Project Call for 2022 ERBE Cohort

MaREI Supervisor	Dr. Ken Bruton, Director Intelligent Efficiency Research Group
Institution	University College Cork
Co-Supervisor & Institution (if known – please note this is not a requirement at application stage):	TBC
PhD Proposal Title:	Applying Digital Twins to assess the potential of Demand Response programmes on industrial sites.
Alignment with ERBE Themes: (200 words max – please specify if the project aligns with 1 or more of the ERBE Themes)	This project cuts across both ERBE Theme 1 and Theme 2; Theme 1: Flexibility and resilience: This project will seek to increase the industrial flexible load integration into the national grid. This will assist in aiding the achievement of renewable energy integration targets. It will also aid the resilience of the national grid in terms mitigating the risk of blackouts during high demand periods. Theme 2: Technology and system performance: Data driven digital twins will be utilised to assist decision support and mitigate the risk of including industrial assets in the demand response programmes.

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PhD Proposal Abstract: (500 words max)	The Irish electricity grid represents a clear and highly representative example of a national electricity grid that is significantly influenced by renewable energy sources (RESs), with these making up the second largest source of electricity after natural gas[1].Wind generation is the main source of renewable electricity generated in Ireland, accounting for a normalised figure of 31.3% of all electricity generated in 2019 [2]. As wind is a particularly volatile, largely unpredictable and mostly non-dispatchable source of non-synchronous energy [3], it can have a destabilising effect on the grid and increase its requirement in relation to the available flexible capacity. The Integrated Single Electricity Market (I-SEM) is the wholesale electricity market arrangement for the Island of Ireland. EirGrid in the Republic of Ireland and the System Operator for Northern Ireland (SONI) are the transmission system operators (TSOs) responsible for maintaining the instantaneous balance of supply and demand. The intended operating frequency of the Irish national grid is 50 Hz, which is often used as an indicator of the health of the grid, as any imbalance between supply and demand will cause it to fluctuate from its perfectly balanced 50 Hz frequency [4]. The normal operating range is between 49.8 and 50.2 Hz, but excursions outside these bounds can occur if there are sudden changes in system demand, generation or interconnector flow [5]. It is essential that TSOs maintain equilibrium as significant fluctuations can damage power systems or in extreme cases lead to blackouts. In order to maintain this equilibrium, supply and demand side must work in tandem. In order to achieve this goal in an efficient and resilient manner, data from both sides of the grid must be effectively utilised to assist decision making with regard to industrial asset utilisation which will facilitate the maximum possible renewable energy integration. Initially this project will consider four research questions, namely; - RQ1: “What are the current research trends in the demand response domain?” - RQ2: “What is the current state of demand response application in industries?” - RQ3: “What are the most significant barriers in adopting demand response programs in industries?” - RQ4: “What measures can influence the widespread adoption/deployment of demand response in industries?”

	Following on from this initial research the development of digital twins of disparate assets (chillers, compressors, HVAC equipment etc) on industrial sites will be carried out. These digital twins will be employed to optimise Demand Response programme participation while minimising the risk to both the end user and the national grid. Modelling revenue generation, process interference and other factors will be key to understanding the potential of demand response on an industrial site. Scenario modelling will then be utilised to comprehensively assess participation options.
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)	This project will leverage on the expertise of the Intelligent Efficiency Research Group in areas such as digital twins and data analytics to automate the identification and quantification for the demand response potential of industrial sites. Achieving flexibility in the energy system is of significant interest for energy system planners and users in recent times because of the large-scale integration of renewable energy resources in the electrical grid. The intermittent nature of renewable energy sources presents some significant challenges for electric grid operators to maintain a stable and reliable electricity grid operation. Currently, there are many services associated with the smart grid that assist in accommodating renewable sources in the grid by compensating for their challenges. One such service is termed as Demand Response Program (DR). Demand Response is an incentive-based program where the utility operator gives their customers an incentive to reduce their demand for a certain period. Industries have a high potential to provide demand response service to the grid because of their higher energy consumption and diversity in flexible assets. For an industrial site to participate in DR, it must identify and quantify how much flexibility is present. Generally, onsite surveys or energy audits are performed to derive these quantities. However, this process is time-consuming, expensive, and relies solely on an experienced individual's information. Alternatively, a data-driven approach for flexibility evaluation is favourable due to the minimal process data required and potential for automation exploitation. This project will be supervised by Dr. Ken Bruton and Dr. Dominic O' Sullivan of the Intelligent Efficiency Research Group (https://www.ucc.ie/en/ierg/description/) in UCC. UK co-supervisors will be appointed on

	success. The project will be undertaken in collaboration with local industrial partner companies, academic partners in Ireland, the EU and the USA.

[1] M. Howley, D. Dineen, M. Holland, and SEAI, "Renewable energy in Ireland 2020," p. 48, 2020.

[2] M. Howley, "Energy in Ireland Energy in Ireland," no. 2, pp. 1–45, 2020.

[3] E. M. Carlini, R. Schroeder, J. M. Birkebæk, and F. Massaro, "EU transition in power sector: How RES affects the design and operations of transmission power systems," *Electr. Power Syst. Res.*, vol. 169, no. April 2018, pp. 74–91, 2019.

[4] Eirgrid, "Industry Guide to the I-SEM," Dublin, 2017.

[5] EirGrid, "Quick Guide to the Integrated Single Electricity Market," p. 12, 2016.

[6] K. Wohlfarth, M. Klobasa, and R. Gutknecht, "Demand response in the service sector – Theoretical, technical and practical potentials," *Appl. Energy*, vol. 258, no. October 2019, p. 114089, 2020.