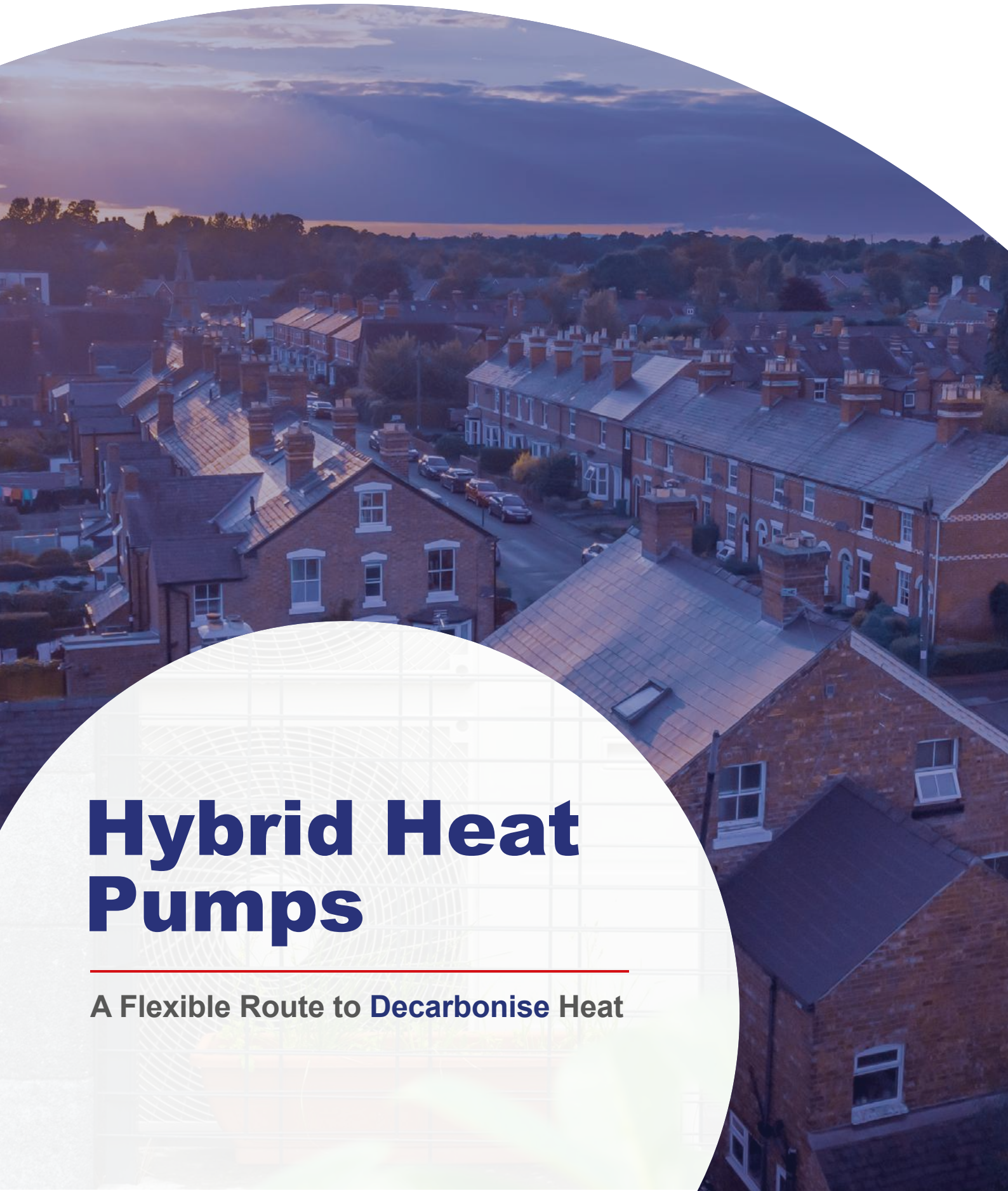
Hybrid Heating & Hot Water

HHIC
HEATING & HOTWATER INDUSTRY COUNCIL



Hybrid Heat Pumps

A Flexible Route to Decarbonise Heat

Contents

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HHIC is a member organisation committed to effectively driving, supporting and promoting the sustained growth of the UK domestic heating and hot water industry

01. Executive Summary

Hybrid heating systems use a combination of two or more technologies generating heat to provide heating and hot water for a building. Heat can be generated by an appliance or group of appliances with a main master control. The use of an air source electric heat pump alongside a gas condensing boiler is the most common hybrid heating system, which offers a significant carbon reduction when compared to a traditional appliance such as a gas boiler. For clarity, the term 'hybrid heat pump' is used throughout this paper to refer to that particular set up.

There is an opportunity to further decarbonise hybrid systems in the future by using either blended or pure hydrogen, as well as through the introduction of biofuels like BioLPG. The environmental impact of electrically powered heat sources will also fall progressively as a greater portion of the energy generated from the national grid comes from renewables.

When installed on existing heating and/or hot water systems, hybrid heat pumps have a greater role to play in the decarbonisation of heat than is currently supported by government policy. In order to achieve Net Zero by 2050, the UK's Climate Change Committee (CCC) now recommends a carbon reduction of 68% by 2030 and 78% by 2035 when compared to 1990 levels. These ambitious targets are creating pressure and driving industry towards the greenest solutions. However, other potentially useful technologies that can minimise disruption to consumers as they transition to low-carbon heating.

It's the heating industry's responsibility to examine all possible routes to low-carbon heating, especially those that offer the most practical support to consumers and installers. Hybrid heat pumps are a readily available technology and offer the greatest flexibility when retrofitting existing properties. As such, they should have been included in the latest Heat and Buildings Strategy – not least because they give the best shot of achieving installation targets set by the government in 2021.

Hybrid heat pumps have previously been cited as a key technology to decarbonise heat.[1] Their performance has also been evaluated in the Wales and West Freedom Project, Element Energy's hybrid heat pumps report and the Electrification of Heat (EoH) field trials. However, when the current Renewable Heat Incentive (RHI) scheme finished in March 2022 and has been replaced with the Boiler Upgrade Scheme, hybrid heat pumps will no longer be funded and only all-electric heat pump installations will be supported. It's also important to note that hybrid heat pumps are not fully recognised in Energy Performance Certificates (EPCs) despite significantly improving energy efficiency.

One of the biggest challenges for fitting all-electric heat pumps is the upfront cost of the product itself. The need for additional fabric and a hot water cylinder are also a concern for existing homes, with the potential to cause significant disruption. Consumers need to be made aware of the benefits of lower-temperature heating systems and acknowledge the behavioural changes required when using this type of system.

1 https://www.theccc.org.uk/publication/development-of-trajectories-for-residential-heat-decarbonisation-to-inform-the-sixth-carbon-budget-element-energy/

Hybrid heat pumps solve many practical issues while also reducing costs. They can also deliver emissions savings today and futureproof a property's existing heating system when the decarbonisation of fuel is more readily available. Systems running on an electric heat pump along with natural gas, LPG, or oil are an effective and immediate interim solution that could be seen as a boiler plus measure, helping to accelerate the transition to low-carbon heating.[2] Hybrid heat pumps can also be upgraded easily to a range of future low- or carbon-free heating options, including:

a. All-electric heat pump

b. Electric-hydrogen hybrid heat pump

c. Electric-biofuel hybrid heat pump,

d. Electric heat pump and instantaneous electric

Low-carbon gases including bio-LPG are already available in low volumes. Pursuing a hybridisation strategy can extend the availability of this fuel to more homes as volume develops. Off-grid homes are the most difficult to treat and many owners are already supporting their system with secondary heating such as wood burners. The LPG industry plans to increase output of bio-LPG in the coming years, offering further opportunity to decarbonise for those using this set up. For on-grid homes, there are plans to blend natural gas with 20% hydrogen by 2023. This will deliver carbon savings of around 7%.

HHIC represents heating appliance manufacturers that produce heat pumps and are planning to launch hydrogen-ready boilers in line with government policy. However, members are concerned the government's focus on full electrification of heat in the 2020s risks delaying action on the decarbonisation of domestic heating and hot water. With proper government support, hybrid heat pumps can deliver on targets and forge the path to Net Zero without having to wait for the 'right' technology to enter the market.

2 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/730607/boiler-plus-policy-clarification.pdf

HHIC recommends the following points are considered:

- With BEIS support, industry can produce a minimum control standard for hybrids to enable them to deliver the required policy goals. This action is only worthwhile if they are included in the relevant policy and incentive schemes
- Defined hybrid use cases should be created and recognised in PAS 1878, Energy Smart Appliances. This will align equivalent customer experiences for comfort, carbon and cost, and offer parameters and operational logic that correctly regulates the intended operation.
- A Smart Systems and Flexibility Plan 2.0 that will regulate control standards for all low-carbon technologies, including heat pumps, and will follow the approach taken for smart electric vehicle (EV) charging. HHIC recommends this is brought forward, and a specific standard for hybrid heat pumps is introduced which supports the CCC's 80:20 space heating requirement.[3]
- Hybrid heat pumps are included/recognised alongside all-electric heat pump solutions in future heat in buildings regulation, policy and affordability schemes. This should include both integrated and non-integrated appliances, given comparable carbon emissions reductions, and with both new and existing gas condensing, LPG or oil boilers using a single 'hybrid' intelligent control.
- Hybrid heat pumps are recognised as a practical and affordable solution for both existing on-grid and off-grid homes. They provide interim emissions reductions and prepare a property for future upgrades, including an all-electric heat pump, hydrogen-ready boiler or transition to an electric-low-carbon gas hybrid heat pump. (See options page 4)
- Policy should include the addition of a heat pump and intelligent control system for a condensing boiler that is already installed in the home. This approach has the potential to quickly decarbonise existing systems without removing a boiler before its end-of-life. Minimum standards are required to define when this approach is appropriate.
- Focus on consumer experience and awareness of the different technologies available should be substantially increased. Hybrid heat pumps maintain the familiarity of a condensing gas boiler and offer the first step towards decarbonisation. They also allow homeowners to get accustomed to heat pumps and how they work, while at the same time delivering a reduction in carbon emissions.
- Hybrid heat pumps offer flexible fuel demand-side response capacity, through constant storage and favourable tariff recharging. Time of use fuel tariffs that maintain affordable pricing and carbon optimisation against peak demand loading should be explored.
- Hybrid heat pumps should be fully recognised in Energy Performance Certificates (EPCs) as they significantly improve a building's energy efficiency.

3 https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021

02. Introduction

The provision of heating for space and hot water forms a major part of the UK's energy transition. Emissions reduction targets of 68% by 2030 and 78% by 2035 make for a daunting challenge, and that's before Net Zero by 2050 is also factored in. There must be a level playing field for manufacturers of low-carbon heating technologies, as this will promote choice among consumers and also encourage innovation within the industry. This should also be reflected in supporting policy and legislation.

For existing homes, the transition to low-carbon heating is not straightforward and there is no single solution. Many consumers are also unaware of the challenges around existing fossil fuel gas boilers, including condensing models, that will have to be replaced to achieve long-term climate targets.

Two key technologies that feature heavily in government policy are electric heat pumps and hydrogen-ready gas appliances. Hybrid heat pumps combine electric driven heat pumps with a condensing boiler and a single intelligent control that manages selection of the primary fuel source. This set up optimises the system for cost or carbon. Upgrading a condensing boiler system with a hybrid heat pump increases energy efficiency, reduces carbon emissions and is an easy adaption that prepares the heating system for further decarbonisation measures.

By using a hybrid, 80% of the space heating demand is delivered by a technology that is around 3 times more efficient (based on energy input/output controls strategy and usage) when compared to a condensing gas boiler that has an energy efficiency of <1. On a hybrid system, where the heat pump meets 80% of space heating demand and a gas boiler covers the remainder, you can assume an average Coefficient of Performance (CoP) around 2.6. This will vary depending on house type and age, but for many it will be a cheaper and less-disruptive choice than using a heat pump on its own. As such, it should be considered as a practical solution to avoid delays to the decarbonisation of heating and hot water.

A hybrid heat pump is a flexible way to decarbonise heating and hot water, while also delivering significant and immediate carbon savings. This set up also prepares the building for later upgrades when the final low- or zero-carbon heating solution becomes widely available. After the initial installation consumers need to upgrade their building fabric, as this helps to reduce heat demand, before eventually deciding whether to use an all-electric heat pump system or remain with a hybrid set up. Those that choose the latter will see the natural gas feeding boiler phased out with either hydrogen or use of biofuel.

There is currently low market demand from consumers for low-carbon heating. There are several reasons for this, including up-front investment cost, installation disruption and minimal running cost savings due to the high price gap between gas and electricity in today's energy market. Heat pump sales were estimated at around 50,000 units per year in 2021. Energy tariffs may need to adapt during the electrification of heat to encourage conversion. Hybrid heat pumps can mitigate fuel poverty and help those less able during that transition.

Hybrid heat pumps are an enabler for the eventual uptake of all-electric heat pumps or hydrogen boilers and offer a viable route to full decarbonisation in the future. But this can only happen with the right awareness, incentives and regulatory support.

New build homes are forecast to account for roughly 300,000 heat pumps a year, with the remaining 300,000 needed to meet government targets coming from the able to pay sector and social housing when funding is available. Deep renovation will be needed for an estimated 15.5 million homes to achieve suitable heat pump outputs and lower flow temperatures.[4] Remedial work will also be needed to create space needed for hot water cylinders and outdoor units. Many of these homes will benefit from hybrid heat pumps and contribute towards 2035 targets. Further details on housing stock can be found in the HHIC's Heating Up to Net Zero report.

At the same time, grid congestion and reinforcement management will vary between different parts of the UK. Not least because different regions will have different assets. Hybrid heat pumps installed at scale with controls having highest grid priority in operation can provide supply security and lower costs for those experiencing fuel poverty.

4 https://files.bregroup.com/bretrust/The-Housing-Stock-of-the-United-Kingdom_Report_BRE-Trust.pdf

03. The Challenge to Decarbonise Existing Homes

The decarbonisation of existing homes is one of the biggest challenges to the UK achieving Net Zero by 2050.

Analysis shows a near-total decarbonisation of UK housing stock is required to hit government targets. This will have a profound impact on the way people heat up their homes and generate hot water, and will also require changes to everyday behaviour. This monumental challenge involves not just policy and funding pathways but also the uptake of new and unfamiliar technologies at scale.

Fabric First

A fabric-first approach must be taken long before any appliance is installed. This will improve a property's heat retention and lower demand on the fuel used to generate heat and hot water. Many UK homes are still a long way off the basic level of insulation required to achieve minimal thermal performance. This is a problem as all existing UK homes will need to achieve an EPC band of C or above by 2035 – not just to properly support the lower temperatures used by a full heat pump system but also to minimise any extra costs to the consumer.

The English Housing Survey 2019-20[5] reported that:

- 86% of homes in England had full double-glazing, up from 73% in 2009
- 50% of homes had cavity or solid wall insulation, up from 39% in 2009
- 39% of homes had 200mm or more of loft insulation, up from 24% in 2009

While moving in the right direction, these figures reflect the problem existing homes face as the country transitions to low-carbon heat and hot water. Many homeowners will need to implement basic measures to improve the energy performance of their homes, and factor in the associated costs when installing a low-temperature system. Reduced heat loss ultimately leads to better overall system, so the need for investment is apparent.

Three relatively simple insulation measures can significantly reduce the heat demand of UK homes:

- Minimum of 200mm of loft insulation
- Double-glazing
- Cavity wall insulation

5 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945013/2019-20_EHS_Headline_Report.pdf (see page 41)
https://www.gov.uk/government/statistics/english-housing-survey-2019-to-2020-headline-report

Homes built with no cavity require external or internal insulation and are more difficult to treat. The English Housing Survey clearly shows existing homes have a long way to go in lowering heat loss. The Energy Saving Trust's website shows cost savings vary depending on house type. It also estimates the energy saving by insulation measure.

Figure 1. Insulating Homes

Measure	Percentage Installed (England and Wales)	Heat Loss Compared to No Insulation
Homes With Loft Insulation 200mm or Above	39%	25%
Cavity or Solid Wall Insulation	50%	35%
Double Glazing	86%	18%

Note - This is reviewed in more detail in the HHIC's Heating up to Net Zero report. https://hhic.org.uk/resources/8

The Space Challenge

HHIC monthly sales statistics show that over 80% of today's 1.7 million UK annual gas boiler sales are a combination type, providing instantaneous hot water without the use of a hot water storage tank. These compact combis often fit easily into a kitchen cupboard, utility room or loft space.

One significant challenge of transitioning to a low-temperature heating system is the need for stored water, particularly in existing properties where the space for a cylinder may never have existed or may have been converted.

There is also the requirement for outside space for a heat pump, where the unit must be positioned in an appropriate location adjacent to the property. The benefit of the hybrid is the possibility to use a smaller or more compact wall-hung unit.

04. What is a Hybrid Heat Pump?

Hybrids mean different things to different people. This paper views a hybrid heat pump as the combination of an electric-driven air source heat pump (ASHP) with a new or existing gas condensing boiler alongside a single control that operates the full system. Note – oil and LPG boilers can also be used.

The control is optimised for cost or carbon against the level of comfort required. The measurement of hybrid heat pump performance is important to advise the consumer on minimum, average and maximum cost and carbon savings for a given operating use case.

Hybrid Types

With regular boilers a hot water cylinder is required for storing hot water, unlike for combination boilers that heat water directly from the mains when a hot water tap is turned on. Hybrid heat pumps can operate with either regular or combination boilers depending on the application.

Regular Hybrid Heat Pump System

A regular hybrid heat pump system – with a regular boiler, hot water cylinder and electric heat pump – can optimise for space heating and/or hot water. The single control prioritises the fuel source, operating temperatures and demand priority to the heat emitters and hot water store. Heat pump cylinders are available for demand-side response (with boiler, heat pump, photovoltaic (PV) and battery options). Thermal stores also provide a buffer for heating and/or hot water.

Combi Hybrid Heat Pump System

Combination hybrid heat pumps use the gas combi boiler and heat pump to optimise only the space heating with the control. The boiler then provides all of the instantaneous hot water on demand. This approach avoids the additional expense and space needed to install a new hot water storage tank, especially for those combination boiler installations where there is limited space inside the building.

Integrated or Non-Integrated

Integrated hybrid heat pumps are when the boiler and all, or part, of the heat pump indoor unit is combined into a single main unit. Non-integrated set ups fit the boiler and heat pump as discrete units. When the heat pump is installed with an existing boiler, it typically becomes a non-integrated system. In all cases the right control operating across the full system can ensure it works effectively. This includes the compact-hybrid which includes the boiler and heat pump in one unit.

Hybrid System Configuration

Hybrid heat pumps need to be correctly designed and installed to ensure the correct output and control configuration. This allows the user to achieve optimisation as intended. There are two ways a hybrid heat pump can be configured. Parallel, where the demand is satisfied by the heat pump and the boiler in combination, and switch, where the control selects one heat/fuel source best suited at that time to meet the demand.

Parallel systems must be designed to maintain the flow and return temperatures within the operational limits of the heat pump, while switch systems can operate different flow and return temperatures depending on which heat source is selected at that time.

Hybrid Heat Pump Controls

The control of a hybrid heat pump system is critical to its success, both in terms of end user comfort and energy optimisation.

Hybrid heat pumps can be operated on a timed schedule or continuously. The control selects the most appropriate operation mode and fuel source based on the comfort/demand (temperature set point) and the user's preferences (cost/carbon). Parameters in the control determine the trigger points to achieve best optimisation.

These can include:

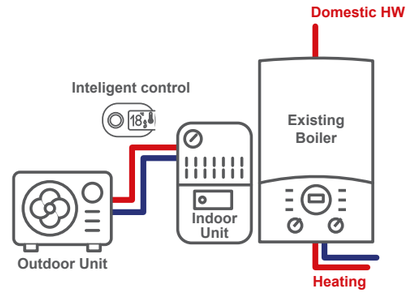
- Fuel tariff
- Outside temperature
- Fuel carbon intensity
- Calculated operational heat source efficiency
- Calculated threshold for carbon or cost

This optimisation of fuel sources makes hybrid heat pumps very efficient. For buildings with good levels of insulation, the system will operate mostly on heat pump mode during spring and autumn and only use the condensing boiler during the coldest days of the year. Field trials have been undertaken and continue to run to study the real-life consumer behaviour and operation of hybrid heat pumps and the in-use heat demand satisfied by them.

There is ongoing hybrid control development aiming to optimise both cost and carbon for a minimum carbon-switching threshold, as well as best running cost approach given gas is present both as one of the primary fuels and as the marginal fuel in the electric generation mix.

Examples of system configurations are shown below.

Figure 2. Examples of system configurationst



Retrofit Hybrid

Heat pump (5-8kW) added to an existing condensing gas boiler with intelligent control

- Boiler needs to be in good condition and condensing type
- Lowest cost option
- Small heat pump used saving space and smaller electricity supply required (8-10 amp)
- Could be added to a system boiler but new cylinder is required

Hybrid Combination system

Existing heat generator is replaced with a hybrid heat pump and intelligent control

- Hot water is supplied by the boiler and supports during cold periods
- Medium cost option
- Small heat pump used saving space and smaller electricity supply required (8-10amp)

Hybrid with Stored Hot Water

Existing heat generator is replaced and heat pump contributes to both heating and stored hot water

- A new hot water cylinder is required
- High upfront cost but future proof

Compact Hybrid

Existing heat generator is replaced with one internal unit containing a condensing combination boiler and small heat pump

- Can also supply stored hot water using a cylinder
- Competitive cost option
- Electricity supply is small (8-10amp)

05. The Benefits of Hybrid Heat Pumps

The changes required to fit an all-electric space and hot water heat pump are significant for most homes. In an ideal situation, fabric and system upgrades to a property will reduce the heat demand while also preparing the property for low-temperature heating.

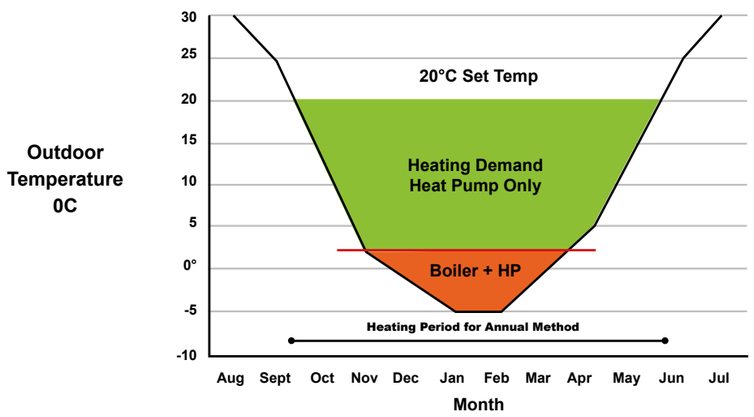
If space is available outside for the heat pump and inside for the cylinder, then the consumer can enjoy heating and hot water along with lower carbon emissions. This also delivers the best emissions reductions possible as low-carbon electricity becomes more widely available. More information on the upgrades required for a full low temperature heat pump system can be found in the Heating up to Net Zero paper produced by HHIC, MARC and HWA.

However, in many cases fabric and system upgrades mean extra cost and disruption. Solid wall insulation, for example, is not always practical and affordable to install all at once. Often the replacement of a heating appliance is a distress purchase when the property is suddenly without heating and hot water in the colder months and there is an immediate need for a replacement. In this situation, the installation of a hybrid heat pump system offers a solution if the homeowner does not want, or cannot make, extensive changes to their property at the same time.

This approach can yield up to 55% carbon savings[8] as an average across different building types, with far less modification or disruption. While still using natural gas, it also lays the groundwork for all-electric and low-carbon gas modifications at a later stage. Providing the existing boiler is a high-efficiency condensing type, a heat pump can be sized at a minimum of 50% of the property's heat demand and provide 80% of the space heating supply over a full year. This would cover most of winter, with the boiler providing the demand for the hot water, and only being used for heating during the very coldest periods. As the grid further decarbonises the carbon savings will increase.

The graph below demonstrates a typical domestic hybrid heat pump load profile and how much of the annual heating it will provide.

Figure 4. Example Hybrid Heat Pump Load Profile (Alpha Heating Innovation)

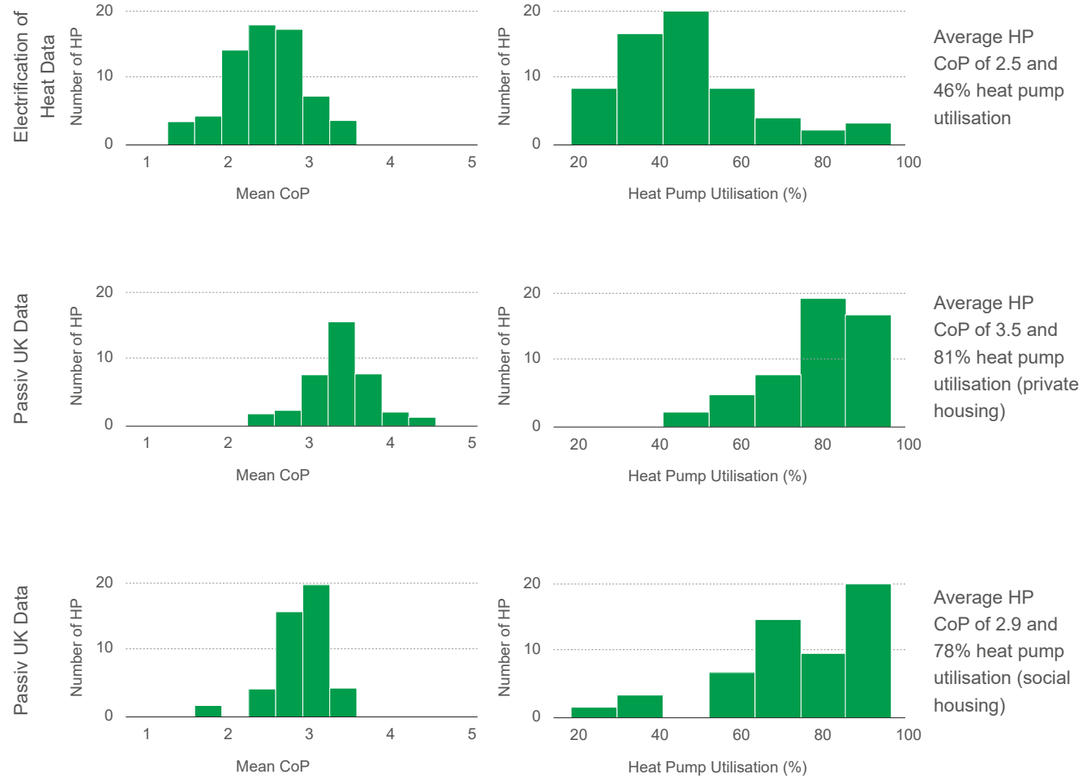


The property will still need to have appropriate external space to site the smaller heat pump outdoor unit and planning permission if the unit exceeds 0.6 m^3 (or fails to comply with MCS 020 or subsequent requirements). However, at 50% of the maximum heat demand of the property this is unlikely to be an issue.[6]

Data provided by Passiv UK (currently pre-publication) compares hybrid heat pumps deployed as part of the BEIS Electrification of Heat (EoH) trial with hybrids deployed in other off-grid or social housing schemes. The EoH hybrids did not have specific smart controls, while the other trials used a smart control system that automatically learns the thermal characteristics of the home, optimising the operation of heat pump in response.

*In all trials Passiv UK provided monitoring services for the heat pumps.

Figure 4. Hybrid Heat Pump Trials



6 https://www.planningportal.co.uk/info/200130/common_projects/27/heat_pumps/2

The EoH trial data reflects wide variance around the mean hybrid CoP and heat pump utilisation rates. Hybrids managed with smart controls show less variability, demonstrating a greater consistency for households. This highlights the benefits of an intelligent control that is managing the operation of the heat pump in relation to household behaviours and the outside temperature, and validates the theory that in a high-quality hybrid installation up to 80% of the annual heating can be provided by the heat pump.

Across Europe there are growing calls for hybrid heat pumps to be recognised and supported in policy. The following is extracted from two recent papers from Italy and the Netherlands, which offers evidence in support of a practical route to decarbonisng heat and hot water in the UK.[7]

The hybrids study has been completed by the University of Pisa[8] for different property types, insulation levels and varying climate conditions across Italy. Areas D and E detailed in the report have similar climate conditions to the UK and energy costs are also comparable.

The following list details some of the conclusions:

- With a good control strategy the hybrid can deliver similar carbon emissions savings to a heat pump
- The hybrid system (gas boiler unit and HP unit with master control) gives good results for carbon savings, energy and cost in every case study
- The best performing sizing strategy for hybrid systems is to keep the heat pump power below the design heat demand. This maximises the average heat load of the heat pump, so it works optimally
- The best working strategy is to use the heat pump as much as possible, with priority over the boiler
- The boiler delivers better overall performances under colder weather conditions. It fulfils peak demands maintaining comfort without overloading the electricity grid
- It allows compatible use of existing (or new) high-temperature emitters (radiators) and a direct and comfortable direct hot water (DHW) production without the need for storage tanks or discontinuous use of the heating system to provide hot water
- From a cost point of view, hybrids give a more robust response to energy prices variations and to the stability of the electric grid and existing infrastructure

The Dutch Heating Industry (NVI) hybrids study recommends embracing hybrid heating systems and including them as part of the policy for the sustainable built environment up to 2030. It also suggests that a large-scale reduction in carbon emissions can be done in an affordable way.

The NVI's calculations include extra savings when insulation measures allow a lower-temperature heating system to be used. The following list details their conclusions:

a. Hybrids using a smaller heat pump can reduce gas consumption by around 80%

b. The hybrid heat pump is most efficient when temperatures are above two degrees centigrade while the gas boiler is better below. This assists with using a smaller, low-cost heat pump

c. Added flexibility for the gas and electricity network

d. By properly applying a hybrid heating system, it's possible to achieve a significant reduction in heating costs and at the same time save considerably on CO2

7 https://www.verwarmingsindustrie.nl/wp-content/uploads/2021/09/Rapport-Hybride-warmtepompen-NVI-sept2021.pdf

8 https://cloud.anima.it/index.php/s/nBONHAzixV6b6SB

Figure 5. Carbon and Gas Saving using a Hybrid (NVI)

	Co2 Emissions Current	Saving Using Hybrid Ht (80c)	Savings Using Hybrid Lt (50c)	Current Gas Consumption (M3)	Saving Using Hybrid Ht (80c) (M3)	Saving Using Hybrid Lt (50c) (M3)
Apartment	1371 kg	762 kg	1063 kg	770	342	173
Poorly Insulated Terraced House	2314 kg	1285 kg	N/A	1300	578	N/A
Average Dutch Terraced House	1958 kg	1088 kg	1518 kg	1100	489	247
Well Insulated Terraced House	1602 kg	890 kg	1228 kg	900	400	210
Poorly Insulated Half of Semi Detached House	3026 kg	1632 kg	N/A	1700	783	N/A
Well Insulated Half of Semi Detached House	2314 kg	1285 kg	1796 kg	1300	578	291
Poorly Insulated Detached House	4450 kg	2307 kg	N/A	2500	1205	N/A
Well Insulated Detached House	3026 kg	1632 kg	2339 kg	1700	783	386
NI Average	2205 kg	1225 kg	1709 kg	1239	551	279

Hybrid heat pumps allow lower-output heat pumps to be used, and coupled with the flexible dual fuel heat source can give many benefits:

- An adapted heating system ready for low-carbon gas and electricity, facilitating the balance of demand for the electricity grid, limiting demand peaks using the condensing gas boiler as required
- Savings on fuel bills with dynamic tariff price structures by shifting consumption and optimising the operation of the heat/fuel sources to when demand (and price) is low. The two heat sources mean that back up and energy demand can be varied to offer greater grid flexibility, which can be further increased with a specially designed hot water store
- Suitable and convenient means to renovate existing heating systems in both on-grid and off-grid gas networks, and flexibility to work with both regular and combination boilers
- Lower-output heat pumps are typically smaller and quieter, requiring less external space for installation and are often wall mountable for easier siting
- Less demand is placed on the household electrical system and electrical grid, particularly at peak times.
- Lower embodied carbon in smaller heat pumps, on a like for like supply chain basis, further benefits the environment

- House heat loads need to be accurately calculated and understood. Radiator circuits may require fewer upgrades and are often suitable as they are designed for houses before insulation measures were introduced. Renovations can still be made over time for further energy savings when the customer is undertaking home improvements. This makes the initial heat pump installation quicker and more cost-effective, while retaining the same function and familiarity of a traditional heating system
- The lower up-front costs of a smaller heat pump with an existing or new condensing boiler. Further savings are made as only minor radiator changes are required when compared to an all-electric heat pump, which often require a redesign
- Gives the homeowner time to upgrade fabric and radiators. Depending on choice and availability, they can then choose to upgrade to either a full-electric heat pump system, permanent low-carbon gas hybrid, or zero carbon gas boiler system
- Smaller heat pumps require a lower electrical demand, often with only 6-10 amp mains supply necessary. In contrast, all-electric heat pump systems are generally of a larger output and heat pumps over 12kW typically require 18 amps from a dedicated electrical supply

The following details estimated cost comparisons between a complete hybrid heat pump with boiler and a heat pump with intelligent control for installation to an already installed condensing boiler. The third columns details costs for a 12kW heat pump with intelligent control.

Figure 6. Cost Comparison

	5kw Hybrid – Heat Pump (with Boiler) and Intelligent Control	5kw Heat Pump with Intelligent Control for Adding to Already Installed Boiler	12kw Heat Pump with Intelligent Control (Comparison)
Price Range (end customer)	£2,300-£3,400	£1,800-£2,400	£5,000-£6,000

* Note: costs are an average from appliance manufacturers (HHIC members) and for the appliance only, not including installation or any upgrades to the property or heating system.

The table on the next page details a typical household's electrical demand, showing the high electrical load as homeowners move to EVs in addition to the current all-electric domestic appliance trend.

Figure 7. Typical Household Electrical Demand

Appliances		With Boiler	With Heat Pump	With Hybrid
		AMPS	AMPS	AMPS
Ring Main (Sockets 1)		30	30	30
Ring Main (Sockets 2)		30	30	30
Lighting Circuit 1		6	6	6
Lighting Circuit 2		6	6	6
Cooker	10kW	30	30	30
Electric Shower	8.5 - 10.8 kW	40	40	40
Gas Boiler	15/30kW	3		3
Heat Pump	7/12kW		20	8
Ev Car Charger	7kW	30	30	30
Current Total (Amps) Household Appliances		175	192	183
Dishwasher	2kW	8		
Kettle	2kW	8		
Tumble Dryer	2kW	8		
Electric Shower (Typical)	10kW	40		
Electric Cooker	12kW	48		
Washing Machine	2kW	8		

The typical demand on a house electrical system with the addition of the requirements for EV charging is shown in Figure 7 for a boiler, hybrid heat pump and all-electric heat pump.

The loading of a typical household wiring circuit will have to increase. Although diversity will be applied, most homes today already have many electric appliances including cookers and showers. The addition of the EV charger and heat pump means more of a constant load demand during a 24-hour period adding extra demand to the home and electrical network especially at peak demand. The table only demonstrates one EV charger, but many homes have more than one car creating future charging issues. In colder periods, the heat pump would be running for 24 hours and use of a smaller heat pump as part of the hybrid system would reduce household cost and load on the network.

06. Managing the Variability of Hybrid Heat Pumps

Hybrid heat pumps can have a high degree of variability depending on design and operational factors.[9] This should be managed through standards and the correct application of system controls. Doing so will ensure that hybrid systems are delivering genuine carbon savings, therefore allowing them to be included in both policy and incentive schemes.

Is important that controls are able to adjust performance to suit comfort, cost and carbon requirements. This will optimise the system and inform the consumer of the intended outcome of the settings they have specified. The control also needs to be capable of accommodating:

- Electricity distribution network operator (DNO) capacity signals
- Virtual private wire/microgrid signals
- On-site generation and storage if present/desired
- Offer easy-to-use scheduling of heat demand, as well as comfort and cost optimisation

A function in the controls can be applied to minimise the total system carbon emissions across the gas and electric heat/fuel sources, e.g. minimum CoP threshold based on a point-in-time marginal generation mix.

No CoP threshold would be necessary when electricity is not using fossil fuel sources. Similarly, the carbon emissions function would no longer be required when both grids are decarbonised, defaulting solely to energy efficiency and energy fuel source price tariffs to optimise for cost.

The installation must be capable of performance monitoring, with the provision of measured data to demonstrate the cost and carbon impact. The system should also be able assist during the retrofit of homes and buildings alongside decarbonisation of gas and electricity upstream of the meter. Funding schemes can use this control data to check use cases with in-situ data.

Hybrids are readily available but overlooked as a potentially useful technology. They should be included in government policy. HHIC recommends the following:

- There is currently no agreed control specifications or inclusion of hybrid control systems in standards. With BEIS support, industry can produce a minimum control standard for hybrids to enable them to deliver the required policy goals. This action is only worthwhile if they are included in the relevant policy and incentive schemes
- Defined hybrid control use cases should be created and recognised in PAS 1878, Energy Smart Appliances, to align equivalent customer experiences for comfort, carbon, cost, parameters and operational logic that correctly regulates the intended operation
- Creation of a Smart Systems and Flexibility Plan 2.0 that will regulate control standards for all low-carbon technologies, including heat pumps, and will follow the approach taken for smart EV charging. HHIC believes this should be brought forward, and a specific standard for hybrid heat pumps is introduced which supports the CCC's 80:20 space heating requirement.

9 (Element Energy report for BEIS)

07. Skills and Training

To support the move to low-carbon heating, heating design and installation engineers will need a good understanding of how insulation measures affect thermal performance and the overall heat demand of a property depending on its fabric heat loss.

Room-by-room heat loss calculations can determine the lower system temperature and flow rate an existing heating system can operate at, as well as the benefit and costs of the fabric and system measures on the heating appliance and system specification. Encouraging all heating engineers including those that are Gas Safe Registered or heat pump specialists, to complete training to gain an understanding of heating system design and commissioning, including the effects of low temperatures, must be a priority for both industry and government.

Many manufactures already provide installer engineer training for both heat pumps and hybrids. This usually covers off how they work and how they can be designed and installed into existing heating systems. However, training should also give engineers the knowledge needed to help consumers with gas and electricity tariffs, including how to search for available options as not all standard variable rates represent the best deals.

It should be noted that manufacturers recommend annual servicing of hybrid units, which require both gas and electrical skill. Although this is likely to be a higher cost than a single appliance service, it could be completed together during the same visit.

BEIS has carried out research to understand the existing skills base within the UK heating industry and the measures needed to increase the number of low-carbon heating installers. This has resulted in ongoing discussions regarding training for heating engineers across the industry. There is no doubt that installers of hybrid heat pumps will also require skills for both heat pumps and condensing gas boilers.

Industry is in the process of adding extensions to training. One example is to update the high-level system design criteria, including heat loss calculation and emitter sizing, and make this part of the mandatory syllabus for new entrants to the Accredited Certification Scheme (ACS) and central heating competence (CENWAT). IGEM's IG/1 Standards for Training in Gas Work applies to all new entrants undertaking training for the ACS assessment and will apply to apprenticeships of this type, as well as managed learning programs. There is also a low-temperature/carbon course currently under development by CIPHE.

It's clear that ongoing training will be required to ensure quality installations. But heating installers will not readily engage with this unless there is a customer demand for the product, which will require support in relevant government policy.

08. Government Support for Hybrid Heat Pumps

The CCC recommended hybrid heat pumps in its 2019 report into UK housing.[10] It advised wide deployment in buildings on the gas grid, suggesting an installation target of 10 million by 2035. In the Sixth Carbon Budget published in December 2020, the CCC continued to include hybrid heat pumps in its policy recommendations, noting the need to create a level playing field for the technology as this will ensure it's an integral part of PAS 2035 retrofit coordinator advice.

The CCC also advised on the uncertainty around how hybrid technologies will perform in-situ. Based on work undertaken by Imperial College London, the base assumption remains that hybrid heat pumps can operate in heat pump mode up to 80% of the time, with separate trial data (e.g. from Passiv Systems, when combined with smart controls) supporting this. Trials undertaken by Energy Systems Catapult have shown that performance can be highly variable and dependent on household heating behaviours.[11] This demonstrates the requirement for an agreed minimum control specification across industry.

Hybrid heat pumps used to qualify for grant funding under the RHI and the Sustainable Warmth Local Authority Delivery (LAD) competition. Under the recent Green Homes Grant Voucher Scheme, hybrid heat pump installations also qualified, provided the heat pump element of any hybrid system could provide the vast majority of the space heating demand for the property.

The Boiler Upgrade Scheme (BUS), the replacement for domestic RHI, introduced in April 2022 will only provide funding for heat pumps that provide 100% of the space heating and hot water demand. This effectively discontinues financial support for hybrid heat pumps.

EPCs are a widely used measures of the energy performance of buildings but are known to need improvement. Issues around consistency and accuracy, for example, have been noted, as well how effective they are for promoting action and behavioural change.

The government's EPC plan was published in September 2020 and set out a series of actions following calls for evidence in July 2018. To maximise the effectiveness of improving the performance of the existing housing stock, EPCs should provide a trusted, accurate and reliable measure of energy performance and engage consumers on their energy consumption.

Consumers and third parties should also have access to the data to inform their decisions. Some industry figures have suggested the introduction of a home building passport. EPCs are familiar to homeowners, so it makes sense that any additional requirements are captured under the existing EPC framework.

10 https://www.theccc.org.uk/publication/uk-housing-fit-for-the-future/

11 https://www.theccc.org.uk/publication/sixth-carbon-budget/

Assessment of heating systems for low-carbon readiness is best suited to qualified installers. The package label requirement in Ecodesign has limited uptake by heating installers, as there is little value in completing this system efficiency calculation. When a hybrid heat pump is installed, it would be beneficial to link this efficiency calculation to the EPC.[12]

The HHIC white paper Heating Up to Net Zero highlights the benefits of expanding the Benchmark scheme. Mainly as a way to capture data for an improved EPC scheme. The Benchmark document could serve as the platform for recording completed works but also for the assessment of future energy-saving heating system upgrades. The Benchmark has the potential to become the heating system chapter of any future home energy passport.

The following information is linked to research from the University of Pisa discussed in chapter four of this paper. It refers to government support in Italy and is provided by Alpha Heating, which manufactures heating products.

In 2021, Italy reported sales of 150,000 heat pump units, including a significant number that were part of a factory-supplied hybrid package. This is an overall uplift of 188% on the previous year. All-electric heat pumps accounted for 60% of the market share, while hybrids took the remaining 40%. This demonstrates significant success for hybrid use in an established market.

Support incentives in Italy are based on solutions that increase the property's energy performance, similar to the EPC and RD-SAP process. Measures have to be undertaken to increase by a stepped amount, much like improving an EPC rating from a D to a B. Funding up to a value of €96,000 is available when improvements meet the required standard. This includes initial insulation measures and a wide range of renewable technologies such as:

- Solar PV
- Micro generation
- Fuel cells
- Micro cogeneration (for example CHP)
- Biomass
- Heat pumps
- Factory supplied hybrids with dedicated controls

Of the technologies included, heat pumps and hybrids are the most popular option. Italy's funding is based on the size of a property and the heating design load, with example funding values of €1,300 per kW for all-electric heat pumps and €1,550 for a hybrid per kW used by the heat pump component. This higher value for hybrids reflects the smaller-sized heat pump still giving emissions and efficiency benefits. Currently, only factory-supplied hybrid packages qualify for the incentive.

The payments are made through a reduction in income tax and usually facilitated through organisations and banks to help with the initial costs. This can amount up to 110% payment back on the original cost of the upgrades, which the consumer will receive back spread over five years.

Easier retrofit installation and less disruption are the main reason hybrids have experienced considerable growth in the space of a year, though carbon emissions reductions also appear to attract homeowners as the University of Pisa's research shows.

12 https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/boilers/05-energy-labelling-space-and-combi-heater-c-2013-817.pdf

09. Conclusions

Hybrid Size, Cost and Flexibility

- Hybrids using a smaller heat pump can still meet 80% of a household's annual energy demand, without making changes to the existing hydronic heating system
- Hybrids can be fitted to a large number of the 15 million homes that already have a combination boiler, causing far less disruption for the homeowner
- Hybrids are more flexible to install and produce less noise compared to an all-electric heat pump installation,
- Adding a smaller heat pump and hybrid control to an existing boiler creates a hybrid heat pump at a relatively low cost
- Users can spread investment in property renovation over time to improve insulation and transition to a low-temperature system, reducing carbon emissions while also maintaining comfort
- Heat pump and hybrid controls can be fitted to different heat sources and boiler types such as regular or combination boilers

Energy Network Benefits, Policy and User Choice

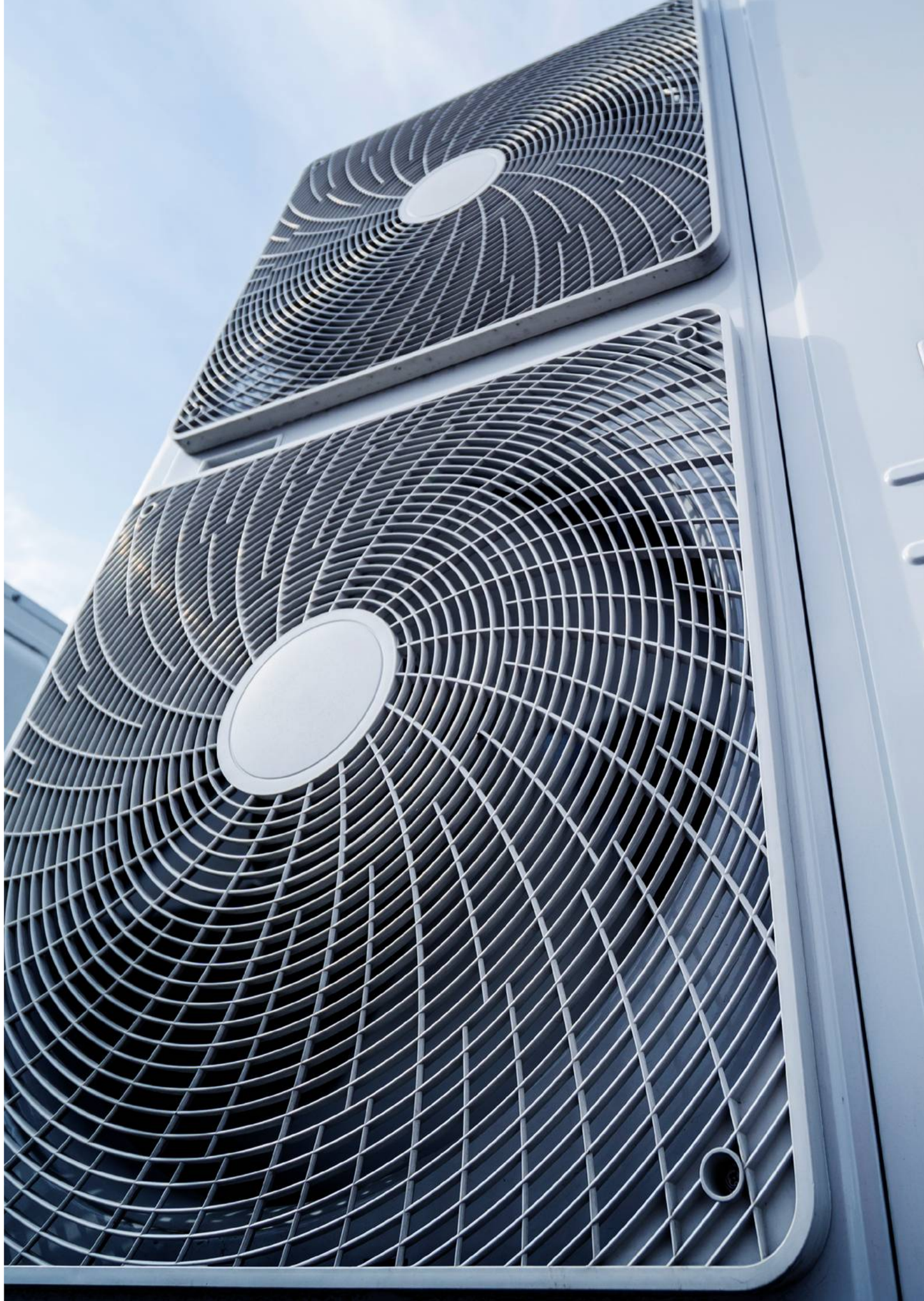
- Hybrid heat pumps offer better choice and adapt the home for both low-electricity and low-carbon gas technologies (including 100% hydrogen), making it easier to introduce future strategy and policy
- In 2023, the introduction of a 20% hydrogen blend with natural gas will deliver further carbon savings when using the boiler as part of the hybrid system, be this regular or combination type
- For homes with a hot water cylinder, there is the potential to use off-peak electricity for heating and storing hot water to balance the energy supply
- Heat pumps can run on off-peak electricity with a temperature set back to maintain comfort in winter temperatures.
- The continued use of existing gas infrastructure avoids the roll-out of new district heating systems where applicable
- The energy networks can benefit from the local integration of gas and electricity enabled by hybrid heating solutions. Using a smaller heat pump reduces peak power demand and investments in grid reinforcement compared to full electrification. Hybrid systems can switch between gas and electricity adding further flexibility and resilience

Additional for Off Grid Users

- The combination of a heat pump with an LPG or oil condensing boiler along with biofuel can significantly reduce carbon emissions
- There is opportunity to reduce the reliance on high-carbon secondary heating used in off-gas grid homes and reduce emissions of particulate matter

10. References and Notes

1. **Heat Pump Planning Permission**
   https://www.planningportal.co.uk/info/200130/common_projects/27/heat_pumps/2
2. **IGEM IG1 – Standards of Training in Gas Work**
   Systems running on electric along with natural gas, LPG, or oil are an effective and immediate interim solution that could be seen as a boiler plus measure, helping to accelerate the transition to low-carbon heating.
3. **Low-Carbon Heating Technician Apprenticeship**
   Level 3 trailblazer proposal now approved, A standard is being developed as the next stage (i.e. defining knowledge, skills and behaviours required of the occupation), three-year duration envisaged, funding TBC.
4. **Plumbing and Domestic Heating Technician**
   Typical four-year duration, due for review, max funding £21,000. Overview of all heating tech and one chosen specialism, e.g. gas, oil, environmental tech (ASHP, solar etc).
5. **Gas Engineering Operative**
   Typical 18-month duration, gas focus. Will be impacted by IG/1, max funding £22,000.
   https://www.instituteforapprenticeships.org/apprenticeship-standards/gas-engineering-operative-v1-1
6. **Plumbing and Domestic Heating Technician**
   https://www.instituteforapprenticeships.org/apprenticeship-standards/plumbing-and-domestic-heating-technician-v1-0
7. **CIPHE Low-Temperature/Carbon Qualification**
   https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/boilers/05-energy-labelling-space-and-combi-heater-c-2013-817.pdf
8. **Unlocking the hybrid heating potential in European buildings**
   https://hybridheatingeurope.eu/wp-content/uploads/2021/03/hhe_vision-paper_final.pdf



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To find more about HHIC visit **www.hhic.org.uk**

info@hhic.org.uk

01926 513777

@hhic

HHIC
Camden House
Warwick Road
Kenilworth
CV8 1TH