EQUINOX

Learning from trial three: Daily morning heat pump flexibility

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1. Glossary of terms

- **Constraint Managed Zones:** Areas of the electricity network where demand or generation is actively managed to avoid network constraints and maintain system stability
- **Customers:** A term EQUINOX uses when referring to customers of energy suppliers generally
- **Demand response:** A strategy that adjusts electricity usage by consumers in response to supply conditions, such as price signals or grid needs
- **Demand turn up:** Demand response when more electricity is consumed relative to a baseline
- **Demand turndown:** Demand response when less electricity is consumed relative to a baseline
- **Difference-in-Differences:** A method that compares changes over time between a treatment and control group to estimate the effect of an intervention
- **Distribution Network Operator:** A company licensed to operate the electricity distribution network in a specific region of the UK
- **Dynamic:** An NGED flexibility product procured to support unscheduled maintenance, with a duration from between 30 mins to several hours, on a single day
- **Equitable novel flexibility exchange (EQUINOX)**: The name of the project
- **Events:** periods of the day when participants were asked to provide demand response
- **Flexibility Service Provider:** An entity that offers or procures flexible energy resources to help balance electricity supply and demand in response to grid needs
- **Heat pump homes:** Households with heat pumps
- **National Energy System Operator:** The UK's publicly owned, independent body responsible for planning and operating the electricity and gas systems across Great Britain
- **National Grid Electricity Distribution (NGED):** The UK's largest Distribution Network Operator
- **Network Innovation Competition:** A programme funding energy network innovation projects
- **The Office of Gas and Electricity Markets (Ofgem):** The UK's energy regulator responsible for protecting consumers and ensuring a secure, sustainable and affordable energy system
- **Participants:** A term EQUINOX uses to refer to customers enrolled in the EQUINOX trials
- **Root Mean Square:** A supporting method for aggregating demand response standard error impacts by squaring each standard error with a grouping of events, averaging them, and taking the square root
- **SP Energy Networks (SPEN):** A UK Distribution Network Operator
- **Secure:** An NGED flexibility product procured for peak load management, with a duration from between 30 mins to several hours, on a single day
- **Sustain:** An NGED flexibility product procured for constraint management, with a duration of 4-hours daily Monday to Friday across consecutive weeks
- **United Kingdom:** The United Kingdom of Great Britain and Northern Ireland

2. Context

2.1 Introduction to EQUINOX

Equitable Novel Flexibility Exchange (EQUINOX) is a Network Innovation Competition (NIC) project funded by the Office of Gas and Electricity Markets (Ofgem). It is led by National Grid Electricity Distribution (NGED), the UK's largest regional Distribution Network Operator (DNO) and supported by multiple project partners[1]. It is developing, trialling, and where proven, implementing suitable arrangements at scale that can maximise participation of domestic heat pumps in DNO procured flexibility[2] while meeting the needs of all customers, including those with potential vulnerabilities.

Heat pumps are expected to become a mainstream choice to decarbonise home heating in the United Kingdom (UK). The National Energy System Operator (NESO) forecasts an increase in annual heat pump installations from 95,000 in 2024 to more than 1.1 million by 2035[3]. The electrification of heat therefore stands to substantially increase electricity demand. If this new demand coincides with existing demand peaks, demand may more frequently exceed the capacity of DNO infrastructure e.g. substations and cables. Increased demand could exacerbate existing constraints or create new ones. Constraints are ultimately resolved through network reinforcement but can also be managed in the short- to medium- term through procurement of flexibility. In many instances, it is more cost-effective for DNOs to defer reinforcement by procuring flexibility, rather than reinforcing immediately.

EQUINOX is iteratively testing novel commercial arrangements for heat pump flexibility across three trial periods between 2022-25 (Figure 1). The trials measure demand response from heat pumps to better understand the customer experience of heat pump flexibility.

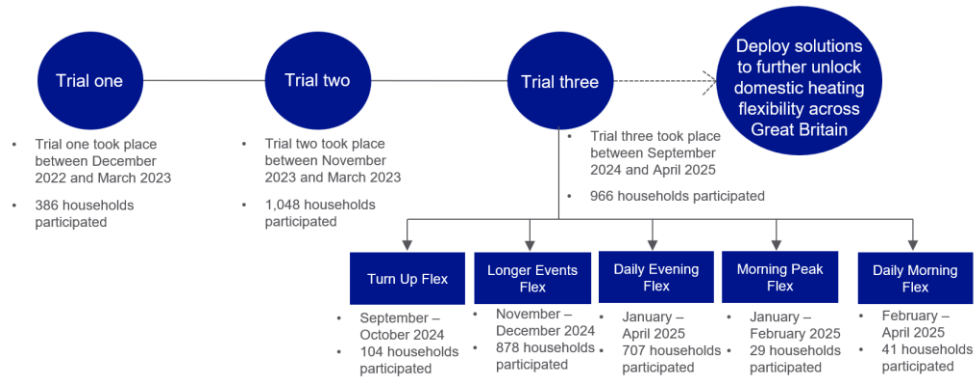

Figure 1: EQUINOX project overview

[1] A full list of project partners can be found in Appendix A.

[2] As defined by NGED, flexibility is reducing loads on the network by using customers' ability to change their usage patterns by either reducing consumption, changing their electricity habits, or (at a larger commercial scale) switching on generators. Flex In Five An Overview of Flexibility

[3] NESO records show over 95,000 annual heat pump installations in 2024, rising to 1.13 million to 1.46 million by 2035 across its three net zero compatible Future Energy Scenarios (FES): Hydrogen Evolution, Electric Engagement, and Holistic Transition. Future Energy Scenarios 2025 Data Workbook V001

Trial one[4] ran across winter 2022-23 with almost 400 participating households ("participants") and was a successful proof of concept for heat pump flexibility. Trial two[5] (winter 2023-24) iterated on the results of trial one, increasing the participants pool to over 1,000 customers. This increased scale permitted closer analysis of demand response volumes and used commercial arrangements that more closely mimicked existing DNO flexibility products typically used for unlocking flexibility from electric vehicle charging or other assets. Trial three, held between September 2024 and April 2025, built on the results of trial one and two to investigate additional opportunities for heat pump flexibility to support networks. Specifically, trial three aimed to:

- Test potential for domestic heat pump flexibility during the morning peak as well as the evening peak.
- Uncover the potential for domestic heat pump homes to offer daily flexibility.
- Explore longer heat pump flexibility events, beyond the two-hours tested in trials one and two.
- Test the customer proposition for stacking flexibility from heat pump homes through EQUINOX with an active flexibility product run by NESO. Stacking offers the prospect for customers to unlock greater rewards from flexibility participation and the opportunity for DNOs and NESO to procure flexibility services from the same assets[6].
- Improve understanding of how customer vulnerability should be defined in the context of heating flexibility.

To achieve these aims, we split trial three into five mini-trials each focusing on different aspects of demand response and customer experience.

2.2 Trial three mini-trials

Each mini-trial focused on different aspects of heat pump flexibility:

- **Heat pump turn up flexibility ('Turn Up Flex'):** demand turn up[7] events on non-consecutive days, between 11am - 1pm.
- **Longer heat pump flexibility events ('Longer Events Flex'):** demand turndown[8] events of differing lengths, on non-consecutive days, between 4-8pm.
- **Daily evening heat pump flexibility ('Daily Evening Flex'):** 'everyday' demand turndown events on weekdays, across consecutive weeks and occurring between 4-8pm.
- **Morning heat pump flexibility events ('Morning Peak Flex'):** demand turndown events on non-consecutive days, between 8-10am.
- **Daily morning heat pump flexibility ('Daily Morning Flex'):** daily demand turndown events on weekdays, across consecutive weeks and between both 8-10am and 5-7pm of the same day.

This report focuses on Daily Morning Flex.

[4] Trial one report: Initial Insights on the Effectiveness of Commercial Methods
[5] Trial two report: Learning from trialling novel commercial methods Project deliverable 4
[6] Stacking is when assets provide flexibility to more than one flexibility service. See the Energy Network Association's report: Revenue Stacking Explainer and FAQ's.
[7] Demand response when more electricity is consumed relative to a baseline.
[8] Demand response when less electricity is consumed relative to a baseline.

3. Daily Morning Flex trial design

3.1 Introduction and aims

EQUINOX trial one (winter 2022-3) and trial two (winter 2023-4) demonstrated heat pump flexibility could help reduce electricity demand during the weekday evening peak times for networks between 4-8pm. However, they primarily tested two-hour turndown events two to three times per week on non-consecutive weekdays, in a format aligned to NGED's Secure and Dynamic flexibility products[9].

Trial three aimed to assess the feasibility of heat pumps to support networks in additional ways not tested in trials one and two. This included trialling for the first time in EQUINOX events in the morning time between 8-10am, which is another period of high electricity demand for networks. The Morning Peak Flex mini-trial confirmed that heat pump homes could provide morning turndown without causing significant inconvenience or discomfort for inhabitants – though only tested this on non-consecutive days.

As a next step for morning flexibility, we sought to test whether it could be provided on a daily basis. Specifically, we sought to understand whether households could provide flexibility every morning, and also on both mornings and evenings within the same day. This objective built on insights from network impact analysis we conducted following trial two, which scaled up its results to estimate the potential value of heat pump flexibility in addressing a real CMZ. Our analysis indicated that heat pump homes could deliver most value if they participated in a format closer to NGED's Sustain product, which requires daily flexibility across consecutive weekdays during the 4–8pm evening peak[10]. By contrast, our analysis indicated that procuring households through trial two's non-consecutive day format diluted the flexibility they could provide due to the need to stagger them across different days. If heat pump homes could participate daily for two hours they would be better placed to support networks in resolving CMZs.

We anticipated that customers would be able to participate in daily flexibility in the mornings based on our feedback from Morning Peak Flex – after which many participants reported they would be willing to provide flexibility daily between 8-10am[11]. We also anticipated customers would be open to evening daily flexibility based on their feedback following the Week of Consecutive Events mini-trial that we held immediately following trial two in April 2024, when participants successfully turned down from 6–8pm across five consecutive weekdays[12].

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[9] Secure, procured for peak load management, and Dynamic, procured for unscheduled maintenance, are both scheduled from between 30 mins to several hours, on a single day. When trial three was designed these products were still actively procured by NGED. They have now been largely replaced by Operational Utilisation, which procures short-term flexibility lasting for a single day. See NGED's report on the new products formalisation: Distribution Flexibility Services Procurement Statement.

[10] When trial three was designed, Sustain was a commercial flexibility product procured by NGED. Flexibility products have since been updated and NGED's daily flexibility product is now 'Scheduled Utilisation'. The mini-trial designs in trial three were considered in relation to previous products but focused on structural aspects of flexibility that remain relevant to network needs.

[11] See full report: "Learning from trial three: Morning heat pump flexibility events"

[12] For the Week of Consecutive Events mini-trial, 81% of participants (n=439) reported that they would be willing to participate in flexibility offerings asking them to turn down across five consecutive days. See full report: "Learning from trialling novel commercial methods: Week of consecutive events".

An additional factor that we considered in trial three was facilitating customer participation in multiple, "stacked", flexibility services. We saw in trial two that customers indicated an appetite for being able to choose to access multiple flexibility products where possible, with 69% of customers indicating that they would have liked to have been able to participate in products for NESO's Demand Flexibility Service (DFS), alongside their participation in EQUINOX trials.

In Daily Morning Flex we aimed to assess:

- Whether heat pump homes can deliver daily demand response in the morning, and later in both morning and evening periods.
- Whether this daily demand response can be achieved alongside high rates of participant satisfaction and minimal impact on comfort – including for those with potential vulnerabilities.
- The customer experience of stacking daily EQUINOX trial events with ad-hoc NESO DFS events.

3.2 Trial structure

Daily Morning Flex was carried out over eight weeks between February and April 2025. A total of 41 ScottishPower customers took part, all allocated to the treatment group. 29 of these had already taken part in Morning Peak Flex, and 12 additional participants were recruited before the start of Daily Morning Flex.

We asked treatment participants to turn down their heat pumps daily between 8-10am from Monday to Friday for all eight weeks of the mini-trial. For the last four weeks of the mini-trial, we also asked participants to turn down their heat pumps daily between 5-7pm from Monday to Friday. We did not recruit a control group. Instead, for comparison purposes, we used the aggregate electricity consumption of anonymised ScottishPower customers with heat pumps that were not signed up to the mini-trial.

We originally sought to test stacking of EQUINOX with NESO's Demand Flexibility Service (DFS)[13], since it is a NESO service ScottishPower already offers to their customers on the Power Saver Plus programme. However, in the weeks leading up to the mini-trial ScottishPower did not participate in any DFS events. Therefore, we decided to hold simulated DFS events instead to enable us to test stacking of the EQUINOX mini-trial with another service. We held four simulated DFS events—one every two weeks—held at 5-6pm to coincide with the 4-7pm period when DFS events are typically held.

We held the first two simulated DFS events when participants were only taking part in daily morning peak events. We asked participants to participate in the EQUINOX morning flexibility events in the morning, plus the simulated DFS events in the evening, on the same day.

We held the final two simulated DFS events when participants took part in both morning and evening peak events. These two simulated DFS events intentionally overlapped with the 5-7pm events. To maximise participants' potential earnings during trial three, per the DFS design, they were encouraged to turn down any device in their home when a simulated DFS event was called, rather than just their heat pump.

[13] A NESO-run programme that enables households and businesses to earn rewards from their registered DFS service provider in return for shifting their electricity usage during DFS events: "Demand Flexibility Service explained".

3.3 Participant details

3.3.1 Trial eligibility

To be eligible for Daily Morning Flex, we required that all participants:

- be a current electricity supply customer of ScottishPower;
- have a working electricity smart meter that has been successfully sending meter readings on a half-hourly basis for at least 80% of the time in the 15 days prior to being invited to take part in a mini-trial;
- reside within the NGED or SP Energy Networks (SPEN) licenses areas;
- opt in to be part of EQUINOX by completing sign-up surveys as requested and accept terms and conditions of the mini-trial;
- have and use a heat pump as the primary method of heating their home (and this heat pump must not be shared with any other residence(s)); and
- be using an electricity import tariff (tariff) that does not have different prices for electricity between 8am and 10pm (e.g. a tariff with an off-peak price 1300 – 1600 is not permitted)[14].

3.3.2 Recruitment approach

All 29 ScottishPower customers who participated in the Morning Peak Flex mini-trial also signed up to the Daily Morning Flex mini-trial. To encourage additional sign-ups for Daily Morning Flex, ScottishPower offered a £10 sign-up incentive. This saw a further 12 households signing up to Daily Morning Flex for a total of 41 participants[15]. ScottishPower's recruitment pool for both mini-trials covered approximately 800 customers across the NGED and SPEN license areas who had installed heat pumps through the Energy Company Obligation (ECO4)[16].

Due to the small number of customers recruited, we assigned all 41 participants to the treatment group that would be asked to reduce their heat pumps' electricity consumption during event times. We did not assign any participants to a control group that would not be asked to turn down their heat pump but still allow their electricity consumption data to be used for data comparison purposes. Instead, for data comparison purposes ScottishPower used aggregated anonymised data from other customers with heat pumps.

3.3.3 Demographics

Of the 41 participants recruited, 26 completed the start of trial survey which captured demographic details like household characteristics, property details and potential vulnerability factors.

For trial three we refined our approach to categorise, identify and account for potential vulnerabilities. This involved considering a higher number of individual and combined potential vulnerability factors, identified through a bespoke

[14] Customers were eligible if on a tariff with a fixed price across each 24-hour period, or if on a tariff with a fixed daytime price but reduced or variable prices overnight. We included this eligibility criteria because in trial two we saw that participants with a tariff with multiple daytime unit rates were already providing daily flexibility for up to 3-hours Monday to Friday – likely in response to their tariffs price signal. For this mini-trial we wanted participants to not have a pre-existing incentive to turn down, so any turn down they did achieve could be attributed to the mini-trial.

[15] We offered the £10 sign-up payment to those who had participated in Morning Peak Flex as well for equity reasons.

[16] ECO is an obligation placed on energy suppliers to deliver energy efficiency measures to households in fuel poverty. ECO4 is the 4th iteration of this scheme. Energy Company Obligation - Ofgem

Equitable Participation Framework (EPF)[17]. We identified eight self-reported factors[18] that would contribute to whether a household was considered potentially vulnerable or non-vulnerable.

We classified households as potentially vulnerable only if they met one of the following three criteria:

- The household was defined as having a low income[19] according to their household composition. Households were also removed from the vulnerability segmentation if they were classified as low income, but self-reported that they were able to regularly afford their energy bills.
- Someone within the household self-reported having a health condition exacerbated by the cold; or
- The household met at least two of the self-reported EPF vulnerability factors such as having individuals in the home of a certain age, home being poorly insulated or single occupancy.

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- 65% of participants (17 participants) who completed the start of trial survey could be classed as potentially vulnerable.
- 42% (11 participants) could be classified as low income or in fuel poverty – a higher figure than the UK national average of 36%[20].

Given that recruitment targeted ECO4 scheme recipients, some of the 11 non-respondents may also meet the potential vulnerability criteria. This high proportion of potentially vulnerable participants in Daily Morning Flex provides essential context for interpreting the mini-trial outcomes and evaluating the broader feasibility of implementing morning peak events.

[17] See "Project Deliverable 5: Learning from Engaging Customers" for a detailed explanation of the customer engagement.
[18] The eight vulnerability factors included: Having a health condition exacerbated by the cold, having a disability or long-term health condition, having children under 5 years old in the home, having individuals over the age of 75 in the home, home being poorly insulated, living alone, being a lone parent and meeting the low-income threshold.
[19] Households were classified as low income based on their household composition and annual household income, in alignment with the UK minimum income standard.
[20] The Minimum Income Standard sets out what the public agree is needed to live in dignity and the income require to meet this standard. See Minimum income standard - Joseph Rowntree Foundation.

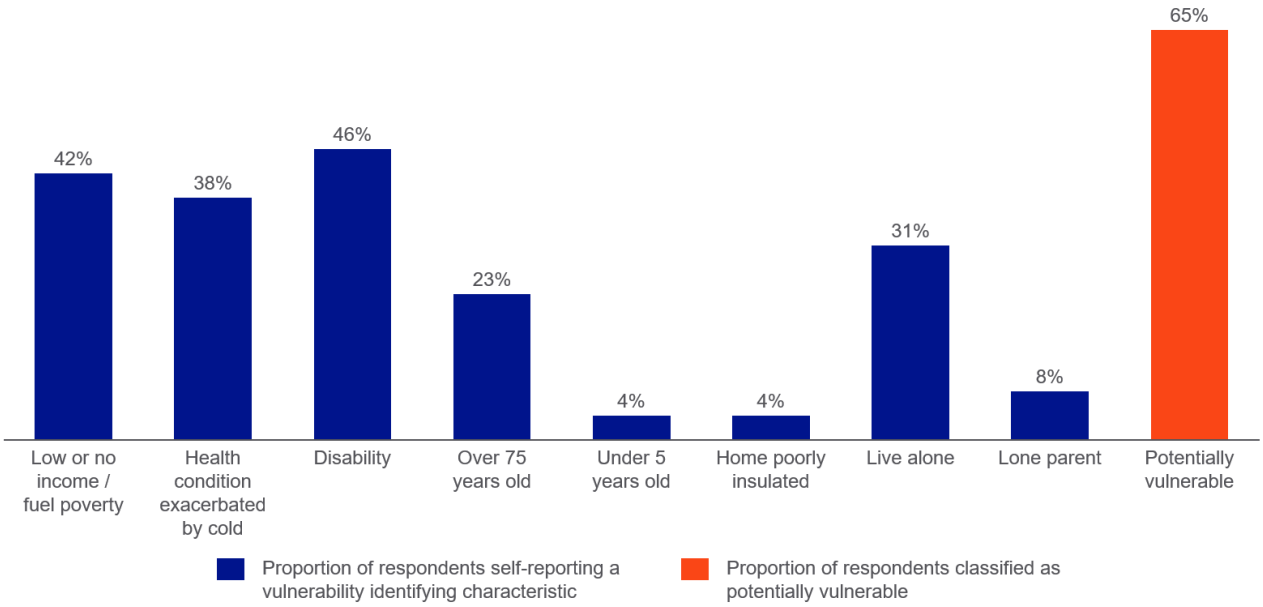

Figure 2: Proportion of potentially vulnerable participants in Daily Morning Flex (n=26)

3.4 Commercial arrangements

3.4.1 Daily Morning Flex settlement approach

We rewarded participants through a combination of methods. They received £5 for completing each of the start and end-of-trial surveys. Those who chose to participate in a one-to-one interview received £15. There was no requirement to opt-in to individual events and participants received the event incentive of £2-3 per week based on their consumption during events remaining below their personalised trial baseline for four out of five weekdays – £2 for the first 4-weeks when they were being asked to provide demand response during only the mornings and then £3 for the final 4-weeks when they were being asked to additionally provide demand response during the evenings (see Section 3.4.2 for more details). The event incentive value was based on average market rates offered by NGED for similar flexibility products, and our expectations of how much demand response participants would deliver over two hours based on the trial two results[21]. Table 1 summarises the commercial arrangements for Daily Morning Flex.

[21] NGED procurement prices for Sustain in 2023/4 range from £0.01/kWh to £4.60/kWh, averaging £0.30/kWh. Based on the average value, and the average performance from trial two of 0.57 kWh per participant over 2 hours.

Table 1: Daily Morning Flex treatment participant commercial arrangements

Item	Treatment participant
Payment structure	£5 for completion of start of trial survey £5 for completion of end of trial survey £15 for participating in an interview £10 sign up incentive £2-3 per week for each week electricity consumption is maintained below their nominated baseline during event times, on at least 4 out 5 days
Control type	Manual and remote customer control
Notice period	Day ahead
Eligible supplier tariffs	No tariff with multiple unit rates between 8am-10pm, which might incentivise load shifting during the daytime. Any other tariff accepted
Event duration	Two hours
Event timing	Two hours between 8-10am; Two hours between 5-7pm
Event frequency	One 8-10am event per weekday (Monday-Friday) for the first four weeks; one 8-10am and one 5-7pm event per weekday (Monday-Friday) for the last four weeks
Supplier notice	Informed by NGED on Wednesday of the preceding week

3.4.2 Daily Morning Flex personalised trial baselines

To detect turndown and be able to reward participants with the event incentive, we used a personalised trial baseline approach, adapted from the industry standard p376 baseline method[22]. In previous EQUINOX trials we have used the p376 method to calculate a baseline for each participant that is refreshed for each turndown event, based on that participant's recent consumption on preceding non-event days. Although this has worked well, it is not a suitable method for daily flexibility events as the baseline would not be updated for each event and would soon lose relevance as a counterfactual for electricity consumption during events. For some commercial flexibility services, a

[22] For settlement, the p376 method uses the last 10 non-event weekdays to generate an average consumption value per settlement period, resulting in a half-hourly baseline demand profile for an event day. A participant's demand response is calculated by deducting their observed electricity consumption from their baseline consumption. Demand response achieved is then multiplied by their utilisation payment rate for that event to determine the performance incentive owed to that participant. See Elexon report for full details of the p376 method.

nominated baseline is assigned based on non-personalised factors such as average demand patterns and consumption volumes of homes with the same type of technology (e.g. heat pump or EV charger). For Daily Morning Flex, we used the relatively small-scale nature of the mini-trial to innovate a baseline approach that was both personalised for each participant and did not change from event to event. This allowed us to detect heat pump turndown at the home smart meter level, without specific asset metering, and to reward each participant for their performance in trial events. We do not present this trial baseline methodology as being directly suited to wider commercial use.

Personalised trial baselines were daily electricity consumption forecasts that we calculated per settlement period, each day of Daily Morning Flex mini-trial period. These were based on each participant's average consumption during the same settlement periods across 30 similar non-event days in November-December 2024 and were a set values for each participant that were not updated from week to week or between events. This approach aimed to capture an average of each customer's consumption across a spread of winter temperatures that might be representative of external temperatures across the mini-trial period. To prioritise customer engagement and recognise that this method may under-report turndown on colder event days, we increased each participant's raw baseline by 10% during the mini-trial, making the event incentive more achievable. As illustrated in Fig. 3 participants were considered to have achieved turndown in an event if their electricity consumption in that period remained below their personalised trial baseline. Eligibility for the event incentive was based on achieving turndown for at least four of five weekdays each week and did not change based on the volume of turndown. The Daily Morning Flex personalised trial baselines were only used for customer settlement in the mini-trial and were not used to evaluate overall demand response

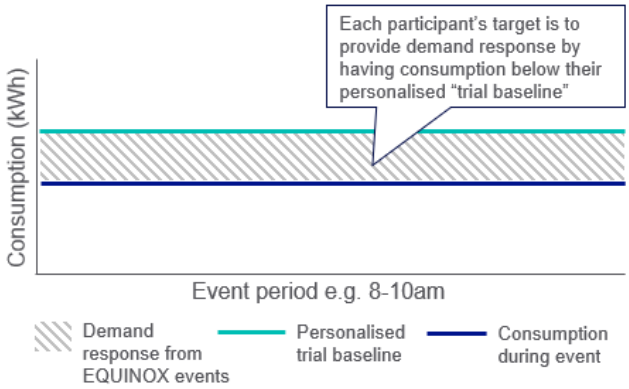

Figure 3: Schematic of Daily Morning Flex settlement approach for customers

3.4.3 Stacking with a simulated DFS service

As discussed in Section 3.2, Daily Morning Flex participants could also participate in a simulated version of NESO's DFS, which we ran during the mini-trial period as an addition. Whereas during the EQUINOX events we asked participants to turn down only their heat pumps, during our simulated DFS events we allowed participants to respond using any device of their choice—consistent with real DFS events.

Our objectives around service stacking were aimed at observing customer appetite for participating in general turndown simulated DFS events alongside heat pump turndown Daily Evening Flex events. EQUINOX trial three was not designed to test the full end to end industry processes for service stacking, or for settlement. Our learnings focus was on the customer experience of participating in both services simultaneously, and not on demonstrations of how processes could work for stacking flexibility services more broadly. We will cover aspects of what may follow next in the project "Deliverable 6: Recommended transition of learning to BaU" report (December 2025).

DFS rewards demand response on a £/kWh delivered turndown basis, using the p376 method. The method compares forecasted consumption to actual consumption during event hours. We adopted the same approach for our simulated DFS events – rewarding participants on a £/kWh basis for delivered turndown. This meant rewarding participants through the simulated DFS events for additional turndown beyond what was expected for their participation in the EQUINOX mini-trial. Based on possible payment ranges for DFS events shared by NESO, ScottishPower decided that £0.30/kWh was the minimum rate it would offer to its customers for a real DFS event. We therefore chose this rate for the simulated DFS events.

Figure 4 shows how we expected settlement would work during the simulated DFS events, depending on whether they occurred in weeks 1–4 (no overlap with EQUINOX events) or weeks 5–8 (with overlap):

- The light blue line is expected demand if there is no demand response event (baseline).
- The red line is demand during an EQUINOX event, based on a request for heat pump turndown.
- The dark blue line is demand during a simulated DFS event, based on a request for turndown from any device.
- The fully grey shaded area represents additional demand response that would be settled through the simulated DFS system.
- The partially grey shaded area represents demand response from the EQUINOX event.

In weeks 1–4, we planned to hold EQUINOX events from 8–10am only. There would be no overlap with the simulated DFS events we held on two days at 5–6pm. We therefore expected that participants' baselines would not include turndown behaviour during the times allocated for the simulated DFS events, so any reductions during those events would be settled entirely through the simulated DFS system.

In weeks 5–8, we planned for EQUINOX events to run between 5–7pm, overlapping with the two simulated DFS events scheduled from 5–6pm. We therefore expected that participants' baselines would already include turndown behaviour from their heat pump during the simulated DFS events window. This would mean only additional reductions, likely from devices other than their heat pump, would be settled through the simulated DFS system.

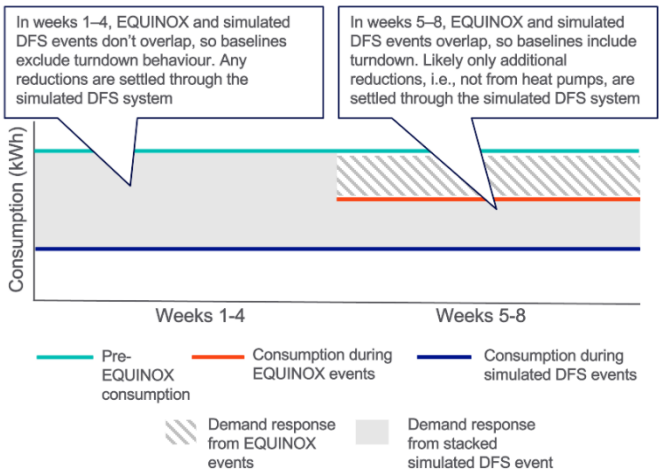

Figure 4: Schematic of settlement approach for simulated DFS events for Daily Morning Flex participants

3.5 Analysis approach

3.5.1 Difference in Difference approach for Daily Morning Flex

Following industry best practice for evaluating trial programmes, we leveraged a Difference-in-Difference (DiD) approach to calculating demand response. DiD approaches provide an estimate of programme demand response when energy consumption from the entire treatment group is compared to the entire control group for each event. We used a simple average to develop average point estimates of demand response per week and for the full mini-trial duration, though we used the Root Mean Square (RMS) method to calculate aggregate errors[23].

We did not have a formal control group, but we used the consumption data of anonymised ScottishPower customers with heat pumps. We selected these customers based on how closely their historic consumption patterns matched those of the recruited treatment group. Matching consumption patterns allowed us to reasonably attribute any differences in consumption during event periods to the effects of the programme treatment.

To ensure that only data associated with Daily Morning Flex informed the DiD calculations, we excluded any day with a simulated DFS event.

3.5.2 Customer experience evaluation approach for Daily Morning Flex

As well as demand response, customer experience was a key focus. Throughout all the mini-trials, including Daily Morning Flex, we prioritised equitable access and participation for all customers, including those experiencing vulnerability or fuel poverty. We employed a mixed-methods approach, combining quantitative surveys with qualitative interviews and focus groups to explore customer willingness to engage in heat pump flexibility. This approach helped us to understand the experiences and barriers for potentially vulnerable customers. We sent out several surveys to capture self-reported behaviour change during events and satisfaction with various event design elements. These included:

- An end of trial survey.
- Four one-to-one interviews.

To track participation rate, we asked participants to self-report whether they intended to participate each day.

3.5.3 Demand response evaluation approach for the simulated DFS events

We did not adopt the DiD method to evaluate the impact of participants' involvement in the simulated DFS events. It was not an aim of the mini-trial to develop distinct measurements of demand response for the DFS events. Instead, the aim was to identify a mechanism for heat pump homes to participate in both DNO and NESO flexibility services – and be rewarded by both services. Therefore, we took a simple average of the delivered turndown in each event based on the average payment participants received.

3.5.4 Customer experience evaluation approach for the simulated DFS events

We also evaluated the participant experience of the simulated DFS events, incorporating DFS and stacking-focused questions in the end of trial survey that was sent out to all Daily Morning Flex participants.

[23] The full DiD and RMS approach is provided in Appendix B.

4. Demand response results

Section 4 presents the DiD findings for our aim of assessing whether participants could consistently turn down demand over the full eight weeks—indicating potential for daily morning and evening flexibility products. Section 4.1 shows average demand response results for morning only events in weeks 1-4, morning events in weeks 5-8, and evening events in weeks 5-8. Section 4.2 shows week on week results, alongside self-reported participation and temperature data, which we investigated alongside the DiD results to identify any trends.

4.1 Demand response

Based on our DiD analysis, participants did not achieve statistically significant demand response during weeks 1-4, when they were only turning down in the mornings. However, they did achieve statistically significant demand response during weeks 5-8, for both the morning periods and the evening periods. Figure 5 shows the average point estimates and confidence intervals (CI) for these periods, across all weeks, alongside EQUINOX trial two results for comparison.

Figure 5 shows:

- 0.04 kW for morning events in weeks 1-4 (-0.05 kW to 0.14 kW 90% CI. Since the CI crosses the 0 kW line, this is not statistically significant).
- 0.14 kW for morning events in weeks 5-8 (0.04 kW to 0.24 kW 90% CI).
- 0.20 kW for evening events in weeks 5-8 (0.09 to 0.20 kW 90% CI).
- 0.29 kW for trial two (0.15 to 0.43 kW 90% CI).

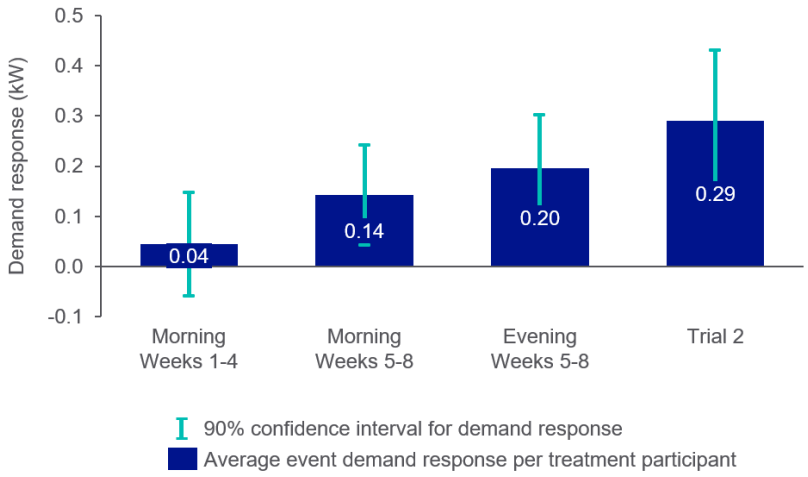

Figure 5: Average demand response per treatment participant across morning events in weeks 1-4, morning events in weeks 5-8 and evening events in weeks 5-8, compared with trial 2 average

It is unclear why there was a lack of statistically significant demand response for the week 1-4 morning periods, compared to the morning and evening periods during weeks 5-8. This could be due to participants becoming more familiar with the mini-trial, or it could be due to the small sample size and the limitations this imposes upon DiD analysis in general. We consider it likely that some level of demand response was achieved during the morning only events, since there were no major increases in self-reported participation by the mini-trial participants, as is discussed in Section 4.2.

Since the CIs for the week 5-8 morning and evening events overlap, we cannot conclude there is a statistically significant difference between the demand response magnitude of the two event times.

Daily Morning Flex 's week 5-8 DiD results were comparable to the trial two results, meaning that overall, these findings suggest that heat pump homes can contribute to daily morning and evening peak flexibility.

4.2 Weekly demand response

We also used DiD to investigate week-on-week demand response and determine whether participants experienced fatigue or responded differently under varying weather conditions. We did not identify any evidence of fatigue, with self-reported participation remaining broadly consistent throughout the mini-trial albeit with a small rise for the morning periods during weeks 5-8. Demand response tended to increase as temperatures rose, but there were noticeable outliers to this trend suggesting its relationship was coincidental rather than causal.

Figure 6 (below) shows average weekly demand response. Figure 7 (also below) presents self-reported participation[24] and temperature[25] during event times:

- Morning events showed a clear upward trend in demand response as the mini-trial progressed, rising from a statistically insignificant point estimate of -0.04 kW in week 1 to a statistically significant point estimate of 0.27 kW in week 8.
- Evening events, held only in weeks 5-8, showed higher average demand response than the morning events in weeks 1-4. However, considering each week individually shows that only weeks 5 and 7 resulted in statistically significant demand response.
- Self-reported participation averaged 37% across weeks 1-8. 41% (17) of participants did not meet the reward criteria of reducing their consumption below their baseline. Only 2 of these 17 participants completed any surveys, indicating disengagement that likely contributed to the low overall participation rate.
- Self-reported participation during morning events rose slightly: it averaged at 16 (39%) in weeks 1-4, then 18 (44%) in weeks 5-8. Evening self-reported participation was stable at around 16 (39%), except for week 7, when it dropped to 13 (32%). The changes in self-reported participation were so marginal that they do not appear to have been correlated with rising demand response.
- Temperature increased over the mini-trial, from 3°C in week 1 to 14°C during week 8's evening periods. While temperature increase broadly aligns with rising demand response, major outliers to this trend in weeks 6 and 7 suggest it may not be a causal correlation. Furthermore, trial two found that demand response per participant *increases* as temperatures fall, since there is more demand to abate[26]. As a further complicating factor, the mini-trial was only held in the late winter from February to April, and during an unseasonably warm winter[27].

[24] Average weekly participants: Each day, participants were asked to self-reported whether they took part in the event. This metric represents the average number of participants who reported participations across the five days of the week.
[25] ScottishPower provided an average temperature per daily settlement period per week, based on the local weather characteristics for all their customers signed up to the trial.
[26] In trial two, based on 36 events with over 1,000 participants, we observed a trend whereby 0.07 kW greater demand response per treatment participant could be expected per 1°C drop in temperature from the 6.1°C trial average.
[27] According to the Met Office, March temperatures were 1.3°C above the seasonal average, making it the UK's 10th warmest March on record. March 2025 Monthly Weather Report.

Overall, we found that demand response increased as the mini-trial progressed, especially during morning events. The increase does not appear to be explained by self-reported participation, which did not change substantially week on week, nor by temperature for reasons explored above. The increase in demand response was more likely due to:

- Participants becoming more accustomed to morning events over time.
- The small sample size, meaning changes in behaviour amongst a few individuals could have had a large impact on the overall results.

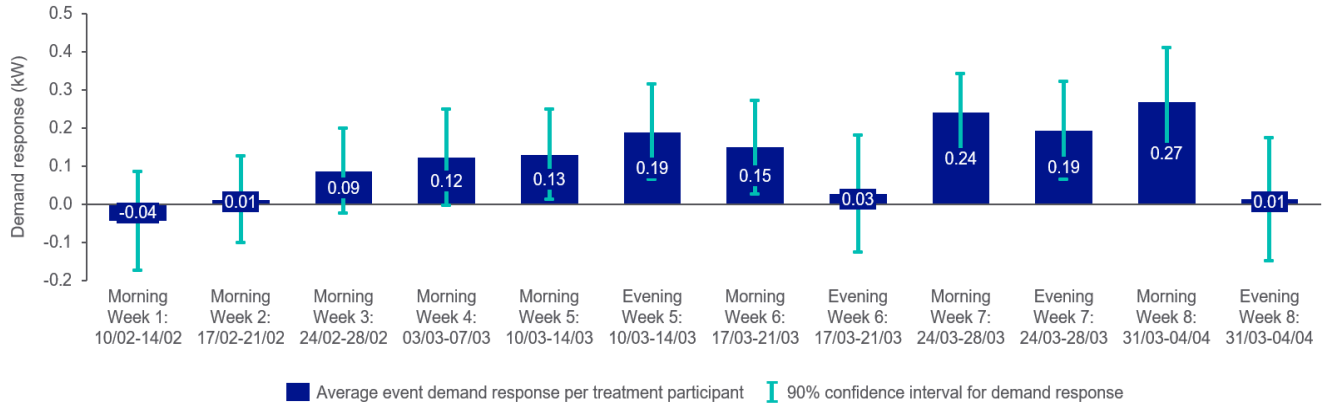

Figure 6: Average week over week demand response per treatment participant

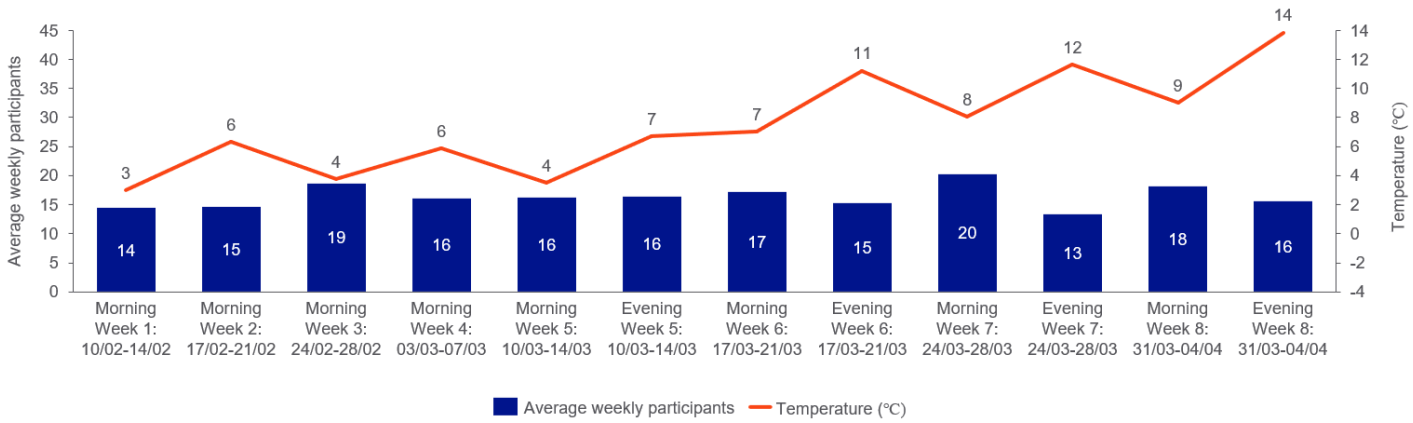

Figure 7: Average week over week demand response per treatment participant, and average temperature during event times

In summary, the Daily Morning Flex mini-trial's DiD findings suggest morning and evening daily flexibility is achievable with heat pump homes. We anticipate irregularities of data within individual event weeks would likely have been resolved through implementation of a larger trial.

5. Customer experience results

Section 5 presents our findings for our aim of determining whether daily morning and evening demand response can be achieved alongside high rates of participant satisfaction and minimal impact on comfort – including for those with potential vulnerabilities. This section presents findings from surveys that we sent to trial participants to gather insights into the customer experience, consisting of a start of trial survey and an end of trial survey[28]. Section 5.1 outlines our findings on trial satisfaction, Section 5.2 outlines our findings on event satisfaction, Section 5.3 outlines our findings on event timings, and Section 5.4 outlines our findings on comfort.

5.1 Trial satisfaction

Centring customer experience as a key focus during the trial design phase contributed to high levels of customer satisfaction. We surveyed participants on overall mini-trial satisfaction in the end of trial survey. 83% of respondents (20 participants) reported that they were satisfied with the trial. This satisfaction rate aligned with the trial satisfaction rate reported for EQUINOX trial two (79%), which is encouraging given the increased intensity of the requested demand response behaviour in Daily Morning Flex relative to trial two. We are encouraged by customer appetite to participate in a range of novel commercial offerings while also being able to maintain high customer satisfaction. The high satisfaction rate highlights the success of our customer-centric trial design approach.

Event payment satisfaction varied. This was predominantly motivated by whether participants felt as though the event payments received were a fair reflection of the effort to participate, rather than a reflection of any impact on comfort. Although the event incentive was based on average market rates offered by NGED for similar flexibility products, this does not represent a business-as-usual customer offering, which may incorporate additional flexibility values. We explore payment satisfaction in more detail in "EQUINOX trial three: Engaging vulnerable customers".

5.2 Event frequency satisfaction

During Daily Morning Flex, participants experienced both daily and twice-daily event frequencies. We evaluated their views on this frequency in the end of trial survey, via one question focused on daily events[29] (Figure 88) and one on twice-daily events[30] (Figure 99). Respondents widely viewed both daily and twice daily events positively: 88% reported daily events to be too little or neither too much nor too little; 71% reported this for the twice daily events.

[28] 26/41 participants completed the start of trial survey and 24/41 completed the end of trial survey.
[29] Participants were asked in the end of trial survey: "During the first four weeks of the EQUINOX sustain trial, there was one event per day for 5 consecutive days. What is your view on this frequency?"
[30] Participants were asked in the end of trial survey: "During the first four weeks of the EQUINOX sustain trial, there was two events per day for 5 consecutive days. What is your view on this frequency?"

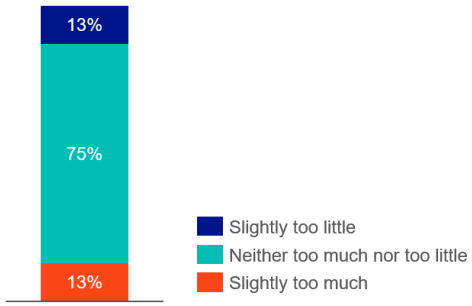

Figure 8: Participant views on daily event frequency (n=24)

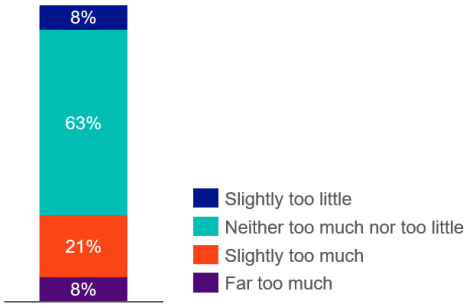

Figure 9: Participant views on twice daily event frequency (n=24)

We did not observe a clear difference in views between potentially vulnerable and non-vulnerable participants. All participants who found the event frequency to be 'far too much' were non-vulnerable. All three participants reporting daily events to be 'slightly too much' were non-vulnerable, as were the two who found twice daily events 'far too much'. Overall, most participants responded positively to both daily and twice-daily events, with a slightly stronger preference for daily events.

5.3 Event timing satisfaction

In the end of trial survey, we asked participants about their preferences between morning and evening peak events[31]. As shown in Figure 10, more participants preferred morning events (46%) to evening events (21%). The remainder had no preference. This is consistent with our findings from the Morning Peak Flex mini-trial and highlights the potential for morning peak flexibility to be implemented at scale. We saw no variation in responses between non-vulnerable and potentially vulnerable participants.

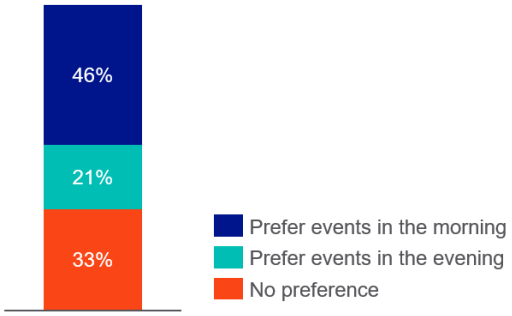

Figure 10: Self reported event timing preference of participants (n=24)

We asked participants to explain their preferences in free text responses[32]. Figure 11 shows a selection of these responses. Consistent with our findings from the Morning Peak Flex mini-trial, household schedules were the primary driver of event timing preferences. These results indicate that individual participant circumstances, especially their schedule, most significantly impact timing preferences.

[31] Participants were asked in the end of trial survey: "During the trial, EQUINOX events took place in the morning (8-10am) and evening (5-7pm). Which time slot did you prefer?"

[32] Participants who preferred morning events were asked "Why do you prefer morning events?" and participants who preferred evening events were asked "Why do you prefer evening events?"

	Preferred morning events	Preferred evening events
Preference related to schedule (12 responses)	• "I play golf in the mornings so am not at home on some days." • "Less likely to notice any difference as out of the home" • "Didn't affect cooking times whereas the evening did occasionally."	• "No work so easier to get time to adjust" • "Usually have had our tea by 5pm and are settled down watching tv, so not using extra heating"
Preference related to other reasons (4 responses)	• "Less impact on household" • "Heating already off"	• "Easier to manage the heating"

Figure 11: Selected free text responses describing why participants either preferred morning or evening events

5.4 Overall comfort

Most participants reported no change or only a minor change in comfort during the eight weeks of the mini-trial. Figure 12 shows participant responses on comfort from the end of trial survey[33]. 54% indicated neutral or no change in comfort levels, 33% responded that it made their home feel slightly cool and 13% reported it made their home cool. We observed no clear difference in responses between potentially vulnerable and non-vulnerable participants.

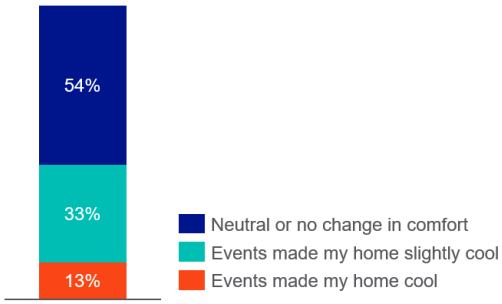

Figure 12: Self-reported participant impact on comfort levels in the end of trial survey (n=24)

For those who reported a change in comfort, in the end of trial survey and during interviews, we predominately heard that participants would use extra layers to help compensate. These results suggest that everyday heat pump flexibility is generally well tolerated, though comfort levels varied across participants. It is also worth noting that the unseasonably warm winter may have influenced findings.

We also asked the 46% (11 participants) who experienced a change in comfort how frequently they felt this change[34]. Figure 13 shows that four participants felt this change in comfort infrequently, two participants felt this change more than half the time and two participants felt this change every time they participated. Therefore, only a minority experienced a change in comfort across the mini-trial's duration. Variations in customer comfort are a key consideration for heat flexibility, highlighting the importance of designing programmes with customers in mind.

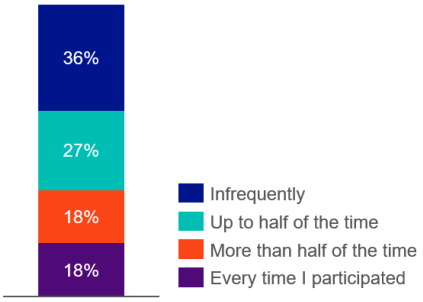

Figure 13: Self-reported frequency of participant change in comfort across the full mini-trial period (n=11)

Overall, we believe that the Daily Morning Flex mini-trial customer experience findings demonstrate that daily flexibility, both in the morning and evening, can be achieved while maintaining customer satisfaction and with minimal impact on comfort. We additionally saw no reason to consider that participants with potential vulnerabilities should be unable to safely participate.

[33] Participants were asked: "Do you think that taking part in the events has impacted the comfort levels in your home?"
[34] Participants were asked "How often did taking part in events have this impact on comfort levels in your home?" in the end of trial survey.

6. Stacking results

Section 6 presents the findings for our aim of assessing the customer experience of stacking daily EQUINOX trial events with ad-hoc NESO DFS events – though in practice we simulated the DFS events. Section 6.1 presents findings on the amount of additional demand response detected, and Section 6.2 presents findings on customer views of taking part in the simulated DFS events alongside Daily Morning Flex.

6.1 Demand response

As discussed in Section 3.4 EQUINOX participants were invited to four simulated DFS events, all between 5-6pm:

- Events 1-2 took place during the first four weeks of the mini-trial, with no overlap of the Daily Morning Flex events held in the mornings of the same day.
- Events 3-4 took place in the last four weeks, overlapping with EQUINOX events in the evening.

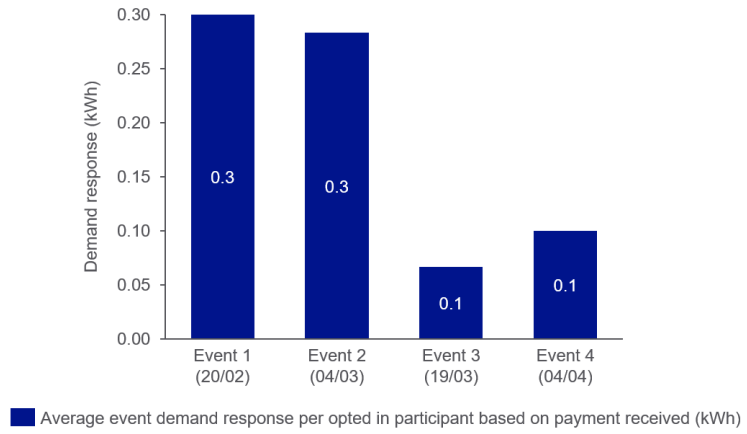

Figure 14: Average demand response per opted in participant for each simulated DFS event, based on the average payment amount recieved per opted in participant

Figure 14 presents the average demand response achieved by each simulated DFS event per opted-in participant[35], back-calculated using the payment amount received by participants. Events 1-2 saw opted in participants achieve approximately 0.3 kWh of demand response. In events 3-4 this declined to around 0.1 kWh, which was expected.

During events 1-2, we measured participant turndown against demand forecasts, which reflected a 10-day period without any turndown behaviour between 5-6pm. By events 3-4, the baseline incorporated turndown behaviour from the daily flexibility instruction between 5-7pm, resulting in a lower forecasted demand. As a result, even if participants maintained the same behaviours, the additional demand response detected would appear lower due to the reduced baseline it was being compared against.

Overall, the mini-trial was an effective demonstration of engaging heat pump homes in stacking. On average, mini-trial participants who opted into the simulated DFS events were paid across all events. The participation suggests it was an effective model for customers to earn additional payments by engaging in multiple flexibility offerings.

[35] Opted in: reported to ScottishPower they intended to participate in the simulated DFS event when it was called.

6.2 Customer experience

We asked participants in the end of trial survey if they participated in simulated DFS events[36]. 54% of respondents self-reported participating in simulated DFS events during Daily Morning Flex, as shown in Figure 15.

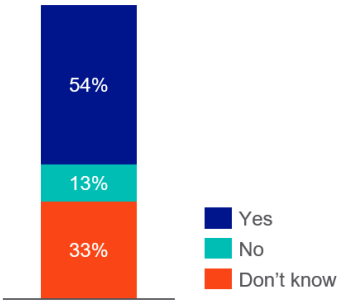

Figure 15: Participants' self-reported participation rate in DFS events (n=24)

Overall, participants were satisfied with participating in both Daily Morning Flex and simulated DFS events. 85% reported they would recommend the arrangement[37]. The high recommendation suggests that participants who could engage in both flexibility offerings simultaneously found the experience positive and worthwhile. It is an encouraging result, given that stacking offers the potential to unlock greater rewards for customers while also maximising the engagement of flexible assets to support DNOs and NESO.

In addition, we asked participants who took part in simulated DFS events if they had a preference on their timing. As shown in Figure 16, there was a fairly even split between those preferring alignment with EQUINOX events and those with no preference. Notably, none preferred DFS events at different times on the same day. Preferences may reflect the convenience of engaging with both services during the evening peak, though this cannot be confirmed – we also acknowledge that this conclusion is based on a small sample size of just 13 respondents.

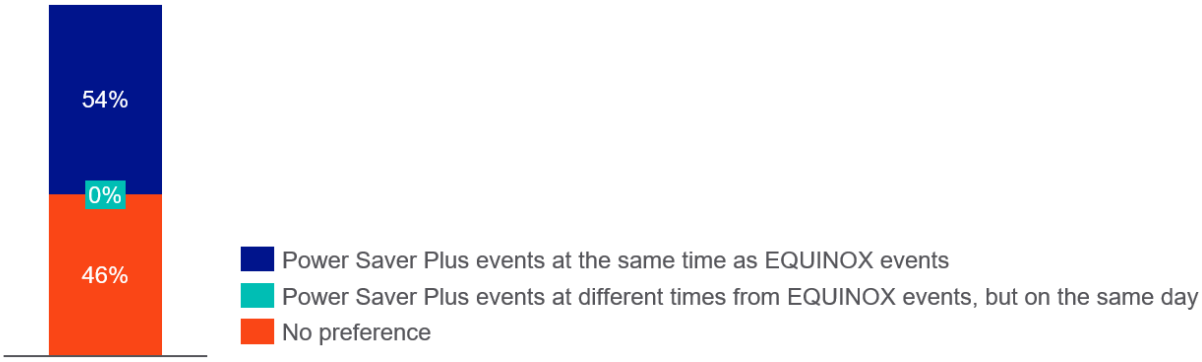

Figure 16: Participant preferences of DFS events at the same time as EQUINOX events, or different time but on the same day (n=13)

These findings show that in addition to being able to receive rewards for their efforts, participants reported high satisfaction with participating in the Simulated DFS events alongside Daily Morning Flex – and would be inclined to participate in further stacked services in future.

[36] Participants were asked in the end of trial survey: "Did you participate in Power Saver Plus events during the EQUINOX sustain trial?"

[37] Participants who reported participating in Power Saver Plus events were asked in the end of trial survey: "Would you recommend participating in Power Saver Plus events alongside EQUINOX events to others?"

7. Summary

The results of Daily Morning Flex indicate strong potential for heat pump homes to participate in daily flexibility during consecutive morning and evening peak flexibility events, and to participate in stacked DNO and NESO flexibility services. The main takeaways are summarised below:

1. **Overall, our findings suggest heat pump homes can engage in daily morning and evening flexibility. Participants achieved statistically significant demand response during the second half of the mini-trial, when events were held in both the mornings and evenings**. The DiD analysis produced inconclusive results for weeks 1–4's morning-only events, but participants conclusively reduced their demand by an average 0.14 kW in the mornings and 0.20 kW in the evenings for weeks 5-8. Self-reported turndown participation remained stable averaging 39% for each half of the mini-trial. While temperatures rose significantly over the trial period, it is unclear whether this had a causal or merely coincidental correlation to rising demand response. We detected no evening demand response during the two warmest weeks of the trial, marking a major outlier in the increasing demand response trend. We believe the trend in demand response is more likely due to limitations of the DiD method in small trials, where individual behaviour can disproportionately influence results.

2. **High satisfaction rates indicate willingness to participate in daily flexibility.** 83% of participants reported they were satisfied with the trial overall. 88% of participants reported they were happy with the daily event frequency and 71% of participants were happy with the twice-daily event frequency. These figures suggest daily and twice daily flexibility are suitable for most customers, with a stronger preference shown for daily events.

3. **Morning events were slightly preferred to evening events.** More participants preferred morning events (46%) to evening events (21%). Preferences were primarily driven by participants' individual schedules. These results highlight the potential for widespread acceptance of morning peak flexibility amongst heat pump homes.

4. **Participants generally maintained comfort during the events, with minimal disruption reported.** Over half (54%) noticed no change, while 33% felt their home was slightly cool and only 13% found it cool. Just 8% experienced a change in comfort every day. These findings suggest daily flexibility can be implemented without a substantial impact on comfort.

5. **Participants successfully engaged in Daily Morning Flex alongside a simulated version of NESO's DFS, unlocking greater value and demonstrating a model for stacking of flexibility services**. 54% of treatment participants self-reported participating in simulated DFS events, 85% of whom reported that they would recommend the dual services participation approach arrangement to others.

In conclusion, the results of the Daily Morning Flex mini-trial indicate a strong potential for heat pump homes to participate in commercially procured daily flexibility, during both morning and evening times. For DNOs, these

findings provide encouraging evidence that leveraging heat pump flexibility through daily flexibility is achievable. For Flexibility Service Providers, these insights provide insights into how to effectively engage customers with heat pumps in flexibility markets. Daily Morning Flex also demonstrated high satisfaction in participation in stacked events, showing the customer appetite to be able to participate in multiple services.

8. Appendix A: Project partners

EQUINOX is led by NGED, along with multiple project partners and collaborators, as detailed in Table 2.

Table 2: List of EQUINOX partners and collaborators

Name	Project function	Role
National Grid Electricity Distribution	DNO	Project lead. Responsible for running the technical integration, trial design and project management and knowledge workstreams.
Guidehouse	Consultancy	Partner. Responsible for supporting the commercial arrangement design and customer engagement workstreams. Supporting on trial design, data analysis, project management and knowledge dissemination.
Octopus Energy	Energy supplier	Partners. Responsible for planning and delivering EQUINOX trials with participants from their customer base. Supporting all project workstreams as commercial flexibility service providers and customer experts.
Sero	Energy supplier[38]	
ScottishPower	Energy supplier	
Passiv UK	Smart technology company	Partner. Responsible for simulating the flexibility impacts for different intervention strategies and household archetypes.
West Midlands Combined Authority	Local government	Partner. Responsible for coordinating a social housing heat pump installation programme which can contribute customers to trials two and three. Also advising on equitable participation.
Welsh Government	Government	Partner. Responsible for running a social housing heat pump installation programme which can contribute customers to trial three.
National Energy Action	Charity	Collaborator. Responsible for running participant focus groups to understand trial perceptions. NEA will ensure that the needs of customers with vulnerabilities are accounted for in the trial design.
SP Energy Networks	DNO	Partner. A DNO brought on board to ensure that the design is interoperable for all DNOs. SPEN's license areas will join trial three.
National Energy System Operator	NESO	Collaborator. Responsible for sharing learnings between EQUINOX and other NESO flexibility programmes.

[38] Sero is not an energy supplier but assuming the role for the purpose of trial's one and two.

9. Appendix B: Difference in Difference approach

As detailed in Section 3.5, the DiD approach was used to determine the treatment effect during Daily Morning Flex.

Equation 1Equation 1 below provides the DiD specification used to calculate an estimate of demand response for each event. Equation 2 details the calculation of uncertainty (standard error). For the trial average analysis, the load profiles run through Equation 1 were representative averages of all the individual load profiles for each day of the trial. For the week-by-week analysis the load profiles run through Equation 1 were a representative average of all the individual load profiles for each weekday in that week. Equation 2 Equation 3. RMS standard error calculationEquation 3details the calculation we used to aggregate the standard errors to generate an overall average demand response impact across multiple events.

Equation 1: DiD demand response calculation[39]

$$Demand\ response = \left[mean(observed\ demand_{treatment,\ event}) - mean(observed\ demand_{control,\ event})\right] - \left[mean(observed\ demand_{treatment,\ non-event}) - mean(observed\ demand_{control,\ non-event})\right]$$

Equation 2: DiD standard error calculation[40]

$$Demand\ response\ standard\ error = \sqrt{\frac{Variance(observed\ demand_{treatment,\ event})}{Customer\ count_{treatment,event}} + \frac{Variance(observed\ demand_{control,\ event})}{Customer\ count_{control,event}} + \frac{Variance(observed\ demand_{treatment,\ non-event})}{Customer\ count_{treatment,non-event}} + \frac{Variance(observed\ demand_{control,\ non-event})}{Customer\ count_{control,non-event}}}$$

The treatment group participants were deemed to have delivered demand response for an event if they increased their energy consumption during the event as per Equation 1Equation 1.

As detailed in Section 3.5, the RMS approach was used to determine the aggregated standard error during Daily Morning Flex. Equation 3 below provides the RMS specification used to calculate an estimated standard error grouped across events.

Equation 3. RMS standard error calculation[41]

$$Root\ Mean\ Square\ (RMS) = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(SE_i)^2}$$

[39] Observed Demand = household consumption in kWh; Treatment = group of customers called to participate during an event; Control = group of customers not called to participate; Event = time frame during which consumption was averaged across the treatment or control group of customers on event days; Non-event = time frame during which consumption was averaged across the treatment or control group of customers on non-event days.

[40] Variance = statistical measure quantifying estimate uncertainty; Customer count = number of customers called during event.

[41] SE_i = standard error from event *i*; *N* = total number of events.