EQUINOX

Equitable Participation Framework

February 2026

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Version control

Issue	Date
D v0.1	December 25
FINAL	February 2026

Publication control

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Table of contents

1. Executive Summary

Purpose and Objectives of this report

EQUINOX is testing new commercial and technical arrangements to reward households with heat pumps for participating in flexibility by temporarily altering their heating choices without compromising on comfort, with a particular focus on ensuring those with vulnerabilities or who are fuel poor are able to participate

. The Equitable Participation Framework (EPF) is a bespoke framework identifying key factors affecting access and engagement with heating flexibility offerings, and applying these in the development of hypotheses, the analysis of project results and in the formation of subsequent recommendations with the aim of supporting the delivery of a fair and inclusive energy transition.

This report covers the development, application, and lessons learnt from the EPF within the EQUINOX project. It outlines the rationale for the identified vulnerability factors, the process of developing the framework, and how it has been applied to support recruitment, hypothesis formation, and trial result segmentation. The report also provides insights into how the EPF can be adapted for other projects, emphasising the need for a bespoke approach.

Why an EPF is needed

A bespoke EPF is crucial for developing an understanding of how different groups, particularly potentially vulnerable and fuel-poor households, navigate and participate in heating flexibility. This understanding supports a Just Transition, by enabling the design of heating flexibility offerings that ensure the benefits they offer are accessible to all.

Development of the EPF

The EPF was developed through a comprehensive process involving literature reviews, expert consultations, and analysis of existing frameworks. The framework identifies factors that increase the likelihood of vulnerability in the context of heating flexibility, aiming to support targeted recruitment, hypothesis formation, and trial result segmentation.

Key Vulnerability Factors

The EPF identifies several factors considered primary vulnerability factors with direct mechanisms of action that can put a household at increased risk of being in a vulnerable situation, including age, education, language skills, income, health, housing conditions, and personal situation. These factors are used to target recruitment and ensure safe and effective participation in heating flexibility trials.

Application in EQUINOX

The EPF has been developed for and applied to the EQUINOX project via the development of personas used to identify and develop hypotheses, to segment and analyse project results and to develop recommendations both to enhance equitable participation in the trial and to improve equitable participation in future heating flexibility offering design. It was, and can be used , to identify any safeguarding risks to ensure participation in the trial is both equitable and safe.

Adapting the EPF to Other Projects

The EQUINOX EPF can be used as a framework to guide and support the development of bespoke equitable participation frameworks for other projects and beyond, ensuring that representation is as broad as possible wherever it is needed. A bespoke framework is required for each project because vulnerability depends on the specific context and conditions participants are subjected to. Key steps for adapting the EPF included:

1. **Identify the specific mechanisms that drive potential vulnerability**: understanding the specific ways participants may find themselves in vulnerable situations within the context of the project help identify and refine the factors that indicate potential vulnerability. It involves identifying the driving factors that increase the risk of detriment or which affect a participant's ability to engage effectively and safely with the offering.
2. **Literature Review and Expert Consultation**: utilise existing research and consult with experts to further identify potential vulnerability factors relevant to the new project, keeping the identified mechanisms driving potential vulnerability in mind. This helps to inform the creation of a comprehensive longlist of factors.
3. **Refine and Shortlist Factors**: analyse the longlist to refine and shortlist factors that have the most significant impact on potential vulnerability. This involves considering the mechanisms of action and how strongly a factor drives potential vulnerability accordingly, interactions with other factors, and the practicality of measuring these factors.
4. **Develop Personas and Customer Journeys**: create personas representing different combinations of vulnerability factors and map out their experience along the customer journey. This helps inform an understanding of how these factors affect engagement and to identify potential challenges and needs.
5. **Formulate Recommendations and Hypotheses**: based on the personas and customer journeys, develop tailored recommendations for enhancing equitable participation and formulate hypotheses to be tested in the project.
6. **Implement and Monitor**: Apply the adapted framework to the project, identifying potentially vulnerable participants, implementing the project-specific recommendations, and monitoring the participation and engagement of identified potentially vulnerable groups. The insight from applying the framework may lead to further adjustments to it as needed based on the

findings, as well as further recommendations for research and for enhancing equitable participation in BAU.

Lessons Learned

An overarching message to be drawn from the development of the EPF is the need a bespoke approach to equitable participation in each project. It is particularly important to understand and identify the specific and direct mechanisms driving how a person or a household becomes vulnerable, and lessons can be drawn from the process to develop the EQUINOX EPF about the value of validating them through customer journey testing and the development of personas.

We identified six insights from the development of the EPF which can be valuable for other projects:

1. **There is a lot of pre-existing work on vulnerability which should be used as an initial basis to generate a more bespoke understanding of potential vulnerability for the specific case being considered**: in shaping the EPF, the value of existing research into potential vulnerability factors as a foundation to inform the further elaboration of a bespoke understanding of vulnerability for the project in question was clear. Therefore, both the process to develop an EPF, as well as some of the insights and vulnerability factors from the EQUINOX EPF, can and should also be adapted for other projects.

2. **It is essential to understand the mechanisms by which participants in projects or flexibility offerings may find themselves in a vulnerable situation**: vulnerability depends upon the situation and the need for special care, support, or protection because of characteristics like age or health conditions will depend on the environment and specific circumstances a person or household find themselves in. By identifying these mechanisms and aligning them to identified vulnerability factors, we can be sure that the factors are driving potential vulnerability themselves and that we are less likely to capture households who are not actually vulnerable in our definition.

3. **There are many common 'vulnerability factors', but not all have clear direct mechanisms to drive potential vulnerability**: where factors do not have clear, direct mechanisms on participant vulnerability, their inclusion as a vulnerability factor should be carefully considered and in most cases, they should be excluded entirely.

4. **Using a wide range of vulnerability factors can increase the pool of potentially vulnerable participants significantly**: vulnerability is likely to be more widespread than has previously been thought. This is not a problem, rather it is an opportunity to ensure more households are able to engage in market mechanisms. It does, however, underline the importance of understanding the mechanisms by which households find themselves in a vulnerable situation.

In the case of the EQUINOX project, applying the Equitable Participation Framework increased the proportion of potentially vulnerable participants from 20-22% in the first two trials, to around 47% in Trial 3.

5. **We can combine factors – and take into account mitigating factors - to improve segmentation of results according to the EPF:** this allows for consideration of mitigating factors that reduce the likelihood households with one or more vulnerability factors are actually in a vulnerable situation, and also reduces the risk that using certain vulnerability factors capture large numbers of households who are only slightly more likely to be in a vulnerable situation.

   By focusing on participants with multiple and/or certain combinations of vulnerability factors indicators, the EPF enabled the project to focus on the participants most at risk of being in a vulnerable situation. This approach should in turn increase the fidelity of the results.

6. **A bespoke approach to equitable participation can deliver valuable insights**: because vulnerability depends upon the situation, we cannot develop a single framework for potential vulnerability that will apply in the case of every project. The EPF provides a methodology to develop consistent but bespoke frameworks for each project._

The bespoke EPF supports the generation of recommendations for enhancing recruitment, participation, and safeguarding in heating flexibility trials, as well as for the transition to BAU. These include targeted communication, enhanced monitoring, and considering how to mitigate wider, structurally embedded societal issues such as income inequality and digital exclusion.

Conclusion

The EPF and the framework to develop it are valuable tools for ensuring equitable participation in heating flexibility offerings. By identifying and addressing vulnerability factors. Its application can help ensure the delivery of a fair and inclusive energy transition. The process developed for the EQUINOX EPF can and should be tailored to other projects, ensuring that each project can effectively address the questions around equitable access and engagement, taking into account the unique circumstances and mechanisms by which participants can find themselves in a situation of vulnerability.

1. Purpose

The EQUINOX project is investigating the potential for individuals to benefit from Demand Side Flexibility (DSF) response through their heat pumps. DSF presents an opportunity to lower energy costs by rewarding consumers for adapting to demand fluctuations, ultimately contributing to a more cost-effective energy transition, including by avoiding costly infrastructure upgrades to accommodate the growing demand on the electricity grid resulting from the widespread adoption of heat pumps.

To understand and ultimately to unlock the full potential for DSF from heat pumps, including by ensuring the benefits of flexibility to customers are equitable, we need to understand how different groups access and engage with heating flexibility offerings, including fuel poor and vulnerable households. The Equitable Participation Framework (EPF) for the EQUINOX project aims to facilitate the development of this understanding and guide future heating flexibility offerings by identifying the key factors which can affect how well a customer accesses and engages with them. In the case of EQUINOX, these key factors are used to support recruitment to the EQUINOX trial, as well as the formation of hypotheses, and the segmentation of trial results.

Purpose: why we need an EPF

In line with the project's full title, 'EQUItable NOvel Flexibility eXchange', our focus is on understanding how customers, particularly those who are vulnerable or fuel poor, navigate and participate in emerging commercial arrangements for heating flexibility. Understanding the variation in customer experience has been emphasised by the Centre for Sustainable Energy's 'Smart and Fair?' project[1], which underscores the importance of considering the needs of fuel poor and vulnerable households in fostering a fair and equitable energy transition.

To measure this, we need to include and identify statistically useful numbers of participants from households who may be classed as potentially vulnerable with regards to home heating access. Given the complexity of factors that increase the likelihood someone is in a vulnerable situation with regards to their home heating[2], we should also strive to make sure the pool of trial participants is as representative of the UK population as possible.

As of Spring 2024, two trials will have been completed under the EQUINOX project, with the final and third trial scheduled for Winter 2024/25. Between the first and second trial, the number of participants more than doubled, building off the initial enthusiasm shown by participants. During Trial 1, participation averaged 82% across all EQUINOX events, with roughly 60% vulnerable and

[1] Centre for Sustainable Energy – smart and Fair? https://www.cse.org.uk/projects/view/1359
[2] This includes factors which would determine if someone were vulnerable to the cold.

non-vulnerable customers taking part in every single event. Although we perceive an improvement in the inclusion of some more vulnerable groups

in Trial 2, overall trial participation has not mirrored the demographic makeup of the UK. This disparity can be largely attributed to the current pattern of heat pump ownership in the UK, which is skewed towards the 'early adopter' demographic[4], broadly comprising wealthier than average households who also tend to be older and be more likely to be owner occupiers than the UK as a whole.

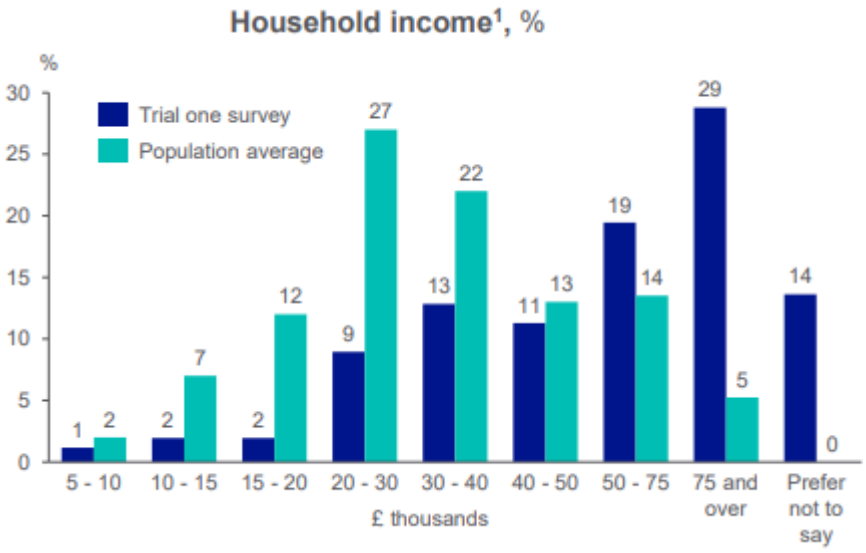


Figure 1: graph from Trial 1 for the Octopus cohort showing household income by decile in the trial versus household income on average across the UK. Credit: EQUINOX Trial One Customer Experience – August 2023 v.10 PowerPoint Presentation. Household income source: Office for National Statistics, Census 2021; EQUINOX UK-Wide Survey August 2022.

Objectives and aims of the EPF

The EPF is developed in the context of the EQUINOX project with the aim of supporting it to answer the project question, "How do DNOs ensure that fuel poor and vulnerable customers have an equal opportunity to participate in flexibility services?". It will also help to develop understanding around how much demand side flexibility can be unlocked in practice from heat pumps by building a picture of how flexibility may be limited or unlocked in some environments.
However, the rationale for the identified vulnerability factors, as well as the process and logic for developing the framework is likely to be valuable more broadly to energy markets and to other projects in the DSF and energy transition sphere more generally.

To facilitate recruitment of households with a higher likelihood of being in a vulnerable situation, to ensure adequate safeguarding of these potentially vulnerable participants, and to enable better analysis of results with regards to potential customer vulnerability, the EPF should enable consideration of:

- Which household or personal factors might necessitate targeted engagement for recruitment to heating flexibility offerings.
- How identified factors affect engagement with heating flexibility offerings, and which might mean:
  - Households/people need adaptations upfront to engage in the trial and / or heating DSF generally.
  - It is unlikely to be safe for households/people to engage in heating DSF and the trial (and any safeguards which could be implemented to mitigate risks to acceptable levels).

The initial objectives are therefore to:

- **Identify the factors** which could be considered to increase the likelihood a participant is in a vulnerable situation with regards to home heating, or the use of heat pumps, particularly in a flexible way.
- **Identify compounding and interacting factors**, as well as possible other markers that can indicate if a participant is disadvantaged or in a situation that may impact their ability to unlock the benefits of heating DSF.
- **Consider which factors are most relevant and valuable** for targeting and segmenting participants to maximise the participation from households classed as at risk of being in a vulnerable situation with regards to their access to adequate home heating.

The framework should then be used to support targeted recruitment of participants, as well as the development of hypotheses and segmentation for analysis of participant engagement data, to ensure the EQUINOX project meets its full objectives.

How is the EPF used in EQUINOX?

The framework is used to identify which vulnerability characteristics have been addressed by the EQUINOX trials to date, and to identify gaps which should be addressed in terms of monitoring the impacts of vulnerability in Trial 3 and beyond, including through building case studies / personas. It should also support safeguarding by ensuring the project engages appropriately and sensitively with households exhibiting vulnerability factors.

More detail is available in section 5 to show how the EPF was applied in the EQUINOX project.

Guide to the following sections of this document

The remaining sections in this document consider how the EPF was developed, outlining the rationale for why the final vulnerability factors were chosen, how it has been applied to the

EQUINOX project in more detail and finally, how it could be valuable to other projects and applied to wider energy system innovations and offerings.

2. How the EPF was developed: foundation

This section sets out how the EPF was developed, outline the overall process, but focusing on the foundational phase: the development of a list of vulnerability factors and their indicators for the project. This firststeps involved defining what the EPF needed to achieve, before exploring and identifying an initial longlist of factors through a literature review. The longlist was then refined as set out in section 4. The wider process to apply the EPF to the EQUINOX project, including to develop hypotheses is explored in sections 5 and 6.

What should the EPF look like?

The principle of the EPF was to help the team identify, target and safeguard households in situations which need additional support to engage in heating flexibility offerings, or who are more likely to be in a vulnerable situation with regards to heating flexibility offerings and where deemed appropriate for its use to continue beyond the lifecycle of EQUINOX. To do this, we first needed to understand and identify which factors increased the potential vulnerability of participants to harm or which reduce the likelihood they can engage effectively and safely with heating flexibility offerings.

The identification of vulnerability factors is achieved by considering the mechanisms underpinning *how* a person or a household may be negatively impacted or face barriers to engage effectively and safely with heating flexibility offerings. The 'vulnerability factor list' can then be applied to target recruitment, explore and identify hypotheses for how different households will engage (or not) with heating flexibility and to consider what activities and safeguards are needed to facilitate optimal, safe and equitable engagement by the greatest number of customers in heating flexibility - and to identify where there may be equitability gaps that remain to be addressed.

In its most basic form therefore, the EPF appears as **a list of characteristics or 'vulnerability factors'**, **accompanied by indicators and some detail on mechanisms of action**. The framework itself is how the EPF is applied in the case of the project; but in effect it consists of **two key strands of work**:

1. **Understanding how the factors affect a customer's journey engaging with the heating or other flexibility offering:** this is explored on a factor-by-factor basis, as well as through qualitative exploration via persona analysis. The expected impacts can then be used to formulate hypotheses that are assessed in Trials, where safe to do so.
2. **Identifying recommendations:** these should help to avoid harm to customers with the identified vulnerability factors.

Defining vulnerability: identifying mechanisms that lead to participants being in a vulnerable situation

When it comes to heat pump users and their ability to engage with heat pump flexibility schemes, 'vulnerability' is not limited to households in fuel poverty. We need to consider how participating in the project impacts customers.

For example as EQUINOX trial participants are requested to turn down (or turn off) their heat pumps for up to two hours at a time, the direct impact could be a reduction in their home's internal temperature. Customers may therefore be at higher risk of being in a vulnerable situation if they are more likely to suffer detriment from the cold, or if they experience situations which prevent full participation in the flexibility events – resulting in not obtaining associated benefits such as payments.

To identify which customers are vulnerable in this context, we should identify factors that increase the risk of vulnerability to the cold or increase space heating temperature sensitivity. This includes factors that increase the risk of houses being underheated relative to occupants' needs both during and outside of trial events, as participation in those events could lower house temperatures further. On the other hand, underheating can also decrease the capacity to engage in and benefit from participation in heating flexibility, and in line with this we should also consider factors that make it difficult to engage in heating flexibility offerings or events in the first place.

Through reflection and discussion, we identified three main ways a household or customer may find themselves in a more vulnerable situation. These include any factor which:

1. Makes it difficult to engage with heating DSF, especially in a safe and effective way.
2. Makes people susceptible to harm from home underheating.
3. Puts people at risk of lack of access to adequate home heating for a decent quality of life.

Additionally, as we are developing an *Equitable* Participation Framework, the list should consider the range of factors that generally put people at higher risk of being in a vulnerable situation, particularly regarding energy use, as well as markers of groups who have been underrepresented compared to the UK population in the trial to date. Consideration should be given to whether factors could compound or interact with other factors, putting certain groups at greater risk of vulnerability regarding access to adequate home heating, or making it more difficult to engage with heat pump flexibility schemes.

We also considered and developed a **definition of what being vulnerable actually means** to inform these mechanisms, building off the wider review of vulnerability work and literature, settling on the following statement:

> *Being vulnerable is defined as in need of special care, support, or protection, for example because of age, disability, risk of abuse or neglect.* ***Vulnerability***

> ***depends upon the situation.*** *An equitable participation framework in the context of the EQUINOX project should consider* ***what puts someone in a vulnerable situation from a heating perspective.*** *This roughly means identifying the driving factors that increase the risk someone suffers detriment to their quality of life because of their need for – and the limits to the availability of – [energy or] heat. This may be signalled by their 'vulnerability to cold/heat' but may also be manifested by a limit to a person's access to energy for heat essential to a good quality of life, including through its affordability.*
>
> *It should also* ***consider what factors make some people less likely to engage – or to engage effectively and safely – with demand side heat pump flexibility*** *if given the opportunity.*
>
> *Finally, it should also consider other disadvantaging factors or underrepresentation makers, which may interact with, compound, or increase the likelihood of being in a vulnerable situation[5].*

Reflecting on this definition, it is very likely that more factors will be identified than can be used effectively to segment or target recruitment of participants. This was the case for the EQUINOX vulnerability factor list, which therefore had to be shortlisted. The process of shortlisting is explored more in section 4 and the application of this shortlist is considered further in section5. However, these additional factors are useful for building personas to communicate and understand customer journeys and may be used to indicate and map areas where extra support may be needed to unlock the potential benefits of heat pump flexibility equitably across the UK.

Literature and previous vulnerability work review to identify vulnerability factors

To identify potential vulnerability factors under the identified mechanisms and conditions noted above, we reviewed existing literature and practice. This included reviewing the:

- Priority Services Register (PSR) Eligibility Criteria
- Fuel Poverty definitions and criteria, including the devolved administration criteria for enhanced heating regimes, as indicated by the Fuel Poverty (Enhanced Heating) (Scotland) Regulations 2020
- Ofgem Consumer Vulnerability Strategy (2025)
- Centre for Sustainable Energy, "Mapping customer vulnerability: Methodology", March 2017, Report to Western Power Distribution (WPD)[3].

[3] This population mapping exercise sought to identify vulnerable households in the WPD (now NGED) distribution area to support the identification of people who would benefit from registering on their PSR or who find it hard to pay for the energy they need. It includes lists of vulnerable characteristics and corresponding, useful data sources.

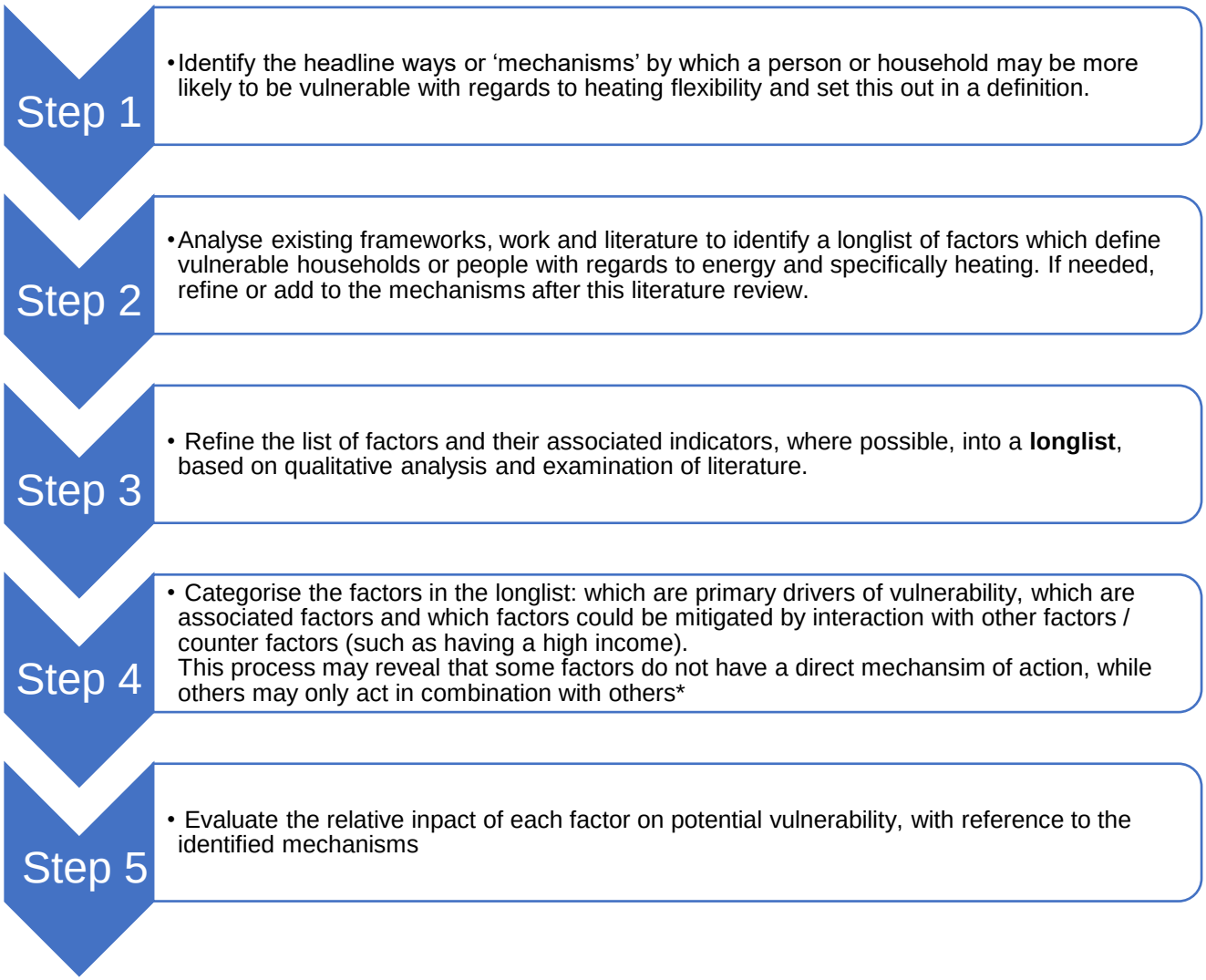
In parallel, WMCA held conversations with colleagues from across the WMCA Strategy, Economy and Net Zero directorate with expertise in vulnerability and equitability issues, and with other EQUINOX partners, such as National Energy Action who supported the development of the framework with their expertise in energy poverty issues.

In addition to the above mentioned sources, we examined existing research and 'vulnerability indexes' such as the Vermont Heat Vulnerability Index and the Social Vulnerability Index.

A full list of the literature reviewed is referenced in Annex H.

Summary of the process to identify vulnerability factors and build an EPF

The headline steps are set out below, and the full process is explored in more detail in subsequent sections. Some of the steps are iterative, for example step 1 can be revisited and refined after the literature review in step 2.



* As part of this review, improvements to vulnerability indicators, should be considered as well as potential combinations of factors that may be made, for example to avoid 'duplication'.

Where no mechanism is identified, this doesn't mean the factor should not be included, but it might not be considered a 'primary vulnerability factor' for the purposes of the Trial. Where factors are expected to compound risk of vulnerability, this may signal a need for further research and tracking of the factor when designing trials and future initiatives/offerings.

Step 6
- **Shortlist factors** by selecting those with the greatest and clearest impact on potential vulnerability and remove duplication by combining factors where relevant to do so.

Step 7
- Refine the indicators and descriptions and add more detail if needed to the mechanisms by which they act.

Step 8
- Use the identified factors to **build an overall bespoke Equitable Participation Framework**.

Step 8a
- Develop a 'customer journey', explicitly laying out the typical customer engagement and action points during the trial.

Step 8b
- Via the customer journey consider how the Vulnerability Factors might specifically affect household participation and engagement at each stage of participation - in the trial and in heating DSF generally. This can then be used to **identify needs and recommendations** to enhance equitable participation.

Step 8c
- Combine vulnerability factors into **personas** to further test (theoretically) how households might engage with heating DSF and the trial. This stage could also be complemented by market testing / interviews to test assumptions.

Step 8d
- **Develop hypotheses** from these persona-tested customer journey experiences. The hypotheses can be tested as part of project trials and to formulate general recommendations to improve equitable participation in the trial and access to heating DSF.

The EPF vulnerability factor list can then be further applied to support trial results segmentation and analysis (see section 5). The EPF is therefore a combination of the vulnerability factor list, the supporting recommendations, the associated hypotheses and the application in terms of trial recruitment and results analysis.

Following the development of the EPF, the project should apply the factors. For EQUINOX this meant:

- Implementing the recommendations to support recruitment, as well as to support equitable participation in trials.
- Considering what other safeguards may be needed and which can be implemented in the trials to improve household participation[4] and ensure heating DSF is safe and avoids unacceptable harm to participants.
- For households for where the barriers to engaging in heating DSF might be insurmountable in practice; reflect on what this means (and what measures need to be taken) to ensure any roll out of heating DSF is as equitable as possible.

[4] Without undermining the need to test hypotheses, where safe and reasonable to do so.

3. Vulnerability Factors and their indicators

This section outlines the vulnerability factors identified in the development of the EQUINOX EPF.

Identification – longlist

From an analysis of existing frameworks, literature and through conversations with those working within the energy and inclusion field, the following vulnerability indicators were identified to warrant further examination for their relevance to vulnerability relative to heating DSF:

- **Age**
  - elderly (over 65, 75 or 85)
  - young (under 5)
- **Education and skills**
  - Illiterate, or low level of literacy
  - Innumerate
  - Highest qualification equivalent to GCSE C or below in English and/or maths
  - Lack of confidence using smart technology
  - No internet access
- **Language**
  - English not a first language
  - English level below C1 standard / can't speak English well
  - Require documents translated into another format or language (maybe more inclusive) – in line with PSR approach
- **Minority ethnic background**
- **Fuel poverty**
- **Low-income**
- **Unemployed**
- **Heath**
  - Blind or partially sighted
  - Deaf or hard of hearing
  - Chronic illness
  - Anxiety, depression or mental health conditions
  - Cognitive disability or impairment

  - Physical disability
  - Disability that limits activity
  - Obesity
  - Self-reported poor/ill health
  - Health condition exacerbated by the cold
  - Use medical equipment reliant on electricity or water.

- **Housing:**
  - Insulation level / energy inefficient home
  - Crowding (more than 1 person per room)

- **Situation**
  - Lone parent
  - Renting
  - No internet access
  - No smartphone
  - Living alone
  - Experiencing personal tragedy: bereavement or relationship breakdown
  - Pre-payment meter

- **Gender**

This list is drawn from a qualitative assessment based on factors pulled (and in some cases adapted/ combined) from the analysis of existing frameworks and from conversations with experts working in the field of inclusive growth, communities and the just transition in the energy sector (see section 4 for further detail on the development of the longlist). A full extract of the longlist analysis, together with the associated details is available in Annex C.

Complex factors: the example of gender

In some cases, the direct modes of action of a factor can be hard to identify and / or the factor may capture too broad a swathe of the population to be useful in the context of the project for analysis. Gender is a good example.

Gender is too blunt an indicator to be useful as a vulnerability factor on its own. Far from all women are in a vulnerable situation with regards to energy, heat or DSF. However, while gender can be *correlated* to the risk of having or experiencing one of the above vulnerability factors due to their socio-spatial distribution between genders, it is likely that gender can also be both a direct driver of heating vulnerability, and a compounding factor where other vulnerability factors are present.

This complexity is demonstrated in the socio-spatial research conducted by Robinson (2019)[6], which points to several gender sensitive indicators that specifically raise the risk for women. These factors combine and interact with other vulnerability indicators to raise the vulnerability risk of some women, in certain circumstances.

Therefore, an approach towards gender must consider that particular groups of women, ***not women as a homogeneous group***, are prone to energy poverty. As such, we do not use gender as a single indicator of vulnerability in the case of heating DSF but did consider using it as a compounding factor.

We also need to consider that some gender-sensitive indicators (where women are disproportionately represented), such as not speaking English well, may be captured directly by other 'vulnerability factors' tracked in our analysis. In these cases, gender is an indicator of potential vulnerability but is not a primary driving factor.

In proceeding, we considered whether to:

- Note when households identified to have a vulnerability factor include women.
- Increase the weighting of certain vulnerability factors when a household includes women.

However, given the limits of the project and the complexity in determining 'household gender' when household composition is mixed, we chose in this instance to avoid further analysis of gender as part of the project, but instead note it here as an important factor for further research around flexibility offerings.

Identification – process of shortlisting

The Vulnerability Factors are presented as a list, captured in an Excel Workbook. However, the project cannot effectively examine the effects of over 30 vulnerability factors – many of which are either too blunt to be used to segregate customers, do not have a clear mode of action, or overlap with other factors –, so the longlist had to be refined into a shortlist. This was achieved via several steps, which included refining and consolidating the factors, rather than simply removing them:

1. **Identifying duplicated factors, or factors which could be combined / improved**

   Some factors are vague e.g. 'poor / bad health / chronic illness' and overlap with, or closely relate to others, such as 'disability limiting physical activity', 'physical disability', 'anxiety, depression or mental health conditions', or 'health condition exacerbated by cold'. Considering the mechanism by which each factor acts can help identify duplications or lead to refinement of final vulnerability factors which more clearly relate to the mechanism by which a person or household is potentially in a more vulnerable situation.

2. **Identifying factors which are too vague to be useful**
   For instance, English not a first language is removed as it is too blunt and does not take into account the level of a person's English. It is substituted by the shortlisted vulnerability factors "Cannot access or understand documents in English and / or require communications in a special format" and "English or maths below functional skills level."
3. **Identifying factors for which the direct impact on potential vulnerability is judged insufficient, where there is no clear mechanism of action, or which are likely superseded by intersecting factors**
   In some cases, intersecting or correlating factors associated with a factor might have a greater impact on vulnerability and can mean a factor is not useful on its own. For example, crowding was removed as a less important direct causal factor of increased risk of vulnerability with regards to heating DSF than the probable intersecting and correlating factors such as low-income, poor health and fuel poverty. Similarly, deaf or hard of hearing was removed, as the mechanism of interaction with heating flexibility offerings is not clear. The strength of a factor in contributing directly to a mechanism of action to drive vulnerability was evaluated, as can be seen in the extract from the table presented in Annex D (Figure 1) below.

   However, it should be noted some factors deemed not to have clear direct mode of action were retained in the final shortlist as 'additional factors'. This included complex factors (explored above) such as gender, renting and minority ethnic background in the case of the EQUINOX EPF. This reflected both their prevalence in the literature as important factors and their likely intersection with other more directly impacting vulnerability factors. It is suggested that where data exists, these 'additional factors' can be examined for potential impacts, but no specific hypotheses are proposed in the context of the project. They signal where further research may be necessary in the context of heating flexibility offerings.

4. **Identifying factors which would not be appropriate to include in the project for ethical or safety reasons, or which cannot be measured or indicated**
   These factors remain important to consider but will not be studied by the project. For example, we removed anxiety, depression or mental health conditions, in part as it is likely to be very sensitive information, and it may not be safe / ethical for people in this situation to take part in a project such as EQUINOX. It is also adequately captured by shortlisted vulnerability factor "Suffer from a cognitive impairment or mental health condition which limits their ability to carry out 'normal' household tasks."

The figure below is an extract from the workbook used to analyse the impacts of different factors according to mechanism. The full table is captured in Annex D.

Ref.	Primary factor	Category	Sub category 1	Sub-category 2	Makes it difficult to engage with heating DSF, especially in a safe and effective way	Makes people susceptible to harm from home underheating / 'vulnerable to cold/heat'	Puts people at risk of lack of access to adequate home heating for a decent quality of life
7	Disability limiting physical activity	Health	Personal characteristic	Biological / Physical	Medium	High	High
8	Housing: insulation or home energy	Environmental	Situation	Building / Environment /	Low	Low	High
9	No internet access	Environmental	Situation	Building / Environment /	Very high	Low	Low
10	Lack of confidence using smart	Other	Situation	Skills-linked	High	Low	Low
11	Health condition exacerbated by cold	Health	Personal characteristic	Biological / Physical	Medium	Very high	High
12	Pre-payment meter	Environmental	Situation	Building / Environment /	High	Low	Medium
13	Age: elderly	Demographic	Personal characteristic	Biological / Physical	Medium	High	Low

Figure 1: extract from the workbook used to analyse the impacts of different factors according to mechanism. A rating was given (low to very high) for how the factor might drive potential vulnerability through the 3 mechanisms identified. Categorisation also helped identify 'overlapping' or duplicative factors.

In some cases, it may be too complicated to measure or calculate a factor, so a proxy can be identified. For example, the final Vulnerability Factors for this project include **Fuel Poverty**, however, the data to calculate this is extensive and would need to be optional as much may be considered too sensitive / intrusive to obtain in this project. A proxy measure or indicator is therefore instead proposed, based on self-reporting of underheating, using NEA best-practice to assess households through this approach. We explore selecting indicators in more detail later in this section.

Finally, as noted above, although this process focused on confirming factors with a direct mode of action to increase household or participant vulnerability,

Final vulnerability factor list

Following the analysis of the long list of factors, working through the potential intersectional, correlating and mitigating factors, as well as a how a factor affects the potential a household is in a vulnerable situation with regards to heating flexibility offerings, an initial shortlist of 17 vulnerability and equitability factors was developed. These reflect the combination of some of the 33 long-list factors, and the removal of some others in accordance with the shortlisting process outlined in the above sub-section.

Each factor is accompanied by a:

- Reference number

- A description
- Suggested indicators to identify households with the factor as part of the EQUINOX trial
- Further notes to aid in application and identification of appropriate indicators
- Derivation from the longlist (using long list factor reference numbers)
- Links to the 'Inclusive Growth Fundamentals' set out by the WMCA – for further context on how it relates to equitability

The first 14 Vulnerability Factors can also be termed **Primary Vulnerability Factors (PVFs).** These factors can directly increase the potential a household or a person is in a vulnerable situation from a heating DSF perspective. Of course, not all households with a PVF will be in a vulnerable situation. At the same time, some of the PVFs remain impractical to include within the context of the EQUINOX project trials – as was the case for "Cannot access or understand written documents in English and / or require communications in a special format". We therefore further refined and focused in on certain vulnerability factors – and decided upon our specific approach regarding each factor – in the implementation phase of the development of the Equitable Participation Framework.

The **3 additional factors** identified do not have a direct impact on how a household engages in heating DSF, or may only exert very weak impacts, including renting, minority ethnic background and gender. As the direct mechanism by which these factors mean a household may be in a more vulnerable situation is not clear cut, we avoided using these factors alone to segment trial results in the EQUINOX project. The suggested approach is instead to use them to build personas, and to identify where households with a PVF may be particularly vulnerable because of the presence of these factors. They can also be monitored to observe if there are any differences in how households in these groups interact with heating DSF and point to further study needed.

Annex A sets out the final vulnerability factor list used by the EQUINOX EPF.

Selecting indicators

Once the final vulnerability factor list has been identified, it is important to identify indicators of the factor, or where direct indicators are not available, effective proxies. These should be reliable and accessible.

Using proxies

In some cases, it may not be feasible to gather information necessary to establish whether or not a participant presents a particular vulnerability factor. This was certainly the case for fuel poverty, for which we therefore considered various proxies, including self-reported inability to pay fuel bills. However, we wanted to ensure we also captured the potentially negative impacts on heating flexibility offering engagement of low income more broadly – particularly where households were paying their energy bills but perhaps struggling in other ways due to their low income.

Establishing thresholds for different participant types

It is not always reasonable or accurate to apply the same indicator to every participant as the presence of a factor will depend on the characteristics of the participants themselves. This is the case for income.

It is not realistic to establish a single threshold income level to define low income, as an income for one household may be sufficient to cover all needs, but for another it is not due to differences in household composition and age, for example. As such we opted to use an adapted measure, based on the Annual UK Minimum Income Standard established by Loughborough University's Centre for Research in Social Policy (CRSP). This is published annually, from research informing budgets defined for different household types and based on what members of the public think is needed for a minimum acceptable standard of living in the UK. The Joseph Rowntree Foundation funds the main research into the AMIS (see table in Annex used based on applying the 2024 Minimum Income Calculator[5]).

Household 'archetypes' based on member participation were used to define AMIS thresholds that are more adapted than a single threshold figure to define low income for all households. The result was a minimum income threshold that ranged from £17,155.00 for a single adult (pensioner) household to £108,210.00 for a household comprising 2 adults and 4 children in 2024.

[5] Available at: Minimum Income Calculator

4. Applying the EPF in EQUINOX

In this section, we explore in more detail how the EPF was applied to the EQUINOX project, and particularly to Trial 3. The focus is therefore on step 8, as set out in the subsection 'Summary of the process to identify vulnerability factors and build an Equitable Participation Framework' in Section 3, which follows on from the identification of the vulnerability factor shortlist. It is developed with a view to the process being useful for future projects wanting to develop and apply an equitability framework.

Develop a Customer Journey

The customer journey sets out the process and experience of a typical customer during the trial and/or during an assumed business as usual heating demand side flexibility 'event'. The customer journey for EQUINOX is set out below, with **blue** boxes signalling trial specific stages, and **purple** boxes representing stages that could apply to both a BAU and trial customer journey.

CONTACT AND SIGN-UP

Potential household recruits receive information from their energy suppliers or other EQUINOX partners and are invited to express a general interest in taking part in the trial.
This engagement is typically through online methods - email, or via online expression of interest / sign-up forms.

'EVENTS'

Trial participants receive notifications by email or app to turn down their heat pumps for specified time periods. The notification period varies and may be correlated with payment amount and turndown level.
N.B. In Trial 3, some customers may also receive invitations to turn up their heat pump for specific events.

POST-EVENT SURVEYS

Trial participants receive an invitation to complete a post-event survey after each event.
The survey is shared via the app or via email.

BILL PAYMENTS

Trial participants receive energy bill credits or other rewards for taking part in events from their energy supplier.
These credits or rewards are detailed on their energy bill and available in apps.

TRIAL FOCUS GROUPS AND INTERVIEWS

Some trial participants are invited to take part in focus groups and interviews.

MID- AND END-OF-TRIAL SURVEYS

Trial participants receive information from energy suppliers / EQUINOX partners about the trial and are invited to complete the mid-trial and end-of-trial surveys online.
As for the start of trial surveys. This engagement is through online methods, such as email and possibly through apps. The surveys are online.

The journey provides a guide to navigate how a hypothetical person or household in a more vulnerable situation might experience taking part in the Trial or heating DSF more generally. Each factor should be considered against each 'stage' in turn, and potential issues/need/challenges for households or people with these particular factors should be identified. From these**, initial recommendations can be developed**. We developed recommendations to address the impact of individual primary vulnerability factors on:

a) Recruitment and any special measures that should be taken to facilitate recruitment;
b) EQUINOX trial participation, including any special measures that should be taken to ensure safe and effective participation;
c) Participation in heating DSF generally.

While the recommendations provide some suggestions for mitigating potential negative impacts, we recognise that not all negative impacts may be possible to mitigate.

Combine vulnerability factors into personas

The personas represent fictional characters of potentially vulnerable trial participants. These are primarily hypothetical but have been refined based on discussions with the Inclusive Growth team

at WMCA and have been defined following review by EQUINOX partners, drawing on the profiles and experiences of participants encountered in the focus groups and interviews.

These allow for further testing of the vulnerability factors before they are field-tested and can help to identify any cases where it might not be possible, ethically or safely, to test the impact of vulnerability factors in actual trials. The process of developing and running personas through the customer journey can also be very helpful in identifying and helping validate potential compounding and interacting factors.

A random name generator was used to generate names and households were constructed using combinations of all the primary vulnerability factors. Not all combinations were possible: 14 vulnerability factors could be combined in sets of two to create 91 different sets. If each were to be combined with an additional factor, that would mean at least 364 different sets. We therefore made a judgement on likely combinations and ensured that every primary vulnerability factor was included in at least one persona. 9 personas were eventually developed (example included in Annex I).

The personas are more in depth than standalone vulnerability factors. Each persona has a story and individual circumstances, which allow vulnerability factors to be 'tested' in a more real world' scenario. This can help identify further mitigating or compounding factors and interactions and identify more nuanced impacts throughout the customer journey.

Each persona was 'run' through the customer journey to identify potential challenges and these were included in the persona, as well being used to refine the recommendations. To help visualise the household and facilitate the process of 'running each through the customer journey' a stock image was added to each persona.

The persona testing could - and ideally should where possible – be complemented by further 'market testing' and interview. Due to project timeline constraints and the experience of focus groups in previous trials, we did not judge this as necessary in the case of the EQUINOX project, however.

Finalising the recommendations and developing hypotheses

Once the persona analysis was complete, we finalised the recommendations and identified potential 'key design features' that could help people with vulnerability factors engage with the EQUINOX trial and heating DSF. The hypotheses are drawn from these identified key features – each assumes the key feature will help enhance or impact engagement in some way. The hypotheses that arise underline how these features may be tested.

Proposed features should ideally be tested before being adopted conclusively as recommendations for improving equitable participation, wherever this is possible. However, some proposed features are likely to be valuable in any instance and/or cannot be tested and so are included as

recommendations on their own, including for the design and development of materials for Trial 3. This was the case for measures that tended to be less resource-intensive and may improve participation across all households, rather than some potentially more vulnerable households specifically. In most cases, these concentrated on clear and accessible communications, while others, such as “communicating about length of the events before they start” and “clearly communicating in the trial materials about the risks of underheating, especially to vulnerable groups, like young children” do in particular aim to mitigate risks to households in more vulnerable situations.

The hypotheses we extracted from this process and tested in EQUINOX are set out below. There are 13 put forward in total, focusing on the effects on vulnerable households as a whole, as well as on specific sub-groups of vulnerable households. Not all were tested in the EQUINOX project directly due to Trial and resource limitations.

- **H1** recruitment of households with more vulnerability factors will be enhanced by non-digital outreach.

  We were limited in how this could be tested, as most recruitment was led by Energy Suppliers. A Local Authority-led approach during a door-knocking exercise conducted by WMCA indicated low take-up among social housing tenants via this approach.

- **H2** relatively lower income households will be more satisfied by [lower] payment amounts than relatively more well-off households.

- **H3** An additional reminder just before the event is particularly important for households subject to external stressors from a low income or with caring responsibilities.

- **H4** A reminder that the event has ended will help to avoid vulnerable households underheating because of events.

- **H5** Remote control is particularly important for households with young children and / or where members have physical disabilities.

- **H6** vulnerable households, particularly those who are either poorly-insulated, or where there are members over the age of 75 or with health conditions exacerbated by the cold will be more likely to leave early or opt out of longer events.

- **H7** Households with young children, which are poorly-insulated, or where there are members over the age of 75 or with health conditions exacerbated by the cold will prefer events before 7pm.

- **H8** Guidance and support on how to ensure heat pumps run optimally and cost-efficiently, combined with advice on how to engage effectively with EQUINIOX events, will increase

participation among households and especially among households experiencing fuel poverty or who report difficulty using or understanding how to use their heat pump.

- **H9** Relatively lower income households will offer lower turndown on average, as will poorly insulated households.
- **H10a** Guidance, tips and advice on how to make the most out of their heat pump will increase trial satisfaction, especially among households with lower turndown and consequently lower payment.
- **H10b** Targeted information about how participant actions help the grid could increase trial satisfaction, especially among households with lower turndown and consequently lower payment.
- **H11** High income households with vulnerability factors will show higher levels or turndown and participation than non-high income households with vulnerability factors.
- **H12** Lower income households will offer greater turn up, once dwelling size is controlled for.

Following the development of the EPF, the project should:

- Implement the recommendations to support recruitment, as well as to support equitable participation in trials.
- Consider what safeguards may be needed and which can be implemented in the trial to improve household participation6 and ensure heating DSF is safe and avoids unacceptable harm to participants.
- For households for which the barriers to engaging in heating DSF might be insurmountable in practice; reflect on what this means (and what measures need to be taken) to ensure any roll out of heating DSF is as equitable as possible.

Focusing in on specific vulnerability factors

Once the hypotheses had been identified, we considered **how they could be tested**. This led to the refinement of the vulnerability factors which the Trial would need to focus on – and which would therefore need to be identified for each participant at the start of each trial.

In general, hypotheses should be tested by comparing engagement of households with vulnerability factors, versus all households (not including the households with vulnerability factors).

While the presence of all 14 Primary Vulnerability factors included in the Equitable Participation Framework should ideally be identified for households in taking part in the trial, we were

[6] Without undermining the need to test hypotheses, where safe and reasonable to do so.

constrained by which hypotheses we could reasonably test through the Trial. Once the EQUINOX partners had discussed the practicalities and possibility of testing specific hypotheses with the EQUINOX partners, and safeguarding considerations were applied, we decided to focus the recruitment and start of trial surveys on 8 factors. This meant determining whether participants were:

I. Households with children under 5
II. Households with members over 75
III. Households where there is a sole occupant (live alone)
IV. Lone parent households
V. Households where at least one member has a physical disability
VI. Households which are poorly insulated (EPC D or below)
VII. Households where at least one member suffers from a health condition exacerbated by the cold or which increases home heating needs
VIII. Households where income is below the standard required for an 'acceptable standard of living' according to their household composition or which are classed as in fuel poverty.

Because of the size of the trial and/or because of the need for safeguards, or because of impracticalities or sensitivities to gathering the information; we did not track and segment for households:

- With a pre-payment meter
- Where the highest qualification of the responsible adults in Maths or English is below level 2
- Where a member suffers from a cognitive impairment, physical condition or other health issue which means there is an 'increased energy usage', or where households suffer from a physical disability, a cognitive impairment or mental health condition which limits their ability to carry out 'everyday' household tasks without assistance – *we instead considered only if households included members who had a disability.*

The exclusion of some of these identified vulnerability factors does not diminish their importance and they should be subject to further research.

Segmenting and analysing the results of the Trials using the EPF

Even after focusing in on specific vulnerability factors, the breadth of the potential vulnerability factors can mean that a significant proportion – and even a majority – of households are identified as potentially vulnerable. While this reflects the widespread and diverse nature of vulnerability, it may also, to an extent, demonstrate a slight over-representation of potential vulnerability, particularly where the presence of other characteristics or counter-factors could mitigate the impact of factors by countering the mechanisms by which they can act.

For example, having a poorly insulated home could be mitigated by having a high income, which permits mitigating behaviours such as ‘going out’ during events, and which may also signal a higher

likelihood of being in general good health. Indeed, many factors are mitigated by having a high income, in a similar way to how the impacts of many factors are exacerbated by having a low income. On the other hand, having a health condition exacerbated by the cold will be far more likely to leave someone potentially more vulnerable when asked to take part in events where their heating is turned off for periods of time, even if their home is well-suited.

In the case of the EQUINOX project, more than half (60%) of participating households were identified as potentially vulnerable if the presence of only one factor was used to determine potential vulnerability. To minimise the risk that our definition of potential vulnerability captured too many non-vulnerable households in practice, we adopted an approach which took into consideration the risk that some households with just one vulnerability factor were not actually vulnerable. This process took into account the mechanisms by which households are rendered potentially vulnerable by the factor.

In this method, we only included:

I. Households defined as having a low income according to their household composition
II. Households where a member/s reported having a health condition exacerbated by the cold
III. Households with at least 2 of the other EPF factors

The result of applying this method to the pool of participants for Trial 3 was that 47% of households were identified as potentially vulnerable for the purposes of the EQUINOX project.

It was insightful that of those identified as potentially vulnerable:

- 30% were identified as being distinctly vulnerable to the cold
- 24% were classed as having a low income[7]
- Only 5% of the potentially vulnerable pool are over 75

The potentially vulnerable group's trial experience can then be compared to the experiences of the group not identified as vulnerable. We are also able to segment for specific vulnerability factors to dive into how variations of potential vulnerability affect participation in heating flexibility offerings.

Safeguarding

Once vulnerability factors and their potential impacts have been identified, it may become clear that in some cases, it is unethical, or the risks of harm are unacceptably high for some groups. In other

[7] A number of households were removed from the segmentation in spite of being classed a low income, however, as they also reported being able to regularly afford their energy bills, contradicting the mechanism we assumed to act to generate a risk of vulnerability in these cases. This signalled there may be other factors we are unaware of that mitigate the impact of these households' low incomes.

cases, appropriate safeguards can be adopted to bring the impact of any threats to safe engagement in the trial down to acceptable levels.

For instance, fuel poor and very low-income households, or households with smart pre-payment meters, may be at risk of underheating when they take part in events. Safeguards that should be implemented include:

- Targeted and clear communication about the risks of underheating, especially to households with vulnerability factors including having young children under 5 years old, or with health conditions exacerbated by the cold or requiring increased home heating;
- Enhanced monitoring of participation, such as through monitoring temperature changes during and just after events in at risk households to identify if underheating or excessive turn down is occurring.
- Reviewing participation at the mid-trial point, including through responses to surveys.

In the Trials, we did not specifically target households with pre-payment meters because of the identified risks for these households of potentially excessively limiting their energy usage and the complexities to including (and rewarding) them equitably in the current trial.

Should heating DSF be widely rolled out, further consideration should be given to ensuring heating DSF is widely accessible to people in more vulnerable situations, including those who may require documents and communications in a different format to standard written English. This might be facilitated by automation and the development of adapted heat pump controls, as well as well as targeted and adapted communication on events, bills and payments.

Comparison of methodologies used to identify vulnerability in Trials 1 and 2

Significantly more participants were identified as potentially vulnerable in Trial 3 than in Trials 1 and 2. This reflected not just increased efforts to recruit a more diverse group, it also reflected the methodology used.

Application of the EPF in Trial 3 saw 47% of participants households identified as potentially vulnerable, compared to 20% of those in Trial two and 22% in Trial one. While 33% of customers are classified as potentially vulnerable when Trial two's vulnerability classification methodology is applied to the Trial three pool of participants, this is significantly lower than when using the EPF.

The limits of increasing equitability of heating DSF

Finally, income inequality, digital exclusion, societal exclusion, and poor home insulation are not only barriers to a Just Transition, but also to the wider energy transition. Any measures to facilitate the engagement of households in these vulnerable situations with heating DSF will only ever serve to partially mitigate the risks of inequitable access and unsafe participation. To fully unlock the

potential for heating DSF and energy transition, it is therefore imperative that these wider issues are addressed at a societal level regionally and nationally.

A wider 'Just Transition' is therefore key to unlocking further demand side flexibility potential across the board. Improvements in inclusive growth and the delivery of area-based transitions, will reduce the prevalence of certain vulnerability factors, meaning they have less impact on the potential for heating DSF.

5. Lessons learned and their application to other projects

The EPF is a bespoke arrangement for the EQUINOX project, focused on potential vulnerability from a demand side flexibility perspective for heating. However, with the right steps, the framework can be adapted and used to generate similarly bespoke vulnerability frameworks for different use cases.

Many vulnerability factors are also likely to be relevant to other cases and projects and both the longlist and final list of vulnerability factors can be used as a resource to facilitate the initial identification of other potential vulnerability factors.

The following section sets out some of the key lessons learned from the process of developing the EPF for EQUINOX to assist in the development of similar frameworks for other projects. Linking all the lessons together is the underlying message that vulnerability depends on the situation, and this is the driving reason a bespoke framework for identifying potential vulnerability and assessing equitability of flexibility offerings is required.

Insight 1: there is a lot of pre-existing work on vulnerability which should be used as an initial basis to generate a more bespoke understanding of potential vulnerability for the specific case being considered

The literature review and discussions with experts revealed a wealth of pre-existing work on the factors that contribute to a person or a household being in a potentially vulnerable situation. This pool of existing research should be used to identify the factors that contribute to a person or a household being in a vulnerable situation in the context of a specific flexibility or other novel system offering.

However, it is important to recognise that vulnerability depends on the situation and the conditions the participant is subjected to. This is why a bespoke set or list of vulnerability factors should be developed for each project, based on an understanding of the mechanism by which a participant could find themselves in a potentially more vulnerable situation. For example, being deaf or hard of hearing was identified in the longlist as a potential vulnerability factor due to its inclusion in various vulnerability studies and lists (such as the PSR) in the case of heating flexibility offerings. However, it did not correspond to any of the three identified mechanisms for putting a participant in a potentially vulnerable situation and had no discernible direct impact on whether a participant would be able to take part in the EQUINOX-style heating flexibility offering being considered. Being deaf or hard of hearing was therefore not included in the final list of vulnerability factors.

Insight 2: it is helpful and important to understand the mechanisms by which participants in projects or flexibility offerings may find themselves in a vulnerable situation

Being vulnerable is defined as in need of special care, support, or protection, for example because of age, disability, risk of abuse or neglect. However, as mentioned in the first lesson above, vulnerability depends upon the situation as the special care someone may or may not need will be affected by what they are trying to engage with or achieve and the environment and circumstances they find themselves in.

To identify whether someone may be in a vulnerable situation, we need to understand the processes for how they might get there. In the case of EQUINOX, this meant understanding what puts someone in a vulnerable situation from the perspective of engaging with heating flexibility.

This resulted in three main mechanisms:

1. Anything that makes it difficult for participants to engage with heating DSF, especially in a safe and effective way
2. Anything which makes participants susceptible to harm from home underheating or which means they are generally vulnerable to 'cold' or 'heat'[8]
3. Anything which puts participants at risk of lack of access to adequate home heating for a decent quality of life (as they may already be underheating their homes).

By identifying these mechanisms and lining them to identified vulnerability factors, we can be sure that the factors are actually driving potential vulnerability themselves. If on the other hand, the identified factors are not actually linked to potential mechanism and do not drive potential vulnerability themselves, their inclusion and use for segmenting trial results may capture too many households who are not actually in a vulnerable situation, rendering segmentation using the factor to analyse results unhelpful.

It should be noted that some factors are indicative of wider structural inequalities and further study is needed to understand their impacts and interactions with heating flexibility offerings

There are cases where potential vulnerability can be indicated by other factors linked to more structural challenges in society. We did not segment for these factors as a clear mechanism of action as not present due to the limitations of the study and the fact that many of these additional factors are indicative of structural issues in society as a whole.

[8] To quantify this, we drew on exiting understandings in policy and Regulation, such as the Fuel Poverty (Targets, Definition and Strategy)(Scotland) Act 2019 and The Fuel Poverty (Enhanced Heating) (Scotland) Regulations 2020 to define 'typical' levels of household heating wherein those with additional heating needs can be defined as anyone requiring (to avoid negative health impacts) heating to be on at least 16 hours a day during the week and at the weekend, and/or, heating to be at least 23°C in the living room and 20°C in other rooms. As a minimum home heating is presumed to typically be no lower than 16 degrees Celsius.

However, an Equitable Participation framework should consider disadvantaging factors or underrepresentation makers which may interact with, compound, or increase the likelihood of being in a vulnerable situation[9]. These factors were recorded in the longlist, and it is noted that larger studies are needed to review their impacts.

Insight 3: there are many common 'vulnerability factors', but not all have clear direct mechanisms to drive potential vulnerability

From an analysis of existing frameworks, literature, and through conversations with those working within the energy and inclusion field, a longlist of potential vulnerability factors was created. To be useful, the longlist was refined into a more manageable shortlist of factors by identifying duplicated factors, factors which are too vague to be useful, and factors for which the direct impact on potential vulnerability is judged insufficient.

While some factors have direct impacts, others, like gender, were removed from the final list because their impact is highly dependent on the participant's specific situation and the presence of other factors. In other words, the mechanism for they act is not clear or discernible enough in the context of the project to warrant segmentation by itself. For example, elderly women living on their own in a rural area and with a low income are much more likely to be in a vulnerable situation with regards to heating flexibility exacerbated by their gender than women living in an affluent 4-person household. In this case, age, living arrangements and income are more important driving factors for potential vulnerability in a first instance.

Due to the project's limits in time, resources, and participant pool, the final factors used for analysis and segmentation were refined based on their direct relevance to driving potential vulnerability. Further study may be warranted in future given the evidence of some direct impacts (as well as circumstantial /associated impacts of gender).

Insight 4: using a wide range of vulnerability factors can increase the pool of potentially vulnerable participants significantly

Vulnerability is likely to be more widespread than often thought, or was initially considered in the first two trials of the EQUINOX project. Understanding the plethora of mechanism by which a participant may find themselves in a vulnerable situation reveals the wide variation in customer experience that must be taken into account if we are to fully unlock the opportunities from heating flexibility.

[9] Some factors may need to be monitored to evaluate how representative the EQUINOX project trials have been and for which further research may be necessary, as not all factors will be possible to study at once in the limited time remaining for the EQUINOX project (as of March 2024).

While this means that a significant proportion – or even a majority – of households are identified as potentially vulnerable, it reflects the widespread and diverse nature of vulnerability. Indeed, in Trial 3, 60% of participants presented at least 1 of the 8 (used) vulnerability factors.

Capturing a broad pool of participants in the definition of potentially vulnerable is not a problem. If the mechanisms for how participants find themselves in a potentially vulnerable situation are clear – and as long as there are few compounding or mitigating circumstances that might be associated with the factor (and therefore actually driving the potential vulnerability) – the participants they capture are more likely to truly face circumstances that necessitate further understanding about how they can engage with the flexibility offering. If, on the other hand, the factors are not actually driving potential vulnerability, their inclusion may capture too many households who are not in a vulnerable situation because they lack the compounding factors or circumstances, rendering segmentation using the factor to analyse results unhelpful.

Insight 5: we can combine factors to improve segmentation of results according to the EPF

Given the breadth of participants that may be captured by a comprehensive suite of vulnerability factors, each with direct mechanisms of action to drive potential vulnerability, it may nonetheless be necessary to focus in on participants who are *particularly* likely to experience vulnerable situations. This may be because the pool of potentially vulnerable and non-vulnerable participants is otherwise not distinct enough.

To do so, it will be necessary to make a judgement on which factors are most important and most likely to indicate true cases of potential vulnerability. As in the example above, gender was considered too blunt and broad, with too vague a mechanism of action, to be useful as a delineating factor for potential vulnerability in the EQUINOX project on its own.

In some cases, factors do themselves have a direct mechanism to drive potential vulnerability, but they may also be more or less likely to be present alongside mitigating factors (such as having a high income in the case of EQUINOX). In these instances, the factor may capture a large proportion of households who, for various reasons of potential circumstance are not actually experienced vulnerability. In these instances, we should also consider the risk that the factor does not capture everyone who may be potentially vulnerable.

In the case of EQUINOX, we achieved this by limiting the classification of a participant's potential vulnerability to circumstances where the household either:

- Self-reported a health condition exacerbated by the cold
- Met the defined low-income threshold
- Met two of the other EPF vulnerability factors to be considered potentially vulnerable.

Instead of 60% of participants being classified as vulnerable, this limited the pool, of potentially vulnerable participants to 47%. The figure is still high, but reflected that except in cases of low

income and health conditions exacerbated by the cold, the vulnerability factors may not in every case indicate an increased potential vulnerability. Moreover, we actually removed 71 participants from the classification of potentially vulnerable due to low-income because their response to the question of whether they could always pay their energy bills on time or not indicated the mechanism by which low income is presumed to drive potential vulnerability in the case of heating flexibility was not affecting these households[10].

Insight 6: a bespoke approach to equitable participation can deliver valuable insights

Because vulnerability depends upon the situation, we cannot develop a single framework for potential vulnerability that will apply in the case of every project. The EPF for EQUINOX is a bespoke arrangement focused on potential vulnerability from a demand side flexibility perspective for heating. However, with the right steps, the framework can be adapted and used to generate similarly bespoke vulnerability frameworks for different use cases.

The process of identifying mechanisms of action for how a person or a household becomes vulnerable and validating them through customer journey testing and the development of personas is an invaluable part of developing a bespoke EPF for a project. This approach can deliver valuable insights and help ensure that the project meets its objectives.

Applying the EPF process to other projects

The subsection “Summary of the process to identify vulnerability factors and build an Equitable Participation Framework” of Section 3 sets out the steps followed to develop the EPF for EQUINOX. The foundations provided by the long and final vulnerability factor lists, and the outline of the methodology followed, can hopefully ease the process to develop future bespoke frameworks.

While the EPF used for this project and the insights gathered from its application can be valuable to other projects and use cases, especially where these relate to heating or demand side flexibility more generally, it is strongly advised to develop a bespoke framework. This begins with the identification of mechanisms for how a person or household may find themselves in a vulnerable situation within the context of the project or its subject. Where the mechanisms are shared with the three headline mechanisms identified for EQUINOX therefore, the same vulnerability factors can be identified – at least for the longlist.

[10] In spite of this, 24% of participants were still classified as potentially vulnerable due to having a low income.

Annex A: Final Vulnerability factors

The 8 vulnerability factors, drawn from the shortlisted Primary Vulnerability Factors and which were tracked and used for segmenting and analysing the results of Trial 3 in EQUINOX are listed below.

I. Households with children under 5
II. Households with members over 75
III. Households where there is a sole occupant (live alone)
IV. Lone parent households
V. Households where at least one member has a physical disability
VI. Households which are poorly insulated (EPC D or below)
VII. Households where at least one member suffers from a health condition exacerbated by the cold or which increases home heating needs
VIII. Households where income is below the standard required for an 'acceptable standard of living' according to their household composition or which are classed as in fuel poverty.

Annex B: Defining key terms

In the definition of the vulnerability factors and for their measurement, we needed to set a clear understanding of what was meant by certain key terms. For the purposes of the EQUINOX EPF, these were:

'Typical' level of home heating needed

Relevant to the factor "Health condition exacerbated by cold or which increases home heating needs above 'typical' levels", we drew the definition from the Fuel Poverty (Targets, Definition and Strategy)(Scotland) Act 2019, as well as The Fuel Poverty (Enhanced Heating) (Scotland) Regulations 2020.
In this definition, above 'typical' means any household which requires heating to be on at least 16 hours a day during the week and at the weekend and/ or for heating to be at least 23°C in the living room and 20°C in other rooms.

'Cold'

Also relevant to the factor "Health condition exacerbated by cold or which increases home heating needs above 'typical' levels", this means below 16 degrees Celsius, or any temperature below that required for a household member to avoid negative health impacts, whichever is higher.

'Normal household tasks'

Relevant to the factors "a physical disability limiting the ability to carry out 'everyday' household tasks without assistance" and "Suffer from a cognitive impairment or mental health condition which limits their ability to carry out 'everyday' household tasks without assistance". Building on existing literature and rom conversations with experts, including the NEA, we defined normal household tasks to include being able to make use of your home safely, including using domestic appliances such as the cooker, fridge, heating system, vacuum cleaner and kettle; and keeping your home clean, safe and hygienic.

It is ultimately a subjective measure.

'Increased energy usage'

Relevant to the factor "Suffer from a cognitive impairment, physical condition or other health issue which means there is an 'increased energy usage', this means that additional energy usage (either as fuel or electricity) is required above the levels that would be required in a typical household with the same number and ages of household members. This may be because of additional appliances or equipment to meet particular health needs, or it may be because certain appliances or

household equipment must be kept running for longer periods to meet particular health needs. It is ultimately a subjective measure.

Annex C: longlist of vulnerability factors

The below table represents an extract of the longlist for the EQUINOX EPF. Further columns included mitigations / aggravations, impact if not all households, other notes and intersecting factors, issues with assessing metric or identifying people or households.

Ref.	Vulnerability factor	Description	Suggested indicator(s)	Rationale	Sources (ANNEX)
1	Illiterate or low level of literacy	A responsible adult in the household cannot read or write in English, or can only do so in a limited way.	Self-reported literacy level	If a person is illiterate, they may find it hard to access information about DSF, including requests to turn up or down a heat pump, and therefore to engage with it	Judgement - derived from [3], [4], research review, including [7] and [8], as well as expert conversations (Guidehouse, NEA, WMCA)
2	Innumerate	A responsible adult in the household lacks basic numeracy skills	Self-reported numeracy level	If a person is innumerate, they may find it hard to access information about DSF, including requests to turn up or down a heat pump, and therefore to engage with it	Judgement - derived from [3], [4], research review, including [7] and [8], as well as expert conversations (Guidehouse, NEA, WMCA)
3	Fuel poverty	Using Scottish Fuel Poverty Regulations metric: • Fuel costs necessary for the home to meet 'requisite temperatures'	Self-reported /calculated based on Scottish (2019) Fuel Poverty Act metric OR Based on	If a household is in fuel poverty, they may struggle to pay bills and may therefore be: (a) hesitant to engage in perceived 'risk taking' with new DSF technologies or schemes (b) more likely to	[2] [3] [4] [5] [13]

		for the 'requisite number of hours', and any other reasonable fuel needs exceed 10% of the households adjusted net income • AND/OR income is equivalent to at least 90% of the minimum income standard applicable to the household (as defined by the Centre for Research in Social Policy at Loughborough University) after deduction of the notional costs allocated as part of that standard to rent, fuel, childcare, council tax and water rates.	English definition and including only households with EPC of Band D or below and with a residual household income falling below the poverty line OR Our own 'hybrid' metric for practical or design reasons	underheat both before and during DSF events - possibly compounded by perverse incentives - and therefore more likely suffer negative impacts from cold during or after DSF events (c) find it harder to find the time or mental energy to engage in heat pump DSF opportunities.	
4	Poor / bad health / chronic illness	This is a self-reported status of a person in the household being in long-term poor or	Self-reported	People in poor or bad health may face higher stresses to manage their condition, which may make engaging with DSF more challenging.	[1] [2] [3] [4] [5]

		bad health (meaning a health condition that requires ongoing treatment over at least a year, or which cannot be cured)		They may also be more susceptible to harm from DSF if it reduces temperatures in their home.	
5	Blind/partially sighted	A responsible adult in the household is registered blind or partially sighted.	Self-reported	People who are blind or partially sighted may find it harder to engage with DSF because of greater challenges to accessing information, or from difficulties to engage with heat pump controls.	[1] and from logical judgement
6	Cognitive impairment	A responsible adult in the household has a cognitive disability affecting their ability to understand new or complex information, to think, to learn, to remember, to pay attention, to communicate, to use judgement or to make decisions.	Self-reported	People with cognitive impairments may find it harder to engage with heat pump controls, or to access and understand information about DSF. They may also have higher energy needs.	Research review including: [7] [8] [3] [4] - especially dementia [10]

7	Disability limiting physical activity	A person in the household has any disability which limits 'everyday' physical activities or movement.	Self-reported	People with disabilities limiting their physical activity are more likely to spend a greater amount of time sedentary and are therefore at greater risk from the cold.	[1] [3] [4]
8	Housing: insulation or home energy inefficiency	Any household with an EPC rating of D or below, or any household lacking ordinary levels of insulation (none of the following: loft insulation, cavity or external wall insulation)	Self-reported / measured	Poorly insulated houses will lose heat at a faster rate and are therefore more likely to experience significant temperature drops during heat pump DSF events.	[2] - English definition requires home to be EPC band D or below. [3] [4] [5] - derived from consideration about 'acclimation' and own judgement based on conversation with informed experts
9	No internet access	No connection to the internet in the home by household members.	Self-reported	People without internet access will struggle to access information and to engage with DSF events. They are more likely to lack the digital skills or confidence to navigate and use novel or smart technologies. Ofcom recognises that these aspects of digital exclusion may also be intertwined with access	[3] [9] [10]

				to the internet from an affordability perspective, so this may also signal vulnerability from a financial perspective.	
10	Lack of confidence using smart technology	Adults in the household are report low or no confidence in using smart technology to manage energy use in the home	Self-reported	People who lack confidence or skills to use smart technology are more likely to struggle to engage effectively or safely with heat pump DSF. They might also struggle to use their heat pump effectively, generating a greater risk of underheating.	[3] [9] [10]
11	Health condition exacerbated by cold	A household member who has a health condition whose effects are made worse by 'the cold' (where a definition of cold is required, it refers to any temperature below that required for a household member to avoid negative health impacts)	Self-reported: examples could include asthma, arthritis and joint inflammation, cardiac conditions, thyroid issues, diabetes, joint pain - but these should not be limited.	Where a household member has a health condition exacerbated by the cold, they are more at risk of harm if heat pump DSF reduces the temperature of their home.	[2] [3] [4] [12] As well as own judgement and conversations with informed experts.

12	Pre-payment meter	A household has a pre-payment meter installed.	Self-reported	Households with prepayment meters are more likely to face higher charges for energy, be in fuel poverty, or to struggle to manage and afford their energy bills, so may be more at risk of underheating their homes.	[3] [6] - according to the ODI, 30.6% of households using prepay electricity meters are in fuel poverty
13	Age: elderly	Age of household members including at least 1 person over 75 years old.	Self reported age of household members (>75)	Elderly people are: * More likely to be sedentary * More often at home during the day (retired) * May have reduced thermoregulation ability (more sensitive to the cold) or suffer from health conditions etc. * As a consequence of the above, they may be at greater risk of negative impact from fuel poverty. * May be more likely to be digitally excluded	[1] 'pensionable age' [3] 'over 65' [4] 'over 65, 75 or 85' [5] 'over 65' [12]
14	Age: young	Age of household members including at least 1 child under 5 years old.	Self reported age of household members (<5)	Children under 5: * May have reduced thermoregulation ability * Are more likely to suffer negative impacts from exposure to the cold	[1] [2] [3] [4] [5] [6] - 20.4% of households with children aged 0-4 years are in fuel poverty

15	English not a first language	English is not the first language of any adult in the household.	Self-reported	May find it harder to engage with heat pump controls, or to access and understand energy bills or information about DSF and payments, including requests to turn up or down a heat pump.	[1] [4] [6] [11] [12]
16	Can't speak English well or can't speak English	Adults in the household can't speak English well, or can't speak English. This may be qualified as adults / an adult in the household having an English level below B1 level in the Common European Framework of Reference for Languages (CEFR). B2 level English means a person can: - understand the main ideas of complex texts on concrete or abstract topics, including some technical discussions - express themselves	Self-reported (indicate a level of B1 or below)	May find it harder to engage with heat pump controls, or to access and understand energy bills or information about DSF and payments, including requests to turn up or down a heat pump.	[1] [4] [6] [11] [12]

		fluently and spontaneously enough to comfortably communicate with other English speakers - produce clear, detailed text on many subjects and explain a complex viewpoint on a topic, including expressing advantages and disadvantages.			
17	Require documents to be translated into another format or language than standard formatted English.	Any adult in the household requires documents to be translated into another format or language than English e.g. larger text, Welsh, braille.	Self-reported / apparent from engagement	May find it harder to engage with heat pump controls, or to access and understand information about DSF and payments, including requests to turn up or down a heat pump.	[1] [4] [6] [11] [12]

18	Low-income	Following the DWP definition, this should be defined as any family earning less than 60% of the national median pay, or we may use the latest annual Minimum Income Standard set out by Loughborough University's Centre for Research in Social Policy.	Self-reported income	Low-income households may experience a higher stress environment, struggle to pay bills and may therefore be: (a) hesitant to engage in perceived 'risk taking' with new DSF technologies or schemes (b) more likely to underheat both before and during DSF events - possibly compounded by perverse incentives - and therefore more likely suffer negative impacts from cold during or after DSF events (c) find it harder to find the time or mental energy to engage in heat pump DSF opportunities.	[2] [3] [4] [12] [13]
19	Unemployed	This should be defined as long-term unemployed and refer to anyone who has been out of work for six months or more, whilst actively seeking a job.	Self-reported	Unemployed people are more likely to be at home more often and so may be at greater risk from the cold. They are also more likely to be in a low-income household, or in fuel poverty, meaning they may be: (a) hesitant to engage in perceived 'risk taking' with new DSF technologies or schemes (b) more likely to underheat both before and during DSF events - possibly compounded by perverse incentives - and therefore more likely	[3] [4] [5] [13]

				suffer negative impacts from cold during or after DSF events As they may experience a higher stress environment, they may also find it harder to engage in heat pump DSF opportunities.	
20	Anxiety, depression or mental health conditions	Any adult in the household suffers from anxiety, depression or any other mental health condition	Self-reported	People suffering from these conditions may find it harder to engage with, access and understand complex information about heat pump DSF, or to use their heat pump. They may also be more likely to be sedentary and so they may be more at risk of harm if heat pump DSF reduces the temperature of their home.	[1] [2] [3] [4]
21	Physical disability	Any member of the household suffers from a physical disability	Self-reported	People with physical disabilities may struggle to access their heat pump to control it (a problem if they have no remote access). They may also be more sedentary, or their disability may restrict their movement, meaning they may be more often sedentary and so more at risk of harm if heat pump DSF reduces the temperature of their home.	[1] [2] [3] [4]

22	Use medical equipment reliant on electricity or water	Any member of the household must use medical equipment reliant on electricity or water	Self-reported	Those with medical equipment reliant on electricity or water may need to e sedentary when using it and so they may be more at risk of harm if heat pump DSF reduces the temperature of their home. They may also believe that they cannot use their equipment during events, and so either be unable to take part or put themselves at risk of harm. Finally their equipment may be expensive to run and increase their fuel costs, increasing the risk they cannot afford to pay their energy bills	[1] [8]
23	Crowding	A household that contains more occupants than bedrooms based on the ages and relationships of household members.	Self-reported occupancy (simplified, counting couples as 1 and pairs of children under 10 as 1) / number of bedrooms >/= 1	People in crowded homes are more likely to be in higher stress environments and so may find engaging with heat pump DSF challenging. They are also more likely to be in lower income households and my therefore be at greater risk of fuel poverty.	[4] [5]

24	Lone parent	Only one adult in a household with a child / children	Self-reported	Lone parents may experience a higher stress environment and so may find engaging with heat pump DSF challenging from a mental energy and time point of view. Finally, because they are more likely to have only one income stream, they may be more likely to have a low income and/or to experience fuel poverty.	[3] [4] [5] [6] [12]
25	No smartphone access	No adult in the household has access to a smartphone	Self-reported	People without a smartphone may find it more challenging to control their heat pump and are more likely to be unable to control it remotely, limiting their ability to engage with heat pump DSF when outside the home. People without a smartphone are also more likely to be digitally excluded.	[3] [9] [10]
26	Living alone	Only one person lives in the household.	Self-reported 1 person per household	People who live alone may find it harder to find the time to engage in heat pump DSF as they cannot 'share the burden' of responding to events.	[3] [4] - 'lone pensioners' [12]

27	Deaf or hard of hearing	Any of the household occupants are deaf or hard of hearing	Self-reported	May find it harder to engage with heat pump controls, if those controls include associated noise signals, impacting their ability to turn up or down a heat pump.	[1]
28	Renting	The household occupants rent their accommodation	Self-reported	People who are renting have less control over the quality of their housing, which may therefore be less well-insulated. Renters are also more likely to not have chosen to have a heat pump and so may not be confident, or may lack the skills, to use the heat pump effectively.	[3] [4] [6]
29	Low education level	Below GCSE C in English / maths (Grade D or below)	Self-reported education level below GCSE C equivalent in English / maths	People with a low education level are more likely to have a low income and so are more likely to experience fuel poverty or struggle to pay energy bills. They may also find it harder to access and understand heat pump controls and the opportunities presented by heat pump DSF.	[4] [5]

30	Minority ethnic background	A person is from a minority ethnic background (not White British)	Self-reported	People who are from a minority ethnic background have lower incomes on average and so may be more likely to experience fuel poverty.	[4] [10]
31	Obese	Any of the household occupants are obese.	Self-reported	People who are obese are more likely to find it harder to be active and so may be more sedentary, increasing their risk of vulnerability to the cold. They are also more likely to have health conditions that could make them more at risk of harm due to the cold.	[5]
32	Gender	The household includes a woman	Self-reported	Gender is rather to blunt to be useful on its own. Not all women are in a vulnerable situation with regards to energy, heat or DSF. However, there is some evidence that women are more likely to suffer from the impacts of energy poverty or from the cold, either physiologically or psychologically (due to e.g. the burden of care more often falling on them). Where a household includes women and	[12]

				exhibits other vulnerability indicators, it may be warrant an additional weighting, in some circumstances.	
33	Experiencing personal tragedy	A responsible adult in the household is experiencing bereavement or long-term relationship breakdown.	Self-reported	People experiencing bereavement may find it harder to find the time or mental energy to engage in heat pump DSF opportunities.	[3]

ANNEX E: EQUINOX hypotheses and proposed segmentation

The table below captures the initial set of hypotheses drawn from the identification of the primary vulnerability factors for EQUINOX, and their application through personas to the customer journey. Not all were feasible to test within the EQUINOX project.

HH = Household
VF = Vulnerability Factor

Hypothesis	Vulnerable group(s) of interest	Notes
H1: recruitment of households with more vulnerability factors will be enhanced by non-digital outreach.	• All HH classed as potentially vulnerable	This was initially tested by WMCA, who attempted to recruit households via door knocking, as well as via an initial non-digital contact form sent as a direct mail out. However, limitations of the project meant further direct testing of this hypothesis was not taken forwards.
H2: relatively lower income households will be more satisfied by [lower] payment amounts than relatively more well-off households.	• Classed as 'low income'	
H3: An additional reminder just before the event is particularly important for households subject to external stressors from a low income or with caring responsibilities.	• HHs where income is below the standard required for an 'acceptable standard of living' according to their HH composition or which are classed as in fuel poverty	It may also be worth looking at whether there is an effect for HHs who have young children (under 5) in general and/or who have young children AND are relatively low-income.

	• Lone parent HHs	
H4: A reminder that the event has ended will help to avoid vulnerable households underheating because of events.	• HHs with children under 5 • HHs where at least one member suffers from a health condition exacerbated by the cold or which increases home heating needs.	Unless there is the possibility to monitor household temperature post-event, this will probably need to be via feedback from mid and end of trial surveys only.
H5: Remote control is particularly important for households with young children and / or where members have physical disabilities.	• HHs with children under 5 • Households where at least one member has a physical disability	This might not be feasible to test as part of the events if remote control is not sufficiently represented within vulnerable groups. However, it could be analysed in survey results through a question such as, "would being able to control your heat pump from your smart phone help you engage in events?"
H6: vulnerable households, particularly those who are either poorly-insulated, or where there are members over the age of 75 or with health conditions exacerbated by the cold will be more likely to leave early or opt out of longer events.	• Poorly insulated HHs • HHs where members are over the age of 75 • HHs with children under 5 • HHs where at least one member suffers from a health condition exacerbated by the cold or which increases home heating needs	
H7: Households with young children, which are poorly-insulated, or where there are members over the age of 75 or with health conditions exacerbated by the cold will prefer events before 7pm.	• Poorly insulated HHs • HHs where members are over the age of 75 • HHs with children under 5 • HHs where at least one member suffers from a health condition	The Trial could offer the possibility to opt out of events after 7pm from the very start and opt out choice be observed between groups.

	exacerbated by the cold, or which increases home heating needs	
H8: Guidance and support on how to ensure heat pumps run optimally and cost-efficiently, combined with advice on how to engage effectively with EQUINOX events, will increase participation among households and especially among households experiencing fuel poverty or who report difficulty using or understanding how to use their heat pump.	• All HH with at least 1 of the 15 VFs • [we are not proposing to segregate for other HH groups, unless there are statistically significant numbers, particularly of low-income HHs with young children and digitally excluded HHs)	We considered whether it would be feasible to organise guidance halfway through the trial – after the mid-trial survey ends, potentially with recruited households in the West Midlands area, but this was not practical in the timeline and challenges to recruit specifically with the West Midlands meant we couldn't guarantee a sufficient participant pool to follow through with this. The hypothesis is retained for information and could be further investigated. We will also seek insights into the validity of this hypotheses via the social housing tenant survey being led by WMCA with Bromford Housing Group and include relevant questions within end of trial surveys.
H9: Relatively lower income households will offer lower turndown on average, as will poorly insulated households.	• Poorly insulated HHs • HHs where income is below the standard required for an 'acceptable standard of living' according to their HH composition or which are classed as in fuel poverty	

H10a: Guidance, tips and advice on how to make the most out of their heat pump will increase trial satisfaction, especially among households with lower turndown and consequently lower payment.	• Poorly insulated HHs • HHs where income is below the standard required for an 'acceptable standard of living' according to their HH composition or which are classed as in fuel poverty	As noted for H8, we could not directly test this as part of the EQUINOX project.
H10b: Targeted information about how participant actions help the grid could increase trial satisfaction, especially among households with lower turndown and consequently lower payment.	• Poorly insulated HHs (5) • HHs where income is below the standard required for an 'acceptable standard of living' according to their HH composition or which are classed as in fuel poverty (7)	It may be challenging to provide this data within the scope of the trial. On the other hand, insight about trial participation motivations and feedback on the information given about the intended impact of heating DSF with bills may provide insights.
H11: High income households with vulnerability factors will show higher levels or turndown and participation than non-high income households with vulnerability factors.	• All HH with at least 1 of the 15 VFs (excluding high income HHs) versus high income HHs with at least 1 of the 15 VFs.	This will need to be extracted from any effect of home footprint and heat pump size.
H12: Lower income households will offer greater turn up, once dwelling size is controlled for.	• HHs where income is below the standard required for an 'acceptable standard of living' according to their HH composition or which are classed as in fuel poverty	This will be relevant only for turn up trials if and when run with an adequate participant pool.

Annex F: EQUINOX summary of recommendations for equitability within the Trial

While we should test hypotheses, there may be cases where it makes sense to adapt trial activities and communications to ensure equitable participation within the Trial (especially where this can increase representation from participants with higher risk of potential vulnerability). They were developed through consideration of the interaction of participants with vulnerability factors with the Trial via the customer journey analysis, using both vulnerability factor on their own and the personas. The full list of recommendation for EQUINOX are captured below. These are not the final recommendations for BAU, although some will be relevant to this as well.

Recruitment recommendations

RECRUITMENT recommendations
Ensure recruitment materials are clear, concise and use simple to understand language
Clearly and explicitly communicate and make available information about the impact of previous trials on comfort
Clearly and explicitly communicate, if possible, that there will be no obligation to turn down heating during trial events if it is not right for the household at that time – and that no penalty would apply for not taking part at any time
Clearly and explicitly that there is no need to reduce other energy / electricity usage to take part in the trial and trial events.
Ensure communications ask if potential recruitments have a heat pump in their home, rather than e.g. only referring to heat pump owners.
Target households who have benefited from government schemes to retrofit low-income households
Reach out through multiple hosts (public bodies and private energy suppliers)
Provide additional information to reassure customers about the financial risks of taking part e.g. through drop downs or further FAQ sheets

Recruit though non-digital, as well as digital methods, such as direct mail outs (with FREEPOST sign-up forms) and door-knocking
Avoid putting households at risk of 'financially losing out' from taking part in the trial, including by enabling stacking and by ensuring 'rewards' also include either direct financial compensation or energy bill credits.
Start of trial surveys should be as concise as possible, with a clear indication of the time it will take to complete; such as by including a progress bar. They should also enable users to save progress and return later.
Include an optional free text box on start and end of trial surveys to explain complex situations
Provide the opportunity to complete start of trial surveys over the phone

Recommendations during the Trial

TRIAL recommendations
Keep communications simple and clear. For example, messaging should ask participants to "turn down their heating" to save money during the hours of the event
Agree on a maximum number of communications per week
Trial communication must stress that households should not underheat their homes when taking part in the trial. *Information about the risks of underheating could be coupled with a contact (email and ideally also telephone) for further information and advice about participating on the trial.*
Trial communication and bill payment information must be clear and concise, in easy-to-understand language.
Communication should be clear and explicit that there is no need to reduce other energy / electricity usage to take part in the trial and trial events.
Communication should be clear and explicit that households do not have to turn off their heat pump or turn it down for the whole event period.
A simple to access contact (email and ideally also telephone) to ask questions about the trial and to access advice about participating should be made available and included in communication materials
The opportunity to respond to post-event surveys by phone call or text message

Simple ‘icon-based’/ ‘emoticon’-based responses to post-event surveys
'Accessible’ format versions of the post-event survey should be made available
Post-event surveys should be as easy to complete as possible: e.g. integrate them into emails and limit the number of ‘clicks’ to access surveys [ideally to 'single click throughs']
Consider a nominal financial reward for completing post-event surveys / a proportion of post-event surveys, in addition to the reward for mid-trial and end-of-trial surveys. This reward should be clearly promoted.
The opportunity to respond to start, mid and end of trial surveys by phone call or text message
The possibility to save progress and continue filling in surveys later. Progress should be signalled by a progress bar (or equivalent)
The level of compensation for completing surveys should be made clear and explicit at the start
'Accessible’ format versions of surveys should be made available
Include an optional free text box on start, mid and end of trial surveys to explain complex situations
The option to attend focus groups and interviews with someone else
Plenty of notice should be given, as well as guidance, on what is expected in the focus groups or interviews.
Opportunities to take part in focus groups / interviews at weekends or later in the evening
Clear information on how the focus groups and interviews would be compensated should be provided
Participants should be able to take part in interviews over the phone, rather than only online
Targeted and supported engagement in focus groups / interviews
Ensuring ‘rewards’ for trial participation also include either direct financial compensation or energy bill credits.
For households with smart pre-payment meters: provide an early indication of how much money will be credited to their smart meter may help ensure those households can pre-heat their home before the event, without financial worry
Bill payments should be as clear and concise as possible but could be accompanied by further ‘breakdown’ to explain to each household ‘how many events they took part in’, ‘how much notice they were given’, ‘turndown provided’, and ‘how much they were paid’.

Notifications should be provided, wherever possible, on the day before events, or in the [early] morning before
Send a reminder just before an event
Notifications about events via non-digital means (such as a phone call, or text).
Clear EQUINOX branding on notifications and the hours (and date) of events highlighted / emphasised at the top of the message
A standing reminder about events that day in their energy supplier's app
Communication about length of the events before they start
Include opportunities to take part in events in evenings as well as mornings
Opportunities to opt out of events at certain times, especially after 7pm
If trial events run over 2 hours, participants should be able to opt-out and be confident they will still receive payment for the turn down they have provided. *If compatible with trial objectives and design*, it may be advantageous to give forewarning that a trial event may be extended.
During the trial, monitor turndown by household to identify households with significant drops in KWh usage and conduct 'wellbeing checks', removing households from the trial if necessary
Clear communication as part of the trial materials on the risks of underheating, especially to vulnerable groups, like young children
A reminder to turn the heat pump / heating back up after the event, or that the event has ended
Take measures to improve access to remote control of the heat pump
Provide targeted heat pump use and control advice / training to ensure it runs optimally and cost-efficiently.
Provide targeted information about their turn down (including the amount the household has delivered) and how it is helping the grid could provide some additional motivation to keep going on the trial, especially where payment is perceived as low

In addition to the above recommendations for recruitment and trial features, it wass recommended that household engagement with heating DSF is monitored to identify any excessive turn down or turn up. Excessive turn down or turn up could result in household members being exposed to dangerous internal temperatures, which could eb harmful to their health and wellbeing. All

households can be monitored to identify if turn down or turn up is above what would be expected for a dwelling of that size, based on previous trial data trends.

In the case of some households the risks of over or underheating in response to heating DSF may be higher and/or the risk of harm more severe. As such, wherever possible, temperature monitoring may be an additional safeguard to consider for such households and additional attention should be paid to the behaviour of these households. Thes include households:

- Which are very low income, or fuel poor
- With a smart prepayment meter
- Where a member or members suffer from a health condition aggravated by the cold or which enhances heating needs

It could also include households where there are children under 5 years old or adults over 75 years old.

Annex G: Annual Minimum Income Standard thresholds used in Trial 3

Household composition	Total HH members	Retired?	MIS for household lower limit	MIS for household upper limit	Average upper and lower limit
1 adult	1		£28,018	£29,541	£28,780
1 adult	1	Y	£17,155	£20,480	£17,155
1 adult + 1 child	2		£48,909	£51,363	£50,136
1 adult + 2 children	3		£65,358	£83,207	£74,283
1 adult + 3 children	4		£86,171	£100,000	£93,086
2 adults	2		£39,444	£39,444	£39,444
2 adults	2	Y (both)	£27,725	£27,725	£27,725
2 adults + 1 child	3		£56,396	£65,810	£61,103
2 adults + 2 children	4		£69,268	£84,636	£76,952
2 adults + 3 children	5		£82,194	£126,373	£104,284
2 adults + 4 children	6		£96,080	£162,613	£129,347

Annex I: Persona Example

Jessie's journey: Low-income household, with a pre-payment meter and a health condition aggravated by cold

CONTACT AND SIGN-UP

Jessie needs plenty of time to sign up. She's having to juggle a lot of demands and stress, especially because she is now the primary carer for both Evette and their 7-year-old son, Freddie.

Even though she is organised and keeps on top of her emails, she is much more likely to engage if communications about the trial are short and clear, accompanied by a few gentle reminders through her app and via email.

Features that help Jessie take part in heating DSF / heating DSF trials like EQUINOX:

- Short and clear communications about the opportunity
- Single click-throughs for sign-up
- Signposted, drop-down FAQ sections where she can quickly find any question and its answer.

'EVENTS'

If Evette is facing a bad relapse with her MS, they might not be able to offer much, if any turn down. They also find it challenging to take part in events between 7 and 9pm, as the house needs to be warm while Freddie has his tea and does his homework before bed.

Longer events are also a real problem for Evette. They are worried that they'll start to feel the heat loss, and this could cause Evette harm.

As they are on a smart pre-payment meter, they don't see monetary benefits straight away. During Trial 2, they were able to pre-heat on the cheaper time of use tariff, but in Trial 3 they no longer benefit from this and so pre-heating can cause them to run short of money until their smart meter is topped-up with credit.

Features that help Jessie take part in heating DSF / heating DSF trials like EQUINOX:

- Short and clear communication about length of the events and/or reassurance that payment will be made for part-participation in longer events, combined with the option to 'opt-out' halfway through.
- An early indication of how much money will be credited to their smart meter would help ensure Jessie can pre-heat their home before the event, without financial worry.

POST-EVENT SURVEYS

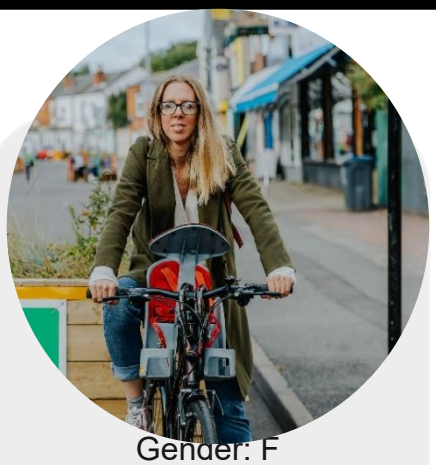
Jessie and Evette often fail to complete post-event surveys due to family life pressure. The event comes and goes and is then forgotten - if payment was offered, they might remember!

Changes that help Jessie feed into the post-event surveys would include incentivising participation through a small payment for completion.

Jessie and Evette don't face too much trouble on the other aspects of the trial or with heating DSF in general, although it is helpful to have evening focus groups and interviews available. They would also prefer credit to their bill over rewards, in order to have more control over their spending.

EQUINOX

Low income, with a pre-payment meter and a health condition aggravated by cold



Gender: F
Location: Durham
Highest qualification level: 6
Household Income: £33000

Jessie lives with her partner, Evette and their 7-year-old son Freddie. Evette's condition and having Freddie mean they can't go out so much as they used to and routines are important, but they do try to get out to the park after school and love taking weekend picnics. It's been tough to keep on top of finances recently, especially since Evette was diagnosed with a severe form of Multiple Sclerosis. They are careful to make each penny count and this is why Jessie got a smart pre-payment meter installed last year.

On why she is taking part in EQUINOX

Jessie studied a sustainability-related degree and has always been interested in the environment. She is keen to do as much as she can in for the green transition in her situation, and the opportunity to make a bit of money is a bonus.

Household characteristics

Composition: 2 adults, 1 child under 5
Type: 3- bedroom semi
Tenure: Owned, with a mortgage
EPC: C

Preferred communication modes

Jessie and Evette like apps they can quickly access on their phones, which also give email notifications.

Talking about her experience with her heat pump

"I love to show our friends and family a heat pump can work! It also works best when kept running continuously, which is great for Evette"
"I'm worried about the heating dropping and making Evette's condition worse. I like to pre-heat the house before we get back from going out, but I couldn't do that once when my phone was stolen. It took ages to warm up again, which was tough for Evette who had just come back from the hospital…"

Primary reason for having a heat pump:

The **opportunity** came through a government grant and the boiler needed replacing.

Familiarity with heat pump

Strong

Jessie and Evette are quite tech-savvy so feel they know how to work it well.

Interest in technology

High

Interest in the environment

High

Interest in opportunities to save money

High

nationalgrid

Annex J Glossary

Term	Definition
DSF	Demand Side Flexibility
FSP	Flexibility Service Provider

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Avonbank
Feeder Road
Bristol BS2 0TB
United Kingdom

nationalgrid.co.uk