Northwestern | CENTER FOR **ENGINEERING SUSTAINABILITY AND RESILIENCE**

2019 Seed Funding Awards Announced to Support Innovative, High-Risk, and/or Enabling Collaborative Research to Enhance Engineering Sustainability and Resilience

Five interdisciplinary teams of faculty members have been awarded $60,000 each to support 18-month collaborative research projects. All five projects represent new collaborations among the faculty members and provide support for graduate student(s) and/or postdoctoral fellow(s). Results from these projects will be presented at a Center for Engineering Sustainability and Resilience poster session in spring 2021 and will provide preliminary data to support proposals for funding from federal agencies, foundations and/or industry.

Executive summaries for the selected projects are listed below alphabetically by PI last name:

Sensing Material Properties as Nature Intends

Lead-PI: James Hambleton
Assistant Professor
Department of Civil and Environmental Engineering

Co-PI: Simge Kucukyavuz
Associate Professor
Department of Industrial Engineering and Management Sciences

This exploratory project imagines a highly non-traditional approach to devise novel test methods for characterizing the properties of natural and manufactured materials that are essential to the design of sustainable and resilient infrastructure. The central idea is that the material itself should inform the test method that most effectively reveals the material's properties, a concept that will be explored by forging a new collaboration between researchers in Civil and Environmental Engineering (CEE) and Industrial Engineering and Management Sciences (IEMS). Existing methods for inferring the mechanical properties of materials through lab experiments or field tests have evolved largely by trial and error, and there is no general, systematic approach for evaluating one possible approach against another. Moreover, existing characterization techniques are inadequate for determining all parameters required to define the material's behavior, particularly when the number of parameters is large. Advances in this project will enable the discovery of new devices and testing protocols that will potentially revolutionize the way material properties are measured, both in the lab and in the field.

What is the Air Quality and CO_2 Impact of an Electric Vehicle Transition?

Lead-PI: Adilson E. Motter
Charles E. and Emma H. Morrison Professor
Department of Physics and Astronomy

Co-PI: Daniel M. Abrams
Associate Professor
Department of Engineering Sciences and Applied Mathematics

Co-PI: Daniel E. Horton
Assistant Professor
Department of Earth and Planetary Sciences

This project will quantify the precise impact of the electrification of the transportation sector on the emission of greenhouse gases. Current estimates are ad hoc and rather crude due to difficulties in predicting the battery-charging power source and attendant emissions as well as the efficiency of vehicles in a post-electrification world. This pilot project will circumvent these limitations by combining multiple types of data and computational models with calculations to identify which power plants will power electric vehicles across the country. The work will use data on the actual design of the U.S. power system planned for the next several years. The expected results have the potential to inform best practices with regard to electric vehicle adoption, power generation, and greenhouse gas emission reductions.

Nature-Inspired Enhanced Microplastics Digestion – Capture and Biodegradation by Flexible Fibers with Attached Microorganisms

Lead-PI: Kyoo Chul Park
Assistant Professor
Department of Mechanical Engineering

Co-PI: George Wells
Assistant Professor
Department of Civil and Environmental Engineering

The overarching goal of the proposed research is to engineer flexible fibers with attached microorganisms for the energy-efficient capture and biodegradation of unwanted waterborne microplastic particles. The proposed functional surface design approach is inspired by (i) baleen whales that capture microscale planktons using the flexible fiber structures and (ii) mealworms that eat plastics using the plastics-degrading microorganisms in their gut. We envision that understanding the science behind the physico-chemical and biological interaction between the microorganism enhanced flexible fibers and microplastics would lead to the development of sustainable solutions to the urgent challenge of plastic pollution.

Multi-Scale Analysis of Electrocatalytic Reactor Processes using a Combined Experimental and Modeling Approach

Lead-PI: Linsey Seitz
Assistant Professor
Department of Chemical and Biological Engineering

Co-PI: Niall Mangan
Assistant Professor
Department of Engineering Sciences and Applied Mathematics

Renewable energy sources, such as wind and solar, contribute a growing fraction of our global energy supply, largely due to technology advances that have improved capture efficiencies and reduced costs, even compared to fossil-based electricity. By developing sustainable processes to use the electricity from these intermittent sources to produce liquid fuels and chemical products, we can store the energy in a transportable form and buffer from their inherent intermittency. Electrocatalytic processes are a promising route to accomplish this task as they enable production of myriad fuels and chemicals, which may allow us to augment or even replace current commercial processes and significantly reduce or eliminate greenhouse gas emissions. Since electrocatalytic processes can operate at room temperature and pressure, they also open opportunities for distributed manufacturing of high-value products. Unfortunately, exciting opportunities for electrocatalytic technologies are limited by our understanding of the complex relationships between bulk reactor properties in operational devices and the local catalyst environment which influences reaction efficiency and selectivity towards desired products. Using a combination of fundamental experiments and multi-scale modeling, we will investigate the coupling between these bulk and local scales to bridge the gap between carefully controlled laboratory catalyst environments and operational electrocatalytic reactors. Our initial study will investigate electrocatalytic production of hydrogen peroxide, as a sustainable alternative to the current industrial process, which is energy intensive and produces significant waste. Hydrogen peroxide is an environmentally friendly oxidant that is used in large quantities for a variety of industries, including water treatment. Through this work, we will build fundamental understanding of electrocatalytic reactors necessary to develop technologies for effective coupling of renewable electricity from wind and solar to sustainable production of fuels and chemicals.

Towards a Circular Bioeconomy: Recovery of Nitrogen as a Value-Added Product from Farm Animal Manure

Lead-PI: George Wells
Assistant Professor
Department of Civil and Environmental Engineering

Co-PI: Keith Tyo
Associate Professor
Department of Chemical and Biological Engineering

Wet wastes, including manure, municipal wastewater, and food waste, contain valuable nitrogen, carbon, and phosphorus that could be used to make fertilizers, biofuels, and bio-based chemicals in order to offset current non-sustainable production of these important goods from fossil fuels. Instead, these wastes currently require additional energy for treatment and disposal, or at worst are released, causing harm to ecological systems. We propose to develop technology to enable recovery of valuable products from wet wastes, resulting in a significant step toward a more circular bioeconomy. Support from CESR will allow us to demonstrate baseline feasibility for low-cost preparation of manure for bioprocessing and recovering waste nitrogen, a key technical challenge requiring outside the box solutions. The innovation of the proposed approach lies in recovery of waste nitrogen in a form that can be reused. The proposed work would also lay the groundwork for development of integrated technologies for recovery of carbon as a feedstock for biofuels or bioproducts, and phosphorus as a fertilizer.