ONE Planet
Doctoral Training Partnership

Natural Environment Research Council

Project title: Rewiring energy infrastructure for net zero and climate resilience
Ref: OP2456

Keywords: Climate Resilience, Environmental Informatics, Uncertain Climate Extremes, Net-Zero Transition.

One Planet Research Theme: Climate & Climate Change ☒ | Environmental Informatics ☒

Supervisory Team: Dr. Shahab Dehghan, Newcastle University

Research Gaps and Key Questions: The UK's ambitious climate target of bringing emissions to net zero will require a radical transformation of the energy system by 2050. Even greater integration of renewables into today's energy system will be key to achieving this goal. However, uncertainties arising from natural variability and climate change in weather-dependent renewables pose serious challenges to the energy system resilience during extreme weather events. This project will develop and apply an innovative, data-driven, environmental informatics framework to model the resilience of a net-zero energy system. This will be used to address three key research questions: 1) How can the energy system resilience be quantified, and how can it be stress tested under future climate change? 2) What cost-effective infrastructure transition pathways can deliver resilient, net zero, energy systems? 3) What flexibility is needed across different energy sectors and vectors to achieve balanced costs, carbon emissions, and resilience?

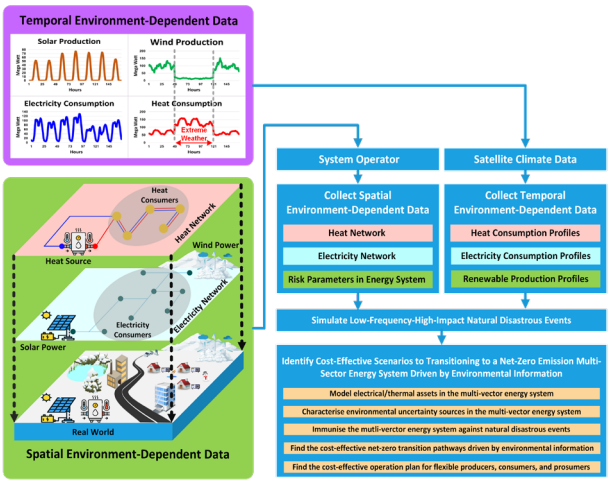

Fig. 1. Proposed environmental informatics framework for transitioning to a net-zero energy system.

Project Description: In 2019, the UK became the first major economy in the world to set legislation to decarbonise integrated energy systems (e.g., electricity, heat, and fuel) by 2050. Electricity will underpin this energy transition, aiming to decarbonise the UK's electricity sector by 2035. Electrification of other energy sectors such as transportation to achieve the UK's climate target makes the energy system resilience more critical, especially during climate extremes triggering cascading failures. This will necessitate a holistic 'rewiring' of all energy system parts, including electricity and heat sectors. However, if the future energy system is to remain resilient to changes in climate, then this rewiring must be driven by spatial and temporal environmental informatics. Key to enabling resilience will be the use of flexible resources. Essentially, this amounts to using different types of weather-dependent renewable sources to compensate for any disruption to other energy sectors of the system. This is easier said than done due to differences in production, transmission, consumption, storage, and response time of different sectors of the energy system (e.g., electricity/heat/hydrogen). However, if a whole system approach is taken, these mismatches also provide a mechanism for introducing flexibility and resilience into the system. This project will address this challenge by developing and applying an innovative, data-driven, environmental informatics model. This will integrate temporal climate-dependent data on energy use from multiple energy sectors with spatial data on the built environment and infrastructure networks. The model will integrate energy, structural reliability, along with weather, climate, and operational characteristics that mediate resilience. The tool will be applied to answer the three research questions mentioned above. The findings will provide the first set of infrastructure transition pathways for the UK energy system that are cost-effective, achieve net zero, and are resilient to projected changes in heat, wind, and flooding extremes.

Essential (E) and Desirable (D) Prerequisites: E1: 2.1 or equivalent (or above) in Electrical Engineering, Civil Engineering, or Environmental Engineering; **E2:** Knowledge of programming in Python, Julia or other high-level languages; **E3:** Knowledge of working with weather and climate data; **D1:** Knowledge of modelling and optimising energy systems; **D2:** Knowledge of environmental informatics and analytics; **D3:** Knowledge of optimisation under uncertainty; **D4:** Ability to work across disciplines; **D5:** Relevant industrial experience.

For more information, please contact Dr. Shahab Dehghan (shahab.dehghan@newcastle.ac.uk).

Newcastle University

Northumbria University NEWCASTLE