Kensa Group Response: Environmental Audit Committee Inquiry Heat resilience and sustainable cooling August 2023

About Kensa: Kensa is a manufacturer, installer, training provider and financier of ground source and networked heat pumps based in Truro, Cornwall. Kensa represents approximately 50% of the ground source heat pump (GSHP) market, manufactures all its products in the UK, has been operating for 24 years and is part-owned by Legal and General and Octopus Energy. Kensa is pioneering the concept of networked GSHPs, an approach that sees GSHPs installed in individual homes, and each connected to a shared network beneath the road, just like the gas grid. This contrasts with typical GSHP installations that instead require each home to have the space (and money) available to have individual ground arrays installed in the garden. This approach could be the optimal heating solution for an estimated 60% of UK homes[1], and is increasingly built into assumptions about future home heating including modelling from National Grid[2] and the Committee on Climate Change[3]. Critically, within the subject of this inquiry, GSHPs can provide 'passive cooling' at very low costs to consumers.

Introduction: Kensa welcomes the opportunity to provide evidence to this EAC inquiry. This is a subject of particular interest to Kensa; a major secondary benefit of GSHPs is their ability to provide 'passive cooling', a low-cost and energy-efficient cooling solution. It is estimated that the UK will see a 30% increase in the number of days each year with uncomfortably hot temperatures[4] and we are already seeing the impact of this. Around 20% of England's housing stock already overheat and 36% have a 'high risk' of overheating in future[5], this number rises to 55% in London. Increases in temperatures will put pressure on people, buildings, and energy systems as we try to find resources and technologies to reduce overheating.

Increased cooling needs are impacting our carbon footprint and electricity consumption. Globally it is estimated that air conditioning is already responsible for around 4% of greenhouse gas emissions[6], and this will only rise. In the UK it is estimated that air-conditioning already accounts for 10% of UK electricity consumption[7] (corresponding to around 2% of emissions) and in July of last year, we saw coal-fired power stations being turned on to meet the increase in demand caused, largely, by air conditioning during the heat waves. Importantly, the UK historically has not needed to worry about peak electricity demand and capacity margins during the summer. But as cooling requirements increase this could become a major issue, particularly as power generators and network providers use this period of reduced demand for shutdown and maintenance.

To minimise further increases in electricity consumption and emissions from cooling we must take a planned approach ensuring the lowest cost and most energy efficient options available are taken first. Advice from the Climate Change Committee[8] and conclusions from the BEIS report, Cooling in the UK[9], is to take a 'passive first' approach to cooling, using those measures that require no or very low energy and only calling on active cooling where strictly necessary. We would wholeheartedly endorse this advice.

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[1] BRE (2020) *The Housing Stock of the United Kingdom.* States that 73% of UK homes are terraced, flats or semi-detached. Kensa estimates that of these 73%, approximately 60% are located in areas of appropriate heat demand (500-7,000 kWh/m/yr) to ensure networked heat pumps are the lowest cost heating option, with the remaining 13% more suitable for individual heat pumps.
[2] National Grid (2023) Future Energy Scenarios. Consumer Transformation and Leading the Way scenarios project 8 and 7 million GSHPs installed in homes by 2050 (around 40% of total heat pumps) with the majority being networked.
[3] Climate Change Committee (2020) Development Trajectories for residential heat decarbonisation to inform the sixth carbon budget. Modelling projects 5.3 million homes heated by GSHPs by 2050, around 20% of all homes and a similar number to the total for all district heating.
[4] University of Oxford – The Future of Cooling
[5] Resolution Foundation (2023) It's getting hot in here
[6] US National Renewable Energy Laboratory
[7] CIBSE (2016) https://www.cibsejournal.com/news/a-tenth-of-uk-electricity-used-for-air-conditioning/
[8] Climate Change Committee (2023) Progress in Adapting to Climate Change 2023 Report to Parliament
[9] BEIS (2021) Cooling in the UK

The government should start to look at heating and cooling as part of the same policy challenge, moving to a heating and cooling, or thermal comfort, strategy rather than a near-exclusive focus on heat. Considerations around the cost, grid impact, energy consumption, and practicality of installing new heating technologies need to also consider all these factors in relation to cooling. Given the dual role that some heat pumps can play in both heating and cooling, it is evident that the government's heat pump policies must also start to consider cooling.

Inquiry Questions:

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? Given Kensa's expertise in the manufacture and installation of heat pumps, we have chosen to focus our response on this question. However, aspects of our answer will touch on considerations from other questions from the terms of reference.

GSHP Passive Cooling: Passive cooling refers to cooling measures that consume low or no energy, including blinds, shutters, fans, reflective roofs, and specialised glazing. In the context of heat pumps, passive cooling refers to the ability of a ground source system to provide cooling to a building without actively using the heat pump itself, simply using the cooler temperature of the ground in comparison to the air. This contrasts with 'active' cooling that some heat pumps systems can provide in which the heat pump is used in reverse to actively cool a building, either via chilled water (air/ground-to-water systems) or cooled air (air-to-air).

Before looking in more detail at how passive cooling from GSHPs works in practise, it is worth summarising the main benefits that GSHPs can provide with respect to cooling:

- **Lower electricity consumption compared to active cooling:** Passive cooling uses considerably less electricity than active or full air-conditioning. As demonstrated from a recent trial of passive cooling (see below), Kensa estimates that passive cooling uses less than 1/3 of the electricity that an air conditioning unit would do to cool the same sized space. The more active cooling we can displace using passive cooling the more we will be able to minimise increases in electricity consumption and peak grid demand resulting from increased cooling.
- **Easy and low cost retrofit:** In the current absence of adequate consideration of a home's likely future cooling needs when installing a heat pump, the installation of a GSHP provides a no or low regrets option. Even in the case where the GSHP system isn't installed to provide cooling in the first instance, modifications can be made easily and at low cost (£1k-1.5K) to provide passive cooling. This contrasts with virtually all ASHP installations in UK domestic properties today which would have to be replaced with a reversible heat pump and the installation of a new emitter circuit to provide active cooling, with no option available for passive cooling.
- **Crossover with buildings most suitable for networked heat pumps and those most at risk of overheating:** Most future GSHP installations in the UK will be part of heat pump networks connecting multiple dwellings rather than individual installations. A networked approach is where the major cost reductions are available through economies of scale and, crucially, the optimal means of installing heat pumps (of any form) into many property types like small terraces and tower blocks. Significant numbers of such properties will be unsuitable for individual ASHPs due to outdoor space constraints and many areas will not be heat dense enough for centralised heat networks. At the same time, such properties' space constraints will also limit their cooling options. Networked heat pumps can provide an energy efficiency and cost-effective solution to both these issues. Critically it is these sorts of properties that are already identified as the most at risk of overheating in the future. New Research from the Resolution Foundation[10], notes that "*flats and smaller homes have a higher risk* [of overheating]*, as they are less able to dissipate heat…. properties in urban environments are more exposed to 'heat-*

[10] Resolution Foundation (2023) Its Getting Hot in Here

island' effects – whereby built-up areas experience significantly warmer temperatures than rural locations – causing both hotter days and less cooling overnight."

- **Passive cooling increases the efficiency of the GSHP system:** When passive cooling is in operation in a GSHP system, the heat from the building is transferred to the ground array (underground pipework), gradually increasing its temperature. This helps 'recharge' the ground array making the overall system more efficient for providing hot water at any time of year, and for providing heating during the heating season. Furthermore, the addition of this heat during the summer months means the ground array could be sized smaller than otherwise would be the case, saving money on the installation costs of the array as fewer and smaller boreholes could be required.

How passive cooling works in practice: Passive cooling using a GSHP system draws the brine (water and anti-freeze) up from the ground array into the building. Because the ground remains around 10°C in the UK throughout the year, in the summer the ground is significantly cooler than the air temperature and able to provide some cooling to buildings. The brine is drawn into the building using the water pump in the GSHP or a separate pump depending on the setup chosen. The brine is then pumped to a fan coil, where warm air from the building is blown over a coil containing the cold brine, cooling the air which is then blown into the room thus providing passive cooling.

At the same time, the warm air blown over the coil heats the brine, which is then pumped back to the ground array thus removing heat from the room. The brine returning to the ground array is cooled once again by the lower ground temperature before being drawn back again into the building to provide more cooling. As the brine cools in the ground, it transfers the heat it absorbed from the building thus improving the heating efficiency of the system later in the year (see above).

There are several different technical setups that can be used inside the building to achieve this passive cooling, but the basic principles are the same and the only element of the GSHP that is used is the water pump to draw brine into the building. As noted above, passive cooling uses very little electricity, just that required for the water pump and the fan coil unit. This system can work on an individual home basis, or even more effectively as part of a heat pump network in which multiple dwellings and buildings both draw heat from and provide heat to the ground array.

In 2022 Kensa tested the effectiveness of its passive cooling system at the Mill Housing Estate, Cardiff. This took place from 11th July until 27th October - a period which encapsulates the two heatwaves experienced by the UK in 2022. The key findings of this study were as follows:

- During the July heat wave when external temperatures reached 32.6C, Kensa's system was able to maintain the main living space temperature at a comfortable 21C.
- The control room, which did not have a passive cooling system installed, reached 28C.
- During the time that the passive system was in operation, the average difference between the cooled room and the control room as 5C.
- The passive cooling system used a 200W fan and with an average cooling period of 10.4 hours a day, consuming an average of 2.1kWh a day. At today's electricity prices this would cost £0.62/day to run and emit 431g CO2.
- The equivalent figures of an air conditioning unit would be 7.0 kWh, £2.08, and 1400g CO2 each day – 3.3 times higher than the passive cooling system[11].

There are some important considerations for passive cooling through GSHPs that should be noted:

- It is not recommended to provide cooling (either active or passive) directly via a home's traditional central heating system as this could cause condensation on pipework, radiators, and underfloor

[11] These calculations assume an air condition requirement of 125w/m2 and a EER of 2.6. The room size is 13.92m2.

heating. Instead, a parallel system distributing cold liquid/brine to fan coils in separate rooms is the recommended approach. This parallel system would cost around £1,000-£1,500 per room to add, and Kensa has developed a passive cooling module to do this.

- The cost and practicalities of installing a fan coil in each room where cooling is needed practically limits the passive cooling to one or two rooms in a home. Increasing the number of fan coils above this number is perfectly possible technically, but economically it would make more sense to install fan coil/convector radiators in each room, which would provide heating and cooling to all rooms in the building. Such considerations should therefore ideally be made when putting in heating system.
- Passive cooling from GSHPs is unlikely to a be a complete solution for commercial buildings given the additional heat emitting sources in these buildings and therefore the higher cooling requirement. In such buildings an active/passive (i.e. a system capable of providing both) system should be provided whereby as much cooling is provided passively where possible (where temperatures are more moderate outside) and active cooling takes over when needed. Such as system would install fan convector radiators in all rooms rather than the simplified fan coil system detailed earlier.
- There is a theoretical limit to how much cooling can be provided by a ground array over a given summer period. As heat is returned to the ground from the building, the ground will gradually grow warmer and its ability to provide cooling will reduce. The effectiveness of the cooling would start to reduce at around 12C and would be cease once the array reached about 18C. In reality, a correctly designed ground array for domestic use would never reach such temperatures in the UK, and for the vast majority of homes in the UK we do not envisage active cooling will be required.

Active cooling and reversible heat pumps: Looking beyond the possibility of passive cooling from GSHPs, there will be cases in which active cooling will be required. For a host of reasons the majority of homes will not have GSHPs installed and where their cooling requirements are above those which can be provided by other passive options (fans, blinds, reflective roofing), then active cooling options will be required. Currently, the highest level of GSHPs foreseen in any public forecasting is National Grid's Future Energy Scenario 2023, with the 'Consumer Transformation' scenario envisaging 8.8 million GSHPs installed by 2050, representing just under 30% of total homes. 2020 modelling for the Climate Change Committee put this figure at 5.3 million, and current government policy looks likely to deliver significantly below this level. (See policy recommendations below). In short, the vast majority of heat pumps that will be installed will be air-source heat pumps (ASHPs) which have no capacity for passive cooling, and the majority of those being installed in homes now do not have the capacity for active cooling either.

Air-to-air heat pumps are already widely used in commercial buildings and nearly all will offer the ability to provide heating and cooling. However, these are not commonly used in domestic buildings and are not actively supported by government policy. They are therefore unlikely to play much of a role in homes in the future.

Air-to-water heat pumps are by far the most common type of heat pump installed in homes today both due to government support and their lower upfront costs compared to GSHPs. However, very few of these heat pumps are reversible and it is not straight forward to modify them to be so. Providing cooling with an ASHP requires a reversal of the gas circuit so the cooling gets diverted to the heat exchanger and the heat gets diverted to an internal fan assisted radiator. This requires a "reversing valve" and an additional software to manage the refrigeration circuit when this happens. It would also require new fan convector radiators. The additional complications of adapting an ASHP installation means that unless the dual heating and cooling requirements of a building are considered at the time of an ASHPs installation, i.e., a choice is made to install a reversible ASHP and the right radiators, then the homes will either need to install a separate/parallel cooling system later or replace its heat pump and radiators at a later date.

A building/home that already has a GSHP installed, and it is later decided it need an active cooling system could be adapted slightly more easily, but it is far from ideal. The existing GSHP could be adapted to operate in reverse as all GSHPs already have a cold and hot liquid circulating when in operation and the direction of these flows simply needs to be reversed with an external valve. The radiators would also need to be replaced. Active cooling from a GSHP would still only require a small amount of electricity, as the temperature of the water from the ground array is never likely to be significantly above the temperature required to cool a room. Even in a situation where the ground array had heated to 15C (extremely unlikely) the difference between this and the preferred 10C needed for cooling is minimal and therefore the active cooling would be as efficient as possible.

Importantly, the assessment of whether a building/home will need cooling should be done at the time of the installation of a heat pump. Adapting a pre-existing system to provide cooling that wasn't originally intended to do so can be expensive and complicated. Given the enormous challenge and costs we already face in replacing every home's heating system over the next three decades, it would be foresighted of the government to avoid such a situation and consider the UK's cooling needs alongside its heating requirements. Where homes will need some form of cooling beyond that which could be provided through building design and adaptation, this need should be considered at the same time as heating system replacement. For example, heat loss assessments required in advance of heat pump installations could incorporate cooling assessments at the same time with a recommendation for the best solution to cater for both requirements.

Policy Recommendations:

- **A heating and cooling strategy**: With increasing attention being paid to the UK's future cooling requirements, and the significant overlap these considerations have with the government's existing heat and buildings strategy, a combined heating and cooling/thermal comfort strategy is required. Given the role that heat pumps can play in passive and active cooling and the central role they are already playing in heat decarbonisation, it is vital that policies are designed that ensure we deliver the lowest cost and most energy efficient options for these combined requirements.

  Importantly from a GSHP perspective, such a strategy should re-evaluate the importance of GSHPs given their ability to provide energy efficient and low-cost heating and cooling. Where/if it is shown overall costs (individual household and system-wide) and energy consumption would be lower for heating and cooling by increasing the number of GSHPs installed, government policy should be developed to help achieve this outcome. A recent study from Element Energy has already modelled this specifically with regards to heating and has demonstrated that the combined costs of installing heat pumps into all new and existing homes, and the upgrades to the UK's electricity system required to meet the additional electricity demand from heat pumps would be £15/billion a year lower if all homes had GSHPs compared to a scenario in which just 15% did.[12]

- **Supportive policy for GSHPs:** Regardless of the development of a cooling strategy for the UK is clear from the perspective of Kensa, as a manufacturer and installer of GSHPs, that the technology will play only a small role in the UK unless we see important shifts in policy from the government. There are notable holes in the government's heat decarbonisation approach, not least continued delays in decisions on the phase-out of fossil fuel boilers, but even once/if these are addressed there are GSHP-specific challenges that need addressing. The government's approach to date has largely been to see GSHPs and ASHPs as a single technology, with the same benefits and challenges, and the same supply chain in need for development. Whilst the technologies share a lot in common there are notable differences including around a 40% higher efficiency for GSHPs (reducing energy bills and peak electricity demand), higher upfront costs but lower lifetime costs, the ability to passively cool, and unique elements of GSHP supply chains that need development (e.g., drill rig operators).

  Perhaps most importantly, large scale deployment of GSHPs will rely on a networked/area-based approach with many homes all connecting to the same infrastructure put into the street by companies

[12] Element Energy (2023) Low Carbon Heat Study

like Kensa. This is a capital and infrastructure heavy endeavour which will only become viable for private sector finance if the right market and policy conditions are in place. Despite our concerns about delays in heat policy, there has been important progress on both heat pump and heat network policy. However, networked heat pumps sit in a policy gap between these two technologies and unless this gap is addressed it will be impossible to develop the industry at scale, achieve the cost reductions required, and even enter the retrofit market in any meaningful way. At a very high level, the policy developments required are:

Market Certainty for Heat Pumps: One of the greatest obstacles to overall heat pump deployment, and necessary supply chain development, is a continued lack of certainty about the future market. Government can significantly reduce this uncertainty by providing clarity as quickly as possible on the following:

- Future Homes Standard introduction, signalling to the market that from 2025 onwards no new houses will be connected to the gas grid.
- Boiler phase out, setting a clear timeframe for when replacement of fossil fuel boilers will no longer be possible.

Electricity vs Gas Prices: Heat pumps are on average three times more energy efficient than a gas boiler. However, despite the huge energy efficiencies available through GSHPs, gas boilers are still cheaper to run due to the huge disparity between electricity and gas prices (circa 4.5 times more expensive historically). Reducing the disparity between electricity and gas prices can be achieved through:

- Removing the myriad of levies (RO, FIT, CfD, ECO) from electricity bills.
- Reform of electricity market arrangements (REMA) to decouple electricity and gas prices.
- Reform carbon pricing which currently places a price of £80/tonne on electricity and £0/tonne on gas.

Reform of support schemes: Industry's aim is to be subsidy free by 2028 and with the likely ban on gas boilers in new properties from 2025 we are on the verge of this ambition in the new build sector. However, with most heat pump installations set to occur in existing homes, there is a need for short-term support to incentives their uptake. There are five different schemes that can support heat pump installation in various different buildings, but most are poorly designed to support heat pumps, particularly GSHPs. Support schemes must recognise the long-term benefits GSHP can provide as a technology in their own right (100-year lifetime of infrastructure, best possible heating efficiency, private sector funded networks, applicability to flats/terraces) and provide targeted support over the next 5 years to develop the market for GSHP and help us build the UK supply chain and economies of scale necessary to be subsidy free by 2028.

Local Area Energy Planning: Meeting our future heating and cooling requirements is a huge challenge and will require using all the approaches and technologies we have at our disposal: ASHP, GSHP, heat networks, hydrogen, and passive cooling. However, it is increasingly clear that a planned strategic approach needs to be taken. Leaving everything up to develop 'organically' or through consumer preferences would result in huge additional infrastructure costs, vastly increase energy consumption and waste time and resources we do not have. Instead, we must see the development of Local Area Energy Plans across the UK that detail the energy demands and availability in each area and plan accordingly. This should include a mapping of the UK to identify the most appropriate heating and cooling technologies for a given area, taking into account grid capacity, heat and cooling demand, heat density and building types. Some local authorities are starting to adopt this approach, but we need all to be supported to do it and to have some uniformity and coordination. The Future Systems Operator would seem the most appropriate body to take on this role.

Contact:

Richard Warren
Director of Public Affairs

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