



Project Call for 2022 ERBE Cohort

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| MaREI Supervisor | Dr. Ciara Ahern, School of Mechanical and Design Engineering, TU Dublin; Dublin Energy Lab |
| Institution | TU Dublin |
| Co-Supervisor & Institution (if known – please note this is not a requirement at application stage): | <p>Prof. Brian Norton, Head of Energy Research at the Tyndall National Institute</p> <p>Prof. Brian Ó Gallachóir, Professor of Energy Engineering in University College Cork’s School of Engineering, Vice-Director of UCC’s Environmental Research Institute and Director of the national SFI MaREI Centre.</p> <p>A further supervisor from a UK ERBE partner will be identified if successful.</p> |
| PhD Proposal Title: | <p>Sustainable & Healthy Buildings:</p> <p>Development and cost-optimal scenario analysis of a real-time dwelling energy stock model to inform climate policy decisions.</p> |

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Alignment with ERBE Themes: (200 words max – please specify if the project aligns with 1 or more of the ERBE Themes)

Households account for over a quarter (27%) of end-use energy in EU28 (23% in Ireland) and are considered in policy to have ‘enormous’ potential for CO₂ reduction. Policy is driving rapid change in the sector, approximately 60% of the Irish housing stock is well insulated. This level of retrofit is significantly more than is estimated by policy meaning that policy is lagging the renovation wave while also raising questions as to whether it is reasonable to seek the burden of CO₂ mitigation from this sector.

“Effective policy making starts with an accurate picture of the challenge”

Economidou et al. 2011

An output of MaREI’s research strength in buildings is the development of the MaREI National Retrofitting Modelling Group, focusing on the retrofitting challenge. MaREI is well placed to train the retrofitting leaders of tomorrow but we need to first understand the extent of the challenge.

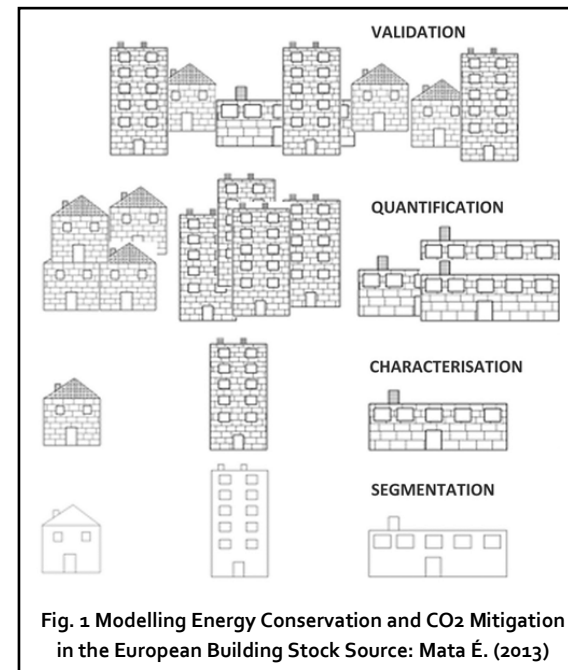
MaREI are developing machine learning methods automating the creation of **real-time** stock models from EPC datasets, facilitating real-time decision-making, providing insight **matching the pace of renovation**. This research, in the context of Ireland’s Residential Climate action targets and using the generalisable methodologies developed, will energy model the Irish Housing Stock to inform policy aligning with Theme 2 - decarbonisation of the built environment through design, monitoring and regulation.

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PhD Proposal Abstract: (500 words max)

This student will work under the MaREI National Retrofitting Modelling Group in partnership with fellow ERBE CDT PhD students already established in this area. This research, in the context of Ireland's residential climate action targets, will model energy conservation and CO₂ mitigation in a dwelling stock as described by Figure 1:

- **Segmentation:** Model energy demand and supply of reference dwellings/archetypes using dynamic simulation programmes to develop new knowledge to inform policy.
- **Characterisation:** Specifically, model Reference Dwellings (RD's) in order to facilitate;
 - the identification of sensitive parameters important to overall performance,
 - through changing such parameters, forecasting the consequences of specific scenarios or policy-interventions,
 - policy-makers in preparing substantive arguments for particular retrofit interventions and contemporaneous insight-driven policies.
- **Quantification:** Through first using the dynamic models created for use at RD or end-use level and then aggregating upwards, to observe, analyse and inform energy use characteristics at stock level.
- **Validation:** Validate model created.
- **Advise** on realisable targets along with specific and tailored policy interventions for a dwelling stock.



The PhD student will gain expertise *inter alia* in, building energy simulation and national/technical strategy evaluation for decarbonisation of national building stocks in a data led manner.

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Energy analyses of dwelling stocks combine a stock model and an energy model. The stock model describes the stock size, composition and renovation status, whereas the energy model describes the average energy intensities of the various segments of the stock and assumed energy savings obtained when dwellings are renovated. Dwelling stock models that include the renovation status of the dwelling stock enable energy analyses of the stock to inform policy.

The all-encompassing disaggregated thermophysical input data required to effectively inform residential stock energy consumption models are computationally intensive and have relied traditionally on laborious manual data analysis. Since it has been impractical to model every single building, it is normal to define a set of reference dwellings (RDs) that are representative of typical national or regional building. RDs are used to produce overall energy saving extrapolations as shown in Figure 1.

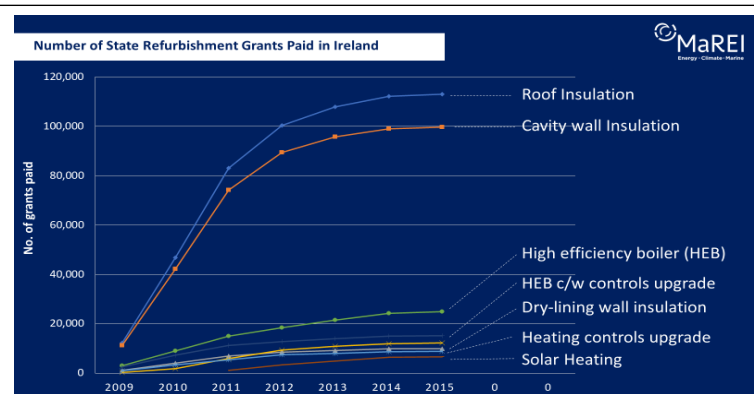



Figure 2 Number of State Refurbishment grants paid in Ireland (Source: Ahern and Norton 2019)

Policy that seeks to reduce domestic energy use is driving rapid change in the sector, the MaREI National Retrofitting Modelling Group established that significant retrofits have taken place in the Irish housing sector (see Figure 2 and Table 1), resulting in approximately 60% of the existing stock being well insulated in 2014 (see Table 2). **The level of retrofit is significantly higher than is assumed by policy which is attributed to energy stock models lagging the renovation wave.**

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Table 1 – Thermal Refurbishment status of the Irish housing stock in 2014 (Source: Ahern & Norton 2019)



| Thermal Refurbishment status of the Irish housing stock in 2014 | | | | Proportion refurbished (%) | U-Value (W/m ² K) |
|---|-------------------------------------|------------------|-------|----------------------------|------------------------------|
| Construction period | Before thermal building regulations | Building Element | Walls | 46 | 0.29 to 0.39* |
| | | | Roofs | 50 | 0.13 to 0.29 |
| | After thermal building regulations | Building Element | Walls | 70 | 0.28 to 0.31 |
| | | | Roofs | 84 | 0.13 to 0.26 |

*With the exception of two storey pre-1900 dwellings at 1.13 W/m²K

Table 2 – Improvement in Thermal Refurbishment status of Irish housing stock from 2001 to 2014 (Source: Norton 2019)

Improvement since 2001

| Year of Survey | | Walls | | Roof | | Double-glazed windows | | Floor | | Source |
|----------------|----|-------|-----------------------------------|------|-----------------------------------|-----------------------|-----------------------------------|-------|-----------------------------------|--------|
| | | % | Mean U-value (W/m ² K) | % | Mean U-value (W/m ² K) | % | Mean U-value (W/m ² K) | % | Mean U-value (W/m ² K) | |
| | | 2001 | 56 | 1.01 | 82 | 1.3 | 61 | - | 25 ^a | |
| 2014 | 58 | 0.66 | 67 | 0.37 | 97 | 2.92 | 53 | 0.59 | Ahern and Norton 2019 | |

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The rate and number of thermal retrofits, ‘the state of a stock’ is captured contemporaneously within national Energy Performance Certificate (EPC) databases. A rapid, robust and automated process to extract information from these datasets is necessary to keep pace with the rate of renovation and to track the effectiveness of policy. The MaREI National Retrofitting Group are defining the conditions for a validated EPC dataset and automating methods for cleaning an EPC dataset to an acceptable level before using machine learning and unsupervised clustering methods to derive objectively, contemporaneous RDs characterising a national stock model. This research will advance this work through micro-modelling the RDs created to ultimately advise realisable cost-optimal retrofit targets along with specific and tailored policy interventions for a national housing stock as per the outline methodology described by Figure 3

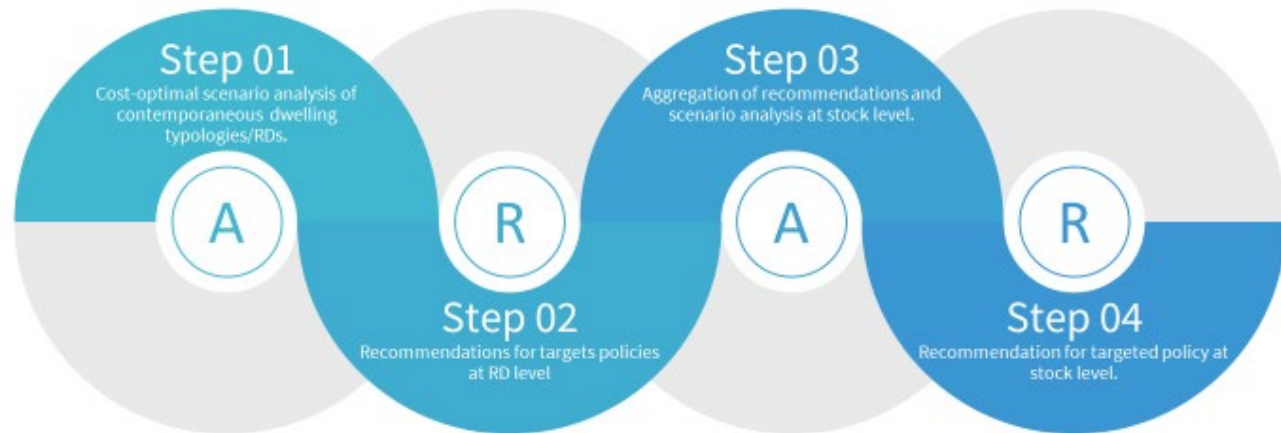


Figure 3 – Outline Project Methodology



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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)

Project Overview

MaREI's National Retrofitting Modelling Group is currently developing a rapid, robust and automated process to extract information from household Energy Performance Certificate datasets to create a real-time stock model for Irish housing. This PhD project will model energy use in Ireland's housing stock using this new information and will develop new knowledge that will directly inform climate policy decisions. The analysis undertaken by the PhD student will address key information gaps that are required to achieve Ireland's ambitious emissions reduction targets. The doctoral candidate will be supported by three leading experts and become part of the ERBE centre for doctoral training team and MaREI's National Retrofitting Modelling Group.

Through completing this PhD, the student will gain expertise *inter alia* in, building energy simulation and national/technical strategy evaluation for decarbonisation of national building stocks in a data led manner to inform national climate policy decisions.

Supervisors

[Dr. Ciara Ahern, TU Dublin](#), is a founding member of the MaREI national retrofitting modelling group and is supervising currently 2 other PhD students working in this area will act as lead supervisor. Ciara has a strong track record in this area having modelled, as far back as 2010, heat pumps retrofitted into a thermally refurbished stock. Since 2014, Ciara has worked closely with [Prof. Brian Norton](#) who is Head of Energy Research at the Tyndall National Institute and who will act as co-supervisor along with [Prof. Brian Ó Gallachóir](#), Professor of Energy Engineering in University College Cork's School of Engineering, Vice-Director of UCC's Environmental Research Institute and Director of the national SFI MaREI Centre. The student will thus be able to benefit from a wealth of experience in this area as well as in the supervision of PhD's.