National Science Foundation (NSF)
Research Experiences for Teachers (RET) Site
RET Site: Integrating data-driven research in Renewable Energy Across Disciplines (I-READ)
Texas A&M University-Kingsville

Summer 2025 Program

June 9, 2025 to July 18, 2025

Research Project List

Project #1: Solar Radiation Big Data Analysis for Strategic Positioning of Residential Solar Panels

Faculty Advisor: Dr. Mohammad Motaher Hossain, Mechanical and Industrial Engineering

i. Motivation: Among different renewable energy technologies, solar cell technologies continue to grow in residential, commercial, agricultural, and industrial applications. Although the power conversion efficiency (PCE) of solar cells is still relatively low, strategic positioning of the solar panels can facilitate achieving the optimum output. The solar radiation big data available at the National Renewable Energy Laboratory (NREL) can be used for that purpose. The project aims to analyze the solar radiation big data to study the positioning of residential solar panels for optimum outcome.

ii. Project Description: Strategic positioning of residential solar panels is of great interest as it would maximize the solar panel output to meet the household needs. The following tasks will be performed: 1) Using the 30 year monthly average solar radiation data of South Texas along with the solar position and intensity (SOLPOS) calculator available on NREL websites, sunlight incidence on the roof and windows, based on a house plan, orientation, and location in South Texas, will be collected and put into Excel. 2) An Excel based visual platform will be developed to explore the power output of solar panels positioned at different places on the roof (considering all incident wavelengths can be absorbed) and windows (considering all wavelengths except visible wavelengths can be absorbed, i.e., selective transmission), based on a house plan, orientation, and location in South Texas. 3) Conduct feasibility study to strategically position the solar panels to achieve optimum output.

iii. Participant Component: Two RET participants will work together in this project to collect necessary data from NREL websites, import the raw data into Excel, clean up the raw data, develop the Excel visual platform, and conduct the feasibility study for strategic positioning.

Project #2: Wind Condition Prediction Using Different Machine Learning Algorithms

Faculty Advisor: Dr. Hua Li, Mechanical and Industrial Engineering

i. Motivation: Wind Condition, especially wind speed, is the key factor for the selection, planning, and development of sites designated for wind farms. Due to the complex nature of wind, wind speed and wind direction are considered to be two of the most important factors influencing the performance of wind turbines and their total energy output. The increasing trend of utilizing clean and environmentally friendly resources has required scientists to improve the current approaches involved in the prediction of wind to maximize energy generation.

ii. Project Description: The creation and advancement of new data analysis techniques, such as machine learning and deep learning, have led to new methods to detect trends, accurately forecast future data, and optimize multiple areas involved in the wind energy distribution network. This project will test different machine learning methods on the accuracy of predicting wind conditions. The major tasks are: 1) Learning the basics of machine learning using either MATLAB or Python, 2) Collecting historical wind condition data from national databases, 3) Testing and comparing different machine learning methods for predicting wind conditions under different scenarios.

iii. Participant Component**:** Two RET participants will work on this project. Both teachers will learn the basics of machine learning and work on data collection. The teachers can choose to work on different machine learning methods or to work on different scenarios using the same machine learning methods.

Project #3: Effect of Daylighting on Students' Learning and Classroom Electricity Consumption

Faculty Advisor: Dr. Hui Shen, Civil and Architectural Engineering

i. Motivation**:** In the past few decades, daylighting has gained increasing importance as the immediate exploitation of solar energy in buildings for energy savings. Psychologically, the presence of controlled daylight positively impacts the overall attitude and well-being of occupants. However, little scientific data exists on students' learning efficiency under different daylighting levels to enhance learning experience. The research question is: "How and to what extent daylighting affects students' learning efficiency and how much electricity can be saved *via* daylighting in the classrooms?"

ii. Project Description**:** The research objective of this project is to measure the effect of daylighting on students' learning efficiency, correlate it with classroom electricity consumption, and estimate annual electricity savings of a typical educational building. The following tasks will be performed: 1) The RET participants will use their teaching experience to design activities that are easy to implement and straightforward to reflect students' learning experience. Multiple metrics will be defined or selected from existing literature to evaluate students' learning efficiency. A questionnaire will be developed to collect participating students' information and feedback about the designed activities, lighting environment, daylighting level, etc. after each test. 2) Repeated tests will be performed under different daylighting levels in classrooms. A group of at least 20 TAMUK students will be recruited to conduct the designed activities under different scenarios: daylight with no electric light, strong daylight with low electric light, weak daylight with strong electric light, and no daylight. Three types of data will be collected for each test: metrics of learning efficiency, amount of daylight, and questionnaire feedback. 3) The collected data will first go through an identification process to determine the preferred lighting level. The presence of daylight will be correlated with students' learning efficiency. Meanwhile, transmitted daylight through windows will be correlated with the light level on work plane to formulate an equation for electric lighting energy simulation. The annual electricity savings from daylight utilization of a typical educational building will be estimated, considering optimal learning efficiency. To ensure its completion within the summer program, Dr. Shen will complete the IRB approval and student recruitment before the summer program starts.

iii. Participant Component**:** Two RET participants will work in this project. They will first complete CITI training and be added into IRB protocol, and work together to: 1) design learning activities and conduct experiments, 2) define metrics of learning efficiency, 3) develop questionnaire, 4) analyze the effect of daylighting on learning efficiency, and 5) develop electricity consumption equations and estimate annual electricity savings from daylighting for a typical educational building.

Project #4: Study the Potential of Converting Food Waste into Renewable Energy in the Backyard

Faculty Advisor: Dr. Xiaoyu Liu, Civil and Architectural Engineering

i. Motivation**:** Food waste accounts for about 14.5% of Municipal Solid Waste generation in the U.S., and up to 98% of which is discarded without recycling and recovering. Households account for the largest portion of food waste, and one person's food waste per year in the U.S. can provide enough renewable energy for powering a 100-watt light bulb for two weeks. However, majority of the existing studies and products on energy recovery from food waste focus on large-scale application, consumers' behavior, and policy, with little information available at the household level. Therefore, the research question is: "Is it feasible to recover energy from household food waste at the residential scale?"

***ii. Project Description*:** The research objective of this project is to study the potential of converting food waste into renewable energy in the backyard through experiments with different combinations of food waste types. The following tasks will be performed: 1) RET participants will derive the data on food waste from the consumer level of USDA Loss-adjusted Food Availability data series, and re-organize it with the household size and geographic region. A proper average daily food waste per household will be determined. 2) RET participants will study and define experimental scenarios covering food waste types with ingredients and household sizes. Experimental platforms will be developed, consisting of two main components (aerobic composting reactor and anaerobic digester) and three auxiliary components (pre-treatment module, energy recovery system, and biogas burner). The reaction residue after the active phase will be moved from composting reactor to the mixing chamber and then sent to an anaerobic digester. RET participants will investigate and determine key parameters for anaerobic process, including total solid content, carbon/nitrogen ratio, pH value and ambient temperature. 3) All the experimental data will be compiled based on the region and household size. Statistical analysis will be conducted to reveal the connections among the potential of food waste recovery, household size and region. Net Present Worth analysis will be applied to show the potential economic benefits of food waste recovery.

***iii. Participant Component*:** Two RET participants will be working together in this project to complete the following tasks: 1) determine the average daily food waste from existing documents, 2) prepare food waste for experiments, and 3) design and construction of experimental platforms. They will collaborate to develop experimental platforms, conduct the experiments, and analyze the data.

Project #5: Wind Farm Layout Study, Future Development, and Cost Analysis

Faculty Advisor: Dr. Kai Jin, Mechanical and Industrial Engineering

***i. Motivation*:** With the rapid growth of wind energy, the wake effects within a wind farm and between the neighboring wind farms have attracted considerable attention as they cause lower power output efficiency and higher cost of energy. Researchers estimated that wakes can extend more than 50 km downwind, resulting in significant economic losses. This project will investigate the impacts of wake effect on wind farm future development. The research question is: "How do the wake effects within a wind farm and between the neighboring wind farms affect the wind farm future development?"

***ii. Project Description*:** The research objective is to evaluate the impacts on the power output and cost of energy of a wind farm due to the wake effects caused within itself and by its neighboring wind farms. The research tasks include: 1) Data related to wind farms in Texas in the last 10 years will be collected from various sources, including wind farm locations, wind turbine characteristics, wind farm power generation, wind speeds, and wind directions. 2) The collected data will be imported into GIS software to create maps, which will be used to create time sequence based dynamic animation for exploratory analysis and calculation of distances between different wind farms. 3) Jensen wake model will be used to analyze wake effect within selected wind farm and its impacts on power output and energy cost by considering selective shutting down of wind turbines in the wind farm. 4) Change in wind speeds and directions caused by neighboring wind farms over 10 years will be analyzed using GIS software, which will then be used to estimate the impact caused by the upwind wind farms before and after they were built.

***iii. Participant Component*:** Two RET participants will work together in this project. They will collect data from available resources, learn to process the raw data in Excel, and visualize the processed data using GIS software. RET participants will learn to use Jensen wake model to analyze the impact of wake effects within a wind farm, and use GIS software to analyze the changes in wind speeds and directions.