-specific properties of additively manufactured</td>
<td>7</td>
</tr>
<tr>
<td>nickel superalloys by nanomechanical testing</td>
<td></td>
</tr>
</tbody>
</table>
**Project #1: Modeling a Wave Energy Converter Power Take Off**

<table>
<thead>
<tr>
<th>Energy Field Research Interest</th>
<th>Renewable Energy Devices and Integration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abstract of the project</strong></td>
<td>Water Bros Desalination, LLC. is a small business developing a lightweight wave-powered desalination device for deployment in the aftermath of a disaster to provide a source of potable water. As one of the finalists in the US Department of Energy’s Waves to Water Prize, they have successfully deployed devices for wave-tank and open-ocean testing. In advance of their future deployments, they are seeking to refine their design to increase its robustness and improve the fidelity of their modeling.</td>
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<tr>
<td><strong>Tasks</strong></td>
<td>The student will assist the team as they update their current MATLAB-Simscape model to a 6 degree of freedom Simscape: Multibody model. Components in the model will be parameterized to allow for simulations across a variety of sea states. Optimal component sizes and settings can then be determined on the basis of water production, reliability, and cost.</td>
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| **Learning Outcomes**         | As a result of this research opportunity, the student will  
  ● work with a small dynamic team developing wave energy technologies for disaster response  
  ● gain an understanding of the potential and challenges inherent in wave energy  
  ● gain proficiency in modeling various spectra of irregular waves  
  ● gain proficiency in using MATLAB, Simscape and Simscape: Multibody to model a mechanical device  
  ● gain proficiency in importing CAD models into Simscape: Multibody for analysis  
  ● use WEC-Sim to model a small wave energy converter  
This will leave the student well prepared for modeling renewable energy systems in their future. |
| **Requirements**              |  |
| **Language Skills**           | English |
| **Software Skills**           | MATLAB, Python |
| **Other skills**              | Statics, Dynamics, Mechanisms, System Dynamics, Strength of Materials would be helpful, but not required |
| **Duration of the project**   | April 1 – September 30 (could be less based on student availability) |
| **Type of research project**  | Renewable Energy / Digital Twins |
| **Responsible Professor**     | Dr. Wesley Williams |
# Project #2: Building Controls for Demand Flexibility

<table>
<thead>
<tr>
<th>Energy Field Research Interest</th>
<th>Energy Storage and Energy Distribution; Efficient Energy Use</th>
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<tbody>
<tr>
<td>Abstract of the project</td>
<td>Sponsored by the Electric Power Research Institute (EPRI), this project aims to use metered data collected by EPRI for a commercial building to develop a thermal model suitable for building controls. The thermal model is then used to explore control algorithms for demand flexibility in buildings.</td>
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<tr>
<td>Tasks</td>
<td>● Literature review</td>
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<td>● Process data collected from field measurements</td>
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<td>● Building control algorithm development</td>
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<td>● Simulation and optimization model implementation and simulation</td>
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<td>● Documentation of research findings.</td>
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<td>Learning Outcomes</td>
<td>● Technical skills of modeling, control, and optimization of residential buildings loads</td>
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<td>● Communication skills by interacting with industry sponsors, faculty mentor, and fellow students</td>
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<td>● Professional and self-regulated skills via active project coordination and management</td>
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<td>Requirements</td>
<td>Have a B.S. Degree in Engineering (Mechanical Engineering preferred)</td>
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<td>Language Skills</td>
<td>Good oral and writing communication skills in English</td>
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<tr>
<td>Software Skills</td>
<td>MATLAB</td>
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<tr>
<td>Other skills</td>
<td>Optimization and thermal resistance-capacitance modeling (preferred)</td>
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<tr>
<td>Duration of the project</td>
<td>April 1 – September 30</td>
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<tr>
<td>Type of research project</td>
<td>Modeling, simulation and optimization</td>
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<tr>
<td>Responsible Professor</td>
<td>Dr. Weimin Wang</td>
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</tbody>
</table>
## Project #3: Artificial Intelligence (AI) based Arc Fault Detection for PV Systems

<table>
<thead>
<tr>
<th>Energy Field Research Interest</th>
<th>Power Conversion and Power Electronics</th>
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</thead>
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### Abstract of the project

In the last decade alone, solar power has experienced an average annual growth rate of 49%. There are now more than 89 GW of solar capacity installed in the U.S. by 2020, enough to power 16 million homes. Currently most large photovoltaic (PV) installations in the U.S. are 600 V DC on buildings and 1000 V DC in utility scale PV farms. The increasing amount of PV systems and DC voltage level have a high potential of creating DC arc faults. Because the deterioration of cables, connectors, conductors, and other system components caused by long-time weathering and aging effect, without adequate scheduled maintenance, the possibility of DC arc occurrence is increasing significantly in PV systems.

Arc fault can cause electric fire hazard due to the partial high temperature plasma (approximately 5000°C or above). Arcing incidents can lead to catastrophic failures such as large-scale fire, posing a significant threat to human safety and industrial/residential properties. In recent years several fire incidents attributed to failures in the PV generation and power distribution system have been reported. Examples include Bakersfield, CA (380 kW) due to arcing to ground fault, and Sonnefeld, Germany (2.4 MW) due to arc fault caused by cracks induced by snow load [1]. In response, industry and regulatory agencies have been undertaking proactive steps to develop and require additional installation practices.

To address above challenges, this project proposes an innovative Artificial Intelligence (AI) based online arc fault detection method for PV systems. The proposed research will develop a realtime fault detection system via a lightweight convolutional neural network for series and parallel arc faults in solar applications.

### Tasks

- Literature review on series ac arc fault detection algorithms
- Developing AI based arc fault detection algorithm
- Training the AI algorithm with real data
- Fine tuning the hyper-parameters for performance boosting
- Testing the algorithm with real data
- Embedding the algorithm in edge computing hardware for real-time testing
- Summarize the findings in a presentation and an IEEE format paper

### Learning Outcomes

- Professional skills e.g. by using AI
- Intercultural competences and social skills by collaborating with an international team
- Collaboration skills by interacting with a team of three universities and four industry companies.

### Requirements

- M.S. student in electrical engineering or computer engineering; familiarity with Artificial Intelligence (AI), principles of power electronics and power distribution.

### Language Skills

- Strong oral and written communication skills.

### Software Skills

- AI programming

### Duration of the project

- April 1 – September 30

### Type of research project

- Project for Electrical Engineering Department Student

### Responsible Professor

- Dr. Tiefu Zhao
**Project #4: Intelligent battery health and safety status monitor**

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<thead>
<tr>
<th>Energy Field Research Interest</th>
<th>Energy Storage and Energy Distribution</th>
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**Abstract of the project**
Lithium-ion Batteries (LIBs) play an important role in the percolation of consumer electronics and the advancement of other developing fields. However, their known safety concerns have been throttling factors hindering the further wide application and next-generation batteries with higher energy density, wide working temperature, long cycle life, and fast charging capability. Traditionally, a major electrochemical failure mechanism for a cell is described as an onset of an internal short circuit (ISC) leading to thermal runaway (TR) followed by a possible volatile explosion if uncompensated. Also, the capacity loss or drop of columbic efficiency can be direct signs of the deterioration of the battery health issues. Understanding their instigating mechanisms of battery health and safety status is crucial to predicting their failure. However, there’s no available methodology to achieve modeling of batteries with high accuracy, physics insights, and fast computational speed for online battery monitoring. To fill this blank, herein, I propose to develop combined machine learning (ML) models and physics-based models to be able to describe and predict the electrochemical behaviors of the batteries with quantitative safety and health warning criteria. In this project, we plan to develop a prototype to achieve for the first time the monitoring of the battery health and safety status in real time.

**Tasks**
1. Understand the developed multiphysics model (baseline model) in our previous work;
2. Identify target cells and conduct health and safety status characterization and evaluation
3. Develop modified multiphysics model and validated by experiment data
4. Train the model using machine learning algorithm
5. Develop a circuit using the trained model and test battery status.
6. Make a prototype machine to demonstrate the function.

**Learning Outcomes**
1. Understanding basic electrochemistry
2. Learn physics-based modeling
3. Develop a prototype

**Requirements**
1. Background in Mechanical Engineering, Physics, Material science and engineering or Electric Engineering

**Language Skills**
Solid math and physics education;
Good at C++ coding.

**Software Skills**
N/A

**Other skills**
Quick self-learning skill

**Duration of the project**
April 1 – September 30

**Type of research project**
Applied Science and Engineering

**Responsible Professor**
Dr. Jun Xu
# Project #5: Exploring location-specific properties of additively manufactured nickel superalloys by nanomechanical testing

<table>
<thead>
<tr>
<th>Energy Field Research Interest</th>
<th>Nuclear Energy and Safety</th>
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## Abstract of the project
Additively manufactured (AM) nickel superalloys have more heterogeneous microstructures and corresponding inferior mechanical properties than the alloys prepared by a conventional method, limiting the application of AM for advanced nuclear energy. An understanding of localized mechanical properties of the heterogenous microstructure is critical to designing/modifying the AM procedure for components with good global performance. However, the localized relationship between microstructure and mechanical property is difficult to explore as the feature dimension is not sufficient for conventional testing. We propose to investigate the role of texture, phase, and grain boundary in localized mechanical properties, such as strength, plasticity, and creep behavior by nanomechanical testing. This proposed work will focus on (a) the development of nanomechanical methods to measure the strength and creep properties at room and elevated temperatures and (b) investigate the relationship between mechanical properties (strength and creep property) and microstructure (texture, phase, precipitates).

## Tasks
(a) Microstructure characterization of superalloys for phase, texture, and grain size distribution;  
(b) Location-specific nanoindentation for localized hardness, modulus and creep behavior;  
(c) High-Temperature nanoindentation on superalloys;  
(d) The correlation of microstructure from additive manufacturing or laser surface treatment and mechanical properties.

## Learning Outcomes
(a) professional skills  
- Mastering nanomechanical testing tools, including nanoindentation (KLA G200) and in situ nanomechanical testing tool (Bruker/Hysitron PI88);  
- Advanced microstructure characterization, including sample preparation, SEM, EDS, EBSD.  
(b) Developing intercultural competences  
- Understand the relationship between microstructure and the mechanics of materials at a smaller scale  
- Application of metallurgy to materials design for additive manufacturing  
(c) Enhancing social skills by being co-mentored by research scientist at Electric Power Research Institute (EPIC) in Charlotte.

## Requirements
Background in materials science and/or solid mechanics

## Language Skills
English

## Software Skills
Will be trained

## Duration of the project
April 1 – September 30

## Type of research project
Collaborative project with EPRI

## Responsible Professor
Dr. Youxing Chen (EPIC)

## Additional Supervisor/Mentor
Dr. John Shingledecker (EPRI)