Opportunity Title: Consortium of Hybrid Resilient Energy Systems Faculty Research Program (FRP) 2023
Opportunity Reference Code: NETL-CHRES-FRP-2023

Organization National Energy Technology Laboratory (NETL)

Reference Code NETL-CHRES-FRP-2023

How to Apply A complete application consists of:

- Profile information
- Educational details
- Relevant experience
- Awards and honors
- Goals, experience, and relevant skills
- Transcripts – Click here for detailed information about acceptable transcripts
- A current resume/CV, including academic history, employment history, relevant experiences, and publication list
- Two educational or professional recommendations

All documents must be in English or include an official English translation. All information and documents must be submitted via Zintellect to be considered for an appointment at the National Energy Technology Laboratory (NETL).

If you have any questions, contact NETLinfo@orau.org.

The Consortium of Hybrid Resilient Energy Systems (CHRES)

The Consortium of Hybrid Resilient Energy Systems (CHRES) program provides summer internship opportunities to undergraduate students, graduate students, recent graduates, and faculty affiliated with the four Consortium member universities: Universidad Ana G. Méndez, Recinto de Gurabo; Universidad de Puerto Rico - Mayagüez; University of New Mexico - Albuquerque; and University of Texas at El Paso. The CHRES program directly supports the U.S. Department of Energy's (DOE's) goal of building a sustainable professional and academic pipeline of the next generation of engineers and scientists, ready to take on the challenges of current and future energy systems.

Program Objectives

The program's objectives are to:

- Provide research and educational experiences to minority students and collaborating faculty members by continuing and improving the consortium programs.
- Increase interaction between partners and between partners and national laboratories.
- Encourage minority students to excel in science, technology, engineering and math by providing them with practical experience and training through project capacity building and learning experience.

- Enlarge scientific, technical knowledge and resource base in the topics of resilient energy (engineering).

The emphasis on a mentored research experience allows CHRES participants to become integral members of NETL's **Hy**brid **Per**formance (HYPER) Facility. Participants gain exposure to current national issues in science and technology, have opportunities to share and exchange innovative ideas and techniques, and make significant contributions to hybrid energy systems and grid resilience projects. To learn more about the HYPER Facility, visit https://www.youtube.com/watch?v=VP1QE5juPOo.

Program Details

- Ten week research experience
- Full-time participation (40 hours/week)
- Appointments will start on **Monday, June 5, 2023** and end on **Friday, August 11, 2023**
- Faculty participants receive a **stipend** of $1,410/week.
- On-site participants at NETL's facility may be eligible for **inbound/outbound travel support** of up to $1,000 and a **housing allowance** of $100/week
- Off-site participants may receive up to $1,000 for **technology support** near the beginning of their appointment
- All CHRES participants are required to present their research project activities and outcomes at the end of the program. This will include a 10-15 minute oral presentation at the CHRES Technical Forum and a 1-2 page extended abstract (research summary).

Faculty member collaborators are sought to engage in collaborative research with scientists at NETL's Research and Innovation Center (R&IC). Individual projects will be modified to accommodate the interest of professors participating in the project. In addition to the projects listed below, other projects could be developed if there is sufficient interest.
Current students are invited apply to the CHRES Professional Internship Program opportunity.

NETL's **Hy**brid **Per**formance (HYPER) facility is a one-of-a-kind facility built to evaluate dynamic operations and to develop control strategies for solid oxide fuel cell / gas turbine (SOFC-GT) hybrids, with expanded reconfigurability and capability. To exploit the advantage of both numerical models and physical systems, as well as gapping the inaccessible technologies, a cyber-physical system (CPS) approach was implemented at the HYPER facility. A CPS fuel cell system was built and integrated with turbomachinery and other supporting components in real time, forming a pilot-scale SOFC-GT integrated system.

NETL's HYPER team is seeking researchers for projects in several areas.

Application Deadline 1/31/2023 11:59:59 PM Eastern Time Zone

Description

1. Fuel Processing and Fuel Flexibility
One particular research interest is to explore the capability of this SOFC-GT hybrid technology under a fuel flexible environment. A one-dimension reformer was built and implemented with the SOFC model in the dSPACE platform. This project will engage in a fuel flexibility modeling study to determine the impact of an array of secondary fuels on SOFC-GT cycle efficiency, and to identify key performance and cost drivers.

2. Fuel Cell Degradation
Fuel cell stack degradation has a big impact on facility costs and operations. This project will use additional experimental data to optimize the HYPER project's existing degradation model, with the expectation to test the control strategy (all the controllers simultaneously) on the HYPER facility. The project will include characterizing of the system in a broad range of operating conditions while the cell is degrading.

3. System Analysis
A novel cycle, composed of a solid oxide electrolyzer cell (SOEC), a solid oxide fuel cell (SOFC), an internal combustion engine (ICE), thermal management, and carbon capture technologies is proposed. This cycle aims to investigate the efficient and cost-effective production of hydrogen and electricity. System studies will be performed for cycle optimization to improve lifespan, efficiency, costs, and operability.

4. Mitigating Compressor Surge and Stall
Compressor surge and stall is one of the main operational challenges in SOFC-GT hybrid systems. The problem arises because of the added large volume between compressor and gas turbine and resultant changes to system fluid dynamics. Acoustic measurements will be used to detect or confirm the onset of compressor stall and surge. The compressor stall and surge and its recovery will be characterized at different transient states. An automated compressor surge recovery will be demonstrated using a cold air bypass strategy at nominal speed and for emergency shutdown.

5. Integration of Energy Storage into Hybrid Power Cycles
The aim of this project is to evaluate the potential for energy storage in hybrid power cycles to enable more effective load following. This will build upon the analysis conducted previously that included both renewables and SOFC-GT hybrids. Energy storage concepts will be simulated and virtually integrated into hybrid cycles. They will be tested for their ability to provide

flexibility and resiliency in power systems which have a high proportion of variable renewable power sources, such as wind and solar.

6. Performance Degradation and On-Line System Identification
It is clear from previous work that an adaptive control approach will be required for highly coupled advanced power systems as components degrade to maintain performance targets. The project goal is to improve performance and extend power system component lifespan using advanced controls and artificial intelligence. NETL researchers are developing an innovative continuous monitoring system to characterize drift from optimal performance by conducting on-line system identification. During this project, degradation of specific components will be characterized using the on-line system identification at nominal and off-design conditions.

7. Developing Cyber-Physical Reformer
NETL researchers have pioneered the cyber physical approach to enable rapid evaluation of a variety of operational configurations while maintaining the accuracy of process dynamics. A cyber-physical reformer incorporates real-time models, experimental hardware, and dynamic data transfer and control. Tests will be planned, conducted, and analyzed to verify dynamic models and evaluate the process limitations of extracting the heat from either auto-thermal reforming, heat exchange in turbine exhaust, or from the SOFC itself.

8. Automated Startup and Shutdown of SOFC-GT Hybrid System
One inherent complexity of the SOFC-GT hybrid system comes from wide discrepancies in the individual component response times, affecting the startup and shutdown of the hybrid system critical dynamic operations. For turbomachinery, this will involve avoiding compressor surge and stall. For the FC system, it will require the thermal management and electrochemical light-off. This project will analyze previous system identification data, and develop and demonstrate an automated dynamic control within the constraints of the supervisory control.

9. Load Following and Supervisory Control
The penetration of renewables requires other power plants to have a rapid load following. This project will investigate the SOFC-GT's load following ability by operating the HYPER facility in response to the grid simulator demand. A supervisory control scheme for load will be developed. The objective is to divide/shift power generation between the fuel cell and the turbine, i.e. responding faster with the gas turbine and then adjusting the fuel cell load over time, while avoiding excessive temperature oscillation in the fuel cell. Temperature variation represents a constraint in the control problem.

10. Machine Learning and Digital Twin
Cyber-physical modeling provides a new modeling paradigm that has the potential to accelerate the design, deployment, and scale-up of advanced energy systems. Cyber-physical models can grow and change during the design and deployment process, and ultimately support development of the digital twin and the physical system of the embodied power plant. This project will use HYPER facility and operational data for machine learning and digital twin research.

11. Conversion of waste plastics to sustainable aviation fuels (SAF)
The aviation industry produced 1 billion tons of carbon emissions in 2019, accounting for 3% of all emissions. Waste plastic-to-SAF is an attractive option as it has a potential to deliver the performance of petroleum-based jet fuel but with a fraction of its carbon footprint while mitigating plastic waste. However, existing state-of-the-art such as pyrolysis or hydrogenolysis are performed at harsh reaction conditions (>300°C), long reaction times (>48 h), utilize expensive catalysts, and petroleum-based solvents. This project will explore the use of non-fossil based green solvents for conversion of plastics to SAF using microwave technology. We will identify suitable green solvents and catalysts and test the effect of different reaction parameters including temperature, reactant ratio, catalyst amounts, pressure. The resulting products will be separated and analyzed for quality and conversion.

12. 3D printing SiC monolith for microwave active catalyst coating
In order to scale-up a process with a newly developed catalyst, a commercial form of catalyst such as foam, monolith, pellet etc. is necessary. Current techniques for developing such forms are limited by shapes and support materials, which are not always compatible with advanced reactor systems such as plasma or microwave-based reactors, creating roadblock for technological advances. In this project we will develop a methodology for building a 3D printed SiC monolith. A printer compatible SiC resin will be prepared and structured into different shapes such as straight channel monoliths, cross-channel monoliths, foam structures, patterned channels etc. based on sound reaction engineering principles. The stress and strain analysis on the structured materials will be performed. The material will be tested for structural integrity under high pressure, high temperature conditions.

Qualifications

Prior research or technical experience is not required to apply or participate in this program.

The ideal candidate would have a strong background in some, but not all, of these elements: MATLAB-Simulink programming, thermodynamics, middleware interface, and dynamic controls.

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Bachelor's Degree, Master's Degree, or Doctoral Degree received within the last 3000 month(s).
- **Discipline(s):**
  - **Chemistry and Materials Sciences** (12)
  - **Communications and Graphics Design** (1)
  - **Computer, Information, and Data Sciences** (17)
  - **Earth and Geosciences** (21)
  - **Engineering** (27)
  - **Environmental and Marine Sciences** (8)
  - **Life Health and Medical Sciences** (7)
  - **Mathematics and Statistics** (11)
  - **Physics** (16)
  - **Science & Engineering-related** (2)
- **Age:** Must be 18 years of age

Affirmation

I certify that:

1. To the best of my knowledge all information contained in this application is accurate
2. I am a current faculty member employed by one of the following universities:
   - Universidad Ana G. Méndez, Recinto de Gurabo
   - Universidad de Puerto Rico - Mayagüez
   - University of New Mexico - Albuquerque
   - University of Texas at El Paso
     Current students are invited apply to the CHRES Professional Internship Program opportunity.
3. I understand that any falsification will render me ineligible for participation and, if found after participation has begun, may require me to reimburse any funds received