Project Call for 2022 ERBE Cohort

MaREI Supervisor	Prof Jamie Goggins, Dr Magdalena Hajdukiewicz
Institution	NUI Galway
Co-Supervisor & Institution (if known – please note this is not a requirement at application stage):	Co-supervisor from UCL or Loughborough University with expertise in building energy, innovative façade systems and/or indoor environmental quality
PhD Proposal Title:	*Innovative façade systems for indoor environmental quality in energy efficient buildings*
Alignment with ERBE Themes: (200 words max – please specify if the project aligns with 1 or more of the ERBE Themes)	This proposal is aligned with ERBE's ***Theme of Comfort, health and well-being***. The core objective of the proposed project is a development of new operational strategies and designs for innovative building façade systems that ensure good quality of indoor environment and reduced energy consumption. By utilising pervasive engineering simulation, i.e. computational fluid dynamics (CFD), on-site measurements and qualitative user-feedback from operating buildings, this research will **produce a holistic analysis of the impact of glass façade designs on IEQ** (specifically in terms of thermal comfort and indoor air quality) and **health, comfort, wellbeing and productivity of building users**.

PhD Proposal Abstract: (500 words max)	**Buildings account for about 40% of the total final energy consumption and 36% of the greenhouse gas emissions**, which makes them **the single largest energy consumer in Europe.** Furthermore, **almost 75% of the EU's building stock is energy inefficient** [1]. Transitioning to a low carbon and climate resilient society requires actions that focus on utilising novel energy efficient solutions in buildings, including building envelope systems. In recent years, **naturally ventilated glass façades** have become a common feature in the design and retrofit of large-scale non-residential buildings, integrating architectural aesthetics and energy efficiency. These façade systems are complex and multifaceted. Thus, introducing them in buildings poses many challenges from economic, engineering, health and behavioural perspectives that can reduce optimal building performance. **Building occupant behaviour** and preferences are important contributors to the **gap between the predicted and actual building energy performance** [2]. Furthermore, with **people spending on average 90% of their lives indoors** [3], the impact of **indoor environmental quality (IEQ) on** the **health, comfort, wellbeing and productivity of building occupants/users is extremely important**. For example, 1 in 6 Europeans live in homes that make them sick [4]. Poor indoor environment quality can cause several respiratory diseases, including sick building syndrome [5], and may result in worker productivity loss (as high as 6-9% [6]), absenteeism and other economic costs. Moreover, with densely populated cities, airtight energy efficient buildings and health risks associated with poor ventilation, as evidenced in the Covid-19 pandemic, improving indoor air quality requires urgent attention and next-generation thinking [7]. This PhD project will utilise both quantitative (i.e. computational fluid dynamics (CFD) simulations validated with on-site measurements) and qualitative (i.e. building occupant feedback) data to (i) **investigate the airflow and heat transfer through a façade system** and (ii) **ensure the IEQ is supported for building occupants**, specifically thermal comfort and indoor air quality. Furthermore, the outcomes of this work will determine the **energy savings potential** with respect to the façade. This **innovative approach stresses the importance of health, comfort, wellbeing and productivity of occupants** in building design and operation, to minimise transmission of airborne diseases, such as Covid-19, and other building related conditions. Utilising full scale operating buildings to collect extensive data to support validation of computational models and to test different operational scenarios, will provide a **paradigm shift** in the design, assessment and operation of naturally ventilated buildings. This interdisciplinary approach, combining **engineering**, **architecture**, **facilities management**, **building physics**, **fluid dynamics**, **health and physiology**, and **occupant behaviour** will result in

	new guidelines for design and operation of naturally ventilated façade systems, which consider the occupants' preference and behaviour as pertinent as the building's energy performance.

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)	Buildings account for about 40% of the total final energy consumption and 36% of the greenhouse gas emissions in Europe. Furthermore, almost 75% of the EU's building stock is energy inefficient. Transitioning to a low carbon and climate resilient society requires actions that focus on utilising novel energy efficient solutions in buildings, including envelope systems. In recent years, naturally ventilated glass façades have become a common feature in the design and retrofit of large-scale non-residential buildings, integrating architectural aesthetics and energy efficiency. These façade systems are complex and multifaceted. Thus, introducing them in buildings poses many challenges from economic, engineering, health and behavioural perspectives that can reduce optimal building performance. Occupant behaviour and preferences are important contributors to the gap between the predicted and actual building energy consumption. People spend on average 90% of their lives indoors. Thus, the impact of indoor environmental quality (IEQ) on the health, comfort, wellbeing and productivity of occupants is extremely important. Poor indoor environment can cause several respiratory diseases, including sick building syndrome, and may result in worker productivity loss, absenteeism and other economic costs. With densely populated cities, airtight energy efficient buildings and health risks associated with poor ventilation, as evidenced in the Covid-19 pandemic, improving indoor air quality requires urgent attention and next-generation thinking. The proposed project focuses on developing **new operational strategies and designs for innovative building façade systems** that ensure good quality of indoor environment and reduced energy consumption. The project will utilise (i) **pervasive engineering simulation**, i.e. computational fluid dynamics (CFD), (ii) **on-site measurements** and (iii) **qualitative user-feedback** from full-scale operating buildings, to facilitate a development of validated computational models and to test different operational scenarios. The project will result in a **holistic analysis of the impact of glass façade designs on IEQ** (specifically in terms of thermal comfort and indoor air quality) and **health, comfort, wellbeing and productivity** of building users. The approach will provide a paradigm shift in the design, assessment and operation of naturally ventilated buildings, which consider the occupants' preference and behaviour as pertinent as the building's energy performance.

References

[1] European Commission, 2019, *Energy performance of buildings directive*, https://ec.europa.eu/
[2] Paone, Bacher, 2018, Energies, 11(4), 953, DOI: 10.3390/en11040953
[3] https://www.epa.gov/report-environment/indoor-air-quality
[4] https://www.env-health.org/wp-content/uploads/2018/05/Healthy-Buildings-Briefing.pdf
[5] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2796751/
[6] Wyon, 2004, Indoor Air, 14 (s7), 92-101, DOI: 10.1111/j.1600-0668.2004.00278.x
[7] Blocken et al. 2021, *Building and Environment*, 193, 107659, DOI: 10.1016/j.buildenv.2021.107659