Project Call for 2022 ERBE Cohort

MaREI Supervisor	Dr. Barry Hayes
Institution	MaREI (University College Cork)
Co-Supervisor & Institution (if known – please note this is not a requirement at application stage):	Not confirmed yet. I have identified Dr. Bianca Howard at Loughborough University as a potential co-supervisor, given her complimentary research expertise in the proposed topic area (Dr. Howard is currently on maternity leave).
PhD Proposal Title:	**On-demand Grid Energy Services from Buildings Aggregated at the Neighbourhood and Energy Community Level**
Alignment with ERBE Themes: (200 words max – please specify if the project aligns with 1 or more of the ERBE Themes)	This project is very closely aligned with the ERBE theme of **Flexibility and Resilience**, as it focuses on the modelling and optimisation of interactions between buildings, the electricity grid, and the energy markets. Specifically, the project examines the potential for new smart control systems and new business models for optimising the combined energy flexibility of domestic buildings aggregated at the neighbourhood and community level. If successful, this project will create a new modelling framework that will benefit both the energy research community and the industry by facilitating better coordination and grid integration of controllable, small-scale energy resources in buildings.

Project Call for 2022 ERBE Cohort

PhD Proposal Abstract: (500 words max)	The integration of photovoltaic panels, electric vehicles, heat pumps, and smart energy controls in buildings is having a transformational effect on our electricity grid, and on our entire energy system. **The potential for smart demand-side grid energy services from domestic and non-domestic buildings to improve energy system flexibility and resilience is vast** - the IEA estimate that flexible demand-side services could save €240 billion of investment in new grid infrastructure by 2040. To date, demand-side grid services have mainly focused on buildings in the industrial sector, where energy demands are large enough to have an impact at the grid scale. **Recent advances in IoT and new markets for electricity and grid flexibility services** are expected to remove many of the barriers for **smaller buildings in the domestic and small commercial sectors to provide energy services to the grid and to participate in energy markets**. This project investigates the potential for **on-demand grid energy services from buildings aggregated at the neighbourhood and energy community level**. It will investigate the application of new deep reinforcement learning methods to the management of flexible energy resources in buildings at the neighbourhood/district scale, and to optimising their participation in energy and flexibility markets. Classical optimisation approaches can struggle when applied in this context due to the high non-linearity, uncertainty, and volatility associated with disaggregated building energy demands. Recent research by the project supervisor's group and others suggests that artificial intelligence tools that learn from their environment over time may offer advantages over classical approaches in this context. The ultimate aim is to develop a new automated tool that assists groups of buildings in energy communities and zero/positive energy districts in optimising their combined energy flexibility and participating in multiple energy markets. The specific objectives are: • To develop and validate electrical energy demand models of domestic buildings aggregated at the neighbourhood and/or community level. These models will incorporate the flexibility available in current and expected near-future building energy demands. • To demonstrate the potential for reinforcement learning approaches to improve management of energy demand and energy flexibility in the context of local groups of buildings participating in energy and flexibility markets.

	• To investigate the potential for the training and validation of neural networks applied in the project in a living laboratory using a "human-in-the-loop" approach, with real-time community behaviour at a project test site used to inform the models developed. This project will be supported with data and expertise from MaREI and UCC's industry partners, local energy community partners, and the ongoing research projects CENTS (www.centsproject.ie) and PED-EU (www.pedeu.net). Case studies and a proof-of-concept demonstrator will be developed using recorded and real-time energy data from buildings in urban areas (Cork city) and rural areas (Aran Islands) in Ireland and elsewhere. The successful candidate will have full access to the computing and experimental research facilities at MaREI UCC and will participate in local and national MaREI events, as well as presenting the results of this research at international academic and industry conferences.

Project Call for 2022 ERBE Cohort

PhD Proposal Summary for inclusion in Student Call Document: (300 words max – please note the student will be indicating their order of preference for all submitted proposals; please ensure this summary includes a project overview & introduction to the supervisor & institution)	The integration of photovoltaic panels, electric vehicles, heat pumps, and smart energy controls in buildings is having a transformational effect on our energy system. **Recent advances in IoT and new markets for grid flexibility services** are now enabling buildings in the domestic and small commercial sectors to participate in energy markets, and to provide new energy services to improve grid resilience. This project investigates the potential for **on-demand grid energy services from buildings aggregated at the neighbourhood and energy community level**. It explores the application of new deep reinforcement learning methods to the management of flexible energy resources in buildings at the neighbourhood and district scale. Recent research suggests that **artificial intelligence tools that learn from their environment over time** can offer advantages over classical approaches in this context. The aim is to develop a new, automated tool that assists groups of buildings in energy communities and zero/positive energy districts in optimising their combined energy flexibility and participating in energy markets. The project will also investigate the potential for the **training of neural networks applied in the project using a "human-in-the-loop" approach, with real-time community behaviour at a project test site used to inform the models** developed. This project will be supported with data and expertise from MaREI and UCC's industry partners, and from local energy community partners. **Supervisor and Institution** The project supervisor is Dr. Barry Hayes, Lecturer in Electrical Power Engineering at University College Cork and a Funded Investigator at the MaREI Centre. Barry leads a research team of two postdocs, three PhDs, and several Masters students at UCC, focused on the operation and planning of future power and energy systems. The PhD student will join a vibrant, international, and highly successful MaREI research community of more than 200 multi-disciplinary researchers across 13 institutions in Ireland.