eHome2

Summary of Key Findings from Phase 2 Research

HEATING SYSTEMS

BARRATT DEVELOPMENTS PLC

University of Salford MANCHESTER

SAINT-GOBAIN

BACKGROUND

Energy House 2.0 is a specially-built climate chamber that will recreate temperatures ranging from -20˚C to +40˚C, as well as simulating wind, rain, snow and solar radiation.

We can test the house in temperatures that would normally be representative from Nordic to African climates. The Energy House 2,0 chamber can simulate the weather conditions in 95% of the world's current climates, as well as the climates predicted in the future.

The climate chamber is the largest of its kind in the world.

This is important because climate change will mean in the next 20, 50 and 100 years, we will see extreme weather events become much more common and last for longer periods of time. We will also see a rise in average temperatures.

The Energy House 2.0 chamber enables testing that helps to futureproof homes and the products that are built into them, using a real-life model and controlled climates. This enables Barratt, Saint-Gobain UK and Ireland, and the wider housebuilding sector, to understand how to optimise design and construction to create a comfortable, affordable and sustainable home.

The Future Homes Standard (FHS) and Scottish equivalent to the Passivhaus Standard - a set of regulations that will be implemented in England, Wales and Scotland from c.2025 - will ensure new homes use low carbon heating and hot water systems and world-leading levels of energy efficiency through the use of high-performing building fabrics.

eHome2 goes beyond the proposed Future Homes Standard and is an important step to ensuring that future housing can be delivered whilst maintaining high standards of design and comfort at affordable prices for consumers.

This work was funded by the Innovate UK: Future Homes Accelerator.

This is the largest piece of research carried out in the world on electrical heating systems under controlled conditions.

UNIQUE AND INDEPENDENT RESEARCH

The Energy House 2.0 is supported by a team of academic and technical experts who work across the fields of building physics, smart energy systems, data analytics and renewable systems, and have a globally-unique research capability in assessing buildings under controlled conditions.

The research analyses the performance of different heating systems installed in eHome2, so that housebuilders can understand which would be best to install in the homes that are built now and in the future.

Multiple heating systems were installed in eHome2 - more than would be installed in a typical home – to enable the research team at Energy House 2.0 to quickly and easily switch between systems for the different experiments.

The heating systems were selected and installed by Barratt Developments and Saint-Gobain, and their partners.

The research team had no input on the design of these systems and were focussed only on the measurement of their performance.

TEST CONDITIONS

The research considers two different heating patterns:

- 24-hour constant heating
- A typical consumer heating pattern (SAP) of 07:00-09:00 and 16:00-23:00

The conditions in the eHome2 and the Energy House 2.0 chamber:

- The temperature in the Living Room was set to 21 °C and all other parts of the home were set to 18 °C
- All methods of heating the home were measured in the same chamber conditions reflecting typical winter (5 °C) and more extreme winter (-5 °C) temperatures in the UK

The following conditions were followed for all tests:

- All external doors and windows were locked and shut throughout testing
- Internal doors were closed during the heating system tests
- All lighting and appliances were turned off for the duration of the tests
- Measurement equipment was powered by an external source
- The building was unoccupied

The research at Energy House 2.0 allows for a comparison between heating technologies at constant extreme temperatures, which up to this moment has not been possible and represents unique research.

Please note: SAP stands for Standard Assessment Procedure, which is the Government's method for calculating the energy performance of a home and its heating system.

KEY FINDINGS

Primary Heating System

- Air Source Heat Pump (Model: Valliant aroTherm Plus 5Kw monobloc)

Heat Emitters:

- Thermaskirt (BM2 and BM3 heated skirting boards)
- Bathroom Towel Radiators (Stelrad Home Classic White)
- Infrared Heating Panels (Curv wall mounted, with Loxone controls and room temperature sensors in each room)
- Heating controls powered by a Loxone Building Management System

Heat Pumps

- The exterior heat pump performed well and was the most effective system. It had the capacity to meet the space heating demand for the property.
- The heat pump's Co-efficient of Performance was 2.6 when it was used constantly and when the temperature in the chamber was 5°C.
- In test conditions, the heat pump cost £2.83 a day to run constantly in the average 5°C winter temperature.
- It could have performed even better if there was a more effective commissioning of the system.

Heat Emitters

- The heat emitters underperformed compared to expectations, particularly at the lower chamber (-5°C) temperature which simulated extreme winter conditions.
- When the chamber was set to the simulated winter temperature of -5°C, and the heating was on constantly for a 24-hour period, the ThermaSkirt system was able to achieve an average temperature of 18°C (3°C below the target temperature) in the living room. All other rooms in the house were able to achieve a range of 1.3°C of the target temperature of 18°C.
- At -5 °C When the heating was set to come on for 2 hours in the morning and 7 hours in the evening, the performance of ThermaSkirt was considerably worse. The living room achieved a maximum temperature of 12°C in the middle of the room, while all other rooms also failed to meet the target temperatures. Instead, temperatures ranged between 10-17°C. The exception were the WC and Bathroom, heated by traditional heated towel rails, which were within 1°C of the target temperature.
- The Infrared heating panels proved to be the least efficient. While they heated the rooms up quicker, they were more expensive to run and showed large differences in room temperatures, with higher temperatures recorded near to the panels and significantly lower temperatures in the middle of the room.
- At -5 °C When the Infrared heating system was on constantly during the 24-hour period, it underheated the living room by 2°C, while other rooms were either within 1°C of the target temperature or overheated by up to 2°C. There was considerable variation in temperature of the air in the living room from 21.1°C near to the panels compared to 17.1°C in the middle of the room.
- At -5 °C When the Infrared panel heating was running for 2 hours in the morning and 7 hours in the evening, the living room achieved a maximum of 15.1°C near to the panels and 11.5°C in the middle of the room. Other rooms showed considerable variations in temperatures within the rooms depending on the closeness to the panel.
- It is firmly believed that the underperformance of the ThermaSkirt and Infrared panel heating systems can be attributed to the system design being under-sized for the rooms, rather than any inherent issue with the system technology.

Summary Performance at 'Extreme Winter Conditions' – Chamber at -5°C

-5C	LIVING ROOM (AVERAGE)	BEDROOM 1 (AVERAGE)	HEAT UP RATE	COST PER DAY
Wet Systems (Thermaskirt and ASHP) (Constant heat)	17.6 - 19.7C	18.3 – 19.4C		£5.51
Wet Systems (AM / PM Heating periods)	10.2 -11.9C	11.2 – 12.2C	0.45C per hour	£4.30
Infrared (Constant heat)	17.1 – 21.1C	17.7 – 19.9C		£13.66
Infrared (AM / PM Heating periods)	11.5-15.1C	14.1 – 17.3C	0.69C per hour	£8.88

Summary Performance at 'Winter Conditions' – Chamber at 5°C

5C (AIR)	LIVING ROOM (AVERAGE)	BEDROOM 1 (AVERAGE)	HEAT UP RATE	COST PER DAY
Wet System (Constant heat)	21.8 – 23.4C	18.5 – 19.3C		£2.83
Wet Systems (AM / PM Heating periods)	17.6 – 19.1C	17.8 – 18.7C	0.44C per hour (Living room)	£2.31
Infrared (Constant heat)	20.7 – 24.6C	18.3 – 19.6C		£8.10
Infrared (AM / PM Heating periods)	17.1 – 21.1C	17.7 – 19.9C	0.62C per hour (Living room)	£6.72

Lounge with ThermaSkirt & Infrared Radiator

KEY LEARNINGS

- The learnings from the earlier Fabric research and this Heating system report identify significant areas, when using new technology, which require consideration early in the design process in a way that differs to how we design and build houses today.
- More thought needs to be given to balanced and co-ordinated design between key design areas to ensure the house consumers receive is comfortable and cost effective.
- A high-performing fabric is essential to give confidence that the building will perform as designed and allow heating design to take place with a high degree of design vs performance confidence.
- The testing revealed that larger heat emitter designs could produce better results
  - For example, by using the larger three pipe version of ThermaSkirt, rather than a two pipe system, the heat outputs can be increased.
  - Further testing of the three pipe version of the thermal skirting board is taking place.
- Also, to achieve consistent temperatures throughout rooms, It is recommended that Infrared panels are placed close to an object such as a sofa, so that they provide optimum heat.
- The capacity of heating systems to maintain internal temperatures when exposed to periodic extremes of external temperatures is a key area to explore further.
- Barratt acknowledges that there also needs to be an investment from housebuilders and suppliers to support consumers to understand how to adapt to the new electrified heating systems that the Future Homes Standard will bring.
- The most common method of heating homes in the UK - gas boilers - are designed to reach temperatures of up to 70°C quickly and be used for short periods of time that fit around the typical consumers' lifestyle (morning and evening heating).
- The electrified heating systems performed poorly when used in this way, but achieved better results when used constantly.
- Equally, there needs to be an investment by the housebuilding sector in green skills and training that is so essential to delivering new lower carbon, electrified heating technologies.

Heat Pump

ThermaSkirt

Infrared Radiator

SPOTLIGHT ON HEATING INNOVATIONS

Vaillant aroTherm Air Source Heat Pump

The primary source of space and hot water provision is provided by a monobloc air to water heat pump system. This is a Vaillant aroTherm Plus 5 kW running on R290 refrigerant (propane), this specification will typically provide 6.4 kW of heating with a COP of 4.07 at an outside air temperature of 2 °C, with a hot water flow temperature of 35 °C.

Vaillant offers its customers worldwide energy-saving heating and hot water systems that increasingly make use of renewable energies. Its product portfolio encompasses high-efficiency boilers, heat pumps and large output boilers for light commercial use as well as a range of intelligent controls, hot water cylinders and accessories.

"With the Future Homes Standard coming in 2025, the Energy House 2.0 was an essential project towards proving the importance of high-quality system design and installation when decarbonising homes with heat pumps. The project has allowed Vaillant the opportunity to work closely with Barratt Developments to design, install, commission and test a heat pump system in chamber conditions set between 5 °C and -5 °C.

Heat pumps are key to supporting the UK's net zero targets and it is fundamental to help battle the common misconceptions that heat pumps don't work in cold conditions. To increase consumer uptake in heat pumps and encourage engineers to upskill to install heat pumps to a high-quality, collaboration must continue across the supply chain.

"This report highlights the importance of good system design with the right sized components. At Vaillant we work with all our partners transitioning to heat pump technology, supporting with system design and training to provide the knowledge to ensure high performance and long-life heating systems."

Mark Wilkins, Technology & Solutions Portfolio Director at Vaillant

ThermaSkirt

Discrete Heat is a Manchester- based manufacturer of the patented ThermaSkirt – the skirting board that heats homes. First seen on BBC's Dragons Den, more than 80,000 ThermaSkirt systems have been installed on both boilers and heat pumps in the UK, and in many overseas countries including the USA, Canada, Australia, as well as Germany, France, Spain and Holland.

The unique system combines the hot water radiators into an aluminium profile, disguised to look like a traditional skirting board, and installed using its patented push fit connectors, brackets and clips. Distributing the infra-red radiant heat at low level and around the room, the system overcomes the comfort and aesthetic issues associated with oversized radiators and the practical issues in fitting underfloor heating into existing buildings or in suspended floors.

Available in a range of styles and colours, once installed the heating system becomes an invisible, integral part of the fabric of the house, saving valuable wall space and improving energy efficiency.

"Despite installing over 80,000 systems over 15 years, and with various independent tests by bodies in the UK, Germany, and Turkey, this is the first time that the ThermaSkirt system has been put through its paces and monitored in a 'real world' environment. Anecdotal evidence from thousands of customers on both boilers and heat pumps is great, but having the ability to control the climate, monitor the energy used and accurately measure the efficiency is a game-changer in the heating ecosphere.

We now know confidently what ThermaSkirt can achieve, and this has guided our future R&D programme to refine the product even further to meet the aspirations of both forward-thinking developers such as Barratt, but also policy stakeholders, as they seek to decarbonise the National Grid in pursuit of net zero. We are grateful to the University of Salford and to Barratt for its clarity of vision."

Martin Wadsworth, Managing Director, Discrete Heat

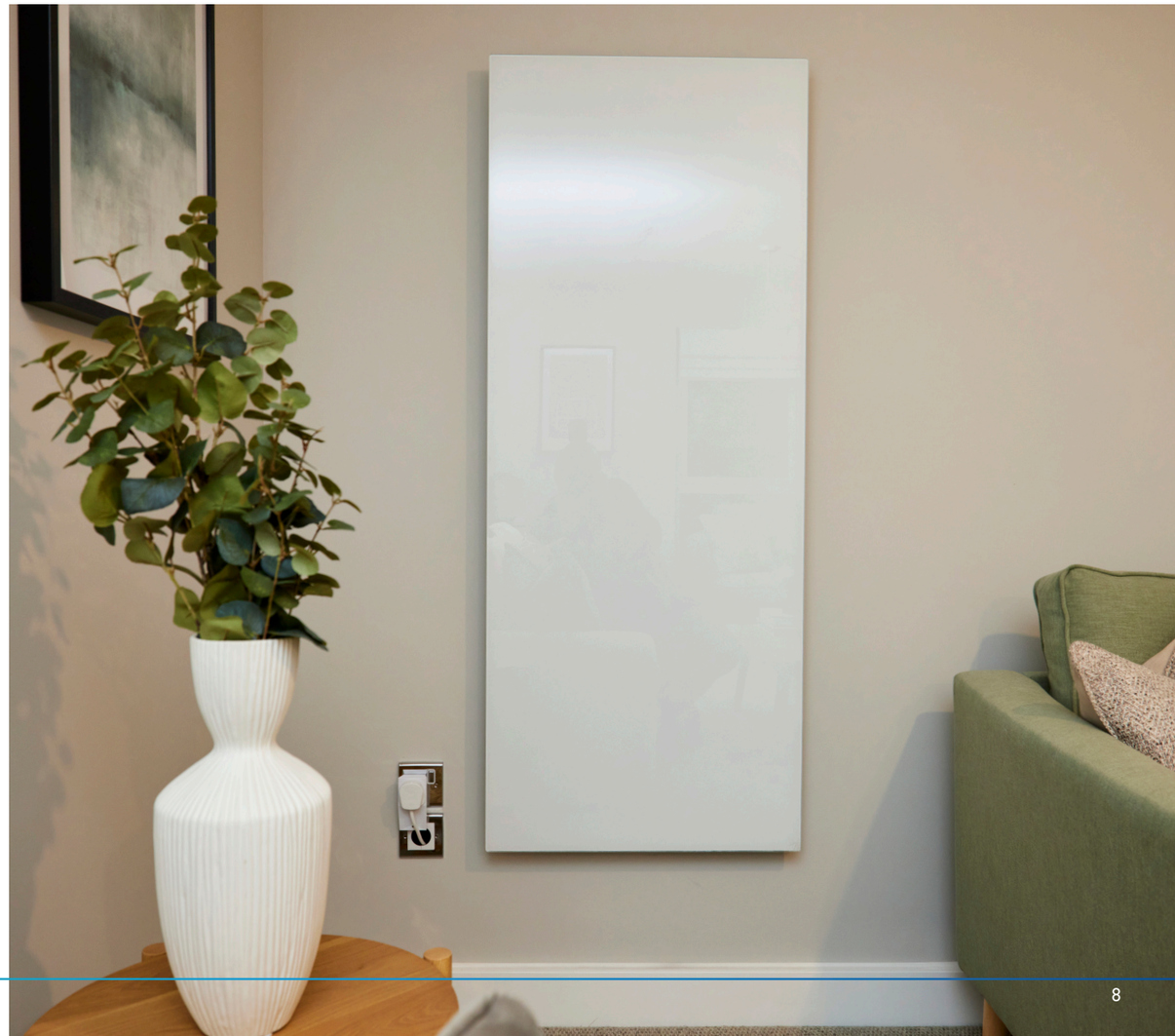
Curv Infrared Heating

eHome2 has an Infrared heating system installed by Curv. This system provides space heating and is controlled through the Loxone system with local temperature sensors in each room.

Project CURV is at the forefront of sustainable home technology, providing energy-efficient solutions designed for both new builds and retrofit properties. With a comprehensive "whole-of-house" approach, the product range includes infrared heating panels, air sourced hot water cylinders, in-roof solar systems, smart EV chargers, and off-peak battery storage devices.

"We are delighted with the outcomes from the trial. Our Infrared and hot water solutions demonstrated significant energy savings and enhanced efficiency, proving their potential to exceed the high EPC standards required for new builds and renovations. These results enable us to refine and optimise our offerings, ensuring homeowners receive the most efficient and sustainable systems available."

Simon Peat, Founder of Project Better Energy



NEXT STEPS

Zed House

In 2021, Barratt Developments partnered with over 40 innovative suppliers to design and build Zed House, a unique zero carbon concept home that showcases the future of the sustainable living in the UK. The Zed House, built on University of Salford's main campus, is the first home in the country to be built by a major housebuilder that goes substantially beyond the Future Homes Standard.

The home has delivered learnings about modern sustainable housing technology, such as an air source heat pump, infrared panels, plaster that eliminates pollutants, a fridge that keeps food fresh for longer, heated skirting boards, air-powered showers, electric vehicle charging points, PV solar panels and battery storage.

Learnings from Zed House were transferred to our products and methods of construction in the Energy House 2.0 project, which enabled us to further test emerging technologies and the fabric that we are using to build homes.

- Following the testing at Zed House and Energy House 2.0, we plan to swap some products to complete further testing, particularly focused on emerging technologies and we will continue to invest in R&D
- Infrared is being further researched to develop this for apartments around the country, in combination with Air Source Heat Pumps, as there is greater demand for hot water rather than heating in apartments.
- There are plans to include more FHS heating systems in more developments from 2025, which will include a combination of infrared heating, ThermaSkirt, Air Source Heat Pumps, and Solar Panels.

FUTURE ENERGY HOUSE 2.0 REPORTS

The next phases of testing will be:

- First quarter of 2025 – running costs of hot water
- Second quarter of 2025 – extreme climate testing and fabric upgrades

MAKING CONSUMERS COMFORTABLE

Making consumers more comfortable with emerging technologies is an essential part of delivering the FHS and delivering zero carbon homes. Barratt Developments held in-depth consumers research into new heating systems in summer 2024 at Zed House and Energy House 2.0.

To understand more about consumers' reactions to zero carbon homes, Barratt wanted to bring consumers face-to-face with both projects to delve into:

- Perceptions of homes built using modern methods of construction – concerns, questions, information needs and perceived benefits or drawbacks.
- Reactions to emerging technologies within the home.

Seven consumers gained an in-depth understanding of Zed House and Energy House 2.0, including first time buyers, second steppers and downsizers.

KEY FINDINGS FROM CONSUMER RESEARCH AT ZED HOUSE AND ENERGY HOUSE 2.0

Kenny, who is a second stepper: **"Looking at all of the technology across all of the buildings, although I loved all of the technology and how it worked and I'd love to have it in my house, my questions were around the practicality of it, living with day by day, the longevity of it."**

Tim, who is a later lifer: **"So, I've looked at some of the innovation that the various housebuilders are offering with their properties. And having looked at half a dozen now, I've got to say that what I've seen today with the innovation provided by Barratt Homes, I'm seriously blown away. I've got to say that it's a Barratt Homes site that I'll be going to have a look at in Leyland in Lancashire."**

Infrared Heating Panels

PERCEIVED BENEFITS

- Ideal for an elderly person who sits in one place for most of the day
- Mirror version was well liked

PERCEIVED DRAWBACKS

- Not aesthetically pleasing
- Heats just one area
- Limits ability to re-arrange furniture
- Nowhere to hang or dry clothing

INITIAL REACTIONS

- All respondents noticed the panel but did not know it's purpose
- All agreed it was not aesthetically pleasing and would not want one in their home unless it could be concealed better
- The mirror version was more appealing. However, most did not see the benefit and would rather have an alternative heating option, which heated the whole house i.e. underfloor heating

ThermaSkirt

PERCEIVED BENEFITS

- Heating all around the room – no cold spots
- More space to place furniture
- Visually concealed

PERCEIVED DRAWBACKS

- Safety concerns i.e. children touching them
- The finish - metal material is too shiny
- Nowhere to hang or dry clothing

INITIAL CONSUMER REACTIONS

- They were not obviously visible in the room, but when highlighted, they garnered high appeal
- Respondents liked that they are already built into the fabric of eHome2, so are not visually or physically disruptive to the room
- They were favoured by all over other heating options (particularly infrared panels) and would be something that consumers would be willing to pay more for

Air Source Heat Pump

PERCEIVED BENEFITS

- A good option given boilers will be phased out

PERCEIVED DRAWBACKS

- Not aesthetically pleasing

INITIAL REACTIONS

- Some members in the group already had an existing knowledge of ASHPs, but many had no knowledge of this feature and its function
- As a result, initial reactions were predominantly focussed on what the pump was and its functions
- Responses to the metal cover shown were positive as the visual appearance was a slight concern for some

Tom, second stepper: **"As soon as I heard about the ThermaSkirt, I was really impressed. I've never seen anything like it before. It's a real space saver."**

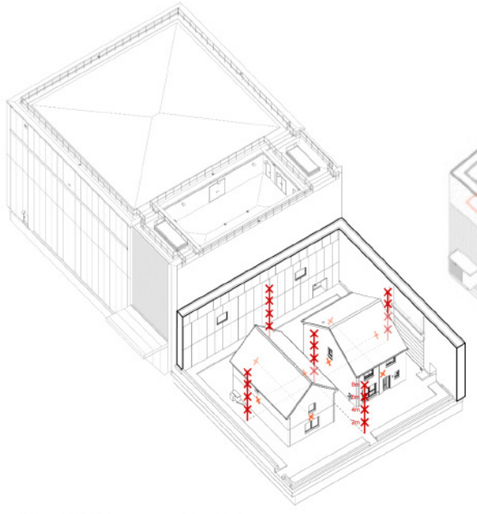
Jacob, first time buyer: **"So the ThermaSkirt heating is the best out of the all the heated appliances that I've seen about such an infrared. The infrared thing I'm not too sure about."**

Tim: **"The ones that have really ticked the box for me are the air source heat pump, which because of the limitation on gas and boilers for the future is something that we're going to have to do. It makes so much sense because it's a cheaper way of providing domestic hot water and heat in your house.**

"I think what fits in very nicely with that is the skirting mounted heating system as opposed to having radiators and that makes a lot of sense for me. And I think photovoltaic panels coupled with the real energy savings and a bonus if you could sell some back to the grid."

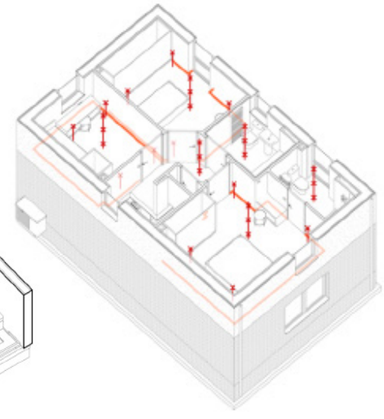
Jacki, who is a later lifer: "So if I'm thinking about the house that I would like, I would have both the ground source heat pump and the solar panels just to cover the weather and the differences between winter and heat equally."

Sensors in Chamber:



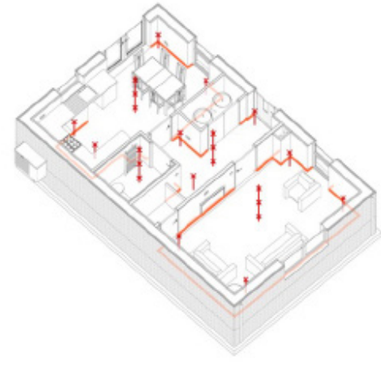
X HygroVUE 10 (temperature & humidity)
X HygroVUE 10 with radiation sealed on the facade

Heating emitters in eHome2 upstairs:



X Thermocouple
ThermaSkirt

Heat emitters in eHome2 downstairs:



X Thermocouple
ThermaSkirt

THE ONEAPP

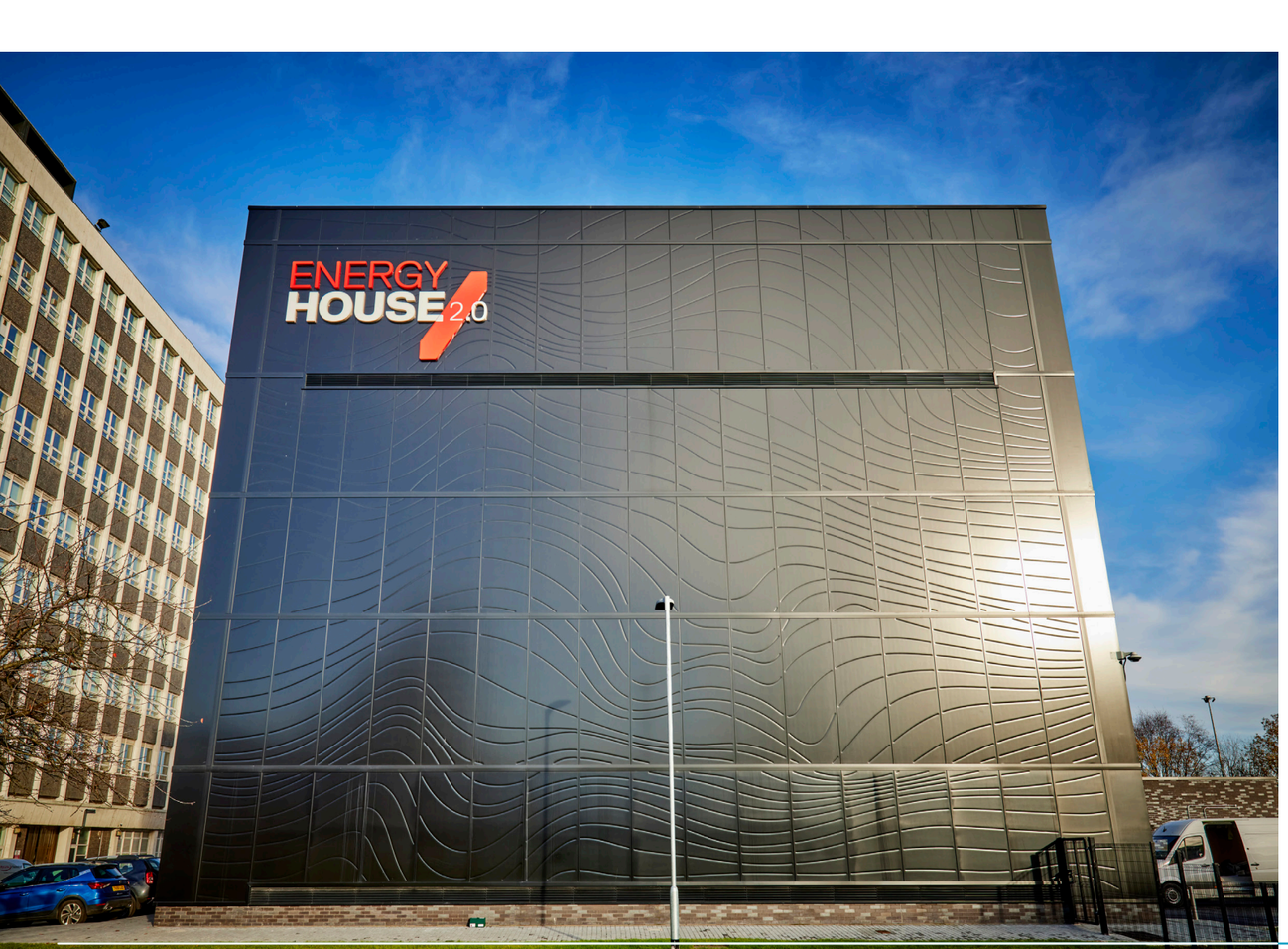
In 2023, Barratt Developments became the headline sponsor of the Friends of Energy House, the sustainability social impact fund. The fund supported a PhD student to carry out valuable research on the eHome2, which has been fed into this report.

In 2024, Barratt continued to be the headline sponsor and funded a new PhD programme to research how digital technology can support consumers in managing domestic energy systems. Its goal is to advance progress in reaching net zero ambitions, address the cost of living and streamline domestic energy management for the convenience of the consumer.

Known as **OneApp**, it is designed to take away consumers' concerns about managing new and unfamiliar technologies.

OneApp will be an energy-systems control app for Net Zero energy transition in Future Homes in the UK. This project will utilise data available through Internet of Things, cloud-based data, and the UK smart meter infrastructure to address challenges around how technologies and trends can be brought together for the benefit of consumers and Net Zero transition.

This project aligns with the overarching aim to support areas critical to the advancement of our national and global move towards net-zero, and additionally will include supporting activity around diversifying the green skills workforce and consumer education to support this.



ENERGY EFFICIENCY ON BARRATT HOMES & DAVID WILSON HOMES' DEVELOPMENTS

Delamere Park

Delamere Park was the first gas-free development built by Barratt. All 82 homes at the development in Frome, Somerset, have no gas supply or gas connection. Instead, they are fitted with an air source heat pump as standard. There is also electric car charging for every home.

Developments across the country now have Part L, low carbon emission features.

Pocklington

Wolds View and Stewarts Reach at Pocklington in East Yorkshire have the full complement of low carbon technology, including Air Source Heat Pumps, underfloor heating, and PV Solar Panels. These homes are designed to be up to 74% more energy efficient.

Rogerson Gardens

The Homes England site in Preston, formerly the site of Whittingham hospital, will have a total of 750 homes.

The first phase has 248 homes, with over half being either affordable or private rent. The homes are built using timber frame kits, built in our own factories.

The second phase will be built with timber frame kits, with wider walls with increased insulation. They will be highly energy efficient with Air Source heat Pumps, PV Solar Panels and mechanical ventilation.

To find out more about the Energy House 2.0 project, visit:
https://www.barrattdevelopments.co.uk/showcase/energy-house2
https://www.saint-gobain.co.uk/ehome2

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