SUSTAINABILITY INITIATIVE

The Future Home Wrap-around Report 2: Heating Systems

THE FUTURE HOME
@ The University of Salford
BETTER WITH Bellway

Bellway's Future Home @ Energy House 2.0

THIS WORK WAS FUNDED BY THE INNOVATE UK: FUTURE HOMES ACCELERATOR

Bellway has laid the foundations for the future by building an experimental new zero carbon-ready home – The Future Home @ The University of Salford.

Designed, built and tested to be better for the people who live there and better for the environment, this ground-breaking research house is part of the Energy House 2.0 Project @ The University of Salford, in partnership with others – and will strongly influence how we use our homes in the future.

Construction of Bellway's dedicated test house, The Future Home, began early in 2022 and the official launch took place in January 2023, with testing beginning shortly afterwards. Bellway has gained many valuable lessons during the design, construction and testing process. This report covers the second set of research analysis – covering the performance of the electrical heating systems.

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HEATING SYSTEMS TESTING

IS BELLWAY'S FUTURE HOME @ ENERGY HOUSE 2.0 INDICATIVE OF THE HOME OF THE FUTURE?

The results of research into the performance of the fabric of Bellway's Future Home – aimed to accurately measure the 'as built' performance of individual building elements against 'design stage' assumptions – were published earlier this year[1].

This testing showed that Bellway's Future Home had verified fabric values that are a very close match to those published in the December 2023 Future Homes Standard (FHS) consultation. This means Bellway has been able to assess the performance of heating solutions within the same fabric as that which will be required to meet the FHS.

WHAT WAS THE AIM OF THE HEATING SYSTEMS TESTING?

The aim of the heating systems research is to identify the real-world operational running costs and efficiencies of heating systems. Perhaps the most significant impact of the Future Homes Standard will be the move away from fossil fuels – from gas boilers to electrical space and water heating. Bellway needs to fully understand the impact of this transition on customers' energy costs.

The unique nature of the Energy House 2.0 laboratory offers the opportunity to review multiple types of heating technologies alongside different combinations of controls and emitters within the same home under varying external temperatures, with the aim of identifying the most suitable solutions to create a comfortable and affordable environment for our customers – the Goldilocks Zone where everything is just right.

KEY CHALLENGES

So, how hard can it be to:

- **Design, install, connect and commission multiple heating systems into the same dwelling?**
- **Ensure an easy transition from one solution to another?**
- **Manage the testing regime to ensure tests are carried out in the same environmental conditions?**

These various challenges were met by the collaboration between Bellway, our supply chain partners, research partners and the academic team from The University of Salford – resulting in the findings published alongside this report.

A roof-mounted Air Source Heat Pump was trialled in The Future Home to consider the challenge of including ASHPs in homes where there is insufficient space to locate an external unit.

[1] Bellway "The Future Home" Baseline Performance Report (Fitton et al., 2024)

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WHAT SOLUTIONS WERE TESTED, AND WHY?

Two types of electrical heating solutions were tested. No gas baseline was considered, because the necessity of moving away from fossil fuels to electricity – both for Bellway's carbon reduction targets and for compliance with the FHS – made a gas baseline irrelevant.

The electrical heating solutions tested were:

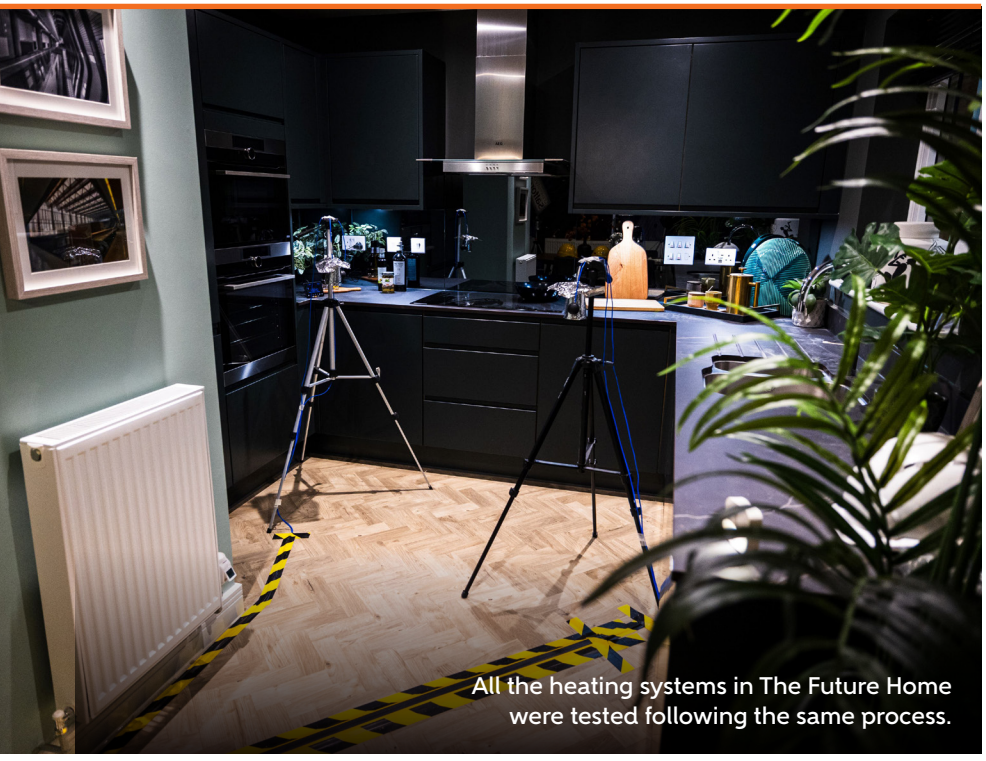
1. **Air Source Heat Pumps**
2. **Direct Radiant Heating**

AIR SOURCE HEAT PUMPS (ASHPS)

Two types of ASHPs were tested, a Monobloc and a Split system. Both systems work under the same principle. Heat from the outdoor air is absorbed in the outdoor unit by cool liquid refrigerant, which is passed through a heat exchanger into the heat pump, which transfers that heat to water in the heating system. The Monobloc system is contained within one single outdoor unit, while the Split system, as the name suggests, has one outdoor unit and one indoor unit.

The performance of ASHPs is measured by the **coefficient of performance (COP)**, which measures the heat pump's efficiency, indicating the ratio of heat output to the electrical energy input.

Emitters
Both traditional convection radiators and underfloor heating were installed, to enable a direct comparison of ASHP efficiency when connected to either type of emitter. The design temperature flow was the same for each option, with radiators installed to both the ground floor and first floor, and an underfloor heating loop installed in a screed applied to the ground floor only. ASHPs operate with the water in the heating system at a much lower temperature (45°C) than gas boilers (around 80°C) – consequently the radiators are larger than those for gas boilers.



All the heating systems in The Future Home were tested following the same process.

INFRARED RADIANT HEATING

Radiant heating systems supply heat directly via wall or ceiling panels. This radiant heat is transmitted though electromagnetic waves. When these waves meet objects within a room, they are converted into heat which warms the space, similar to clothes absorbing the light energy from the sun.

TESTING CONDITIONS AND HEATING PROFILES

All the heating systems were tested following the same process: at 5°C (indicative of the average wintertime temperature in the UK) and -5°C (indicative of the more extreme low temperature that can be experienced in the UK). Two heating profiles were tested:

- SAP pattern – heating on between 7am and 9am and between 4pm and 11pm, with the living room set at 21°C and the rest of the home at 18°C. This is the heating profile assumed by the Standard Assessment Procedure (SAP) which creates Energy Performance Certificates (EPCs) for homes.
- Constant – heating set to a constant 21°C in the living room and 18°C for the remaining rooms for a 24-hour period.

WHAT WAS LEARNT?

FURTHER TESTING TO LOOK AT ALWAYS-ON HEATING AT VARIED TEMPERATURES

The actual heating pattern in a home will be particular to a customer's behaviour and a family's profile may differ to that of a couple or a single occupancy home. The SAP profile gave better running-cost outcomes, with the constant profile giving the highest tested COP. Further research will look at a combination of the two profiles, with the heating on constantly but at a temperature of 15°C during the night and unoccupied daytime hours, and an increase in comfort levels at times of higher occupancy.

AIR SOURCE HEAT PUMPS CAN COST AS LITTLE AS £1.84[2] A DAY TO HEAT A HOME

It is thought that use of Monobloc systems will be more prevalent as the FHS comes into effect, due to the low number of registered F-Gas certified engineers in the UK (who are required to install the pipework between the outdoor and indoor units of a Split system). The house type constructed in the chamber lends itself to the Monobloc as it has both the external location for the heat pump and the internal space to locate a cylinder. The results of testing on the Panasonic Monobloc ASHP are in line with expectations. The measured COP across both heating profiles ranges from 2.5 to 3.7 at 5°C, giving a heating cost as low as £1.84 per day at 5°C with an intermittent pattern.

One of the challenges to overcome is the inclusion of an ASHP into homes where there is insufficient space to locate an external unit. Working with Worcester Bosch, Bellway included a roof-mounted Split ASHP as a 'can we do this?' scenario. The answer is that roofs can indeed be designed to incorporate a heat pump unit, and the unit can be connected to both the heating emitters and the hot water cylinder. The Worcester Bosch unit was a late inclusion to the project, and improvements to the location of the heat pump unit, the air flow around the condenser unit and the overall configuration of controls have been identified. Further work is now required to improve efficiency.

Monobloc ASHP systems are contained within a single outdoor unit. It is thought that this type of system will be more prevalent as the Future Homes Standard comes into effect.

COMBINATION OF RADIATORS AND UNDERFLOOR HEATING WORKS WELL

Control of the heating was via either the Panasonic or Worcester Bosch indoor control panels with the Honeywell Evo Homes digital thermostatic radiator valve (TRV) heads controlling individual room temperatures.

The relatively quick response time of the traditional convection radiators throughout resulted in the lowest recorded running costs under the SAP heating pattern (at 5°C), with the combination of underfloor heating to the ground floor and radiators to the upstairs rooms resulting in the highest recorded COPs in both heating patterns (at 5°C). The ability for a highly insulated ground-floor slab to absorb, retain and evenly distribute heat is a good match to the low-temperature, slow-response output from an ASHP. The conclusion here is that radiators to the first-floor rooms alongside an underfloor heating system to the ground floor results in a good outcome for our customers.

INFRARED RADIANT HEATING OFFERS A SOLUTION FOR FLATS AND MAISONETTES

Radiant heating systems give a developer the option to transition to electrical heating without the need to locate an external ASHP unit – something which is particularly relevant for flats and maisonettes. The Ambion system tested in Bellway's Future Home evidenced high levels of accuracy and control, as well as excellent comfort and responsiveness for the homeowner. The control system is specifically designed for infrared radiant heat and uses computer algorithms rather than thermostats to control the energy input. This means that the customer benefits from consistent even temperatures rather than a system that fluctuates above and below the required temperature. Running costs can be reduced with the introduction of time-of-use tariffs and solar PV. The test results suggest that the Ambion system would be an ideal solution for flats and maisonettes.

[2] Energy running costs were calculated using the Ofgem electric energy price cap of 24.50p/kWh for the period 1st October to 31st December 2024 (Ofgem, 2024)

NEXT STEPS

WHAT ARE THE NEXT STEPS?

The results of this testing will inform Bellway's basic design principles as well as being incorporated into the designs of Bellway house types to meet the FHS.

The heating designs tested were based around Bellway's view of best practice at the time of the design of The Future Home in 2022 and our knowledge of electrical heating has improved since then. The testing showed that with the ASHP Monobloc, set points were not met at -5°C under the SAP heating pattern, and a forensic review of heating designs and test methodology will be conducted to identify a root cause.

Other observations made by the university research team identified improvements that could be made to the configuration of the heating systems. These amendments have been carried out and are now in the process of being tested. It is thought that we will see further improvements to efficiencies and running costs from the same solutions, with the results of these supplementary tests to be published in a separate report once complete.

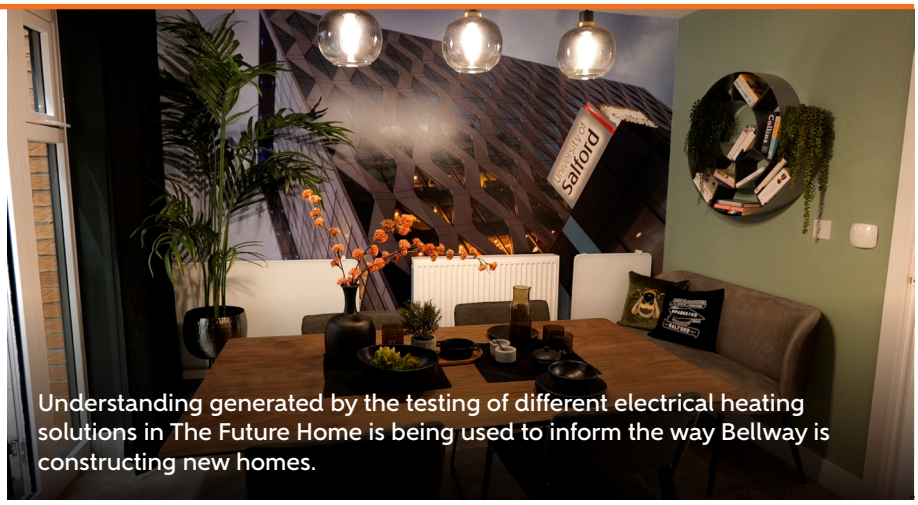
TRAINING AND CUSTOMER ENGAGEMENT

During this research project, Bellway has gathered valuable insight into electrical heating systems and identified areas where extra training and customer engagement is required. Our internal design teams must understand the various components of an electrical heating system and find space to locate them. Our plumbing contractors need to upskill to be able to install and commission ASHPs and our site management teams must understand what constitutes best practice. Most importantly our sales advisors and customer care teams need to understand how best to advise and help customers live with a low-temperature, slow-response heating system.

Understanding generated by The Future Home is being used to inform the way Bellway is constructing new homes, with 13 exemplar homes being built at developments in Callerton, Bolton, and Stafford. 11 of these are now complete.

Elements of The Future Home learning have been incorporated elsewhere with ASHPs to be trialled at sites in all of Bellway's 20 operational divisions, with ASHPs installed at 163 plots in the full year 2024. More than 1,400 further plots are confirmed. Bellway has also started construction at several 'no gas' developments, where ASHPs will be installed at every plot. These are in Cambridgeshire, Suffolk, and Northumberland.

Bellway is also using what it has learned to create a Future Hub – four exemplar plots at its Barton Quarter development in Bolton, which are being used as a Future Homes Standard training hub.



Understanding generated by the testing of different electrical heating solutions in The Future Home is being used to inform the way Bellway is constructing new homes.

REFERENCES

Fitton, R., Diaz, D. H., Farmer, D., Henshaw, G., & Sitmalidis, A. (2024). Bellway "The Future Home" Baseline Performance Report. 06.

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