Future Homes Standard:
Phase 1 Network-to-Emitter Impact Report

April 2023

Version 1.1

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Acknowledgements

With special thanks to the input and involvement of the BEAMA members and James Healey, Director at UK Overheating. We would also like thank the Future Homes Hub for their Ready for Zero report which this document complements and builds upon.

Foreword

The Future Homes Standard will mark the start of an era for the design and construction of operationally zero carbon ready homes in England. The upcoming consultation comes at a critical time for the UK; upfront affordability and energy costs are at the forefront of consumers' minds due to the ongoing cost of living crisis, and professionals within the built environment are adjusting to progressively challenging specification requirements to enable new homes to pass increasingly stringent Net Zero driven regulations.

However, balancing these requirements is not beyond us. We already have the technologies we need to build desirable and future-proofed homes which will require no future intervention with retrofit measures to achieve Net Zero carbon operation. In fact, with a steadily decarbonising electricity grid, and the availability of flexibility services and on-board generation, we should be able to achieve operationally carbon negative homes over time.

Our mature manufacturing supply chains are scalable, with a long history of successfully innovating and supplying low or zero carbon technologies to markets within and beyond the UK. BEAMA members are some of those ready to supply the breadth of technologies required to meet the changing requirements within the built environment.

There will be no single solution to decarbonising new dwellings and we must ensure that regulations remain target based to allow industry to be flexible and, where necessary, innovate; giving scope to always pick the best solution for each individual project. Future homes will be very much delivered through a dwelling and application-based approach.

This is not to say that integrating tested and innovative technologies in the UK will always be straightforward; we face challenges in ensuring design integrity, developing appropriate skills with contractors, provision of all-encompassing Net Zero building modelling, ongoing compliance and enforcement of regulations and, very importantly, occupant education to assure ongoing performance standards.

BEAMA is working hard to collaborate with Government and housebuilders to deliver effective work programmes to de-risk the move to creating future homes. We have no doubt that with the expertise of industry and the wider value chain, combined with engagement from Government, we will be able to produce high quality, healthy homes without compromising affordability and desirability.

Dr Howard Porter
CEO, BEAMA

Executive Summary

When the Future Homes Standard comes into force in 2025, it will represent a landmark moment in which low carbon technologies will be required in dwellings to comply with new building regulations and the Net Zero commitment. We should expect almost exclusively electrified solutions such as heat pumps and direct electric heating, combined with mechanical ventilation and, in some cases, active/passive cooling, to ensure increasingly airtight buildings remain affordable, healthy and comfortable. Each dwelling type will require its own unique application-based specification due to occupancy levels, service use and internal space availability.

Within heating, hot water and comfort cooling, the high carbon reduction target will see the creation of two main energy strategies within new build housing: The first focussed on pairing ground source, air source or water source heat pumps with good levels of fabric; the second on using direct electric space heating or air-to-air heat pump units within dwellings with very low heat profiles, in combination with efficient technologies such as hot water only heat pumps or solar PV.

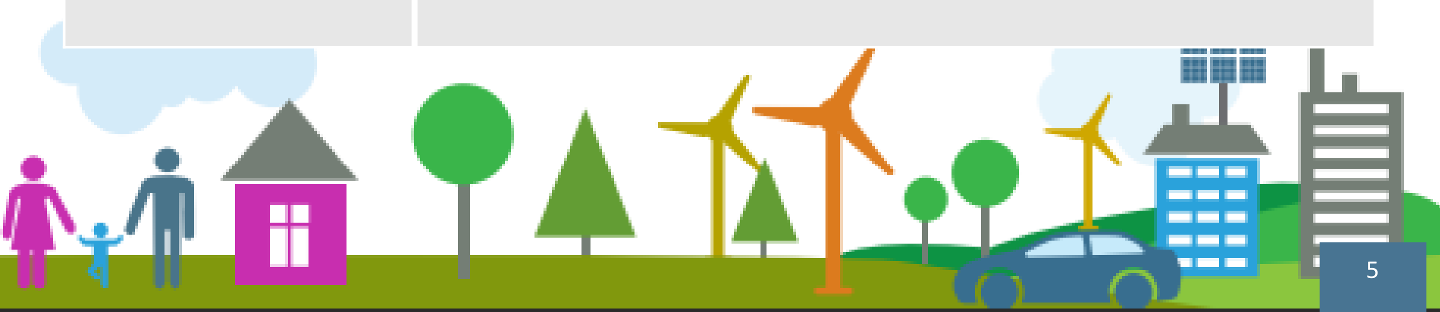
With a focus on a fabric first approach to limit energy demand, more complex mechanical ventilation systems will become increasingly important to mitigate health risks in air-tight dwellings. Delivering safe levels of indoor air quality is critical, and as we focus on low energy demand and running costs, there will be substantial benefits accrued from installing mechanical ventilation with heat recovery to reduce the amount of waste heat being discarded from the dwelling, which the occupant eventually pays to replace.

Introducing some of these technologies at mass scale will require adjustments to the way we design, build and live in new homes. We have used our understanding of these technologies and the challenges they face to make tangible recommendations to Government on how our transition to creating zero carbon ready homes can be better supported. These recommendations look at various areas within new build compliance and technology adoption.

Area	Government Recommendations
Previous learning	• Produce a range of stakeholder specific information, providing digestible content on the key changes within the consultation which can be shared across industry. This should include information targeted at manufacturers regional housebuilders, SAP assessors and installers. • Ensure a BETA version of SAP 11 is available from the start of the consultation period to allow industry to effectively model the impact of proposals. • Include a section at the start of the consultation giving an outlook to the expected changes within the following update to Part L, Part F and Part O, allowing industry to develop long-term strategies and prepare for future requirements.
2025 notional build	• Include an air source heat pump and MVHR within the 2025 notional build, paired with the minimum fabric standard to pass 2025 fabric energy efficiency standards. This will mean any change to less efficient heating or ventilation will need to be balanced with fabric improvements.
SAP 11	• For the Department of Levelling Up, Housing and Communities to support changes to SAP 11 which better promote and represent low carbon technologies which will be used under the Future Holmes Standard. This includes, but is not limited to, the recommendations listed within this section of this report.
Consumer understanding	• Submit an industry call to action document to launch a timed, multi-pronged educational campaign to bring consumers on the net zero journey, including understanding about the importance of healthy homes and how to effectively use low carbon technologies. • Accelerate improvements to existing Government information and advice mechanisms including EPCs to better reflect the benefits of numerous technologies.

	• Create a Public Understanding of Net Zero Technologies Taskforce to drive common standards for handover advice for occupants living with low or zero carbon technologies. This could also be expanded to cover retrofit solutions.
Competency	• Introduce mandatory competent person schemes for designers, installers and commissioners of certain net zero technologies within new dwellings. The details of this scheme can be defined as part of the Future Homes Standard consultation. • Ensure compatibility of competence requirements for safety and energy, utilising the move of the Building Regulations team from the Department for Levelling Up, Housing and Communities to the Health and Safety Executive. • Department for Levelling Up, Housing and Communities and the Health and Safety Executive to explore the topic competency topic with the BSI Committee CPB/1 - Competence in the Built Environment.
Flexibility and smart controls	• Support technologies within the Future Homes Standard which enable demand side flexibility, including, but not limited to, batteries, heat pumps, underfloor heating and electric storage heaters. • Include flexibility as a topic within the industry call to action document to launch a timed, multi-pronged campaign, as recommended within the Consumer understanding section of this report. • The inclusion of a parallel operation alongside the launch of an open-source flexibility module within SAP 11, which allows manufacturers to innovate and build upon that module for future assimilated into core SAP after an IP protected 'closed box' period in the market place.
Overheating	• MVHR with summer bypass functionality should be identified and assessed for functional performance within the PCDB for MVHR. • A SAP convention (Appendix Q) should be created for ceiling sweep

	fans and reversible air-to-air heat pumps to allow for specification as an overheating mitigation strategy, alongside a test and rate regime linked to the Product Characteristics Database. Only rated units to a minimum agreed specification should be approved for overheating strategies. • Dynamic thermal modelling guidance should be revised to recognise and establish criteria for ceiling fan strategies and air-to-air heat pumps.
Cost of electricity	• The Department for Levelling Up, Housing and Communities should take an active role in HM Treasury's pledge to rebalance the cost of energy, championing lower electricity costs to ensure newly constructed electrified homes are not penalised due to outdated energy policy and that short term running costs reflect long term societal costs. • The Government's commitment to rebalance the cost of electricity and gas must be implemented and recognised in SAP and EPCs in time for Future Homes Standard implementation.
Network impact	• The Future Homes Standard should support the specification of technologies, such as heat pumps and smart electric storage heating, which are capable of providing flexibility through demand side response. • Ensure that most new dwelling types can comply with the Future Homes Standard without the use of heat pumps for areas where connections by a DNO are not approved. This includes hot water only heat pumps and water-to-water heat pumps in apartments. • The Department of Levelling Up, Housing and Communities, in collaboration with the Department for Energy Security and Net Zero, to commission an industry wide taskforce to review the challenges and barriers to the future of electrification in regards to electricity grid connection and capacity. This should include manufacturers, developers and DNOs.



2025: Homes for the future

The updates to Approved Document L: Conservation of Fuel and Power (Part L) and Approved Document F: Ventilation (Part F) in 2025 will be a landmark moment for energy efficiency within the residential new build market.

It will be the pivot point at which low carbon technologies become the primary solution for providing space heating and domestic hot water services in new dwellings, paired with high levels of energy efficiency. However, building services comprise of more than just space heating and domestic hot water – the 2025 update, known as the Future Homes Standard, will also impact the way we ventilate dwellings and provide cooling where it is specified for necessity.

The changes will heavily impact the design, procurement and installation procedure for many developers and housebuilders in England. As such, it is important to understand the technology options that will be available to them when looking to build a low carbon home fit for the future.

Key aims of the Future Homes Standard

Although the Future Homes Standard consultation has yet to be published, we already know some of the key aims which government hope to achieve. This includes building new dwellings which:

- Save 75-80% carbon emissions compared to a home built to Part L 2013.
- Are built to a performance standard that means they will not use fossil fuel heating.
- Are zero carbon ready, requiring no energy efficiency retrofit to become zero carbon as the electricity grid decarbonises.

These are aspiring aims from the Government, and they will create a fundamental shift in how we design, build and live within new homes. The upcoming consultation should acknowledge that, in regulatory terms, new build homes provide the easiest opportunity to produce coherent and ambitious policy. If we do not maximise this opportunity to rollout Net Zero compatible heating and ventilation now, we will add emissions to our overall national carbon account, and put more pressure on the need to decarbonise in far more difficult and costly areas.

A two-phase report

The Future Homes Standard consultation is expected to be published in Autumn 2023. Ahead of this, we wanted to use BEAMA's unique position and collective member knowledge of home, transport and network decarbonisation to analyse the potential impact of the Future Homes Standard.

This is why we have created the Phase 1 Network-to-Emitter Impact report, to give a holistic overview of low carbon HVAC technology options which could be specified to provide building services from 2025 and what this shift might mean for broader impacts, such as on the electricity grid. All of these solutions are available to designers now and have supply chains ready to scale up production to meet an increase in demand.

We have built the report around three guiding principles:

1. Technologies must be able to achieve a 75-80% carbon reduction target beyond Part L 2013.
2. Each technology must include a full risk assessment to show impact and prove feasibility.
3. Primary energy will not be considered until target improvement details are published.

The second half of this document reviews recommendations for Government on how we can transition to these solutions successfully. It covers several areas, including consumer understanding, competency and overheating, making tangible suggestions on how challenges or barriers can be overcome.

Phase-two of this report requires SAP 11 BETA software. It will model the technologies listed within this document to show full technical specification details for their use, including the requirement of supporting technologies to meet compliance targets, such as batteries, solar PV and waste water heat recovery.

It will also have an increased focus on demand side flexibility and smart controls within compliance. These are key areas for ensuring energy efficiency and affordability within dwellings, as well as providing load balancing services to the electricity grid as we electrify our homes.

Heating, hot water and cooling

The Part L 2025 update will see the carbon reduction target for new dwellings significantly increase by an expected 75-80%, compared to Part L 2013. This will require a step-change in the way we design thermally comfortable homes, with a holistic consideration of insulation and building services required to meet the carbon reduction target.

As well as providing comfort, CAPEX and OPEX affordability factors will also be vital for the buyer, and the seller. It is key that operational cost and carbon are considered together when looking at an energy strategy for a new development.

Products will need to be assessed against their application efficiency and performance as part of a whole building system rather than stand-alone solutions. This is also the case when balancing heating and energy efficiency with overheating mitigation measures. An additional feature of most electrified heat products is their link to grid and demand response flexibility through smart controls.

This chapter of the report aims to review a number of heating, hot water and cooling solutions which could be used in the future to meet these varying requirements of a home built for the future.

Air-to-water heat pumps

Providing efficient heating, hot water and, potentially, cooling from the air.

Suitable for most housing types, except for smaller apartments with extremely low heat load.

Available with bespoke manufacturer or open controls to allow choice for the developer or occupant.

Connects hydronic emitters such as radiators or underfloor heating. The system can be complemented by PV or waste water heat recovery.

Using electricity to extract usable energy from the air for use in building services.

Air-to-water heat pumps are the most common heat pump in the UK, extracting heat from the ambient air to use for heating, hot water and, where required, comfort cooling. Otherwise known as air source heat pumps, these unit can be used for most dwelling types.

Air source heat pumps come in a range of different sizes – from 3.5kW units designed for individual housing, to much larger units designed to supply heating and hot water to large apartment buildings. This system will usually be provided in monobloc form with all the necessary components in one unit located outside the dwelling. There are options to have air-to-water heat pumps as split units, where the internal components are split between an outdoor unit and a compact indoor unit, linked together by pipework containing refrigerant.

Once installed, these systems link to hydronic emitters within the dwelling, operating with a flow temperature of up to 55°C (as per Part L requirements), but performing best when run at lower temperatures such as 35°C. They can be connected to conventional wet radiators, hydronic underfloor heating, or fan assisted convection heaters. If applied as central plant within an apartment block, heat loss from the distribution system needs to be considered, and there will need to be an interface between the air source heat pump and the apartment, such as a HIU or water-to-water heat pump.

There are several benefits to applying air-to-water heat pumps to a new build dwelling, these include:

- Significant compliance benefits due to the low carbon and high efficiency nature of the system.
- Lower energy bills for occupants, compared to alternative systems, as the heat pump can draw more usable energy from the air than is used to run the unit.
- Efficient low carbon comfort cooling potential when paired with a capable emitter.
- A range of flexible specification options, including internally installed units where roof space is limited on apartment buildings.
- Serves to add value to the dwelling by future proofing the home.

With the recent combined effects of the current global energy crisis and recognition of the urgent need to decarbonise domestic heating, there has been an acceleration of domestic heat pump sales to record levels in Europe, breaching a total of 3 million units in 2021.

The penetration of heat pumps in the UK has been somewhat slower than in most of Europe, but it is accelerating, helped by the performance improvements achieved through ongoing technological advances making heat pumps quieter and more efficient in operation.

Design	Support needed for some designers who have not applied heat pumps before
Installation	Greater awareness needed of certain installation requirements
Skills	Shortage of suitably trained heat pump designers and installers
Supply Chain	Mature and ready to meet increasing demand with new on-shored factories
Upfront cost (inc. install)	Typically £7k - £13k
Energy cost	Lower than other electrical alternatives, dependent on SCoP factors
Commissioning	Systems must be pressure tested and emitters hydraulically balanced
Maintenance	The heating system should be serviced every year
Retrofit requirement	Net zero ready home

A key component in this is the gas used in these products.

F gas regulations are gradually displacing gases with high global warming potential, with more benign 'natural' gases, such as propane. Heat pump product and component manufacturers are consistently finding ways to improve performance overall using these new refrigerants.

The most recent update from the BEIS and Energy Systems Catapult Electrification of Heat Demonstration project[1] within the UK studying 742 domestic heat pump installations showed that measured real world performance of air source heat pumps has significantly increased over recent years, achieving a median seasonal performance factor of 2.80 (280%) and that they performed well even in extreme weather conditions, achieving a median efficiency figure of 2.44 (244%) on the coldest days of the year.

One of the largest potential risks to the successful deployment of air source heat pumps is a lack of competency in design, installation and commissioning, which has been borne out by various studies in recent years. This includes correctly sizing the unit which is critical to efficiency and low occupier bills. However, the critical factor for success starts with design.

The industry recognised the need for greater focus on training as part of a series of initiatives to support the anticipated growth in adoption of heat pumps, and developed industry- supported training programmes to appeal to the next wave of heat pump installers, whether they are newly qualified plumbers or existing fossil-fuel boiler installers seeking to re-train.

[1] Electrification of Heat UK demonstration project - Energy Systems Catapult

Risk Assessment

Air-to-water heat pumps are set to become the most commonly used heat pump in the UK. As this sector of the market grows, there are requirements to upskill the value chain to understand how to design and install them. Occupant education is also key to ensuring that the system is operated as efficiently as possible.

Risk Analysis	Performance Impact	Solution
Potential for poor system design	High	Designer training, including manufacturer led courses and design support, to reinforce importance of accurate heat loss calculations and correct unit size
Impacted performance and increased noise due to poor installation	High	Installer training, including manufacturer led courses and competency schemes, in understanding key areas of heat pump installation
Potential for inefficient operation due to a lack of occupant understanding of how to control an air source heat pump system	High	Occupant handover must include appropriate training for householder, including adequate completion of the Home User Guide
Occupants not used to living with a stored water solution	Medium	Occupant handover should include details on the most effective way to use stored hot water. This could be created as part of an industry wide set of standard information

Hydronic underfloor heating

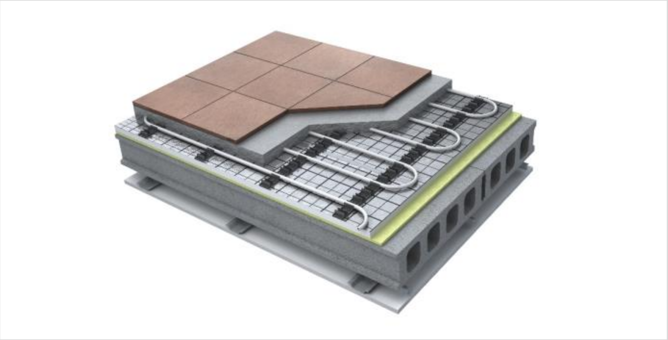
Although radiators have traditionally been the most widely used heat emitter, they largely emit heat by convection. Underfloor heating, on the other hand, emits a higher percentage of heat by radiation. This, combined with the large surface area of the floor, means that dwellings using underfloor heating can heat effectively using lower flow temperatures than those using other heat emitters whilst ensuring occupants have the same perception of warmth.

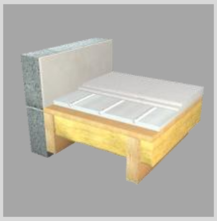
This makes underfloor heating an ideal system to pair with heat pumps, a system which operates most efficiently at flow temperatures of 35°C. This has the potential to reduce energy costs in high heat-loss rooms providing even heat and comfort across the space.

Benefits of underfloor heating include:

- 20% more efficient than traditional radiator-based system when paired with a heat pump.
- Freedom of furniture layout without installing products on walls.
- Long pipe warranty on a low maintenance system.
- Lower energy bills with positive impacts on house value.
- No hot surfaces or hard edges making it a safer solution for children and vulnerable occupants.

For developments looking to only include underfloor heating on the ground floor, and with the heat pump operating with a low flow temperature to maximise the benefits of the underfloor heating, the property will require





Design	Design support available from manufacturers to support installers
Installation	Installation experience is key as critical design areas need to be adhered to
Skills	Skills readily available, understanding required to not deviate from design
Supply Chain	Established and robust plus able to cope with increased demand
Upfront cost (inc. install)	Cost competitive, typically £100 - £200 per m^2
Energy cost	Lower flow temperatures mean improved efficiency of any heat source
Commissioning	Within skill set of most heating engineers (some knowledge required). Must adhere to BS7593
Maintenance	Minimal maintenance required
Retrofit requirement	Zero carbon ready

larger than average radiators on the first floor. This will optimise the system and maximise comfort levels while minimising energy costs. When correctly designed and installed, using top quality components from trusted suppliers, underfloor heating can become a reliable and efficient system which will offer occupants a warm space and lower running costs compared to alternative hydronic systems. It offers a gentle heat which is evenly distributed around a room for increased thermal comfort, often allowing an occupant to turn down the thermostat by a couple of degrees without feeling cold.

It is most important that underfloor heating systems are designed around the floorplan to ensure heat output matches or exceeds the dwelling heat loss without ‘rule of thumb’ calculations. For this reason, a competent design is vital, and manufacturers offer design support to aid industry and ensure the best results for occupants and that the balance of the system is correct. It is important that experienced installers are used with appropriate expertise to make sure all these elements are correct, installing the solution without deviating from the appropriate design.

Consumer education is also key to making the most of an underfloor heating system. It is important to convey to occupants that an underfloor heating system works in a different way to a traditional radiator heating system, which are generally switched on and off more frequently and can be hot to the touch. The underfloor system uses water at a lower temperature and the surface covers the entire floor area. There will be no hot or cold spots in the room, which will be heated evenly. As the heat is generally held longer in the room structure and the overall effect is much gentler, it generally goes unnoticed. The temperature control will be a thermostat in each room which will accurately control and maintain the desired temperature whilst being easy to adjust.

For all but the smallest new build dwellings, this heat pump and emitter combination should be the default option as it represents the most efficient and lowest carbon means of heating available. This is further supported when considering the additional embodied carbon saving potential, offered through the longevity of hydronic underfloor heating alongside the use of non-toxic, reusable plastic pipes.

Risk Assessment

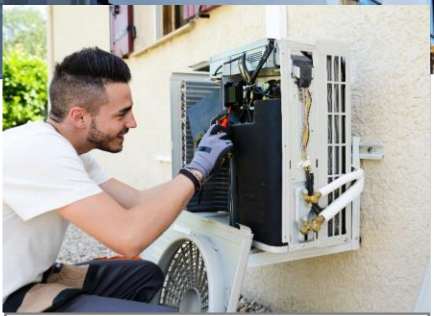
Ensuring quality of design and install is key to providing consistent thermal comfort with underfloor heating. It is capable of providing effective and efficient heating to a space as a low temperature emitter for hydronic systems, helping to reduce the energy bills of occupants.

Risk Analysis	Performance Impact	Solution
Occupants used to radiant surface temperature rather than low temperature emitters	-	Occupant handover must include details on the differences occupants may notice in living with a low temperature emitter
Underfloor heating design not fully considered during dwelling design phase, including pipe spacing	Medium	Increase in designer understanding through education and support from manufacturers
Floor covering is not considered in terms of impact on responsiveness	High	Increase in support for designers to understand requirements of underfloor system to work effectively, including considering underfloor heating system design during the early design stages
Not considering the dew point when specified to emit heating and cooling	High	Education for designers in how to avoid condensation within design, including the use of a dew point sensor to avoid the floor temperature falling too low

Air-to-air heat pumps

Providing space heating and cooling from the air, to the air.

Suitable for small apartments and houses at very high risk of overheating or requiring periodic heat delivery in low heat demand situations.



Available with bespoke manufacturer or open controls to allow choice for the developer or occupant.

Needs to be specified alongside a separate hot water system, such as a hot water only heat pump.

An efficient space heating and cooling solution for individual rooms.

Air-to-air heat pumps can provide space heating and cooling to individual rooms within a dwelling. The technology is more commonly referred to as an air conditioning unit as the most common application is for cooling.

An air-to-air heat pump is similar to an air-to-water heat pump in that it has an outdoor unit which uses electricity to extract more usable heat than it consumes from the external air passing through it. However, instead of distributing the heat throughout the house with hydronic radiators or underfloor heating it, uses one or more wall-mounted units or built-in ducts, which use a fan to blow the heated air around individual rooms. They must be installed by an F-Gas certified installer.

The most significant difference between these products and other forms of heat pumps is that they can all be reversed so that they can cool in the summer months, at the flick of a switch. This is the most common type of heat pump in Europe because of this feature, as it is most frequently selected for its additional cooling function in warmer climates.

Across the world these products are promoted as air-conditioning systems for domestic and light commercial purposes and therefore the economies of scale mean that it is also very competitively priced.

Although sold as air conditioning units, they are actually heat pumps, with several benefits to designs and occupants, including:

- The utilisation of renewable, heat pump technology to provide space heating and cooling, for year- round comfort control in homes highly susceptible to overheating.
- Being less expensive to buy and install than air-to-water and other heat pumps.
- High operational efficiency, with COPs of up to 3.5 with an external temperature of 10°C.
- Ability to install the indoor units high within a room, to offer additional space and flexibility in room design.

As air-to-air heat pumps are room- by -room space heating and cooling units, the system does need to be specified alongside a separate domestic hot water system. This could be a domestic hot water heat pump, an electric water cylinder, or electric instantaneous. As a space heating solution, blowing warm air across a room at high level, can be noisy and is not perceived to be a practical way for distributing heat in the same way that a wet central heating system would be, since hot air rises.

This means that as the primary heating source, air-to-air heat pumps are not suitable for larger houses with a high heating requirement, and should be reserved for smaller, well insulated properties with a small number of rooms.

Nevertheless, the reversable function of these systems make them particularly attractive for

Design	The product selection and system design has to be matched to the heat rather than cooling load
Installation	In apartments careful consideration is required in siting the external and internal units
Skills	Industry wide lack of F-Gas certified installers
Supply Chain	Manufacturing is scalable for growth but will require F-Gas qualified contractors
Upfront cost (inc. install)	Typically £1.5k - £5k per system
Energy cost	Lower than other electrical alternatives, dependent on external temperature
Commissioning	Straightforward involving little more than a system check
Maintenance	An inspection and filter clean is recommended every year
Retrofit requirement	Zero carbon ready

small apartments in urban areas, where overheating is very likely to occur in the summer months and passive measures may not be enough on their own to mitigate the health risk to occupants. This is especially the case where ambient noise and security concerns limit the use of natural ventilation.

Risk Assessment

Air-to-air heat pumps have primarily been used as air conditioning units in the UK. However, there is a role for them to play within zero carbon ready homes, especially in being able to mitigate overheating in high risk geographical locations where all passive means of removing excess heat have been exhausted.

Risk Analysis	Performance Impact	Solution
Product selected is sized for cooling load rather than heating	High	Designer must ensure that the heating requirement is met, whilst cooling is a secondary consideration, when sizing the air-to-air heat pump unit
Condensate is not sufficiently well drained	High	Connecting the condensate to a waste water system or installing a pump should be considered at design stage. Support can be provided by manufacturers
Potential for occupier behaviour to increase operating costs	High	The occupant needs an adequate hand over process for education as to the cost implications of using the unit in cooling mode without using other remedial steps to cool the property beforehand

Ground-to-water heat pumps

Efficient heating, hot water and cooling from the ground.

Suitable for houses and buildings which have the geographical ability to install boreholes or trenches.

Available with bespoke manufacturer or open controls to allow choice for the developer or occupant.

Connects hydronic emitters such as underfloor heating. The system can be complemented by PV or waste-water heat recovery.

Extracting consistent usable energy from the ground for use in building services.

In ground-to-water heat pump systems (otherwise known as ground source heat pumps) the heat from the ground is absorbed by heat pump refrigerant to act as the natural energy source for dwellings heating, hot water and, where required, comfort cooling demand.

Ground source heat pumps are well-suited for a variety of housing applications but are particularly beneficial for larger homes or multi-unit buildings, as they can provide consistent heating across a larger space.

The process of extracting the heat is identical to other heat pump systems, including air-to-water heat pumps. The pipework in the ground is referred to as a ‘closed-loop’ system buried in horizontal trenches or in vertical boreholes. While all heat pumps work by transferring heat from one source to another, there are several advantages of a ground source heat pump over alternative heat pumps and other low carbon systems:

- Ground source heat pumps are generally the most efficient heat pump technology as they draw heat from a source which has year-round stability and warmth (the ground). They are also up to four times as efficient as a natural gas boiler or other fossil fuel system.
- They can extract heat from the ground even when outdoor temperatures are very low due to the depth of the buried pipework.
- Ground source heat pumps tend to be a quiet solution as they do not require an external fan unit.
- They tend to be more environmentally friendly than alternative systems due to their increased efficiency drawing energy from a more stable source, which in turn reduces the amount of energy required to heat and cool the dwelling.

While ground-to-water heat pumps have these advantages, they are also considerably more expensive to buy and install than air source alternatives.

They also tend to have a more limited housing application potential. Homes with limited outdoor space may have difficulty accommodating the necessary underground piping system for the heat exchange, or indeed enabling access to install it.

There are also geographical survey restriction to the use of boreholes, meaning homes which do not have the horizontal space or access for a ground source heat pump, may also be restricted for using a vertical solution.

Design	Support needed for designers who have not applied heat pumps before
Installation	Trenches and boreholes can be geographically restrictive
Skills	Lack of heat pump installers and surveyors for geographical surveys
Supply Chain	Mature supply chain ready to meet increasing demand
Upfront cost (inc. install)	Typically £24k - £40k
Energy cost	Lower than alternatives with a COP of up to 4.5
Commissioning	Check operational efficiency, including pressure in the heating system and brine loop
Maintenance	Required annually, including for warranties and checking refrigerant
Retrofit requirement	Zero carbon ready

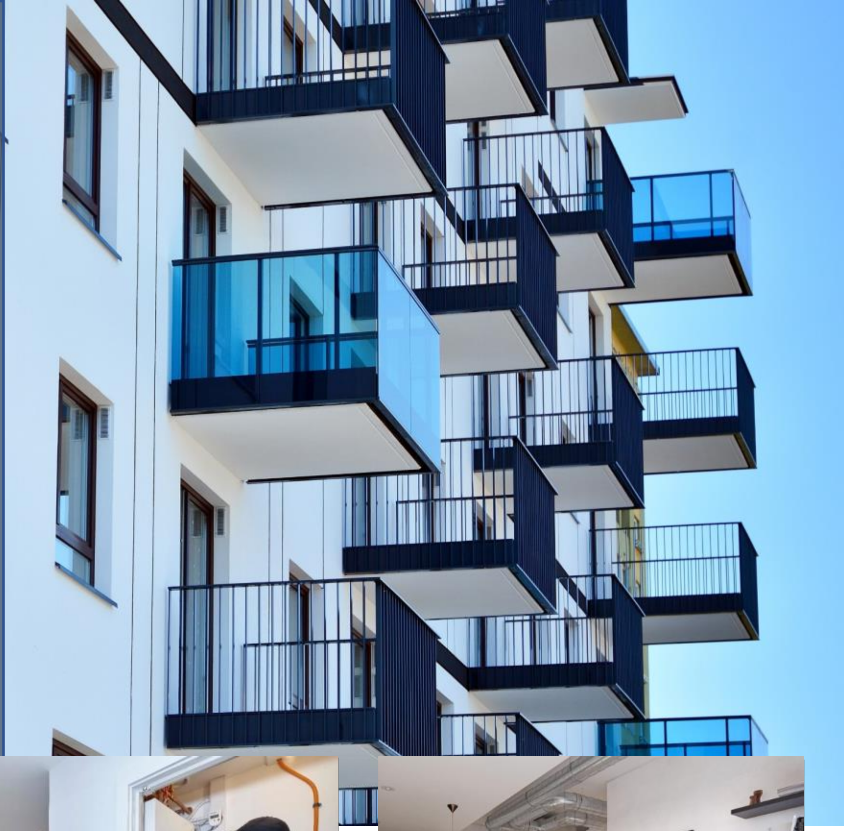
Risk Assessment

Ground-to-water heat pumps are the most efficient units within the heat pump range; however they are still susceptible to the challenges of applying heat pump technology in a sector used to dealing with natural gas.

Risk Analysis	Performance Impact	Solution
Occupant not used to living with heat pump technology	Low	During the hand over process the occupant should be made fully aware of the operational differences between an heat pump and traditional high temperature systems. This should also be clear in the Home User Guide
Occupants not used to living with a stored water solution	Medium	Occupant handover should include details on the most effective way to use stored hot water. This could be created as part of an industry wide set of standard information
Collector array is undersized	High	Pipework design and installation of the groundwork array must be matched to the size of the heat pump otherwise the system will struggle to attain the performance level required
Impacted performance due to poor design or installation	High	Designer and installer training, including manufacturer support, to reinforce importance of accurate design and installation

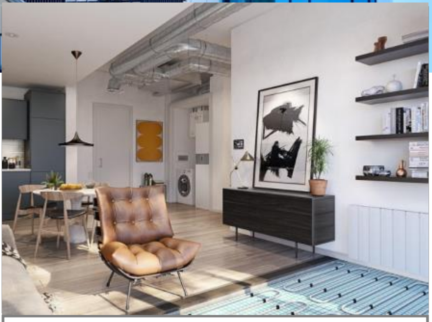
In-apartment water-to-water heat pumps

Efficient heating, hot water and comfort cooling.



Suitable for low and high rise apartment developments and housing estates using a central plant or a district heat network.

Available with manufacturer or open control to allow choice for the developer or homeowner.



Can be paired with hydronic emitters, such as underfloor heating. Must connect to a central plant or district heat network.

Innovative, connected in-apartment heat pumps for multi-residential buildings.

In-apartment water-to-water heat pumps are an innovative solution developed to meet the modern day requirements of multi-residential buildings. They offer a connected way to supply heating, hot water and, where required, comfort cooling to new dwellings.

This solution must be paired with an energy source to provide low grade heat, whether this is central plant, such as a commercial heat pump, or by connection to a district heat network. Each in-apartment unit connects to this source via a water based ambient energy loop which operates at a temperature range often between 10 to 30°C.

Integrated within each in-apartment unit there is a compact modular water-to-water heat pump and domestic water cylinder designed for ‘plug and play’ installation. These units are developed to have a low noise output and designed with careful consideration for maintenance requirements. Where specified, the water-to-water heat pump can be reversible to provide comfort cooling to dwellings in areas at high risk of overheating.

beama

This water-to-water heat pump unit provides domestic hot water to the dwelling, as well as heat (or cooling where required) via hydronic emitters. These could be specified as a range of options, including wet radiators and underfloor heating for heating only applications, and more dynamic emitters, such as fan coils, for heating and cooling designs.

These systems offer manufacturer or open controls, for choice and flexibility. This could include basic controls via a wall thermostat or smart app based controls.

There are several benefits to using an ambient loop system connected to in-apartment water-to-water heat pumps. This includes:

- Highly efficient heating and hot water production due to low distribution losses, with COPs up to 3.0 when paired with air-source heat pump central plant.
- Heating, hot water and cooling through a water based, renewables system, with low quantity refrigerant use within the in-apartment heat pump.
- Potential to capture and re-use waste heat where a heating and cooling system is deployed, with waste heat from cooling operations offering ‘free’ energy to heat the apartment’s integrated domestic hot water cylinder or to be used elsewhere in the building when demand is met.
- Flexibility around the specification of the plant, emitters and controls.
- Compatibility with district heat networks.
- Considered design to meet spatial requirements within a dwelling, simplify installation and make service and maintenance less disruptive for the end user.
- Holistic cost and comfort benefits, including smaller pipework size, reduced central plant size and reduced internal gains from communal system heat loss.

Design	Support required due to differences to traditional, higher temp alternatives
Installation	Size/weight challenges which can be overcome with pre-fabricated install
Skills	Reduced skills complication due to ‘connect and go’ development
Supply Chain	New innovation developed with sizable capacity
Upfront cost (inc. install)	Typically equivalent to alternative heat pump solutions. Very cost effective cooling
Energy cost	Efficiencies of 300% lead to lower running costs
Commissioning	Manufacturer support available
Maintenance	Yearly heat pump maintenance required, simplified with considered design
Retrofit requirement	Net zero ready

Individual water-to-water heat pump units connecting to a communal ambient loop are a relatively new solution for new multi-residential developments. However, this does not mean that they are untested, being built upon similar technology used with non-domestic developments and having already been installed in a number of new residential developments within London and beyond.

These systems work well when paired with district heat networks, whether this is connecting to an existing system or for use with new Fifth Generation heat networks. Fifth Generation heat networks combine low temperature water and heat recovery across the network area, operating around an ambient energy loop between 10°C and 30°C. Each building or apartment on the loop has a heat pump which produces domestic hot water, space heating and, where required, comfort cooling from this low grade heat, which can be a heat source or a heat sink.

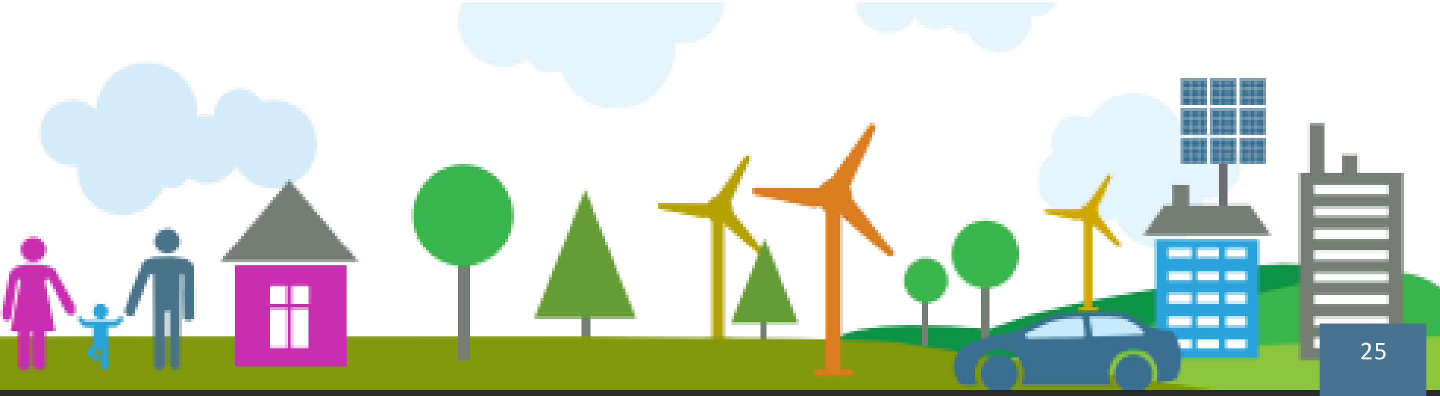
Additional benefits of water-to-water heat pumps connecting to communal or district energy loops includes increased system efficiency and reduced overheating risk. Traditional communal systems within apartment developments can have high distribution heat losses through the internal system pipework. When combined with a fabric first approach, these distribution losses require the central plant or district heating network to produce more heat than each dwelling requires, and the heat loss becomes trapped within the building envelope, contributing to overheating corridors and communal spaces. In comparison, an ambient loop has little to no system losses, increasing system efficiency whilst removing a source of internal heat gain from the building. To make the lower temperature energy within the loop usable, in-apartment heat pumps increase this temperature within each dwelling, with the potential to facilitate waste heat recovery where cooling is in use, be it as part of the system or from a nearby cooling plant.

As with any innovation, it is important that stakeholders from across the building supply chain understand the new system. This is key to ensuring these solutions are designed, installed and used correctly. Manufacturers of these solutions offer support for designers, installers and occupants as part of their introduction to the residential market.

Risk Assessment

Individual water-to-water heat pumps connected to an ambient communal loop or district heat network are still a relatively new system for multi-residential apartment buildings. As a recent innovation, there is an amount of professional and end user education which needs to take place to ensure this solution is designed, installed and used in the most effective and efficient way possible.

Risk Analysis	Performance Impact	Solution
As a new innovation, design and installation requirements are still relatively unknown to designers and installers who are used to more traditional systems	High	Actors across the construction plan of works to be educated by manufacturers and supporting bodies to understand requirements from these systems as new innovations to the market
Occupants not used to living with low temperature heat pump technology	Low	During the hand over process the occupant should be made fully aware of the operational differences between a heat pump and traditional high temperature systems. This should also be clear in the Home User Guide
Occupants not used to living with a stored water solution	Medium	Occupant handover should include details on the most effective way to use stored hot water. This could be created as part of an industry wide set of standard information
Heat network operators view the solution as an individual heating system rather than compatible with district heat networks	-	Manufacturers can support designers with conversations with network operators to understand how the technology can connect to a district heat network



Hot water only heat pumps

Providing hot water to dwellings using renewable technology.

Suitable for small to medium houses and apartments with low heat demand.

On-board manufacturer bespoke controls, with app connection to space heating system in specific circumstances.

Can be incorporated into a system with PV and WWHR. An air-to-air heat pump or electric space heaters can provide space heating.

Using a heat pump to provide domestic hot water within highly airtight dwellings.

Domestic hot water heat pumps consist of a highly efficient package of an air source heat pump and hot water cylinder combined into a single unit, designed to offer only domestic hot water using renewable technology. As dwellings are built using high fabric standards, domestic hot water becomes the highest energy load within new homes. Hot water only heat pumps become a low carbon way of providing for this energy demand, whilst allowing for flexibility in meeting the reduced space heating demand, such as through the use of direct electric heating or air-to-air heat pumps.

Hot water only heat pumps are internally installed units which require ducting from the integrated air source heat pump to the external air. The low energy heat pump extracts heat from air, transferring it directly to the water cylinder to be used as 60°C domestic hot water. Although relatively new to the UK market, they are widely used with Europe for both houses and apartments. They have found benefit since their introduction in the UK due to their use of renewable energy without the requirement for an external unit. The benefits of using a hot water only heat pump includes:

- Compliance benefits for utilising heat pump technology for the highest dwelling energy load, domestic hot water.
- A low electrical load of typically 700W, putting less pressure on the grid and removing the requirement for notifying DNOs of use.
- High efficiencies with COPs of around 3-3.4 with an operating range of -7 to +35°C.
- Well placed in dwellings with low heat demand in combination with an air-to-air heat pumps or direct electric space heating.
- Potential to integrate solar PV and waste water heat recovery into the system.
- Flexible internal placement due to compact footprint with low noise output during operation.
- Potential to combine hot water heat pump and space heating control into an app in specific circumstances.

Hot water only heat pumps are suitable for both apartment dwellings and small to medium houses. They are also highly suitable for passive house developments, which can be designed with no space heating requirement, making hot water only heat pumps an attractive solution compared to the cost and size of heating and hot water heat pumps.

As with any solution, there are considerations to installing a hot water only heat pump within a new home. These include clearances around the unit, which can be installed in a service cupboards or utility rooms, and awareness of ducting requirements, such as maximum pressure drops. Manufacturers are available to help with these design requirements to ensure the system is effective in operation.

There is a risk that this design can be deviated from during installation, which will ultimately

Design	Support often required to ensure ducting design meet minimum criteria
Installation	Relatively straightforward but ducting at risk of design deviation
Skills	Lack of qualified plumbers for hot water solutions as well as experienced installers for ductwork
Supply Chain	Able to increase to meet rising demand
Upfront cost (inc. install)	Typically £3k
Energy cost	Dependent on external air temperature, COPs up to 3-3.4
Commissioning	Required to check operational efficiency
Maintenance	Required annually, including for warranties and checking refrigerant
Retrofit requirement	Zero carbon ready

impact the systems performance. The ducting can also be at risk of being over value engineered to the point of negatively impacting the air source heat pump operation.

Hot water only heat pumps are available within SAP Appendix Q, offering significant renewable contributions to designers. However, SAP is not known for being a flexible system and, with hot water only heat pump relatively new to the UK, there is an official work around to help designers apply these solutions to their developments.

Hot water only heat pumps can be specified to work effectively with a range of complementary solutions. This includes the ability to integrate solar PV into the system and work alongside waste-water heat recovery offering additional efficiency benefits.

Used to great effect in Continental Europe and across several countries throughout the world, domestic hot water heat pumps are frequently paired with electric resistance space heaters and, increasingly, air-to-air heat pumps, in small highly-insulated properties, where the space heating requirement is low. This technology represents one of the most cost-effective and lowest carbon means of heating domestic hot water electrically.

There are educational requirements for occupants living with a hot water only heat pump, especially for those used to instantaneous hot water use. This includes understanding what the technology is and how the air source heat pump element works, as well as how to adjust to living with stored water if they have not done so previously. This should be balanced with information on why moving to stored water is good for running costs and the planet.

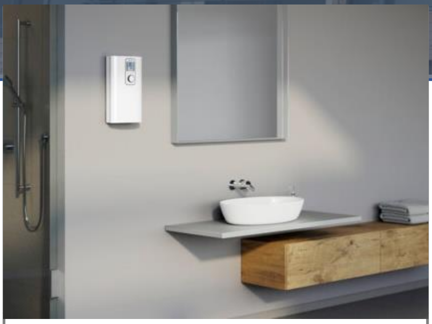
Risk Assessment

Hot water only heat pumps came over to the UK from Europe, where they are a relatively common solution for providing low carbon hot water. When applied to the new build market in England, education is required to understand the solution, including how an air source heat pump works and the requirement behind ducting design and installation.

Risk Analysis	Performance Impact	Solution
Ducting installation deviates from design, including not meeting pressure drop requirements	High	Competency training and on-site checks to ensure the ducting design is followed, including understanding ducting requirements
Excess noise during system operation	-	Manufacturer design and installation advice must be sought and followed to reduce any potential noise impacts on occupants, including the siting of the unit
Inconsistent or inadequate temperatures or flow rates	Medium	The unit must be sized correctly to meet households needs, which manufacturers can support
Occupants not used to living with a stored water solution	Medium	Occupant handover should include details on the most effective way to use stored hot water. This could be created as part of an industry wide set of standard information

Electric hot water

Providing domestic hot water demand with an electric solution.



Suitable for smaller apartments with a reduced hot water load compared to other dwellings.

Available with bespoke manufacturer or open control to allow choice for the developer or occupant.

Potential to integrate PV and WWHR. Requires separate space heating system, such as air-to-air heat pumps or electric space heaters.

Instantaneous and stored hot water solutions, heated using low carbon electricity.

There are a variety of direct electric solutions available to provide low carbon domestic hot water to new build developments. However, carbon is not the only consideration; safety, compliance and affordability criteria must also be met.

For safety, all potential solutions must meet the basic legislative requirements to ensure that the design, installation and maintenance of the system will not pose a risk to householders from bacterial infection or the accommodation of the expansion of the hot water.

With the decarbonisation of heat, electric hot water is an increasingly specified solution. SAP 10.2 is more favourable to instantaneous electric hot water use in small, well insulated apartments. However, it does not accurately model stored hot water use in the same properties, or indeed reflect its load shifting flexibility benefits. To ensure affordability, direct electric hot water solutions perform best in dwellings with a smaller hot water demand. This makes them highly suitable for smaller, well insulated apartments. A separate consideration will also need to be given to meet any on-site renewable targets.

Instantaneous hot water

Instantaneous electric hot water provides for a dwelling's hot water demand at the single point of use without the requirement for stored water capability.

Once a rarity, the use of electric instantaneous domestic water heating in an all-electric home is becoming more common, especially for smaller apartments where using single point instantaneous is a logical, low carbon, cost effective solution.

Specifying instantaneous hot water eliminates the energy loss of standing water in pipes from a water cylinder, whilst being a more practical solution if space is at a premium.

In conjunction with one or more single point instantaneous units serving sinks or basins, an electric shower would ensure all the hot water needs of the property are met.

Design	Support often required to ensure units are not over or under sized
Installation	Simplified compared to a stored hot water alternative
Skills	Market wide shortage of plumbers who are Part P qualified
Supply Chain	Mature market, ready to meet increased demand
Upfront cost (inc. install)	Typically < £1k for one under sink unit and one shower
Energy cost	Low as energy for heating water is paid for as and when it is used
Commissioning	Standard checks for functionality and leaks
Maintenance	Manufacturers recommendations apply but regular inspection is recommended
Retrofit requirement	Zero carbon ready

Risk Assessment

Instantaneous hot water specified to provide hot water a single points of use must ensure that they used in dwellings with a lower hot water demand. This is due to the cost of electricity currently being four times the price of gas and to reduce pressure on the electricity grid at peak times.

Risk Analysis	Performance Impact	Solution
Potential for poor flow temperature	High	Designer must ensure the heater is sized appropriately for the households needs, which manufactures can support
Potential for high running costs	High	Should only be specified within properties with a lower hot water demand

Hot water cylinders

Electric hot water cylinders are specified as either a vented or unvented system. A vented hot water cylinder stores hot water at low pressure and is heated by an electric immersion heater, controlled by a built-in thermostat and a thermal cut-out and open safety vent.

Most of these cylinders are heated at a lower cost during off-peak periods when electricity is cheaper and more abundant and some have a second immersion heater to supplement the heating during peak time if required. This makes electric hot water cylinders a perfect solution for time of use tariffs.

The product is simple in operation and needs fewer safety controls than an unvented unit. However, they do suffer from the effects of poor flow rates which makes it advisable to install an instantaneous electric shower as part of the dwelling's hot water strategy.

An unvented hot water cylinder will take water directly in from the water mains at mains pressure, which is heated by one or two immersion heaters. As the unvented cylinder contains pressurised hot water it must have additional safety devices compared to a vented solution.

The advantages of the unvented cylinder are that it provides high pressure showers and fills sinks and baths quickly, with hot and cold water supplies having a balanced delivery. However, the disadvantage is that the recovery rate is longer when compared to alternatives.

As electric hot water cylinders store a ready supply of hot water, they can be integrated with solar PV or waste water heat recovery, both of which increase the systems efficiency.

Design	The specified cylinder should be appropriate for current and future occupancy levels
Installation	Siting of the product is critical for performance optimisation and ease of access
Skills	Industry wide shortage of plumbers and electricians
Supply Chain	Mature supply chain which can meet increasing demand
Upfront cost (inc. install)	Typically £500 - £700
Energy cost	Cost competitive when utilising the cost benefits of an off-peak tariff
Commissioning	Must be completed by a Part P qualified plumber
Maintenance	Recommended regular checks by a competent service engineer
Retrofit requirement	Zero carbon ready

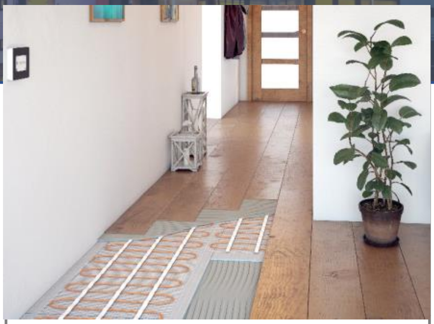
Risk Assessment

Electric hot water cylinders can offer low carbon hot water with the additional benefit of the ability to take advantage of flexible charging, such as with time of use tariffs. However, they have a reduced performance in SAP compared to reality.

Risk Analysis	Performance Impact	Solution
Cylinder isn't large enough to meet hot water demand of the property	-	Designer must size the hot water cylinder correctly, which can supported by the manufacturer
Occupants not used to living with a stored water solution	Medium	Occupant handover should include details on the most effective way to use stored hot water. This could be created as part of an industry wide set of standard information
Low water pressure when specifying vented cylinders	High	Design system with a pump or use an unvented water cylinder as an alternative

Electric space heating

Meeting space heating needs with electric heating solutions.



Suitable for houses and apartments with a low heating demand and desire to reduce embodied carbon.

Sophisticated, un-matched room-by-room controls to increase application efficiency.

Can be paired with a hot water heat pump or electric water cylinder for domestic hot water, and PV for additional efficiency.

Flexible, low-cost electric space heating for use in low heat demand dwellings.

There are many kinds of electric space heating options available for use in new build homes. These systems need to be specified alongside a separate hot water system, such as a hot water heat pump or an electric water cylinder.

Electric resistance heating is a type of heating system that generates heat by passing an electric current through a conductor, typically a heating element made of a resistive material like nichrome wire or tungsten. As the electric current flows through the conductor, it encounters resistance, which causes the conductor to heat up and emit heat.

Electric resistance heating is available in a variety of technology options including electric panel convectors, infra-red heaters, underfloor heating, and storage heating. One of the advantages of electric resistance heating is that it is a relatively low capital cost solution and is simple and easy to install and maintain. Electric heating is 100% efficient at the point of use, offers a cost effective solution in dwellings with a low heat demand. This cost effectiveness will only improve as the cost of gas vs electricity is rebalanced by Government and time-of-use tariffs offer additional flexibility benefits to both the grid and the occupant. This is why electric space heating is best used in dwellings with a low heat profile, with a strategy taking a fabric first approach where the highest energy demand comes from domestic hot water.

In these dwellings, the application of hydronic pipework throughout the home for use as a wet heating system can add un-necessary embodied carbon into the life-cycle assessment of the building. Where the heat profile allows for reduced space heating use, electric resistive solutions, which can be installed via electrical connections flexibly within individual rooms, offers an embodied carbon benefit over hydronic alternatives.

Electric resistive heating was first introduced in the early 1900s and since that time the products have evolved to have the most sophisticated controls systems available on any heating appliance, with a room-by-room level of control that is unmatched by any other system currently available.

In previous iterations of SAP this type of heating was not favoured, but with SAP 10.2 it is recognised that the electricity grid is gradually decarbonising and therefore electric resistance heating is now an acceptable alternative to heat pumps in certain applications. The Government's commitment to rebalance the cost of electricity versus gas will make this type of heating more attractive over the next few years in advance of the implementation of the Future Homes Standard, and the much-needed EPC reforms to promote decarbonisation rather than hinder it, will play a part.

Electric space heating can be further improved through the utilisation of dynamic controls and demand side response tariffs. Electric space heating solutions are available with a range of control options to help increase application efficiency. These can include open window sensing technology and the use of smart apps for timed control.

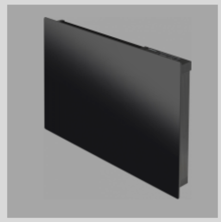
Panel convector heaters

Panel convectors are the most frequently specified type of electric resistance heating within new dwellings in the UK, and the most price competitive. Products are available at entry pricing level, up to luxury solutions developed with high-end design in mind.

Panel convectors are traditionally wall mounted, available in vertical or horizontal orientation and fast-reacting. They are generally noiseless, maintenance free, faultlessly reliable and have an economic life of in excess of 15-20 years.

Fitted with onboard controls or controlled centrally or with an app many of these heaters are now equipped with self- learning, algorithm-driven programmers, which ensure product performance can be tailored to suit the lifestyle of the user.

Electric fluid-filled radiators or other wall-mounted convectors with ceramic or clay cores are also classified by SAP in the same category as conventional open convectors, but they can retain heat for a short period after the product is switched off.



Design	Simple to apply to a design compared to alternatives, with heat sizing offered by manufacturers
Installation	Simplified installation with only one electrical connection required
Skills	Market-wide shortage of electricians
Supply Chain	Mature and scalable manufacturing supply chain with capacity to meet increased demand
Upfront cost (inc. install)	Typically < £1k for an entry level solution
Energy cost	Application and cost of energy dependent, being close to 100% efficient
Commissioning	Not required
Maintenance	Maintenance free
Retrofit requirement	Zero carbon ready

Risk Assessment

Electric panel convectors can often be considered expensive when used in less air-tight. However, it is the application of the solution as one part of a holistic design which depends on its running costs. With low upfront capital costs and minimal to no maintenance, they can be a versatile solution when paired with a fabric first approach and efficient domestic hot water system.

Risk Analysis	Performance Impact	Solution
Potential for higher operating costs	High	Electric resistance heating should only specified within small well insulated properties. Occupants education is also required so they understand how to programme and use heaters on a room-by-room basis
Heater output is not large enough to warm the space	High	Adequate heat sizing at design stage is required, which can be supported by manufacturers

Smart electric storage heaters

Electric storage heaters have come a long way since their introduction to the UK market in 1960's. They are now an increasingly smart and versatile solution, offering a cost-effective way of heating a new dwelling.

The biggest benefit of electric storage heaters is their ability to use low-cost off-peak electricity to store heat in a purpose-designed storage core which has exceptional heat retention properties. This, combined with state-of-the-art insulation, serves to minimise heat losses to ensure that the product is able to heat during the day and still have enough capacity remaining to be used in the evening.

These modern smart electric storage heaters give occupants greater control with a sophisticated electronic programmer enabling end users to pre-set time and temperature profiles to suit their lifestyle.

From a grid capacity point of view, these heaters also provide flexibility to the electricity grid by absorbing energy during periods of low demand and delivering heat when required by occupants, a benefit that is now being actively pursued in the Government policy framework. Storage heaters are now classified as 'energy smart appliances' (ESA) and will soon be mandated to have smart functionality to ensure that all units can respond to price signals from the grid.

For dwellings ready to take advantage of dynamic time of use tariffs, this means that electricity for space heating can be purchased when it is cheaper throughout the day to help reduce occupant energy bills and reduce the pressure on the electricity grid.

Design	Manufacturers offer heat sizing services to help designers ensure thermal comfort
Installation	Simplified installation. Unit is heavier than other direct electric heaters
Skills	Market-wide shortage of electricians
Supply Chain	Mature supply chain who are responding to the future of smart tariffs
Upfront cost (inc. install)	Typically £750-£1000 per heater
Energy cost	Dependent on tariff availability
Commissioning	Not required
Maintenance	No scheduled maintenance required
Retrofit requirement	An upgrade for DSR required for units sold without functionality

Risk Assessment

Storage heaters are not new technologies in the market, but, due to their higher cost compared to other direct electric space heating alternatives, they are not as prevalent in new build as they are in the retrofit and refurbishment markets. This may begin to change as the availability of time of use tariffs enter the market, offering clear benefits to the operational energy cost of a dwelling.

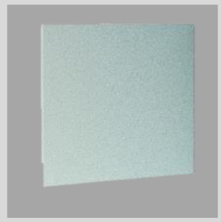
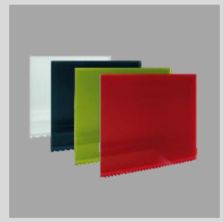
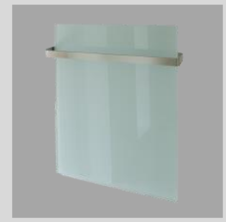
Risk Analysis	Performance Impact	Solution
Heater output is not large enough to warm the space	High	Adequate heat sizing at design stage is required, which can be supported by manufacturers
Over value engineered due to higher upfront cost, impacting overall system efficiency and effectiveness	High	Energy Smart Appliance, such as this, will be mandated to have smart functionality to take advantage of its energy storage and demand side response capabilities. This must be recognised in SAP to overcome upfront cost barriers
Potential for user behaviour to increase running costs beyond those expected	High	Occupant handover must include education on how to effectively operate solution and the importance of tariffs in providing cost benefits

Infra-red heaters

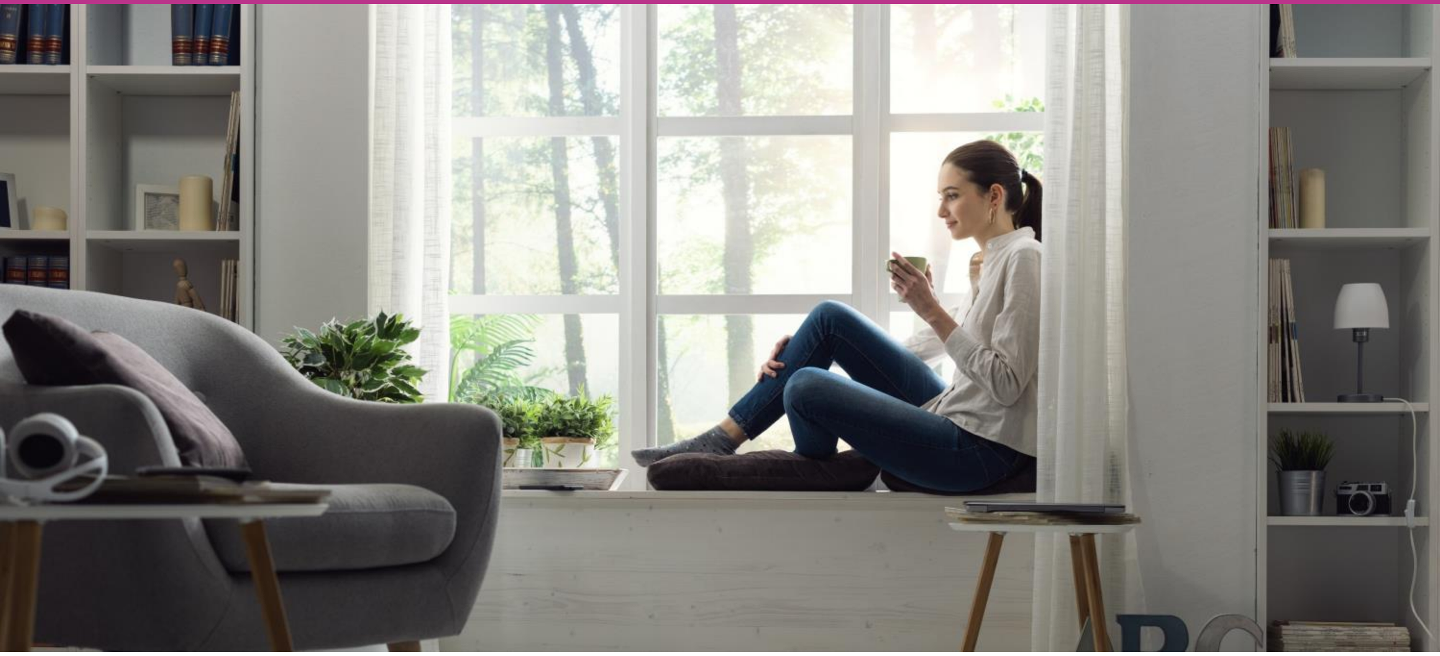
Wall-mounted infra-red heaters differ from more traditionally used panel heaters in that they are designed to emit a much higher proportion of radiant rather than convected heat. This is achieved by ensuring that the surface temperature of the appliance is much hotter than conventional heating systems.

Instead of heating the air in the room, infra-red panels heat things in the direct path of the appliance, be this walls, ceilings, floors or occupants.

In theory the effect of having a higher proportion of radiant than convected heat should enable the householder to reduce the ambient temperature in the room without affecting comfort levels, thereby reducing energy consumption so long as they remain directly in the path of the heater.

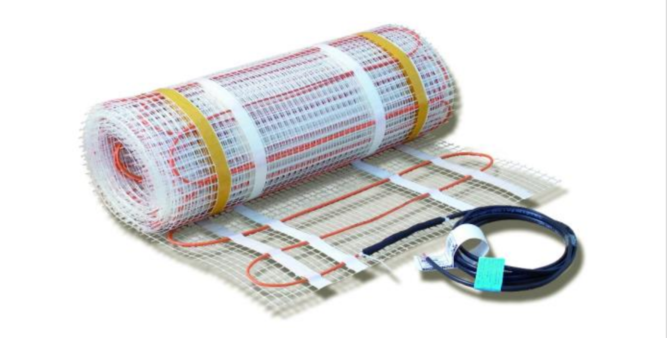
Design	Support required to ensure adequate feeling of warmth within the dwelling
Installation	Simplified installation with two electrical connections required
Skills	Market-wide shortage of electricians
Supply Chain	Mature supply chain ready to meet rising demand
Upfront cost (inc. install)	Typically < £2k
Energy cost	Additional benefit over convective systems not recognised in SAP
Commissioning	Not required
Maintenance	Maintenance free
Retrofit requirement	Zero carbon ready

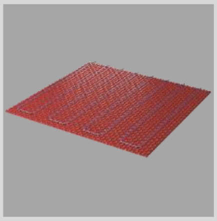


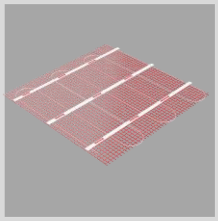
Risk Assessment

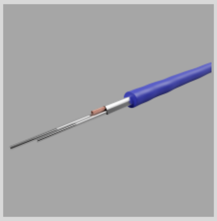
Infra-red heaters need to be sized and installed correctly to ensure an adequate feeling of warmth for occupants, due to the directional nature of the heat supplied. As with other electric heating space heating solutions, they are often viewed as expensive when used in dwellings with high heat loads. However, when designed and installed correctly, they can offer a low cost, effective solution to heating low heat profile homes.

Risk Analysis	Performance Impact	Solution
Potential for higher operating cost	High	Radiant heating should only be specified in small, well insulated properties. Occupant handovers must include education on how to programme and use heaters, including the directional nature of radiant heat
Designer avoids specifying the product due to lack of recognition of advantages of the technology	High	SAP does not currently recognise any advantages of infra-red heating over conventional convector heaters
Heater output is not large enough to warm the space	High	Adequate heat sizing at design stage is required, which can be supported by manufacturers









Electric underfloor heating

Electric underfloor heating allows for total design freedom in the home as it takes up no wall-space, instead offering evenly distributed heat under the whole floor area.

Underfloor heating uses radiant heat to warm the objects and people in the room from the floor up, and because of the uniformity of distribution of heat, it is feasible to reduce the internal air temperature in the room while maintaining comfort levels.

Offering a quick and easy install, electric underfloor heating has been used for many years to supplement the primary heating system within bathrooms, kitchens and conservatories in new-build homes.

SAP 10.2, however, recognises that electric underfloor heating also has a role to play as a primary heating system in well insulated dwellings.

These systems are extremely reliable, have no moving parts and require little to no maintenance and a life expectancy of 30-40 years for the main components. Within dwellings with low space heating demand, operating costs can be kept low whilst keeping the occupants thermally comfortable.

Design	Low profile cables or mats must be designed beneath the floor finish
Installation	Quick and straightforward for competent installers
Skills	Installers should be appropriately qualified and experiences
Supply Chain	Very well developed and able to meet rising demand
Upfront cost (inc. install)	Typically < £2k - £3k
Energy cost	Application and cost of energy dependent, being close to 100% efficient
Commissioning	Not required
Maintenance	Little to no maintenance
Retrofit requirement	Zero carbon ready

Risk Assessment

Electric underfloor heating has previously been known as a supplement to, rather than being the, primary heating system. When used in dwellings with a low demand profile and paired with an efficient domestic hot water system, this is now changing.

Risk Analysis	Performance Impact	Solution
Potential for higher operating costs	High	Solution should only be specified within well insulated dwellings
Lack of occupant understanding on using electric underfloor systems	High	Education at the point of handover, including use case operating profiles, warm-up times and general cost-effective operation

Ventilation

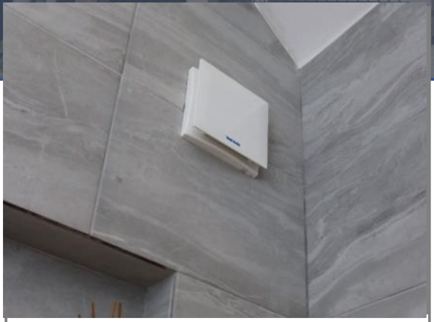
Creating healthy homes is not just about ensuring thermal comfort, but also guaranteeing positive levels of indoor air quality which will ensure health & well-being for occupants. A steady supply of clean fresh air prevents the build-up of mould and potentially dangerous pollutants and viruses which can lead to occupant respiratory problems over time. Progressive changes to Part L have pushed ventilation up the design and specification agenda, with the specification profile for ventilation moving away from intermittent extract fans to better controlled, high performing continuous extract fans and balanced whole dwelling heat recovery systems. Sales statistics for 2023 estimate that the split of homes being built to use natural and intermittent ventilation, continuous ventilation and supply and extract ventilation is now equal at a third each.

The focus on reducing energy demand through energy efficiency has been highly impactful in both reducing occupant bills and reducing pressures on energy supply. However, this fabric first approach has impacted the building's ability to breathe naturally – that is how easily air can flow through the building envelope without help.

As we build increasingly air-tight dwellings to further reduce energy demand, mechanical ventilation is becoming more and more important as the mechanical lungs for a healthy home. In this chapter, we will review these solutions and where they are best used to maximise their impact.

Intermittent extract ventilation

Providing additional ventilation in wet rooms and kitchens.



Suitable for less air-tight dwellings, mainly houses, with a design air permeability higher than $5m^3$ /(h·m^2) at 50Pa.

Available with a range of controls, including humidity sensors, PIR (presence detector) and timers.

Specified alongside background ventilation, such as trickle vents and permeability through the building fabric.

A mechanical boost within dwellings utilising a natural ventilation strategy.

Intermittent extract fans have been commonplace within the new build sector, especially within homes built to previous Part L standards. For dwellings using a natural ventilation strategy, intermittent extract fans within wet rooms and kitchens is a legal requirement.

Part of a natural ventilation strategy, which relies on air permeability and openings for passive air movement within a dwelling, intermittent extract fans have minimum airflow rates which they must comply to, but these are prescribed for most fans, incorporating a range of controls to increase their efficiency through operating time including humidity sensors, PIR (presence detector) and timers. This type of fan can also be available in quiet ranges, to reduce the noise to occupants when in use.

Intermittent extract fans are known to the current construction market. Whilst considered relatively easy to design and install, they still require careful attention to trickle ventilation specification. Some manufacturers offer installation kits which allow the full solution to be installed internally, reducing the risks associated with external installation, such as the danger of working form height.

There are challenges with using intermittent fans, the main is due to occupant behaviour. There is a risk associated with this ventilation strategy that intermittent fans will be turned off if automatically controlled or won't be turned on if manually operated. This is because they are inherently noisier than modern continuous fans due to operating mode. Occupant education is required to address this risk and ensure users understand the natural ventilation options (opening windows or trickle vents) to purge the dwelling of indoor pollutants.

In accordance with Part F 2021, a natural ventilation strategy should only be used in less air-tight dwellings with:

- A design air permeability higher than $5m^3/(h{\cdot}m^2)$ at 50Pa.
- An as-built air permeability higher than $3m^3/(h{\cdot}m^2)$ at 50Pa.

As we have been building our homes to be increasingly air-tight, we are seeing a shift change away from natural to mechanical ventilation strategies to ensure positive and legal levels of indoor air quality. This first began in apartment developments but, following the Part F 2021 update, has also increasingly being seen in the housebuilding market.

Design	Relatively simple if system is correctly sized
Installation	Largely understood, simplified with aids from manufacturers
Skills	Lack of dedicated ventilation specialists in the new build sector
Supply Chain	Mature and scalable manufacturing supply chain
Upfront cost (inc. install)	Typically £450 - £600
Energy cost	Low in operating mode but increased energy losses
Commissioning	Required
Maintenance	General maintenance required
Retrofit requirement	Potential to require a whole-house ventilation system retrofit dependent on future insulation upgrades

Risk Assessment

Natural ventilation with intermittent fans has been the most common ventilation strategy used by the housebuilding industry. Although this strategy can be successful, it relies on certain occupant behaviour, including not turning off/turning on intermittent fans, not closing trickle vents and opening windows to purge the indoor air of pollutants.

Risk Analysis	Performance Impact	Solution
Lack of householder awareness relating to trickle ventilation operation	High	Increased education at handover. Initial commissioning must leave trickle ventilation open
Correct sizing of trickle ventilation	High	Attention to design and specification
Increased heat loss from the home through trickle ventilation	High	Attention to design and specification or alternative system choice
Will not perform in single sided dwellings due to lack of cross flow	Very high	Do not specify in this scenario
Axial Fans specified and/or installed where a centrifugal is required	Very high	Correct specification by systems designer and correct product selection by installation engineer
No condensate drain fitted at bottom of riser to tile vents	Very high	Attention to detail and good understanding of the need for such and consequences of not fitting
SELV not fitted in Zone 1 where 18th edition wiring and RCD protection not in play	Very high	Correct specification of each fan by designer and correct product selection by installation engineer

Risk Analysis	Performance Impact	Solution
Low quality products in the UK market	Medium	Installers pick up cheap fans at their local electrical wholesaler. Education is needed and manufacturers should publish the pressure curve for all System 1 fans on sale

Continuous mechanical extract ventilation

Centralised (cMEV) or decentralised (dMEV) extract ventilation.

Suitable for all housing types, regardless of air permeability levels.

Manual or automatic controls, such as humidity sensors, available to operate between trickle and boost modes.

DMEV is useful for dwellings designed with natural ventilation but with an as-built air permeability higher than $3m^3$ /(h·m^2) at 50Pa.

Whole-house or individual room extract ventilation for effective pollutant removal.

Continuous mechanical extract ventilation operates by continually removing stale air from the home, with fresh outdoor air brought in by background ventilation. This could be via a centralised whole-house system or decentralised units in individual rooms.

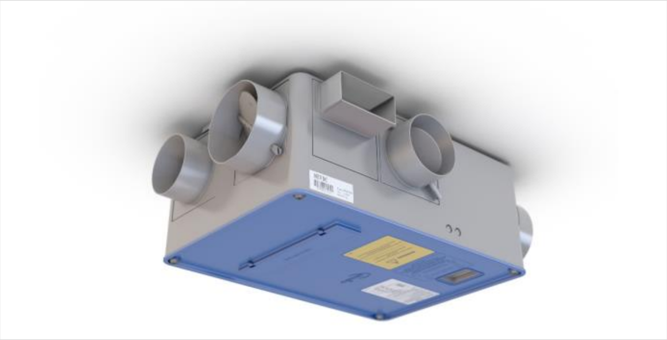
Centralised mechanical extract ventilation (cMEV) consists of a fan installed in a central location, such as a loft or utility cupboard, ducted to rooms within the dwelling, including the kitchen and bathroom. This provides a whole-house system from removing pollutants, allergens, viruses and moisture. As this is a ducted system, care needs to be taken during the design stage to ensure minimum pressure drops and other requirements are met for the system to operate efficiency and quietly. This design must be clearly followed during the installation phase to ensure the design and as-built details align, reducing the potential for a performance gap.

Decentralised mechanical extract ventilation (dMEV) works on a room-by-room basis, compared to cMEV which services the whole house. These individual units run continuously to extract stale or high moisture air from the individual room they service. DMEV systems are often designed within bathrooms, kitchens, utility rooms or other wet rooms.

For new build developments, dMEV is also a potential solution for dwellings built with a natural ventilation strategy but which end up with an as built air permeability higher than $3m^3 /(h.m^2)$ at 50Pa. Under Part F 2021, these dwellings are too air-tight to use natural ventilation in isolation. In this circumstance, the project owner will need to seek expert advice or retrofit a mechanical ventilation system in order to remain compliant with the Building Regulations. Where a retrofit solution is sought, dMEV offers a flexible solution which can be installed with minimal disruption compared to alternatives.

Continuous mechanical extract ventilation can be an effective, low-cost solution to ensuring a healthy indoor environment for occupants in new build homes. However, this goes hand in hand with occupant education which is key to ensuring that a building operates as designed.

Too often, occupants are concerned around the continuous running of a fan which they see as energy intensive. This is not the case, with a cMEV fan costing on average 5p per day to run. By turning off mechanical ventilation systems, occupants are also risking a build-up of mould and pollutants by stopping the fans that ensure their extraction.



Design	Education required on general and ducting design. Whole house calculations required
Installation	Measures required to ensure no design deviation
Skills	Lack of dedicated ventilation specialists in the new build sector
Supply Chain	Mature and scalable supply chain
Upfront cost (inc. install)	Typically £800 - £1000 for cMEV and £520 - £700 for dMEV
Energy cost	Low: <5p per day for DMEV
Commissioning	Required to meet ADF and verify airflow and operational design values
Maintenance	General maintenance required
Retrofit requirement	Potential retrofit to MVHR dependent on future energy efficiency measures

Risk Assessment

With changing Part F regulations, mechanical extract ventilation is being applied to mass new build housing at a higher rate than typically seen before. As with any technology shift, the industry needs to acquire new skills to understand the system requirements and ensure good quality installs. This can overcome with the support of manufacturers and related training courses.

Risk Analysis	Performance Impact	Solution
Incorrect sizing of system due to lack of design capability	High	Attention to design and specification
Poor ductwork installation impacting air flow	High	Clear specification of materials and fitting requirements with verification compared to design values
A potential for poor commissioning	High	Ensure balanced air flow across the system by following initial design and recommended ventilation rates
cMEV: No insulation where ducts are in unheated space (i.e. loft)	Medium	Clear design and specification from consultant with installation by trained engineer
cMEV: Incorrect duct size leading to turbulent air and high induct noise levels	High	Better understanding from designers and installers of impact on air movement when duct size restricted
cMEV: Manual controls not fitted local to areas being served	Low	Ductwork designs to include details of controls, type and location along with product specific wiring diagram
dMEV: No insulation where ducts are in unheated space (i.e. loft)	Medium	Clear design and specification from consultant along with installation by experienced and well-trained engineer

Risk Analysis	Performance Impact	Solution
dMEV: Incorrect duct size leading to turbulent air and high induct noise levels	High	Better understanding from designers and installers of impact on air movement when duct size restricted
dMEV: Manual controls not fitted local to areas being served	Low	Ductwork designs to include details of controls, type and location along with clear wiring diagram specific to product selected

Mechanical ventilation with heat recovery

Efficient supply and extract ventilation.

Suitable for all new dwellings, with SRVHR an option for specific space limited circumstances or operating in a hybrid scenario.

Controls are available to boost dwelling energy efficiency and offer demand side response flexibility.

MVHR systems optimise available heat and coolth from any source due to recovery process.

Combining healthy indoor air quality with energy saving measures.

Mechanical ventilation with heat recovery (MVHR) is an energy efficient supply and extract ventilation system. Whilst extracting stale indoor air, it recovers heat which would have otherwise been lost outside. This heat is transferred to the supply of fresh air coming into the dwelling, which reduces the demand on the central heating system and wastes less paid for heat. MVHR can be a centralised, whole-house system, placed within the heated envelope, or as single room ventilation with heat recovery (SRVHR).

Regardless of whether the system is centralised or decentralised, MVHR can offer many benefits to dwellings looking to be net zero ready:

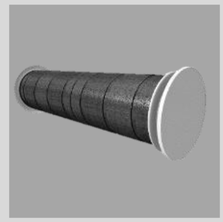
- Absolute assurance of necessary ventilation rates to sustain critical indoor air quality (IAQ) levels over the lifetime of the home.
- A de-risk technology that can operate effectively down to zero air changes, reducing any IAQ risks presented if air tightness standards overshoot design performance.

- The provision of supplementary heat in an environment where the currency of kWh and associated carbon has a high value, and the provision of heat can mitigate alternative expensive methodologies.
- Application flexibility means systems are available for all dwelling types and not just a sub-sector.
- The technology maps across the 'future proof' home objectives.
- Modern systems now provide world leading efficiency performance due to Energy Related Products policy and 'a race to the top' via SAP Appendix Q.
- With appropriate communication protocols and controls in place, MVHR can also offer demand flexibility benefits on a 'limited time' basis along with set-back operation modes.

The sizing of MVHR units and the overall system design will dictate the optimal performance for a MVHR solution. This is due to the need to match flow rates with required ventilation rates and prevailing system pressure.

This requirement is why it is vital to ensure that design specifications from an expert source are followed and not amended, either during future design stage changes or during the installation of the system. There are several reasons why an expert design might be deviated from, including:

- To reduce unit size and potentially cost.
- To specify cheaper duct options that will reduce air flow and render the system unworkable.
- To site the unit in cold spaces (e.g., the loft).
- To accommodate poor critical path planning.



Design	Complex compared to other ventilation systems. Competent designer required
Installation	Value engineering and design deviation risk
Skills	Key competencies required with a lack of dedicated specialists
Supply Chain	Mature and scalable supply chain
Upfront cost (inc. install)	Typically £2.5k - £3k for MVHR and £1.5k - £2.5k for SRVHR
Energy cost	Low, additional heat recovery benefits
Commissioning	Required under Part F
Maintenance	Filter changes: 1-2 years General maintenance: 5 years
Retrofit requirement	Net-zero ready system

MVHR has been designed and adapted to become a high performing solution within the SAP model. The highest performing units within the current SAP PCDB are regularly achieving specific fan power of <0.50W (m^3/hr) and heat exchanger efficiency >90% in K+1 and K+2 applications.

This high-performance nature of MVHR solutions does make them more expensive than other alternatives, but with significant market growth over the past few years this price gap has closed significantly with typical system prices reduced to as little as £2500 (installed). A typical compliant CS1 ventilation system is around £450-£600 incorporating trickle vents as well as quality extract fans. The creates a marginal premium of around £2,000 per dwelling for increased energy efficiency and stable levels of indoor air quality.

Modern systems are now sited in the heated envelope and have light displays to signal when filters require changing. Once switched on and commissioned there is minimal consumer intervention required, save for a filter change every year and maintenance on a five-year basis. The specification of controls can also improve overall system energy performance, which make it possible to:

- Reduce ventilation rates during unoccupied periods to improve energy efficiency.
- Take benefit from price positive 'limited time' flexibility services which can balance network loads vs building demands for demand response and flexibility.

There are changes to SAP which would create a better reflection of the benefits of MVHR and the impact of these additional controls, which we discuss in our SAP 11 recommendations page.

One of the biggest challenges for all mechanical ventilation is occupant behaviour, with the potential for end users to switch systems off, however this is an education challenge rather than a technical one. BEAMA are looking at way to address this to help occupants understand the importance of ventilation and other low carbon system in creating healthy homes.

Single room ventilation with heat recovery

Single room ventilation with heat recover (SRVHR) is typically a deep retrofit ventilation solution. However, its application can extend into the new building sectors where unit siting space or ducting may be a constraint. SRVHR is a decentralised system providing balanced ventilation performance.

Typically, units come as an enclosed system out of the box. SRVHR can be specified alongside MVHR as a hybrid solution to tackle awkward hard to reach spaces with communication protocols in place to ensure co-functionality.

As with MVHR, the benefit of SRVHR in creating net zero ready homes is the provision of supplementary heat in very air-tight dwellings which makes a positive contribution in reducing the demand on the heating system. There are typically two forms of SRVHR:

- Recuperative cells which enable the ventilation of a house directly through the façade. As a result, there is no need for complex air ducts. Built-in sensors within the heat recovery units take automatic measurements based on CO_2, humidity, and indoor and outdoor temperatures. In this way, the system determines how much fresh air needs to be supplied and preheated.
- Regenerative cells which are compact through the wall fans. It ventilates the living space with its high air volume flow, protects against cooling and strong wind pressure and, with its different variants, is also suitable for all installation situations from the basement to the roof.

In both cases, the units have very low SFPs, comparable to MVHR, due to the use of low watt fans.

Risk Assessment

There is a requirement for increased education on ventilation and indoor air quality for different touch points across the building supply chain, including Building Control, installers and occupants.

Risk Analysis	Performance Impact	Solution
Building Control not understanding the critical aspects of system performance and how to assess through the Master Data file	Low	Education of Building Control inspectors through webinars and guidance
Potential for poor system design	Very high	Educating the Architects, M&E consultants, developers, and builders
Potential for poor Installation	Very high	Stop untrained individuals from installing these systems. Educate and train with a focus on delivering installed performance
Chance the contract will be awarded only based on cost	Medium	Educate the client as to why this is almost always a bad option
Risk of value engineering	Medium	Downsizing ductwork should not be an option. Rationalisation of duct routes to avoid fire compartments or to shorten duct routes should be considered
Availability of low-quality products in the UK market	Medium	Clients need to push for higher quality products to be installed, this is an important building element. We must avoid a tick box exercise and focus on providing high quality products and installations for the benefit of the occupant

Risk Analysis	Performance Impact	Solution
Poor Quality installation	Very high	Training & Education required for all installer, as recommended in the *Competency* section of this report
Manual controls not fitted local to areas being served	Low	Ductwork designs to include details of controls, type and location along with clear wiring diagram specific to product selected
No insulation where ducts are in unheated space (i.e. loft)	Medium	Clear design and specification from consultant along with installation by experienced and well trained engineer
Single room ventilation with heat recovery requires multiple penetrations of external fabric both habitable rooms and wet rooms	Medium	Must be considered during the design process to account for additional perforations within the building fabric
Single room ventilation with heat recovery is a relatively new solutions within the new build market	High	The design requirements and product benefits and limitations must be understood by the building designer and those installing the system

Case studies

Since the Future Homes Standard consultation in 2019, the industry has been aware of the proposal to produce net zero ready homes from 2025. Since this consultation, many in the industry have been proactive in undertaking world leading projects to define the homes of the future.

Some of these projects have looked at specifically how to achieve the 75-80% carbon reduction target (compared to Part L 2013) using a variety of different solutions. Others have looked at the application of heat pumps within houses or trialled new and innovative solutions.

While the scale of the challenge facing the residential construction sector is unparalleled, we have already shown that, with time to plan, we have the solutions and the expertise to create net zero ready homes.

Within this chapter, we focus on case studies from across the BEAMA membership to give real, tangible examples of how homes may be built to meet upcoming Part L and Part F standards in 2025.

Project 80: Eco Drive by Midland Heart

To understand the Future Homes Standard challenge, Midland Heart created 'Project 80' which is a research and development programme in collaboration with Birmingham City University (BCU), Tricas Construction Ltd, key product manufacturers and industry bodies, and contractors.

Eco Drive consists of twelve affordable homes built to the details currently known about the Future Home Standard, including an 80% carbon saving compared to Approved Document L 2013 standards. These homes will be monitored to understand the impact of these standards on areas including identifying information requirements for Midland Heart's residents, evaluating the performance of different products and technologies and allowing Midland Heart to make Future Homes decisions based on real life evidence.

The homes on Eco Drive have been designed to provide superior insulation, as well as incorporating low and zero carbon technologies including:

- Vaillant air source heat pumps
- Dimplex hot water heat pumps and panel heaters, paired with an external wall U-value of 0.13 and airtightness test of 1.5
- EnviroVent MVHR units

Upon completion, researchers at Birmingham City University will be working closely with residents to understand how easy the homes are to live in with the new technologies, how cost effective they are, and the living environment such as indoor air quality and temperature. All the evidence gathered will help to inform future policy on how Midland Heart builds new homes in a way that's good for both the environment and for residents.

Zed House: Aim For Zero Carbon by Barratt Developments

In early 2020, Barratt Developments announced its commitment to building zero carbon homes from 2030. The first phase in reaching this audacious target was through building a concept home for the future: the Zed House. The Zed House project is in place to help create zero carbon and nature-friendly homes to minimise people's carbon emissions, going significantly beyond the Government Future Homes Standard by delivering a 125% reduction in carbon emissions.

To help meet Barratt Developments goal, they face the challenge of finding a suitable, efficient, and cost-effective alternative heating solution that minimises carbon emissions compared to traditional heating systems such as oil or LPG boilers.

Modern technologies such as Mitsubishi Electric's Ecodan Air Source Heat Pump provide the perfect solution for the challenge Barratt Development. Being easy to install, the Ecodan unit met the requirements for the Zed House through the system being able to reduce CO_2 emissions whilst also being able to reduce running costs. A 5kW Ecodan with a 170l hot water cylinder was installed supplying heat to the home, paired with underfloor heating downstairs to provide thermal comfort to occupants, alongside PV solar panels and battery storage.

EnviroVent’s MEV 300 was also specified, due to it’s wide use of recyclable materials to reduce the impact on landfill and being designed to ensure that components can easily be replaced.

The Zed House along with being an incredibly environmentally friendly home will now comfortably receive low carbon heat and hot water production for the future.

Lambley Lane, Nottingham by Keepmoat Homes

Housebuilder Keepmoat Homes has developed 33 homes in in Lambley, a village just outside Nottingham. The development is Keepmoat's first scheme delivered to the proposed Future Homes Low Carbon standard and is supported by Homes England. The developer chose specialist suppliers, including underfloor manufacturer WMS, who can provide the technical knowledge and experience required to ensure residents benefit from a low-carbon, ultra-efficient and future-proof home.

Each property features an expertly designed combination of technologies to provide heating and hot water, including an air source heat pump (ASHP), WMS underfloor heating, smart heating and hot water controls and an intelligent hot water cylinder. Post-occupancy, as part of the sale agreement, each home's energy usage is being independently monitored by Birmingham City University for at least 12 months to validate performance.

To meet current Part L requirements, the heating systems designed for Keepmoat's Lambley development were required to demonstrate a maximum flow temperature of 55˚C. As Keepmoat were looking to deliver homes that significantly overperform against both the new Part L requirements and the emerging Future Homes Standard, the design was developed to be Zero Carbon Ready. Given the demanding design requirements, which include the specification of ASHPs, the developer needed its key suppliers to work collaboratively and take a holistic approach to the system design, ensuring the technologies specified work in harmony to maximise efficiency and create both comfortable and healthy environments. Using their specialist experience, WMS collaborated with Keepmoat and fellow suppliers to skilfully trial and design the final, zero-carbon emissions heating system.

For ASHPs to achieve their most effective coefficient of performance (COP) level they need to run between 35-45°C – this is something hydronic (water-based) underfloor heating can easily achieve, making it the ideal technology partner. As ASHPs have far fewer tolerances than the industry is used to, especially when compared to traditional heating systems, precision design and installation are key, so the Keepmoat, Lambley development suppliers collaborated on a series of trials to ensure the efficiency of the overall system.

The final solution designed, specified and being installed by WMS is the AmbiTak underfloor heating system, which provides a quick, flexible and effective form of heating within a screeded floor build-up. WMS has paired the system with the company's most popular digital programmable thermostat – Neostat, which is available as a wired or wireless solution with an accompanying NeoApp smartphone app. The controls selected will enable residents to reduce energy wastage by heating only the rooms required and, crucially, ensure that each home meets the newly introduced regulations.

As part of the considerations, WMS also undertook various trials to ensure the system was calibrated to work effectively with the range of floor finishes Keepmoat has specified throughout the dwellings – this process included WMS providing advice regarding widely available, underlay compatible with underfloor heating. Providing the opportunity for homeowners to make future changes to the floor coverings, floor probes have also been specified to feed data into each individual room thermostat, adding to the system's flexibility.

Trudie McCormick, Technical Development Director at Keepmoat Homes commented "Customer satisfaction is our primary focus. WMS has been a collaborative member of the design team ensuring that the underfloor heating system has been integrated into the wider holistic design. The aspiration is to deliver low-carbon homes that are healthy, comfortable and flexible in design. We are confident that the incorporation of the underfloor heating system supported with ease of control and heating efficiencies will support the delivery of attractive, healthy, low-carbon homes."

Oberry Fields, Warwickshire by Housestyle Countrywide

Heating installer, Be Green Systems, has worked in tandem with developer, Housestyle Countrywide, to develop an estate of nine exclusive three-, four- and five-bedroom properties in the Warwickshire countryside.

Oberry Fields is designed to be a prime example of how new residential properties can achieve outstanding levels of energy efficiency and support a more sustainable future. Each property features a Vaillant flexoTHERM 8kW ground source heat pump, which generates heating and hot water and is designed to reduce running costs and environmental impact. Connected to a ground loop, the flexoTHERM heat pump provides the highest energy efficiency label and heating performance in its class, whilst also boasting a 'Quiet Mark', issued by the Noise Abatement Society.

All properties at the new development have seen the successful installation of the flexoTHERM ground source heat pump solution. A geothermal ground collector has been installed under a nearby road consisting of seven, 120 metre deep sealed pipes in boreholes to extract the thermal energy stored in the ground and provide all the energy requirements for all nine properties.

In addition, a number of other energy saving and sustainable technologies have also been installed to complement the ground source heat pump solution. These include mechanical ventilation and heat recovery, wardrobe ventilation, background comfort cooling, air conditioning, solar PV panels, and solar batteries.

According to estimates from installers Be Green Systems, the technologies in place mean residents can look forward to annual energy bills of approximately £350 to £400 - a significant reduction compared to average residential UK energy bills.

In addition, property owners have the satisfaction that their complete heating, cooling and energy solution is being provided in a sustainable way, with a low carbon footprint and minimal impact on the environment.

Garry Woods, Be Green Systems commented:

“We wanted to create an estate of energy-efficient homes that could showcase how renewable technologies can reliably deliver lower energy consumption, reduced energy costs and minimal environmental impact. Using Vaillant’s flexoTHERM ground source heat pump, we know we have utilised the latest technology alongside additional sustainable technologies incorporated into the new homes. The heat pump effectively provides the energy needed for heating and domestic hot water, but does so in an environmentally-friendly way.

We believe such renewable solutions for homes are the way forward. Vaillant’s extensive experience and expertise when it comes to such technologies, as well as their outstanding levels of service support, made them an ideal partner on this project

The homeowners at the development will enjoy comfortable, warm and highly energy efficient homes, whilst benefiting from reduced energy bills.”

Dundonald Church, Wimbledon designed by Brimelow McSweeney Architects

Dundonald Church is a development in Wimbledon, South London, designed by Brimelow McSweeney Architects with MEP engineers Meinhardt, which includes 18 apartments seamlessly integrated into a contemporary church building. It was a community initiative born from the need to update the existing building that was home to Dundonald Church since 2007.

The focus of the development was on community and sustainability, with particular attention given to thermal efficiency, overall noise reduction and high energy performance. The main incentives for the development were occupier affordability and carbon emission reductions to comply with The London Plan. The ambition for the church, which features operational spaces and offices, was to achieve a Very Good BREAAM status.

Dimplex offered specification advice on the project and provided a heating, hot water and ventilation solution. This comprised of the Zeroth Energy System and the Natural Air 180 for the mechanical ventilation with heat recovery units (MVHR) for the residential development, paired with an air source heat pump central plant and underfloor heating within each apartment.

The innovative ambient network solution was specified as a technology that could be installed within the spatial constraints of the building. It could also reliably supply space heating and hot water whilst achieving the minimum 35% on-site carbon improvement against Part L as required by the Greater London Authority (GLA).

The Zeroth Energy System is a result of a long-term collaboration between Dimplex and UK leading developers. The system provides low carbon heating for larger residential developments whilst reducing carbon emissions and maximising the energy efficiency of a building. Within an ambient design, the central energy loop operates at a temperature of 25°C, maintained by the central plant. The compact Zeroth Heat Pump unit includes an integral water cylinder in each apartment to provide heating and hot water up to 60°C. This methodology minimises the distribution losses and mitigates the overheating effect common in multi-occupancy buildings with high temperature central heating network.

Mark Bryan, MEP Director at Meinhardt commented "The Zeroth technology offers a route for dwellings to provide low carbon heat based on a product of the future. We are very much looking forward to seeing how this system operates as a critical step of reducing our carbon dioxide emissions."

Self-build in East Dulwich, London by architect Jake Edgley

As part of a self-build project in London building his own home, architect Jake Edgley specified a mechanical ventilation with heat recovery (MVHR) system as part of the design, alongside other 'green', environmentally-friendly measures, including non-toxic paint and flooring.

The 400m^2 house was constructed in two halves, each built around a tree, with one MVHR system covering each half of the property. As Jake designs and specifies homes as part of his job, he often experiments with different products on his own property. For this development, he specified Titon's HRV10 Q Plus MHVR unit, as well as Titon's Trimbox NO_2 Filter®. The bedroom area had the Trimbox NO2 Filter® added first, before being rolled out in the other half of the house six months later after a noticeable impact.

Jake explained: "The Trimbox filters work amazingly well, they have completely eradicated any smells coming in from outside […] The MVHR unit is already a good dust filter and this is improved by the Trimbox, and we've also noticed the Trimbox acts as an excellent attenuator to any noise from the MVHR unit. Then there's the added benefit of knowing the units are filtering out any pollutants so, despite being located about 60 meters from a road, the air inside the house remains clean and healthy."

Following this positive first-hand experience, Jake now includes the Trimbox NO2 Filter® as part of every new build domestic ventilation system specified by his company, Edgley Design.

"The Trimbox is a great product, particularly in London areas," he concluded. "Given the rise of environmental toxicity over recent years, we always encourage domestic clients to put MVHR systems into new build homes. Including the Trimbox as part of the system should make perfect sense to homeowners, especially given its capacity to remove diesel particulates and filter toxins from indoor air."

The filter incorporates balanced flow technology to provide class leading absorption of NO_2 and is available in two duty sizes (depending on the duty required). The product is effective in reducing NO_2 to an acceptable mean annual concentration level of 40µQ /m^3, while vastly improving indoor air quality (IAQ). Independent tests have demonstrated the Trimbox to absorb 98% of NO_2, not only in normal, continuous ventilation mode but also at 'boost' or higher ventilation rates.

Invicta Bristol Harbourside by Crest Nicholson

Invicta is part of the award-winning Harbourside in Bristol, a stylish development of studio suites and apartments with private balconies and roof terraces by Crest Nicholson.

With city centre traffic pollution on the rise, the waterfront apartment development in Bristol raised the bar on indoor air quality. Ventilation manufacturer Nuaire supplied a package of low-energy MVHR and MEV systems to the apartments, with the addition of an innovative filtration product that has raised the bar in indoor air quality, making it one of the healthiest postcodes in the city.

Nuaire's Q-Aire Carbon Filter range was utilised for the first time at Harbourside. Its design reduces the amount of airborne contaminants from entering the building, in particular Nitrogen Dioxide. This is becoming part of planning obligations in urban areas where air pollution is higher.

The Q-Aire Carbon Filter was installed on two floors of one façade, to prevent Nitrogen Dioxide and Particulate Matter from traffic on a busy road nearby from entering the apartment. A large number of city centre apartment developments now require carbon filtration on the first two and three floors to reduce air pollution levels.

This belt-and-braces measure has helped Crest Nicholson to meet strict planning conditions whilst ensuring homeowners benefit from the very highest quality of indoor air.

Key recommendations for success

To make the step-change to building net zero ready homes with low carbon heating systems and positive indoor air quality is as successful as possible, we have made several key recommendations to Government.

These aim to enable the removal of barriers for the application of certain technologies and to address challenges within the plan of works process for a new residential development. The recommendations cover a range of areas, including key learnings form the recent 2021 interim regulations, non-compliance risk and interaction with Approved Document O: Overheating in New Residential Dwellings.

We have created these recommendations with a range of industry experts, including the BEAMA membership who have extensive experience in applying electric and renewable solutions to the new build sector.

These are tangible actions for Government to consider for the Future Homes Standard consultation to ensure that the transition to building the homes of the future works for everyone.

Previous learning

Building on insight from the 2021 update to Part L and Part F, and the introduction of Part O.

Key Government Recommendations

- Produce a range of stakeholder specific information, providing digestible content on the key changes within the consultation which can be shared across industry. This should include information targeted at manufacturers regional housebuilders, SAP assessors and installers.
- Ensure a BETA version of SAP 11 is available from the start of the consultation period to allow industry to effectively model the impact of proposals.
- Include a section at the start of the consultation giving an outlook to the expected changes within the following update to Part L, Part F and Part O, allowing industry to develop long-term strategies and prepare for future requirements.

On the 15th June 2022, a 2021 update to Part L, Part F and Part O came into force in England. This interim update – a stepping-stone to the 2025 regulations – was a substantial change for the new residential development sector. The way that these changes were introduced and how industry reacted to them offers insight and learning which can be applied to the impending consultation launch. There are three areas we have identified in particular: industry awareness, modelling capability and mindfulness of future progression.

The last update to Part L and Part F, alongside the introduction of Part O, was one of the largest changes for energy and ventilation related policy since the Building Regulations were introduced. The raft of changes were so vast that nearly one year after their introduction there is still a requirement for education and awareness that the law has changed.

Although Government completes a range of outreach and has been forthcoming with industry engagement in relation to these regulatory changes, we can see a place for more targeted, digestible information from or supported by Government which can shared across industry. These content pieces should be focused and targeted, making them understandable to the stakeholders they are designed for. As an example, stakeholders could include manufacturers, regional housebuilders, SAP assessors and installers. BEAMA would be happy to support both Government or industry with the creation of such content.

A second key insight from the previous consultation was how vital the BETA version of SAP 10.1 was to understanding the impact of the Part L and Part F 2021 proposal. This software allowed for industry to give informed consultation responses as well as to start planning HVAC strategies which could be compliant when the update came into effect. In order to allow the same response to the upcoming Future Homes Standard consultation, we ask that Government ensure a BETA version of SAP 11 is launched at the start of the consultation period.

The final insight we have from the previous update to these regulations was how valuable it was to have insight into the next future development of the regulation. The 2019 Future Homes Standard consultation mainly focused on the interim update which came into force in June 2022. At the start of this consultation, the plans for the 2025 Future Homes Standard were laid out.

This foresight into the future of residential dwelling compliance has been fundamental in allowing industry to complete long-term planning, whether that is in the creation of new housing frameworks within the housebuilding sector or allowing manufacturers to develop new solutions to meet the requirements of the future landscape.

To help continue this, we would support the idea of Government setting out the new build vision beyond 2025 at the start of the upcoming consultation. This could include the date for next Part L, Part F and Part O update, as well expected performance standards.

We appreciate the complexity of developing these regulations. To ensure the greatest chance of success, we would also urge Government to ensure that the upcoming Future Homes Standard consultation is fully consistent with our Net Zero requirements and have been fully discussed with other energy-related teams and taskforces.

2025 notional building

Setting the HVAC technologies used within the Part L notional building.

Key Government Recommendations

- Include an air source heat pump and MVHR within the 2025 notional build, paired with the minimum fabric standard to pass 2025 fabric energy efficiency standards. This will mean any change to less efficient heating or ventilation will need to be balanced with fabric improvements.

The notional building within Part L helps to give a theoretical example to industry on how a dwelling could be built to pass current compliance standards. Previously, this has always included a natural gas boiler, which has signalled to industry that fossil fuel systems are a route to compliance. The notional building is a useful guide for designers, especially when there are significant changes to Part L, which helps to set out the vision of future housing.

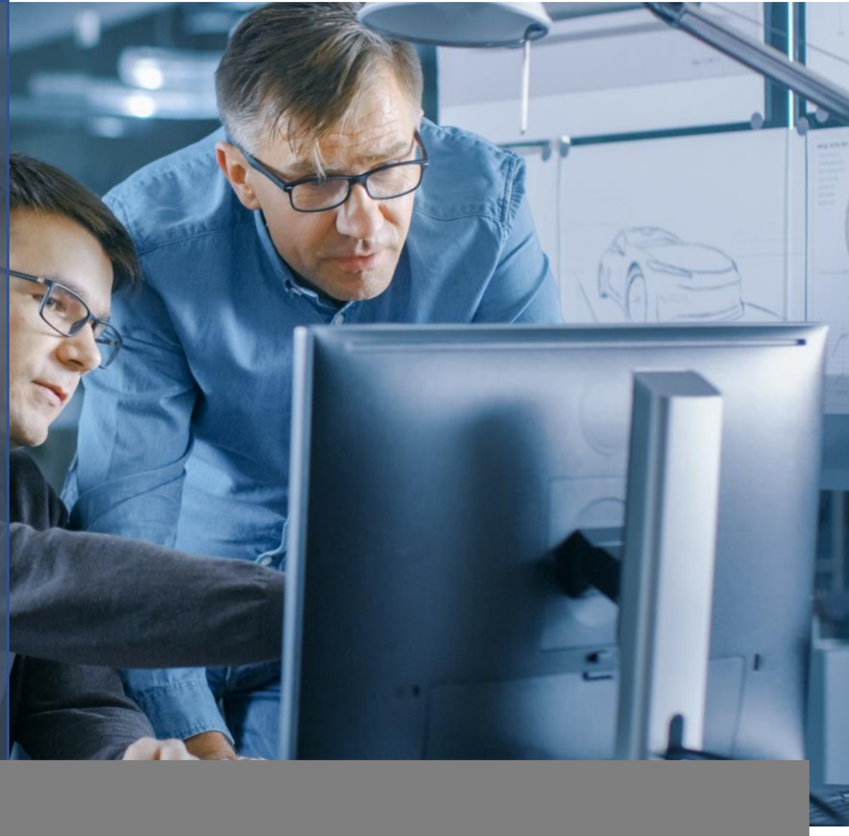
For the Future Homes Standards, we believe that the notional building should have the most efficient heating and hot water system and ensure heat recovery capabilities within ventilation. This should be paired with the minimum building fabric standards to pass the fabric energy efficiency target, which should be improved compared to 2021 compliance standards. However, the consultation and following Regulation should make it very clear that notional buildings are only a guide and that other technologies can be specified.

This would support the use on an air-source heat pump to provide space heating and hot water, and MVHR to reduce wasted heat through ventilation to create a highly efficient, net zero ready notional dwelling. It is important that the MVHR unit is also equipped with summer bypass to help mitigate overheating in the warmer months.

Where specifiers look to design a building without a heat pump or ventilation without heat recovery provisions, this notional specification makes them aware that the change will need to be balanced against fabric improvements or additional low carbon technologies, such as PV or waste-water heat recovery, to ensure a similar performance to the notional dwelling.

SAP 11

Ensuring functionality to support the use of affordable, low carbon solutions.



Key Recommendations

- For the Department of Levelling Up, Housing and Communities to support changes to SAP 11 which better promote and represent low carbon technologies which will be used under the Future Holmes Standard. This includes, but is not limited to, the recommendations listed within this section of this report.

As new build homes continue the transition away from fossil fuel systems to low carbon electric alternatives, we must ensure that the supporting mechanisms rise to the challenge to support this change. For Part L and Part F as part of the Future Homes Standard, this means ensuring that the Standard Assessment Procedure (SAP) is updated appropriately and timely, moving from SAP 10.2 to SAP 11.

There are changes to the current SAP 10.2 methodology and software which would better promote and represent the low carbon technologies which will be used under the Future Homes Standard, including those listed within this report. If these changes were implemented within SAP 11, it would reduce some of the disconnect between the evolving Building Regulations and the methodology and software which support compliance.

We would strongly support the Department of Levelling Up, Housing and Communities and the Building Research Establishment in introducing some of these changes, which align to previous pledges for improvement made by Government to remove limitations to the specification of advantageous low carbon technologies.

Ventilation

- The Product Characteristic Data Base (PCDB) and SAP Appendix Q (or future iteration) calculations need to move closer to the core algorithm in SAP. The PCDB runs separate worksheets for ventilation when they should incorporate the science into a whole house methodology including dynamic thermal modelling.

- There is currently no appropriate methodology within SAP to provide controls benefits for ventilation systems. This can be addressed in a simple way by following the ERP controls definitions and performance factors which are commonplace but attract no energy benefit.
- Single room ventilation with heat recovery cannot currently be calculated in SAP. On the basis that if you cannot calculate it, you cannot specify it, its omission needs to be addressed within SAP 11. This can be handled either in core SAP or as an Appendix Q process with associated PCDB product data listing.
- SAP currently makes no allowances for the use of ceiling fans as a solution to overheating issues that may be present at peak high temperatures. These need to be considered within core SAP and balanced against reduced use of active cooling.

The treatment of controls should be a very simple addition to the SAP model. Performance factors for control use are already laid out within prevailing Energy Related Product standards:

- Central Demand Control which can continuously regulate fan speed(s) and flow rate based on a single sensor = 0.85 factor.
- Local Demand Control which can continuously regulate fan speed(s) and flow rate based on multiple sensors = 0.65.

Heating and hot water

- Future energy pricing policy which re-balance the cost of gas vs electricity must be reflected in SAP 11. If this is not done, housebuilders will have challenges in selling new homes due to SAP ratings and EPCs, as well as mixed messaging to house buyers.
- Primary energy should not be included as a compliance metric under the Future Homes Standard to ensure no unintended consequences for electrification.
- Domestic hot water system need to be modelled more accurately within the SAP methodology and software. We would be happy to support the Government and the BRE in defining how this can be best achieved.
- The carbon factors used within SAP 11 should be long term averages to ensure they reflect the carbon intensity of energy throughout SAP 11’s use.
- EPC’s need to be updated and subsequently reflected in SAP to support electric heating technologies which will be used to achieve the aims of the Future Homes Standard.
- SAP needs to model all heat pump technologies more accurately to reward efficiency. We would be happy to support the Government and the BRE in defining how this can be best achieved.
- SAP 10.2 currently deals with underfloor heating by applying levels of penalty to the calculations based on construction techniques that are no longer used. Tests conducted at Salford University are showing that overlay underfloor systems respond almost the same as radiators, and screed systems respond far quicker than was previously considered whilst continuing to provide heat to the room for extended periods after the heating is turned off. This needs to be reflected in SAP 11, and, in before SAP 11 is available, should be an addendum to the current SAP methodology.

Supporting innovation

- We welcome the launch of a new open-source flexibility module within SAP 11, however, as discussed in the *Flexibility and smart controls* section of this paper, a parallel operation should also be launched at the same time which allows manufacturers to innovate and build upon that module with 'closed box' solutions for future assimilation into core SAP after an IP protected period in the marketplace.
- There should be increased awareness and understanding in industry of the process of recognising new and innovative technologies in SAP, as well as some of the potential challenges within the current limitations of the compliance software. This would be especially helpful for a smaller manufacturers who may not be aware of the process at all. The BRE are working on improved guidance for this process which Government should support. The Department for Levelling Up, Housing and Communities, alongside other Government departments, should also actively encourage manufacturers to innovate within this space without SAP being a barrier.
- It is important that performance data used in SAP is robust and trustworthy, to protect consumers and ensure a level playing field for manufacturers. Products which have more conservative performance data whilst further evidence is being developed should be reviewed regularly to ensure their performance within SAP matches the most up to date data. This could help support innovative products through having their partial recognition while manufacturers build their evidence base.

Consumer understanding

Making sure occupants understand low carbon technologies and how they create healthy homes.

Key Government Recommendations

- Submit an industry call to action document to launch a timed, multi-pronged educational campaign to bring consumers on the net zero journey, including understanding about the importance of healthy homes and how to effectively use low carbon technologies.
- Accelerate improvements to existing Government information and advice mechanisms including EPCs to better reflect the benefits of numerous technologies.
- Create a Public Understanding of Net Zero Technologies Taskforce to drive common standards for handover advice for occupants living with low or zero carbon technologies. This could also be expanded to cover retrofit solutions.

Changes to the Building Regulations have transformed the way that we design and build new dwellings, with the Future Homes Standard likely to have the largest impact to date as we transition away from fossil fuels system to creating low carbon, future proofed homes. As we continue on this journey, it is important that we also bring the public along with us so that they understand and support the development of homes which change the way that we live.

To make this successful, both industry and the Government need to embark on a public awareness campaign, which gives consumers a greater understanding of net zero and how this may impact homes. This needs to go hand in hand with education on what makes a healthy home, including what is considered thermally comfortable and how to ensure positive levels of indoor air quality.

This will help to support the desirability for new homes built to the Future Homes Standard which use low carbon technologies whilst simultaneously assisting homes to perform as designed, by removing occupant behaviours which limit the efficiency and effectiveness of net zero systems. This includes the differences of living with a low temperature heat pump system with stored, rather than instantaneous, domestic hot water, how to effectively use heating controls or dynamic tariffs, and the importance of ensuring mechanical ventilation systems are used as intended.

This would need to be a multi-faceted campaign, joining together Government action with multiple companies across the sector to release targeted, educational content to the public at the same time.

Government would need to submit an industry call to action document, setting out timings and terms of reference for the campaign, which industry can build plans and release almost simultaneously for maximum impact and reach. BEAMA would be happy to support this endeavour.

To support the uptake of low carbon solutions, the Department for Levelling Up, Housing and Communities should also accelerate improvements to existing Government information and advice mechanisms to better reflect the benefits of numerous technologies.

This is especially key for EPCs, and by implication SAP 11, ensuring that they are fit for purpose in supporting the transition away from fossil fuel technologies. This will help to ensure that the technologies supported by the high carbon reduction target also offer positive EPC results, making it simpler for both designers and occupants in understanding the efficiency of their dwellings. EPCs will also need accommodate Government's plan to rebalance gas and electricity pricing, which is key to ensuring the demand for new electrified homes.

We would also support the creation of a new taskforce aimed at driving common standards for handover advice to occupant living with Net Zero technologies. This could be expanded to cover retrofit solutions as an aid to installers.

Competency

A fit for purpose competency scheme guided by a zero tolerance principle to design deviation.

Key Government Recommendations

- Introduce mandatory competent person schemes for designers, installers and commissioners of certain net zero technologies within new dwellings. The details of this scheme can be defined as part of the Future Homes Standard consultation.
- Ensure compatibility of competence requirements for safety and energy, utilising the move of the Building Regulations team from the Department for Levelling Up, Housing and Communities to the Health and Safety Executive.
- Department for Levelling Up, Housing and Communities and the Health and Safety Executive to explore the topic competency topic with the BSI Committee CPB/1 - Competence in the Built Environment.

The push towards net zero in buildings, including new homes, has competency implications for nearly all building services technologies due to the complexity of increasingly integrated and aligned services. Most of the risk associated with deployment is centred around competency in design, installation and commissioning.

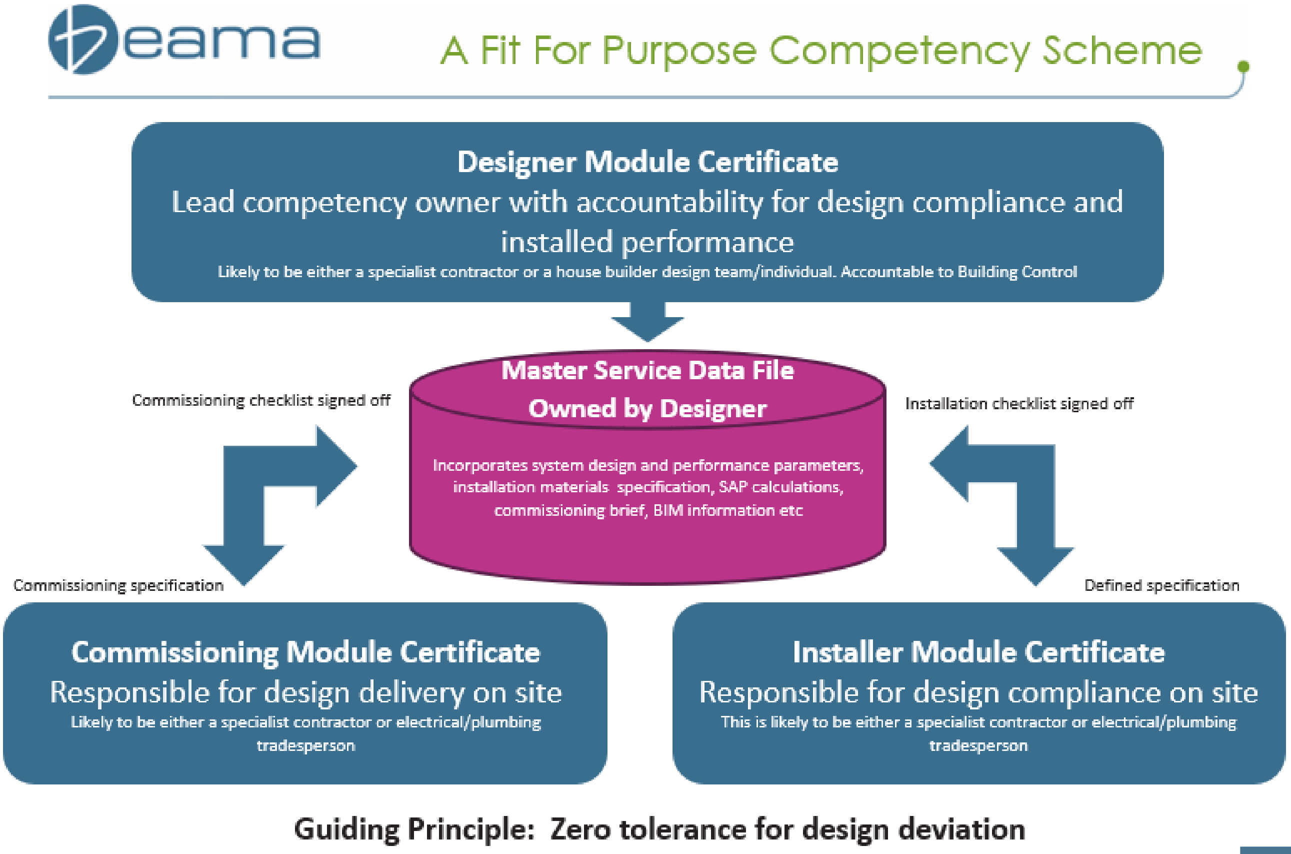
Competency reaches many areas of construction, including ventilation, heating, hot water and methods of construction being accurately applied on site. It is key to closing the gap between as-designed and as-built performance and ensuring that occupants have a positive experience of net zero technologies. In many of these cases, there is no need for additional evidence gathering to establish where problems occur as they have been well documented over recent years. The challenge is to introduce effective and rigorously enforced compliance standards which bring a disaggregated design (and procurement), installation and commissioning process together.

Typically, more complex low carbon solutions, such as ventilation systems and heat pumps, are designed based on site plans considered by system manufacturers, specialist contractors/designers, or M&E consultants. In all cases accurate building design parameters are required to prevent problems through procurement, installation and commissioning. On site, system installation may be conducted by a specialist contractor although it is quite common for this work to be undertaken by one, or all, of a selection of trades , such as plumbers or electricians. Commissioning is also in the hands of either a lead site expert or potentially an unqualified tradesperson, including the initial installer.

It should be noted that there are already some commercially compelling levers in place to incentivise housebuilders to ensure optimally performing heating and ventilation systems are handed over to a new customer. These can be found within SAP and are presented as beneficial in-use factors when a system complies with a competent persons scheme. However, there is currently no effective competent person regime in new build due to the perception that this is picked up by Building Control.

Mandatory competent person schemes for designers, installers and commissioners of certain net zero technologies within new dwellings is required. Design competency must be a separate module for certification and approval. Similar to the requirements under the BREL report, the building designer becomes, in effect, the owner of the installation and all of the accountability for performance that comes with that responsibility.

By introducing a competent person scheme for the design, installation and commissioning of certain net zero technologies, there can be greater confidence that the system is suitably designed and correctly applied on site. The scheme should have the guiding principle of zero tolerance to design deviation.



As the Building Regulations team move from the Department for Levelling Up, Housing and Communities to the Health and Safety Executive, this is also a new opportunity to ensure compatibility of competence requirements for safety to energy. Attention should also be given to competency of authorities, as well as ensuring adequate resources go to enforcement and providing consumer redress.

We would invite the Department for Levelling Up, Housing and Communities and the Health and Safety Executive to engage with the CPB/1 - Competence in the Built Environment BSI Committee.

CPB/1 is responsible to the Standards Policy and Strategy Committee for the standardisation needs for competence in the built environment. They are responsible for defining, developing and delivering standardisation outputs for the competence of those involved in the procurement, design, construction, management and maintenance of buildings, including higher risk buildings as defined under the Building Safety Act. BEAMA would be happy to facilitate this introduction.

Flexibility and smart controls

Recognising the benefits with new build compliance.

Key Government Recommendations

- **Support technologies within the Future Homes Standard which enable demand side flexibility, including, but not limited to, batteries, heat pumps, underfloor heating and electric storage heaters.**
- **Include flexibility as a topic within the industry call to action document to launch a timed, multi-pronged campaign, as recommended within the Consumer understanding section of this report.**
- **The inclusion of a parallel operation alongside the launch of an open-source flexibility module within SAP 11, which allows manufacturers to innovate and build upon that module for future assimilated into core SAP after an IP protected 'closed box' period in the market place.**

Net zero will only be possible if we decarbonise heat and transport, but to do so will place stresses on the energy system at an unprecedented level. The infrastructure requirements to support decarbonisation will be enormous in scale, and yet the energy system will also need to become both smart and flexible to ensure affordability and security of supply.

Flexibility, or the ability of the power system to adapt efficiently and quickly to changes in electricity supply and demand, will enable the development of a safe and secure net zero electricity system that can operate cost-effectively at any time, and in any weather, throughout the year.

To maximise the benefits of demand-side flexibility however, households and businesses will need to play an active role in the development and operation of the country's energy system, and, for flexibility to be rolled out successfully, it is crucial that business models are developed which unlock its value.

It is also vital that consumers are convinced of the benefit of flexibility to themselves as well as to the electricity grid. Several studies have attempted to estimate the potential cost savings of flexibility on the UK grid, with one estimate from a report from the Carbon Trust[2] suggesting that the likely savings of system flexibility to the Grid at up to £40 bn by 2050. The Government has already proposed and consulted on a set of standards for energy smart appliances which hold the greatest potential for flexibility, including batteries, heat pumps, underfloor heating and electric storage heaters, with the option to extend to other heating appliances in the future.

By incorporating these appliances into new build homes there are several benefits for both occupants and the grid, including reduced peak demand by incentivizing customers to use energy during off-peak hours via time of use tariffs, improved load balancing through the use of energy smart appliances and a potential reduction in household energy bills by up to £40 per year by 2030, and up to £190 per year by 2050, according to a 2019 report by the Committee on Climate Change[3].

With demand side flexibility such a key part of future homes in the UK, we welcome the introduction of the open-source flexibility module which will come out alongside SAP 11. However, we recommend that a parallel operation should take place in conjunction with this which allows manufacturers and build upon that module. Within a minimum three year commercialised 'closed box' window, the best of the core features built within this parallel operation can be assimilated into core SAP. This encourages manufacturers to innovate and refine their energy management offers and build their commercial propositions for new build homes around the carbon benefits they attract within SAP compliance.

Overall, energy smart appliances and time-of-use tariffs can provide several benefits to the electricity grid, helping to ensure a more reliable, sustainable, and efficient energy system. However, for these to be utilised across the new build industry to create futureproofed dwellings which support the greater net zero ambition, Part L, and by extension SAP 11, needs to support the use of these technologies within compliance procedures.

[2] Key findings - Flexibility in Great Britain - The Carbon Trust
[3] Electrification of Heat UK demonstration project - Energy Systems Catapult

Overheating

Cooling strategies which balance Part L, Part F and Part O compliance.

Key Government Recommendations

- MVHR with summer bypass functionality should be identified and assessed for functional performance within the PCDB for MVHR.
- A SAP convention (Appendix Q) should be created for ceiling sweep fans and reversible air-to-air heat pumps to allow for specification as an overheating mitigation strategy, alongside a test and rate regime linked to the Product Characteristics Database. Only rated units to a minimum agreed specification should be approved for overheating strategies.
- Dynamic thermal modelling guidance should be revised to recognise and establish criteria for ceiling fan strategies and air-to-air heat pumps.

Since the introduction of Approved Document O in 2021, overheating within new residential developments has been brought into the spotlight. However, there has been difficulty for developers and housebuilders in balancing the new requirements under Part O with those of Part L and Part F. This has been particularly challenging in the high risk areas, such as Southern and South Eastern regions, with London and Gatwick being particular overheating hot spots. These risks are increased when there are constraints to opening a window due to noise, air pollution or security issues.

Those involved in the design of new dwellings are keen to keep internal temperatures comfortable. If we assume a comfortable temperature during the day is 21°C in habitable rooms (reducing to 18°C in sleeping areas), the challenge is to reduce the comfort gap between the ideal and the actual temperature.

What options are there for low carbon, energy efficient active cooling?

For the purposes of this paper, we assume that a housebuilder has made the maximum provisions for good site selection to avoid environmental risks, orientation, solar shading, low G-value glazing and the internal heat gain reductions, such as merging of living rooms and kitchens. Their contribution to lowering overheating is demonstrated via dynamic thermal modelling, determining the cooling requirement and performance rating against comfort temperatures. But what are the options if a development needs intervention beyond passive measures? We have review three active methods of cooling which fall into a specific hierarchy, driven by what we believe is the direction of travel for Future Homes.

Whole house balanced mechanical ventilation with heat recovery (and summer bypass)

Given that the fabric standards of the Future Homes Standard will begin to steer specification towards mechanical ventilation, MVHR with summer bypass capabilities can offer a noticeable thermal comfort benefit to a new dwelling. Summer bypass allows air to physically bypass the inbuilt heat exchanger (which help to reduce waste heat in winter) whilst maintaining sufficient air flow to expel excess heat. However, MVHR with summer bypass is not currently reflected within compliance procedure and units must be specified at the design stage to meet a sufficient flow rate to remove excess heat. Contribution of this solution to reducing overheating risk should be assessed in the context of dynamic thermal load modelling and, through a suitable convention, SAP.

There are various methods of providing a bypass function with MVHR:

- Modulation that relates the desired comfort temperature set point to the actual outdoor/indoor temperature. These units may incorporate a boost supply function during cooler periods of the day, which is important when considering that overheating will be most acutely felt by homeowners during sleeping hours.
- Summer slowdown, reducing the volume of 'tempered' air (i.e. still passing through the heat exchanger) into the dwelling. Unit bypass activated by pre-set outdoor temperature signal. Automatic temperature point summer bypass providing a physical bypass to the heat exchanger, providing air volume flow at sufficient levels. Unit bypass is activated by an automatic external temperature point e.g. 21°C.

Ceiling (or sweep) fans

Beyond utilising the existing ventilation strategy for comfort cooling, the UK should look to warmer climates for their solution to overheating. Studies in the USA[4] and Australia[5] have estimated the comfort cooling impact of ceiling fans to be anywhere between 1°C and 4°C.

Ceiling (or sweep) fans focus on cooling the person, not the space, due to perceptive cooling due to the body's reaction to the sweep effect – that is direct air flow causing sweat to evaporate from the skin, helping the occupant to feel cooler. The impact of this will be driven by the number of fans, the fan size (900mm-1400mm) and air speed (0.55m/sec – 0.77m/sec), which can be calculated from the floor area of each habitable room.

In the UK, policy generally dismisses ceiling fans due to the lack of mass market deployment, linked to historic climatic conditions. However, the technology has a very clear functional correlation to overheating strategies and with operational consumption generally below 4W (due to the use of EC motors), presents a low active kWh demand profile. As with MVHR, performance and cooling benefit will be determined by dynamic thermal modelling and SAP.

Reversible air-to-air heat pumps

Air-to-air heat pumps are normally specified to meet a dwellings heating requirements and will have an increasingly important role to play in future homes, This is because they are a flexible, space heating solution where there is a low dwelling heat load and separate hot water strategy, such as domestic hot water only heat pumps.

When specified as a revisable heat pump which can provide active low carbon, comfort cooling, air-to-air heat pump units should not be sized for the potential coolth load, but rather to meet the heat load, whilst being capable of providing a cooling service in extreme overheating circumstances.

However, the consumption of a typical reversible heat pump will increase by a factor of four in cooling mode. Therefore, its consumption profile must be modelled within SAP for estimated 'peak cooling load' periods as defined by Dynamic Thermal Modelling linked to propensity for overheating rather than general comfort cooling preferred by householders.

The latter will always be difficult, if not impossible, to define in real use. Without a common and regulated means of allowing for energy efficient, environmentally conscious active cooling in extreme circumstances, there is an increased risk of portable unit deployment or post completion installs which do not have the ability to comply with minimum performance standards (set by regulations and SAP). These can contribute to heat loss through poor air permeability after by perforating a hole within the building fabric. As with the previous solutions, Dynamic Thermal Modelling is required along with a method of identifying unit performance in cooling mode.

[4] Cooling energy savings and occupant feedback in a two year retrofit evaluation of 99 automated ceiling fans staged with air conditioning – ScienceDirect
[5] The potential for indoor fans to change air conditioning use while maintaining human thermal comfort during hot weather: an analysis of energy demand and associated greenhouse gas emissions - The Lancet Planetary Health

Cost of electricity

Ensuring compliant homes are affordable to operate.

Key Government Recommendations

- The Department for Levelling Up, Housing and Communities should take an active role in HM Treasury’s pledge to rebalance the cost of energy, championing lower electricity costs to ensure newly constructed electrified homes are not penalised due to outdated energy policy and that short term running costs reflect long term societal costs.
- The Government's commitment to rebalance the cost of electricity and gas must be implemented and recognised in SAP and EPCs in time for Future Homes Standard implementation.

The introduction of the Future Homes Standard in 2025 is expected to end the use of fossil fuel heating within new build homes. This will pave the way for the electrification of heat, which offers building designers a range of low carbon and flexible solutions to create compliant healthy homes.

The Government has recently committed to rebalancing the cost of gas vs electricity. This is a very welcome development, however this future energy pricing policy must be reflected in SAP 11. If it is not reflected, it may be difficult to sell or encourage tenants into new homes due to EPC ratings and mixed messaging to potential occupants.

The current status of the energy market means that electrified dwellings will face a reputational barrier from consumers, as electricity is currently four times the price of natural gas. This will impact the demand for low carbon homes and increase the risk that new homes (even those built with highlight efficient heat pumps) may not offer the lower running costs expected from a new build development, especially if the occupant is used to having a natural gas boiler.

Although the cost of energy is not directly within the remit of the Department for Levelling Up, Housing and Communities (DLUHC), we strongly believe that they should be strong and vocal champions for the rebalancing of levies across electricity and natural gas, and the decoupling of electricity from that of natural gas prices.

Network impact

Connection and capacity consideration from the consumer unit out to the network.

Key Recommendations

- The Future Homes Standard should support the specification of technologies, such as heat pumps and smart electric storage heating, which are capable of providing flexibility through demand side response.
- Ensure that most new dwelling types can comply with the Future Homes Standard without the use of heat pumps for areas where connections by a DNO are not approved. This includes hot water only heat pumps and water-to-water heat pumps in apartments.
- The Department of Levelling Up, Housing and Communities, in collaboration with the Department for Energy Security and Net Zero, to commission an industry wide taskforce to review the challenges and barriers to the future of electrification in regards to electricity grid connection and capacity. This should include manufacturers, developers and DNOs.

The electrification and movement away from using natural gas and other fossil fuels in domestic properties will have a significant impact on the electrical infrastructure within our homes. The Future Homes Standard will see low carbon technologies such a heat pumps and whole house mechanical ventilation systems become more common place within new build houses at the same time that electric vehicle charging will become mandatory under Approved Document S.

This will add a significant load to the network and to domestic wiring systems. Single phase supplies and loading of these networks will be dramatically changed, especially as consumer patterns have altered with many people now working form their homes. Load balancing techniques through demand side response capabilities will be vital to alleviating some of this necessary but additional burden.

The Future Homes Standard should ensure that technologies which enables this flexibility as time of use tariffs become available are supported during the compliance procedure. This includes heat pumps and smart storage heaters. Without bringing this flexibility online, there will be increased pressure on the electricity grid, especially as the existing housing stock is retrofitted for net zero and more electric vehicles are purchased by occupants and charged at home.

A second key area to address to ensure the success of the Future Homes Standard is the ability for DNOs to respond to and approve new connection requests. As more new build developments, some of which will could be major large scale projects, turn to heat pumps to pass new build compliance there must be assurances that a response will be timely and barriers to approval removed. Where approval can not be granted, there must be provision within the Future Homes Standard to design a compliant dwelling without the requirement for heat pumps.

There are solutions which can help housing development and apartments in an area with limited grid capacity. These include creating low heat demand homes which contain a hot water only heat pump and air-to-air heat pumps or direct electric space heating; and, for apartment developments, using water-to-water heat pumps on an ambient loop which can significantly reduce central plant size due to reduced output requirements.

Even without the move to the Future Homes Standard there is a backlog of requests following a year of unprecedented demand for the connection of heat pumps and electric vehicle charging points. In one recent report, a spokesperson from the Energy Networks Association commented that "The industry has received 69GW of new connection requests in the year to October 2022 alone. That's an entire grid's worth of capacity in just one year."[6]

We also need a continuation of the change in the regulatory environment to better facilitate the transformational change to the network environment driven not least by the increase in peak demand from 65GW today to a potential 200GW by 2050. We strongly urge Government to use their position to support the industry, including manufacturers, developers and DNOs, to come together to collectively solve the challenges to network connections and electricity capacity.

[6] Centrica: DNOs are holding up EV and heat pump connections - Utility Week

Moving forward

As we look to build new dwellings under the Future Homes Standard, it is important that there is awareness of the types of solutions that are available to designers to meet the high carbon savings required to create zero carbon ready homes.

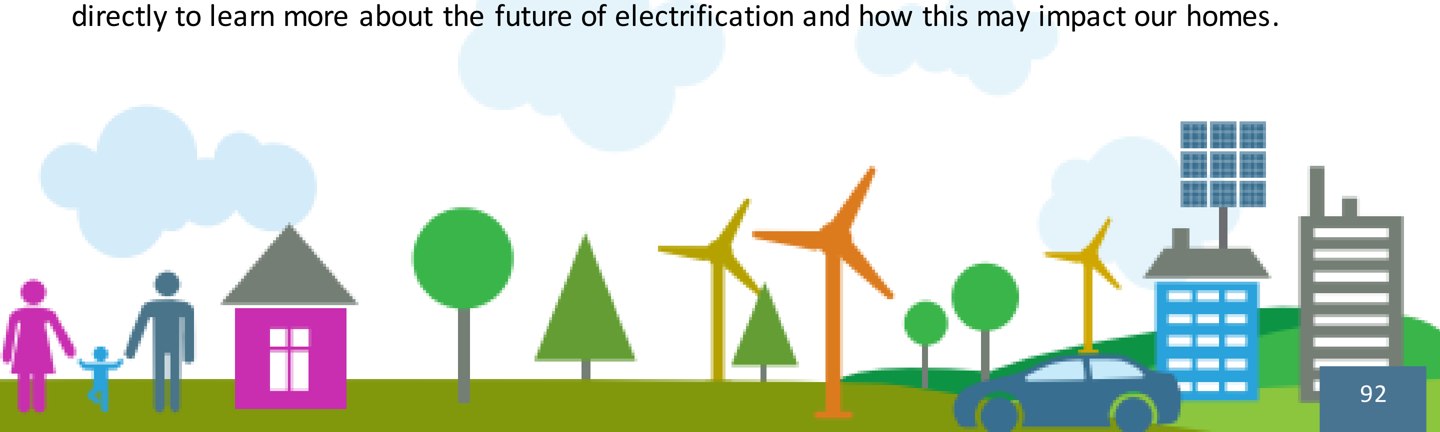
There is no doubt that we need to move to the creation of future-proofed homes which minimise unintended consequences on health and affordability. The electrification of heat is a clear and proven route to doing this, combined with a fabric-first approach to the energy strategy collectively with mechanical ventilation.

Moving to this approach will require a shift to thinking about building design and compliance holistically, considering solutions in terms of their application efficiency as part of a system rather than individual solutions. This will require a cultural shift from industry which we are already seeing from building designers, but, perhaps more importantly, increased flexibility and a target-based approach from Government and SAP as the supporting compliance system.

In this phase-one report, we have made several recommendations to Government on what they could do to support the progression of creating the homes of the future. BEAMA and our membership see these recommendations as key to realising the aims of the Future Home Standard and the creation of affordable, healthy homes. We would be happy to support Government in providing any further information which they may find useful before, during or after the Future Homes Standard consultation period.

This report is by no means the end to the impact assessment journey. Phase-two will begin once we have access to SAP 11 BETA software and sight of the Future Homes Standard consultation. We will be modelling our suggested technologies to obtain the technical data behind their use as compliant systems within feasible homes. We will also use this data to review broader technical impacts beyond compliance, such impact on the dwellings electrical systems and impact, on scale, on the electricity network.

We will also be turning our attention to the refurbishment market, looking at how future regulations and environmental targets may impact how we address the challenge of retrofitting the existing housing stock. We would urge anyone looking for more information, whether you work for the Government, a developer, specifier, or are an installer, to contact BEAMA or our members directly to learn more about the future of electrification and how this may impact our homes.



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