EPSRC and SFI Centre for Doctoral Training in Energy Resilience and the Built Environment

Loughborough University

Fully-funded 4-year PhD Project at Loughborough University – The implications of a warming climate for summertime cooling in UK homes

Project Title	The implications of a warming climate for summertime cooling in UK homes
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Context (what is the wider social, political and technical context that leads to this work, why is it important)	Summertime overheating in homes causes ill-health and in extreme cases death. The extent and severity of overheating is likely to increase as summers continue to warm and heat waves become more common. Flats and other dwellings in the South-East of England are particularly prone to overheating in the summer. The current design guidance it to reduce window areas, include shading and enable passive ventilation, as a way of combatting the summer heat. However, it is likely that at some point in the future, and in some dwellings in some parts of the country, such passive measures may no longer be enough to maintain comfortable summer conditions. New dwellings and those being refurbished may require active summer cooling, e.g., air-conditioning. The widespread use of summertime air-conditioning could place an unacceptable burden on the electricity supply network and increase energy bills, which would bear down most heavily on societies least wealth citizens. On the other hand, without active cooling, the incidence of morbidity and mortality might increase unacceptably. This project will address questions such as: in which dwellings can passive cooling measures maintain thermally comfortable temperatures in summertime? What are the characteristics of dwellings that will require active cooling to remain

	thermally comfortable? What is the energy burden and cost of such cooling? As the work unfolds, it might also be possible to explore how the cooling might be provided most efficiently.
Project Description	There has been much work on overheating in UK dwellings and the Loughborough team have been in the vanguard of this research. However, there is relatively little recent work on how overheating might be reduced in existing homes. Refurbishment can reduce wintertime energy demand, but it can also reduce or increase the risk of summertime overheating. Understanding, through modelling and by forensic analysis of monitored data, how overheating is affected by different energy efficiency improvements will be an important aspect of this work. **Part 1:** At some point in the future, especially in the warmer parts of the UK and in cities, some homes, notably flats, may not be comfortable if passive overheating prevention measures (ventilation, internal heat gain reduction and shading) are used. Understanding when and where such passive measures are inadequate will be an important step forward for UK heat mitigation policies. **Part 2:** In dwellings that cannot be kept cool passively, some form of mechanical cooling might be needed. Invariably this means an electrically-driven system, either a full air conditioning unit, or comfort cooling using a heat pump (which may be reversible to provide heat in winter). Low cost, low energy and unobtrusive solutions are ideal. However, in blocks of flats a communal cooling system might be used with costs covered by the community of households that benefit. The cooling options and their energy demands etc. will be investigated. Then, for the dwellings that cannot be kept cool passively, the electrical energy use for cooling will be predicted. By aggregating the

	demands for many homes, the loads on the local and national grid can be determined. The above creates a full research programme although the first part alone may prove sufficiently demanding for the award of a PhD.
Aims and Objectives	The aims are: to predict whether some homes, in some UK locations, and at some future time will need mechanical cooling to maintain summertime thermal comfort; and to identify the extent, magnitude and timing of the cooling need and so the load on the electricity supply network. The objectives are: 1. To review the literature on overheating in UK homes and prior estimates of the potential need for cooling. 2. To identify which homes might provide summertime thermal comfort through passive litigation measures and which are likely to need mechanical cooling. 3. To identify alternative mechanical cooling methods and their implied energy demands, costs and installation practicalities. 4. To calculate the additional loads on the electricity grid and how these vary with time and weather, especially heat waves.
Methods: (Measurements, data sources, methods of analysis, etc)	The principal research method will be dynamic thermal modelling of different UK dwelling archetypes. Archetypes will build on previously developed dwelling descriptions for UK homes. Alternative overheating mitigation strategies will be tested for each archetype and their performance under different projected future weather conditions predicted. Aggregation of the electrical energy demands from many dwellings may require the use of other tools such as python. A thorough triage of prior research literature is an important precursor to the project.

Expected Outcomes	Government policy advisors and others will gain a much clearer understanding of the potential for refurbishment as a vehicle for mitigating the effects of elevated summer temperatures. Those concerned with the local and national electricity grid will appreciate the likely additional loads caused by air-conditioning or other mechanical cooling methods.
Multidisciplinary Aspects (what different skills and knowledge will this project develop)	The work will entail a knowledge of building physics and digital data analysis. An appreciation of the demands placed on households of operating passive control measures will be important.
Skills and Interest Required of Student	A keen interest in numerical modelling and data analysis. An interest in buildings and their energy demand is also important.