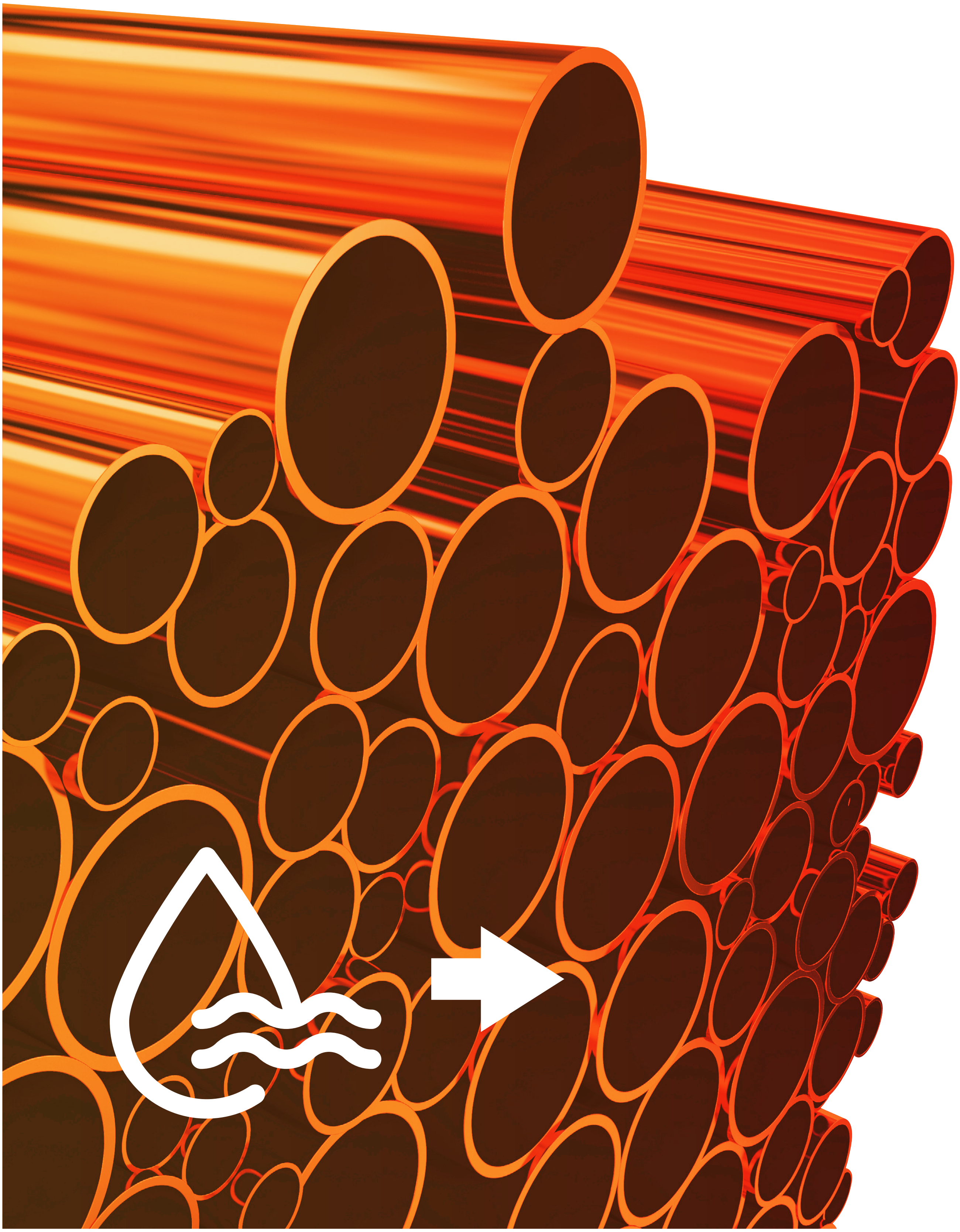
The Mitsubishi Electric Guide to

Residential Air Source Heat Pumps and Microbore Pipework

Guide

ecodan.co.uk



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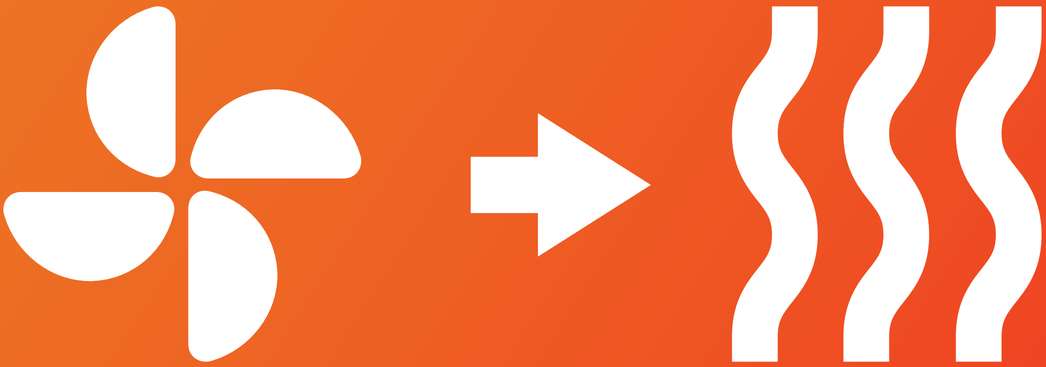


1

Introduction

The UK aims to reduce its reliance on gas boilers with an ambitious target to install **600,000 heat pumps annually by 2028**.

This is a critical element of the UK's mission to achieve **Net Zero greenhouse gas emissions by 2050**.

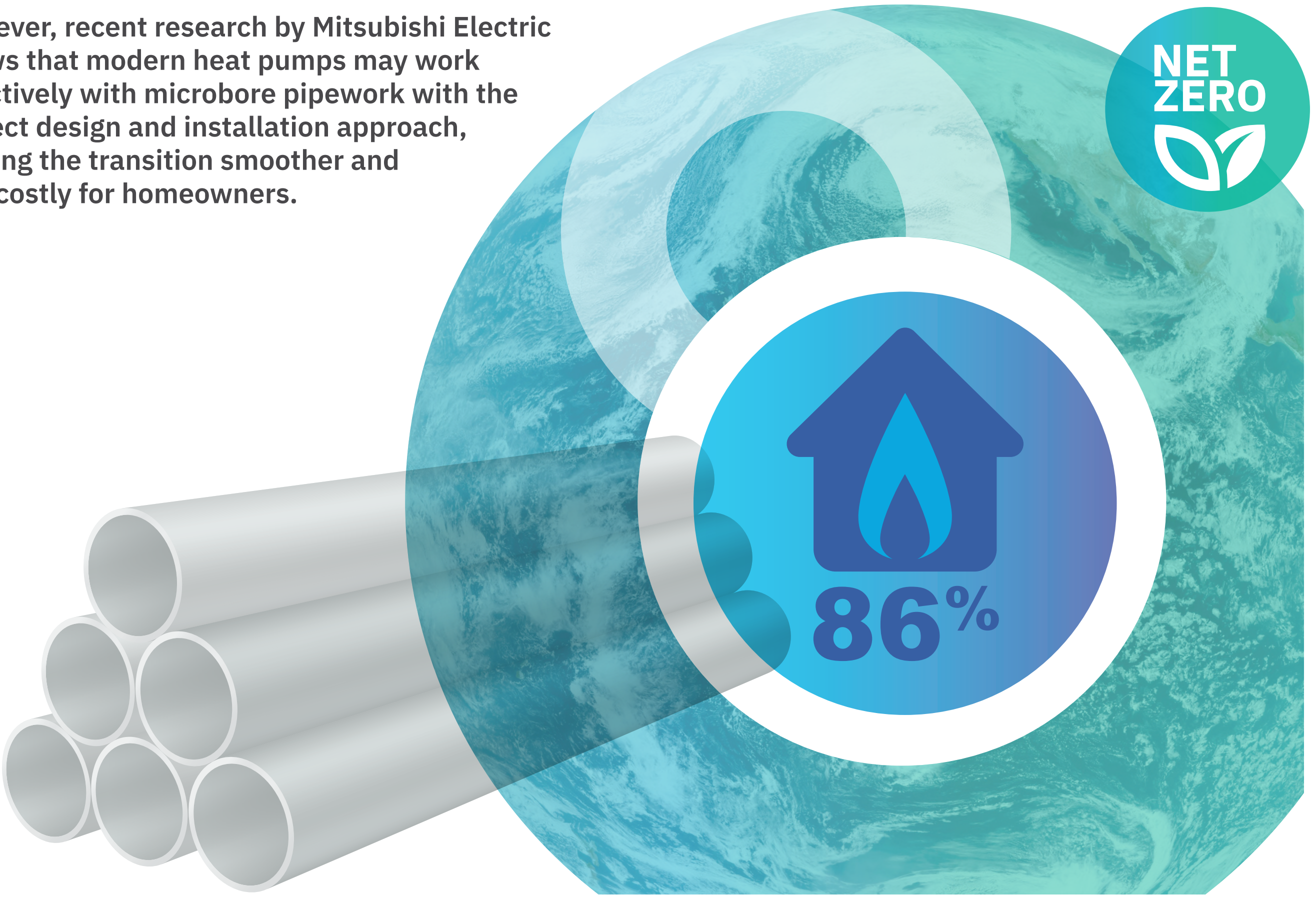
In 2022, the UK’s Climate Change Committee noted: [1]

> We cannot reach Net Zero if we continue to use gas for heat. Changing how we heat our homes and buildings is essential.

Around 80% of the UK’s existing homes will still be in use in 2050[2] and 86% of them use gas boilers[3]. So it’s vital that we tackle the retrofit challenge to make the transition to low-carbon heating.

One of the perceived hurdles to making this change is microbore pipework. This is common in houses built in the 1970s and 1980s and is present in about 4 to 5 million UK homes[4]. There has been a long-standing opinion in the residential heating sector that microbore systems are incompatible with heat pumps, requiring costly and disruptive replacements.

However, recent research by Mitsubishi Electric shows that modern heat pumps may work effectively with microbore pipework with the correct design and installation approach, making the transition smoother and less costly for homeowners.



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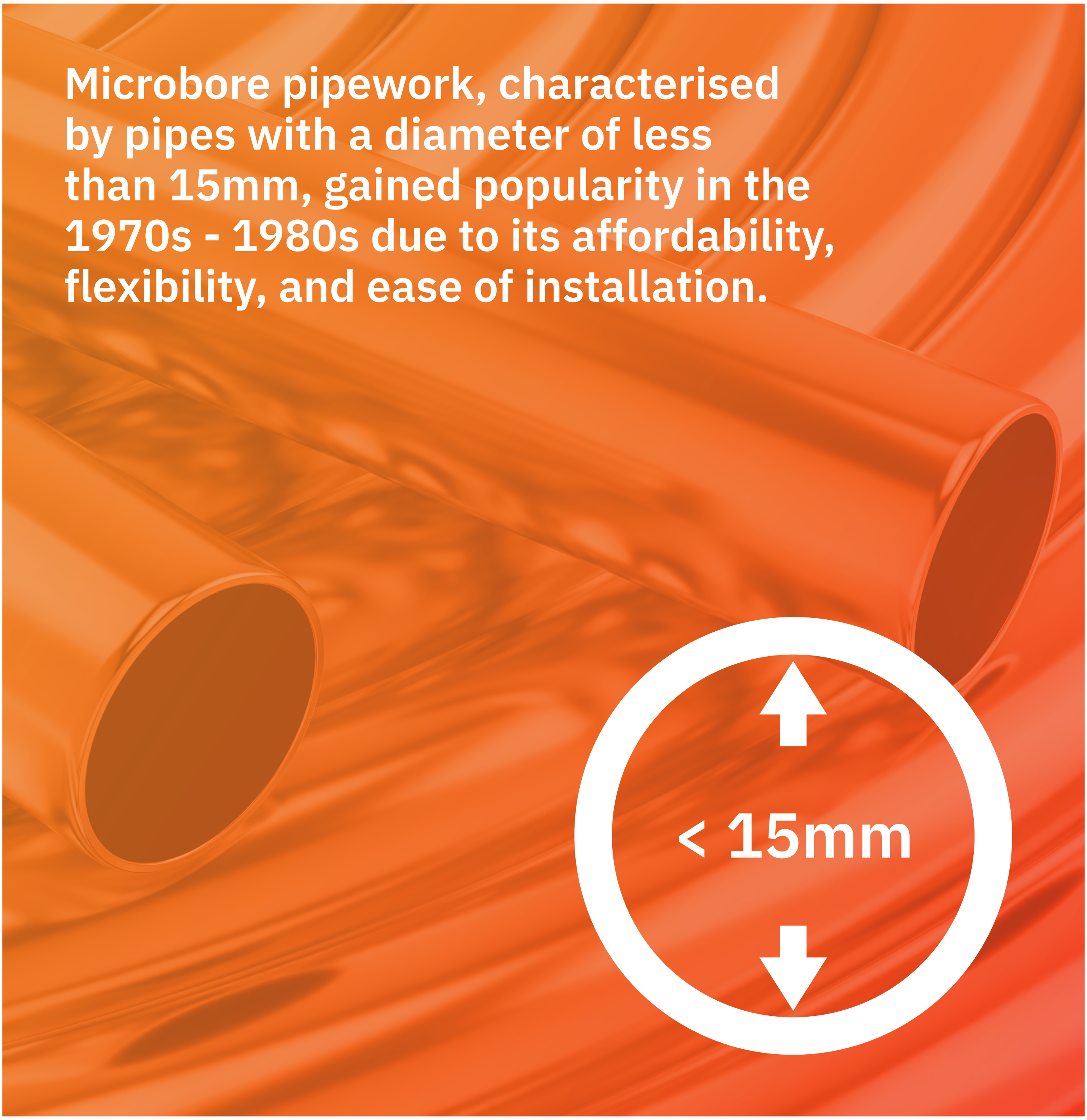
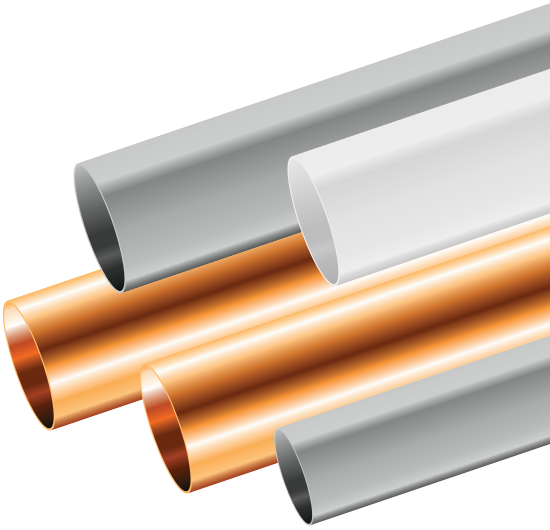
Microbore pipework - history and use



Microbore pipework, characterised by pipes with a diameter of less than 15mm, gained popularity in the 1970s - 1980s due to its affordability, flexibility, and ease of installation.



Initially, copper pipes were predominantly used, right up until the 1980s when microbore systems became widely adopted in new builds, thanks to their affordability, flexibility and ease of installation.

Today, plastic microbore pipes, which offer even greater flexibility and corrosion resistance, have revived interest in this system. Despite some historical limitations, such as blockages and reduced heat transfer, microbore therefore remains a viable option for gas boiler system installers, particularly in modern new-build homes.

The UK’s shift from gas boilers to air source heat pumps (ASHPs) raises concerns about the compatibility of microbore systems due to the different operating conditions.

For example, non-condensing boilers operate at higher flow temperatures and ΔT (Delta T, the difference between flow and return temperatures), while ASHPs typically operate at lower temperatures and smaller ΔT, which could impact the effectiveness of microbore systems.

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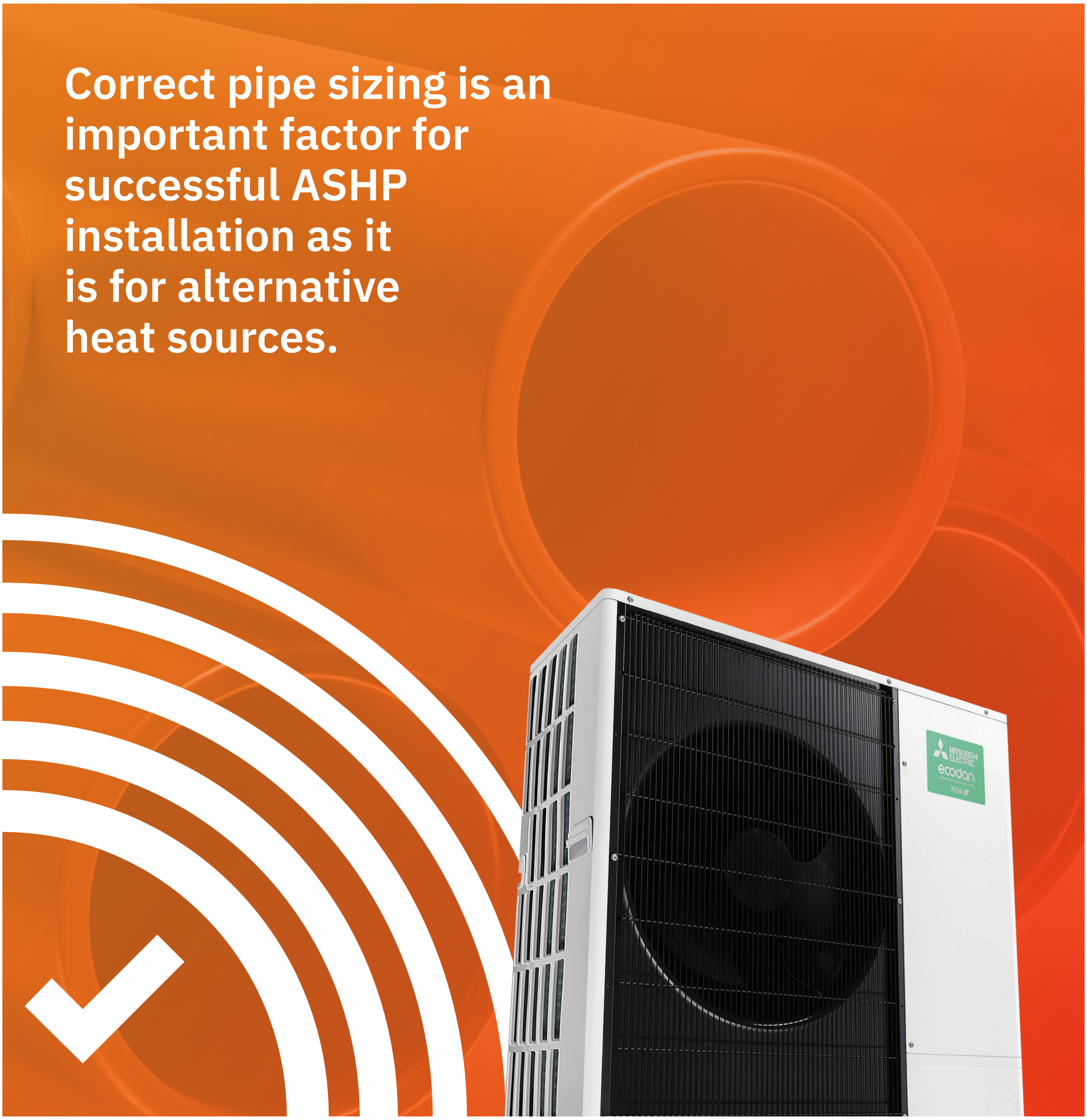
Pipework and air source heat pumps



Correct pipe sizing is an important factor for successful ASHP installation as it is for alternative heat sources.

The table below highlights the main issues caused by over- or under-sizing:

Oversized pipes	Undersized pipes
Increased installation costs due to larger pipes and fittings	Reduced heat transfer due to higher pressure drop and restriction of water flow rate
Reduced heat transfer due to lower flow velocities	Potential for noise and vibration due to higher flow velocities
Increased risk of sediment build-up and corrosion due to lower flow velocities	Increased strain and erosion due to higher flow velocities
Increased heat loss and energy consumption due to a larger pipe surface area	Higher energy bills due to non-optimal system operation
Higher energy bills due to non-optimal system operation	

So, pipe sizing is a key issue for successful ASHP installation, and it's one that can have a significant impact on residential heat pump retrofit projects.

With this in mind, Mitsubishi Electric conducted a study on the compatibility of microbore pipework with Ecodan air source heat pumps, aiming to determine whether the two systems can work effectively together. The key question was whether Ecodan heat pumps can match the operating conditions of microbore systems and what could otherwise be done to achieve compatibility.

The outcome of the study is that, with the correct design and installation, **Ecodan heat pumps can be integrated with existing microbore systems**. This can be achieved by matching operating conditions of the heat pump with those of the existing heat distribution system (e.g. pipes and emitters such as radiators, underfloor heating and fan-coils), particularly in terms of flow temperature and ΔT.

The table below shows that the **Ecodan R290 range** of heat pumps can match gas boiler operating conditions; hence, making it a suitable replacement. However, it is **crucial to assess its suitability based on specific heating requirements**. Factors such as flow rate, heat load, and compliance with CIBSE guidelines, including pressure drop and flow velocity limitations of 350 Pa/m and 1m/s, respectively, should be carefully considered to ensure optimal performance and efficiency.

Heat Source	**Operating flow temperature** (Gas boiler)	**Max flow temperature** (ASHP)	**Operating delta T** (ΔT)
Non-condensing boiler	≈ 75°C		≈ 10°C
Condensing boiler	≈ 70°C		≈ 20°C
Ecodan R32 air source heat pump		≈ 60°C	≈ 5-10°C
Ecodan R290 air source heat pump		≈ 75°C	≈ 3°C - 20°C

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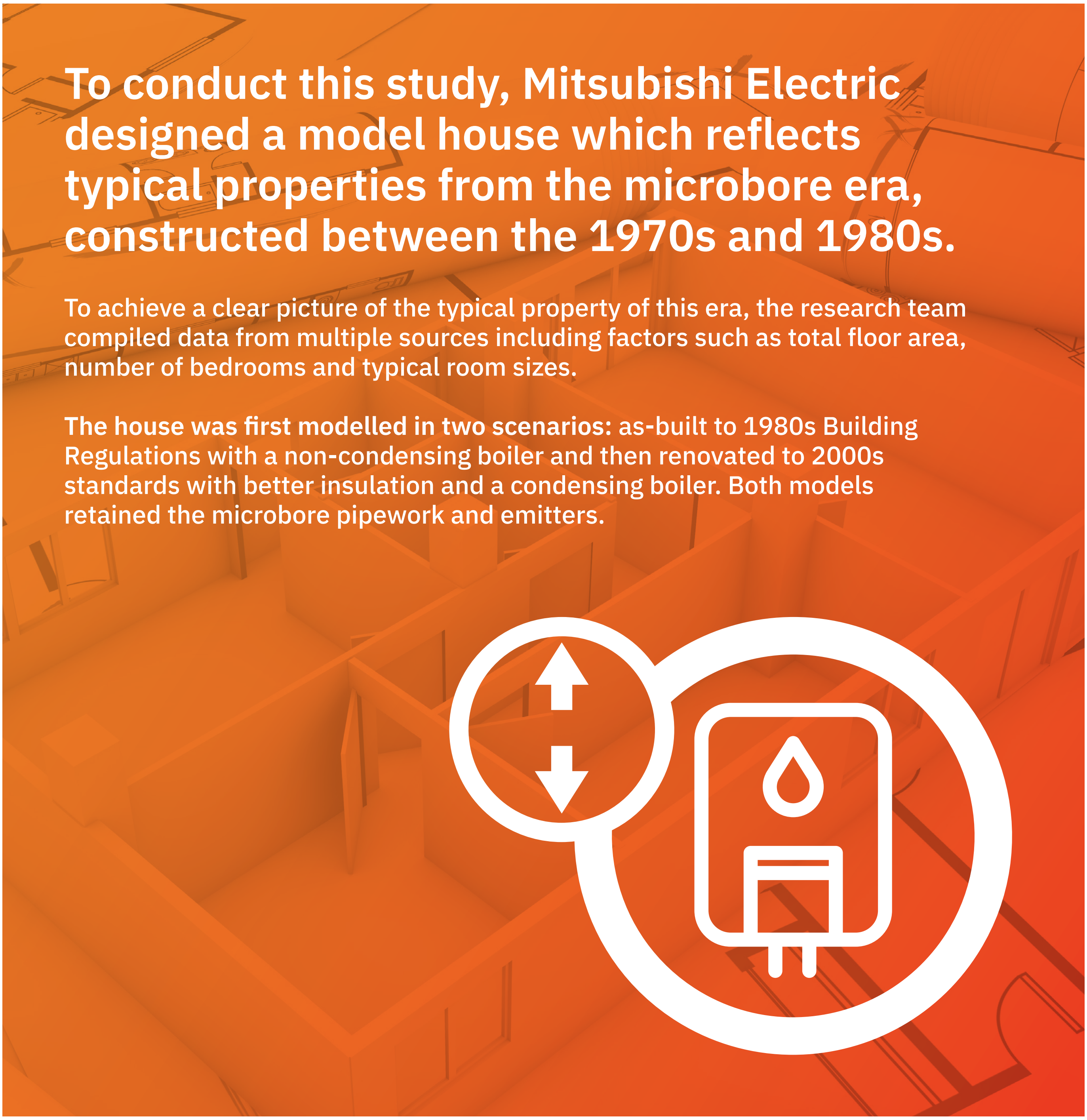
Microbore and boiler systems - the current picture



To conduct this study, Mitsubishi Electric designed a model house which reflects typical properties from the microbore era, constructed between the 1970s and 1980s.

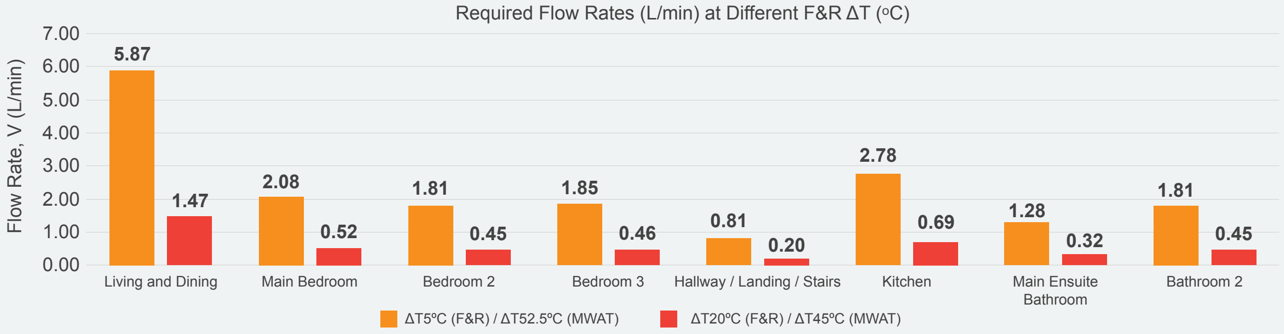
To achieve a clear picture of the typical property of this era, the research team compiled data from multiple sources including factors such as total floor area, number of bedrooms and typical room sizes.

The house was first modelled in two scenarios: as-built to 1980s Building Regulations with a non-condensing boiler and then renovated to 2000s standards with better insulation and a condensing boiler. Both models retained the microbore pipework and emitters.

The findings from this exercise show that the renovation reduced heat losses and flow rates.

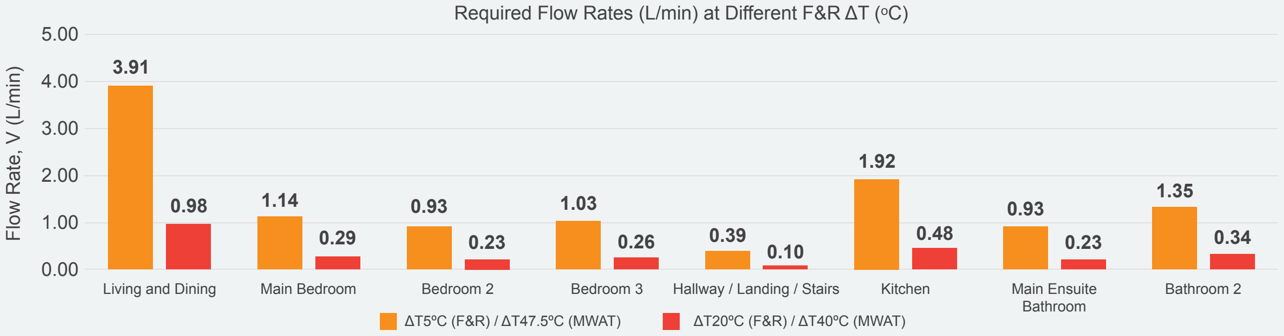
As Built Model House

Heating system: **Non-condensing boiler** Operating conditions: **Flow temp. = 75°C ΔT = 10°C** Room design temp. **= 20°C**



Renovated Model House

Heating system: **Condensing boiler** Operating conditions: Flow temp. **= 70°C ΔT = 20°C** Room design temp. **= 20°C**



The above highlights the impact that varying operating conditions (flow and return ΔT) have on the flow rates of different rooms in both models.

The figures above indicate that, for the modelled home before and after renovation, as the flow and return ΔT increases from 5°C to 20°C, the flow rates decreased significantly for each room. This indicates that heating demands can be met with narrower or smaller pipework, including rooms with higher heat loss in the model (the living and dining rooms).

In addition, in the renovated model, the improved insulation lowered the property's peak heat loss. This lowers the flow rate required and improves the overall heating system's performance. The modelling indicated that homes have seen advantages from using condensing boilers with microbore systems. The increased flow and return ΔT (compared to non-condensing) enabled the use of smaller pipework due to lower water flow rates. However, with the drive to decarbonise heating, we need to understand the impact of taking the next step in retrofitting a home with microbore pipework by including an air source heat pump.

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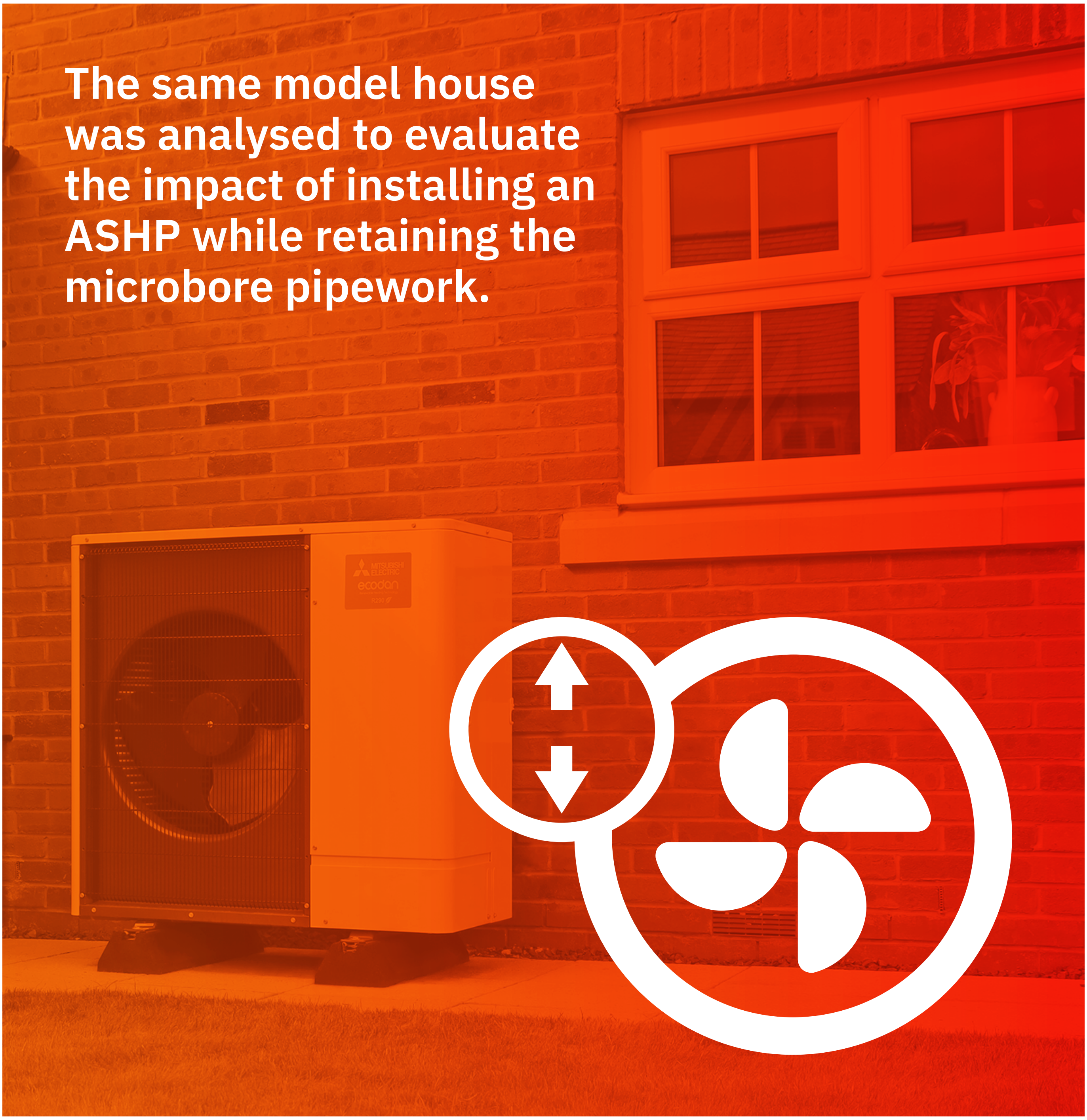
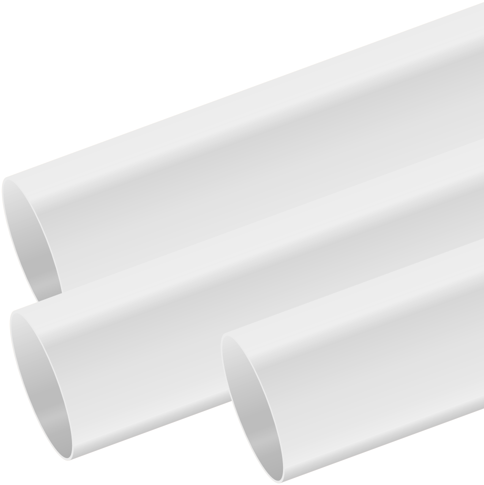
Microbore and heat pumps - modelling the future



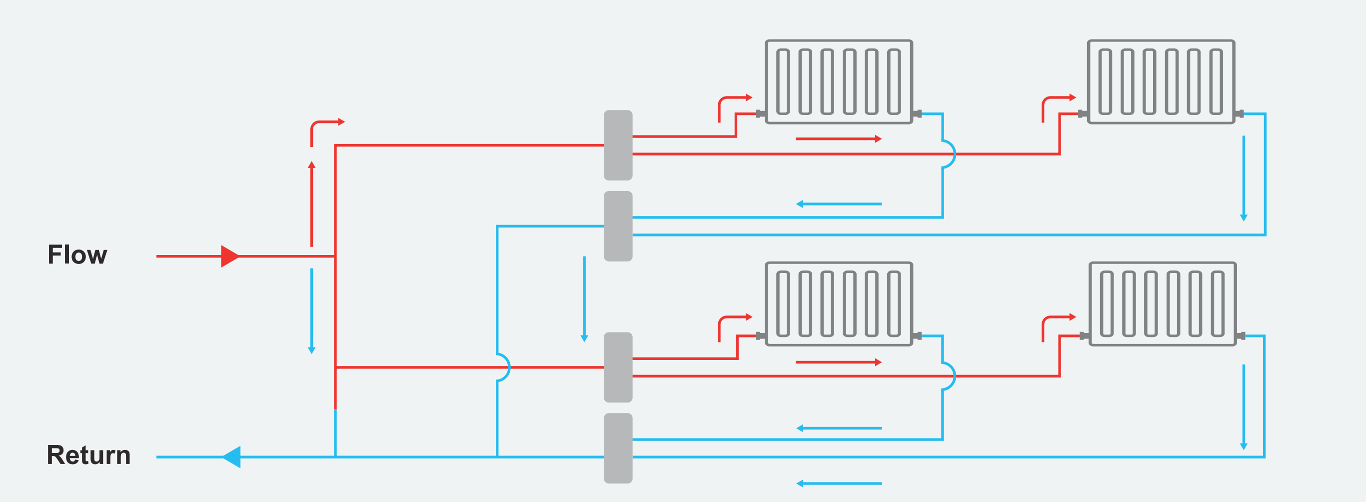
The same model house was analysed to evaluate the impact of installing an ASHP while retaining the microbore pipework.



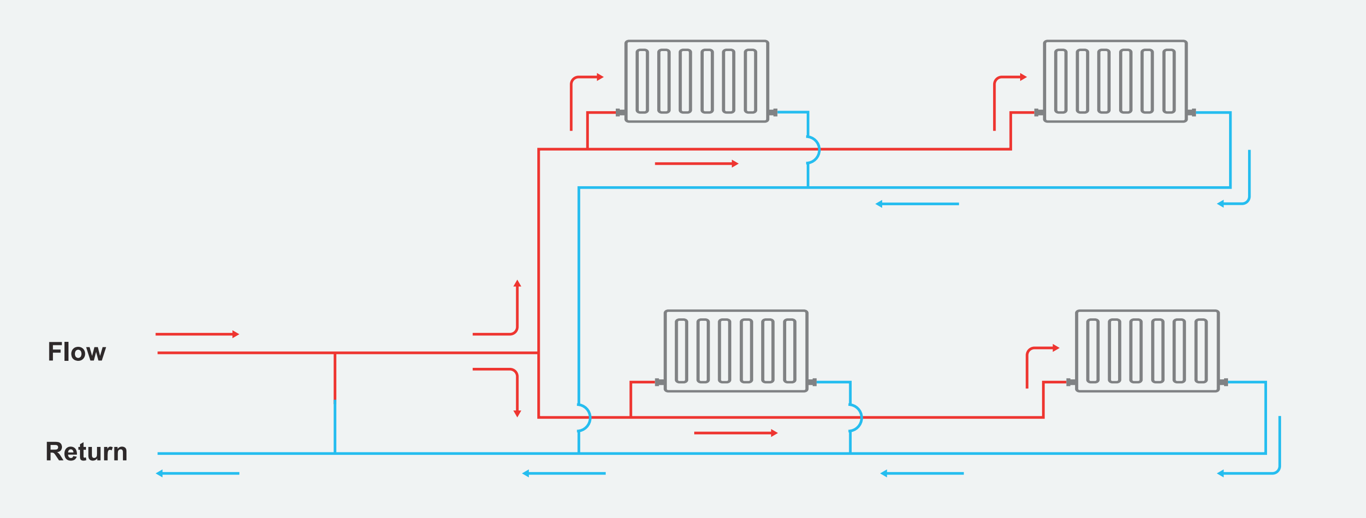
Two typical heating pipework configurations were considered: **the manifold system and the flow-and-return system, shown in the diagram below.**

Both are commonly found in homes that contain microbore pipework.

Manifold pipework configuration



Flow and return pipework configuration

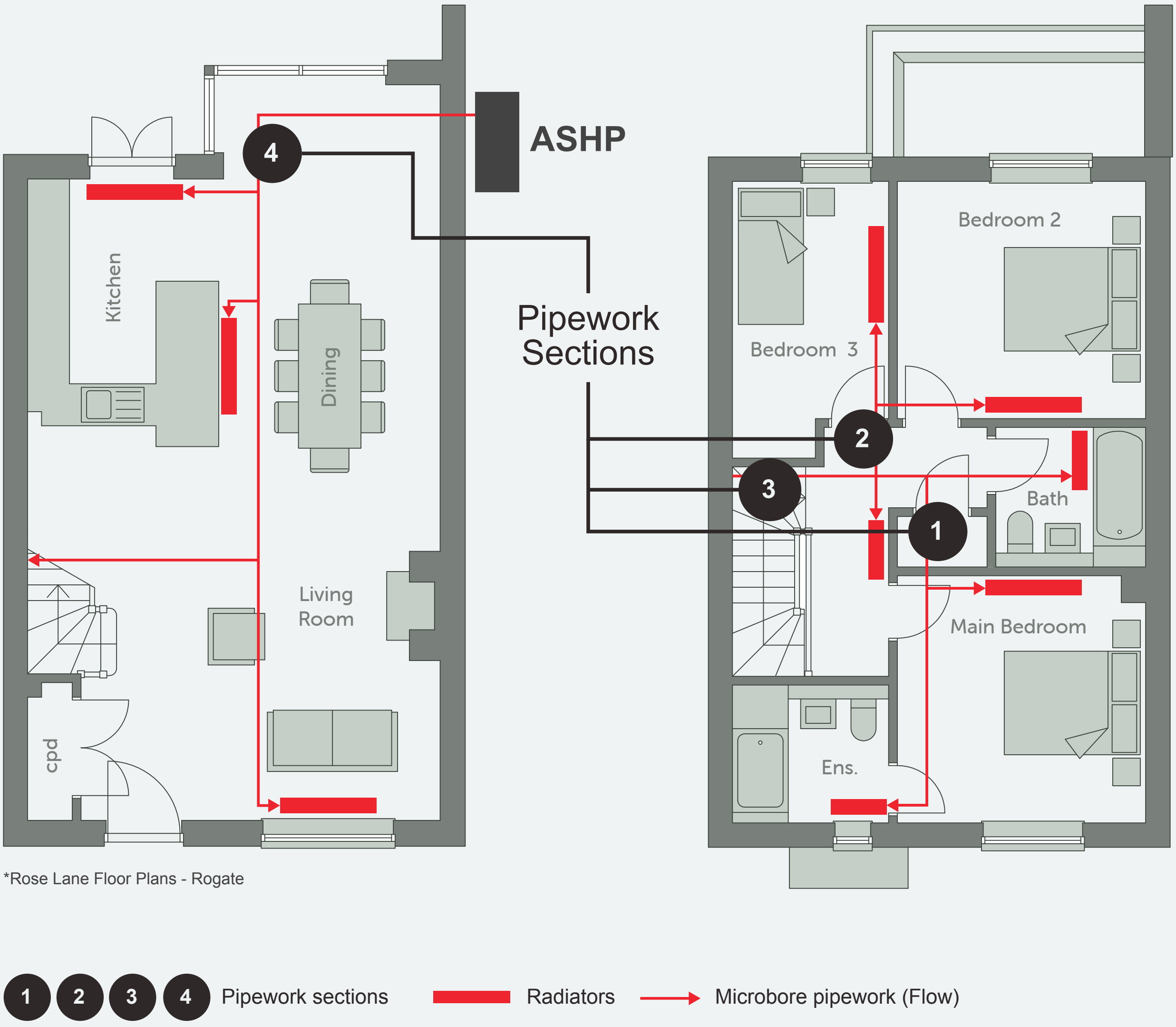


Further analysis assumes that the modelled home has the flow-and-return pipework configuration. This is a more challenging scenario for the study as it features a common pipework feeding multiple radiators. This restricts water flow rates (compared to the manifold system and increases pressure drop).

The diagram below shows a visual representation of the model house floor plan which includes the flow pipework layout, pipework sections, ASHP location, and radiator positions.

Hydraulic separation such as a buffer tank, has been excluded from the model. This allowed an assessment of the scenario with the least disruption and likely lowest cost for ASHP retrofitting.

The diagram shows that the house is divided into four pipework sections. For instance, section 1 feeds the pipework and radiators across the main bedroom and en suite. Section 4 feeds the pipework and radiators for all rooms in the house. All four sections are used to determine the flow rates and corresponding pipe sizes required to meet heating demand.



*Rose Lane Floor Plans - Rogate

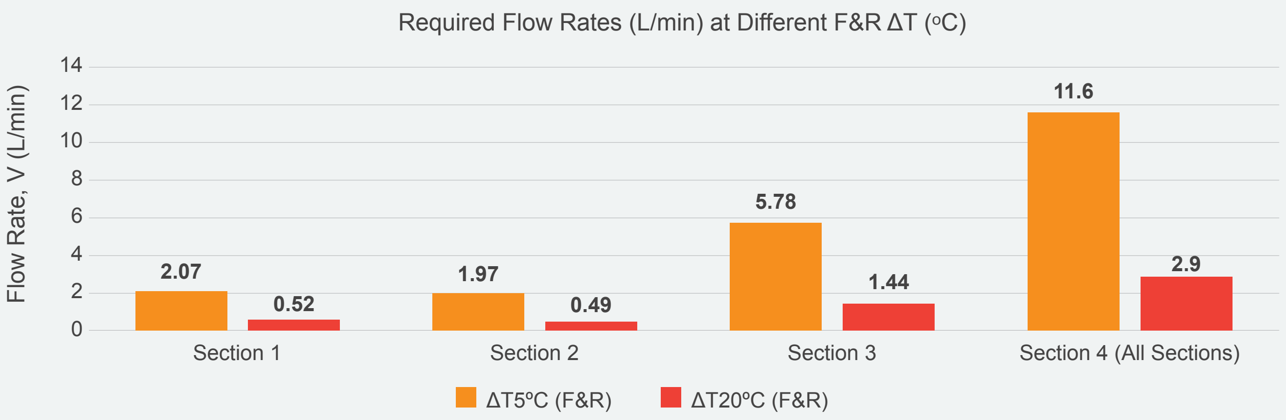
Conducting a section-by-section analysis on the renovated model house, reveals that flow rates gradually increase from Section 1 to Section 4. This is due to Section 4 being the main pipe system responsible for distributing heat to all the radiators in various rooms.

Notably, the modelling highlights that as ΔT increases from 5°C to 20°C, the total required flow rate significantly decreases. For example, in Section 4, flow rate drops from 11.6 L/min to 2.9 L/min. This introduces the opportunity to use smaller pipes across different sections of the house.

These results are shown in the graph below:

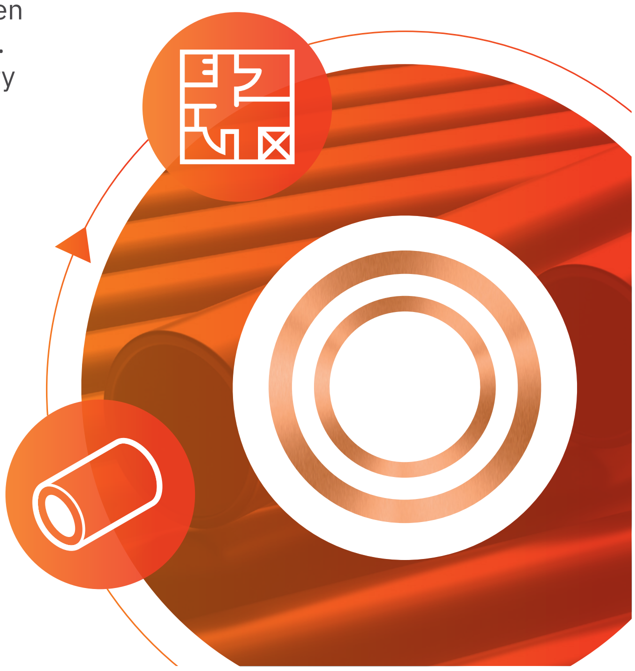
Renovated Model House

Heating system: **ASHP** Operating conditions: **Flow temp. = 70°C ΔT = 20°C** Room design temp. **= 20°C**



It is important to note that microbore pipework is most often found in Sections 1, 2 and 3 for a typical microbore system. This modelling exercise focused on evaluating the feasibility of microbore in these sections.

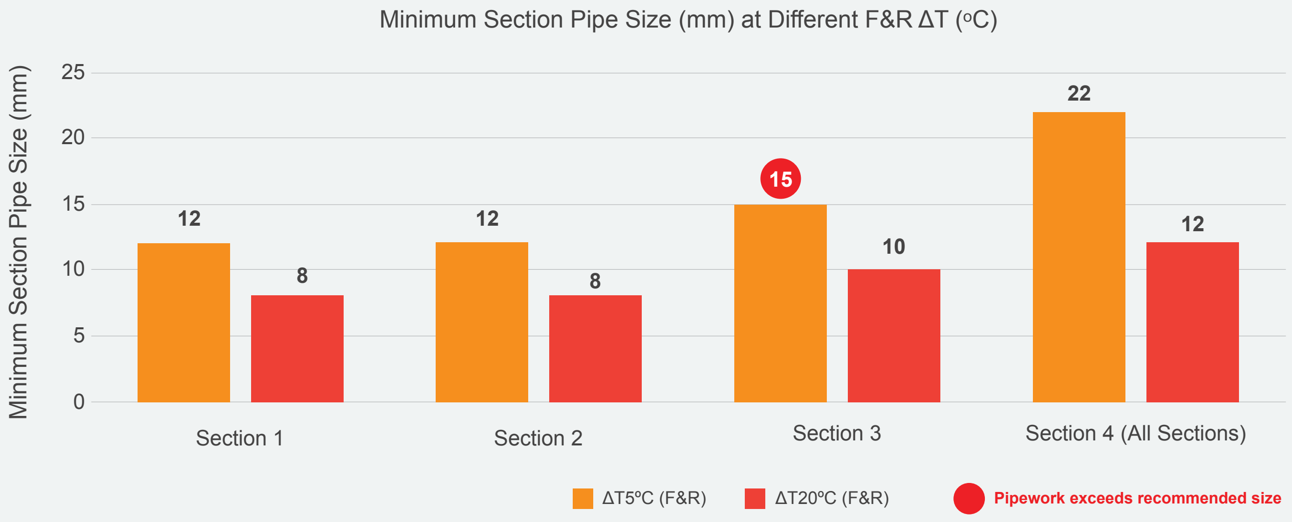
In contrast, Section 4 usually employs larger pipework of sizes, such as 15mm or 22mm to ensure adequate heat distribution. This was included in the modelling to set a realistic baseline.



Pipes exceeding the recommended section pipe size mentioned above are highlighted in red in the graph below.

Renovated Model House

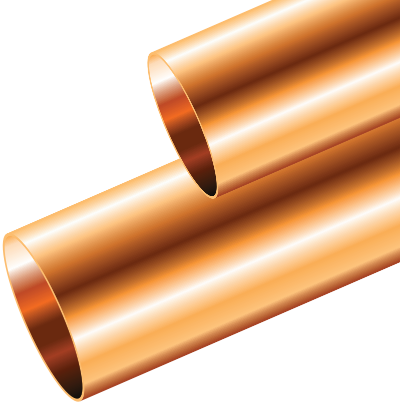
Heating system: **ASHP** Operating conditions: **Flow temp. = 70°C ΔT = 20°C** Room design temp. **= 20°C**



We can see here that in the renovated model house for a 5°C ΔT, only Section 3 exceeded the recommended pipework size. However, for a system with microbore pipework it would be less common to expect a system to operate on a ΔT of 5°C.

This shows that for a typical renovated microbore house, a ΔT of 10°C may be sufficient to meet heating demands on microbore pipes. Increasing the ΔT to 20°C allowed the entire house to be heated using microbore pipes, including Section 4 which feeds the whole pipework system.

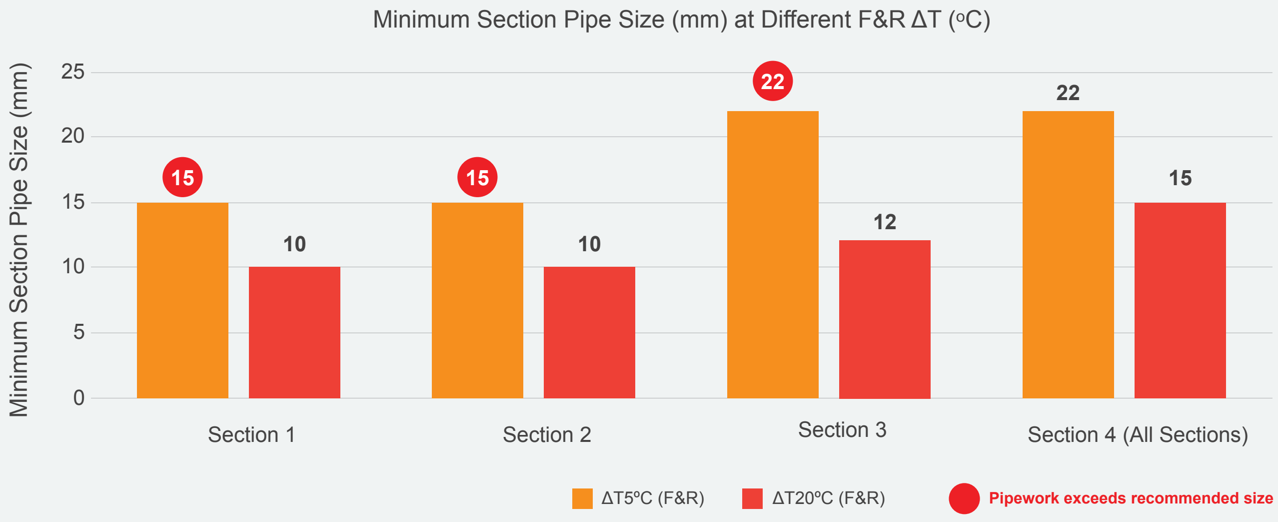
If we also consider the as-built house with microbore pipework and a non-condensing boiler replaced by an ASHP, the findings are also positive.



The graph below shows that Sections 1, 2 and 3 required pipework over 12mm when the flow-and-return ΔT was at 5ºC. However, increasing that ΔT to 20ºC allows for the use of microbore pipes due to a significant reduction in flow rates.

As Built Model House

Heating system: **ASHP** Operating conditions: **Flow temp. = 75°C ΔT = 10°C** Room design temp. **= 20°C**



In conclusion, the modelling shows that both microbore pipework and ASHPs can effectively meet heating requirements at a ΔT higher than 10ºC. A lower ΔT may require further analysis, but based on these findings could be feasible.

The results are a positive step towards the UK's goal of decarbonising residential heating systems. ASHPs and microbore pipework can be compatible, which means that retrofits can be far less disruptive and costly than first thought. However, there are some important points to consider when carrying out this type of project.

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Working with microbore pipework in a heat pump system

To empower installers navigating the complexities of ASHP retrofits in existing microbore central heating systems, a comprehensive process flowchart was developed.

This flowchart serves as a step-by-step guide, streamlining the ASHP transition process and ensuring adherence to best practices.

By considering factors like the existing system's operating conditions (i.e. flow temperature and ΔT) and matching them with compatible ASHP models, the flowchart minimizes the need for costly and disruptive property upgrades, like pipework changes, radiator replacements, or added insulation.

Furthermore, the flowchart offers a framework adaptable to a broad market, recognizing that every house presents unique requirements.

Click here to download the Flowchart

Mitsubishi Electric's research has highlighted a set of guidance recommendations for installers working with microbore systems and ASHPs for retrofit projects:

1. Match existing heating system operating conditions (e.g. flow and return temperature, flow rate, ΔT) to minimise remedial works.
2. Consider the suitability of existing heat emitters if existing heating system operating conditions cannot be matched. Radiators may need to be replaced and/or added if the flow rate is decreased to suit existing pipe size.
3. Consider the use of hydraulic separation if existing heating system operating conditions cannot be matched. For example, a low loss header could be introduced to balance ASHP and heating system flow rates.
4. Do not use antifreeze fluid. Instead, apply an alternative method of freeze protection. For example a ‘freeze stat function’ is available on Ecodan controls.
5. Ensure the condition of the microbore pipework is suitable by checking for damage, leaks or blockages.
6. Ensure that the ASHP operation requirements (e.g. flow rate and minimum space heating circuit volume) are satisfied.

Field Trial

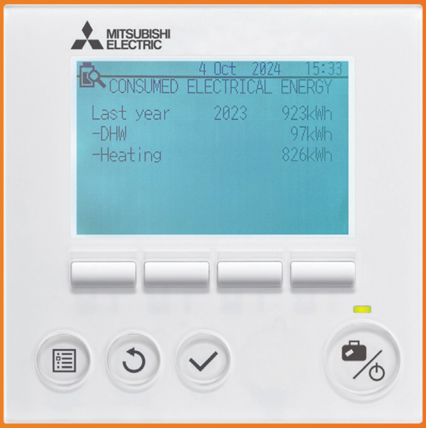
Mitsubishi Electric have monitored a successful install of an Ecodan heat pump with microbore.

The installer reinforces the feasibility of this integration. He emphasises the importance of proper design and calculations, highlighting cost savings and minimal disruption as significant benefits.

“Design and planning are critical, as with any heat pump installation, but providing the calculations have been carried out and show the pipework and radiators are suitable, it makes a lot of sense.”

Adding that integrating an ASHP with microbore pipework is a good idea where calculations allow, highlighting: **“The system is run in Weather compensation mode, with a maximum flow temperature of 45°C without any issues.”**

The benefits of retrofitting a heat pump by this approach: **“Obviously there is a considerable cost saving both in terms of new pipe and radiators as well as minimised disruption and labour.”**



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CONSUMED ELECTRICAL ENERGY
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-DHW                   97kWh
-Heating              826kWh
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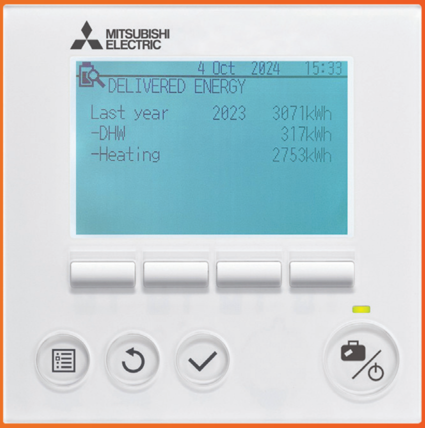

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4 Oct  2024    15:33
DELIVERED ENERGY
Last year     2023   3071kWh
-DHW                  317kWh
-Heating             2753kWh
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Property details:

- **Age: 2001**
- **Size: 110 m² / 4 Bed**
- **R32 Ecodan 6kW with Pre-Plumbed 210L cylinder** (including Low Loss Header)
- **The ASHP to cylinder cupboard flow and return extend 9m in 28mm pipes**
- **The main heating flow and return extend 6m in 22mm pipes, with an average of 2.5m of 10mm copper pipes running to each of the 12 radiators and 2 towel rails**

7

References

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Take stock of the UK Government's Heat and Buildings Strategy (March, 2022)
www.theccc.org.uk/2022/03/09/taking-stock-of-the-uk-governments-heat-and-buildings-strategy/

(2) N. Z. C. Guide, "Retrofit or New Build? - Summary," Net Zero Carbon Guide.
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(3) English Housing Survey Energy report, 2019-20.
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(4) "UK domestic heating and hot water systems and how to prepare them for a greener future." Accessed: Jun. 25, 2024. [Online].
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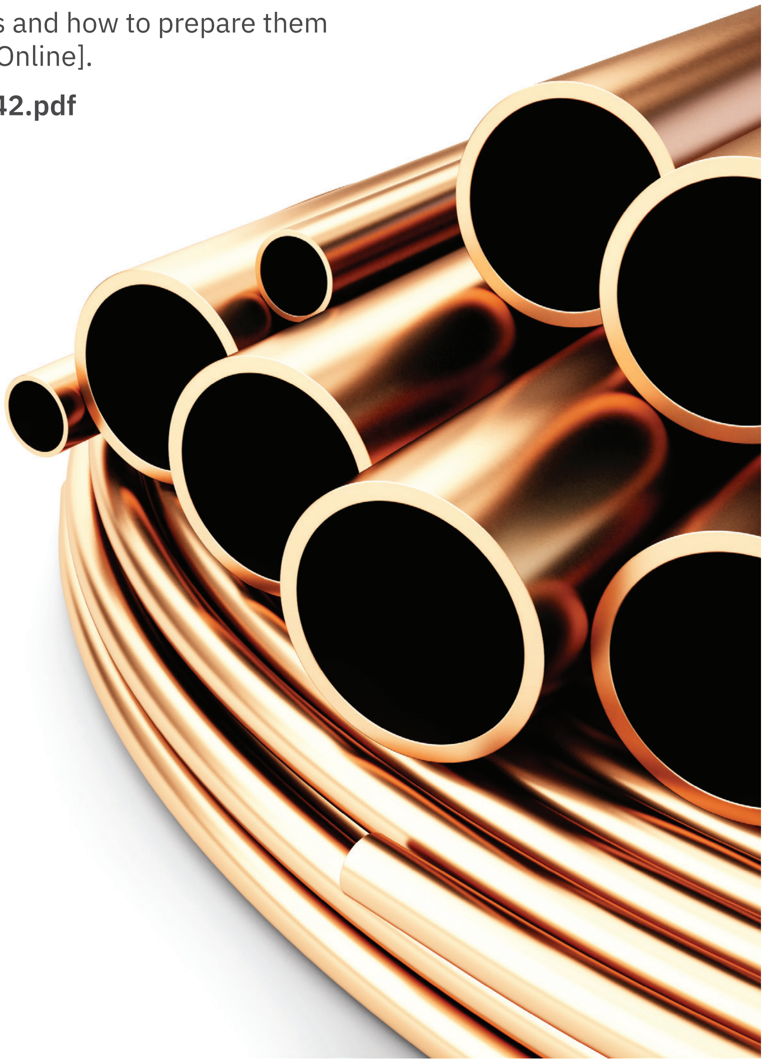

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Note: The fuse rating is for guidance only and please refer to the relevant databook for detailed specification. It is the responsibility of a qualified electrician/electrical engineer to select the correct cable size and fuse rating based on current regulation and site specific conditions. Mitsubishi Electric's air conditioning equipment and heat pump systems contain a fluorinated greenhouse gas, R410A (GWP:2088), R290 (GWP:3), R32 (GWP:675), R407C (GWP:1774), R134a (GWP:1430), R513A (GWP:631), R454B (GWP:466), R454C (GWP:148), R1234ze (GWP:7) or R1234yf (GWP:4). *These GWP values are based on Regulation (EU) No 517/2014 from IPCC 4th edition. In case of Regulation (EU) No.626/2011 from IPCC 3rd edition, these are as follows. R410A (GWP:1975), R32 (GWP:550), R407C (GWP:1650) or R134a (GWP:1300).

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Green Gateway
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Mitsubishi Electric UK's commitment
to the environment

Effective as of October 2024