EQUINOX

Learnings from trial three: Heat pump turn up 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**: 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
- **Demand Turn Up Services**: Flexibility market products that procure increases in electricity consumption
- **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**: Company licensed to operate the electricity distribution network in a specific region of the UK
- **Equitable novel flexibility exchange (EQUINOX)**: the name of the project
- **Events**: periods of the day when EQUINOX trial participants were asked to provide demand response
- **Heat pump homes**: households with heat pumps
- **Low Carbon Technology**: Innovative technologies that cut or eliminate greenhouse gas emissions
- **National Grid Electricity Distribution**: the UK's largest regional Distribution Network Operator
- **Network Innovation Competition**: a programme that funded energy network innovation projects
- **Participants**: term EQUINOX uses when referring to customers enrolled in the EQUINOX trials
- **Photovoltaic**: Technology that converts sunlight directly into electricity using semiconductor materials
- **Randomised Control Trial**: A study where participants are randomly assigned to a treatment group (receives the intervention) or a control group (used for comparison) to measure an intervention's effect
- **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
- **Scottish Power Energy Networks**: A UK Distribution Network Operator
- **The Office of Gas and Electricity Markets**: the UK's energy regulator responsible for protecting consumers and ensuring a secure, sustainable, and affordable energy system
- **United Kingdom:** The United Kingdom of Great Britain and Northern Ireland
- **Variable Renewable Energy**: renewable energy sources, primarily wind and solar power, whose electricity generation is intermittent and dependent on fluctuating environmental conditions

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.

[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

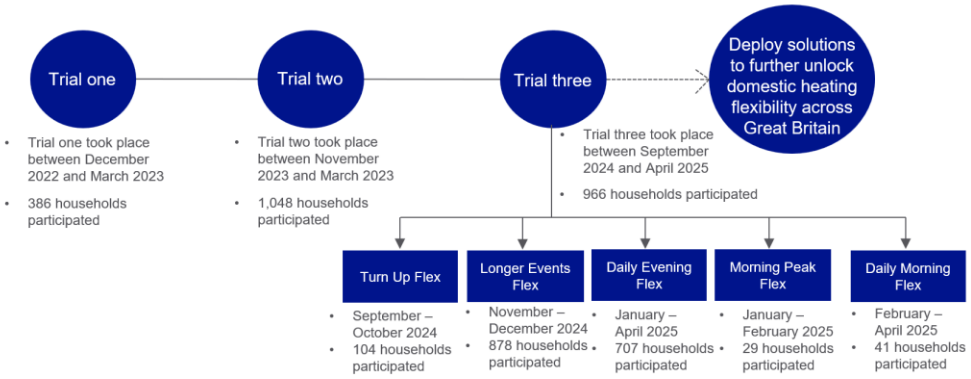

Figure 1: EQUINOX project overview

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:

[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
.

- **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 Turn Up Flex.

3. Turn Up Flex trial design

3.1 Introduction and aim

The Turn Up Flex mini-trial set out to explore ways in which heat pump flexibility might be able to support networks through demand turn up activity. Variable Renewable Energy (VRE) generation sources like solar photovoltaic (PV) and wind turbines are a cornerstone of the transition to net zero but their intermittency creates new challenges for managing network congestion. One approach to managing constraints is to decrease supply by curtailing generators[9]. Another approach is to increase demand by incentivising consumers to use more electricity during peaks of generation[10]. Demand response that can increase electricity consumption ('turn up') may be a valuable flexibility resource for DNOs & National Energy System Operator (NESO) that are managing increasing volumes of VRE generation. Using heat pumps in this way could be an exciting opportunity to boost usage of home heating, while providing a network benefit.

Demand Turn Up services are still nascent and as a first step for assessing their potential engagement by heat pump homes, this mini-trial had a limited scope and was carried out with 106 customers. The main aims were to assess:

- Whether heat pumps can provide measurable demand turn up during the day (loosely coinciding with peaks in solar generation)
- How much of that turn up could be attributed to heat pump activity.
- The customer experience of participating in this type of flexibility.

3.2 Trial structure

[7] Demand response when more electricity is consumed relative to a baseline.
[8] Demand response when less electricity is consumed relative to a baseline.
[9] Curtailing generators: when networks instruct the generator to turn down/off.
[10] A predictable peak period for solar generation is noon in Summer, though wind turbines peak during periods of high wind in any season.

Turn Up Flex was carried out over three weeks, starting in late-September 2024. Eligible customers from Octopus Energy were invited to take part in six 2-hour turn up events on non-consecutive days. The first three events were "heat pump only" turn up events, asking participants to increase electricity consumption associated with their heat pumps and hot water heating, but not from any other sources. The latter three events were "general" turn up events, where participants could increase electricity consumption through any activity, including use of their heat pump, electric vehicle charging or any general household load. Events were grouped in this way to improve participants' adherence to "heat pump only" events as all consumption was measured at the property boundary meter and not at specific asset meters. Having two event types also allowed an initial comparison of demand response volumes between "heat pump only" and "general" turn up events, which may be indicative of how demand response volumes could change as heat pumps are installed in more homes.

To compensate for a small trial size, we recruited a second group of customers to act as a control group. These customers had homes outside of the eligible postcodes but otherwise met the trial eligibility requirements detailed below. Control group customers took part in a sign-up survey and end of winter survey, and were rewarded for that participation, but were not otherwise contacted during the trial or asked to engage in any behavioural change.

3.3 Trial participants

3.3.1 Eligibility

To be eligible to participate in Turn Up Flex, in general customers were required to:

- Be on supply with Octopus Energy.
- Have a pre-installed air-to-water or ground-to-water heat pump as their primary method for home heating.
- Have an electricity smart meter that was consistently providing half-hourly meter reads.

To be part of the active trial (the "treatment group") customers also had to be resident within a list of prescribed postcodes in the NGED license areas. The list of eligible postcodes correlated to areas supplied by substations that peak demand was considerably below their rated capacity and that had network monitoring equipment in place. This requirement was put in place to avoid any undesired network impact that could occur if demand response volumes were very high.

Participants for the control group were recruited from locations that were not supplied by substations on the prescribed list but shared a generalised location (postcode outcode) with that list. This approach is a departure from a pure randomised control trial (RCT) and was selected to maximise the size of the treatment group while maintaining a high level of geographic matching for the control group.

There were no eligibility requirements related to customers' electricity import tariff, export tariff or to the presence of additional low carbon technologies (LCTs).

3.3.2 Recruitment approach

Octopus Energy led customer recruitment, conducting it via emails which included messaging about the trial objectives, a description of what would be requested of customers participating, and potential financial benefits of taking part. Customers received an invitation to either the treatment group or to the control group, depending on their eligibility, and had to agree to trial Terms and Conditions and complete a recruitment survey to become trial participants. 54 participants were recruited to the treatment group and a further 52 customers signed up to the control group.

3.3.3 Demographics

We used self-reported participant data[11] to understand how representative the participants were of the wider UK population – an important criteria for understanding the wider applicability of the mini-trial results:

- Homeowners were overrepresented among trial participants compared to the UK average. Nearly all participants (99%) lived in a property they owned and 1% paid social rent, compared to the UK average of 64% of individuals owning their home and 17% paying social rent.[12]
- High income households also tended to be overrepresented: 53% of participants had a household income that exceeds £50,000 per year; 21% of participants annual household income was between £20,000 - £24,999. This differed from the UK average with 19% of individuals in the UK having an income that exceeds £50,000 per year and 27% of individuals in the UK having an income between £20,000 - £30,000.
- Participants' homes tended to be more energy efficient, with 72% living in a home with an EPC rating of A, B, or C. This was higher than the average EPC rating for a home in the UK, at an EPC rating of D.[13]

These differences between the trial participants and the general population are in line with our experience in previous EQUINOX trials and based on survey results[14] are thought to reflect the mismatch between current heat pump owners and the wider population. Although Turn Up Flex is an important early exploration of the potential for heat pump homes to engage in demand response by increasing consumption, we recommend caution when applying its trial results to much broader populations that may interact differently with heat pumps than this participant group.

3.4 Commercial arrangements for Turn Up Flex

To assess the demand turn up potential for heat pump homes in this mini-trial, commercial arrangements and event design emulated expected network flexibility needs where possible and otherwise prioritised simplicity and customer convenience. Design of the commercial arrangements and events are summarised in Table 1 each of the treatment group and control group participants.

Error! Reference source not found.**Table 1: Turn Up Flex treatment commercial arrangements**

[11] Customer demographic data was self-reported through an optional start of trial survey administered by Guidehouse. 73 participants (69% of enrolled treatment and control customers) completed it.
[12] Office for National Statistics, Census 2021
[13] Office for National Statistics, Census 2021
[14] This is discussed in further detail in "Project Deliverable 5: Learnings from engaging customers"

Item	Treatment participant	Control participant
Payment structure	£5 for completion of recruitment survey £5 for completion of start of trial survey £5 for completion of end of trial survey Utilisation payment (per kWh)	£5 for completion of recruitment survey £5 for completion of start of trial survey Further £10 incentive available in Spring 2025 for customers who remained a part of the control group across Longer Events Flex and Daily Evening Flex
Control type	Manual and remote customer control	
Notice period	Day ahead	
Payment amounts	Matched to the customer's unit rate during events, representing a "free" electricity reward	
Eligible supplier tariffs	Any tariff	
Event duration	Two hours	
Event timing	11am - 1pm	
Event frequency	One to three events per week	
Supplier notice	Informed by NGED on Wednesday of the preceding week	

As shown in Table 1, all turn up events were held over two hours in the middle of the day, on weekdays or weekends, reflecting an expectation that times when demand turn up may be procured may often correlate with peaks in solar generation. Similarly, participants received a day ahead notice of events to reflect how a network may use this type of demand response. We had also obtained favourable feedback on this notice period from EQUINOX trial two participants. NGED notified suppliers of events on the preceding Wednesday to simplify operational delivery.

We held events on non-consecutive days to avoid any potential issues of demand turn up on an event day subsequently impacting demand turn up activity on the following day. All participants controlled their own heat pumps and other LCTs during events, with no third party-controlled demand response. For simplicity, we only considered demand response for home electricity import and did not measure changes in export volume. Where participants had export capabilities, they were offered to take part in events but cautioned that they should make their own decisions as to whether the commercial arrangements were worthwhile in the context of their existing import and export tariff rates. We captured changes in export behaviour in customer surveys.

Participants were not required to opt-in to individual events. They were eligible for the utilisation incentive so long as they were enrolled in the trial before the event notification was sent. Turn Up Flex used a utilisation payment structure, rewarding customers based on their electricity consumption during events. For simplicity, we adopted a “free” electricity approach, rewarding customers by crediting their energy accounts with the full cost of electricity used during event periods (e.g. if a participant’s home smart meter recorded 1.2kWh of consumption during an event, the customer was later credited for 1.2kWh at their existing unit rate). For settlement purposes and to account for instances where participants’ smart tariffs had different unit rates during the event, we calculated this on a per half hour basis. This “free” electricity approach can be considered as the ceiling price that networks currently offer for turn up demand response. Participants in the treatment group could also earn up to £15 for completing surveys at the start and end of the trial.

Participants in the control group provided a comparison for both demand response volumes and for ‘typical’ energy consumption behaviours without the influence of EQUINOX events. To reflect that value, we incentivised control group participation via an initial incentive of up to £10 for surveys upon sign up and a further £10 incentive in Spring 2025 for customers who remained a part of the control group across Longer Events Flex[15] and Daily Evening Flex[16].

3.5 Analysis approach for Turn Up Flex

Following industry best practice for evaluating trial programmes, we utilised a Difference-in-Difference (DiD) approach for 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 across each of the three-heat pump and three-general events, though we used the Root Mean Square (RMS) method to calculate aggregate errors[17].

To confirm the control group’s suitability, we compared it with the treatment group across key metrics. Both groups were similar in energy use, heat pump size, and ownership of technologies like Solar PV and batteries. Prior exposure to flexibility initiatives, including smart tariffs and EQUINOX trials, was also comparable. These similarities supported the use of the DiD approach.

We evaluated participant experience through a series of surveys. These captured self-reported behavioural change during events and satisfaction with event design elements and the overall experience. These surveys were:

- End of trial survey.
- Six short post-event surveys that were sent out following each event.

[15] Trial that tested 2-4 hour evening flexibility events 2-3 days per week for 6 weeks. Full report: “Learnings from trial three: Longer heat pump flexibility events”

[16] Trial that tested 2 hour and 4 hour evening flexibility daily Monday to Friday for 11 weeks. Full report: “Learnings from trial three: Daily evening heat pump flexibility”

[17] The full DiD and RMS approach is provided in Appendix B: Difference in Difference approach

4. Demand response results

Section 4.1 outlines our main findings for the trial aim of determining whether heat pump homes can provide demand turn up during the day, and approximately how much of that demand response can be attributed to heat pump activity. Section 4.2 reports on a series of observational findings from the mini-trial. The trial design did not permit a full set of analysis in these areas, but the findings are of interest for networks engaging in turn up demand response.

4.1 Main findings

4.1.1 Event incentives

We incentivised demand response by crediting participants for electricity consumption during events, amounting to “free” electricity.’ Participants used a total of 1.04 MWh of electricity across the six events, amounting to over £250 of event rewards.

4.1.2 Demand response volume

We saw a statistically significant increase in average electricity consumption from both event types in Turn Up Flex (Figure 2). In heat pump only events, participants had an average upwards demand response of 0.88 kW (95% confidence interval 0.71 kW to 1.05 kW). The average upwards demand response in general events was 1.35kW (95% confidence interval 1.10 kW to 1.60 kW). This suggests that two thirds of demand response in general events can be achieved by changes in heat pump behaviour alone 18. These results are a promising demonstration of the turn up potential of heat pump homes and suggest that networks may be able to access an increasing volume of domestic turn up as more homes electrify their heating.

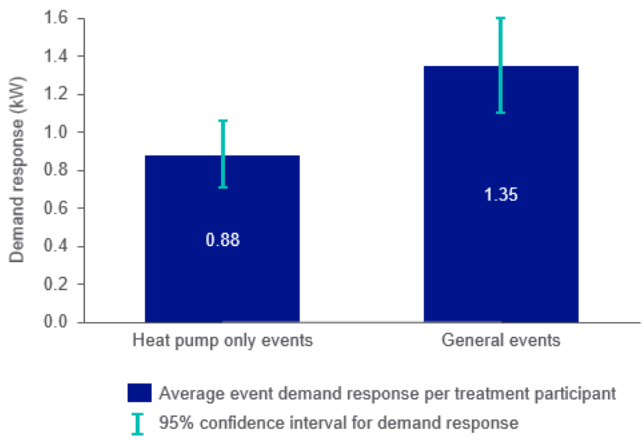

Figure 2: Average demand turn up per treatment participant by event type

Figure 3 presents the demand response results on a per-event basis. The amount of demand response varied more between the initial three heat pump only events than between the latter three general events. Overall, participants provided statistically significant demand response in five out of six events. Heat pump event 2 was the exception[19]. We reviewed the operational aspects of this event (e.g. day of week, successful sending of the event invitations) and did not find a likely explanation for a lower demand response. In this context, we attribute that variation to the small size of the

[18] We explore this further in Figure 6 (below), with survey results showing self-reported behavioural change by event type.

[19] We did not detect statistically significant turn up for heat pump event 2, as indicated by the 95% confidence interval crossing of the 0 kW line, meaning we cannot conclude that demand turn up greater than 0 kW was achieved.

trial and expect that we may not have seen such variation with a larger participant group or over a greater number of events.

For heat pump event 1, we caution that an element of participant enthusiasm may have contributed to a larger demand response than seen in subsequent events. This is somewhat supported by post-event survey results (Section 5). Participants self-reported more non-heat pump behavioural changes in heat pump event 1 than in subsequent events.

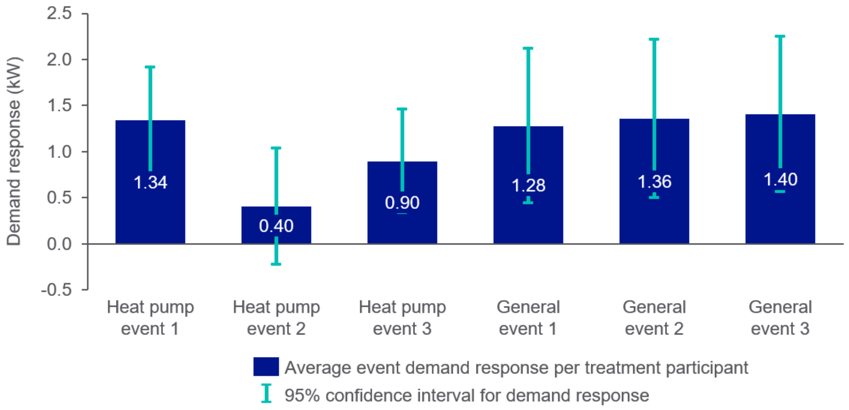

Figure 3: Average demand turn up per treatment participant for all events

Demand response volumes were more consistent in the general turn up events, but we cannot determine whether this is an effect of the event type or of participants becoming more familiar with trial events and settling into a sustainable approach to the requested demand response. This is a shortfall of the mini-trial structure and would become clearer in a larger scale trial with more events.

4.1.3 Demand profiles

To provide an alternative view of these results, Figure 4 and Figure 5 show the average half hourly demand profile for each of the treatment and control groups (solid lines), for heat pump events and general events, respectively. The dotted lines represent a historical baseline for each group, constructed from the p376 method[20]. The 2-hour event window is highlighted in blue.

[20] The p376 baseline method was used in EQUINOX trial two and constructs a personalised historic baseline for each participant based on the average of their consumption on the last 10 similar non-event days (for weekdays) or the last 4 similar non-event days (for weekends and holidays): See Elexon report for full details of the p376 method.

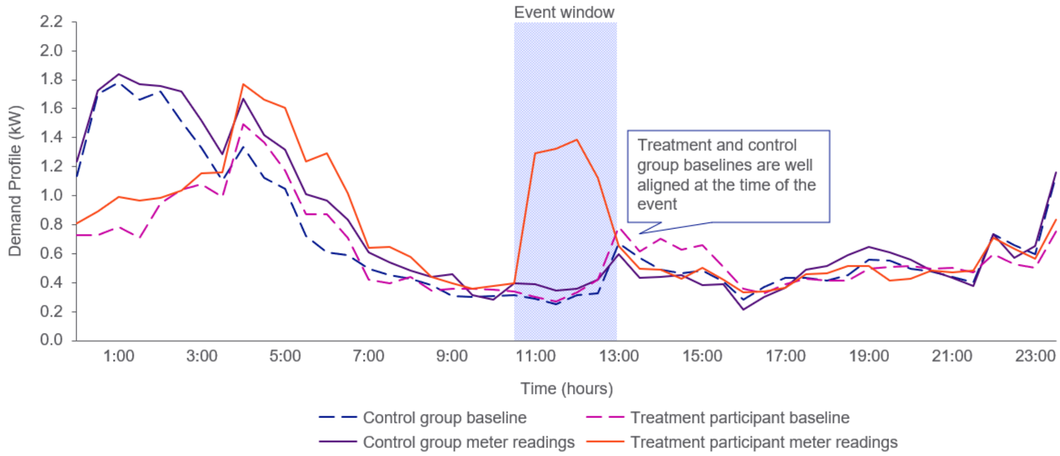

Figure 4: Average demand profile of EQUINOX participants, for heat pump events only

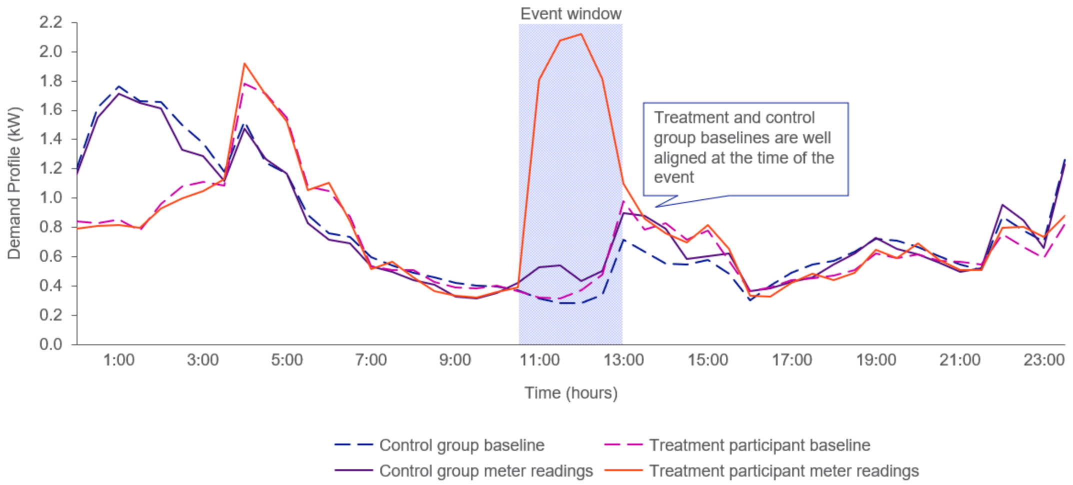

Figure 5: Average demand profile of EQUINOX participants, for general events only

The baselines in each graph are reasonably well matched to actual demand as measured by 'meter readings' for both sets of participants, apart from within the event window where the treatment group shows a considerable increase in demand versus the baseline for both event types. This is a 'raw' view of the data used for the DiD calculation to produce the results in Figure 2 and Figure 3 but adds further context for the typical demand profiles of these participants outside of the event window and on non-event days. The most striking feature outside of the event window is the overnight peaks in demand driven by existing price signals from participants' time of use tariffs. These represent a mix of different smart tariffs with different 'off-peak' windows and are typically associated with electric vehicle charging. Where the treatment and control group do not have a well-matched mix of time of use tariffs, we see these different signals driving different average customer behaviour; the control group have a greater proportion of load peaking at 1am whereas the treatment group have their greatest overnight peak at 4am. The DiD approach for measuring demand response is particularly valuable in this context, where participants are already exposed to flexibility incentives.

For heat pump only events, the event window peak of the treatment group does not exceed the overnight peak for either group. For general events, the demand response during events does exceed the average overnight peak. These results suggest that customers with existing flexibility in response to time of use tariffs can also provide turn up demand response for specific flexibility events.

4.1.4 Technology use

We invited participants to complete a short post-event survey straight after each event. It asked them to self-report which technologies they used during events.

The results in Figure 6 support the trend of greater demand response during the general events compared with the heat pump only events. Participants reported heat pump use at virtually the same rate for both: each approximately 90%. However, the use of all other technologies increased during the general events. On average, 47% of participants reported using additional household technologies during the heat pump events, mostly through “running the dishwasher” or “doing laundry”. We suspect that this additional behaviour represents a misunderstanding of the request to restrict turn up demand response to the heat pump. This is an expected weakness of the trial design (not having heat pump specific metering) but appears to occur at a low level. In the general events, 78% reported using other household devices. The biggest change was the reported increase in the categories “running the dishwasher or doing laundry” and “cooking with electric appliances”. Together, these saw a 26% increase between event types. These results align with Figure 2, which showed higher average demand response for the general events.

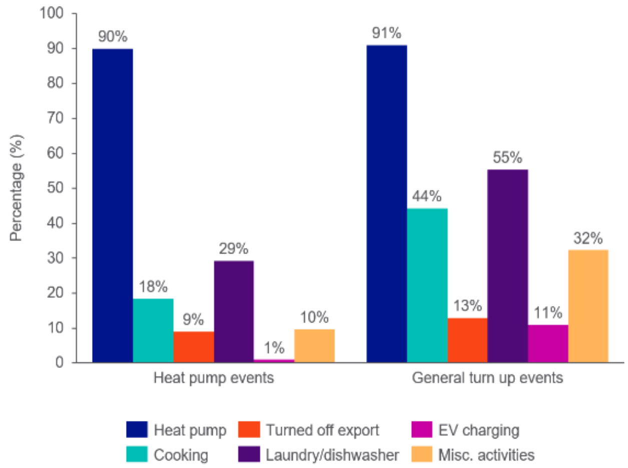

Figure 6: Percentage of treatment participants who self-reported use of various technologies during events in the post-event surveys, by heat pump events (n=44) and general turn up events (n=42)

4.2 Observational findings

This section covers observational findings from Turn Up Flex. The trial design did not permit a full set of analysis in these areas, but the findings may be of interest for networks engaging in turn up demand response.

4.2.1 Export capable participants

A high proportion of participants in the mini-trial had export connections: 63% in the treatment group and 73% in the control group. Almost all export capable participants reported having solar PV, and almost 50% of participants reported having home batteries (46% in the treatment group, 50% in the control group). This is not exceptional in the context of previous EQUINOX trial participants, but we are not able to confirm if this is reflective of the wider population of heat pump homes.

Export capability added a layer of complexity for participants, since they could be in a position to export from their PV or batteries during the times chosen for events – and be paid for doing so. This was the opposite of the behaviour requested of them by the trial – which rather proposed to reward them for consuming more energy. As such, we cautioned export capable participants to make their own consideration of whether participation in events was worthwhile to them, on the understanding that demand response would only be measured and rewarded based on imported electricity.

Helping to inform the experiences of export-capable participants during Turn Up Flex, amongst export-capable treatment group participants completing all six post-event surveys, 71% (12 out of a total 17 participants) reported they had participated in all six events. This aligned with the 70% participation rate reported across all treatment participants completing the survey, suggesting export capability did not lead to low participation with the events.

Yet as shown by Figure 7, in selected free text responses in the end of trial survey[21] three out of the 14 export-capable participants who completed the end of trial survey reported difficulties in trial participation, two participants found the events inconvenient since they had solar PV and batteries and one participant commented that it did not make sense for them to participate because they could already meet their electricity needs through their solar panels.

	Selected responses
Difficulty of participation	*"It is important to understand and offer clear advice to the customers that have Solar and Batteries"* *"The events were a lot of effort because we have solar and batteries"*
Limited value	*"Several of the events were of limited use as on warm sunny days there was no need to use heating and solar provided for all electricity needs."*

Figure 7: Selected free text responses from treatment participants with export capability, from end of trial survey

Additionally, across all six events, an average of four out of 13 export-capable treatment participants reported self-curtailment during at least one event through post-event surveys. This meant they could have exported electricity to the grid from solar PV or batteries but chose not to do so. At the same time, they increased their electricity consumption imports from the grid.

These findings suggest that export capable customers are open to engaging in demand turn up. However, without appropriate incentives or mechanisms, these customers may see limited benefits from participation. The proportion of homes with export capability is likely to increase in future as the prevalence of solar PV and home battery ownership increases. It will therefore be increasingly important for commercial demand turn up programmes to account for the behaviours and motivations of export-capable participants.

4.2.2 Demand shifting versus creation

This mini-trial focused on demand turn-up events but was not designed to distinguish whether increased demand during events resulted from demand shifting (usage that would have occurred anyway, just at a

[21] End of trial survey question stated: "Is there anything else you'd like to tell us?"

different time) or demand creation (additional usage that wouldn't have occurred otherwise, such as increasing the temperature to which a home or hot water is heated). Understanding this distinction could be valuable, as it may reveal indirect benefits—like reduced demand during peak times or improved customer comfort through enhanced heating. This is particularly relevant for vulnerable customers, who often self-ration electricity to manage costs, and may benefit from opportunities to increase comfort during incentivised periods.

We conducted exploratory analysis of participants' consumption data to assess whether demand creation or demand shifting drove demand turn-up. We also included questions in the end of trial survey to gather qualitative insights. Overall, the findings were inconclusive. The diversity of customer tariffs and the small sample size prevented us from being able to investigate changes in consumption at other times within event days. While we could compare consumption between event days and non-event days, the results were not statistically significant, preventing us from drawing any conclusions. Survey responses were mixed, with participants reporting a combination of demand creation and shifting.

Figure 8 shows the results of our exploratory analysis, which aimed to assess whether there was an increase in average whole day consumption for the treatment group on event days. We calculated the DiD between the average daily total energy consumption on event days and baseline days for both the treatment and control groups. A DiD point estimate statistically greater than 0 kWh would have suggested that the treatment group increased their total daily energy consumption on event days—indicating demand creation or demand shifting between days, rather than simply shifting usage within the day. This would have implied that on event days, after controlling for weather and other time-varying factors, the treatment group consumed more energy overall in response to the intervention. Although the point estimate of 2.6 kWh is greater than 0 kWh, the 90% confidence intervals overlap 0 kWh indicating that it is not a statistically significant result. As a result, we cannot conclude with confidence that total consumption on event days was different to that of baseline days, or confirm whether demand creation or demand shifting occurred between days.

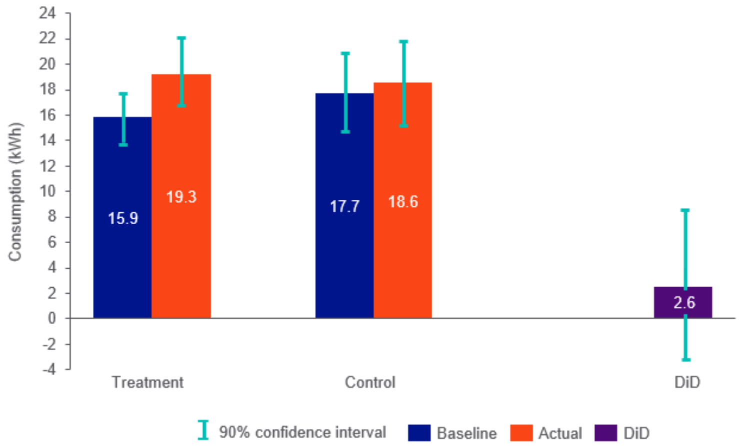

Figure 8: Average event day and baseline day total consumption of treatment and control group, with DiD calculation

On the survey data, Figure 9 shows that 26% (nine participants) indicated they "only shifted" demand, while 63% (22 participants) reported some combination of demand shifting and demand creation. Just three participants reported they had "only created" demand. Figure 10 shows 84% (27 participants) of the treatment group reported within-day shifting when asked when they had shifted their demand to. The responses suggest occurrences of both demand creation and demand shifting, with most demand shifting within-day.

Figure 9: Percentage of participants reporting shifting or creating demand during events, from the end of trial survey (n=35)

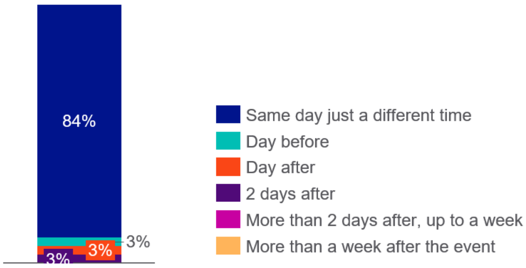

Figure 10: Self-reported time that participants shifted their demand to, from the end of trial survey (n=32)

Overall, these results are inconclusive. It is possible that further study focusing on this area may help to uncover indirect benefits of the event (such as corresponding demand reduction at peak times or improved heating experience for customers).

5. Customer experience results

As well as measuring demand response, it was an aim of Turn Up Flex to explore whether participating in demand turn up events was a positive experience for participants, and whether it may be a sustainable behaviour change beyond the mini-trial. Section 5 presents these findings, with Section 5.1 outlining views on customer comfort, Section 5.2 outlining customer satisfaction, and Section 5.3 outlining view on the notice period we gave to customers before an event.

5.1 Customer comfort

Customer comfort must be prioritised for domestic flexibility provided by low carbon heating, including safeguarding against customers over-heating during demand turn up events. Based on survey responses, most participants experienced no change in comfort or felt warmer in a positive way. We asked treatment group participants about the impact of turn up events on their thermal comfort[22]. 37% (13 participants) indicated the events caused a neutral change or no change to comfort levels. None indicated the events had made their home too cold while just 3% (one participant) indicated the events had made their home too warm. 57% (20 participants) responded that events made their homes warm or slightly warm, though it wasn't immediately clear if they considered this positive or negative (Figure 11).

Participants who indicated a response other than 'neutral or no change in comfort' in Figure 12 were also asked how this change in comfort affected them[23]. We coded their free text responses positive, neutral, and negative. As shown in Figure 13 of the 18 participants[24] who responded, 50% (nine participants) provided responses that indicated a positive change in comfort, 44% (eight participants) indicated neutral or no change, and only one participant indicated a negative change in comfort.

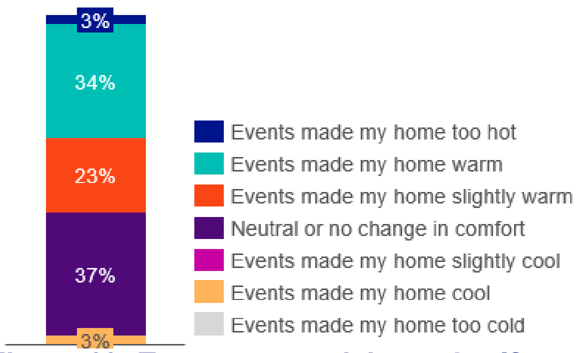

Figure 11: Treatment participants' self-reported impact of events on comfort levels (n=35)

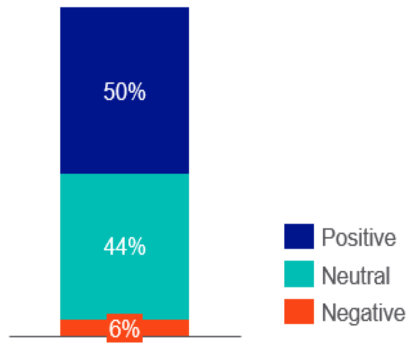

Figure 12:. Percent of participants who experienced a positive, neutral, or negative change in comfort (n=18)

[22] End of trial survey question stated: How much, if at all, did the turn up events impact the comfort levels of your home?

[23] End of trial survey question stated: If at all, has this change in comfort changed how you live in your home during Turn Up events?

[24] 6 participants chose not to reply to the optional question and therefore could not be coded.

Figure 13 shows selected positive, neutral and negative free text responses from participants. Responses indicated that participants largely perceived additional warmth from the events as positive or neutral. Participants shifted the timing of their heat or used more than normal, thus benefiting by warming their home at a lower cost.

	Selected responses
Positive	• Warmer and more productive. • Improved it. Run the house warmer on turn up days which lasts for at least 24 hours as my underfloor heating stores a decent amount of residual heat. • It was wonderful to have a warm bungalow for those two hours instead of being wrapped up in sweaters and blankets because we can't afford to have the heat pump on above 19 even when it's very cold. • I was able to make my home warm enough for me and my 1-year-old and not worry about the extra cost before switching off by 4pm.
Neutral	• Merely shifted time at which I turned up heat. • No change. • There is only a limited degree the heat pump can bump up the temperature over 2 hours and the gains would be felt mainly during midafternoon when I'm not home.
Negative	• Supplementary heating as the underfloor heating takes time to respond; More clothing layers.

Figure 13: Selected free text responses to how a change in comfort due to turn up events impacted how participants lived in their home

As seen in Figure 14, a likely explanation for participants feeling warm was that across all six events space heating was used more than water heating to provide demand turn up[25]. Although not definitive, this was likely due to the autumnal timing of the trial, which saw temperatures range between 11℃ and 17℃.

[25] Analysis based on responses to survey questions: 1) If you increased your space heating during Turn Up events, how did you do this? 2) If you increased your hot water heating in any Turn Up events, how did you do this?

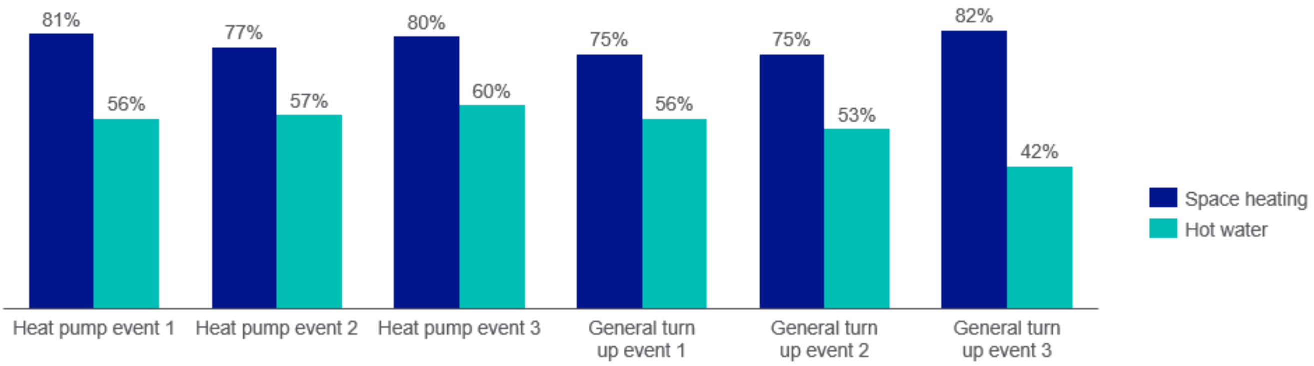

Figure 14: Treatment participants' self-reported use of space heating or water heating in each event

Overall, most participants experienced no change in comfort or felt warmer, likely due to an increased use of space heating. However, it is possible this impact would not have been the same if the turn up events occurred in the peak of the Summer. This is an area for potential further investigation in future turn up trials.

5.2 Satisfaction

Customer satisfaction was high, indicating an appetite to participate in further demand turn up services. The end of trial survey asked participants questions related to trial satisfaction, willingness to participate in an additional turn up trial, and willingness to sign up to an ongoing turn up product. Figure 15 shows that of 35 participants who completed the end of trial survey, 94% indicated they were satisfied with the trial[26].

Figure 16 shows that 97% of participants would participate in an additional turn up trial, though 18% noted this would be dependent on the season in which turn up events took place[27]. Only one participant indicated they would not participate in a turn up trial again.

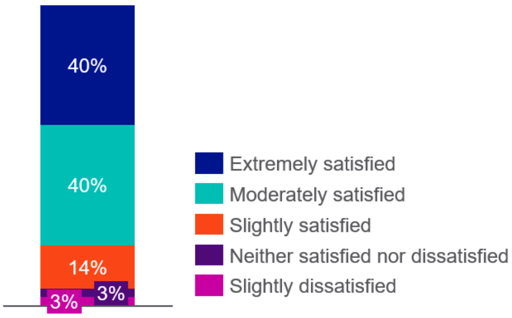

Figure 15: Percent of treatment participants satisfied with the turn up events (n=35)

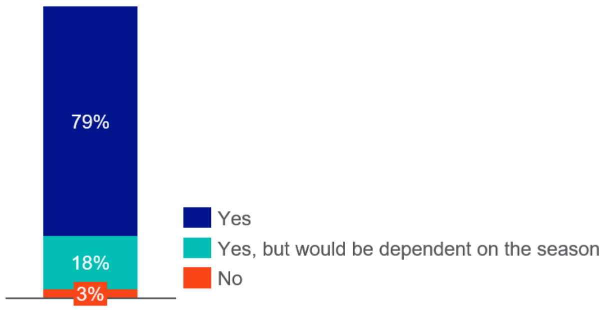

Figure 16: Treatment participants' willing to participate in future turn up trials

[26] End of trial survey question stated: "Overall, how satisfied were you with the Turn Up events?"
[27] End of trial survey question stated: "Based on your experience in this trial, do you think you would participate in an additional turn up trial?"

Figure 17 shows responses on participant willingness to participate in further turn up events[28] 95% (33 participants) would be willing to sign up to an ongoing turn up product similar to the general turn up events. Only one participant was extremely unlikely to sign up to a general turn up product. Survey responses also indicated that the opportunity to participate in further turn up trials increased participants' inclination to adopt additional technologies. Figure 18 shows ~49% (17 participants) would install a thermostat if there were ongoing turn up trials in either the summer or winter.

Overall, these positive survey results highlight not only that customers were satisfied with the trial, but also that they are willing to participate in similar trials or sign up to an ongoing turn up product – including installing new technologies to better enable them to do so. These conclusions demonstrate that domestic demand turn up from heat pump homes can be a promising tool for networks.

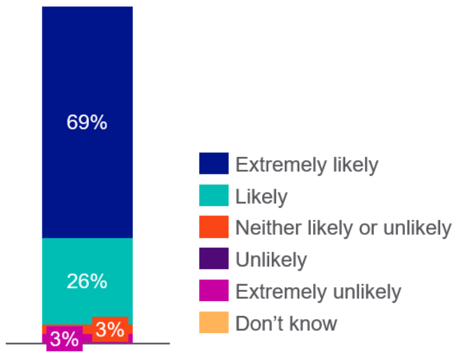

Figure 17: Treatment participants' indicating a likelihood to sign up to an ongoing turn up product (n=35)

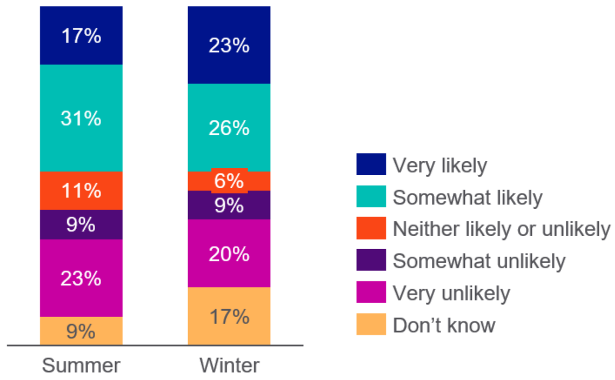

Figure 18: Treatment participants' likelihood to install a smart thermostat if there were ongoing turn up trials in the summer or winter (n=35)

[28] End of trial survey question stated: "How likely would you be to sign up to an ongoing turn up product, similar to the general turn up events?"

5.3 Notice period

5.4

Participants were notified of Turn Up events a day prior to the event via an email from their energy supplier. When asked to assess their satisfaction with this notice period in the end of trial survey, 89% of participants reported they were satisfied[29] (Figure 19). Only 9% were dissatisfied with this notice period.

Participants were also asked about whether this notice period impacted their ability to participate in turn up events[30]. 63% responded that the day ahead notification did not impact their ability to participate in turn up events. The remaining 37% indicated that it did (Figure 20). While these figures are encouraging, we did not explore why some participants reported that this notice period did impact their ability to participate. Further research into this should be investigated as part of any further turn up trials.

Nevertheless, based on the responses to these survey questions, we conclude that a notification a day ahead of an event is broadly sufficient notice to enable customers to participate in turn up events. This can inform flexibility service providers on notification times to procure flexibility from heat pump homes.

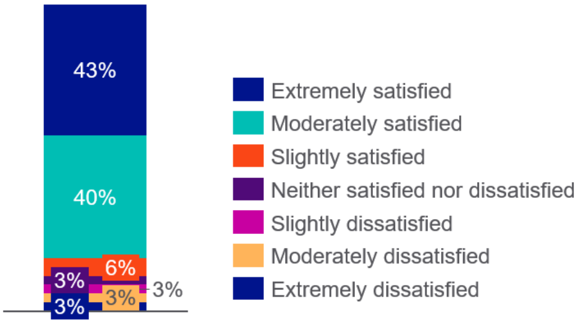

Figure 19: Percentage of participants satisfied with the notice period (n=35)

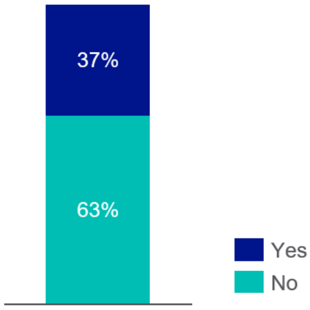

Figure 20: Percentage of participants that reported notice period impacted ability to participate (n=35)

[29] End of trial survey question stated: Notice for Turn Up events was provided the day before an event happened. How satisfied were you with the notice period?
[30] The end of trial survey question stated: Did this notice period impact your ability to participate in turn up events?

6. Summary

We are encouraged by the results of Turn Up Flex, and its implications for heat pump homes to participate in network demand turn up services. The key takeaways are summarised below:

1. **Customers with a heat pump can provide demand turn up during the middle of the day (11am-1pm) via their heat pump.** On average, we detected a statistically significant 0.88 kW of demand turn up per 'heat pump only' events per treatment group participant. These results suggest heat pump homes could deliver measurable turn up demand response for network services.

2. **Heat pumps will provide a significant proportion of potential demand turn up even when customers are able to turn up any asset of their choice.** On average, participants provided 0.88 kW of demand turn up on average during 'heat pump only' events, relative to 1.35 kW for the 'general turn up' events. These results suggest that participants can achieve almost two thirds of the total demand response in general events from changes in heat pump behaviour alone.

3. **We cannot conclude if demand was shifted or created during the trial.** Exploratory analysis did not produce statistically significant evidence to prove or disprove whether average whole day consumption was increased on event days. 63% of participants reported a combination of demand creation and demand shifting. These results leave this area open for future investigation which NGED will consider as part of its BaU transition planning.

4. **Providing demand turn up is well tolerated by customers.** 94% of participants self-reported being satisfied with Turn Up Flex. These survey results suggest that customers would be willing to participate in similar trials or sign up to an ongoing turn up product.

5. **Results are encouraging but it was not possible to conclusively evaluate customer comfort.** Many treatment participants experienced no change in comfort (37%). Most reported their home became slightly warmer (57%). Based on free text feedback it appears they broadly viewed this positively, but the results are not definitive. Further trialling of demand turn up, particularly during warmer seasons, could bolster these results.

6. **Smart thermostats uptake may increase if customers can participate in demand turn up services.** 48% of participants reported that would install a smart thermostat if there were ongoing turn up trials in the summer, and 49% reported they would do so if there were ongoing turn up trials in the winter.

7. **Day ahead notification is sufficient for customers to provide turn up flexibility.** 89% of participants indicated they were satisfied with a day-ahead notification. This demonstrates customers can respond to network flexibility requests within operationally relevant timescales.

7. 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
NGED	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[31]	
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.

[31] Sero is not an energy supplier but assuming the role for the purpose of trials one and two.

8. Appendix B: Difference in Difference approach

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

Equation 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). Equation 3. RMS standard error calculationEquation 3 details 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[32]

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

Equation 2: DiD standard error calculation[33]

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

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 1.

As detailed in Section 3.5, the Root Mean Square (RMS) approach was used to determine the aggregated standard error during Turn Up Flex. Equation 3 below provides the RMS specification used to calculate an estimated standard error grouped across events.

[32] 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.
[33] Variance = statistical measure quantifying estimate uncertainty; Customer count = number of customers called during event.

Equation 3. RMS standard error calculation[34]

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

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

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