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POWERING HOMES, **POWERING GROWTH**

A PRACTICAL PATH TO HEAT DECARBONISATION

4/11/25

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Executive Summary

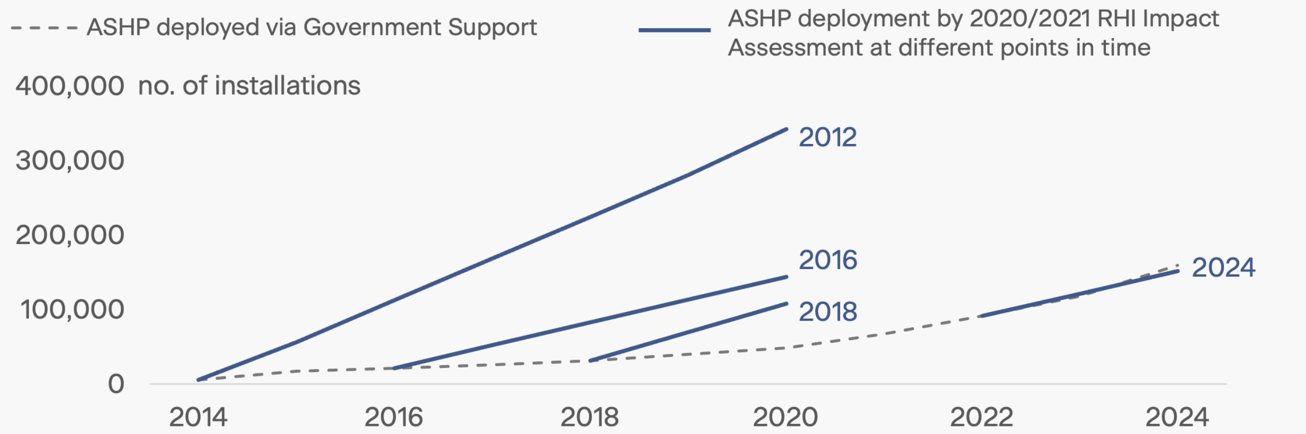
Demand for heat pumps needs to increase by nearly 50% every year to 2030, equivalent to nearly 450,000 installations in 2030. This figure needs to grow further to 1,500,000 in 2035. This is the conclusion of the Climate Change Committee's (CCC) Carbon Budget 7 paper.

The CCC's role is to advise the Government on how best to meet its legally binding carbon budgets on the way to Net Zero. It has repeatedly advised the Government that heat pumps will need to play a major role in decarbonising heat. In its Carbon Budget 6 advice, it envisaged heat pump sales reaching over one million per year by 2030. In the intervening five years, its ambition has been clearly deferred.

This is due to the following problem. Over the past fifteen years, Government policies aimed at promoting heat pump adoption have faced significant challenges. Despite launching at least four initiatives to boost deployment, the results have not met expectations. Specifically, air source heat pumps integrated into wet heating systems, which the CCC identifies as crucial, have not achieved the anticipated deployment levels.

Figure 1.

Actual Air Source Heat Pump (ASHP) deployment versus Government projections



Data source: Department of Energy and Climate Change's Future Heating Strategic Framework

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This stems from a particular approach to policymaking. In-preselecting a technology to maximise decarbonisation, policymakers bet on a single route to policy success. This opened delivery to numerous risks by excluding possibilities for alternate solutions and reducing flexibility. Unfortunately, this route has proved broadly unsuccessful. Heat pumps have not simply failed to be deployed in the numbers expected but have also failed to come down in price.

Sticking to this narrow policy route bears ongoing risks. Previous withdrawals of support have seen heat pump deployment collapse. This means that support equivalent to the current Boiler Upgrade Scheme voucher of £7,500 per installation will need to be maintained to have any chance of achieving decarbonisation targets with heat pumps alone. The cumulative cost of this, to the taxpayer or the billpayer, could hit £8bn by 2030 and £46bn by 2035, at which point 75% of homes would still not have a heat pump.

There is an alternative, and that is to start from an outcome-based approach. That means introducing more flexibility into heat decarbonisation policy. This would enable all kinds of technologies that promise reductions in emissions – bivalent systems, hybrid heat pumps, heat batteries and solutions as yet unknown. Doing this puts customers in charge of finding the solution that works for them and could unlock a cheaper path to 2030.

01 What's wrong with how we're decarbonising heat?

Space Heating

Any home in Britain could be kept warm by a heat pump. A heat pump works by extracting thermal energy from its environment, through a working fluid. It then compresses that working fluid to increase its temperature to a desired level. They extract more energy from the environment than they use. Indeed, heat pumps can output multiples of the energy they receive. As the difference between the outside temperature and the desired indoor temperature increases, heat pumps become less efficient. Yet, a properly sized heat pump can still transfer enough heat into a building to compensate for the heat lost through its walls, roof, and floor.

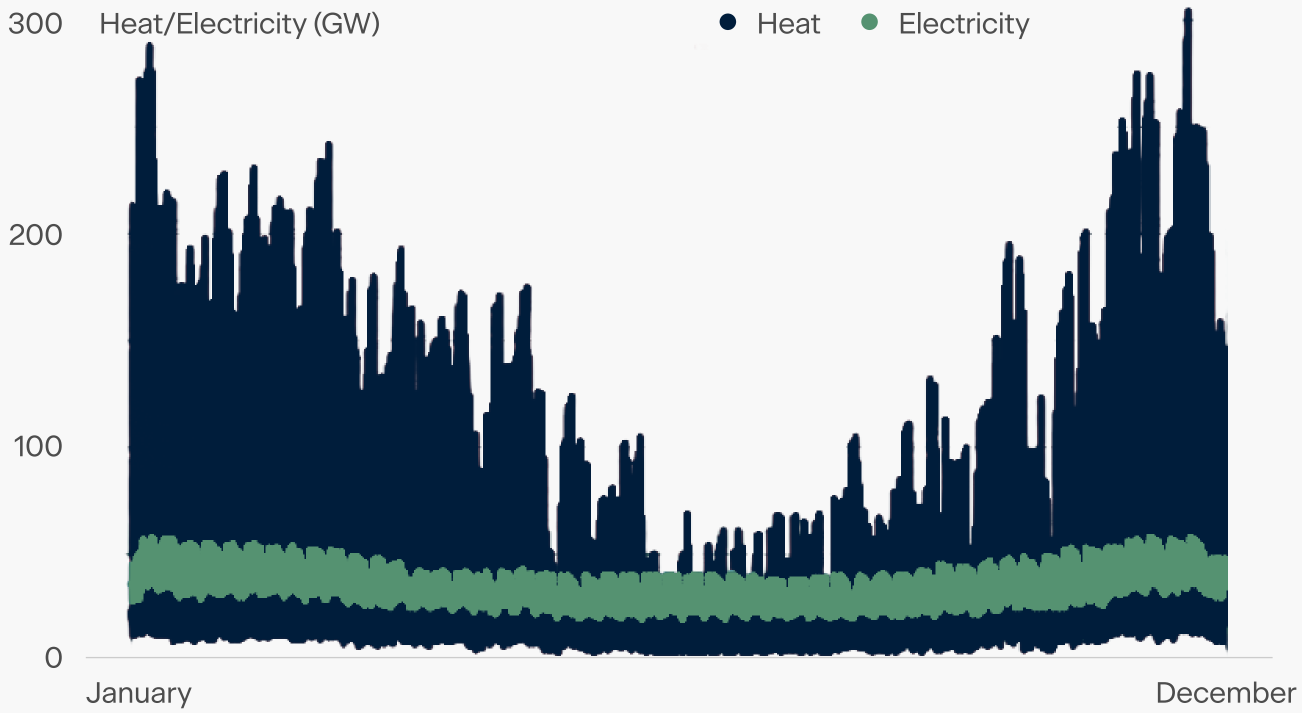
Another technology that could heat any home in Britain is a Multi-Mission Radioisotope Thermoelectric Generator, or MMRTG for short. These are devices that produce heat and power from the decay of plutonium-238 and are used to power missions in space. With a thermal output of 2,000 watts, six MMRTGs would be enough to heat the average home in the UK without requiring refuelling for decades. With a capital cost of a little over a half a billion pounds, they may be out of the reach of the average consumer without innovative financing offers. They may also require significant internal works including additional lead shielding, which would impact their ability to directly replace a gas boiler.

The previous example illustrates that technical feasibility does not always equate to practical or deliverable solutions. Despite this, heat decarbonisation policy has prioritised technical feasibility over the past fifteen years, leading to significant implementation challenges.

Figure 1 below is from the erstwhile Department of Energy and Climate Change's Future Heating Strategic Framework in 2012.[1] It shows the problem for which the Government has been seeking a solution through its approach to heat decarbonisation. Heat demand is much more seasonal than power demand and differs significantly between peaks and minimums. The flexibility to support this trend is currently met primarily through gas boilers. The gas network is built to deliver such swings in need. Swapping out gas boilers for simple resistive heaters would lead to a power system with enormous amounts of idle capacity in the demand troughs, such as at night and the summer months.

Figure 1.

Peak heat demand versus peak electricity demand



Current policy conditions require the Government to decarbonise the economy in the most cost-effective way possible. Over-building the power system to such an extent would, therefore, not be compatible with this need. To address this issue, it is essential for the Government to implement strategies aimed at reducing electricity consumption during periods of peak heat demand. This can be achieved by enhancing energy efficiency, increasing the utilisation of energy storage technologies, incentivising individuals to decrease usage during peak times, and improving methods to extract more energy from existing inputs.

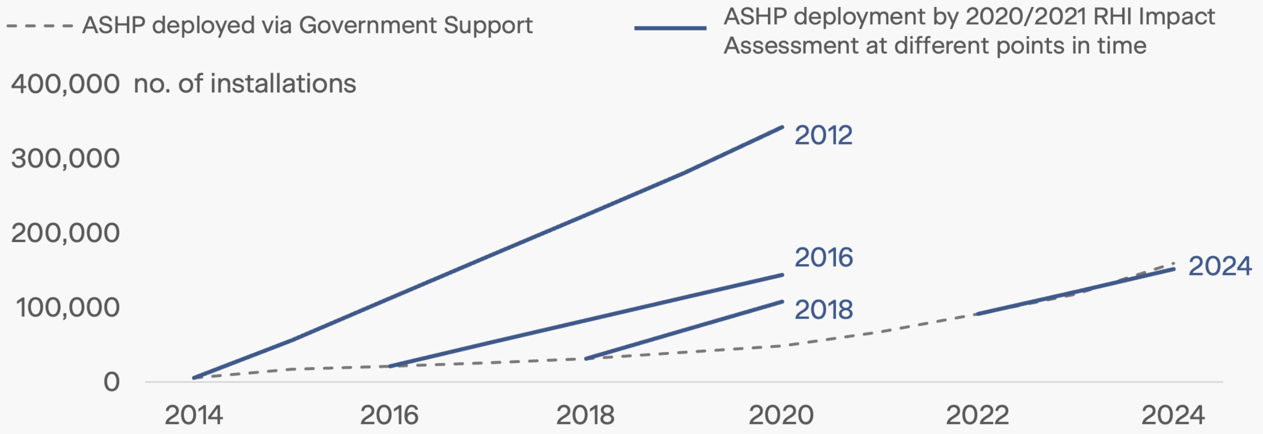
Heat pumps, which can produce multiple units of energy from a single unit of input, can be an important part of the solution. It is reasonable to believe that, if they dominated heating demand, they would serve the peaks in the above chart using considerably less electricity than a resistive heater. Heat pumps installed today use about 60% less electricity to provide the same amount of heat at peak.[2] This would make the system-level problem of heat decarbonisation easier to solve. Through this lens, the Government's long-term emphasis on heat pumps appears compatible with the above policy need.

On the next page, we explore why policymaking to date has, however, underdelivered against this need.

A legacy of over-optimistic projections

Figure 2.

Actual Air Source Heat Pump (ASHP) deployment versus Government projections[3]



Data source: Department of Energy and Climate Change's Future Heating Strategic Framework

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Since 2003 the Government has incentivised the public to install heat pumps. The Clear Skies scheme,[4] which supported the installation of ground source heat pumps amongst other measures, was succeeded by the Low Carbon Building Programme in 2007 for domestic properties. Funding for both of these schemes was limited and they were heavily over-subscribed.

In 2009, the EU's Renewable Energy Directive (RED) introduced a target for renewable energy production. RED counted heat pumps towards renewables targets on a net output basis, and therefore rendered them an appealing solution to meeting the RED target.

As part of the Government's response to the RED target, the Low Carbon Building Programme was replaced by the Renewable Heat Premium Payment (RHPP) scheme. This gave householders a voucher to reduce the upfront cost of various renewable heating technologies, including heat pumps. Running between 2011 and 2014 it issued about 11,000 vouchers for heat pumps, including nearly 8,000 for ASHPs.[5] Householders could receive up to £1,300 towards the cost of an ASHP, or £2,300 towards the cost of a ground source heat pump (GSHP). This represented a contribution of about 10-20%[6] to upfront costs.

As post-financial crisis concerns around Government spending rose, the RHPP was replaced with the Renewable Heat Incentive (RHI), which represented a lower in-year cost on the Government per device delivered. This provided householders with seven years of incentive payments against the heat their heat pump was expected to generate. This created a higher total cost, but spread over a longer period of time. The Government set the level of the incentive based on how much it thought people would need to be paid to choose a heat pump instead of a gas boiler. This was essentially the Government's view of the 'hurdle rate' heat pumps faced in terms of higher upfront cost, unfamiliarity and complexity of installation.

The RHI currently costs about £1.2bn per year[7] across a range of heating technologies, and by 2024 had cost cumulatively almost £7bn.[8] About 15% of this was allocated to the domestic scheme, which delivered less than 8% of the heat produced by the RHI.[9]

80,024 ASHPs installed under the Domestic RHI had received on average 9.5p per unit of heat generated by 2024.[10] Participants received the incentive for seven years after installation, meaning that each installation cost the taxpayer approximately £5,930.[11]

In 2022, the RHI was replaced for new installations with a second voucher scheme, the Boiler Upgrade Scheme (BUS). Initially paying out at £5,000 per installation, rising to £7,500 in 2023, the BUS was intended as a stopgap before the implementation of the Clean Heat Market Mechanism (CHMM), which began on April 1st 2025. While the RHI and BUS subsidise consumers, the CHMM is an obligation on firms who sell over 20,000 gas boilers or 1,000 oil boilers per year. They are required to sell a certain percentage of heat pumps as part of their market share. For every heat pump they sell they get a certificate towards this requirement, and for every hybrid heat pump, half a certificate. For 2025 this obligation is 6% of sales over 20,000 units. Failing to meet this carries a buy-out cost of £500 per missed unit.[12] Regulations to implement this scheme passed in January 2025.

Until they reach their target, suppliers have an incentive to offer a discount of up to £499 per installation to reduce their buy-out cost. If ASHPs continue to have a total installation cost in the region of £13,000[13] then the discount may not be effective at stimulating demand and reducing the supplier's buy-out cost. Gas boilers currently cost about £3,000[14] to install, giving them a cost advantage over ASHPs of about £10,000. The CHMM will make only a marginal dent in the cost comparison, especially as a heat pump installed under MCS requirements is unlikely to save running costs and may increase them.[15] Assuming that the Government neither increases the penalty nor reduces its ASHP ambitions the Government might have to continue to run the BUS alongside the CHMM beyond 2025, reducing the cost advantage of a gas boiler to £2,000. We will discuss whether this is sustainable in the next chapter.

What all these schemes have in common is the risk of pre-selecting a single route to decarbonisation, as illustrated in Figure 2. Over the past fifteen years, policy to encourage heat pump uptake has consistently under-delivered. Despite spending billions of pounds of public money in this effort, the results have been minimal.

There are multiple reasons that the Government can cite in defence of this underperformance. These include the UK housing stock being less suitable for heat pumps, and therefore on average more expensive, electricity prices being relatively higher than gas, the installer base for heat pumps being limited and pushing up prices, and heat pumps being an unfamiliar technology compared to a gas boiler. These factors, however, could have been eased through policy intervention. There is a more prosaic explanation.

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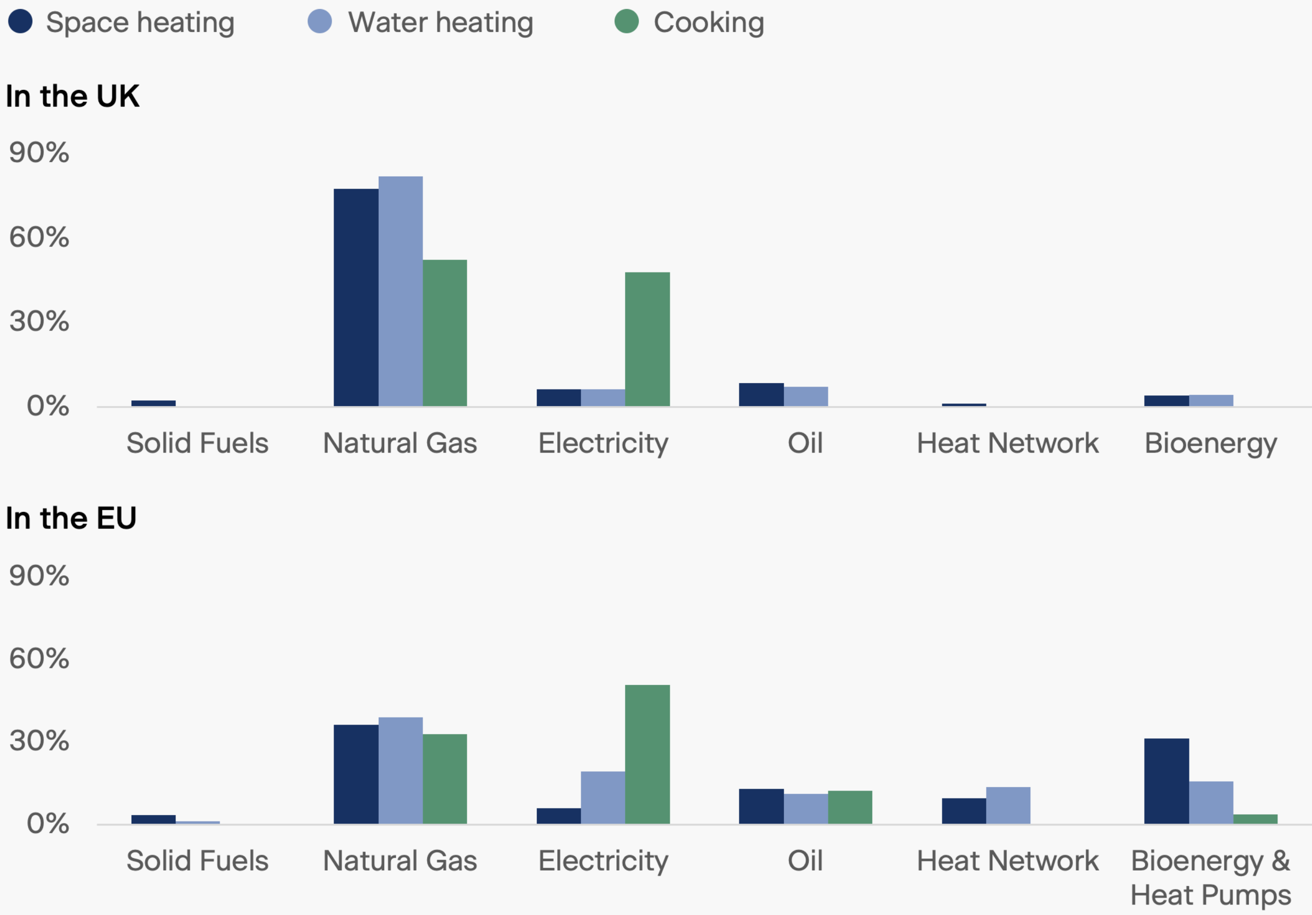
The RHI currently costs about **£1.2bn per year** across a range of heating technologies, and **by 2024 had cost cumulatively almost £7bn**

Policy to fit a model, not policy to fit consumers

Consider the different heating systems on display in Figures 3.[16,17]

Figure 3.

The heat vector mix – different heating technologies at play



Data source: UK Government's Department for Energy Security and Net Zero, Eurostat

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The EU has a more heterogeneous set of heating technologies than the UK. Rather than a heating system overwhelmingly dominated by gas; electricity, oil, bioenergy and heat networks play a significant role. This is sometimes the case within an individual home: a Finnish home may have air-to-air heat pumps installed to heat and cool specific rooms, an air-to-water heat pump to provide heat from underfloor heating, and an oil burner for hot water. This is a response to the very specific customer requirements that the boreal Finnish climate represents. Heterogeneity ensures that there is in-house resilience.

Despite this value, there is little scope within the UK Government's modelling framework to portray such an outcome. Baked into this work is an assumption that a given home will switch its heating device in its entirety. This seems to derive from the status quo, in which the majority of UK homes have a single heating device: the gas boiler. The Government only started considering policy support to air-to-air heat pumps – which do not need to heat an entire property – in late 2024.[18] Rather than looking for a dynamic and flexible policy solution the RHPP, the RHI, the BUS and the CHMM all modelled a narrow route to delivery.

This analytical parsimony extends to heat regulation more broadly. The model needs heat pumps to be as efficient as possible to minimise system costs, even if this means higher upfront costs for the consumer. To maintain this efficiency, heat pump installation is regulated under the Microgeneration Certification Scheme (MCS), which specifies installation design requirements. Only heat pumps certified and installed under the MCS can qualify for Government incentives, so the majority of installations are carried out under the MCS.

The point of the MCS is to set a minimum standard for heat pump performance, but in reality, installers are rewarded for meeting the letter of the regulations, rather than the spirit. This translates into suboptimal real-world performance, rather analogous to the poor real-world performance of condensing boilers. These are frequently installed with flow temperatures in excess of the condensing point of 55ºC, meaning they run less efficiently than advertised. While the efficiency of the heat pump itself is important, the most important factor in determining heat output per electricity input is the design and installation of the heating system it serves.

The best performing air source heat pump installation in the UK multiplies the electrical input by an average factor of 5 over the course of a year,[19] known as a Seasonal Performance Factor.[20] A trial by DESNZ and the Energy System Catapult has established that heat pumps installed in line with MCS requirements in 2019 have a median performance of 2.78.[21] This is more than a third lower than the best in class in 2025, and 18% lower than the performance MCS compliance should engender.

Installer Perspectives on MCS

For the purposes of this paper we spoke to several installers currently deploying heat pumps in the UK. Some key themes emerged:

MCS does not understand system design. It is based on the domestic heating design guide published by CIBSE[22] and effectively acts as a 'check box' for installers, compliance with which does not guarantee performance.

This is because the CIBSE guide does not treat the property as a whole but rather as a collection of individual rooms, which means that the thermal mass of the entire property is not properly taken into account for the purposes of balancing heating loads.

In addition, key parameters within the CIBSE guide are contested, including the number of air changes a property will experience over a heating cycle.

It is therefore reasonably easy to demonstrate compliance with MCS to inspectors, but the best performing installers prefer to pay it lip service and take their own approach to system design.

The Government's instinctual response to this will be to keep tweaking the MCS regulations, on the assumption that there is a route to solving all policy issues within the current approach. This is unlikely; households are simply too heterogeneous for a one-size-fits-all approach. Meanwhile, the MCS acts as a disincentive on installers to design the best possible system for their customers, as they get paid either way. Indeed, the immediate response of MCS to the above results has been to double down on over-specification by mandating that installers assume that every heat pump has the same seasonal Coefficient of Performance.[23]

The average unit cost of electricity for domestic customers in 2024 was 26p/kwh. The average unit cost of gas for domestic customers in 2024 was 7.1p/kWh.[24] Assuming a gas boiler efficiency of 85%, someone who had a heat pump installed as part of the above trial paid 9.35p per unit of heat while someone with a gas boiler paid 8.4p. The properties included in the trial were not even the least suitable for heat pump installation; about a third of the properties surveyed for the trial were rejected, mostly for practical or technical reasons.

While the Government is to be commended for funding a trial that exposes limitations to the current approach, there is a risk that, in its response, it may opt to refine the (narrow) status quo. But, as we have shown above, the status quo has no room to offer the policy dynamism which Britain's households and consumers need. Instead, a new outlook is required. Without this, the Government faces a significant risk.

The Risk of Missing

The Government's ability to meet its Net Zero obligations is contingent on heat decarbonisation. In its 2023 Carbon Budget Delivery Plan, it projected a need for 3.6-3.8 million heat pumps installed in domestic properties in 2030 to meet the fifth Carbon Budget, which covers the period 2028-2032.[25]

The CCC has somewhat deferred and reduced its recommended deployment trajectory since then, aiming for 1 million heat pumps in 2030 and 7.5 million in 2035. This can be attributed to a number of factors, including slower economic growth over the intervening period (which has led to lower emissions from the economy as a whole) and slower than anticipated progress towards the original target under current policy.

Since the 2014 launch of the domestic RHI, 160,000 air source heat pumps have been installed in UK homes under Government schemes. A further 30,000 have been installed under the MCS without support.[26] This means that 700,000 heat pumps would need to be installed annually from now to hit that target. To deliver the 2023 plan, the annual installation rate would need to surpass the total number of heat pumps installed in the UK over the past 15 years.

A significant proportion of these could be delivered as part of a requirement on housebuilders to install heat pumps in more efficient new builds, but without displacing any emissions from the existing housing stock, this would still leave a hole in the Government's carbon budget of at least 3.3 $mtCO_{2e}$ per year, rising in Carbon Budget 6. This is equivalent to the emissions of about two and half million cars. The UK's climate change regime will compel the Government to act in some way, and in the next chapter we look at what will happen if it continues on its current path.

02 What will this mean for consumers and the taxpayer?

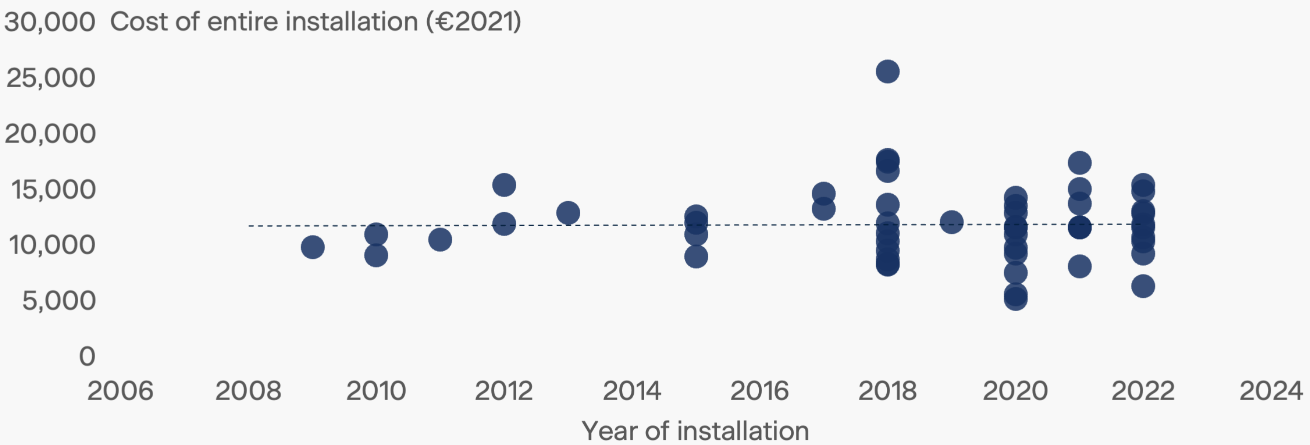
The Cost of Current Plans

An important part of the Government's strategy of the last fifteen years to increase deployment levels was policies aimed at reducing the cost of heat pumps. The 2012 RHI Impact Assessment explicitly set out building a robust supply chain as a goal, stating that it could "reduce pressures and costs of deployment in the 2020s significantly".[27] This has not happened (Figures 4 and 5).[28]

Footnote 28 is referred to Figure 4 and Figure 5 source is the same as footnote 26 from p.11.

Figure 4.

Single-point ASHP installation costs in the UK



Data Source: Note - See footnote 28

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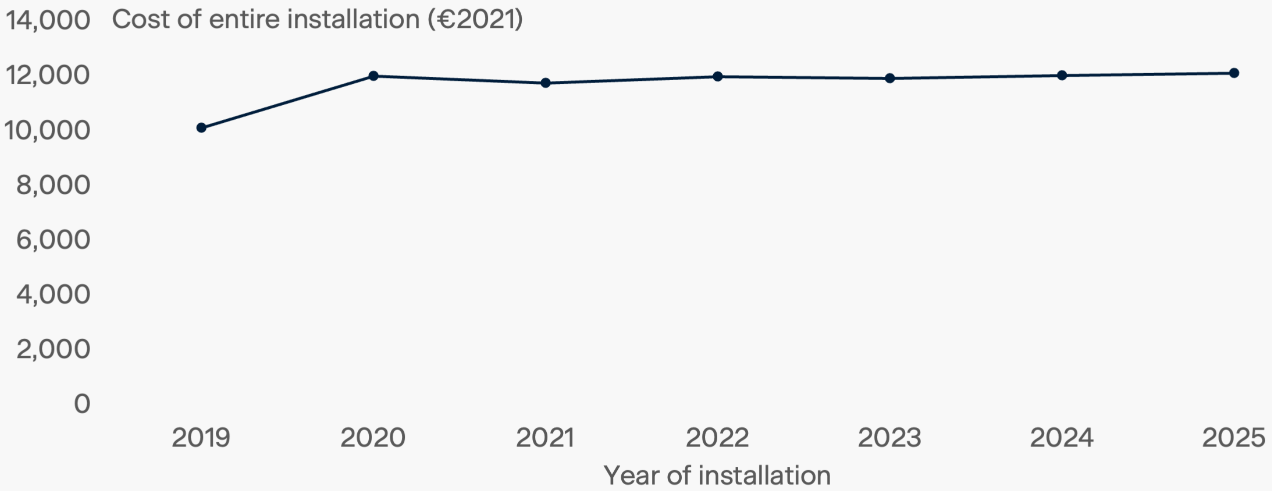
Figure 5.

Average costs of ASHP installation under MCS-enabled schemes



Data source: MCS Certified (2025). Installation Insights Dashboard.

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Now, policy success is contingent on cost reductions greater than those that any other country in the world has been able to deliver. The 2021 Heat and Buildings Strategy set an ambition of reducing heat pump installation and running costs to parity with gas boilers by 2030.[29] This implies that the Government wants to reduce their costs by 75% in five years. The only time any low carbon technology has achieved cost reductions even close to this was solar in the 1980s, when a very immature technology rapidly came down in price.

Heat pumps are not a new technology; they were invented by Lord Kelvin in 1852 and first installed in a UK home in the early 20th century. Delivering cost reduction at the device level is therefore challenging, and in recent years manufacturers have instead concentrated on experimenting with alternative refrigerants to enable higher COPs at higher output temperatures.[30] This means that the need to install larger emitters – i.e. big radiators – will be reduced, which will reduce costs and time of installation. However, it is unlikely that the performance achieved will equal those of lower temperature systems.

It is likely that some further economies of scale can be achieved in manufacturing and distribution, but the limited scale of UK deployment should not be projected onto global markets, which are already substantial. The IEA estimates that 110 GW of heat pumps were manufactured and traded in 2023.[31] That is equivalent to roughly 11 million domestic heat pumps globally. They expect that to more than double to 265 GW by 2035, a rate that implies steady economies of scale but nothing like the solar expansion. The global market, of course, is not in the gift of national governments. In an increasingly geopolitically complex world, overseas mass production to decarbonise domestic heat carries risk, but onshoring to high-cost Britain is unlikely to help the drive to reduce costs.

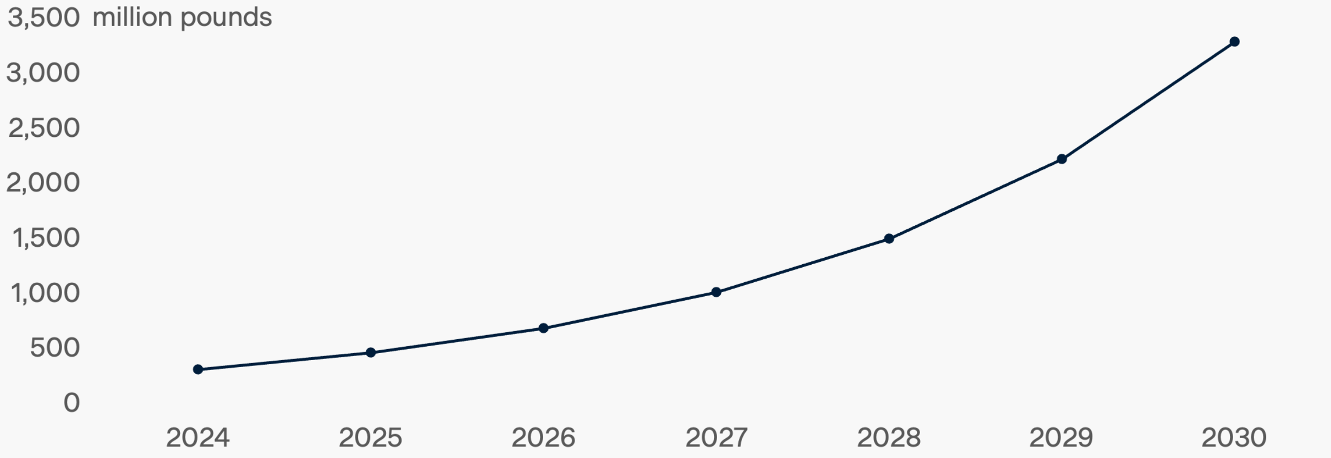
Even if we control for these geopolitical risks, the fundamental driver of heat pump costs – the cost of installation – will remain, even if higher temperature heat pumps become a fixture. This is because, for most properties, a standalone heat pump installation is not simple. It generally involves new radiators, new pipework, new electrical work and new controls. It may require improved insulation and glazing. Heat pump installation requires a wider range of skills than the replacement of a gas boiler – system designers, plumbers, electricians, plant room engineers and more besides. While individuals can hold all of these skills, such individuals tend to carry significant costs. Our interviews with installers have indicated that most businesses are seeking to expand by developing teams of specialists rather than master engineers.

For consumers, this means that, rather than paying for a gas fitter to work for a day, they are paying for a team of three to four specialists to work for several days. Once a home and heating system has been re-engineered, swapping out a heat pump looks (in economic terms) more like installing a gas boiler, but the challenge for policymaking is how to retrofit a large proportion of the housing stock when the initial costs so far exceed (a) the energy bill savings and (b) the Government's fiscal resources.

Given that policy is focused on the device rather than the system, we think it is reasonable to assume that costs remain constant for the next five years. To achieve the heat pump install figure specified in the seventh Carbon Budget of nearly 450,000 per year in 2030, installs need to increase by nearly 50% each year. This implies a significant additional cost compared to the status quo. Figure 6 below shows this additional cost in each year.[32]

Figure 6.

Additional cost of heat pump roll-out



Data source: Stonehaven analysis – for our analysis of both schemes we have assumed the BUS voucher of £7,500 is sufficient to drive uptake at the scale given. We have assumed it needs to remain constant to 2030 as ASHPs follow their existing cost trajectory

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The Government may choose to combine the BUS and the CHMM to try to provide sufficient support to achieve the target, but the total quantum of cost – which to 2030 is about £9bn – must be covered. If we assume that the CHMM is the sole instrument used to deploy heat pumps, and further assume that a buy-out at the BUS grant level of £7,500 is needed to incentivise installation, then the additional costs boiler suppliers will need to pass on to consumers buying boilers reaches £2,500 per year in 2030.[33]

The Other Cost For Everyone

The expansion of heat pump heating is constrained by more factors than just the installation cost. In order to ensure that as many consumers as possible can install a heat pump – even if they do not in fact buy one – the electricity network needs reinforcement. Power networks were originally designed to support household loads that did not include charging an electric vehicle or gaining all their heat from an electrical source. Because heat pumps are a sustained load unlike a kettle or a washing machine, the grid needs to be designed to enable many households to run their heat pump at once. This has consequences across the grid. The transmission network will need additional capacity. Generating or storage capacity will need to be more than doubled to meet peak demand in a high electrification scenario. Additional equipment for system services such as inertia will be required as increased demand meets reduced synchronous generating capacity. On the local network, necessary improvements include replacement or additional transformers, upgrading (and in some cases undergrounding) cables and fuses. Houses built decades ago may discover they share a common circuit with their neighbour that limits the size of fuse they can install, necessitating the unbundling of these connections.[34]

By default, these costs will be recovered through network charges which apply to all consumers equally. The National Infrastructure Commission has estimated that the costs to upgrade the distribution network will reach £37-50bn up to 2050.[35] These costs are for upgrades for both heat pumps and electric vehicles. The NIC sees a potential need for an additional £25bn of investment to ensure that the network is robust to a particularly cold winter. A Government study from 2022 put the wider cost of reinforcing the whole grid at £40-110bn by 2050, increasing network costs to £270-350bn (approx. £10,000 per household) over the period.[36]

If this investment is agreed by Ofgem, the local network component is likely to add at least £2bn per year to the total cost of the power system. According to the NIC, this is equivalent to £5-25 p.a. to the typical domestic consumer, again regardless of whether they buy a heat pump or not.

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A Failure to Take Advantage

One of the biggest missed opportunities of the transition to a renewables-heavy power system is that most consumers are not taking advantage of it. By 2030 it is likely that the power system will be oversupplied with electricity for up to a quarter of the year.[37] At those times, electric heat will be very cheap for consumers – if they can access these prices.

But most consumers do not. Consumers can benefit from very low wholesale prices in periods of over-supply if they switch to a Time Of Use (TOU) tariff, especially a so-called 'Agile' service.[38] An Agile tariff means that consumers pay in line with the marginal price of wholesale electricity at the time of their demand, higher when supply is tighter and lower when there is an abundance of electricity. But consumers also need a practical method to shift most of their demand to periods with low prices. For that, they need both devices (such as heat pumps and batteries) that can time-shift a material proportion of their energy demand, and control systems that make it convenient to do so without adversely affecting their comfort.

Right now, any consumer can access a TOU tariff by signing up with a provider who offers one. Various suppliers offer options including cheaper power at weekends[39] and type-of-use tariffs that run devices in line with wholesale prices but offer consumers a flat rate.[40] These tariffs are targeted primarily at consumers who have already purchased devices like an EV or a heat pump rather than being generally promoted.

To provide such a tariff, a supplier needs to balance their TOU customers' demand with generation in real time. Currently, rather than access their actual demand, suppliers assume most of their customers follow a standard 'load profile'. There are eight such profiles that suppliers use to balance or 'settle' their customers' demand,[41] which generally works across the economy.

With more widespread use of TOU tariffs, and increased time-shifting of demand and embedded generation (such as rooftop solar), the discrepancies between customers' assumed and actual demand will increase. Suppliers are unsurprisingly reluctant to increase their risk by moving away from fixed profile-based demand calculations to floating half-hourly metered demand. But this does not reduce the risk; it externalises it to the system operator, and from them to all consumers. A mismatch between where costs are incurred and where they fall threatens increasing inefficiency in the future. As the electricity market is forced towards a more dynamic model by the electrification of heat and transport and the increasing share of renewables, it will be important to transition away from load profiles and towards compulsory market-wide settlement based on actual data.

The smart meter roll-out is intended to help facilitate this, but is struggling to capture the entire market. Even if everyone has a smart meter, suppliers are not obliged to settle every consumer in line with their actual demand. This means that consumers with low impacts on the system are essentially obliged to cross-subsidise those with high impacts. Right now, consumers are able to elect to move to half-hourly settlement, which reflects the 30-minute intervals electricity trading takes place in. So far, 1.4m consumers have done so,[42] some of whom may have opted into Agile-style tariffs. 30 million consumers, however, have not.

A process to move all consumers to half hourly settlement began in 2021 but has been subject to repeated delays.[43] The earliest point for this move is now in 2026, a good two years after the original deadline. There are no guarantees that this timeline will be kept. By itself, it will not be sufficient to encourage most consumers to move to TOU tariffs. Doing so would require half hourly settlement to create a genuine competitive threat to existing non-TOU tariffs on the market. Suppliers will be free to continue to use average consumption across consumers for the purposes of buying power to avoid investing in new business models until absolutely necessary. This means that they will be reluctant to heavily promote ToU tariffs, at least in the short term.

A Need for Competition

What underlies this challenge is the parlous state of competition in the energy retail sector. Ofgem has spent the last few decades driving competition by prioritising consumers' ability to switch between suppliers, rather than thinking about how suppliers could compete on the basis of novel consumer propositions.

A market based purely on switching between suppliers on the basis of a commodity price does not represent enough of a competitive threat to prompt incumbents to chase time of use tariffs. Instead, it is vital to create new avenues of competition that allow new entrants – and existing ones – to use half hourly settlement as a route to offering new value to consumers.

What is key to this more competitive process is ending the assumption that the household is the unit of energy demand. There is no technical reason why consumers cannot have one supplier for their electric vehicle, another for their heat pump and another for their general household demand. Specialised suppliers able to magnify the particular characteristics of a device in service of a market position would represent a threat to incumbents inasmuch as they would be able to offer cheaper power for that device on a sustained basis.

Unlocking this value means allowing consumers to buy energy at a device level. This would significantly improve consumer choice, as well as materially moving the market towards time of use.[44]

03 What should we do instead?

The optimal path

What is clear from the last fifteen years is that there is room for a new line of policy questioning. Instead of, "How do we persuade consumers to switch to a technology our model prefers?" we should consider asking, "How do we create a framework that lets consumers work out how to decarbonise heat in a way that works for them?"

By focusing on the technology, we have overlooked the home. More precisely, we have not thought of the home as a tiny energy system with the consumer at its heart. The stakeholders we consulted during our research emphasised that heat pumps are the only option that satisfies the modelled requirements of a decarbonising energy system, and that this cost must simply be absorbed. But this is more about the path dependency of the existing policy framework than the reality of homes and networks.

If consumers can capture cheap prices from a TOU tariff and use them to provide heat later on, for instance through preheating their home or through dedicated thermal storage, then the relative efficiency of a heat pump becomes less important. More frequent periods of cheap electricity combined with very spiky peaks puts a premium on flexibility. This means that for some homes there is a potential proposition for alternatives such as a large battery with a cheap immersion heater, an air-to-air heat pump to provide heat to a primary living space, or a hybrid/bivalent system that switches between gas and electricity depending on the price of each. The latter in particular achieves the re-engineering of a heating system that may be necessary for a future dedicated heat pump at a lower upfront cost and with a clearer consumer proposition (Box 2 on p.21). More sophisticated system controls may find ways to manage the thermal mass of a building as a proxy energy store and use simple resistive heaters to achieve economic benefits exceeding those of a heat pump. Each is conditional on the state of the specific property and the occupants' circumstances, which is something that cannot be known from Whitehall.

Heat is not like electricity generation. The Government has been able to make choices about the technology we use for electricity generation by intervening in the incentives investors are subject to. This has not required consumers to consent. But heat offers unique challenges. It enters into the domestic sphere, and relates to deeply personal questions of comfort and health. Our starting point must be the consumer, not a mathematical model. What we should take from the model, however, is the wider impact a consumer can have – in economic parlance, the externalities their choices impose. Ideally, we should build our market around that, and do the following:

Expand UK carbon taxation to domestic heat – including gas and heating oil - and redistribute the proceeds. The UK's Emissions Trading Scheme places a cost on carbon by capping the volume of greenhouse gases emitted in particular sectors and enabling the trading of permits to emit under that cap. While the political and transaction costs may prohibit extending the scheme to domestic consumers, creating a tax that achieves a more predictable effect may be more achievable. Extending carbon taxation to domestic heat has traditionally been seen as politically impossible, but if the money recovered from this did not simply vanish into the Treasury but rather was redistributed progressively,[45] the political impact could be eased. The EU plans to extend its own carbon pricing scheme to domestic properties, but instead of returning the cash back to citizens will issue it from a centralised fund in line with its policy preferences around decarbonisation and protecting vulnerable consumers.[46]

An alternative to extending a carbon tax to domestic heat is to rebalance existing levies from electricity to fossil fuels, as has been advocated by multiple bodies.[47] This would shift the cost of decarbonisation away from increasingly clean power and onto fossil fuels to better reflect overall externalities, incentivising greater use of power.

Reform standing charges to reflect local peak demand. Figure 1 at the start of this paper shows that, if every consumer bought an electric boiler to decarbonise their heat, we would be exposed to much higher costs for a larger network and more generation capacity that would lie unused for much of the year. For an individual, an electric boiler may be a cheaper upfront option, and – right now – the wider impact of that choice is not something for which they must pay.

Network costs are recovered from consumers through a fixed standing charge regardless of any individual consumer's impact on the network. They are levied on suppliers at an aggregate level, and passed through to consumers on that basis. Much like with the move to market-wide half hourly settlement, it is economically optimal – as well as fairest – to move towards a system whereby consumers pay for their network impact. This means charging consumers different levels of network costs depending on their demand at local peaks – i.e. on the specific transformer that serves their neighbourhood.[48] This would benefit heat pumps and potentially heat batteries and storage heaters over electric boilers, as they have a lower peak electricity demand.
It would also benefit fossil fuel boilers. In the short run this would slightly offset a move towards taxing domestic carbon emissions, reducing the political cost of doing so.

Reconfigure the retail market to focus on genuine competition, rather than switching. The pathway to maximum use of Time Of Use tariffs – with consequent benefits for the rest of the system – is through rendering the retail market a much more rivalrous place, where any source of value for consumers is sought after. Meter splitting and market wide half hourly settlement are part of this, but there is a more expansive vision to enable different players to compete to provide asset-level tariffs without regard to existing licence restrictions. This could involve moving away from the Universal Service Obligation, as set out in Stonehaven's previous paper, "Reinventing Retail".[49]

Decouple the MCS from any policy measures so that it becomes just one option amongst a range of consumer protection measures that suppliers might adopt. Given that the MCS as it stands has been unable to guarantee performance and represents a significant barrier to market entry, it is not clear that it would play a meaningful role in a world where technology choices are less prescriptive. Rather, product standards and quality schemes enforced by trading standards would offer a route to hold installers to their advertised levels of performance, and existing ombudsmen could provide a dispute resolution mechanism. Ofgem should be tasked with identifying cost-efficient ways of verifying published installation performance, potentially through random inspections.

With the above changes in place, we would expect consumers to switch to lower carbon heating sources over time. These could include traditional air to water heat pumps – or may extend to heat batteries, air to air heat pumps, and / or Bivalent systems. The principle we should prioritise is decarbonisation, not whether a particular technology has "won".

BOX 2

Bivalent Heat

A bivalent heating system integrates two different heat sources, typically combining a heat pump with a gas or oil boiler. Note that this differs from what is often termed a 'hybrid' system, which typically requires installation of a joint boiler/heat pump system with its own automated switchover control.

They are often deployed by adding a second heat source (typically the heat pump) to an existing unit (typically the boiler), helping to keep down capital costs. The modes of operation that have traditionally been deployed are illustrated in Figure 7. However, their scant attention to maximising value is a factor in the technology's limited market penetration.[50] Bivalent systems offer the possibility of switching between fuels based on whatever is cheaper at that point, guaranteeing savings.

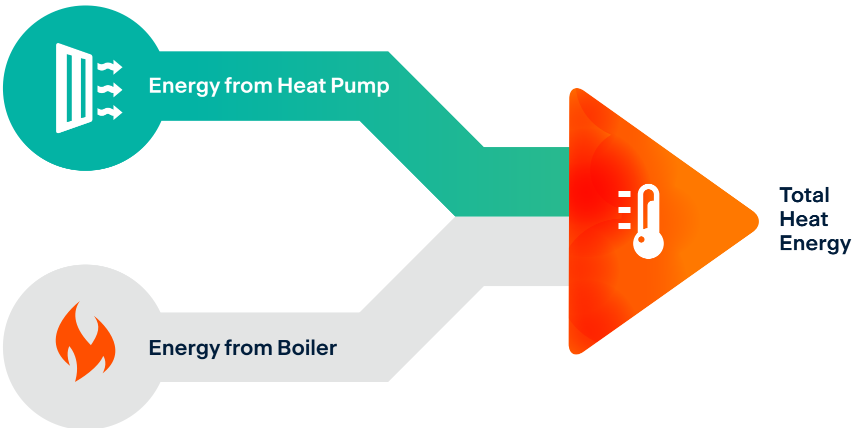
Figure 7.

Two traditional configurations for bivalent heat pump systems

01

Bivalent in parallel

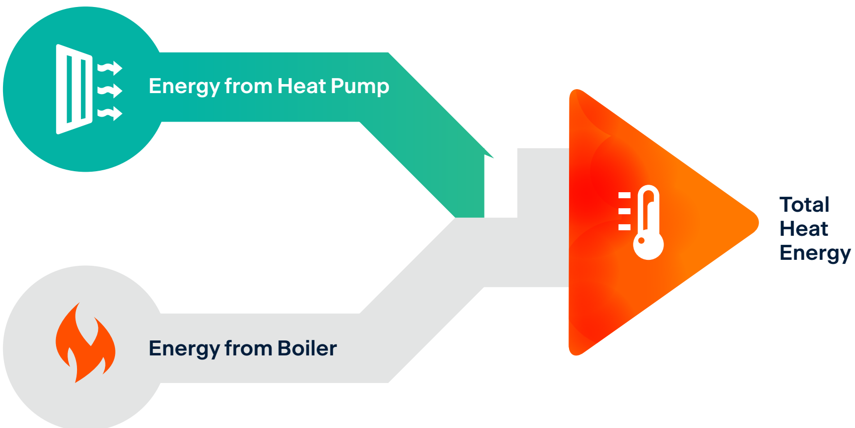
Heat pump working simultaneously or in parallel with a boiler (for example, the lead heat source, with the boiler topping up capacity or flow temperature when required)



02

Bivalent changeover

Heat pump working in isolation from the boiler (for example, the heat pump operates as the lead heat source until it can no longer meet requirements, at which point it stops operating and the boiler takes over)



Bivalent systems have several advantages over heat pump-only (or monovalent) heating:

Improved reliability and efficiency in cold climates: Heat pumps operate efficiently in moderate temperatures but lose performance as temperatures drop significantly. In very cold conditions, their efficiency (measured as the coefficient of performance, or COP) decreases, requiring more electricity to produce heat. A bivalent system mitigates this issue by complementing the heat pump with a heat source whose performance is less affected by the weather.

Lower energy costs: In many cases, using a secondary heat source – such as natural gas or biomass – can be more cost-effective than running an electric heat pump. This flexibility allows users to switch to the most economical energy source based on availability and price fluctuations and may remove the need for costly and sometimes impractical home improvements.

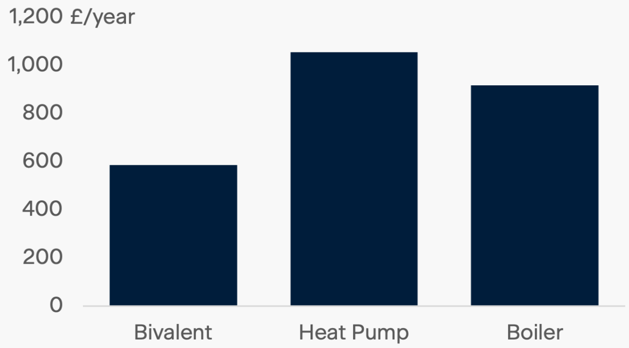
Reduced system stresses: It reduces load demand on the electricity network during peak periods, reducing the extent of costly grid upgrades and constraint payments which end up on consumer bills. Figure 8 below shows the cost performance of Summerleaze's Bountifuel system using a TOU tariff compared to a standalone heat pump or gas boiler. Given that it can switch to whichever fuel is cheapest, it will always be cheaper to run than either device. This means that this is very much a pro-growth policy, directly putting more money into consumers' pockets.

Lower heat pump costs and longer lifespan: Since the heat pump does not have to work at full capacity during the coldest days, upfront costs are reduced for consumers as they can purchase a smaller unit (heat pump costs rise by c.£700 per kW).[52] The Government could in turn save money due to a reduced need for the BUS to meet its unrealistic target of 70+% installation cost reduction by 2030.[53]

A political pathway to meeting Carbon Budgets: For all these reasons, bivalent systems can be an easier sell to the public, who, as shown above, have not taken to monovalent systems. Bivalent systems may not decarbonise heat fully, but they introduce the public to heat pumps in a controlled and cost-effective way. And because most bivalent systems aim to maximise the use of the heat pump, it typically produces most of the heat, the heat pump is used a majority of the time, still enabling a pathway to meeting our Carbon Budgets. Figure 9 below shows the carbon performance of Summerleaze's Bountifuel system in 2024. Because it switches to gas when the electricity system is particularly carbon-intensive, it can out-perform an electrical heat pump under such conditions.

Figure 8.

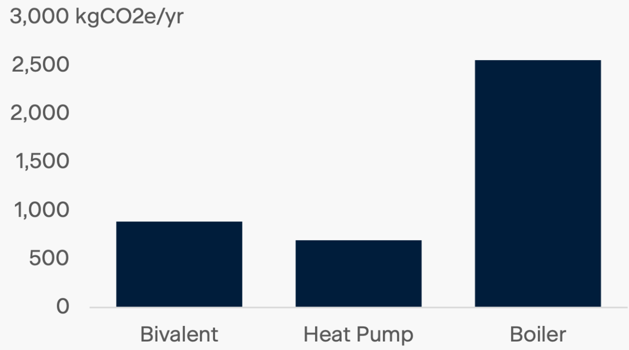
Relative fuel costs of bivalent systems versus heat pump or gas boiler[51]



Data source: Stonehaven analysis based on in-situ performance of a bivalent systems providing heat equivalent to a gas boiler demand of 13.8MWh

Figure 9.

Greenhouse Gas emissions per year by device in 2024



Data source: Stonehaven analysis based on in-situ performance of a bivalent systems providing heat equivalent to a gas boiler demand of 13.8MWh

The Path of Least Resistance

Unfortunately, the above measures represent a radical break with the status quo, one so radical that it may not be possible for the Government to implement it in time. In particular, carbon pricing on domestic heat is so politically toxic that its mooted use within the EU is causing pushback against the entire EU ETS regime.[54] Our recommendations below therefore seek to balance delivery against pragmatism.

1. Use the Warm Homes Plan to create a fresh start for heat strategy, one that better reflects the heterogeneity of households and the centrality of the consumer

The Government has inherited the wrong strategic approach to heat decarbonisation. Rather than the central problem of heat policy being, "How do we get heat pumps into households?" it should instead be, "How do we enable consumers to judge what heat decarbonisation system would work for their house?"

The answer to that question will almost certainly be to let companies compete to provide solutions that offer full or partial decarbonisation solutions that also offer upsides to the consumer. If everyone in the country installed a simple air to air heat pump to warm their living room and provide cooling in the summer, a significant proportion of our heating emissions would vanish. Much as the Government has sensibly retained gas backup to support power decarbonisation,[55] if we are able to provide an easier onramp to heat decarbonisation to as many households as possible we do not necessarily have to decarbonise entire households at once.

The Civil Service runs on modelling, and to achieve the above, particular changes are necessary. Modelling should seek to reflect the reality of the market and options for households rather than treating heat decarbonisation as a simple pump on pump off switch. This means:

- Splitting out household level interventions including radiator changes and control systems from the simple replacement of a single heat generator, enabling partial decarbonisation at the home level. Use historic rates of learning and consumer uptake of such assets as a starting point, modified by how benefits of each can change as wholesale prices become more volatile;

- Making learning rates endogenous to the model based on uptake and UK share of a global market rather than fixed at the outset. If a Monte Carlo analysis reveals that an initial uptick in heat battery deployment is enough to bring down its cost to a level where it becomes preferable to enough customers to install a single device rather than change radiators, this should have implications for policy.

- Treat future policy changes as partially endogenous too. In the event that Bivalent systems have higher uptake, the Government would likely respond by investing more in lower carbon gas, including biomethane.

- Create scenarios based on believable states of the world by changing input assumptions and cost trajectories in an internally coherent manner.

The aim of the above is to re-centre consumer preference over their own home in the broader context of a much more volatile world. For the fulfilment of the last point, scenarios should include:

- A plausible short-run scenario in which a reduction in the BUS to satisfy short-run fiscal targets and political reluctance to raise the CHMM buy-out price sees heat pump deployment falling back, leading to further investment in other technologies for decarbonising heat, including more widespread use of hybrid and bivalent solutions.

- A return to globalisation scenario, in which the USA pivots back to shoring up the currently crumbling global trade order and seeks rapprochement with China. China invests heavily in compressors and controls and renders heat pumps cheaper. This scenario, lamentably, is less plausible.

- A scenario which sees further breakdowns in global trade and leaves Chinese production only accessible to UK markets at a steep price. This slows down the rate of installation of electrical generation, particularly solar, and forces the UK to rely more heavily on indigenous production. In this world, greater use of local resources sees a stronger emphasis on bioenergy of various kinds

The Government's Warm Homes Plan should reflect this revised approach, starting from an analytical base that doesn't centre the system but rather centres the consumer and the world they inhabit.

2. Revision of the Clean Heat Market Mechanism (CHMM) and wind-down of the Boiler Upgrade Scheme (BUS)

Following the initial announcement of the CHMM, its opponents launched a concerted campaign to make it politically unpalatable, labelling it a 'boiler tax'.[56] Any addition to the cost of living is politically contentious, but it is worth noting that a tax that is levied on 1.7-1.8 million households per year is less contentious than one levied on 30 million households. A tax on boilers that reflected the cost of the carbon emitted over their lifetime would therefore be a less contentious way of implementing a carbon tax.

A typical gas boiler produces about 2.2 tonnes of CO_2e per year[57] and will last for about 15 years. Average carbon prices in the UK Emissions Trading Scheme have varied between £40-65 over the past two years,[58] making a nominal carbon price of £50/tonne reasonable. This implies a lifetime carbon cost of a gas boiler to be £1,650. Levying this as an actual tax on the purchase of a boiler would go some way towards redressing the upfront cost disparity between a boiler and low carbon heating, as well as being fiscally positive. It would also avoid the complexity of the CHMM as it is currently designed, enabling consumers to figure out which device works for them rather than Whitehall.

However, Government policy has inertia, and the CHMM is already underway. It can, and should, be substantively reworked in advance of the next year of the scheme. Rather than an effort to promote a single technology it should be re-focused on carbon and the consumer.

A refocused CHMM should:

- Target a particular 'boiler tax' level rather than a particular technology;

- Oblige suppliers to reduce the total forward emissions of their sales by a percentage every year to create this tax, and;
- Generate credits against this obligation from the actual emission reductions of installed devices rather than the reductions assumed for that technology.[59]

The Government's current approach to the CHMM buy-out price – starting low and then increasing – needs to be reversed. If the scheme targets a particular 'boiler tax', then when the initial number of low carbon installations is low, the buy-out price would need to be high to generate that tax level. As the market share of low carbon devices increases, the buy-out price should decrease.

This creates pressure on providers to lower the price of their products, something missing from the BUS and CHMM as currently designed. This pressure is increased through the technologically agnostic nature of the scheme, as heat pump providers would no longer only be competing with each other but with a range of potential alternatives.

To get the level of the 'boiler tax' correct, we need to ensure that we are allocating costs and benefits carefully. A scheme in which a boiler is taxed and that tax is refunded to low carbon heat purchasers creates a double benefit: the value of avoiding the carbon tax plus the value of that refund. The total benefit to low carbon heat purchasers that the scheme should target should therefore be £1,650. In 2025/26 when the CHMM obligation is equivalent to 6% of domestic heat carbon emissions, a total benefit of £1,650 gives a buy-out price of £1551 and a boiler tax of £99. By 2030 when the CHMM will need to be 33% to meet the CCC's carbon target, the boiler tax would reach £552 while the buy-out - which is essentially the subsidy to low carbon heat - would fall to £1098.

A boiler tax of effectively £100 is almost certainly more politically palatable than moving straight to £1,650, which is effectively a 50% increase in the cost of installation. However, £1,650 is based on the UKETS price which only covers traded sectors – power generation, heavy industry and certain types of transport. It is almost certainly considerably lower than the price needed to prompt behaviour change in the non-traded sectors. The Energy System Catapult has proposed a 'central target' carbon price of £245/tCO2e, equivalent to a 'boiler tax' of £8,085.

Levying a boiler tax at this level is almost certainly politically impossible. But the approach to allocating costs and benefits we outline above could use this price to generate a boiler tax of ~£500 in 2025/26 with a subsidy to low carbon heat of ~£7,600. This makes it an almost like for like replacement for the value of the BUS. However, this level of support is likely to be more politically challenging than £50/tCO2e.

This approach would equip Government with a lever capable of guaranteeing compliance with carbon budgets without having to select technologies at the outset. If decarbonisation is the objective of policymaking, decarbonisation should be the measure. We would recommend cancelling the BUS and implementing this measure from the 2026/27 CHMM period.

"

By 2030, the carbon price per boiler would **increase to £552** and the subsidy to low carbon heat would **fall to £1098**.

While progress towards delivering market-wide half hourly settlement continues, we need a step change in the sophistication of our retail market to ensure that new entrants can compete to provide cheaper time of use tariffs. This means, as a minimum, supporting meter splitting as discussed in Chapter 2.

This has previously been mooted[60] via modifications to industry codes, but was rejected as a complete proposal by the relevant code body on the grounds of clear short-run costs and less certain future benefits when the roll-out of low carbon technologies was less progressed. The UK now enjoys extended periods of lower prices as renewable penetration has grown, and will enjoy more as the system is built out to 2050. These are correlated to renewable output, not just demand peaks.

New modifications that provide part of the benefit – such as splitting import and export meters[61] – have been laid, indicating the appetite for the change. There is no particular reason to delay this change, especially given that it will be unlikely to come into force much before half hourly settlement does. We recommend that a modification to the relevant industry code that permits device-level meter splitting be laid and accepted at pace.

“

A boiler tax of effectively **£100 is almost certainly more politically palatable** than moving straight to **£1,650, which is effectively a 50% increase in the cost of installation.**

04 Conclusion

After 15 years of insufficient progress, it is imperative to reassess the UK's strategy towards heat decarbonisation. This paper highlights that the observed shortcomings have a structural basis, rooted in a policy shift from focusing on renewable heat to emphasising decarbonisation at the system level, rather than at the household level. Our proposed vision advocates for a future of heat decarbonisation that involves a diverse array of interventions, tailored to consumer preferences and financial capabilities, rather than simply replacing gas boilers with heat pumps.

Our evolving decarbonised power system presents the possibility of providing cheap electric heating for significant parts of the year. However, restricting access to this benefit through the initial costs associated with heat pumps may weaken the political momentum for decarbonisation. Effective implementation requires the Government to empower businesses to determine consumer preferences and potential benefits, as opposed to centralised decision-making from Whitehall. Achieving this could enable us to deliver the expectations set by our ambitious carbon budgets, advancing at a pace that might currently seem unattainable.

Endnotes

1 The Future of Heating: A strategic framework for low carbon heat in the UK. Note that this was derived from Robert Sansom's work, available here: Sansom_Impact_of_heat_pathways_on_economics_low_carbon_heating_Sept-2012.pdf. Watson et al refined Sansom's assumptions in Decarbonising domestic heating: What is the peak GB demand? (Energy Policy vol.126, Mar 2019) to produce a somewhat lower estimated peak heat demand, but it was still more than three times (170 GW) as high as peak electricity demand (50 GW), and the seasonality and peak/trough volatility remained much greater than for electricity. They estimated that a ramp rate of 60 GW/h was required to cope with this volatility.

2 Electrification of Heat Demonstration Project. During minimum design temperatures (-6C to 0C) this work found COPs fell to between 2.32 to 2.57. 60% here refers to a COP of 2.5.

3 Domestic_RHI_Impact_Assessment.pdf (2012), https://assets.publishing.service.gov.uk/media/5a7f33ae40f0b6230268e104/RHI_Reform_Govt_Response_Impact_Assessment_FINAL.pdf (2016), The Renewable Heat Incentive Scheme Regulations 2018 (2018), Heat pump deployment statistics: December 2024 - GOV.UK, Future support for low carbon heat - GOV.UK (2022). Note that the 2016 and 2018 impact assessments did not include a deployment projection and so one has been inferred using a household gas demand of 15,000 kwh/pa (Source, average gas demand has declined over the last decade), a boiler efficiency of 90% and an ASHP Coefficient of Performance (COP) of 3. The 2022 projection was based on the earlier lower level of (£5k) of support, rather than the 2023 increase to £7,500.

4 Clear Skies scheme provides £10 million boost | Archive Titles | Building

5 Renewable Heat Premium Payment scheme statistics - GOV.UK

6 In-year costs taken from Reducing heat pump installed costs: Reviewing historic trends and assessing future prospects - ScienceDirect

7 Financial statements - GOV.UK

8 Non-domestic RHI: £5.937bn (Ofgem, NDRHI Annual Report Scheme Year 13 Dataset, https://www.ofgem.gov.uk/publications/non-domestic-renewable-heat-incentive-annual-report-april-2023-march-2024) Domestic RHI: £1.057bn (Ofgem, DRHI 2023-24 Annual Report Dataset, https://www.ofgem.gov.uk/publications/domestic-renewable-heat-incentive-annual-report-april-2023-march-2024)

9 Total heat generated (inc biomethane injected) under the RHI by 2024: Non-domestic RHI: 104,949 GWh; Domestic RHI: 8,841 GWh. Data from Annual Reports, see previous footnote. Domestic Air-Source Heat Pumps contributed 3.5%.

10 DHRI 2023-24 Annual Report, see previous footnotes.

11 80,024 ASHPs received £72,275,591 in Scheme Year 10 (2023-24). In calculating these figures we have excluded the first year of the scheme as it indicated a very low average output per device compared to subsequent scheme years. DHRI 2023-24 Annual Report. See previous footnotes.

12 The Clean Heat Market Mechanism Regulations 2024.

13 Boiler Upgrade Scheme statistics: November 2024 - GOV.UK. Data on the composition of these costs is less available, but estimates from interviewees indicate the heat pump can cost between 40-60% of the total cost of installation.

14 New Boiler Cost in 2025: Prices & Installation | Checkatrade

15 In the latest energy price cap, gas costs 6.99 p/kWh and electricity costs 27.03 p/kWh, a ratio of 3.87. The difference between the average efficiency of a gas boiler and of a heat pump would have to be greater than 3.87 for a heat pump to offer any saving. As the studies cited on p.8 illustrate, the annual average efficiencies (SPF or SCOP) of ASHPs varies from

16 Energy Consumption in the UK - data.gov.uk

17 Energy consumption in households - Statistics Explained. Note that this excludes solar heating systems.

18 Air-to-air heat pumps: literature review - GOV.UK

19 HeatpumpMonitor.org, accessed 24/2/2025.

20 There are a range of types of SPF calculation. For the purposes of this paper any SPFs should be assumed to be H4 referring to the entirety of the heating system.

21 EoH-Project-Summary-Report.pdf

22 Domestic heating design guide (2021) | CIBSE

23 MCS-031-external-information-and-guidance-.pdf

24 Annual domestic energy bills - GOV.UK

25 Carbon Budget Delivery Plan

26 https://datadashboard.mcscertified.com/InstallationInsights accessed 18/3/2025

27 Renewable Heat Incentive - Domestic Impact Assessment

28 Mark Winskel, Philip Heptonstall, Robert Gross, "Reducing heat pump installed costs: Reviewing historic trends and assessing future prospects", Applied Energy, Volume 375, 2024 (https://www.sciencedirect.com/science/article/pii/S0306261924013977).

29 HM Government – Heat and Buildings Strategy

30 E.g. New Heat Pump Technology Opens Door For More Installations. Note that novel refrigerants such as propane and its derivatives can carry health and safety challenges if they are unable to be easily disposed of.

31 IEA, "A turnaround is in sight for heat pump markets" (Feb 2025). https://www.iea.org/commentaries/is-a-turnaround-in-sight-for-heat-pump-markets

32 For our analysis of both schemes we have assumed the BUS voucher of £7,500 is sufficient to drive uptake at the scale given. We have assumed it needs to remain constant to 2030 as ASHPs follow their existing cost trajectory.

33 Assuming the CHMM reaches 33% in 2030 in line with CCC projections in CB7.

34 Household fuses can range from 30A upwards, although most properties will have 80-100A. A household bundled with its neighbour or with a 30A fuse will almost certainly require works to enable the installation of a heat pump.

35 https://nic.org.uk/studies-reports/electricity-distribution-networks-report

36 BEIS/Ofgem, Electricity Networks Strategic Framework: Enabling a secure, net zero energy system (Aug 2022), Appendix 1: Electricity Networks Modelling. https://assets.publishing.service.gov.uk/media/6690f4320808eaf43b50ce42/electricity-networks-strategic-framework-appendix-1.pdf. The document notes that this is a gross cost of grid improvement, not taking into account any offsetting savings in other parts of the energy system, although it also does not take into account any additional costs in other parts of

37 UKERC, forthcoming. A summary of this paper can be found here: Zonal Pricing, Volume Risk and the 2030 Clean Power Target | UKERC | The UK Energy Research Centre.

38 E.g. Agile Octopus | Octopus Energy

39 EDF brings free electricity days back for March

40 Heat Pump Plus tariff add-on | OVO

41 Profiling - Elexon BSC

42 Metering data from the Trading Operations Report - Elexon BSC accessed 24/2/25

43 E.g. Decision on Market-wide Half Hourly Settlement Change Request CR055 ('Amendments to M10 and corresponding milestones')

44 Reinventing Retail Energy: Making the energy retail market fit for the next generation - Stonehaven

45 An option for a more sophisticated approach to identifying need is provided in Rebuilding trust: How we can tackle energy debt through greater understanding - Stonehaven. Alternatively, the Economists' Statement on Carbon Dividends points to redistribution on a flat basis: Economists' Statement on Carbon Dividends Organized by the Climate Leadership Council.

46 Directive - 2023/959 - EN - EUR-Lex

47 E.g. Finding ways to deliver cheaper electricity by rebalancing levies | Nesta and Electricity levy rebalancing: Make clean heat accessible to all UK households - E3G.

48 We assume this would be a minimum of 33kv rather than lower voltages, but would likely need a demand minima to establish a 'neighbourhood' for the purposes of charging.

49 Reinventing Retail Energy: Making the energy retail market fit for the next generation - Stonehaven

50 Figure 8 is taken from The balance of power: the bivalent approach to heat pumps - CIBSE Journal.

51 Figure 9 and 10 are taken from in-house analysis based on in-situ performance of a bivalent systems providing heat equivalent to a gas boiler demand of 13.8MWh.

52 Reducing heat pump installed costs: Reviewing historic trends and assessing future prospects - ScienceDirect. Average of single point UK heat pump costs per KW, excluding installation costs.

53 Figure Y is taken from Reducing heat pump installed costs: Reviewing historic trends and assessing future prospects - ScienceDirect. The 70% figure is inferred from the Government's stated goal to see heat pumps achieve cost parity with gas boilers by 2030, set in the 2021 Heat and Buildings Strategy: Heat and buildings strategy - GOV.UK.

54 Poland takes hard line on EU carbon price for heating - Euractiv

55 Clean Power 2030 | National Energy System Operator

56 E.g. Labour set to bring back 'boiler tax', say industry sources

57 A gas boiler emits more annual CO2 than seven transatlantic flights | Nesta

58 UK ETS: Carbon prices for use in civil penalties, 2024 - GOV.UK and UK ETS: Carbon prices for use in civil penalties, 2025 - GOV.UK.

59 This could be policed through the random inspection route identified above.

60 P379 'Multiple Suppliers through Meter Splitting' - Elexon BSC

61 P459 Allowing different Supplier Agents to be appointed to Import and Export MSIDs - Elexon BSC

ABOUT THE AUTHORS

ADAM BELL

Adam is Director of Policy at Stonehaven. He joined us from BEIS, where as Head of Energy Strategy he worked on the 2020 Energy White Paper, and in earlier roles on heat decarbonisation strategy and on CFD auction design.

He is one of Britain's leading experts on energy and decarbonisation policy and is regularly featured in print and broadcast media.