Written evidence submitted by Building Research Establishment (BRE)

About BRE

BRE is here to contribute to a thriving and sustainable world, by developing science-led solutions to built environment challenges. This includes a rigorous programme of testing products for safety and performance which contributes to the formulation of building regulations, measuring and reporting on issues including energy efficiency, and operating assessment frameworks for the sustainability of buildings.

BRE has been working with developers and owners for many years to reduce the environmental impact of construction processes, materials and operations, as well as providing information and advice on all aspects of the sustainability of buildings throughout their lifecycle. For over thirty years, we have operated BREEAM, a world leading certification scheme for the built environment. Over 2 million buildings worldwide are registered with BREEAM, and its technical standards have already been recognised within the National Design Guide as offering a route to best practice.

Response

BRE has responded to the questions where we felt our expertise is of most value.

- 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?

As this is quite a specific technical question, we do not believe it can be answered within the limitations of this consultation. Likewise, sustainable cooling solutions and adaptation strategies will differ for non-domestic buildings, homes and the whole built environment. However, BRE would like to investigate and research these issues further.

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

Often when it comes to housing, the answer is not always technical but instead, might be social/cultural, and connected with adaptation. Consequently, this often requires careful consideration when it comes to solutions for mitigation.

BRE advises government or other bodies on energy efficiency and retrofit we also include our experience of work on overheating and the prevention of it. As such, we would like to signpost the Committee to the following documents:

- *Technical Memorandum 59 Design methodology for the assessment of overheating risk in homes,* Chartered Institution of Building Services Engineers (2017).
- *Overheating in New Homes: A review of the Evidence*, NHBC Foundation (2012).
- *Overheating in New Homes,* Good Homes Alliance (2019).

- Does the current planning framework do enough to encourage heat resilience measures such as cooling shelters, water bodies, green infrastructure and shading to be integrated into urban planning? Where such measures are incorporated, how accessible and successful are they?

At present, BRE feels that the current planning framework does not do enough to encourage heat resilience measures. We feel that the planning system needs to encourage a more systems-based approach with clear spatial priorities that are linked to climatic, environmental, economic and social objectives. Often the current planning system is unable to -take into consideration heat resilience issues, as they need to be delivered at a more macro scale.

- 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?

BRE believes that a national retrofit strategy is required to ensure that houses are easy, low carbon and cheap to heat during winter months, but do not require additional cooling in the summer period.

- What role might reversible heat pumps (which can act as both heating and cooling systems) and other emerging technological solutions, such as the development of smart materials, play in meeting future cooling demands?

On the face of it, a reversible heat pump feels like a viable solution to increasing cases of overheating. Technology is developing rapidly in this area but, at the moment, we highlight the following points relating to reversible heating and cooling using different heat pump technologies.

Air to air heat pump systems are most often used in homes to provide both cooling and heating. However, these are most effective heating solutions for smaller, more thermally efficient homes. BRE have concerns that these – often relatively low-cost systems - should not be over-specified in homes where their use as a primary heating system could be less appropriate and potentially lead to high heating costs."

Air to water systems – the most common type of heat pumps in the UK - usually supply both heating and hot water. The key problem with having a combination heater delivering cooling is that if called upon to deliver hot water while doing space cooling, the system would need to reverse and re-warm the water it had just cooled down and then continue to deliver hot water to the cylinder. This action is highly inefficient.

Ground source heat pumps, where there is appropriate pipework in the home, can offer cooling at the same time as hot water heating. However, such GSHPs are not suitable for all properties, requiring outside space for the installation of the ground source loop.

The latest district heating systems (so called 5th generation) are highly efficient and can offer simultaneous heating and cooling in homes. These need greater adoption and could be an effective solution, particularly for flats (where they do not require external units). Overcoming planning and other barriers to the wider roll out of new district heating systems is an essential policy priority.

To distribute cooling in homes (perhaps combined with GSHP or 5th Generation district heating system-based cooling), thermally active building systems have been developed. These are usually based on water loops being embedded in the fabric of the building, particularly ceilings and then cool water passing through the pipes. This achieves both convective and radiative cooling to occupants of the space, therefore being more effective than air cooling systems. This is a promising technology.

More detailed explanation of these points is provided below.

Heat Pumps

<u>Air to air systems</u>
Heat pumps that offer cooling as standard tend to be air to air in configuration. These units are usually referred to as split or multi split systems depending on the number of indoor units being served by a single outdoor unit.

While the efficiency (co-efficiencies of performance – CoPs) of these systems are good, there is a very significant risk that very cheap units will be installed in existing dwellings. For example, in flat blocks a multi split system could serve a number of flats, each with several rooms. The cheapest units on the market are single pre-charged splits and so can be self-installed.

This is a particular a risk for thermally inefficient house with poor levels of air tightness, where this approach could be highly wasteful and, or, expensive to run. It is therefore important that policy does not incentivise the installation of air-to-air systems in homes that are not suited to this technology – particularly in larger homes that are not as well thermally insulated.

One of the greatest problems at a national level with providing direct cooling to dwellings via air-based systems is the coincidence of the load with other peak loads from commercial and industrial systems. Using air to cool provides no phase shifting of the load. Installing solar PV alongside the air-to-air heat pumps would reduce this problem, as well as reducing running costs, but many homes (particularly flats) where air-to-air systems are otherwise suitable do not have roof space for solar PV.

Air-to-air heat pumps do not heat hot water, and hot water demand is often met through direct electric heating (in contrast an air to water heat pump will provide both space and water heating). However, If installed in a new build, where modern high levels of insulation reduce heating and cooling demand, then there are some systems on the market that can use the rejected heat from the cooling and ventilation function to heat water. This system can be highly efficient, providing cooling and hot water at the same time. These systems are currently relatively large duties, aimed at the commercial market, but could be applied to blocks of flats.

Air to water heat pumps

The most common type of heat pump currently installed is the air to water heat pump.

We understand the thrust of your question as relating to the potential for heat pumps to provide cooling in homes. However, we would just like to clarify one technical point: for the past 10 years all air to water units on sale have been 'reversible'. This reversibility allows – at outside air temperatures below around 5°C - a heat pump to defrost the evaporator coil quickly, drawing heat from the house to raise the temperature of the evaporator and then revert back to heating mode, removing heat from the outside air and heating the water delivered to the house.

Almost all of the air to water heat pumps currently being installed are 'combination' heat pumps, i.e. they provide heat to both space heating and domestic hot water to a cylinder. The key problem with having a combination heater delivering cooling is that if called upon to deliver hot water while doing space cooling, the system would need to reverse and re-warm the water it had just cooled down and then continue to deliver hot water to the cylinder, before reversing again and cooling the water in the local pipes as it resumed cooling. This action is highly inefficient and currently there are no standard air to water combination units on the market that offer a solution to this issue.

Further, attempting to provide space cooling using an air to water heat pump would require that an efficient means of delivering the cooling was installed in the house. This could either be fan coil units, cooling air blown into the rooms, or though cooled fabric elements of the building, i.e. the ceilings. Both approaches are viable, but currently, not widely used. Heat pumps are often matched with under floor heating, but providing any significant level of cooling duty through a floor-based system could result in discomfort more than efficient space cooling.

Ground source heat pumps (GSHPs) suffer from similar limitations to air source heat pumps if the pipe distribution system used for the space heating is to be used for cooling. However, where a separate cooling pipework is installed in the home, GSHP systems can be used simultaneously for both cooling and water heating. The ground stays at a steady temperature that is usually warmer than the air in winter, and cooler in summer. With GSHP, a loop in the ground is filled with brine that is warmed or cooled to the temperature of the ground. On hot days, the cool brine can be used to directly cool water inside the home, serving under floor cooling pipework and fan coils units. The heat pump will, separately, provide the hot water.

Heat pumps combined with mechanical ventilation heat recovery
Highly energy efficient, air-tight homes (principally new build homes) use mechanical ventilation and heat recovery systems. Heat pumps installed in MVHR units can reverse and offer small potential cooling loads. The limiting issue with heat pumps that are linked directly to ventilation systems is the cooling duty that can be achieved when delivering cooled air at flow rates used for ventilation is very small. To be effective the units could only be considered as peak load lopping for bedrooms.

Emerging technologies

Modern district heating systems: For blocks of flats, and potentially dense urban developments, district heating systems of the future could offer a viable route to provision of both heating and cooling. The Generation 5 based district heating systems circulate water at between 5 and 25°C. and have separate warm and cold pipes, though both at relatively close to ambient temperatures. With district heating, a secondary heat pump located in each dwelling, is used to increase the temperature of the hot water for hot water and space heating. A cooling system installed off the primary water loop, can give access to the cool water in the district heating system for fan coils or cooling systems embedded in the fabric of the building. Such systems offer massive potential, but the infrastructure required for a communal system will always be a significant barrier for developers.

Thermally active building systems: Attempting to reduce the peak load of cooling demand, and at the same time phase shift the peak to a period of lower electrical demand requires some form of thermal storage. One aspect of a building that can assist in this is the thermal mass, however, on its own this has limited potential to provide long term comfort and may be counterproductive if heat is not rejected every night. To address this issue systems called thermally active building systems (TABS) have been developed, these are usually based on water loops being embedded in the fabric of the building, particularly ceilings and then cool water passing through the pipes. This achieves both convective and radiative cooling to occupants of the space, therefore more effective than air only cooling systems.

Evaporative cooling systems: These offer very limited cooling potential and are currently not available for single dwelling sized rooms. Currently systems tend to be used in large server type applications where temperatures are limited to ~25°C.

Phase change materials: These have been suggested as a viable solution, but embedded PCMs in walls and ceiling panels offers very limited cooling capability and would not be sufficiently effective to limit temperatures in a dwelling over an extended period of time. Using phase change materials in cold water storage systems does offer the potential to increase the storage capacity of a given tank. A system suitable for storing sufficient cooled water to serve a dwelling over a hot day/night would be expensive and thus only suitable for a small range of dwellings.

- How can cleaner refrigerants with low or zero global warming potentials support the UK's cooling needs while contributing to the national emission reduction targets?

BREEAM, the world's leading science-based suite of validation and certification systems for sustainable built environment projects first developed in 1990, has criteria around refrigerants as part of its assessment ratings. The criteria encourage buildings not to have refrigerants in the first place. However, where buildings do have them, refrigerants should have leak detection and ensure they have the lowest GWP as possible.

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

BRE is still awaiting the detailed consultation of the Government's Future Homes Standard. What has currently been proposed is an uplift in Building Regulations (Minimum Standards) Part L, F and O. Building Regulations provide the minimum requirements for homes. In 2014, BRE launched the Home Quality Mark, which allows developers to consider overheating in a holistic manner alongside linked issues such as daylighting, security (window opening at night) and what is outside the building (i.e. greenery, etc).

In the summer months, high density homes are more likely to be too warm for occupants. With greater levels of hard building materials around it is more difficult for the heat to reduce at night, meaning over prolonged periods of hot weather homes get hotter and hotter. People may also not be able to leave windows open due to noise, security or air pollution. Careful consideration of shading, ventilation, and inclusion of green and/or, natural areas can help to keep the temperatures acceptable. Going forward, with a changing climate we should expect more hotter days, which means making buildings more resilient more important.

- We would also like to refer you to the *AVO Residential Design Guide* published in January 2020. The Acoustics, Ventilation and Overheating Guide recommends an approach to acoustic assessments for new residential development that take due regard of the interdependence of provisions for acoustics, ventilation, and overheating.

- Does the UK need a dedicated Heat Resilience Strategy? What lessons can be learned from other nations when it comes to national strategies for heat resilience?

BRE believes that a Heat Resilience Strategy is required for the UK and would be more than happy to contribute to the research around development of such a strategy.

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