SAMSUNG
Climate Solutions

A new approach to heating:

Finding ways to decarbonise the UK's heating in homes and other buildings

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Contents

Introduction

In June 2019, the UK government set a national target of net zero emissions by 2050 – the first country in the world to do so. The objective means that, by 2050, the UK's greenhouse gas emissions must be no more than the emissions it removes from the atmosphere.

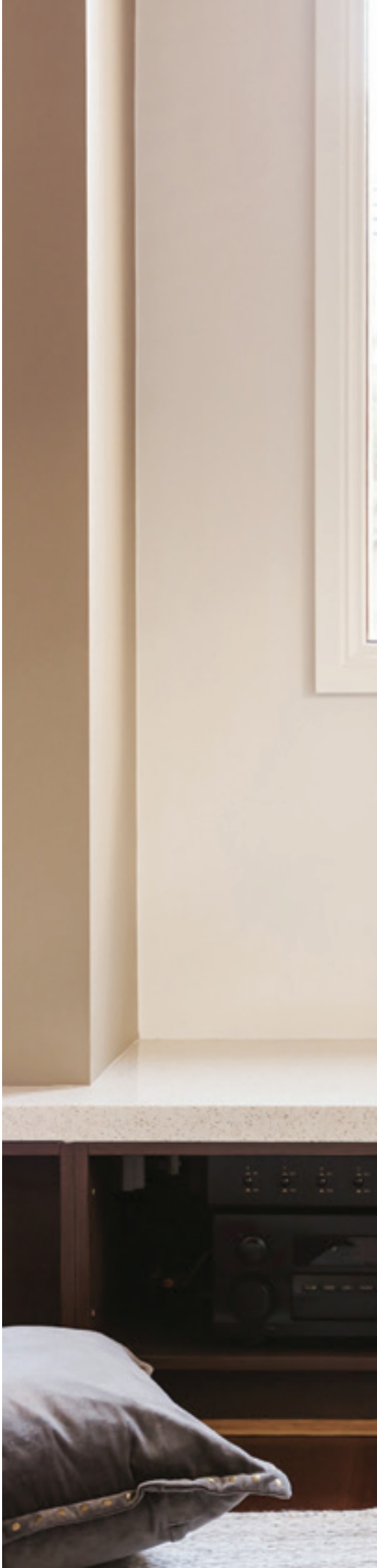
One of the key goals is the reduction of carbon dioxide (CO_2) emissions, which are a significant contributor to global warming. The government refers to this as 'decarbonising the economy'. Energy regulator, Ofgem reports[1] that the UK has been relatively successful in lowering its CO_2 emissions – with a cut of 40% since 1990. In 2019, the UK sourced more than half of its electricity from renewable or low carbon sources.

But now, much of the low-hanging fruit of decarbonisation has been picked. We need more effort to reach that 2050 target, and today, the challenges are more formidable. One of the most critical areas under scrutiny is heating in our homes and other buildings.

Heating in our buildings is a significant contributor to CO_2 emissions. According to figures from the Energy Saving Trust[2], in 2017 heating accounted for an average of 2,745kg of CO^2 emissions per UK household. To achieve net-zero by 2050, that average household figure for heating would have to fall to just 138kg of CO_2 per year. Non-domestic fuel consumption for heating is lower but remains one of the key contributors to UK emissions.

According to the Department for Business, Energy & Industrial Strategy (BEIS), gas is the predominant source of heating[3]. Around 85% of UK households and 65% of non-domestic buildings use natural gas for heating. As BEIS states: "Meeting our greenhouse gas emissions targets, therefore, requires a fundamental shift away from the use of natural gas".

This report will consider the possible alternative sources and technologies for heating our homes and other buildings.



The low-hanging fruit of decarbonisation has been picked

Driving change – legislation and incentives

In pursuit of the 2050 goal, the government is driving change in our national heating habits with a combination of legislation and incentives.

A single technology will not provide all the answers to decarbonising UK heating. However, government is currently prioritising: heat networks, heat pumps, hydrogen and biogas. “It is not yet clear which combination of these will work best at scale and keep costs down. Different approaches need to be tested further as we develop a long-term plan that delivers the best solution for consumers,” says the government website.

The government has introduced (or is consulting on) several strategies and proposals. Most of these include policies for shifting heating away from reliance on fossil fuel sources.

Different approaches need to be tested further as we develop a long-term plan that delivers the best solution for consumers

The Ten Point Plan for a Green Industrial Revolution

Announced in November 2020, the Ten Point Plan[4] is the government's roadmap for moving the UK to its net zero goal by 2050, while creating new jobs and boosting the national economy. It encompasses a range of industries and sectors from zero emission vehicles to carbon capture and use of nuclear power.

It also builds on previous commitments to move the UK away from its reliance on fossil fuels for space heating and hot water. It therefore brings together a number of other regulations and schemes, such as the Future Homes Standard and Clean Heat Grant Scheme, under one policy umbrella.

The Plan sets the ambition of 600,000 heat pump installations per year by 2028. Homes built to the Future Homes Standard (see below) will be what the government terms 'zero carbon ready' so that they can optimise the use of this technology. It also confirms targets such as improving around 1.5 million UK homes to EPC standard C by 2030 (set out in the Clean Growth Strategy) through green home finance initiatives.

The Green Homes Grant[5] has been extended by another year under the plan, so that it will operate until March 2022. The Grant allows homeowners and landlords of domestic properties to apply for up to £5,000 to pay for up to 66% of the costs of energy-saving measures such as insulation or the installation of a heat pump.

One important point to note is that the Plan highlights the government's intention to set out a Heat and Buildings Strategy in 2021. In the same year, government will also launch a "world class energy related products framework". The aim is to "push for products to use less energy, resources and materials."

The Future Homes Standard

This Standard[6] will be introduced in 2025. One of its most high-profile commitments is to prohibit the use of gas heating for space and hot water in new homes from 2025. This reflects the government's Ten Point Plan, although some in government have expressed an ambition to see this date brought forward to 2023.

The Standard also places strong emphasis on the energy efficiency of dwellings. Homes built to the Standard will have 75% to 80% lower CO_2 emissions than dwellings constructed to current Building Regulations.

In its consultation on the Future Homes Standard, the government singled out heat pumps as a technology that will play a vital part in achieving its energy efficiency and carbon-reduction goals. To support this, the consultation proposes a requirement that domestic heating systems are designed to support flowrate temperatures of 55oC or lower in wet space heating systems. The report also points out that this temperature range also supports more efficient operation of condensing boilers.

The Standard also places strong emphasis on the energy efficiency of dwellings

The Renewable Heat Incentive (RHI) and Clean Heat Grant Scheme

Government is keen to support a move away from fossil-fuel based heating, but without an over-reliance on subsidies. The Non-Domestic RHI will close in April 2021, though the Domestic RHI has been slightly extended to March 2022.

To be eligible under the non-domestic RHI, air-to-water heat pumps are required to be heating-only. This means they must not be designed to provide cooling. They must also not be hybrid heat pumps (that is, using heat which has been expelled from a building or from a process that generates heat).

Ground- or water-source heat pumps can be 'reversible' i.e. they can provide both heating and cooling. However, only energy used for the heating process must be measured for payments under the scheme.

The domestic RHI does allow the use of air source heat pumps for space heating or space heating only. They may also provide cooling, but they must use liquid to provide the space heating element of the system. The rules are the same for domestic ground source heat pumps.

The government is set to introduce the Clean Heat Grant Scheme (CHGS) to replace the RHI in April 2022[7]. The proposed scheme (currently under consultation) will offer £4,000 for households and small non-dwellings to support the installation of low carbon heating systems.

Government would like to focus on a grant scheme, rather than payments to technology owners, believing that this will be a greater incentive for householders and smaller businesses.

The focus is very much on heat pumps (air, ground and water-sourced) up to 45kW, though government has said it will consider biomass in some circumstances. The proposed rules on types of heat pump systems that will be eligible for the new scheme appear to be very similar to the current RHI rules. Hybrid heat pumps will not be supported. BEIS has announced that funding for the CHGS will be available until March 2024.

As the government states:

"We are now looking at the best ways to cut carbon emissions from heat during the 2020s, thinking about how we can reduce reliance on subsidy."

The CHGS' flat-rate approach aims to encourage the market to find the most cost-effective solution for projects.

Building Regulations – dwellings

The next iterations of Part L and Part F of the Building Regulations 2020 will reflect the Future Homes Standard and drive delivery of its policies with 'a meaningful and achievable increase to energy efficiency standards for new homes'. The government will also be incorporating relevant conclusions from the Independent Review of Building Regulations and Fire Safety currently being led by Dame Judith Hackitt.

One of the essential changes to Part L for domestic buildings will include the use of an updated Standard Assessment Procedure – SAP10. It is applied to demonstrate the energy performance of dwellings for compliance with the Building Regulations. SAP10 has already been released, but designers do not have to use it until the introduction of the updated Part L.

The major change introduced by SAP10 is the 'carbon factor'. This value represents the amount of CO2 produced by different fuels. Previously, SAP set the carbon factor for electricity at just over double that of gas. However, since the electricity grid has reduced its CO2 emissions, the factor for electric heating in SAP10 is now much closer to gas, making electric heating a more attractive option for designers.

Building Regulations and MEES – non-dwellings

Consultation on Building Regulations relating to non-domestic buildings will follow after the domestic Part L update, so the industry should expect further changes in the next couple of years. Improving business energy efficiency is high on the agenda, with the government's Heat in Buildings Group stating that it will be:

> **"Improving the way businesses use energy, to support the delivery of our ambition to reduce business energy use by 20% by 2030."**

In January 2020, the government closed its consultation on the future of Minimum Energy Efficiency Standards for non-domestic, privately rented buildings[8]. Currently, MEES requires a minimum EPC of F for non-dwellings (with some exceptions). The government is proposing to raise that minimum, either to a B or C, by 2030. There is also discussion over whether there should be a single implementation date or a series of milestones across the next decade. The outcome of the consultation is expected shortly.

The government will also be incorporating relevant conclusions from the Independent Review of Building Regulations

The Clean Growth Strategy

The Strategy[9] was written in 2018. However, it is an interesting document as many of its policies and proposals still stand and we see that they are now being implemented through legislation and government investment.

The Strategy covers the entire UK economy, including transport and industry. But changing how we heat our homes and other buildings is high on its agenda. Government sets out its overall objective of meeting its environmental goals 'at the lowest possible net cost to UK taxpayers, consumers and businesses.'

It focuses on phasing out the installation of 'high carbon fossil fuel heating' in new and existing buildings in areas currently off the gas grid during the 2020s. Energy efficiency is a vital element of reducing the need for energy overall. The Strategy, therefore, includes investment to upgrade homes, with 'as many homes as possible' upgraded to EPC Band C by 2030 'where practical, cost-effective and affordable' – as reflected in the recently launched Ten Point Plan.

Similarly, minimum energy efficiency standards (MEES) for rented commercial buildings are to be raised, with a particular focus on helping SMEs achieve better energy efficiency.

We can see that the move to decarbonising the UK economy is underway in many areas simultaneously. While switching heating away from fossil fuels is an integral part of the solution, it also has to be accompanied by an overall drive to ensure buildings are also more energy efficient – which applies equally to new-build and existing properties. A greener electricity grid is an important power source, but it is far from unlimited as we shall discuss later in this document.

Changing how we heat our homes and other buildings is high on its agenda

Heating technologies – options for the future

Condensing boilers have been mandated by law since 2007 in England and Wales. They were introduced as being far more efficient than non-condensing types. Since that time, condensing boilers have become the bedrock of heating systems for homes and non-dwellings.

Finding alternatives to what has been a reliable and familiar technology is no easy feat. Government is therefore not relying on a single technology to replace the gas condensing boiler. Numerous reports and consultations point to four 'favoured' heating alternatives:

1. Hydrogen or other gases
2. District or Network Heating systems
3. Heat pumps

Hydrogen – a replacement for natural gas?

There are currently trials underway examining the practicality of hydrogen as a fuel source for heating. The often-cited benefit is that the heat source in buildings and homes would look and operate like our familiar gas boilers – making them an easy 'swap' for households.

But a switch to hydrogen at scale for domestic heating is a technical challenge. For example, the existing 284,000km network of gas pipes is not all suited to transport hydrogen. All pipes would all have to be polyethylene, as hydrogen reacts with metal pipework. Around 90% of the network will be upgraded by 2030, but there is a significant amount of work to do. Many older gas meters would also have to be updated.

There have been trials of using a 20% mix of hydrogen with natural gas. The benefit of this approach is that no changes are required to the existing delivery systems. However, that would still leave 80% of the mix relying on a fossil fuel.

Methods for manufacturing hydrogen also have their problems. It can be extracted from natural gas, known as 'natural gas reforming'. The process removes carbon from the gas, but then raises the question of what to do with that carbon. Electrolysis can also be used to produce hydrogen, with the application of electricity through water. When the hydrogen is then burned, the only by-product is water. While this is more environmentally acceptable, it is considered an expensive production method.

Another hurdle to using 100% hydrogen as a source for heating and hot water is that the UK would be the first country in the world to attempt it, so there are few examples to follow.

A study for the Committee on Climate Change (CCC) by Imperial College[10] showed that the hydrogen solution would be a high-cost option. But hydrogen has not been ruled out by the CCC or government. We are likely to see its wider use as a fuel for heat networks, as well as other sectors such as transport.

District or Network Heating systems – sharing the heat load

The government Clean Growth Strategy, highlights heat networks (or district heating) as a crucial part of lowering emissions from heating. The government wants to create long-term investment for heat networks, particularly in areas of high heat demand such as urban centres, campuses and business parks.

There are already 14,000 heat networks in the UK providing heating and hot water to around 480,000 consumers – domestic and business. In its recent consultation document[11] (which closed on 1st June 2020) the government states:

"We know there is significant potential for the number and scale of heat networks to increase dramatically. We estimate that up to £16 billion of capital investment could be needed for heat networks to deliver their full contribution to net-zero."

One of the benefits of a heat network is that it can make use of a range of fuels – including heat pumps; geothermal; recovered heat from waste; solar thermal. The 'energy centres' at the heart of a heat network can make use of a mix of the most suitable sources available.

Support for this technology is already working through the Heat Network Investment Project (HNIP) and Heat Network Delivery Unit (HNDU). The recent consultation focused on offering the end-users of heat networks strong consumer protections to ensure fair pricing and good quality outcomes. Government is proposing that Ofgem takes oversight of this market.

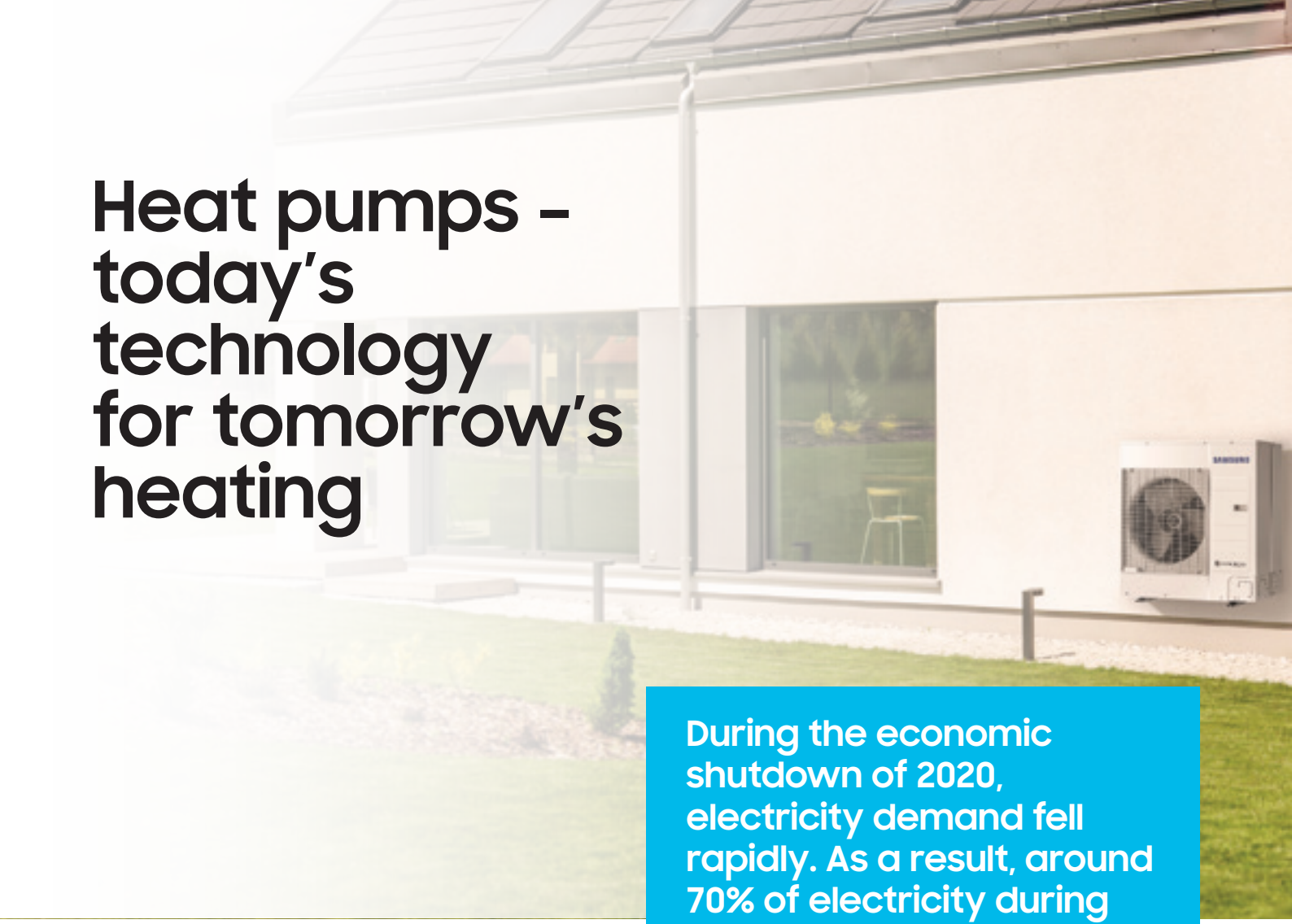
Legislation does not stand still. Government will continue to develop new approaches to encouraging take-up of low-carbon heating systems in homes and offices. It is essential for manufacturers, designers and installers to be aware of where future policy may lead. For example, in a report titled Off Grid, Off Carbon, released in Spring 2020, the Sustainable Energy Association set out its vision[12].

The SEA recommendation is that Government adopts a 'carbon intensity standard' for heating. Its focus is on homes that are currently off the gas grid, and therefore more likely to use fuels such as oil for heating, for example. The Standard would support take-up of low carbon options while also considering the energy performance of the whole dwelling.

This is one suggestion of many, but it does indicate that industry is currently looking at a number of potential ways forward to reduce our reliance on fossil fuels for heating and hot water.

Our next section considers heat pumps for homes and non-dwellings.

Heat pumps – today's technology for tomorrow's heating



During the economic shutdown of 2020, electricity demand fell rapidly. As a result, around 70% of electricity during April, May and June 2020 was produced from renewable sources

An air-source heat pump uses heat energy from the ambient air to provide space and water heating. Heat is transferred from the ambient air to the interior of the building through a hydronic system (e.g. underfloor heating) or an air-based system.

A heat pump uses electricity to drive this heat transfer process. But for every 1kW of electrical energy input, a heat pump captures 2kW of ambient energy – a total of 3kW. This figure is expressed as a coefficient of performance (COP) of 3.00.

Generally, heat pump efficiencies are shown as seasonal COPs (SCOPs). This reflects product performance across a range of outdoor temperatures and delivered hot water temperatures. For example, a typical heat pump might have a seasonal COP of 4.409 when providing water at 35oC; and 3.127 at 55oC flow temperature. SCOPs are calculated using the British Standard BS EN 14825:2018, which gives the temperatures and part-load conditions and the calculation methods.

It is this highly efficient use of electricity that makes heat pumps an attractive option for the future of heating. This is important because one of the challenges faced by the UK is that as our grid relies increasingly on renewable energy sources, managing and balancing power output is more complicated. Simply switching to electric heating without consideration for how much power we consume could create significant balancing problems on the supply-side.

Research by Imperial College for energy company Drax[13] illustrates these issues clearly. During the economic shutdown of 2020, electricity demand fell rapidly. As a result, around 70% of electricity during April, May and June 2020 was produced from renewable sources. This was excellent news for emissions reduction.

However, while the UK was producing its greenest ever electricity, the costs for managing the grid rose to over £100 million.

Dr Iain Staffell of Imperial College who led the research said:

"The past few months have given the country a glimpse into the future of our power system, with higher levels of renewable energy and lower demand making for a difficult balancing act. To help the country further, it is vital that flexible technologies which provide power and system stability play an increasing role in our grid."

With its highly efficient use of electric power, there can be no doubt that heat pumps will play a significant part in the future of our heating. The technology can no longer be considered 'new', as it has successfully been installed in homes and non-dwellings across the UK. This gives heat pump the advantage of being an established heating option.

Figures show that around 25,000 heat pumps were sold in the UK in 2018, and numbers continue to rise[14].The majority of these were air source. But according to the Committee for Climate Change, we need to install 19 million heat pumps to reach our 2050 net-zero carbon goals. The UK's Heat Pump Association (HPA) points out that this will require an installation rate of 1 million per year by the mid-2030s[15]. The recently launched Ten Point Plan is aiming for 600,000 installations per year by 2028.

It is clear why government policy will play a vital role in meeting these targets. If legislation pushes housebuilders towards the use of heat pumps for heating in new homes, that would create a significant boost for the market. And heat pumps will become a more familiar sight in UK homes. Some housebuilders are embracing heat pumps as an option. For example, Samsung Climate Solutions has recently partnered with eco-friendly housing company Etopia to supply its domestic heat pumps to 6,000 new sustainable homes.

A flexible solution

Another benefit of heat pump technology is that it can be used in a variety of configurations. It can deliver heating into homes or other buildings at a range of temperatures to suit the project requirements. Heat pump manufacturers are investing in technology that can service the non-domestic market's requirements for higher temperature hot water, all the way up to 80oC in some cases.

What's more, heat pumps can be used in conjunction with other heating and hot water technologies to suit the exact requirements of a particular project. They can also be used alongside other renewable technologies, helping to boost the energy-saving of the entire heating and hot water system.

For example, it is possible to combine a heat pump with a solar thermal installation. A cylinder for hot water storage can be fed from the solar thermal system, providing pre-heating for the heat pump. Not only does this harness more than one renewable technology, it also greatly reduces energy costs for the operator.

The latest developments in heat pumps mean that there are numerous options for designers and installers to apply the technology.

Heat pumps can be used in conjunction with other heating and hot water technologies to suit the exact requirements of a particular project

A choice of heating delivery mechanisms

Heat pumps deliver heat through one of two media: air or water. This means that they are able to deliver heating through radiators, for example, offering a very familiar heat output for most UK householders.

Underfloor heating (UFH) is also successful in conjunction with heat pumps, as it requires lower, steady temperatures to deliver space heating. Again, this is a method of heating that is familiar in both domestic and non-domestic settings.

Heat pumps can also offer air-to-air space heating delivery, which has the benefit of achieving required temperatures quickly

Heat pumps can also offer air-to-air space heating delivery, which has the benefit of achieving required temperatures quickly. With an air-to-air heat pump it's also possible to provide cooling into spaces at similar levels of efficiency as heating.

And with the government's own predictions showing increasingly hot summers in the UK, this capability could prove very attractive to residents in cities, for example, where temperatures are the highest. Air-to-air heat pumps are excluded from the RHI scheme, so this version of the technology is not supported with grants. The situation may change in the future as, government has not yet finalised the technology list for the replacement Clean Heat Grant to be introduced in 2022.

Heat pumps will also supply hot water for domestic projects, and are increasingly capable of supplying energy-efficient hot water at higher temperatures (up to 80oC in some cases) for non-domestic buildings. This has the added benefit of removing the requirement for a gas boiler for domestic hot water needs – reducing capital costs as well as allowing the building to switch entirely to electric heating and hot water production.

Looking to the future – smart heating and smart buildings

We have the technology to deliver a large-scale switch to energy-efficient electric heating. Developments in heat pumps in terms of flow temperatures make them a solution that works for homes and non-dwellings. Numerous buildings have been operating heat pump heating systems successfully and over several years. The technology is tried and tested – and offers immediate carbon savings.

But shifting the market will require government intervention. We saw this when condensing boilers were introduced into the UK – legislation was needed to make it happen. One of the most important steps will be encouraging housebuilders to provide their customers with heat pumps from day one – and this looks set to occur from 2025 under the Future Homes Standard.

The market also needs to have the confidence to encourage investment and growth. If we are to deliver millions of heat pumps over the next decades, then we need more trained installers. They will not only ensure that each heat pump operates at optimum efficiency; they can educate end-users about getting the most from their system. The UK Heat Pump Association (HPA) has called for a SkillCard for heat pump installers that is similar to the Gas Safe scheme to provide further assurance for consumers.

The issue of modernising the UK electricity grid as we switch away from fossil fuels is another challenge. The National Grid itself has pointed out that more investment in updated infrastructure is required as we use electricity more. The Energy Task Force, commissioned by BEIS, called for better data sharing across the electricity grid[16] – estimating that a 'smart and flexible' system could save up to £40 billion by 2050.

Smart controls in our homes and other buildings also offer the potential to help balance demand. Today's heat pumps are supplied with state-of-the-art sensors and controls that make operation weather-sensitive and easy for users to manage. Systems are also designed to allow for connection to solar photovoltaics. This may well be an essential element of our electric future, as buildings become producers of electric energy as well as users.

For example, the Samsung Climate Hub with an air source heat pump uses artificial intelligence (AI) technology to keep the indoor domestic climate perfectly balanced. It analyses room conditions and usage patterns, while also using motion detectors to ensure that heating is only provided when its needed – making the system even more energy efficient.

In spite of the challenges we face in decarbonising our heating and hot water in the UK, the outlook seems good. Samsung Climate Solutions' own projection is that the air source heat pump market is set to grow significantly. New-build homes are likely to dominate take-up of these technologies however, supported by legislation such as the Future Homes Standard, and successors to the RHI scheme, retrofitting will take off from around 2026.

Conclusions

The switch away from fossil fuels for heating our buildings has never been so important – or so achievable – as it is today. We have the technology to make heating in our homes and other buildings more energy-efficient and affordable, while reducing our national carbon footprint.

The political will to achieve our net-zero by 2050 goal is apparent, and the heat pumps market is showing signs of growth. Our approach to residential homes and commercial spaces has to change to meet new demands from occupants. And Samsung Climate Solutions is ready to push the boundaries of technology, innovation and design to help deliver the vision of heating for the future.

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Samsung Electronics Air Conditioner Europe B.V.
Evert van de Beekstraat 310, 1118 CX Schiphol
P.O. Box 75810, 1118 ZZ Schiphol
+31 (0)8 81 41 61 00
The Netherlands

SAMSUNG