Policy Brief

Unlocking heat pump flexibility to deliver low-carbon heating and support the electricity grid

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Executive summary

Heating our buildings accounts for around 20% of UK greenhouse gas emissions, so decarbonising heat is essential for achieving net zero. Heat pumps and heat networks are proven, scalable options for cutting emissions but there are concerns that electrifying heating will worsen winter peaks in electricity use and make power system operation more challenging. This brief explores how far heat pump flexibility can be unlocked to deliver smarter, lower-carbon heating for homes while supporting energy networks. A suite of research studies funded by the Energy Demand Research Centre (EDRC) examined how tariffs, controls, and technology choices affect heat pump demand, system impacts and comfort.

The research found that carefully designed tariffs, used with sensible scheduling, could bring some part of space-heating and hot water demand forward in the afternoon to take pressure off evening peaks. At a neighbourhood scale, borehole fields with water-to-water heat pumps as part of a district heating system can supply efficient, shared, low-carbon heat and act as thermal storage. Where heat pumps are used in district heating systems, the thermal inertia of buildings, pipework and thermal energy storage allows short-term demand-side flexibility. However, acceptable temperature ranges still limit how far, and how often, systems can be shifted.

Policy recommendations

The electrification of heat supports numerous policy goals, including UK energy independence, decarbonisation, and potentially cheaper bills. Flexibility can help deliver cost-effective electrification. Yet there are many reasons why delivering flexibility is difficult. Tariffs change constantly, installers are not energy supply specialists, and most residents are uninterested in becoming energy bill experts. Policy action should be targeted at overcoming these barriers.

The Warm Homes Agency should support delivery of good quality heat pump installation that takes account of different household needs. It should also give guidance to consumers in choosing flexible tariffs and understanding the best combination of retrofit upgrades and heating systems. Vulnerable consumers should be prioritised for support.

The Government should also work with Ofgem to drive forward the heating-as-a-service market, delegating the challenge of system complexity to a few companies supporting millions of consumers with up-to-date technical and market expertise for configuration and operation. Making grant subsidies available through heating-as-a-service providers could be a key enabler in bringing down bills for low-income households.

Local authorities and other relevant stakeholders should engage with district heat network providers to enable households to switch to district heat where that is a good choice (such as in high density urban areas). These systems can support seasonal flexibility when combined with heat pumps that are designed to draw heat away from homes in summer (through heat storage underground) while providing heating in winter. The local area energy planning system could help maximise these opportunities.

Key findings

- Time-of-use tariffs and smart heating controls can incentivise consumers to pre-heat buildings before the evening electricity demand peak, reducing costs while maintaining consumer comfort.

- Conversations about different ownership models for heating, including the potential for 'heating as a service', represent an opportunity to engage consumers on the benefits of flexible tariffs.

- Minor retrofits (such as draught proofing, double glazing, and insulating the hot water tank) that help improve building efficiency may well be accepted by consumers alongside the installation of a heat pump, helping to reduce heating demand overall.

- In district heating systems, when electricity system frequency changes, variable speed heat pumps can be controlled to temporarily reduce electricity consumption without compromising consumer needs.

- The use of ground source heat pumps in district heating and cooling networks can help support both short-term flexibility (through thermal inertia) and seasonal heat storage (storing heat in the ground that has been captured through the cooling of properties during the summer months).

Introduction

Switching to heat pumps is key to delivering net zero targets, as 20% of UK greenhouse gas emissions arise from heating homes, principally with gas [1]. Accommodating the additional demand from heat pumps on the electricity network, however, requires energy supply and demand to be balanced, and whilst storage can help with balancing, batteries are an expensive approach to energy storage. EDRC therefore set out to explore, through a suite of research projects, how 'flexibility' in the timing of demand for heating can help balance the grid, and how heat pump deployment could in fact support the wider energy system.

Background

Heat pumps and heat networks are proven, efficient, scalable technologies that can run entirely on renewable electricity. The government target is for over 450,000 heat pumps to be installed annually by 2030 (including through retrofits of existing buildings), and the installation of electric systems or district heat networks as required by the Future Homes and Buildings Standards (updated March 2026). This creates challenges for the electricity grid, with variability both in supply (intermittent renewables) and demand (daily and seasonal variability) [2,3].

EDRC's research projects investigated how flexibility can help manage this challenge. Thermal storage – in the ground, air, water, and the building fabric – allows both individual and networked heat pump systems to adjust electricity demand for short periods while maintaining acceptable indoor temperatures. The research set out to consider ways of utilising this 'thermal inertia' to help balance the electricity grid.

Research findings

Electricity pricing models can help smooth winter evening demand peaks

The Hong et al. (2025) study [4] developed a model to investigate how time-of-use or 'TOU' tariffs (where the price varies according to time of day) and 'dynamic' tariffs (where prices vary in real-time depending on supply and demand) might impact electricity demand in homes using air-source heat pumps to supply both space heating and hot water. When heat pumps can be run during cheap periods (so called Demand Turn-up Windows) to pre-heat homes or hot water cylinders, demand can be reshaped in response to electricity price signals, providing opportunities for lower energy bills. The study compared rule-based controls with more sophisticated (dynamic rolling-horizon optimisation-based) controls, showing how the latter can reduce operational costs and electricity consumption, while modulating heat output within acceptable temperature levels.

Ownership and control are preferred, but alternative ownership options are acceptable as part of a package of home upgrades and flexible tariffs

The Pawlak et al. (2026) study surveyed over 1,000 UK households on their preferences for hypothetical heating options [5]. Uptake of low-carbon options was found to be driven by both upfront and monthly costs, as well as contextual factors like property characteristics, individual attitudes and perceptions. On average, a 1% reduction in the upfront cost led to a 1.35-2.3% higher probability of a household acquiring a heat pump, i.e. elasticity between -0.46 and -2.28. The results show low-income households being impacted by both heat pump cost and low efficiency (EPC rating) of their properties. However, interest-free or low-interest loans (4% in the study context) can partially offset the burden of investment, while minor retrofits are a broadly accepted means of improving energy efficiency. Full ownership and control of heating was the preferred option, valued at around £330 annually, compared to a service-based model. Consumers in the study were willing to consider different ownership models, variable electricity pricing and demand side flexibility measures, if they saw tangible, monetary benefits.

In a separate study, Agyeman and Calvillo Munoz (2026) [6] looked specifically at how flexible tariffs together with ‘Heating-as-a-Service’ (HaaS) models (where providers finance the heat pump and energy costs for a monthly subscription) could improve affordability. The analysis compared the cost of running air-source heat pumps and gas boilers in a range of different household types. Where the HaaS provider had access to flexible tariffs and the £7,500 heat pump grant, heat-pump-based HaaS was more affordable than both private heat pump installation and ownership and private gas boiler installation and ownership. As the available grant covered more of the system cost requirements in smaller, lower-energy homes, they received a proportionally higher cost benefit than larger, higher energy-use homes.

District heating systems with heat pumps can support short-term and seasonal flexibility

Two studies looked at flexibility from district heating systems using heat pumps. The study by Yan and Walker (2025) [7] modelled whether variable speed heat pumps in a district heating system could be controlled to temporarily reduce electricity consumption when system frequency changed. It found that regulating the rotational speed of the heat pump compressor could raise or lower power consumption in seconds and for up to several minutes, supporting grid frequency without substantially impacting indoor temperatures.

A second study by Hernandez and Qadrdan (2026) [8] looked at how upgrading a district heating system in South Wales to use a ground source heating and cooling system could guarantee sufficient energy for heating in winter while maintaining stable ground temperatures, and store heat energy derived from household cooling during the summer.

During the heating season, the borehole field predominantly operates in discharging mode to supply heat to the system. During the cooling season, warm return temperatures from the network can be used to charge the borehole field through heat rejection to the ground, thereby providing thermal storage and supporting operational flexibility (Fig 1). The research found that two complementary forms of flexibility can be unlocked by a well-sized borehole field: short-term flexibility through control of flow rates and temperatures, and long-term flexibility through seasonal ground thermal storage.

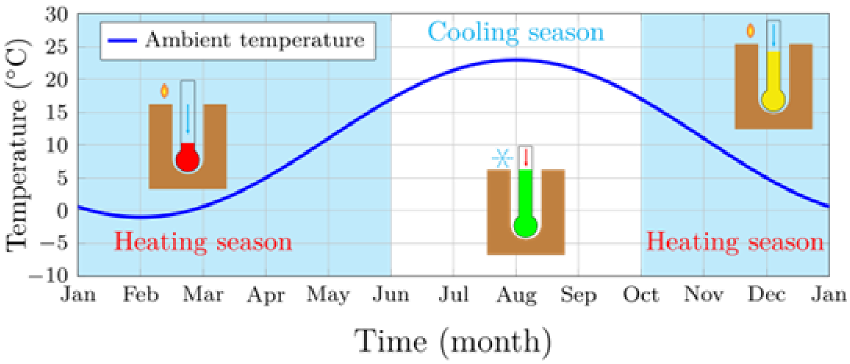

Fig 1. Schematic representation of the annual ambient temperature profile, highlighting the heating and cooling seasons and the corresponding charging and discharging states of the borehole field.

Conclusion

With the right planning and tariffs in place, heat pumps can deliver low-carbon heating and cooling and also help to smooth out electricity peaks and troughs through a range of flexibility mechanisms. Flexibility can be delivered on a timeframe of a few minutes (with in-built controls helping to balance demand and supply), a few hours (using tariffs to incentivise space and water heating during cheaper, lower-carbon periods) or a few months (where ground source heat pumps are used in a water-to-water network that stores heat underground).

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About EDRC

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