



Committee on
Fuel Poverty

How to ensure a successful transition to heat pumps for households at risk of fuel poverty

Technical annex

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Annex A: Research methodology

This annex provides the detailed research methodology for the study '*Understanding the factors that will ensure a smooth heat pump transition for households at risk of fuel poverty*' commissioned by the Department for Energy Security and Net Zero (DESNZ) on behalf of the Committee on Fuel Poverty (CFP).

The research is structured around three research questions:

Research Question 1: What are the lived experiences of households at risk of fuel poverty with heat pumps?

- What are the experiences of households at risk of fuel poverty living with heat pumps, in terms of fuel bills, comfort and satisfaction?
- How do households at risk of fuel poverty use and manage their heat pump systems in response to their heating needs and daily schedule?
- How did the quality of installation and commissioning shape their day-to-day experience?
- How adequate was the information and support they received before, during and after installation?
- What has been their experience of using additional technology or services, such as solar PV or smart electricity tariffs, alongside their heat pumps?

Research Question 2: What determines whether a transition to a heat pump increases or reduces fuel bills for households at risk of fuel poverty?

- What heat pump design, installation and commissioning factors determine real-world heat pump performance?
- What is the scale of variation in running costs between well performing and poorly performing systems?
- How do property characteristics, heating patterns, household behaviours and control strategies affect performance?
- What role can complementary measures such as solar PV, battery storage and time-of-use tariffs play in reducing running costs?

Research Question 3: How to ensure a positive transition to heat pumps for households at risk of fuel poverty?

- What interventions are needed to improve system performance through design, installation and commissioning?
- Which households face the greatest risk in the transition, and how can programmes identify and protect them?
- What does the evidence suggest about minimum standards for post-installation monitoring and support?

The scope of this research is England only, consistent with the statutory framework for fuel poverty and the remit of the CFP.

A1: Qualitative interviews with fuel poor households

A1.1: Sampling strategy

The qualitative research employed a maximum diversity (purposive) sampling approach designed to capture the widest feasible range of experiences among fuel poor households with heat pumps. Rather than applying strict quotas, the research team maintained a sampling matrix and monitored diversity across primary and secondary criteria throughout recruitment, adjusting targeting as the sample developed.

Screening criteria excluded residents of devolved administrations, and those employed in market research, journalism or household energy systems.

Primary sampling criteria

- Household classified as at risk of being in fuel poverty
- Participants have lived with a heat pump for at least one full winter
- Household composition: single person, couples, families with children, multigenerational households
- Previous heating system: gas boiler, electric storage heaters, other systems (including oil)
- Tenure: social rented, private rented, owner-occupier

Secondary sampling criteria

- Property characteristics: type, age, energy efficiency rating
- Heat pump type: air source versus ground source, installation route and funding scheme
- Household vulnerabilities: disability, chronic health conditions, elderly members, young children
- Financial factors: payment method, smart meter status, severity of fuel cost burden
- Geographic region: ensuring coverage across different parts of England

There was a preference for households with no more than two years of experience, to support accurate recall of life before the heat pump, though this was applied flexibly given the limited available pool.

A1.2: Defining and assessing fuel poverty status

Fuel poverty in England is officially defined using the Low Income Low Energy Efficiency (LILEE) measure. Under this definition, a household is considered fuel poor if it meets both of two conditions:

- The property has an energy efficiency rating of band D, E, F, or G (i.e. below band C)
- After paying their modelled fuel costs, the household's remaining income would fall below the poverty line, defined as 60% of median equivalised income after housing costs.

In practice, identifying sufficient numbers of households with heat pumps meeting the strict LILEE definition was expected to be challenging, since many properties receiving heat pump installations through funded schemes had also received fabric improvements that raised their EPC rating above band D. The research therefore adopted a pragmatic approach: participation in fuel poverty schemes including Energy Company Obligation 4 (ECO4), Social Housing Decarbonisation Fund (SHDF), Home Upgrade Grant (HUG), Green Homes Grant Local Authority Delivery (LAD) served as a primary recruitment indicator. A dedicated screening questionnaire subsequently collected information on income levels, household costs, household composition and ages enabling us to assess fuel poverty status for recruited households via the CSE Fuel Poverty Calculator (see below). The LILEE assessment was therefore conducted retrospectively, once the achieved sample had been confirmed, rather than as a real-time eligibility screen at the point of recruitment.

The screening questionnaire captured the information necessary to determine fuel poverty status on a case-by-case basis, including:

- Household income (total income for the whole household, not just the person being screened)
- Housing costs (including mortgage payments, rent, and Council Tax)
- Energy costs
- Modelled energy costs, Energy Performance Certificate (EPC) rating, and modelled heating demand, collected by the Carbon Trust from the EPC register for each participant's property
- Household composition, including the number of persons aged over and under 14 who regularly live in the household, to enable accurate equivalisation
- Receipt of winter fuel payments and other fuel bill support

Fuel poverty status was then calculated on a case-by-case basis using the [Centre for Sustainable Energy \(CSE\) Fuel Poverty Calculator](#), which applies the LILEE methodology. The calculation uses the modified OECD equivalence scale, which assigns a weight of 0.67

to the first adult, 0.33 to each additional person aged 14 or over, and 0.20 to each child under 14. After subtracting housing costs and modelled fuel costs from household income, the remaining figure was compared against the poverty threshold for that household's composition (60% of median equivalised income).

Table 1 sets out the approximate poverty thresholds for different household types, based around a reference value of 60% of a median income for a couple with no children (£34,000 before housing costs in 2024 values).

Table 1: Approximate poverty thresholds by household composition

Household type	Equivalence factor	Approximate poverty threshold
Single adult	0.67	£13,668
Couple, no children	1.00	£20,400
Lone parent, one child under 14	0.87	£17,748
Lone parent, two children under 14	1.07	£21,828
Couple, one child under 14	1.20	£24,480
Couple, two children under 14	1.40	£28,560
Couple, two children (one under 14, one 14+)	1.53	£31,212
Couple, two children over 14	1.66	£33,864
Single pensioner	0.67	£13,668
Pensioner couple	1.00	£20,400

Source: Households Below Average Income, DWP, FYE 2024. Note: Thresholds are before housing costs and fuel bills are deducted.

It is important to note several caveats to this approach. All values relating to income, housing costs, benefits, and fuel payments were self-reported by participants, who may not have known all the relevant figures precisely. The research team did not ask for verification or documentation. Furthermore, participants provided information of their household income before tax. Therefore, to estimate the income after tax amount needed for the fuel poverty calculator, an assumption was made for all non-retired households that they were entitled to the standard tax-free Personal Allowance of £12,570. In a small minority of cases where the property did not have a registered Energy Performance Certificate, modelled energy costs could not be determined. Consequently, the research cannot state categorically that all participants met the technical LILEE definition of fuel poverty, and the sample is described throughout the report as households “at risk of fuel poverty” rather than as a confirmed fuel

poor sample. In practice, the great majority of participants were able to report household income, rent or mortgage costs, and energy bills with reasonable precision. A smaller number were less certain on specific figures, particularly where income was variable or where bills were paid through extended-period direct debits; in these cases the screening responses recorded the participant's best estimate. Given the retrospective use of the data to characterise the achieved sample rather than to determine individual eligibility, this approach was judged acceptable.

A1.3: Recruitment approach

Recruitment was conducted through a multi-channel strategy, with the primary route being referrals from five local authority and Registered Social Landlord (RSL) partners who had delivered heat pump installations to low-income households through funded schemes including HUG, SHDF and ECO.

The local authority and Registered Social Landlord partners engaged were drawn from the Carbon Trust's existing relationships with organisations delivering fuel poverty programmes across the South West, East of England and North West regions of England. Partners identified potentially eligible households from their installation records and facilitated initial contact, with Ipsos's specialist recruitment agency (Paton Williamson Consultancy) then administering the screening questionnaire to assess eligibility and willingness to participate.

Supplementary recruitment channels were also used, including the DESNZ ECO4 evaluation sample frame (for households who had consented to further research contact) and targeted outreach through community organisations.

Recruitment materials avoided stigmatising language, framing the research as understanding experiences to improve heat pump deployment rather than studying fuel poverty per se.

To incentivise involvement, and as a "thank you" for taking part, participants received a £50.00 voucher for participation in the in-depth interview and a further £30.00 voucher for participation in the diary task.

A1.4: Achieved sample

In total, 29 interviews were conducted: 20 in-home and nine online (by video call or telephone). The achieved sample covered six regions of England across the five recruitment partner areas plus additional participants recruited through supplementary channels. Full details of the achieved sample against all sampling criteria, including the demographic, property, and system characteristics of each participant, are provided in Annex B.

A1.5: Data collection approach

Interview protocol

Each interview lasted approximately 60–90 minutes. The research employed a dual-researcher model, with an Ipsos social researcher and a Carbon Trust technical expert jointly attending each in-home visit. The interview protocol comprised two integrated components:

Qualitative discussion (led by the Ipsos researcher): A semi-structured interview exploring the participant's complete heat pump journey, covering the decision or allocation process for receiving a heat pump; the installation experience and any disruption; the handover and initial guidance received; the evolution of heating behaviours since installation; current operational patterns and comfort levels; understanding of controls and settings; any problems encountered and support received; financial impacts and bill changes; and overall satisfaction.

Technical system audit (led by the Carbon Trust researcher): Documentation of system characteristics and performance data where accessible from the system's controls and interfaces. This included system specifications (make, model, capacity, installation date); performance metrics from displays or apps (seasonal performance factor, energy consumption); flow temperature settings and weather compensation configuration; hot water settings; and a visual survey of the property including radiator sizing, insulation, and pipework.

The interview topic guide used can be found in Annex C1.

Technical data capture

Some level of technical data was captured for all 20 in-home interviews. However, the completeness of data varied across the sample. The main factor influencing the ability to collect comprehensive technical data was the capability of the heat pump's own control system and user interface: some systems did not record or display the full range of performance metrics sought (for example, seasonal performance factor, cumulative energy consumption, or flow temperature history). Details of the technical data available for each interview, and the implications for the analysis, are discussed in the relevant findings chapters. The technical data capture pro-forma used can be found in Annex C3.

Online interviews

Nine interviews were conducted online (by video call or telephone) where participants were unable to or preferred not to host an in-home visit. These interviews followed the same qualitative topic guide but did not include a technical system audit, as the technical expert was not present in the property. Participants were asked to describe their system and settings verbally where possible, with recognised limitations on the accuracy of this approach given they are not technical experts. Five of the nine online interviews were

affected by connectivity or engagement difficulties, resulting in incomplete data in some topic areas; these five interviews are noted in the achieved sample table. All 29 interviews are included in the analysis.

Heating diary

Participants were asked to complete a seven-day structured paper diary capturing daily heating decisions, comfort levels, clothing adjustments, and room use patterns. The heating diary can be found in Annex C2. For the first four interviews the diary was completed after the interview. It then became apparent that the interview itself could influence participants' heating behaviours and awareness, and from the fifth interview onwards the diary was completed before the interview to capture habitual practices without this potential bias. For in-person interviews, paper format was chosen to ensure accessibility for digitally excluded participants. For interviewees participating online or over the phone the diary was sent to participants over email to be completed online or printed out and then emailed or posted back to Ipsos. The diary was designed to capture micro-practices that participants might not consciously recall during interviews, such as heating only specific rooms at specific times, use of supplementary heating sources, and daily comfort ratings.

Heating diary completion and analysis

All 29 participants completed the seven-day structured heating diary. In practice, the diaries largely confirmed the accounts participants provided during interviews rather than yielding substantial additional data. They did, however, serve a useful confirmatory function, providing a structured record of day-to-day heating decisions against which interview accounts could be cross-checked. Where diary data added nuance or specificity, this has been noted in the relevant sections of the main report.

A1.6: Analysis approach

Qualitative data were analysed using Ipsos's established thematic framework methodology, following the approach developed by [Ritchie and Spencer \(1994\)](#). This method involves five stages: familiarisation with the data; identifying a thematic framework based on the topic guide structure while allowing emergent themes; indexing (applying the framework systematically across all transcripts); charting (creating matrices with cases as rows and themes as columns); and mapping and interpretation (identifying patterns, associations, and explanations within the charted data).

To ensure the accuracy of the data, a random sample of four transcripts was checked against the original audio recordings. Furthermore, the recordings were consulted in any instances where the transcripts were unclear or information appeared to be missing, a process that helps verify the accuracy of the transcribed data.

The framework approach enables systematic within-case and between-case analysis while retaining the richness of participants' own language and accounts. The analysis was strengthened through a process of dual coding. The interviewer first populated the analysis

grid with their own notes and interpretations. A second researcher then enriched this by adding further detail and verbatim quotes directly from the transcripts. This collaborative approach to coding helps to mitigate individual researcher bias and adds depth to the interpretation of the data. Finally, to ensure consistency in the application of the thematic framework and the overall quality of the analysis, all analytical work was quality assured by an Ipsos research director. This provided a final layer of oversight and ensured the research findings were robust and well-founded.

The Carbon Trust technical team contributed technical interpretation to the analysis, identifying patterns between reported behaviours and experiences on the one hand, and measured system performance on the other. This integrated analysis process enabled the research to link qualitative accounts of comfort, satisfaction, and heating behaviour with observable technical characteristics of each system.

Thematic framework

The thematic framework used for the analysis was structured around eight primary domains, each containing between four and fifteen sub-themes. The framework was developed deductively from the topic guide structure while allowing for emergent themes identified during familiarisation. The domains and sub-themes are set out below.

Domain 1: Household and property profile. Sub-themes: length of time in property; household composition; typical weekly routine and occupancy patterns; health conditions in household; ease or difficulty of keeping the home warm; previous heating system; smart meter ownership; energy payment method; energy tariff; additional technology (e.g. solar PV).

Domain 2: Journey to getting a heat pump. Sub-themes: timing and circumstances of installation (or whether pre-installed at move-in); other changes made to the home at the time of installation; how the household came to receive a heat pump (choice, offer, landlord decision); funding scheme (if known); expectations and prior knowledge of heat pumps; concerns before installation; experience of the installation process.

Domain 3: Living with the heat pump. Sub-themes: typical heating pattern (continuous, intermittent, scheduled); method of controlling heating (thermostat, timer, app, radiator valves); typical temperature set point; use of schedules or manual temperature changes; whether all rooms are heated and why; whether heating habits change over the week and why; whether heating behaviour has changed since installation and why; use of supplementary heating methods; preference for manual control versus automatic operation; trust in automatic or smart features; understanding of controls and confidence using them; anything participants did not understand but wanted to know; comparison with previous heating system operation; hot water use.

Domain 4: Information received from heat pump installation (for participants present at installation). Sub-themes: information provided at installation; who provided the

information or advice; how the participant found the information or advice; whether the participant was able to apply the advice; anything the participant was unsure about afterwards; whether the participant conducted their own research; whether anyone returned after installation to check performance; confidence level after handover; anything the participant would have liked done differently.

Domain 5: Information received (for participants who moved into a property with an existing heat pump). Sub-themes: awareness of the heat pump before moving in; information or instructions received; who provided the information; how the participant learned to use the heat pump; confidence when first moved in; additional support the participant wished they had received.

Domain 6: Impact on finances and comfort. Sub-themes: changes to energy bills since the heat pump was installed; adjustments made to budgeting or heating use as a result; receipt of support with energy bills; current comfort levels in cold weather and comparison with previous heating system; heat rationing.

Domain 7: Overall reflections. Sub-themes: best things about having a heat pump; challenges or downsides; whether the participant would choose a heat pump again and why; advice for other households; interviewer reflections.

Domain 8: Heating diary. Sub-themes: daily heating times; rooms heated each day; reasons for heating particular rooms; daily comfort level; other actions taken to keep warm; comparison with the previous week; typical control method; thermostat set point; behaviour when out or overnight; key messages for future heat pump recipients.

Technical data capture completeness

Of the 20 in-home visits, heat pump make and model were recorded for 19 systems (one was not accessible). Third-party thermostat presence was recorded for all 20 systems (yes/no and make and model). Weather compensation status was confirmed for 15 systems (enabled on ten, not enabled on five), could not be determined for five. Hot water set point temperature was recorded for 17 systems. kWh electricity use and heat output were available, enabling the calculation of an indicative Seasonal Performance Factor (SPF) measurement, for 14 systems; for the remaining six, the system's controls did not display cumulative performance data or the measurement period was too short to be meaningful.

kWh electricity usage and kWh heat yield values were read from each system's on-board manufacturer monitoring over the longest measurement period available on the display at the time of the visit. This was typically for the last 365 days but in a minority of cases, periods between 30 days and 120 days were used based on the availability of data. Manufacturer on board energy and heat meters have typically not been verified through Measuring Instruments Directive (MID) certified metering¹, and should be treated as

¹ The Measuring Instruments Directive is a European standard (EU Directive 2014/32/EU) that ensures devices measuring electricity, gas, water, or heat are highly accurate, reliable, and trustworthy.

indicative of relative performance rather than as precise seasonal measurements. 'Not available' indicates that the system's controls did not display cumulative performance data or that the controls were inoperable at the time of interview. Indicative SPF values for the 14 systems where the measurement was available are shown in Table 2 below; per-system technical data is held in the project records and can be made available to DESNZ on request.

Table 2: Indicative Seasonal Performance Factor (SPF) values recorded during in-home technical audits (participant IDs removed)

Indicative SPF	Source / measurement period
5.8	System on-board display
2.9	System on-board display
3.5	System on-board display
2.2	System on-board display
1.3	System on-board display
3.3	System on-board display
Not available	Information not available via controls
2.5	System on-board display
4.0	System on-board display
3.6	System on-board display
Not available	Information not available via controls
Not available	Information not available via controls
2.7	System on-board display
1.9	System on-board display
3.0	System on-board display
Not available	Information not available via controls
Not available	Information not available via controls
3.2	System on-board display
Not available	Information not available via controls
3.1	System on-board display

A1.7: Ethical approval and safeguarding

This research involved significant ethical considerations, particularly given the potential vulnerability of participants. To ensure the study was conducted to the highest ethical standards, all research protocols were reviewed and approved by Ipsos's Business Excellence Service and Ethics Board. This review ensured full compliance with Government Social Research (GSR) ethical guidelines and all relevant data protection requirements.

Several key ethical risks were identified, and specific mitigation strategies were implemented. These are summarised in Table 3.

Table 3: Ethical risks and mitigation strategies

Ethical risk	Mitigation
Participant distress when discussing sensitive topics such as heating affordability	All interviewers were trained in handling sensitive conversations with care. Signposting information to welfare and support services was provided to all participants. Participants were informed at the outset that they could pause or terminate the interview at any time without consequence.
Disclosure of severe hardship	A clear safeguarding protocol was in place, managed by Ipsos's Disclosure Board. The limits of confidentiality were explained upfront, and rapid escalation procedures were established to ensure a response within a maximum of 48 hours.
Digital exclusion affecting participation	A paper-based diary option was offered alongside digital methods, and telephone interviews were made available as an alternative to online formats. Multiple communication channels were used during recruitment to reach a wide range of individuals.
Incentive payments impacting participants' benefits	Payments were made using vouchers rather than cash transfers, and signposting to financial advice services was provided. The value of payments was carefully calibrated to be a fair recompense for participants' time without being coercive.
Power imbalances between researchers and participants	All recruitment and research materials were written in plain English. Verbal consent options were available to ensure accessibility, and the voluntary nature of participation was emphasised at every stage. Proactive steps were taken to promote equity and inclusion, ensuring diverse representation across household types, tenures, and demographic characteristics.

A1.8: Data security

Robust data management procedures were followed to protect participant confidentiality. All data are stored on secure Carbon Trust and Ipsos servers with appropriate encryption and access controls. In line with Ipsos' privacy policy, all personal data will be permanently deleted once quality control checks are completed, within three months of the project's completion.

A1.9: Reporting conventions and limitations

Qualitative findings in the findings report are presented using language that describes the strength and consistency of themes identified across the sample, rather than numerical counts or quantitative terms that would imply statistical representativeness. The report avoids terms that invite the question "how many?" and instead uses thematic descriptors to convey the nature and weight of findings. The following conventions are used throughout:

Table 4: Descriptive language for qualitative reporting

Descriptive language	Meaning
A consistent theme / A universal experience	A finding identified consistently across the sample
A recurring pattern	A finding that emerged strongly across the sample, though not universally
A common experience	A finding shared by a notable proportion of participants
In some cases	A finding that emerged in a number of interviews but was not the dominant pattern
This was not a universal experience	A finding identified in a minority of cases
One notable exception was	A finding from a small number of interviews, reported where it provides important insight
Individual case study	A specific household experience used to illustrate a particular issue in depth

Qualitative findings may spotlight challenges and issues that the sector needs to address, but this research cannot determine how prevalent those issues are or could be across the wider population of fuel poor households with heat pumps. The qualitative sample of 29 interviews was purposively selected to maximise diversity of experience rather than to be statistically representative, and findings cannot be used to estimate the proportion of the population experiencing any particular outcome. The secondary data analysis, which draws on larger datasets (742 and 383 systems respectively), provides broader quantitative context, though these datasets are also not representative of the fuel poor population specifically (see Annex A2.3).

A2: Secondary data analysis

A2.1: Datasets

The secondary data analysis drew on two major UK heat pump monitoring datasets:

Electrification of Heat (EoH) demonstration dataset: This dataset, commissioned by BEIS/DESNZ, contains data from 742 heat pump installations monitored over two heating seasons, 450 of which met quality thresholds set by the Energy Systems Catapult (ESC). It provides installation characteristics (system make, model, capacity, heat pump type), property specifications (age, type, floor area), and 2-minute interval and annualised performance data including SPF. The dataset includes properties across England and Scotland, spanning a range of dwelling types and ages. The data is licensed under the Open Government Licence v3.0 and was accessed via the eoh.heatpumpmonitor.org platform developed by Open Energy Monitor, which provides visualisation of each system using the MyHeatpump dashboard.

Heat Pump Monitor (HPM) dataset: Operated by Open Energy Monitor, this dataset comprises 383 heat pump systems self-reported by owners using the Open Energy Monitor platform, predominantly installed by specialist installers with actively engaged homeowners. Data are accessed through the public API at HeatPumpMonitor.org. The data are made available under the Creative Commons Attribution 4.0 International License.

Analysis of Ofgem data of in-situ heat pump performance by rb&m research (DESNZ, November 2024): A third source referenced in the main report is the analysis of approximately 1,700 heat pump installations certified under MCS (of which approximately 1,400 are air source), drawing on smart meter and on-board monitoring data. This sample reports annual SPF only and does not include the system-level operational data (flow temperatures, compressor power, cycling patterns) used in the primary analysis for this project. It is referenced in the findings report as part of the wider available evidence base on heat pump performance from UK installations. RHI installations subject to Metering for Payment are metered precisely because their usage patterns are not typical: for example, they may rely on secondary heating, use a bivalent system that combines a heat pump with a boiler, or be second homes.

A2.2: Analytical approach

All systems in the EoH cleansed dataset were individually reviewed through visual inspection of their two-minute resolution timeseries data, accessed via the eoh.heatpumpmonitor.org platform developed by Open Energy Monitor using the MyHeatpump dashboard. This review built upon previous work by Trystan Lea and Glyn Hudson of Open Energy Monitor, who visually categorised 165 Vaillant Arotherm systems in the EoH dataset by weather compensation quality (Good, OK, Bad). Their categorisation and analysis framework informed the broader review.

In parallel, the HPM dataset was analysed via the HeatPumpMonitor.org public API. Subsets of the full dataset were used for different parts of the analysis, as indicated in the relevant tables and figures in the findings report. These systems, predominantly well-commissioned and operating continuously with correct weather compensation, provided a performance baseline against which EoH system behaviour could be compared. The core analytical method was comparative, examining how performance of systems on EoH and HPM differed.

Technical factors analysis

The analysis investigated and sought to quantify the performance impact of the following key commissioning and installation factors:

- **Flow temperature settings:** Comparison of weighted mean flow temperatures across both datasets. A best-fit regression line of SPF on weighted mean flow temperature was fitted across the HPM dataset (which is predominantly well-commissioned) to establish an empirical benchmark of the SPF that a well-commissioned system would be expected to achieve at any given flow temperature. EoH systems were then plotted against this benchmark; systems falling well below the line at low flow temperatures indicate underperformance that flow temperature alone does not explain, consistent with commissioning issues other than flow temperature being the binding constraint.
- **Weather compensation:** Comparison of systems with weather compensation enabled versus disabled, building on the Open Energy Monitor categorisation of 165 Vaillant systems. Whether weather compensation was enabled and effectively calibrated was determined from each system's visual signature in the timeseries data: correctly calibrated systems run continuously with steady flow temperatures that adjust gradually with outdoor temperature, whereas systems without effective weather compensation show flow temperatures cycling through peaks and troughs as the system ramps to a fixed flow temperature and switches off. Because weather compensation is itself a control strategy, this classification reflects the associated operating behaviour rather than treating control strategy as a separate variable. Normalised distributions of compressor speed, expressed as the proportion of operating time spent at each power level (unweighted by time or season), were compared across the groups. Systems without effective weather compensation were associated with a greater share of operating time at higher, less efficient compressor speeds.
- **Compressor operating regimes:** Normalised histograms of electrical power draw were compared across EoH systems with and without weather compensation, and against HPM systems. Electrical power draw is used here as a proxy for compressor speed: in an air source heat pump, the compressor is by some distance the largest electrical load and its power draw scales closely with operating speed. This proxy does not distinguish between the compressor and auxiliary loads such as circulation

pumps and fans, but on the sustained operating periods examined the compressor dominates the signal. The analysis quantified the proportion of operating time spent at different compressor speed bands.

- **Oversizing:** Oversizing factors were calculated for both datasets as the ratio of rated heat pump output to inferred peak heat loss. Inferred peak heat loss was derived from the relationship between daily heat output and mean external temperature, scaled to a design condition (an internal temperature of 21°C and an external temperature of minus 2°C). This is an operational estimate rather than a design heat loss calculation to BS EN 12831-1:2017, so the resulting oversizing factor is expressed relative to inferred peak demand and does not directly correspond to oversizing relative to an MCS design heat loss. Coefficient of Performance (COP) was then compared across oversizing bands for both datasets. As set out in Section A2.3, inferred heat loss for intermittently operated systems is likely to be understated, which inflates their apparent oversizing factor.
- **Cycling patterns:** An attempt was made to quantify cycling. However, this proved unreliable as a diagnostic, since well-commissioned systems in mild weather can cycle as frequently as poorly commissioned systems with high fixed flow temperatures.
- **Hot water configuration:** The annual cost of producing domestic hot water depends on three factors: the temperature the cylinder is heated to (lower temperatures allow the heat pump to run more efficiently), how often the cylinder reheats (frequent short reheats are less efficient than fewer, longer cycles), and whether the heat pump or an electric immersion heater is doing the work (the immersion heater is around three times more expensive per unit of heat). The analysis examined each of these factors using case studies in the data, comparing efficient configurations (for example, a best-case optimised cylinder running at 45°C achieving a hot water COP of 4.5, which represents the top of the range observed on HPM rather than typical performance), against inefficient ones (for example, a system where the immersion heater was cycling frequently, giving an effective COP of 1.78). The results inform the hot water cost analysis presented in Section 3.4 of the main report.
- **Percentage of ideal Carnot COP:** This metric, which captures how efficiently a heat pump operates relative to the theoretical maximum for its operating temperatures, was used to identify systems with unexplained underperformance beyond what flow temperature alone would predict.
- **Zoning, Thermostatic Radiator Valves (TRVs), and buffers/hydraulic separation:** These factors were investigated but could not be reliably quantified from the available data. Zoning and TRV effects would require flow rate data not present in the cleansed EoH dataset. Buffer tank effects were examined using HPM metadata, though sample sizes were small.

The analysis was conducted in Python using pandas, NumPy, Matplotlib, and SciPy.

Solar PV generation profiles were obtained from the [EU PVGIS API \(v5.3\)](#) using the SARAH3 radiation database.

Behavioural patterns analysis

The analysis also investigated the efficiency and cost implications of different heating behaviours, including:

- **Intermittent versus continuous heating:** Winter months (December, January, February) within each system's validated data window were analysed. A system was classified as intermittent if it operated for less than 20% of night time hours (23:00 to 05:00); otherwise it was classified as continuous. The overnight window was chosen because it is the period when continuously operating systems would be expected to remain active, whereas systems on a schedule or thermostatic on/off control would typically be switched off. The 20% threshold was chosen as a tolerance allowing for brief defrost cycles, late-evening operation, or short early-morning preheat without misclassifying a timed system as continuous; the classification is not highly sensitive to thresholds between 10% and 30%, but does not capture finer gradations of partial-night operation. A system was defined as actively heating when heating flow temperature was present and non-null, heat output exceeded 500 W, and electricity consumption exceeded 300 W.
- **Operating time analysis:** The percentage of winter time each system spent actively heating was calculated for both datasets and plotted against COP. A colour-mapped analysis by oversizing factor was used to investigate correlation to operating time and COP.
- **Secondary and supplementary heating use:** Inferred from EoH timeseries data where room temperatures were observed rising while the heat pump was off and no heat was being delivered, during periods when passive solar gain could not explain the increase. This was interpreted as evidence of secondary electric heater use. Prevalence of this was noted but not fully explored.
- **Partial versus whole-house heating:** Investigated but could not be reliably quantified due to the absence of individual room temperature or zone valve data in both datasets.

Housing archetype bill modelling

A key output of the secondary data analysis was a set of modelled running cost tables for different housing archetypes, comparing heat pump performance at different efficiency levels against various counterfactual heating fuels (gas, oil, direct electric, storage heaters). These tables enable the research to quantify the financial risk to fuel poor households of suboptimal heat pump performance and to identify the performance thresholds at which a heat pump becomes cost-neutral or cost-positive relative to the previous heating system. The running cost modelling methodology, including tariff and fuel price assumptions, is set out in Section A3.

A2.3: Dataset caveats and limitations

Several important caveats apply to the interpretation of the secondary data analysis:

- **Population representativeness:** Neither the EoH nor HPM datasets were designed to be representative of heat pump installations in fuel poor households specifically. The EoH dataset reflects the characteristics of the demonstration programme's participants, who were predominantly owner-occupiers in able-to-pay contexts. The HPM dataset is self-selected, comprising households who have voluntarily installed monitoring equipment. Both datasets therefore include relatively few systems in fuel poor homes, and findings should be interpreted as evidence on general heat pump performance factors rather than as directly representative of the fuel poor population.
- **Dataset comparability:** The two datasets differ in their structure, monitoring periods, and the variables recorded. We have only made comparisons between datasets where data availability and comparability allows and findings are presented with clear indication of which dataset they are derived from.
- **Observational data:** The data are observational rather than experimental, meaning that associations between factors and performance outcomes cannot be interpreted as definitive causal relationships. In particular, the inability to perform A/B testing (running the same system intermittently and then continuously, or with different weather compensation settings) limits the strength of conclusions about individual factors. However, case studies where EoH participants corrected commissioning errors on their own systems provide quasi-experimental evidence supporting the direction of effects observed.
- **Oversizing measurement:** Inferred heat loss derived from EoH systems is likely understated due to intermittent operation, inflating apparent oversizing factors. This limitation is discussed in detail in the findings report.
- **Heat meter accuracy:** The analysis assumes that heat meter data in both the EoH and HPM datasets are accurate. However, heat meter measurement errors, particularly at low flow rates, may introduce systemic biases in reported COP values.

A3: Running cost modelling

A3.1: Overview and approach

The running cost analysis uses a two-stage modelling approach to estimate annual heat pump electricity costs for different housing archetypes and system configurations. The first stage uses a dynamic heat pump simulator to generate realistic, time-varying electricity demand profiles for each scenario. The second stage uses a domestic electricity and cost model, developed by the Carbon Trust, to convert these demand profiles into annual running costs under different tariff, solar PV, and battery storage configurations.

This approach captures the interaction between weather-driven heating demand, temperature-dependent heat pump efficiency, time-varying solar generation, battery state of charge, and time-varying electricity prices. It avoids the limitations of simpler calculations that assume fixed seasonal efficiencies or annual average conditions, and provides a transparent basis for comparing cost outcomes across different system configurations and household scenarios.

Running cost estimates for counterfactual heating systems (gas boilers, oil boilers, LPG boilers, direct electric heating, and electric storage heaters) are calculated separately using standard efficiency assumptions and current fuel prices, applied to the same annual heat demand figures used in the heat pump modelling.

Results are intended to be illustrative and comparative rather than predictive of individual household bills. They support evidence-based discussion about the relative affordability of heat pumps at different performance levels and the financial risk to fuel poor households of suboptimal system performance.

A3.2: Cost modelling scenarios for fuel poor archetypes

Two complementary modelled comparisons are presented in the findings report. Each uses a different archetype framing appropriate to the question it addresses.

Static counterfactual comparison (main report Table 6)

The static comparison in Section 3.10 of the findings report compares heat pump running costs at different SPF levels against alternative heating systems (gas, oil, LPG, direct electric, storage heaters) under the assumption that annual heat demand is unchanged by the system transition. Three household archetypes are used, corresponding to Ofgem's Typical Domestic Consumption Values (TDCVs) for low, medium and high use households. Useful heat demand is calculated as the gas TDCV (7,500 / 11,500 / 17,000 kWh) multiplied by an assumed gas boiler efficiency of 85%, giving 6,375 / 9,775 / 14,450 kWh per year. Non-heating electricity is included at the Ofgem TDCV figures of 1,800 / 2,700 / 4,100 kWh per year. This framing was chosen for comparability with Ofgem price cap fuel bill estimates, which are also referenced to TDCVs.

Dynamic simulation of complementary measures (main report Table 7)

The dynamic simulation in Section 3.11 of the findings report examines the cost outcomes of combining a heat pump with solar PV, battery storage and a time-of-use tariff across a range of SPF levels. Because this comparison is sensitive to dwelling characteristics in ways that a constant-demand calculation is not, the archetypes are defined by their physical characteristics (and resulting design heat loss) rather than by a fixed annual demand, informed by common dwelling characteristics in the fuel poor stock per DESNZ Annual Fuel Poverty Statistics 2025. Five archetypes were modelled in total, spanning the fuel poor stock from a small insulated flat (around 8,000 kWh annual heat demand) to a large solid-walled house (around 27,000 kWh). Three of these, set out in Table 5 below, are presented in the findings report as indicative of the range across the fuel poor stock.

Table 5: Dwelling archetypes used in the dynamic cost modelling

Archetype	Description	Floor area (m ²)	Wall type	Design heat loss	Solar PV	Battery
Semi-detached	Cavity-insulated semi-detached, couple with dependent children	84	Insulated cavity	4.5 kW	3.5 kWp	7 kWh
Mid-terrace	Solid-walled mid-terrace, couple, no dependent children	95	Solid uninsulated	7.0 kW	3.5 kWp	7 kWh
Detached	Cavity-walled detached, retired couple	129	Uninsulated cavity	10.5 kW	5.3 kWp	7 kWh

Annual heat demand emerges from the simulation rather than being prescribed: at higher SPFs the modelling assumes more continuous operation, which increases modelled demand by up to 7% relative to the lower-SPF scenarios. This reflects the empirical pattern that higher-performing systems are operated more continuously (Section 3.8 of the findings report). Heat demand and resulting fuel bills are higher than the Ofgem typical values, reflecting the skew of the fuel poor stock toward less efficient dwellings and the use of modelled rather than measured consumption.

A3.3: Dynamic heat pump simulator

The heat pump electricity demand profiles used in the running cost modelling were generated using the dynamic heat pump simulator developed by Trystan Lea of Open Energy Monitor (https://openenergymonitor.org/tools/dynamic_heatpump_v1.html). This simulator models a typical dwelling with a wet central heating system served by an air source heat pump, operating at high time resolution over a full calendar year.

Time resolution and simulation period

The simulator runs internally at a 30-second timestep, allowing short-term cycling, control response, and temperature changes to be captured. A five-day warm-up period is run before the analysis period to allow indoor temperatures to stabilise. Each scenario is then simulated for a full calendar year.

Weather and input data

The simulator uses a single, consistent set of weather and price data covering a full year, including outside air temperature, solar conditions (used to represent both passive solar gains and photovoltaic output), and half-hourly electricity prices from a smart tariff. These inputs allow the model to reflect cold spells, mild periods, and seasonal variation, as well as changes in electricity prices through the day.

Building thermal model

The dwelling is represented using a simplified thermal model that captures heat loss through the building fabric, heat storage within the structure and indoor air, and internal heat gains from occupants and appliances. The overall heat loss of the dwelling is set to match each housing archetype. Solar gains are included dynamically and are reduced when indoor temperatures become high, representing real-world responses such as shading or ventilation. The heating system is represented as a single water circuit serving radiators, with radiator output varying with water temperature and indoor temperature using standard non-linear relationships. Flow and return temperatures respond to heating demand rather than being fixed, allowing the model to capture the relationship between load, water temperature, and heat pump efficiency.

Heat pump control strategies

The simulator represents different real-world patterns of system operation through two alternative control strategies, reflecting observed differences between higher- and lower-performing heat pump installations.

Modulating control (higher-SPF systems): Higher-SPF systems are modelled using a modulating control strategy, in which heat pump output adapts continuously in response to indoor conditions. Under this approach, heat delivery responds smoothly to indoor temperature deviation from the setpoint, operation tends to be steady and continuous with minimal cycling, and flow temperatures are generally kept as low as possible for the

prevailing heat demand. This control strategy is representative of well-configured modern heat pump systems with appropriately sized emitters and effective commissioning.

On/off control (lower-SPF systems): Lower-SPF systems are modelled using a fixed-speed compressor with on/off thermostatic control. The heat pump operates at a single fixed output level when running, switching on when indoor temperature falls below the setpoint and off once it is exceeded. This results in shorter, higher-temperature heating cycles, greater temperature overshoot and undershoot around the setpoint, more frequent cycling, and lower average efficiency, particularly during mild conditions. This approach is intended to represent a range of real-world situations associated with lower observed performance, including limited modulation capability, conservative control settings, or systems operating in a boiler-like manner.

The simulator parameters for each control strategy were calibrated to produce SPFs consistent with the values observed in the EoH and HPM datasets. Specifically, the modulating control strategy was calibrated to achieve an SPF in the range observed in the HPM dataset (mean 3.9), while the on/off control strategy was calibrated to achieve performance consistent with the lower end of the EoH dataset (SPF 2.0 to 2.8). This calibration ensures that the modelled cost outcomes reflect the real-world performance gap identified in the secondary data analysis (Section A2).

Two caveats apply to this calibration. First, the HPM dataset is not representative of the wider installed base. The Ofgem MCS in-situ analysis (Section A2.1) suggests that typical real-world performance across the wider installed base is closer to the EoH end of the range. The modulating strategy in the simulator should therefore be read as illustrating what is achievable under good design, installation and commissioning, not as a typical benchmark. The on/off strategy is correspondingly more typical of the wider installed base. Second, modern heat pump products vary in their modulating capability; the simulator was parameterised on a single representative product (Vaillant Arotherm), and lower-cost models with more limited turn-down may achieve modulating-strategy SPFs somewhat below the HPM mean. Results are therefore presented across a range of SPF values rather than at a single point estimate, in order to span the realistic range of in-situ performance.

Heat pump performance calculation

Heat pump electricity consumption is calculated using an instantaneous COP that varies with outdoor temperature, flow temperature, and operating load. This ensures that heat pump efficiency is lower during cold periods and high heating demand, and higher during milder periods, rather than assuming a fixed seasonal efficiency. Electrical consumption from circulation pumps and standby operation is included. Defrost cycles are not modelled, leading to a small overestimate of annual performance. Domestic hot water is not included in the simulator; electricity demand for hot water heating is instead calculated within the domestic electricity and cost model.

A3.4: Domestic electricity and cost model

The domestic electricity and cost model, developed by the Carbon Trust, takes the half-hourly heat pump demand profiles produced by the simulator and combines them with household electricity use, solar PV generation, battery storage behaviour, and electricity tariffs to estimate annual electricity costs. The model operates at half-hourly resolution, consistent with UK electricity billing periods.

Components of the cost calculation

For each half-hour period, the model accounts for heat pump electricity demand (from the simulator output), electricity use for domestic hot water, other household electricity use, on-site solar PV generation (where present), battery charging and discharging (where present), electricity imported from the grid, and the electricity unit price applicable at that time. Results are summed to produce annual consumption and cost totals.

Electricity use for domestic hot water is represented using a simplified approach based on cylinder size, temperature rise, and an assumed coefficient of performance consistent with overall heat pump performance in each scenario. Solar PV generation, where included, is calculated dynamically based on solar irradiance data obtained from the EU PVGIS API (v5.3) using the SARA3 radiation database, at a single representative geographic location. Panel orientation, panel tilt and inverter losses follow the PVGIS query parameters used for the analysis. Any generation surplus to on-site demand is used to charge the battery (if present); remaining surplus is exported and credited at an assumed export rate of 5p/kWh, consistent with the value applied in the findings report.

Battery storage is represented using a simple rule-based approach: charging occurs when surplus solar or low-cost grid electricity (under a smart tariff) is available, and discharging offsets on-site demand during higher-cost periods. The model tracks battery state of charge over time. Three simplifications are made for tractability. Battery degradation is not modelled: the battery is assumed to retain its rated capacity across the modelled year, which slightly overstates lifetime savings but has negligible effect on first-year costs (the focus of the analysis). Cycling limits beyond depth-of-discharge are not imposed, as the rule-based logic does not produce cycle counts that would materially shorten battery life. Advanced optimisation, such as model-predictive control or grid-services participation, is not modelled, because these capabilities are not standard in the residential installations the modelling is intended to represent; modelling them would risk overstating the savings available to a fuel poor household relying on default settings.

A3.5: Tariff and fuel price assumptions

The running cost calculations use the Ofgem price cap for Q2 2026 (April to June 2026) as the baseline tariff assumption. Under this price cap, the electricity unit rate is 24.67p/kWh and the gas unit rate is 5.74p/kWh (both inclusive of VAT at 5%). The electricity standing charge is 57.21p/day (£209/year) and the gas standing charge 29.09p/day (£106/year).

Standing charges are included in the running cost comparisons in the findings report (electricity standing charge on all rows; gas standing charge on the gas boiler row only), but are excluded from the dynamic comparison in Table 7 of the findings report, which presents household electricity costs under different complementary-measure packages. Households retaining a gas connection for cooking alongside a heat pump or other non-gas heating system would carry an additional £106/year.

For scenarios involving a time-of-use (smart) tariff, half-hourly electricity prices are used as an input to the cost model, allowing the analysis to capture the potential for shifting heat pump demand to lower-cost periods. The smart tariff structure used in the modelling is based on the published Octopus Cosy tariff profile available at the time of analysis.

Running costs for electric storage heaters in the main report are calculated using an Economy 7 weighted rate of 15.4p/kWh, reflecting the fact that the majority of storage heater households are on multi-register tariffs that provide a lower overnight rate for storage heating. In Section 3 of the findings report, a flat-rate figure of 24.67p/kWh is used for direct electric heating comparisons, representing households on a single-register tariff without an off-peak component.

Table 6: Fuel price and efficiency assumptions for counterfactual heating systems

Heating system	Fuel price (p/kWh)	Assumed system efficiency	Source
Gas boiler (condensing)	5.74	85%	Ofgem Q2 2026 price cap; SAP convention for condensing boilers in service
Oil boiler	8.0–10.0	80%	Boiler Juice / EST; range reflects recent volatility
LPG boiler	12.5	80%	Energy Saving Trust
Direct electric heating	24.67	100%	Ofgem Q2 2026 price cap
Electric storage heaters (Economy 7)	15.4 (weighted)	100%	Weighted Economy 7 rate, per main report Table 6

Running costs for counterfactual heating systems are calculated by dividing each archetype's annual heat demand by the assumed system efficiency to obtain the fuel consumption required to deliver that heat, and then multiplying by the applicable fuel price. This approach assumes that heat demand is the same regardless of heating system, which provides a like-for-like comparison but does not account for differences in heating patterns between system types (for example, the tendency toward continuous heating with heat pumps compared with intermittent heating with boilers). The implications of this simplification are discussed in the main report.

For oil, a range of 8 to 10p/kWh is used to reflect the significant price volatility observed in domestic heating oil markets at the time of writing. Cost comparisons involving oil are therefore presented as ranges rather than point estimates.

A3.6: Modelling limitations

Several important limitations apply to the interpretation of the running cost modelling:

- **Simulator simplifications:** The dynamic heat pump simulator uses a simplified thermal model and does not replicate specific manufacturer control algorithms. Defrost cycles are not modelled, leading to a small overestimate of annual performance. Control behaviour is represented through two stylised strategies rather than the full range of real-world configurations.
- **Hot water representation:** Domestic hot water heating is represented using a simplified approach based on assumed COP values rather than modelling tank dynamics, reheat cycles, and immersion heater activation in detail. This may understate the efficiency penalty of poorly configured hot water systems, which the secondary data analysis (Section A2.2) identified as a significant factor in some installations.
- **Comfort take-back:** The counterfactual comparison assumes that annual heat demand is the same regardless of heating system. In practice, fuel poor households transitioning from intermittent or partial heating to continuous heat pump operation may experience an increase in total heat demand (the 'comfort take-back' effect discussed in the main report), meaning that before-and-after bill comparisons are not like-for-like.
- **Solar PV and battery:** Solar PV and battery savings are calculated dynamically but assume a single geographic location for solar irradiance. Battery degradation, cycling limits, and advanced optimisation strategies are not modelled. Surplus electricity is credited at an assumed export rate of 5p/kWh (per Table 7 of the findings report).
- **Weather variability:** The modelling uses a single year of weather data and does not account for year-to-year weather variability. Cost outcomes would differ in colder or milder winters than the modelled year.

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- **Interpretation:** Results are intended to support comparative analysis of different system configurations and performance levels. They should not be interpreted as precise predictions of individual household bills, which will depend on occupancy patterns, thermostat settings, dwelling-specific characteristics, and tariff arrangements not captured in the modelling.
 - **Counterfactual efficiency assumptions:** Gas boiler efficiency is assumed at 85% (condensing) throughout the modelling and the main report cost tables. Oil and LPG boiler efficiency is assumed at 80%. These are standard assumptions for comparative analysis, but actual boiler efficiency varies with age, maintenance and operating conditions.

A4: Rapid evidence assessments

A4.1: Overview and approach

Three rapid evidence assessments (REAs) were conducted to synthesise the existing UK evidence base relevant to each research question. The REAs followed a consistent five-stage process: source identification, source screening against inclusion and exclusion criteria, quality assessment, prioritisation, and data extraction and synthesis. Detailed evidence review protocols, including search strategies and inclusion/exclusion criteria, were developed separately for each research question and shared with DESNZ for approval. The evidence reviews for all three research questions were conducted in parallel between November 2025 and February 2026.

As rapid evidence assessments rather than full systematic reviews, these reviews prioritised breadth of coverage and timeliness within the project's compressed timescales, while maintaining transparency about the search strategy, screening decisions, and confidence levels in findings. Evidence review findings are integrated throughout the main report rather than presented as a standalone chapter.

A4.2: Source identification

Sources were identified through a combination of systematic database searching, targeted grey literature searches, snowballing from key references, and AI-assisted deep search to identify additional sources.

Databases and repositories searched

- Academic databases: Web of Science, Scopus, Google Scholar
- Government repositories: DESNZ and DLUHC publications, scheme evaluation reports
- Sector and industry publications: Energy Systems Catapult, Building Research Establishment, Heat Pump Association, Heat Pump Federation, MCS

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- Grey literature from established organisations: Citizens Advice, National Energy Action, Resolution Foundation, Nesta, Centre for Sustainable Energy
 - Scheme evaluations: ECO (phases 2t, 3, 4), SHDF (Waves 1 and 2), Boiler Upgrade Scheme, Home Upgrade Grant, Local Authority Delivery
 - Cost data sources: Solar Energy UK, DESNZ cost reports, industry pricing surveys
 - Training and workforce bodies: Building Engineering Services Association (BESA), Chartered Institution of Building Services Engineers (CIBSE), training provider publications

Search strings were developed iteratively for academic databases, combining terms relating to fuel poverty, heat pumps, heating behaviours, performance factors, and scheme evaluations. Grey literature searches used targeted keyword combinations via Google and sector-specific repositories. Where appropriate, snowballing was applied to the reference lists and citing literature of key sources to identify additional relevant material.

Following manual searching, an AI-assisted deep search tool (Perplexity AI) was used as a supplementary identification method to surface additional sources that may not have appeared through conventional search routes. AI was used solely for source identification, not for summarisation or analysis. All sources identified through AI search were subjected to the same screening and quality assessment process as those identified through manual methods.

Search strings

Search strings were developed iteratively for academic databases, combining terms relating to the specific research areas for each research question. The search strategies and detailed inclusion and exclusion criteria for each research question were set out in separate evidence review protocol documents approved by DESNZ. Key search strings included:

RQ1 (Fuel poor heating behaviours and experiences): Search strings included: (fuel poverty OR fuel poor OR low income OR vulnerable) AND (heating OR energy) AND (behaviour OR action OR habit OR practice); heat pump AND (fuel poverty OR low income OR vulnerable household OR energy poverty) AND (UK OR England OR Britain OR social housing); heat pump AND (heating behaviour OR user experience OR customer journey OR installation OR performance) AND (energy efficiency OR retrofit); (ECO4 OR Social Housing Decarbonisation Fund OR SHDF OR Boiler Upgrade Scheme OR BUS) AND (evaluation OR impact OR barrier OR enabler); fuel poor household AND (low carbon heating OR heat pump adoption OR transition OR barriers OR support).

RQ2 (Technical performance factors): Search strings for academic databases included: heat pump AND (coefficient of performance OR COP OR SCOP OR SPF OR efficiency) AND (flow temperature OR weather compensation OR commissioning); heat pump AND (intermittent heating OR continuous heating OR heating pattern OR setback) AND (efficiency OR performance OR energy consumption); heat pump AND (sizing OR oversize

OR undersize) AND (cycling OR efficiency OR performance); air source heat pump AND (field trial OR monitoring OR real-world OR in-situ) AND (UK OR England OR Britain).

RQ3 (Interventions, costs and policy): Search strings included: heat pump AND (social housing OR housing association OR local authority) AND (deployment OR rollout OR installation); heat pump AND (installer OR workforce OR supply chain) AND (training OR competency OR skills) AND (UK OR England); heat pump AND (solar PV OR battery storage OR monitoring) AND (cost OR installed cost) AND (UK OR England); heat pump AND (ECO OR Energy Company Obligation OR SHDF OR Social Housing Decarbonisation Fund) AND (evaluation OR assessment OR impact).

A4.3: Source screening

Identified sources were screened against inclusion and exclusion criteria developed for each research question. The criteria were designed to ensure relevance to the UK policy context, recency, and a minimum quality threshold.

Evidence review for RQ1: Fuel poor heating behaviours

The RQ1 evidence review focused on two primary research areas: how fuel poor households interact with their heating systems (behaviours, coping strategies, patterns); and evidence on fuel poor households' experiences with heat pumps specifically.

Inclusion criteria required: UK-focused sources published since 2022 (with flexibility for seminal older studies) addressing heating behaviours, experiences, or coping strategies among low-income or fuel poor populations; empirical data, robust policy evaluations, or stakeholder insights; peer-reviewed articles, government publications, credible NGO reports and industry analyses with transparent methods. Sources from non-UK contexts were included where directly transferable.

Exclusion criteria applied to: studies focused solely on non-UK contexts unless highly transferable; sources lacking transparency in methods or data; evidence on commercial or industrial heat pumps only; publications before 2022 unless directly addressing fuel poverty, providing empirical installation evidence, or foundational to the field.

Evidence review for RQ2: Technical performance factors

The RQ2 evidence review focused on technical and behavioural factors affecting heat pump performance and running costs. This review drew more heavily on technical literature, field trial reports, and monitoring studies.

Inclusion criteria required: UK-focused evidence on heat pump performance, prioritising England where available; international evidence where directly applicable to UK housing stock and climate; empirical performance data from field trials, monitoring studies or laboratory testing; peer-reviewed articles, government publications and credible technical

reports with transparent methods; studies quantifying impacts of installation, commissioning or operational factors on efficiency.

Exclusion criteria applied to: studies focused solely on non-UK contexts where findings are not transferable; publications before 2015 unless providing foundational empirical evidence; theoretical modelling without empirical validation; marketing materials without technical substantiation.

Evidence review for RQ3: Interventions, costs, and policy

The RQ3 evidence review was organised into four research areas: delivery contexts and customer journeys; supply chain skills and training; intervention costs; and the policy and regulatory landscape. This review drew heavily on scheme evaluation reports, regulatory and standards documentation (MCS, PAS 2035, TrustMark), training body publications, and cost data from industry sources.

Inclusion criteria required: UK-focused evidence on heat pump deployment programmes and policies in low-income or fuel poor contexts, or transferable evidence from analogous energy efficiency programme delivery, prioritising England; scheme evaluations with transparent methodology; cost data from credible sources with clear provenance; best practice guidance from recognised industry or government bodies; evidence on workforce training, competency frameworks and quality assurance.

Exclusion criteria applied to: studies focused solely on non-UK contexts where policy learning is not transferable; publications before 2020 unless providing foundational evidence on scheme design or fuel poverty policy; marketing materials or advocacy documents without empirical substantiation; outdated cost data (pre-2022) unless providing relevant historical trends.

A4.4: Quality assessment and prioritisation

All sources passing initial screening were assessed for both quality and relevance using a proportionate, qualitative High/Medium/Low (HML) rating framework against each, applied consistently across all three research questions. The quality framework assessed clarity of aims and methods, appropriateness of design, data robustness and transparency, risk of bias indicators, and institutional credibility. The HML ratings were documented in an evidence matrix alongside an assessment of relevance to the specific research question.

Sources were then prioritised by combining quality and relevance ratings. Where the number of sources exceeded 20 per research question, lower-priority sources were excluded from in-depth extraction, though key findings from excluded sources were noted where they corroborated or contradicted evidence from higher-priority material. The prioritised source list for RQ1 was shared with DESNZ for review before extraction proceeded. For RQ2 and RQ3, extraction proceeded in parallel with ongoing DESNZ engagement on the research.

A4.5: Data extraction and synthesis

Evidence was extracted systematically from prioritised sources using a standardised evidence matrix template. The synthesis maintained a critical perspective on evidence quality, and transparently documented gaps in the evidence base. Where evidence quality was mixed, findings were weighted and caveated accordingly.

Evidence review findings are integrated throughout the main report: supporting the policy and sector context; providing existing evidence on fuel poor heating behaviours; reinforcing and addressing gaps in the secondary data analysis; and underpinning the recommendations and suggested actions.

A4.6: Evidence review limitations

As rapid evidence assessments conducted within compressed project timescales, these reviews have inherent limitations. They do not claim to be exhaustive systematic reviews and may not have captured all relevant literature, particularly unpublished or in-progress work. Grey literature sources are inherently less standardised in quality than peer-reviewed academic research. The use of AI for supplementary source identification, while adding breadth, introduces some uncertainty about comprehensiveness. These limitations are acknowledged, and the evidence reviews should be understood as providing a robust but not definitive overview of the current evidence landscape.

A5: Evidence synthesis and triangulation

The final stage of the research brought together findings from all three strands (qualitative interviews, secondary data analysis, and evidence reviews) into an integrated evidence synthesis. The synthesis was structured around the three research questions, with cross-evidence mapping used to identify where findings converged, diverged, or addressed complementary aspects of the same issue.

The synthesis process involved charting findings from each strand against the key factors and themes identified in the analysis, enabling systematic triangulation.

Recommendations were developed through an evidence-to-action process, with each recommendation linked to specific evidence and classified by the strength of the supporting evidence base.

Annex B: Qualitative sample characteristics

This section presents the full achieved sample for the qualitative interviews with households at risk of fuel poverty. A total of 29 interviews were completed between January and February 2026.

Tables 7 to 9 present summary frequency counts for the achieved sample across the primary sampling dimensions.

Several tables summarising the qualitative sample including income levels, health conditions and fuel poverty status have not been provided here in the interests of the interview participants but were made available to the DESNZ research team during the project development.

Table 7: Achieved sample by demographic characteristics

Category	Number of participants
Gender	
Female	17
Male	12
Age band	
25-34	2
35-54	7
55-64	4
65-74	11
75+	5
Ethnicity	
Asian / Asian British	1
Other	2
White/White British	26
Household composition	

Category	Number of participants
Single	9
Couple	12
With children (<14)	3
With adult dependants	5
Disability or long-term health condition in household	
None reported	18
Participant only	4
Another household member only	4
Both participant and another household member	3

Table 8: Achieved sample by housing and heating characteristics

Category	Number of participants
Tenure	
Owner-occupier	18
Social renting	9
Private renting	2
Property type	
Bungalow	9
Detached	3
Flat/maisonette	2
Semi-detached	9
Terraced	6
Home age	
Pre-1919	7
1919-2020	20

Category	Number of participants
Post-2020	1
Unknown	1
Heat pump type	
Air source	26
Ground source	0
Unknown	3
Previous heating	
Electric storage heaters	6
Other electric (convector, plug-in, electric boiler, wall-hung)	9
Oil-fired system	6
Mains gas	2
LPG	1
Solid fuel	1
Heat pump pre-installed (previous system not used by	3
Unknown	1
Time since installation	
Less than 1 year	6
1-2 years	9
2+ years	14

Note: the screening criterion required at least one full winter's experience with the heat pump. Six participants had been in the property with the heat pump for fewer than 12 calendar months at the point of interview but had all experienced at least one full heating season, in line with the screening criterion.

Table 9: Achieved sample by region and financial indicators

Category	Number of participants (n=29)
Region	
East of England	4
North East	2
North West	4
South East (excluding London)	1
South West	17
Yorkshire and the Humber	1
Reports rationing energy use	
Yes	20
No	9
Reports struggling to pay energy bills	
Yes	7
No	22
Monthly energy bill range	
£50-£83	10
£83-£117	9
£117-£150	3
£150-£184	1
£184-£217	5
£218-£250	1
Payment method	
DD (no smart)	1

Category	Number of participants (n=29)
DD (smart)	25
Other	1
Smart prepay	2

Annex C: Research instruments

C1: Interview topic guide

Heat Pumps and Fuel Poverty Interview Topic Guide

Notes to researcher

- **Bold text:** Main questions to ask
- Bullet points: Probes related to main questions

Italics: General instructions for interviewer

Red text: Instructions about observations and technical data capture

- **[PRIORITY]:** Critical questions that must be covered even if time is short

Research Overview and Consent

The Committee on Fuel Poverty is an independent advisory body sponsored by the Department for Energy Security and Net Zero (DESNZ). The Committee provides advice to government on reducing fuel poverty in England. DESNZ, on behalf of the Committee, has commissioned Carbon Trust and Ipsos to carry out this research to understand the lived experience of households with a heat pump installed.

The aim of this interview is to understand your experience of living with a heat pump. We will talk about how you heat your home, how you use the controls, what information you were given about the system, and your overall experience. We will also collect some information about how your heat pump is set up.

We will be talking about some potentially sensitive topics today related to health issues and home heating costs. If you do not feel comfortable answering any questions, that is not a problem, and we can skip over them. We can take a break at any time, and you can stop the interview at any point.

Interview structure

Part 1 (approximately 40 minutes): We will sit down and have a chat about your experience with the heat pump.

Part 2 (approximately 20 minutes): With your permission, my colleague from Carbon Trust will join us to look at the heat pump system and collect some technical information, while we continue our conversation.

Ethics and GDPR

Interviewer to turn on the recorder and record consent to take part, for the discussion to be recorded, and for pictures to be taken.

Ipsos operates according to the Market Research Society Code of Conduct and the General Data Protection Regulation. Your participation is voluntary and everything you say will be anonymous. Neither DESNZ nor the Committee on Fuel Poverty will be able to identify you from the data or in the report. You can withdraw your consent at any point before data is anonymised in February 2026.

Can I check that you are happy for the discussion to be recorded?

With your permission we would like to take photos of the heat pump unit, the controls, and your radiators. Are you happy for these pictures to be taken?

Section 1: Your Household

Aim: To understand the household context, occupancy patterns, and any health factors that affect heating needs. This information helps us understand why you heat your home the way you do.

 **5–8 minutes**

To start, it would be really helpful to understand a little bit about your home and who lives here.

Could you tell me who lives here in the household with you?

- Ages of household members, relationship to you

[PRIORITY] Could you describe a typical week for your household? When are people usually at home?

- Work patterns, school runs, caring responsibilities
- Who is home during the day? Who is home in the evenings?
- Any differences between weekdays and weekends?

Does anyone in the household have any health conditions or disabilities that might affect how you need to heat your home?

- Conditions that mean you feel the cold more, or need stable temperatures
- Any mobility issues that affect where people spend time in the home

Before the heat pump was installed, what kind of heating system did you have?

- Gas boiler, electric storage heaters, oil boiler, or something else?

Do you have a smart meter?

Section 2: How You Heat Your Home Now

Aim: To understand current heating behaviours, patterns, and any self-rationing. This is the core of the research – understanding what people actually do.

 **10–12 minutes**

Heating patterns and schedules

[PRIORITY] Can you walk me through how you typically heat your home?

- When do you decide to start using the heating? Is it a certain time of year, or when it gets cold outside?
- What times of day is the heating typically on?
- Is it on all the time at a low level, or does it come on and off at certain times?
- Do you keep the heating on when you go out, or turn it off?

[PRIORITY] Do you heat all the rooms in your home, or just some of them?

- Which rooms do you heat? Which rooms do you leave unheated or cooler?
- How do you control which rooms are heated? Do you turn radiators off, or use the valves on individual radiators?
- Why do you heat some rooms and not others?

What temperature do you try to keep your home at?

- Do you set different temperatures for different times of day?
- Do you turn the temperature down overnight?

Secondary heating and coping strategies

[PRIORITY] Do you use any other ways of keeping warm apart from the heat pump?

- Electric heaters, fan heaters, oil-filled radiators?
- Hot water bottles, electric blankets?
- Wearing extra layers of clothing?
- When do you use these? Why do you use them instead of the heat pump?

Cost considerations

[PRIORITY] Are there times when you keep the heating lower than you would like to, or turn it off when you would prefer it to be on?

- Is this because of the cost of heating?
- How do you decide when you can afford to have the heating on?

Section 3: How This Compares to Your Previous Heating

Aim: To understand how heating behaviours have changed since the heat pump was installed, and identify 'sticky' behaviours carried over from previous systems.

 **8–10 minutes**

[PRIORITY] Thinking back to your previous heating system, how did you used to heat your home?

- Did you have the heating on all the time, or at certain times of day?
- Did you heat all the rooms, or just some of them?

- What temperature did you set it to?

[PRIORITY] Have you changed how you heat your home since the heat pump was installed?

- What's different now compared to before?
- What's stayed the same?
- Why did you make these changes, or why have you kept doing things the same way?

Were you told that you might need to use the heat pump differently from your old heating system?

- What were you told?
- Have you been able to follow that advice?

Comfort comparison

How comfortable do you feel in your home now in winter, compared to before you had the heat pump?

- Is your home warmer, cooler, or about the same?
- Does the heat feel different? Some people say heat pumps feel different to boilers.
- Are there any cold spots in your home?
- Any issues with damp or mould?

What about hot water? Is there enough? Is it hot enough?

- How does this compare to your previous system?

Section 4: Controls and Settings

Aim: To understand what controls people have, how they use them, and their level of understanding. This will be supplemented by direct observation in Part 2.

🕒 8–10 minutes

Controls used

[PRIORITY] Let's talk about the controls. What do you use to control your heating?

- Do you have a thermostat on the wall?
- Do you have a timer or programmer?
- Do you use an app on your phone?
- Do you adjust the valves on individual radiators?

[PRIORITY] Which of these do you actually use regularly? Which do you never touch?

- Why don't you use some of them?
- Are there any buttons or settings you're not sure what they do?

Understanding of controls

Do you feel you understand how the controls work and how to use them properly?

- What's easy to understand? What's confusing?
- Is there anything you would like to be able to do but don't know how?

Preferences for control

[PRIORITY] Some people like to be in control of their heating and adjust things manually. Others prefer a system that runs automatically. What's your preference?

- How important is it to you to have the final say on when the heating is on and off?
- Would you be happy for the system to manage itself automatically if it meant lower bills?
- How much do you trust automatic or 'smart' features to make the right decisions?

Section 5: Information and Advice You Were Given

Aim: To understand what information, advice and guidance was provided about operating the heat pump efficiently, and where gaps exist.

 **8–10 minutes**

Note: Follow Route 1 if the heat pump was installed while they lived there, Route 2 if they moved into a property with an existing heat pump.

Route 1: Heat pump installed while living there

[PRIORITY] When the heat pump was installed, were you given any information about how to use it?

- Did anyone show you how to use the controls?
- Did they leave you a manual or any written instructions?
- How long was the explanation? Was it enough?

[PRIORITY] Were you given any advice about the best way to run a heat pump efficiently?

- Were you told anything about how heat pumps work differently from boilers?
- Were you given any advice about temperatures, or having the heating on for longer at lower settings?
- Who gave you this advice – the installers, your landlord, someone else?

Did anyone come back after the installation to check how you were getting on?

- Did anyone check the system was working properly after you'd used it for a while?
- Would a follow-up visit have been helpful?

How confident did you feel about using the system right after it was installed?

Route 2: Moved into property with existing heat pump

[PRIORITY] When you moved in, what information were you given about the heating system?

- Did the landlord or letting agent explain how it worked?

- Were you given a manual or any written instructions?
- Was there any demonstration of how to use it?

How did you learn how to actually use it day-to-day?

- Was it trial and error? Did you look things up online?
- Did you have to contact your landlord or a technician for help?

Both routes: Understanding of efficient operation

[PRIORITY] Have you heard anything about the best way to run a heat pump to keep costs down?

- Where did you hear this – from the installer, your landlord, online, friends, somewhere else?

Note: The following questions explore awareness of efficient operation without suggesting their current behaviours are wrong. Ask in a neutral, curious way.

Some people say heat pumps work best when they're left running for longer periods at lower temperatures, rather than turning them on and off. Had you heard that before? What do you think about that?

Some people say you shouldn't turn individual radiators down when you have a heat pump, because it's better for the whole house to be the same temperature. Had you heard that? What do you think?

Is there anything about running your heat pump efficiently that you're unsure about or would like to know more about?

Section 6: Energy Bills and Costs

Aim: To understand the financial context and any bill changes since the heat pump was installed. This helps explain self-rationing behaviours.

🕒 5–8 minutes

Interviewer note: These questions may be sensitive. Remind participant they can skip any questions they're not comfortable answering.

Have you noticed a change in your energy bills since the heat pump was installed?

- Have they gone up, down, or stayed about the same?
- By roughly how much?

If participant has recent bills available: Could I take a note of your electricity usage from a recent bill? We're interested in how many kilowatt hours you use, not what you pay.

How do you pay for your energy?

- Monthly direct debit, prepayment meter, quarterly bills?
- Has this changed since you had the heat pump?

Overall, do you feel your heating is more or less affordable now compared to your old system?

Do you receive any help with your energy bills?

- Any grants, discounts, or benefits that help with energy costs?

What energy tariff are you on? Do you know if it's a standard tariff, or a special rate?

- Some people have tariffs with cheaper electricity at certain times of day. Do you have anything like that?
- Would you be interested in a tariff like that if it could reduce your bills?
- Do you know how you would go about changing your tariff? Would you need to go through your landlord?

Section 7: Overall Reflections

Aim: To capture overall satisfaction, identify what would have helped, and understand receptiveness to changes that could improve their experience.

 **5 minutes**

Reflecting on your experience with the heat pump so far, what have been the best things about it?

And what have been the biggest challenges or downsides?

Has the heat pump been reliable? Have you had any problems or breakdowns?

- If yes: What happened? Who did you contact? How was it resolved?

If you were given the choice, would you choose to have a heat pump? Why or why not?

[PRIORITY] Thinking about other households like yours, what would make the move to a heat pump easier?

- What advice or support would help?
- What information would be useful, and how would you want to receive it?
- What could the installers or your landlord have done differently?

Part 2: Looking at the Heat Pump System

Aim: To observe the system, collect technical data, and see how the participant interacts with controls. The Carbon Trust colleague will join for this section.

 **20 minutes**

Interviewer note: Introduce the Carbon Trust colleague to the participant. Explain that they will look at the heat pump system together while continuing to chat. The Carbon Trust colleague will complete the technical data collection form.

System tour

Could you show us the different parts of the heating system?

- Let the participant lead. Prompt if needed for: the outdoor unit, the indoor unit or hot water cylinder, the main thermostat or controller

Were any other changes made to your home when the heat pump was installed?

- New radiators? Extra insulation? New windows or doors? New pipework?

Controls demonstration

Can you show us how you would use this system to warm your home?

- What buttons or settings do you use?
- If it feels too cold, what would you change?
- If it feels too warm, what would you change?

What temperature is the thermostat set to at the moment?

- Is this what you normally have it set to?
- Do you set it lower overnight? What do you set it to?

Can you remember who set up these settings originally? Have you changed them?

Hot water

Can you show me how you control the hot water?

- What temperature is it set to?
- How do you know when you have enough hot water?

Outdoor unit

Do you ever have to think about the outdoor unit?

- Have you been told to do anything to maintain it?

Materials and support

Do you have any materials, leaflets, or booklets about the heat pump?

- How often do you look at them?

Has anyone come to check or fine-tune the system since it was first installed?

- Was that helpful?

Technical Data Collection

Carbon Trust colleague to complete during/after system observation. Document the following:

System identification

- Heat pump make and model
- Heat pump capacity (kW)
- Installation date (if visible/known)
- Hot water cylinder make/model and capacity

Temperature settings

- Room thermostat set point (°C)
- Overnight setback temperature (if any) (°C)
- Flow temperature for space heating (°C)

- Hot water cylinder temperature set point (°C)

Weather compensation

- Is weather compensation enabled? (Yes/No/Cannot determine)
- If yes: Weather compensation curve settings (minimum and maximum flow temperatures)

Energy consumption (if available from display or meter)

- Electricity consumed (kWh) – ideally previous 12 months
- Heat generated (kWh) – ideally previous 12 months
- Calculated SPF if data available

Property observations

- Radiator types and sizing (appear adequate/undersized/mixed)
- TRV positions observed
- Visible insulation or draught-proofing
- Any visible issues (condensation, damp, etc.)

Photos to take (with consent)

- Outdoor unit; indoor unit / hot water cylinder; main controller/thermostat display; system settings screens; representative radiator with TRV; any energy display showing consumption/generation data
- Where consent permits, a selection of representative photographs from the technical audits illustrating common configuration issues (third-party thermostat installations, weather compensation set-up displays, hot water settings, radiator and emitter sizing) is available from the Carbon Trust on request. Photographs are not reproduced in this annex in order to preserve participant anonymity.

Wrap-up and Heating Diary Introduction²

🕒 5–10 minutes

Return with participant to the place where you started the discussion.

Thank you so much for showing us the system and for sharing your experiences. It's been really helpful.

Is there anything else you would like to mention that we haven't covered?

Introducing the heating diary

Note: this diary-introduction section reflects the first four interviews, when the diary was completed after the interview. From the fifth interview onwards the diary was completed before the interview (see Section A1.5), and the introduction was given at the start of the session with the wording adjusted to refer to the upcoming interview.

² Subsequently amended to be completed prior to interview

The final part of the research is a heating diary. We would like you to keep a record of how you use your heating over the next week. This will help us understand how heating patterns vary from day to day.

Here is the diary. Let me explain how it works:

- Please fill it in every day for the next week, starting tomorrow
- Each day, we ask whether you used the heating, when it was on, which rooms you heated, and how comfortable you felt
- We also ask about any other things you did to keep warm, like using extra heaters or wearing more layers
- On the last day, there are a few extra questions about the week as a whole
- It should only take a few minutes each day

When you have completed the diary, please return it to us using the pre-paid envelope provided, or by email. As a thank you for completing the diary, you will receive an additional £30 voucher.

Do you have any questions about the diary?

Closing

Thank you once again for your valuable time today. Your participation is anonymous and your responses will help inform how the government supports households moving to heat pumps.

C2: Heating diary

Note: the version of the heating diary shown below was used for the first four interviews, when the diary was completed after the interview. As described in Section A1.5, from the fifth interview onwards the diary was completed before the interview to avoid the risk that the interview itself would influence reported heating behaviours; the participant-facing wording in later iterations was amended accordingly to refer to the upcoming interview rather than a completed one.

The heating diary was a seven-day structured instrument. For the first four interviews it was completed after the interview; from the fifth interview onwards it was completed before the interview (see Section A1.5). Paper and digital versions were provided. The diary was returned by post (using a pre-paid envelope) or by email.

Introduction provided to participants

Thank you so much for completing an interview with Ipsos and Carbon Trust. This heating diary is so we can understand a little bit more about your heating behaviours over a week. As with everything you send us, your answers will be held in strict confidence. We will be producing a report for our client, the Department for Energy Security and Net Zero (DESNZ), but we will report on these diaries as a whole and will not be sharing any identifiable information with DESNZ.

Please be as honest as possible in this diary – we want to get a clear and realistic understanding of your heating behaviours over the course of the week.

As a reminder, for successful completion of this diary, you will receive a £30 flexible shopping voucher as a thank you for your time.

Daily questions (Days 1–7)

Each day, participants were asked the following questions:

Q1. Has your heat pump been switched on today? [Yes / No]

Q2. If your heat pump has been switched on today, please fill out the below:

- When? [Write in times or periods, e.g. '2–4pm', 'all day', 'overnight']
- For how long?
- Which rooms in your home did you heat?
- If you did not heat the whole house, why did you heat particular rooms?

Q3. If your heat pump has been on today, please rate on a scale of 1–5 how comfortable your home has been today.

- 1 = Not comfortable at all; 2 = Quite uncomfortable; 3 = Slightly comfortable; 4 = Very comfortable; 5 = Completely comfortable

Q4. Are there any rooms in your home that you find easier or more difficult to heat?

- Yes – more difficult to heat than other rooms [which rooms and why]
- Yes – easier to heat than other rooms [which rooms and why]
- No – I have not noticed differences between rooms

Q5. Did you do anything else today to keep you/others in your household warm?

- Yes – clothing adjustments e.g. putting on a jumper [describe]
- Yes – used other methods of heating e.g. a portable heater [describe]
- Yes – used other methods of heating e.g. a hot water bottle [describe]
- Yes – another way of keeping warm [describe]
- No – I did not use any other method of keeping warm today [explain why]

Additional questions on Day 7

On the final day, participants were asked the following additional questions covering the week as a whole:

Q6. Thinking about the last week as a whole, would you say you have used your heat pump more or less than the week before?

- I have used my heat pump more this week / I have not used my heat pump differently / I have used my heat pump less this week / I cannot remember

Q7. If you have changed how much you use your heat pump this week, please write in why. [Open text]

Q8. Thinking about the week as a whole, how comfortable would you say your home was this week? [1–5 scale as above]

Q9. Is there a reason you think your home was more or less comfortable this week? [Open text]

Q10. Have you used your heat pump in a different way this week than you have before?

- I have used my heat pump differently / I have not used my heat pump differently / I cannot remember

Q11. If you have used your heat pump differently, how and why? [Open text]

Q12. Finally, thinking about your heat pump, what are the key messages you would want people who might get a heat pump in the future to know? [Open text]

C3: Technical data capture pro-forma

The technical data capture pro-forma was completed by the Carbon Trust technical expert during each in-home visit. The pro-forma was designed to document the heat pump system's configuration, performance data, and property characteristics in a standardised format, enabling systematic comparison across the 20 in-home visits. The pro-forma template is shown below.

The following fields were recorded for each in-home visit:

Table 10: Technical audit pro forma

Field	Data recorded
Site	[Address / location identifier]
Date of interview	
Date of heat pump installation	
Total floor area (EPC)	m ²
EPC rating	
Estimated space heating demand (EPC)	kWh
Estimated water heating demand (EPC)	kWh
Estimated heat loss range (EPC)	kW
Make and model of heat pump	
Heat pump capacity	kW
Type and model of controller	
Third-party thermostat present	Yes / No
How the participant uses the system	[Description of heating pattern]
Room temperature set point	°C

Setback temperature (if used)	°C
Zoning / TRVs	[Description of TRV positions and zoning]
kWh electricity consumed	[Time period and value]
kWh heat output	[Time period and value]
COP / SPF over measurement period	
Weather compensation enabled	Yes / No / Cannot determine
Weather compensation curve settings	[Min and max flow temperatures if accessible]
External temperature at time of visit	°C
Primary flow temperature at time of visit	°C
Primary return temperature at time of visit	°C
Hot water temperature set point	°C
Hot water reheat settings / hysteresis	[If accessible]
Immersion heater setting	On / Off / Not present
Buffer tank present	Yes / No
Radiator type and sizing	[Adequate / undersized / mixed; panel type]
Visible insulation or draught-proofing	[Description]
Any visible issues	[Condensation, damp, pipework, etc.]
Notes	[Free text observations on system configuration and performance]
Photographs taken	[List of photographs taken with consent]

Photographs were taken with participant consent and included: the outdoor unit, indoor unit or hot water cylinder, main controller or thermostat display, system settings screens (flow temperature, weather compensation), representative radiator with TRV, and any energy display showing consumption or generation data

This publication is available from: www.gov.uk/desnz

Any enquiries regarding this publication should be sent to the Department for Energy Security and Net Zero.

If you need a version of this document in a more accessible format, please email alt.formats@energysecurity.gov.uk. Please tell us what format you need. It will help us if you say what assistive technology you use.