Decarbonising Cooling in UK Homes

University of Exeter

Energy Policy Group

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Policy brief

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Policy areas
Cooling, energy, climate mitigation and adaptation, health, planning and the built environment.

Research focus
Reducing overheating risks and decarbonising cooling in the UK domestic sector.

Method
Desk-based research and semi-structured interviews with 74 UK policy actors working across national & local government, energy systems, technologies, regulation, society, research & innovation, building & systems modelling, housing & planning. Content analysis for identification of key themes.

Summary

- Overheating is already a problem in UK homes, and this will get worse as the climate warms, resulting in increasing levels of mortality, morbidity, and discomfort.
- Without policy intervention it is likely there could be significant further uptake of active cooling by households, leading to direct and indirect carbon emissions, creating new challenges within energy systems, and leading to growing inequalities within society.
- Policymakers need to coordinate and develop an integrated approach to decarbonise cooling, by supporting people to avoid the unnecessary use of active cooling, improving products within the market, and through initiatives to help shift and manage cooling loads within the energy system.
- Supporting a passive first approach is a priority, with information, advice and support a key enabler, alongside improvements to building regulations and planning; existing homes are the main challenge.
- There are five key recommendations to reduce risk and support action: act quickly and comprehensively; seek policy synergies; build on and share best practice; protect the most vulnerable and support all people; lead nationally and support action locally.

This policy brief was written by **Richard Hoggett** and **Richard Lowes**

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Introduction

Extreme heat within the UK is a new challenge, but its impacts are already being seen and are expected to grow as the climate continues to warm. Heat is a 'silent killer' and 'invisible risk' which policy is not yet adequately addressing [1,2]. Active cooling (air conditioning) can help to reduce overheating risks, but it can have negative outcomes for the climate. As with heat risk, there is a perception that cooling policy is lacking, suffering from lower visibility than other climate mitigation and adaptation priorities [3–5]. However, by signing the Global Cooling Pledge, the UK has now committed to producing a national cooling action plan by 2026 [6]. This policy brief sets out the reasons why it will be vital for that action plan and wider policies to consider overheating and cooling in UK homes and it sets out some of the key challenges and opportunities to do that.

The changing climate

"Things have changed quickly, little concern 10yrs ago about overheating, to recognition that impacts severe and happening faster than expected, very few expected to see 40 degree temperatures in Britain."

Higher and extreme temperatures are being recorded across the globe, with Europe currently warming at twice the rate of the global average [7]. 2023 was a record-breaking year with global average temperatures reaching 14.98°C, 1.48°C above the 1850–1900 pre-industrial baseline [8]. These trends have continued into 2024, with May being the twelfth consecutive month of rising global temperatures [9].

The UK has experienced heatwaves in four of the last five years, with the one in 2022 where temperatures exceeded 40°C for the first time described as unprecedented, leading to the UK's first ever red 'extreme heat' warning being issued [10,11]. So far, 2022 and 2023 have been the two hottest years the UK has seen, with all ten of the hottest years on record all occurring since 2003 [12]. As well as heatwaves, average temperatures have continued an upward trend in recent decades. Looking forward the expectation is that there will be ongoing increases in mean temperatures, average summer temperatures, the number of hot days, and heatwave events across all regions of the UK [12–14]. The UK's last Climate Change Risk Assessment identified that increased exposure to heat is a priority action, with a need for all the UK's regions to more urgently develop policy to adapt to increases in the intensity and extent of heatwaves [14]. There are growing calls for, and increasing evidence of, the need for the UK to develop a strategy around heat resilience [1,15].

The impacts of rising temperatures

High and extreme temperatures have economic, social, and environmental impacts, including widespread and pervasive loss and damage to ecosystems, people, settlements, and infrastructure [11,16].

Health and wellbeing

For people, high and extreme temperatures threaten health and well-being and result in the unnecessary loss of life [7], as well as causing increased levels of morbidity and discomfort [17,18]. There is a range of direct and indirect health impacts from high temperatures and changing vulnerabilities across the population – Box 1. Data for the UK suggests there were up to 4,500 excess heat -related deaths in 2022, and projections suggest this could rise to 10,000 per year by 2050 without adequate adaptation [1,10,19]. Whilst heatwaves are a concern, around 75% of heat-related deaths occur from moderate increases in temperatures of between 1°C to 5°C above UK regional temperature thresholds, suggesting risks are more pervasive and prevalent [20].

Wider impacts

High temperatures result in significant economic losses, and these are expected to grow, across local, regional, and national levels [15,18,22]. Lost sleep impacts productivity and can reduce concentration, alertness, and cognitive performance [18], costing the UK economy around £60bn per year [1]. High temperatures are also damaging the natural environment, putting stress on biodiversity [11,23], impacting the ecosystem services they provide, including the role of green and blue space in helping reduce urban temperatures [1,10]. Heat can also make air pollution worse, further exacerbating health issues[24].

Higher temperatures also affect infrastructure, including the energy system across generation and the distribution of power, by reducing efficiencies, lowering capacities, and increasing faults [25,26]. There are also concerns that some assets within the UK energy system are not designed to work over 40°C temperature thresholds [14]. More broadly high temperatures damage and disrupt transport networks, digital infrastructure, water supply, cold chains, wider supply chains [11,22,23,27]. There is also the potential for cascading risks, reflecting the interdependencies that can exist between systems [14,15,28].

Keeping cool

People spend around 90% of their time indoors, but in temperate countries like the UK, buildings have largely been built to retain warmth in winter rather than keep out the heat [10,24,29]. This results in overheating (i.e. heat gains exceed heat losses for a prolonged period) [24], and already, in an average summer around 20% of homes in England experience overheating [2,18,30], at 2°C of warming the experience of overheating in the UK could rise to around 90% of UK homes [29]. Risks are currently higher in London and the southeast [1,30], but all regions of the UK will need to adapt to the increased exposure to heat in homes [31]. Recent research on the 2022 heatwaves highlights that the country is currently ill-prepared for future extreme heat events [10].

There is a reasonable understanding about some of the factors likely to increasing overheating risks, linked to building type and its design and characteristics, tenure, occupancy, and social factors [1,14] and the level of risk is also shaped by outdoor climatic conditions, location and wider geography, the extent to which any urban heat island (UHI) is present, as well as the occupant's behaviour [1,15,24]. Cooling is a solution, providing thermal comfort and reducing health risks from overheating [4], but it can also create new challenges, including those linked to equity. Cooling can be provided through passive measures, such as good insulation, shading, ventilation, reflective surfaces, cool roofs, green and blue spaces and be shaped by wider design decisions [1,3,29,32]. Such approaches do not require ongoing energy use [10] and have the potential to reduce overheating risks in as much as 80% of the stock [29]. Cooling can also be active, or mechanical, ranging from simple and low impact technologies like free-standing or ceiling mounted fans [1,24] through to refrigerant-based air conditioning (AC). Widely used in other sectors, AC is effective, but is more energy intensive and can use climate polluting F-gases, and as such can be a source of both indirect emissions from energy use and direct emissions from the refrigerants [33]. AC can therefore contribute to climate change, whilst more generally, active cooling can increase energy use and household bills, and put pressure on electricity networks [34,35]. AC also generates waste heat that can further increase urban temperatures, contributing to the UHI [18].

Box 1: Heat impacts and vulnerabilities [21]

Direct

Dehydration, heat stress, heat exhaustion and heat stroke, exacerbation and increased risk of death from cardiorespiratory and other diseases, mental health issues, and adverse pregnancy and birth outcomes.

Indirect

Increased risks of accidents, increased transmission of diseases, disruption to sleep, a growth in violence, increased hospital admittance and wider impacts on health services.

Vulnerabilities

Risks are higher for adults over 65 years, people with chronic diseases, those with long term illnesses or disabilities, people with drug and alcohol addictions, the homeless, people living in deprivation, and very young children.

Decarbonising cooling

"If you look at the modelling done so far, its clear a significant chunk of the housing stock will need some form of active cooling in 2050."

Data on the use of active cooling in homes is poor. A widely quoted figure from 2018 suggests that around 5% of homes may have some form of active cooling and that numbers might increase from around 1 million units to up to 18 million by 2050 [3,32]. Whilst market analysis in 2021 estimated that up to 84,000 AC units a year were being installed, split equally between new and existing homes [32]. Domestic cooling demand is estimated to be 5-13 TWh by 2050, potentially adding 39 GW of peak on a typical August weekend [3]. The market for active cooling in the domestic sector is currently relatively immature, but the use of cooling is expected to increase as people's experience of overheating in homes grows. It will therefore be vital that a coherent and strategic approach for decarbonising cooling within homes is included within the forthcoming cooling action plan and other key policies linked to the domestic sector. A useful tool for decarbonising cooling that has been used internationally is the avoid-improve-shift framework – Figure 1 [33]. This sets out the need for a passive first approach as well as the importance of shaping markets so that products are clean and efficient. It also considers strategies to help manage active cooling loads within energy systems, so that fossil fuels do not come onto the system to help meet summer demand peaks, a problem that is already being seen [1]. Action across all three areas is needed.

The figure also shows some of the key policy areas for cooling homes, which are broad and cross-departmental, requiring coordination and alignment across multiple policy areas. It can also be seen that the role of people is central to each area of the framework.

This framework formed the basis for this research and the rest of the policy brief describes the perspectives and insights we found through discussions with 74 policy actors working across these issues. The research approach is summarised in Box 2.

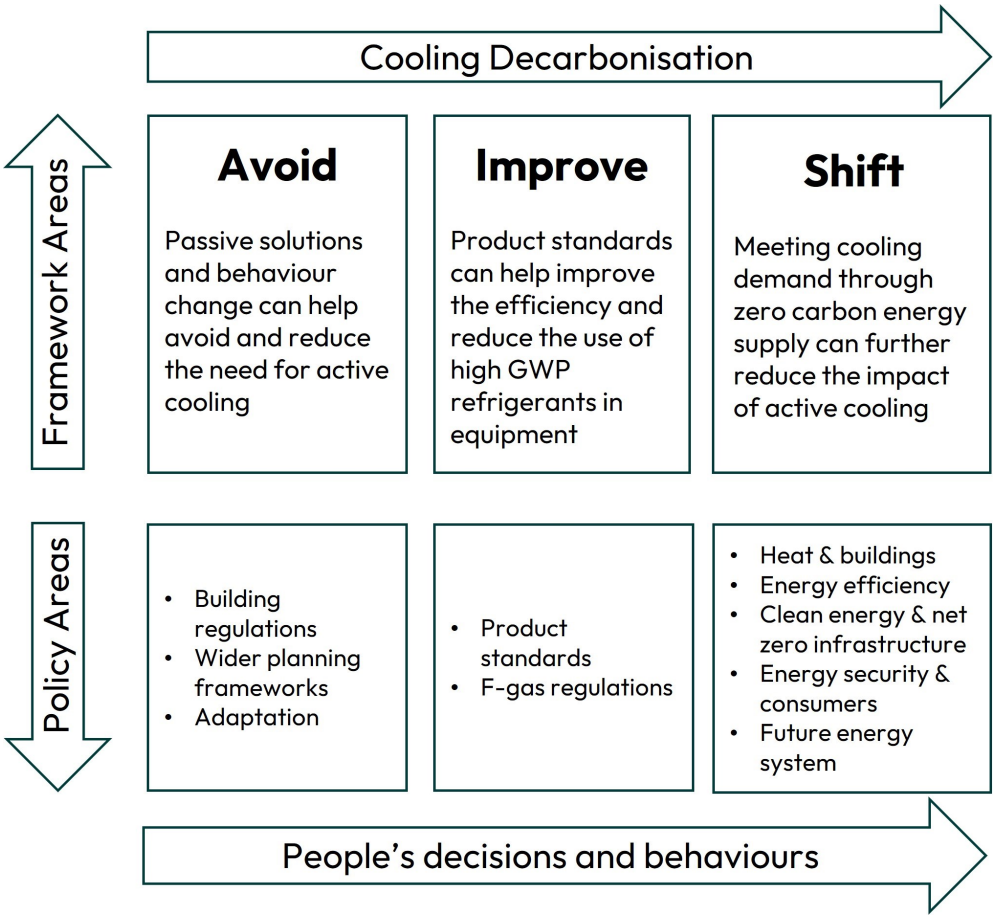

Figure 1. The avoid-improve-shift cooling decarbonisation framework[21]

Research Findings

Avoiding the need for cooling

Passive approaches can reduce overheating risks and improve comfort, make buildings more resilient, and therefore help with equity. Passive cooling can be provided through a range of different measures and is shaped by the behaviour of building occupiers [1,29,32]. As well as helping avoid the need for active cooling, passive approaches will also improve the efficiency and running costs of cooling technologies, if used.

- **Awareness and behaviour are central to passive solutions.** Effective information and advice are needed to help people avoid internal heat gains through the effective use of shading and by avoiding activities that create heat. Information on how to effectively ventilate a property in the right way, at the right time (e.g. night purging), is also central to managing internal heat.
- **Building Regulations should be improved.** Part O on overheating is an important development, but it can be strengthened and applied more broadly. A competency framework for modellers is needed to avoid active cooling going in unnecessarily, skills across thermal and acoustic modelling are vital. For existing homes, the wider application of Part O to refurbishments and conversions is a gap.
- **The main overheating challenge is within the existing stock.** Most of the homes that will be here in 2050 are already built, without consideration to overheating. In addition to better use of Part O, opportunities to assess heat risk in wider programmes around energy efficiency, retrofits, and heat decarbonisation, should be explored. This could make use of existing intervention points, reducing the need for future retrofits, as well as avoiding risks of locking in partial solutions, and better enabling passive approaches, cost reductions and identification of potential health vulnerabilities.
- **Wider planning needs to better support passive approaches.** National planning policy does not currently address overheating risk effectively. Stronger policies are needed on green and blue infrastructure and to encourage better urban planning and design to support passive cooling. Some local authorities have gone further in Local Plans, but inconsistencies in the national planning framework and the inspection regime, skills gaps, and underfunding, means many are unable or unwilling to push for stronger local requirements around overheating and cooling.

Box 2: Research Methods

A two-stage qualitative methodology, using semi-structured interviews and content analysis, alongside a literature review, was used to identify policy challenges and opportunities for the decarbonisation of cooling in homes. This was shaped around the avoid-improve-shift cooling decarbonisation framework. Interviews took place between winter 2022 and summer 2023 over MS Teams, content analysis within NVivo was then used to identify key themes. The sector summary and number of interviewees include:

- **Government**: National, devolved and local government (13)
- **Consultancies:** energy, built environment and modellers (13)
- **Energy:** Companies working within heat, cooling, and storage (11)
- **Energy Industry:** Network operators, energy suppliers, Ofgem, associated trade associations (10)
- **Local Government:** Energy, climate and planning officers, and advisory organisations (7)
- **Wider Civil Society:** NGOs working on energy, climate, buildings, sustainability, and innovation (6)
- **Academia:** cooling, built environment, energy, planning (6)
- **Advisory Organisations:** Statutory advisors, and third sector advice providers (5)
- **Think Tanks:** energy, climate, and sustainability (3)

Improving products, shaping markets

There is considerable scope to improve the efficiency of active cooling products and to reduce the use of higher impact F-gases within refrigerants. Supporting people to take a passive first route, purchase lower impact active cooling, and use AC effectively, will shape how the domestic cooling market develops.

"When [overheating] becomes more common, they will just get fed up and if you have no info and don't know what to do, you walk into a shop and it's £200 for a portable AC unit."

- **People are central to reducing the impact from cooling homes.** Without effective advice and support, in response to heatwaves, there is a risk people will jump straight to an active cooling solution, without considering passive options. Furthermore, labelling on its own will not drive climate resilient behaviours, nor will it help inform people of low impact cooling choices, including the type of F-gases within AC, where advice is lacking. Consumer information on using active cooling effectively will also be important as there are risks that cool homes become a new social norm, with AC run for longer than required at temperature set points that are lower than needed.
- **Regional and international approaches are central to improving cooling products.** Relative to Europe, the UK domestic cooling market is small, so ongoing alignment to the rules and regulations within the European trading bloc on product standards and F-gas reductions will be central to improving cooling technologies within the UK market. More broadly, the UK should continue its active role in helping drive innovation and improvements in cooling products internationally.
- **Policy packages are the most effective way to transform markets for cooling products.** As well as information and advice, a policy approach that combines eco-design and labelling, minimum energy performance standards (MEPS) and financial incentives is likely to be most effective at transforming the cooling market. Currently the UK only has eco-design and labelling in place, MEPS are due by 2030, there are no financial incentives for efficient cooling. Speeding up the introduction of MEPS and supporting the purchase of the most efficient products, particularly for vulnerable consumers, would help.

"If people are only using cooling for a month year.... they will probably go for very cheap products."

- **Solutions cannot just be left to the market.** The UK domestic cooling market is immature, but there is a clear market pull from consumers and a market push from manufacturers underway. Given the health and equity issues of overheating, cooling cannot just be left to the market. Policy should encourage passive and low impact cooling, that is affordable and readily available to those that need it most. Particular attention should be given to supporting innovation, manufacturing, and supply chains for passive cooling, to help grow the market and support consumers to take a passive first approach.
- **Wider opportunities should be explored.** The potential to ban the least efficient and most polluting domestic cooling products, in terms of F-gas choice, would help to rapidly improve the market. More broadly, opportunities to better link policy and regulation across product standards and F-gases should be explored, to avoid policy silos and to better help shape product policy across standards, markets, consumer information and advice. Ongoing work to ensure interoperability and smart controls for energy products will also play an important role in shaping how flexible domestic cooling might be.

Shifting and managing cooling loads

As the demand for cooling increases it will become increasingly important to understand and manage cooling loads within the energy system.

- **Cooling flexibility will become increasingly important.** As the energy system decarbonises and the use of variable renewables increases, demand side flexibility will be important to reduce system costs and the need for fossil fuel generation. Flexing cooling loads will be helped by wider demand-side policies, including the use of PV and energy storage, improvements to the thermal efficiency of existing homes, and better clarity, information, and support around consumer participation in demand-side flexibility.
- **More work is needed to understand cooling loads**. Currently system operators and networks have very low visibility of cooling loads from the domestic sector, and more widely there is little understanding on the amount of domestic cooling in use, or how this may grow. This lack of information feeds into the modelling and scenarios used across energy system planning.
- **Cooling loads may create challenges for networks and system operation.** Despite the uncertainties, cooling loads are likely to be considerably lower than demand from heating and transport. As such, there are unlikely to be capacity issues for meeting cooling demands. However, peak loads may become more problematic, in part because cooling demand is likely to be quite 'peaky' in its nature, with loads potentially coinciding with existing system peaks. Although cooling demand is not currently causing problems for networks and system operation, there are concerns that there may be a rapid and clustered uptake of cooling in response to heatwaves, which could result in increasing network constraints. As has already been seen, this may also result in fossil fuel generation coming onto the system.
- **Other challenges for networks are likely to emerge from increased cooling demand**. High temperatures are likely to increase cooling demand, whilst also resulting in falling efficiencies within the energy system, increasing the risk of network constraints and faults. Managing faults in extreme temperatures will create new health and safety concerns for network engineers. In addition, currently low demand in the summer provides important maintenance windows for networks (and generators), as summer demand for cooling increases, the time and ease of carrying out maintenance will become more challenging.

"For AC [we] have no knowledge of either domestic or non-domestic, cooling is a blind spot."

"As we experience more frequent and intense heatwaves, we [may] suddenly see a bow wave of people wanting AC and that might be very clustered, because people can see a neighbour has it and see the benefits."

Aligning cooling and heating

The decarbonisation of heat is central to reducing emissions from the domestic sector and there may be opportunities to deliver this, whilst also considering cooling. This could reduce resource use if a single technology provides both heating and cooling requirements, whilst also helping avoid future retrofitting work, reducing lock-in risks, building more effective supply chains, and potentially saving consumers money.

" We should be thinking about how we provide year round comfort to people, linking to health as an outcome."

- **Thermal comfort would be a better policy framing for the Heat and Buildings strategy.** As the climate changes, ensuring homes are cool in the summer and warm in the winter will become increasingly important for people's health and well-being. The main policy framework is currently overly focussed on the provision of low-carbon heat, this is a missed opportunity that will deliver partial solutions. There is also a need to better align heat and cooling policy within the Heat and Buildings strategy and within the new cooling action plan.
- **Cooling should be considered in the development of heat networks.** District energy networks can provide heating and cooling through one solution, better enable system flexibility, and help avoid the need to later retrofit a cooling solution. The feasibility, complexity and economics of such networks will be site specific, but with considerable expansion planned for heat networks, assessing the potential for these to be district energy networks is an opportunity.

"It's increasingly clear that heating and cooling as a strategy needs to be considered together, many of the issues across them are similar."

- **Hydronic heat pumps could provide cooling, but more innovation is needed.** Water-based air-source and ground-source heat pumps can be run in reverse to provide cooling, but it is not straightforward because of condensation risks. Ground-source technology may offer better overall efficiencies and has higher potential for flexibility. Manufacturers are starting to bring solutions to market, and this may speed up as the need and demand for cooling increases.
- **Air-to-air heat pumps will be a good solution in some properties to provide both heating and cooling.** These heat pumps are well suited to households without wet central heating. They may be particularly valuable in smaller and harder to treat properties and some national pilots may help better identify the role they might play, particularly in high-risk households.
- **Shared ground loops could also have an important role to play.** These systems sit between heat networks and heat pumps and could play an important role in providing street-based solutions in areas that are hard to find another option for, like rows of terraced houses or blocks of flats.

Recommendations for policy

Act quickly and comprehensively (Lead: DESNZ)

- There is a window of opportunity to shape the future of cooling in UK homes, before overheating worsens and the domestic cooling market becomes established. Without action there is a risk that active cooling like AC becomes the default solution and new social norm. This will lock in unnecessary direct and indirect emissions and make wider goals for decarbonising homes and the energy system harder.
- The emphasis should be on encouraging and enabling people to take a passive first approach, by supporting the development of a passive market and giving people the information and support they need to understand and adopt passive approaches.
- More broadly, supporting people around the purchase and effective use of active cooling is likely to be important, alongside action to drive improvements in cooling products within the UK market. Action to encourage and enable the flexible use of active cooling is also likely to become increasingly important as the energy system decarbonises, linked to wider purchase to enable demand-side flexibility.

Seek synergies (Lead: DESNZ, with cross-departmental support)

- Overheating and cooling are relatively temporal and less visible than other policy areas, suffering from a lack of policy capacity and space, so seeking synergies will be vital to driving action.
- Reframing the challenge in terms of thermal comfort and health as an outcome would help break down existing policy silos and better support a higher visibility across departmental responsibilities.
- Doubling down on integrating overheating and cooling into existing programmes that support decarbonisation in homes will deliver cost effective quick wins. This includes embedding the issues into wider policies around energy efficiency, housing retrofits, heat decarbonisation, and climate adaptation.
- Work to develop the skills and supply chain for heat decarbonisation and housing retrofits should consider the opportunity to also provide training on assessing overheating risks and solutions.

Protect the most vulnerable and support all people (Leads: DESNZ and DHSC)

- Many of the most vulnerable and disadvantaged are likely to be in poor housing, in areas that lack green space and suffer from higher pollution and overheating risks. There are also likely to be crossovers with winter fuel poverty, creating a year-round challenge for the least able to adapt. An equitable approach to heat risk should be a policy priority.
- To enable low-carbon climate-resilient behaviours, including those relating to heat risks and the use of low impact cooling, people need effective information and advice, as well as wider interventions to make change easier and help shift social expectations.

Build on, and share best practice (Lead: DESNZ)

- There are many examples of best practice in dealing with overheating and cooling within the UK that should be bought together and shared to help save time and resources.
- Many countries have been dealing with heat resilience for much longer than the UK. Learning from what works elsewhere and how transferable different approaches could be to the UK is an opportunity.
- Such insights could be linked to the planned new DESNZ cooling webpages on the gov.uk website.

Lead nationally and support action locally (DESNZ, DHSC, national/devolved/local government)

- An integrated, joined-up policy approach across heat resilience, cooling, health, climate and energy is needed to provide people with year-round thermal comfort, equitably.
- Health and existing homes are the key challenge, putting the main responsibility on DHSC and DESNZ, but all departments and the Devolved Nations will need to play an active role in tackling the growing risks.
- Whilst national modelling helps identify which houses and areas may be most at risk, effective action is largely about the last mile of detail. Local authorities are therefore central to helping identify risks and solutions, an effective strategy to support them, including resources and skills will be needed.

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