Written evidence submitted by UCL Institute for Environmental Design and Engineering in response to the Environmental Audit Committee inquiry “Heat resilience and sustainable cooling”

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Who we are: The UCL Institute for Environmental Design and Engineering (IEDE) is part of the Bartlett, the faculty ranked 1st for Research Power in the built environment according to the latest Research Excellence Framework (REF) 2021 and has an exceptionally strong record in public policy support and engagement. We are currently leading ground-breaking research on the interaction of indoor and outdoor heat with health and energy efficiency, supported by several organisations and funding bodies, such as the National Institute for Health and Care Research (NIHR), Greater London Authority (GLA), the Chartered Institution of Building Services Engineers (CIBSE), the Department for Energy Security and Net Zero (DESNZ), Natural Environmental Research Council (NERC), Engineering and Physical Sciences Research Council (EPSRC) and Wellcome.

1. What evidence exists on the relationship between heat and human health (mortality and morbidity), and which communities are worst affected?

1.1 High ambient temperatures have long been associated with excess mortality in the UK (1). Mortality increases above a threshold temperature, with the threshold and rate of increase differing depending on location (2). In the absence of adaptation, heat-related deaths are projected to increase by 257% by the 2050s when compared to a current baseline of 2,000 deaths (2). Last summer, the UK experienced record-breaking temperatures of 40.3°C, and 3,271 excess deaths were recorded in England and Wales over the five heatwave periods (3).

1.2 Evidence on the relationship between heat and morbidity exists but is more scarce compared to the association of heat with mortality. Risk of infectious, metabolic and respiratory diseases have been observed to increase during periods of extreme heat (4). Excess hospital admissions constituted approximately 6% of hospital capacity on days of extreme heat (vs 3% on days of extreme cold). Excess hospital admissions were estimated at around 20,000 annually for both hot and cold extremes between 2001 and 2012, costing the NHS more than £20.8 million per year.

1.3 Heat risk can be exacerbated through increased exposure and vulnerability. Adults above 65 years old and those suffering from existing conditions (including respiratory and cardiovascular disease) are typically more vulnerable to extreme heat and heat stress, while children under 5 could also be at higher risk (5). Exposure to extreme heat during pregnancy has been found to increase the risk of still birth (6).

1.4 Urban areas observe increased exposure to heat due to the Urban Heat Island (UHI) effect whereby cities can be warmer than their rural surroundings and because they are more densely populated (7). In London, the UHI intensity is generally around 1 to 1.5 °C on average (8), and has been estimated to contribute 46.6% of heat related mortality for inner London when compared to rural counterfactual scenarios (9). In the West Midlands, the UHI is thought to contribute 40-50% of heat related mortality (7,10).

1.5 The built environment can act as a temperature modifier. People typically spend around 90% of their time indoors making indoor heat exposure a crucial consideration for health (11). Within

London, building characteristics were found to contribute more variability to indoor temperature than location within the UHI (12,13).

1.6 Lower socioeconomic status (SES) can result in a `triple jeopardy' effect with individuals suffering (1) higher exposure to environmental hazards such as heat and (2) increased susceptibility to poor health resulting in (3) health disparities that are driven by environmental factors (14). Inequalities have been identified in heat exposure, with increased temperature in more deprived areas and areas with less access to green space, which has a cooling effect (15,16).

1.7 `Hot-spots' of elevated temperature and vulnerability due to age and SES in London have been identified (17). Particularly at risk is the Borough of Newham—characterised by dense housing and low incomes. Summer fuel poverty could be an emerging issue in these areas as the UK experiences climate change and an ageing population.

2. How can sustainable cooling solutions and adaptation strategies be implemented in such a way as to minimise overheating, reduce energy consumption and prevent overloading of the electricity grid during peak demand?

2.1 Passive adaptation measures (structural and behaviour, including external shutters and window operation) can reduce indoor overheating in buildings and should be considered ahead of active cooling. While active cooling is an effective solution, it is energy intensive and may contribute to the heating of the outdoor environment (18). Passive measures are discussed in response to question 3 for care settings and question 4 for housing.

2.2 Despite the benefits offered by passive adaptation and energy efficiency measures, active cooling may be required towards the 2080s (19,20). However, the use of passive measures is likely to reduce the rate of uptake and use of such technologies, thus, reducing the energy consumption and risk of overloading the electricity grid during peak demand (21).

2.3 When considering cooling solutions, it is crucial that a systems thinking approach is adopted and other building performance factors are considered. In schools, for example, taking stakeholder preferences into consideration revealed that the optimal interventions entailed low/intermediate energy efficiency interventions coupled with external shading, or increased albedo and internal blinds (22). As the levels of energy efficiency increase, a shift from shading and albedo to passive night-time ventilation becomes more effective at preventing overheating; however, fresh air supply during occupied hours remains critical for cognitive performance (20).

3. What actions can be taken to protect those most vulnerable to the impacts of extreme heat?

3.1 Care settings have traditionally placed their focus on keeping their residents warm during the cold months. Even though this should remain an important consideration, overheating has been identified as a current risk in care settings that will intensify with climate change. Thus, it is important to act now to protect vulnerable care home residents from extreme heat (19).

3.2 While well-known advice such as being hydrated remain important, care home residents may also benefit from both structural and simple behavioural interventions, such as window opening, that are easy to implement, and often without incurring additional costs. The appropriateness of each strategy depends on the building's characteristics (23). Newer and well-insulated buildings may benefit more from higher ventilation rates and window shading systems. Older, heavyweight, and thermally inefficient buildings with high heat losses may benefit more from alternative measures, such as the application of highly reflective materials. Overall, the implementation of passive interventions presents a larger overheating reduction potential in modern rather than older buildings, which tend to maintain slightly lower temperatures at all times. Thus, modern buildings may need to be targeted first for overheating reduction interventions.

3.3 Among all passive measures tested, the implementation of night ventilation presents the largest overheating reduction potential, irrespective of building type (23). A more dynamic approach to window opening has also been found to be highly effective (24), depending on the time of the day, the duration of ventilation and the window's openable area. This would require windows opening at times of the day when outdoor temperatures are lower than indoors, i.e. usually mornings, evenings and nighttime, while removing window restrictors to allow sufficient ventilation rates. However, the removal of restrictors would only be possible providing any associated health and safety issues are eliminated. Window opening can be an affordable and intuitive way to improve thermal comfort that could be optimised further with mechanical control.

3.4 Overall, a combination of passive interventions, including nighttime ventilation, is required for the maximum possible reduction of overheating in care homes, both now and in the future (19). The implementation of modest cost adaptations to heat risk was shown to have the potential to be cost-effective and should be considered as an important complement to operational responses (25). However, by 2080s, the higher outdoor temperatures will make nighttime ventilation significantly less effective (19). Where the implementation of passive measures alone is not sufficient, their combination with air-conditioning is likely to enable care homes to maintain a comfortable indoor environment.

4. What can be done to protect the UK's existing public and private sector housing stock from the impacts of extreme heat while ensuring that homes are sufficiently warm in the winter months?

4.1 One in five homes currently overheat, and the percentage of overheated homes is expected to grow in the absence of adaptation (26). To protect the UK's existing housing stock from the impact of extreme heat and cold, the improvement in thermal efficiency should be considered concurrently with overheating adaptation.

4.2 Evidence on which homes are most at risk exists and can inform the prioritisation of adaptation measures. An empirical study of approximately 800 English dwellings revealed that summer indoor temperatures were greatest in mid-terrace house and purpose-built flats, rented accommodation (privately, from local authority or registered social landlords) and households with at least one occupant on means tested or certain disability related benefits (27). Orientation, glazing ratio and poor levels of loft insulation are also crucial determinants of overheating risk (28). Single aspect homes (with windows only on one side) were also shown to be at a greater risk due to reduced effectiveness of window-provided ventilation (29).

4.3 Modelling has shown external shading to be especially effective for overheating mitigation across housing types (30,31). However, the design of such systems needs to be carefully considered, for example, as many windows in UK homes open outwards. Window opening behaviour, as with care settings, is an important determinant of overheating and night-time ventilation is an effective approach (30,32). In combination, adequate ventilation and external shading are effective in addressing concerns of increased indoor overheating risk following energy efficiency retrofit (31,33). However, factors such as noise, poor air quality and security-concerns can limit window-opening (34).

4.4 Passive urban adaptation measures, such as implementing 'cool roofs' (reflective roof surfaces) can lower local outdoor air temperatures and reduce the heat-related health impacts of the UHI intensity. For example, a modelling study to simulate the effects of implementing cool roofs across the West Midlands estimated a reduction in heat related mortality attributable to the UHI effect by up to 25% (10). Modelling also showed that the UHI in winter could offset around 15% of cold-related mortality (35). Further, comparisons of the effects of cool roofs in winter and summer, suggest that the effects of the cool roofs are less pronounced in winter, leading to only modest modification of the UHI intensity (36). Thus, the annual net effect of cool roofs is positive in terms of health benefits and reductions of maximum temperatures. Overall, cool roofs are more effective than other urban cooling strategies, like green roofs (roof with vegetation), to reduce outdoor temperatures (37) but do not offer the same range of additional benefits like the preservation of biodiversity or the providing of additional energy (e.g., from solar PV).

5. To what extent do the Government's Climate Change Risk Assessment and National Adaptation Programme (as well as other related strategies such as the Net Zero Strategy and Heat and Buildings Strategy) identify and address the risks from extreme heat? (Note: The third NAP, covering the five-year period from 2023-2028, is expected to be published in the summer of 2023)

5.1 The 2022 UK Climate Change Risk Assessment (CCRA3) includes risks to human health, wellbeing and productivity from increased exposure to heat under *Priority Risk Area 7*. Here, they highlight the role of building design and technology to reduce occupant exposure to extreme heat, given the amount of time people in the UK spend indoors and the higher adoption of home working and home-based health and social care. To address the risk of indoor overheating in new residential buildings, the Department for Levelling Up, Housing and Communities (DLUHC) introduced overheating mitigation requirements in the Building Regulations (Part O) Dec 2021 (and came into force June 2022) (38). The introduction of Part O is a positive step towards addressing overheating risk. However, given that approximately 1 in 5 existing homes overheat, regulations should be introduced to effectively adapt the current UK housing stock and non-residential buildings (26,39).

5.2 The Third National Adaptation Programme (NAP3) recognises the need to address overheating in existing homes and non-residential buildings and proposes the development of measures to deliver the government's net zero retrofit target while minimising climate change risks. These and other relevant measures will be developed based on research commissioned by DLUHC, DESNZ and others to address existing evidence gaps. According to NAP3, the evidence gaps include "identifying the buildings most vulnerable to extreme heat and where these are located, as well as appropriate adaptation solutions." Evidence on the buildings most prone to overheating exists from both modelling and empirical research (26–28), while modelling has been used to evaluate the effectiveness of passive adaptation measures (30,31). Thus, we believe that some of these gaps have largely been addressed and it is now time to shift the focus towards piloting studies assessing the roll-out of such measures and their real–life performance when implemented across groups of buildings or neighbourhoods. Outputs from this work, together with existing evidence, will feed into the development of a national adaptation programme. The development of this programme should be treated with urgency and in tandem with the net zero retrofit programme. Mitigation and adaptation of the building stock may be considered together in the upcoming Net Zero Strategy and Heat and Buildings Strategy.

5.3 Additionally, NAP3 encourages the provision of local climate projections to each upper tier local authority in order to plan for extreme heat events at the local level. This action may facilitate the distribution of better-tailored, population-level early warning systems for heatwaves, which are recognised as an efficient measure to safeguarding lives (40) and may be implemented in a relatively short time period compared to structural heat adaptation policies, such as stock-level building interventions. Green infrastructure is featured in both the CCRA3 and NAP3 and the Green Infrastructure Framework launched in January 2023 by Natural England provides evidence-based advice on how to design and implement green infrastructure at the national level to reduce risks from extreme heat (41).

6. Does the Government's Future Homes Standard adequately consider overheating in homes? If not, what additional elements should it include?

6.1 The Government's Future Homes Standard evaluates the risk of indoor overheating through Approved Document O (ADO). Two methods are proposed within ADO that can be used to demonstrate compliance with Part O of the Building Regulations (38): (1) a simplified method, and (2) a dynamic thermal modelling method which is largely based on Technical Memorandum 59 (TM59) released by the Chartered Institution of Building Services Engineers (CIBSE) (42).

6.2 While the two methods proposed by ADO may be based on the best available theory and evidence at the time of writing, the effectiveness of ADO in mitigating overheating has yet to be quantified. Doing so is a necessary step in determining whether the Future Homes Standard adequately considers overheating in homes. In the absence of such evidence, one can look at studies that investigated the use of TM59, or the overheating metrics defined within. The choice of software used to implement the TM59 overheating methodology has been shown to significantly impact the assessment's outcome (29). Furthermore, when comparing the indoor overheating risk estimated using the TM59 overheating metrics against occupant-reported thermal discomfort, substantial differences were identified (26,27).

6.3 As discussed under question 5, the Part O amendment and the release of ADO are positive steps in the effort to adapt against a warming climate. However, while new homes are generally considered to be at a greater risk of indoor overheating, evidence suggests that approximately one in five existing homes already overheat (26). Further, there are concerns that home energy efficiency (HEE) measures can, in some circumstances, exacerbate the risk of indoor overheating (33). Thus, policies should aim to reduce indoor overheating risk in the existing domestic (and non-domestic) stock whilst also reducing its environmental footprint.

August 2023

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