EQUINOX

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Design of Novel Commercial Methods & Technical Integration

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1. Executive Summary

EQUINOX (Equitable Novel Flexibility Exchange) is a Network Innovation Competition (NIC) project, funded by Ofgem. Between 2022 and 2025, EQUINOX is developing novel commercial arrangements and supporting technological integrations that unlock flexibility from residential low carbon heating. EQUINOX aims to develop a solution that meets the needs of all consumers, including those with vulnerabilities or experiencing fuel poverty. The purpose of this report is to provide an overview of the design of novel commercial methods and of the technical integrations designed for the first two of three winter trials in the project. This report aims to answer the following questions from the EQUINOX Final Submission Pro forma (FSP):

- How can DNOs and energy suppliers facilitate markets for flexibility to minimise customer bills?
- What technical integration and automation is required to deliver a seamless customer experience?

The project successfully carried out its first trial (henceforth 'trial one') with 386 customer participants between December 2022 and April 2023. The trial tested two novel commercial arrangements which saw domestic households who already had heat pumps installed offered financial incentives to turn their heat pump off/down for limited two-hour periods called EQUINOX events (henceforth 'events') occurring on 'event days' across the trial period. The two commercial arrangements tested in trial one are summarised in Table 1 below.

Table 1: Summary of trial one commercial arrangements

M1 – Save in advance	**M2 – Save as you go**
Customers were paid £25 monthly instalments in advance of that month's events as incentive for participation in subsequent events.	Customers were paid up to £6 per event after the event if they participated.

Learnings from trial one results fed into the design of the trial two commercial arrangements. The main learning that emerged from trial one was that customers on trial one's M1 arrangement (save in advance, monthly payments) participated less reliably compared to customers on trial one's M2 arrangement (save as you go, payments per event), although the amount of turndown provided per participating customer was similar. Therefore, the decision was made to pay customer exclusively per event in trial two. This change opened up the possibility to investigate other variables and aligned EQUINOX with standard flexibility products across the industry. Other learnings from trial one relevant to commercial arrangements related to event length, event frequency, notice periods, and payment amounts. As a result, these were key variables that were tested in trial two commercial arrangements. The three commercial arrangements that will be tested in trial two are summarised in Table 2 below.

Table 2: Summary of trial two commercial arrangements

M1 – High utilisation payment	**M2 – Low utilisation payment**	**M3 – Availability payment + medium utilisation payment**
Customers will be paid per kWh of flexibility based on notice period: Day ahead: £0.80/kWh Morning ahead: £1.60/kWh 2 hours ahead: £2.40/kWh	Customers will be paid per kWh of flexibility based on notice period: Day ahead: £0.40/kWh Morning ahead: £0.80/kWh 2 hours ahead: £1.20/kWh	Aggregator control customers will be paid in advance for the availability of their heat pumps to be turned off remotely and per kWh of flexibility based on notice period: Availability: £8 Day ahead: £0.50/kWh Morning ahead: £1.00/kWh No notice: £1.50/kWh

The commercial arrangements for each trial were used to define the requirements for the technical integration between National Grid, the suppliers (Octopus Energy, Sero, ScottishPower), and customers. This process began by translating requirements into the technical specifications, facilitating technical development with the suppliers, and conducting testing before moving into trial periods where the integration methods were used at scale.

To ensure consistency with our day-to-day flexibility procurement, we have used the Flexible Power platform for sending dispatch signals to each supplier onboarded to the trials. To facilitate this, each set up an application programming interface (API) and from there the systems needed to link to their customers.

For trial one, customers were split between Sero and Octopus Energy, and we successfully demonstrated the initial technical integration processes for their customers during this period. This is being expanded for trial two, as the systems for technical integration for each of those suppliers are being refined, and ScottishPower are being brought into the trial to augment the pool of customers and ensure that methods are scalable with multiple suppliers. We look forward to using the expanded technical integration in trial two and generating learnings for domestic flexibility.

2. Purpose and Guide

2.1. Purpose

This report forms the third deliverable submission to Ofgem for the Equitable Novel Flexibility Exchange (EQUINOX) NIC project. The purpose of this report is to provide an overview of the design of novel commercial methods and technical integration designed for the first two of three flexibility trials in the project.

This includes the requirements of the commercial arrangements and commercial heads of terms between suppliers and customers, and the solution requirements and specifications for technical integration between the distribution network operator (DNO), suppliers, in-home automation, and customers.

The project is iteratively designing and developing new commercial and technical integration methods to reach a reliable and cost effective way for DNOs to procure flexibility from Heat Pumps (HPs) in the future. We are testing how current flexibility service arrangements may need to change to support them, or whether a new product specific to HPs should be used. More detail on this is given in the following sections:

2.2. Guide to this Document

- **Section 3** provides an introduction to EQUINOX, the trials being carried out, and the project partners.
- **Section 4** outlines the process used to design the commercial arrangements for each trial, before providing detail on each of the two arrangements for trial one and the three arrangements for trial two.
- **Section 5** provides an overview of how flexibility procurement is carried out by National Grid, to set the scene for the processes adopted in each trial.
- **Section 6** outlines the technical integration methods between the network, suppliers and their customers, and includes details on the drivers for each design, and the process used to test them.

3. Context

3.1. Introduction to EQUINOX

In 2020, the UK government announced a target to reach 600,000 heat pump installations per year by 2028[1]. Unless new solutions are developed to manage this new electrical load, DNOs are expected to witness a substantial increase in peak demand, triggering significant network reinforcement throughout the Ofgem regulatory price control and investment periods RIIO-ED2 (2023-28) and ED3 (2028-33). Currently, limited viable solutions exist for DNOs and other whole system actors to unlock the flexibility from residential low carbon heat at scale in a reliable, cost-effective, and equitable way. A better understanding of heat pump flexibility resulting from the EQUINOX trials will enable DNOs to plan network reinforcement more efficiently, defer reinforcement, and ultimately provide value for money to electricity network customers while embracing electrification of domestic heating.

EQUINOX is an Ofgem-funded Network Innovation Competition (NIC) project which aims to develop novel commercial arrangements to maximise participation in domestic DNO flexibility services while meeting the needs of all customers, including those with vulnerabilities. The project will pave the way for how DNOs leverage flexibility from heat to manage the increasing network demand while maintaining network reliability, consumer choice, and comfort within homes. In the future, it is expected that the DNO would in its capacity as the Distribution System Operator (DSO) be responsible for this market service.
The commercial arrangements should enable domestic flexibility to come to market. The arrangements should be based on a fully integrated DNO to supplier to customer approach, be able to balance risk and reward across all actors, and manage flexibility from a diverse portfolio of domestic heating assets. The evolution of these commercial arrangements will demonstrate how varying terms between DNOs, suppliers, and customers can influence the amount, cost, and reliability of flexibility from domestic customers. The final commercial arrangements utilised in business as usual (BaU) will have a direct impact on the electricity demand on the network by enabling the deployment of flexibility from low carbon heat.

EQUINOX will test multiple novel commercial arrangements per trial over three winters. Trial one ran from December 2022 to April 2023. Trial one was a proof of concept for commercial-scale UK demand flexibility from residential heating and laid the groundwork for future trials to fine-tune the commercial arrangements.

Trial two is running from November 2023 to March 2024. Analysis of trial one informed design of trial two commercial arrangements towards a solution that more closely reflects BaU.

Trial three will run in winter 2024/25 and test commercial arrangements that will deliver a DNO flexibility product that unlocks cost-effective and widely accessible flexibility from residential low carbon heating. The commercial arrangements for trial three will be informed by trial two results.

[1] HM Government, 2020

The timeline for the trials is shown below in Figure 1.

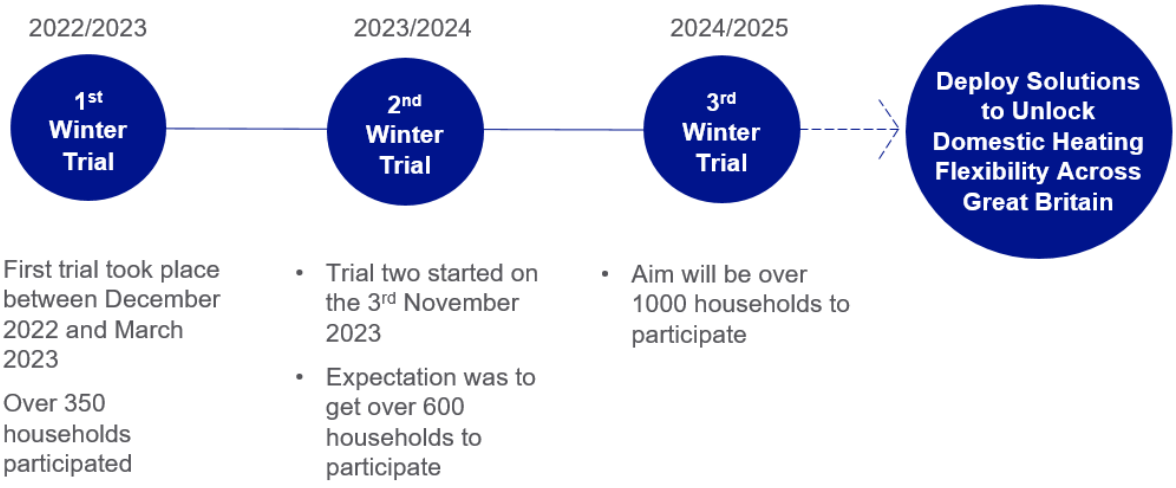

Figure 1: EQUINOX timeline

3.2. Introduction to Project Partners

EQUINOX features multiple project partners and collaborators, as detailed in Table 3.

Table 3: List of EQUINOX partners and collaborators

Company	Name	Project Function	Role
nationalgrid	National Grid Electricity Distribution	DNO	Project lead. We are responsible for running the technical integration, trial design, and project management and knowledge workstreams. We want the EQUINOX product to align with our existing and future DSO flexibility services and products.
Guidehouse Outwit Complexity	Guidehouse	Consultancy	Partner. Responsible for leading the commercial arrangement design and customer engagement workstreams. Supporting on trial design, project management, knowledge dissemination.
octopusenergy	Octopus Energy	Energy supplier and flexibility aggregator	Partner. Responsible for planning and administering the trial with their customers with heat pumps in the National Grid license areas and undertaking data analysis. Octopus

			Energy will also be assisting with commercial arrangement and trial design.
sero	Sero	Energy services provider and flexibility aggregator	Partner. Responsible for planning and administering the trial with their customers with heat pumps in the National Grid license areas and undertaking data analysis. Sero will also be assisting with commercial arrangement and trial design.
ScottishPower	ScottishPower	Energy supplier and flexibility aggregator	Collaborator. A supplier brought on board to ensure interoperability of commercial arrangements and technical integrations. ScottishPower will recruit customers for trials two and three. Responsible for planning and administering the trial with their customers and undertaking data processing. ScottishPower will also be assisting with commercial arrangement and trial design.
passiv	Passiv UK	Smart energy technology company providing digital twin simulations and modelling	Partner. Responsible for simulating the flexibility impacts for different intervention strategies and household archetypes.

West Midlands Combined Authority	West Midlands Combined Authority (WMCA)	Local Government	Partner. Responsible for coordinating a social housing heat pump installation programme which can contribute customers to trials two and three.
Llywodraeth Cymru Welsh Government	Welsh Government	Government	Partner. Responsible for running a social housing heat pump installation programme which can contribute customers to trials two and three.
NEA	National Energy Action (NEA)	Charity	Collaborator. Responsible for running customer focus groups to understand the perceptions of the trials. NEA will ensure that the needs of customers with vulnerabilities are accounted for in the trial design.
SP Energy Networks	SP Energy Networks (SPEN)	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.
ESO	National Grid Electricity System Operator	Electricity System Operator (ESO)	Collaborator. Responsible for sharing learnings between EQUINOX and other ESO flexibility trials, notably the Demand Flexibility Service and Crowdflex.

4. Commercial Arrangements

4.1. Overview of commercial arrangements

As outlined in Section 3.1, EQUINOX aims to develop novel commercial arrangements to maximise participation in domestic DNO flexibility services while meeting the needs of all customers, including those with vulnerabilities. To achieve this, one of the project's workstreams is dedicated to their development. This has identified the elements outlined in Table 4 which should be defined and refined across EQUINOX's three trials.

Table 4: Commercial arrangements elements to be developed throughout EQUINOX

Incentive structure and payment terms	Procurement	Measurement and verification	Use cases and stacking
• Supplier to customer propositions. • Payment structure. • Payment timings. • Conditions of payment.	• Eligible technologies. • Event timings, duration, frequency. • Notice periods for aggregators and customers. • Aggregation requirements.	• Data requirements for participation. • Whether additional measurement technologies are needed. • Baselining customers and calculating flexibility.	• DSO / DNO use cases for flexibility. • Potential for stacking with other flexibility services.

It was decided that 'use cases and stacking' elements would have a greater focus in trials two and three as the DNO use cases for residential low carbon heating flexibility could only be defined once trial one yielded initial results into how much flexibility could be procured from residential low carbon heating assets. The other elements were all integrated into trial one and will be finetuned across trials two and three.

4.2. Trial one commercial arrangements

4.2.1. Guiding principles

We tested two commercial arrangements in trial one, which were developed based on eleven guiding principles, which are detailed below in Table 5. The guiding principles are listed in order of importance as decided by the commercial arrangements workstream, with customer satisfaction being the highest priority in the design of commercial arrangements.

Table 5: Trial one guiding principles

Guiding principle	Description
Customer satisfaction	Customers should trust their supplier and feel empowered to strive for material benefits from the commercial arrangements. Customers should be encouraged to participate through incentives and not anything that could be perceived as punitive.
Measurable impact	Flexibility provided on individual and aggregated household basis needs to be measured to understand micro and macro impacts delivered by the arrangements.
Customers kept safe	Trial one should not put any customers in positions of unsafe living conditions.
Scalable	Commercial arrangements should be scalable across the UK.
Customer comfort	Arrangements should not cause major disruptions to routines or result in large changes in home comfort levels.
Statistically significant results	Trial one should aim for sufficiently large samples across important customer groups (e.g., customers experiencing vulnerabilities).
Simple design	Arrangements should be easy to understand, consistent across customers regardless of localised network impact, and use existing National Grid services (e.g., Flexible Power).
Close reflection of reality	Arrangement design should closely reflect reality to gain insights into realistic customer behaviour. This includes aligning to realistic contractual and procurement arrangements where the network only interacts with the supplier/aggregator.
Transparent	All stakeholders should be open with their thoughts in the design process.
Iterative process	Arrangement designs should be adapted for future trials based on results and customer feedback.
Stakeholder neutral	Arrangement benefits should be spread evenly across stakeholder groups.

These principles drove the design process for trial one and led to multiple high-level decisions which applied across both trial one commercial arrangements.

To meet the **customer satisfaction, scalable, close reflection of reality, and simple design** guiding principles, it was decided that only flexibility from customers with an electricity smart meter operating in smart mode could be procured by suppliers/aggregators. The reasoning was[2]:

- The effort required to estimate the flexibility provided by households without smart meters providing half-hourly readings was deemed too complex, particularly since it would rely on customers providing readings manually both before and after

[2] For more details on reasoning, please see pages 14-15 of EQUINOX's previous report 'Initial Insights on the Effectiveness of Commercial Methods'.

each flexibility event. The reliability of this method could not be guaranteed and would likely have caused inconvenience to customers taking part.

- The burgeoning GB domestic flexibility space is being built on smart meter data from customers. This is a common requirement to other services like National Grid ESO's Demand Flexibility Service (DFS)[3]. Requiring participating customers to have a smart meter is therefore reflective of the reality of domestic flexibility provision.
- The project aligned on not requiring participating households to have any additional equipment installed as part of the trial process such as asset level metering. This was to reduce perceived inconvenience for customers and hence maximise the number of sign-ups to trial one. For this to work, participating households would therefore need to have a smart meter to provide measurable and analysable data, meeting the **measurable impact** guiding principle.

To meet the **simple design and statistically significant results** guiding principles, the only low carbon heating technology directly analysed in trial one was heat pumps, both air-source and ground-source. This is because only heat pumps have sufficiently penetrated the domestic low carbon heating space, providing a large enough pool for Octopus Energy and Sero to recruit from. A requirement for household participation was therefore that they had a working heat pump already installed.

To meet the **simple design and measurable impact** guiding principles, customers signed up to EQUINOX trial one could not participate in any other flexibility trials or services running throughout winter 2022/23, such as Octopus Energy's *Saving Sessions* product for the DFS. The reasoning was:

- Since trial one was a proof of concept for commercial-scale UK demand flexibility from residential heating, the data gathered needed to be as robust as possible. If households were on multiple flexibility schemes at the same time, this could have introduced biases, such as behaviourally prioritising one scheme over the other, which would have made it more difficult to isolate the demand flexibility impact from EQUINOX.
- In its initial winter, the DFS terms of service excluded customers who were already participating in other flexibility market services, such as Constraint Management. Restricting customers in the EQUINOX trial from participating in multiple services was in line with this approach and facilitated a simpler trial design for EQUINOX trial one.

To meet the **close reflection of reality** guiding principle, the Flexible Power platform was used by National Grid to notify Octopus Energy and Sero of upcoming events. Flexible Power is National Grid Electricity Distribution's platform for procuring and managing flexibility provisions in their license areas. This process is described further in Section 5.

4.2.2. Commercial arrangements

While the project Final Submission Pro forma (FSP)[4] proposed three commercial arrangements as shown below in Table 6, trial one was always envisioned to trial two commercial arrangements to keep the design as simple as possible for the proof of concept in the first year. The concepts for M1[5] and M2 in the FSP and the commercial arrangements utilised in trial one were broadly similar. However, the FSP proposed payment by kilowatt hour (kWh) of flexibility provided by customers. It was agreed by the project partners that payment per kWh of flexibility was not the best approach for trial one as discussed in further detail in Section 4.2.4, so customers in trial one were paid for their length of participation regardless of the kWh of flexibility provided.

[3] Source: National Grid ESO.
[4] The FSP was the bid submitted for funding from Ofgem. The document can be found here:
[5] M1 refers to Method 1, a commercial method to unlock flexibility.

Table 6: FSP commercial arrangements

M1 – Save in advance	M2 – Save as you go	M3 – Save in advance & boost as you go
The energy supplier, and in turn the end-customer, receive an upfront flexibility payment in return for offering a fixed, minimum obligation of flexibility.	The energy supplier, and in turn the end-customer, are not committed to a fixed, minimum obligation of flexibility but instead receive payment for the flexibility they provide.	This method is a combination of upfront flexibility payments (M1) and dynamic price signals (M2).

This decision to pay customers based on participation without regard for the kWh of flexibility provided influenced the variables that could be tested by trial one commercial arrangements. A variable that could be tested between groups was the stage at which customers were paid throughout the trial. In trial one, customers could either be paid before or after events. This formed the basis for M1 – save in advance and M2 – save as you go.

The two commercial arrangements designed for trial one, M1 and M2, are summarised in Table 7 below. The trial one commercial arrangement summary can be seen on Page 4 with justification and reasoning in the succeeding pages4.

Table 7: Trial one commercial arrangements

Property	M1 – Save in advance	M2 – Save as you go
Premise	Pre-event payment.	Post-event payment.
Payment structure	Customers were paid **£25 monthly instalments** in advance of that month's events for their assumed participation in them.	Customers were paid **up to £6 per event** after the event **if they participated**.
Fixed vs variable payments	**Fixed** regardless of level of flexibility provided.	**Variable** payment based on length of time heat pump is off (and therefore reliability of participation). *For the first 13 trial one events:* £0 if customer did not participate. £6 if customer participated for 0.5 to 2 hours. *For the final 9 trial one events:* £0 if customer did not participate. £4.50 if customer participated for 0.5 to 1.5 hours. £6 if customer participated for 1.5 to 2 hours.
Payment timing	Customers paid towards the start of the month, credited to monthly electricity bill.	Customers credited to bill weekly/monthly (depending on supplier) after that week/month's events, though participants can still see a breakdown of credit received for each individual event.

Eligible technology	Air source and ground source heat pumps – both customer controlled[6] and aggregator controlled[7], also known as Direct Load Control (DLC).
Event timing	5-7 pm any weekday.
Event duration	2 hours.
Event frequency	2-3 events per week.
Customer notice	Day ahead of events; reminder two – three hours before.
Aggregator notice	Informed by National Grid on Thursday of the following week's events.
Conditions	Continual payment conditional on engagement via participation in events and responding to post-event surveys.

A key aspect of EQUINOX is to design commercial arrangements that unlock flexibility from residential low carbon heating, while meeting the needs of all consumers, including those with vulnerabilities. The trial one commercial arrangements were designed with equity in mind. M1 gave customers with vulnerabilities more flexibility in how they participate, as they could choose whether and for how long they participated in each event while knowing they have already been paid. M2 ensured a £4.50 base payment for participating for only 30 minutes, which was intended to prevent customers with vulnerabilities from keeping their heat pump off too long for comfort and safety while ensuring they could receive meaningful payment for their contribution.

4.2.3. Calibrating trial one customer payments

The payment amounts for both commercial arrangements were calibrated to target all participants earning around £100 across the trial for their event participation. Participants on the M1 arrangement earned £100 by design. For M2, the maximum a participant could earn for full two-hour participation in all 22 trial one events was £132. The £100 target and £6 maximum payment was calibrated based on the following:

- Energy prices over winter 2022/23 were at an all-time high, with the Ofgem price cap set at £3,549 in October 2022, just before trial one was set to start, compared to £1,971 in April 2022[8]. The Energy Price Guarantee was introduced by the UK Government in October 2022 in response to soaring wholesale energy prices and capped unit prices for gas and electricity. The average bill was capped at £2,500 across the duration of trial one[9], so £100 was about 4% of this. The hope was that customers would view this as a not-insignificant sum in return for altering their heating for a maximum of 44 hours.

[6] Customer control: Participating households were required to opt into each flexibility event by turning their heat pump off or down for the event period. They could stop participating at any point during the event. For more details, see page 13 of EQUINOX's previous report 'Initial Insights on the Effectiveness of Commercial Methods'

[7] Aggregator control: The default for participating households was to allow for their heat pump to be turned off directly and remotely by their energy supplier for the event period. Households still had the option to opt-out on a per-event basis. Households under aggregator control could opt out in advance of an event, or at any point during the two-hour event window by informing their supplier. Only a small subset of trial one households had the enabling technology installed for their heat pumps to be aggregator controlled. For more details, see page 13 of EQUINOX's previous report 'Initial Insights on the Effectiveness of Commercial Methods'

[8] Source: Ofgem

[9] Source: UK Government

- The prices set by announced and existing UK and international domestic flexibility schemes helped calibrate payments. The most relevant scheme was National Grid ESO's Demand Flexibility Service (DFS). For *Saving Sessions,* Octopus Energy's product for DFS, a customer could earn up to £100, with customers being paid £3 per 1 kWh of turndown. A heat pump's kWh load will vary across households and models, but across two hours was considered likely to be higher than 1 kWh, so it made sense that the maximum payment was higher for EQUINOX than for *Saving Sessions*'. £100 was also the maximum that could be earned through *Power Move*, OVO Energy's flagship flexibility scheme for winter 2022/23. For more information on these schemes, please see Appendix C: List of Domestic Flexibility Payment Schemes Considered During Development of Trial One Commercial Arrangements.
- As an innovation trial, customer participation was more highly valued than in a BaU market service. The project aims to collect reliable data about quantitative and qualitative aspects of customers' experiences, their home consumption data and information about their homes and installed technologies, meant that it was considered appropriate to reward customers more highly than a stand-alone market service likely could.

4.2.4. Alternative commercial arrangements considered

Several alternative arrangements were considered throughout the trial one design process, based on research of historic and existing UK and international flexibility schemes. The schemes considered are outlined in Appendix C: List of Domestic Flexibility Payment Schemes Considered During Development of Trial One Commercial Arrangements. There were two key alternatives considered for trial one.

Time of Use (ToU) tariff arrangement

The first was a ToU tariff arrangement, which is a pricing plan that prices energy differently depending on the time of day. A ToU tariff is often used to encourage consumers to use electricity at times when it is available at a lower cost. Octopus Energy's Cosy Octopus tariff, specifically for customers with heat pumps, incentivises pre-heating before the morning and evening demands peaks via two periods of lower electricity prices and was launched during trial one. This arrangement was ruled out because EQUINOX aims to introduce event-specific incentives for customers, rather than daily behavioural changes. However, since various trial participants switched to the Cosy tariff during the trial, the impact of ToU tariffs on flexibility provided by residential customers will be explored further in trial two.

Per kWh flexibility payment

The second was a per kWh flexibility payment, whereby customer electricity usage during flexibility events is baselined against their historical consumption and customers are paid per kWh of reduction in their usage during events vs that baseline. This was ruled out for trial one due to concerns around the amount of flexibility that customers could provide with their heat pump and whether or not that would be clear in their smart meter measurements of whole home consumption. Electricity consumption per customer and per day is predictable over an aggregated amount of time or number of customers but can be extremely variable from day to day for one household. If the reduction in consumption generated by a change in heat pump behaviour was negated by an unrelated increase in use of other household appliances, then customers would not receive full reward for carrying out the requested behaviour change. Without knowing that we would consistently see heat pump turndown in the household consumption data it was decided that paying customers directly for their participation was fairer. The decision to not require installation of asset (heat pump) metering in participating households meant that the post-event analysis of flexibility provided was only based on smart meter data covering all household appliances. Considering that:

- This was trial one, and therefore there was no prior data to rely on to convert smart meter readings into accurate estimates of the electricity usage turndown during events attributable to heat pumps being turned off, and;
- Baselining methodologies for calculating turndown from smart meter data at a household level were still nascent in winter 2022/23 and being explored more closely through parallel flexibility trials that winter like DFS.

It was concluded that for trial one, the risk was too high that customers would be unfairly rewarded for the turndown they provided if done so on a per kWh basis. Learnings from trial one and DFS have fed into the design of trial two, where customers *are* being paid per kWh of turndown provided.

4.2.5. Learnings from the trial one design process

The process for trial one commercial arrangement design provided several learnings which the project group recommends for commercial arrangement design within innovation projects across the wider industry. They have also fed into the trial two design.

1. **Review existing innovation and incorporate learnings:** The design process started with a review of existing projects from the UK and abroad related to domestic flexibility, trials at scale, and low carbon heat. It was prudent to draw from existing projects to understand what had already been done and what lessons learned could be applicable to the EQUINOX design. This review informed the design of the commercial arrangements and enabled the project partners to ensure that EQUINOX would be innovative and push boundaries.
2. **Recognise limitations when designing a proof of concept:** The group's assessment of historic and existing domestic flexibility schemes in both the UK and internationally revealed many options for designing a BaU product for commercialising flexibility from domestic low carbon heating. However, it was important to acknowledge contextual limitations when designing the arrangements for trial one. As detailed in sections above, future BaU elements such as paying customer per kWh of flexibility provided were not appropriate in trial one and could only be developed using learnings from trial one itself.
3. **Transparency from partners enables smooth design process:** One of the guiding principles for the design process was transparency from all project partners of preferences, priorities, objectives, and constraints. Through a series of multi-stakeholder ideation and direction setting workshops virtual and in person, followed by detailed planning sessions, were able to understand each partner's goals and limitations and incorporate those into the design, encapsulating the spirit of collaborative innovation.
4. **Agility is key when designing a customer-facing trial:** As detailed above, trial one unfolded to a backdrop of soaring wholesale energy prices which fed through to customer bills. That, alongside a plethora of newly introduced domestic flexibility schemes with different conditions and payment amounts, meant that crucial commercial arrangement elements like payment amounts had to be changed multiple times before the group settled on the final amounts for trial one. Building buffer time into the design process before the trial starts provides a platform for the trial design to be changed with little time to go.
5. **Setting up guiding principles helps guide the design process:** Kicking off the design process by defining and collaboratively ranking the key principles to be followed throughout the process provided the workstream with a great platform to fall back on when it came to making decisions on elements of trial design. For instance, having customer satisfaction and measurable impact as the top two principles ensured that we always checked commercial arrangement design elements against how well they would perform against these two metrics, with additional principles providing further nuance. Reviewing those principles also enabled the identification of focal points for trial two, as detailed in the section below.

4.3. Trial two commercial arrangements

Following the **iterative process** guiding principle, learnings from trial one results fed into the design of the trial two commercial arrangements.

The main learning that emerged from trial one was that customers on trial one's M1 arrangement (save in advance, monthly payments) participated less reliably compared to customers on trial one's M2 arrangement (save as you go, payments per event), although the amount of turndown provided per participating customer was similar. Therefore, the decision was made to pay

customers exclusively per event in trial two. This change opened up the possibility to investigate other variables and aligned EQUINOX with other flexibility products across the industry.

Other learnings from trial one relevant to commercial arrangements related to event length, event frequency, notice periods, and payment amounts. The majority of participants in trial one felt a two-hour event was acceptable, as was up to three events a week. Therefore, these two elements were retained for trial two. The majority of trial one participants also felt that receiving day-ahead notice of an event worked well, but notice periods have been designed to vary in trial two as this is a key variable that must be tested to gauge the ability of customers to provide flexibility in line with the parameters of existing DNO flexibility services and network needs. Most customers in trial one were satisfied with payment amounts, but many indicated that environmental motivators were equally, if not more, important than financial motivators as reasons to participate in the trial[10].

4.3.1. Guiding principles

The design process for trial two commercial arrangements began with a review of the trial one guiding principles in Table 5. The review consisted of an evaluation of how well each guiding principle was adhered to in trial one and whether it would still be relevant for trial two, followed by a brainstorm for additional principles that might be relevant for trial two. When evaluating how well each guiding principle was adhered to in trial one as seen below in the third column, a rating of either 'well', 'somewhat', or 'not well' was given followed by an explanation for the rating in the next column.

All eleven guiding principles from trial one were retained, and one new principle centred on ambition was added as shown below in Table 8. Given the successes of trial one and that EQUINOX is a first of a kind project that will answer key questions on how DNOs can help decarbonise heat in the most cost-efficient manner for customers, the project partners agreed that trials two and three should be even more ambitious and innovative, in an effort to continue to push boundaries.

Table 8: Trial two guiding principles and evaluation of how well principles were followed in trial one

Guiding principle	Description	Evaluation	Explanation
Customer satisfaction	Customers should trust the supplier and feel empowered to strive for material benefits from the arrangements.	**Well**	Customer feedback showed satisfaction with trial.
Measurable impact	Flexibility provided on individual and aggregated household basis needs to be measured to understand micro and macro impacts delivered by the arrangements.	**Well**	Issues encountered are ones seen at national scale, EQUINOX is still pushing boundaries.
Customers kept safe	No trials will put any customers in positions of unsafe living conditions.	**Well**	Customers were kept safe.
Scalable	Commercial arrangements should be scalable across the UK as Business as Usual (BaU).	**Somewhat**	Payment method scalable, but further information is needed on price sensitivity.

[10] For more in-depth information about trial one results, please see EQUINOX's previous report 'Initial Insights on the Effectiveness of Commercial Methods'.

Customer comfort	Arrangements should deliver a fair alteration in home comfort levels.	**Well**	Two-hour period did not cause significant discomfort based on customer feedback.
Statistically significant results	Sufficiently large samples across important customer groups (e.g., customers with vulnerabilities).	**Somewhat**	Believed to be a fair representation of heat pump owner population, but this group are not themselves representative of the UK population.
Simple design	Arrangements should be easy to understand, consistent across all customers regardless of localised network impact, and use existing National Grid services (e.g., Flexible Power).	**Somewhat**	Went well in context of trial, somewhat well in overall scheme of themes. Simplest design is provide flexibility, get paid. Other logistics should be captured separately.
Close reflection of reality	Arrangement design should closely reflect reality to gain insights into realistic customer behaviour.	**Somewhat**	Customer change required reflected reality, but a balance was struck to prioritise trial outcomes and learnings rather than adhering to current market conditions for payments. Reality might not look too different a few years from now, but hard to say in ten years.
Transparent	All stakeholders should be open with their thoughts in the design process.	**Well**	All consortium parties communicated well and collaborated to reach successful compromise where there were differences in approach.
Iterative process	Adapt arrangement designs based on results and customer feedback.	**Well**	Good iteration between trials, including addition of semi-formal stage gates for proceedings of trial two.
Stakeholder neutral	Arrangement benefits should be spread evenly across stakeholder groups.	**Somewhat**	Although not appropriate within the innovation context, stakeholder neutrality would be achieved in a business as usual proposition with these trial principals as a market service.
Ambitious	Trial should be ambitious, innovative, and push boundaries.	**N/A**	New guiding principle for trial two.

4.3.2. Aims

With trial one proving a successful proof of concept for commercial-scale UK demand flexibility from residential low carbon heating, the aim of trial two is to investigate more specific variables as shown below in Table 9, and build on trial one learnings to design commercial arrangements that more closely reflect a potential future BaU product.

Table 9: Variables being tested in trial two

Variable	Description	Justification
Notice period	Customers will receive varied notice periods that align with different DNO flexibility services.	This enables testing of shorter notice flexibility services, which are more valuable to the DNO and to the supplier/customer.
Payment method	Customers will be paid per kWh of turndown provided. They will also be paid more for their flexibility response when given shorter notice.	This brings EQUINOX in line with other BaU DNO flexibility services and builds on successes from trial one.
Time of day	Events will still last two hours but could be scheduled any time between 4-8 pm.	This is to test how flexibility procurement from low carbon heating varies across DNOs' overall evening peak demand period.

4.3.3. Commercial arrangements

Trial two is testing three commercial arrangements, M1, M2, and M3, as shown in Table 10 below.

Table 10: Trial two commercial arrangements

Property	M1	M2	M3
Premise	High utilisation payment (per kWh).	Low utilisation payment (per kWh).	Availability payment + medium utilisation payment (per kWh).
Payment structure	Day ahead: £0.80/kWh. Morning ahead: £1.60/kWh. 2 hours ahead: £2.40/kWh.	Day ahead: £0.40/kWh. Morning ahead: £0.80/kWh. 2 hours ahead: £1.20/kWh.	Day ahead: £0.50/kWh. Morning ahead: £1.00/kWh. No notice: £1.50/kWh. Availability payment: £8 upfront.
Eligible technology	Air source and ground source heat pumps – both customer controlled and aggregator controlled.		Ground source heat pumps – aggregator controlled only[11].
Fixed vs variable	Variable based on kWh of turndown.		

[11] Only Sero households have the requisite technology to trial no-notice events.

Payment timing	Varies by supplier.	
Event timing	Between 4-8 pm any weekday.	
Event duration	2 hours	
Event frequency	2-3 events per week	
Customer notice	Day ahead, morning ahead, two hours ahead	Day ahead, morning ahead, no notice
Aggregator / Supplier notice	Informed by National Grid on Wednesday of the following week's events	
Conditions	Continual payment conditional on engagement via participation in events and responding to post-event surveys. No limitation on customer tariff, fair usage limit communicated in Terms and Conditions to avoid discourage gaming and to-fairly reward customers to only alter their heating appliances during events.	

4.3.4. Key changes from trial one

Trial two commercial arrangements differ from trial one commercial arrangements in three key ways.

- **Payment per kWh**: trial one paid customers a fixed amount for participating in the trial (trial one M1) or in each event (trial one M2), while trial two pays customers per kWh of turndown provided in each event. This change aligns with how suppliers are paid for their flexibility in BaU and tests a direct relationship between supplier pay and customer pay. While making the payment amounts dependent on kWh of turndown provided may impact participation, it is essential to test this for DNOs gather information on the provision of domestic flexibility at different price points.
- **Payment by notice period**: trial one provided notice of events to customers about 24 hours in advance, while trial two is testing different notice periods and paying customers more per kWh for less advance notice of events. This change allows investigation into how customers respond to different notice periods, as in BaU DNOs procure flexibility through market products that have different notice periods to support different network needs. This will therefore reveal for which existing flexibility product(s) residential low carbon heating flexibility is most appropriate. The group of customers on trial two M3 consent to experiencing events with no notice period. In future, more households are expected to have heat pumps enabled for aggregator control and it is relevant for DNOs and suppliers to understand what issues customers may have with this, if any, and whether more or less flexibility is available from these automated appliances compared to those requiring customer input.
- **Increased Focus on Aggregator Control**: trial two arrangement M3 is exclusively for households with heat pumps capable of being aggregator controlled. All M3 households will be Sero customers, recruited from housing developments with the same controllable model of ground source heat pump. With more households expected to have heat pumps enabled for aggregator control in future, this uniformity in sample presents an opportunity to further test variables such as no notice period for events and optimise elements like hot water settings.

4.3.5. Calibrating trial two customer payments

The first step for calibrating the per kWh payments for customers in the trial two commercial arrangements was to convert the trial one payment results into per kWh payments. These calculations are outlined in Table 11, demonstrating that the average trial one M1 and M2 customers received £3.27 per kWh and £3.61 per kWh, respectively.

Table 11: Calculating payment per kWh for trial one (participants per event)

Property	M1 – Save in advance	M2 – Save as you go
Average trial one payment per customer	£100	£116.74
Average event turndown per customer[12]	1.39 kWh	1.47 kWh
Average trial turndown (across 22 events)	30.57 kWh	32.37 kWh
Payment per kWh	£3.27/kWh	£3.61/kWh

As shown in Figure 2, these trial one M1 and M2 payments are significantly higher than the average 2023 ceiling prices for National Grid's Secure, Dynamic, and Sustain flexibility products. They are only on par with the very highest payments for Secure and Dynamic.

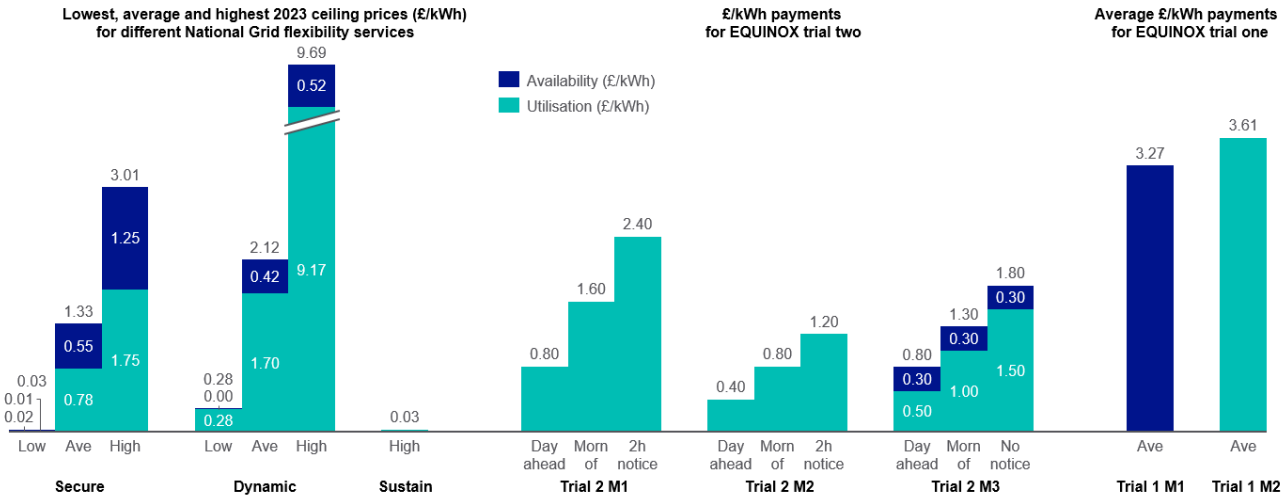

Figure 2: Comparison of the 2023 ceiling prices for National Grid's Secure, Dynamic, and Sustain flexibility services with the trial one and trial two payments from aggregators to customers.

In light of the high levels of customer participation in trial one and in order to test more market-realistic commercial arrangements (moving further away from rewarding customers predominantly for their participation, trial two's commercial arrangements adjust the payment amounts to test alignment with National Grid's existing flexibility services. As Figure 2 shows,

[12]This figure accounts for trial participants that did not opt into particular events.

the trial two payments have therefore been calibrated to be closer to the average Secure and Dynamic payments. The trial two M2 payments are half as large as the trial two M1 payments, enabling learnings as to whether the lower amount is still considered by domestic customers as sufficient incentive to participate in the trial.

The trial two M3 payments include an availability payment to reward customers in advance for being willing to be dispatched by their aggregator with no prior notice. This £8 upfront payment evens out to a per kWh availability payment of £0.30 per kWh, assuming that the customer provides 1.43 kWh of turndown per event. The utilisation payments were calibrated such that the total per kWh payment for a trial two M3 customer would be approximately halfway between a trial two M1 and trial two M2 payment.

Trial two results will indicate which standard DNO flexibility services residential low carbon heating flexibility could be most suitable for (see Section 6 for details on these), or whether new ones will need to be developed. This will reveal the DNO use cases for which such flexibility is most appropriate. Furthermore, National Grid will at the end of the trial provide the participating suppliers with dummy kWh flexibility target values that they would have wished to receive for each event. The suppliers can use trial two results to validate and refine their assumptions on how many and which households they would have procured flexibility from to meet National Grid's targets.

Combining learnings from these two elements will help continue the development of commercial heads of terms between National Grid and aggregators for trial three.

4.3.6. Learnings from the trial two design process

The design process for trial two had the clear starting point of reflecting on trial one and identifying what worked well and what should change. It was important for the workstream to align on priorities up front to avoid rework throughout the process. A continuing challenge during trial two design was balancing ambition with practicality. Due to the success of trial one and questions that emerged from analysis, there was appetite to test multiple variables in trial two. However, it was important to consider customer experience at the forefront and develop something that was not too different from trial one but still showed considerable progress towards a BaU solution. This meant identifying which variables would be feasible to test in trial two and which ones would have to wait until trial three, such as opportunities for stacking different domestic flexibility services to enable customers to participate in other schemes in addition to EQUINOX.

Trial two's design process also effectively incorporated learnings from other trials, such as learnings related to baselining customer turndown from the DFS.

4.4. Next steps

Trial two began in November 2023. The project will collect early feedback from customers before a break in events from mid-December 2023 to early January 2024. Depending on the feedback received, the commercial arrangements detailed in Section 4.3.3 may be tweaked for the resumption of events in the new year.

Trial three of EQUINOX will take place in winter 2024-2025. Analysis of trial two results will enable the project team to consider what changes are needed to the commercial arrangements to support the development of a BaU product in trial three. This will include a better understanding of which of National Grid's four existing flexibility products a residential low carbon heating flexibility product would be most closely aligned to, investigating opportunities for stacking domestic flexibility services, and defining commercial heads of terms between the DSO / DNO and supplier.

The final BaU commercial arrangements will be published in the sixth project deliverable, 'Recommended transition of learning to BaU,' towards the end of 2025.

5. Background to Flexibility Procurement

National Grid Electricity Distribution procures flexibility through its Flexible Power platform. To ensure that the project is well aligned to our business and set up for BaU rollout following completion of the project, EQUINOX is also making use of the platform during the trial periods. This section highlights an overview of what process are put in place within Flexible Power in addition to the requirements needed in order to integrate with Flexibility Service Providers (FSPs).

The Flexible Power platform hosts the ability for FSPs to contract into delivering flexibility to not only National Grid but also other DNOs that include Scottish and Southern Electricity Networks (SSEN), SP Energy Networks (SPEN) and Northern Powergrid (NPg).

In order to achieve this, FSPs must be able to deliver their contracted flexibility within Constraint Management Zones (CMZs). These are constraints that have been identified on the electricity distribution network that are confined to specific geographical locations and can be observed on the locations map[13] on the Flexible Power website.

Flexibility requirements are published on a six monthly basis and provide details of the CMZs that include the time of day and time of year that flexibility services are needed in addition to an indicative forecast of the aggregated MWh requirement that is needed within the specified window. Said windows are generally seasonal in order to aid with constraints observed during the summer and winter.

DNOs procure flexibility in alignment with the services described in the ENA's Open Network (ON) Project DSO ON Service Definitions document. Four services have been developed by the ENA where each cater to different network requirements. The services are described below.

Sustain Service - Scheduled Constraint Management

The Sustain service is used to manage peak demand loading on the network and pre-emptively reduce network loading. The requirement windows for provision of these services will be scheduled and fixed at the point of contract.

Secure Service - Pre-Fault Constraint Management

The Secure service is used to manage peak demand loading on the network and pre-emptively reduce network loading.

Secure requirements are declared a week-ahead each Thursday for the following week (commencing Monday). Payments consist of a fee which is credited when the service is scheduled and a further utilisation payment awarded on delivery.

Dynamic Service - Post-Fault Constraint Management

The Dynamic service has been developed to support the network in the event of specific fault conditions, often during summer maintenance work.

As the service is required following a network fault, it consists of an Availability and Utilisation fee. By accepting an Availability fee, participants are expected to be ready to respond to Utilisation calls within 15 minutes. Dynamic availability windows are declared a week-ahead each Thursday for the following week (commencing Monday).

Restore Service – Restoration Support Management

The Restore service is intended to help with restoration following rare fault conditions. Such events are rare and offer no warning as they depend on failure of assets. Under such circumstances, response can be used to reduce the stress on the network.

[13] Locations (flexiblepower.co.uk)

As the requirement is inherently unpredictable, Restore is based on a premium 'utilisation only' service. This will reward response that aids network restoration, but will pay no arming or availability fees. Participants declared available for the Restore service will be expected to respond to any utilisation calls within 15 minutes and will receive an associated utilisation fee.

Provider Qualification

For an FSP to dispatch their flexibility through Flexible Power, there are firstly a number of qualifications that need to be met need to meet before they can be on boarded and provide a service. The two main qualifications they need to meet are centred on commercial and technical requirements. The reasoning for this qualification stage is to enable FSPs to become eligible to trade; through completing the Periodic Indicative Notice (PIN) response, Pre-Qualification Questionnaire (PQQ) agreeing to the Flexibility Service Agreement[14], building asset groupings and the necessary technical arrangements, such as Application Programming Interface (API) links. They can be seen in Figure *3* below.

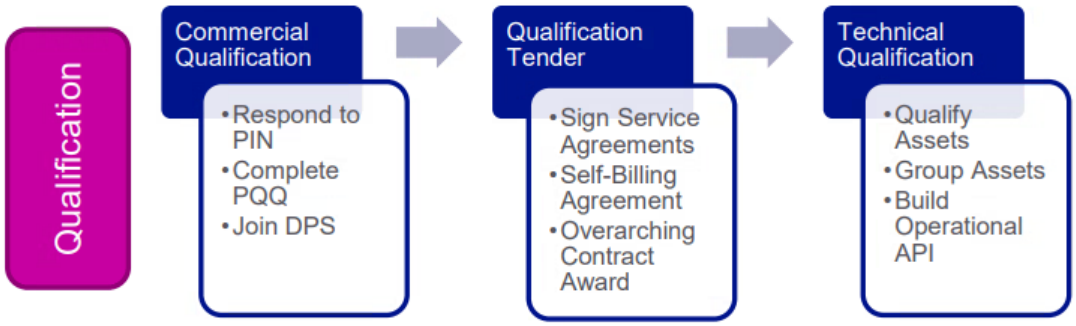

Figure 3 Flexible Power qualification process overview

The process that surrounds the commercial qualification for providing flexibility to National Grid adhere to current UK procurement regulations and is facilitate through the Market Gateway[15]. National Grid's Market Gateway is used for facilitating FSPs into its electricity distribution flexibility programme. Here, parties wishing to provide flexibility services can:

- Complete commercial pre-qualification requirements.
- Receive an Overarching Contract enabling participation in Trade Opportunities.
- Register assets for participation in Trade Opportunities.
- Complete the pre-Trade Technical Requirements needed for the delivery of services.
- Participate in Trade Opportunities for the provision of flexibility services.

In order to access the Market Gateway, an account needs to be created. This is done in order to achieve a low barrier route for FSPs to qualify for a flexibility contract. Once an overarching contract is awarded, the FSP can continue to complete the technical qualification.

Commercial Qualification

The first process of the commercial qualification is the completing the PIN response. This is a type of expression of interest to provide flexibility services and does not commit either party to provide demand response services. Following completion of the

[14] ENA Standard Agreement V1.2_NGED_IMPLEMENTATION_V2 (1).pdf
[15] https://marketgateway.nationalgrid.co.uk/help-and-guidance

PIN, FSPs are required to complete a PQQ on the market gateway. This is where the minimum requirements for offering flexibility services must be met by the FSP that includes a commitment to build an API, provide the ability to send metering data over the API and have Asset(s) that can respond to a dispatch signal within 15 minutes of being notified and with a minimum response of 30 minutes.

Qualification Tender

Once the Commercial Qualification has been completed, an FSP is then able to progress to the Qualification Tender stage. This must be completed in order to receive a contract and FSPs will be required to agree the Flexibility Service Agreement, which breaks down the service terms, trading rules, special requirements and general terms and conditions. The final details the FSP has to carry out is to accept a Self-Billing Agreement, an agreement that allows Flexible Power to raise invoices on a FSPs behalf and complete a supplier details form. This form is used to receive billing information from the FSP.

Technical Qualification

Following completion of the Qualification Tender Stage, the last process commences with the Technical Qualification. This is a stage where an assessment is made to see if a FSP is viable to make trades within Flexible Power. Assets that will carry out response services will be required to be registered, validated and grouped. The required information needed to register an asset can be seen below:

- Asset Location
- Asset MPAN / MSID
- Asset / Technology Type
- Asset capacity in peak MW

An additional requirement is for an API to be built between the FSP and Flexible Power. This allows the start and stop dispatch signals to be received between the two parties and permits a route for metering data to be sent back to Flexible Power for settlement purposes. Flexible Power uses a wide range of assets to use flexibility services that include:

- A grid scale battery
- A single generator (if using DER Level metering)
- Multiple generators (if using Point of Connection metering)
- Individual EV charge points
- Associated Low Carbon Technologies

Meterable Units

Once Assets have been approved, they need to be assigned into logical groups. Meterable Units (MU) are the logical groups and allow the grouping of assets into a joint metering feed and can be created and edited on the Market Gateway. For each Meterable Unit, The FSP has to create a metering API. Pricing, availability and settlement are carried out at this level and it is the place where baselining is applied. It is possible for a range of Meterable Units to be combined into a trade response that ensures the risk around delivery is shared across them. The logical grouping or Meterable Units in a Trade Response can be referred to as Trade Dispatch Groups. The links between Assets, Meterable Units and Trade Responses as shown in the figure 4 below.

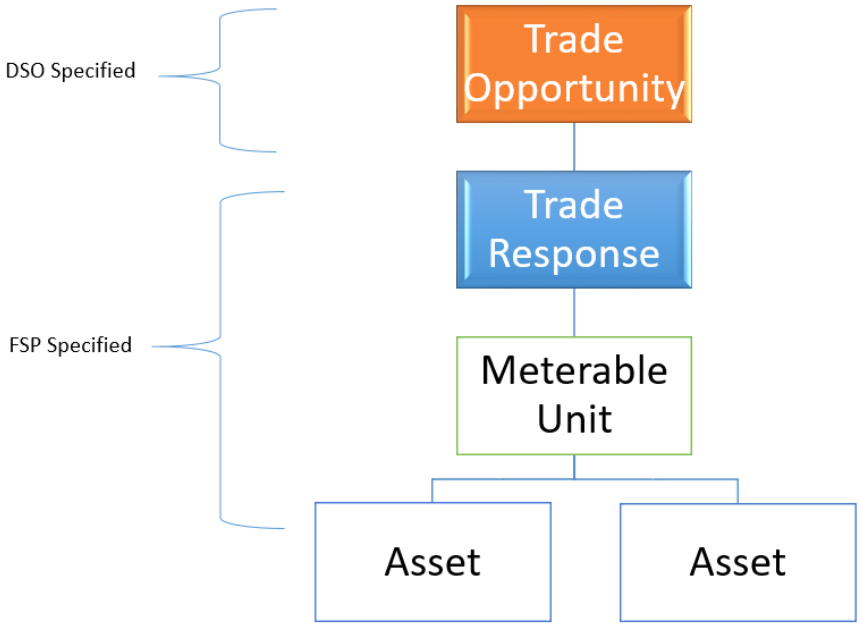

Figure 4: Linkage between asset(s), meterable units, and trade responses

Flexible Power APIs

An Application Programming Interface (API) is a software intermediary that allows two applications to talk to each other. The API removes the requirement for dedicated DSO hardware to be connected at an FSP site in order to collect the metering data and receive instructions from a DSOs control systems. There are a large variety of DER control arrangements, ranging from a single asset such as a standalone generator through to a complex estate with multiple assets or even part of a portfolio under management by a commercial aggregator. Therefore, FSPs are required to implement their own interface for the API to their DER control. The Flexible Power API covers three key areas:

- The collection of metering from the FSP to the DSO via the readings API. This is built of two sub APIs to collect either minute by minute or half hourly metering data. This needs to be built out per MU.
- The sending of Utilisation Instructions from the DSO to the FSP via the Dispatch API. This needs to be built out per Trade Dispatch Group. Within the signal it will detail the component MU IDs.
- The sending of an Emergency Stop from the FSP to the DSO via the Stop API. This is implemented at MU level.

Initially the FSP will be set up with just access to the Sandbox zone. This will allow them understand how the portal works and to test the APIs without any impact on the live zones. A number of tools are provided within the portal to enable self-testing of the API. This include the ability to send simulated Dispatches and see the latest metering signals being received by the portal. Once a Meterable Unit has been created, an associated Meterable Unit will be created on the Flexible Power Operational Portal. At this stage the MU IDs will be available for the FSP to set up their APIs. A Trade Dispatch Group will only be awarded post Tender Award. A Meterable Unit will be considered ready for trades, once we can determine that the FSP can send data to it. We determine this as once we have seen at least 12 meter readings within the last seven days.

Settlement

Each Product is subject to specific payment mechanics. These are designed to encourage full delivery, whilst balancing the level of penalties to ensure the service provision remains attractive. Payments are made up of a combination of an Availability payment and/or a Utilisation payment, each product has a mechanism for clawing back under delivery. The Utilisation payments are assessed on a per metering period basis. There is a Grace Factor, in which delivery is assumed at 100%.

If the output is below this value then a proportion of the payment is removed for every percent of under-delivery. The Penalisation Multiplier determines this proportion. Availability Payments are based on delivery across the month. This looks at the delivery percentage across the different events and calculates a Monthly Delivery Proportion using capped averages (the maximum delivery in any event is 100%). These are only used for the Secure and Dynamic products. The calculation of performance and payments is carried out in the Flexible Power Operational Portal.

The Flexible Power Operational Portal is used to collect metering data. This is used to monitor and pay for delivery. After the end of each event a performance report and earning statement is created on the Flexible Power Operational Portal. This allows FSPs to review their results per event. Examples can be found on the Flexible Power Website. At the end of the month the performance reports are compiled along with the availability payments and reconciliations for any shortfall of delivery into an invoice. A provisional invoice will be produced on the 1st of every month. The FSP then has 14 days to raise any queries. If no query is raised within the 14 day window, the portal will generate a final 'Self-Billing' invoice which can be downloaded for financial records. This is processed by the DSO for payment. The payment terms for the invoice is 60 days.

6. Technical Integration

6.1. Trial One

6.1.1. Aims and Goals

As trial one represented the first of three planned winter trials, it provided the first opportunity to trial the technical integration methods developed and used by EQUINOX to see how effective the process was. The fundamental basis for trial one was simplicity. As the process had never been carried out before, and the forecasted trial participant numbers were relatively low it was used to build learning to support the two additional trials.

Prior to the first trial, it was identified that the best approach was to use the existing capabilities of Flexible Power in order to deliver heat pump flexibility. By adopting Flexible Power as the platform for the first trial, there would be no unnecessary expense carried by the project to develop a platform that would duplicate Flexible Power, and it ensures that work done by the project aligns to our BaU flexibility procurement methods.

On the supplier side, Octopus Energy were already a user of Flexible Power and were making use of their Kraken Flex platform with this. Using the Kraken Flex platform for EQUINOX also limited the additional development work needed and avoided unneeded duplication. There were elements that were developed to link the end-to-end process for EQUINOX including the creation of the API for Sero and signalling testing which are outlined later in this document.

The additional supplier involved in trial one was Sero. Unlike Octopus Energy, they were not using Flexible Power prior to the beginning of trial one. The same work as Octopus Energy was needed but with additional focus on how their home management system would be integrated and operate during the trial. All Sero participants were controlled remotely, so there was an added focus with this due to the autonomous nature that would occur during the trial. This is further detailed later in the document.

Although the EQUINOX trials are utilising the BaU platform of Flexible Power, the Flexibility Standard Agreement[14] has been bypassed in this case due to the nature of running the trials and is not seen as a BaU operation. There are no underlying reasons why suppliers would not be able offer flexibility services due to the standard agreement. After all, one of the three energy suppliers currently offer their services within the BaU environment already. In a real day to day setting, it is an element that suppliers would need to agree to in order to provide their flexibility services.

Both suppliers did have to create an account within Flexible Power and build their API so that the dispatch signals could be received correctly. The high level flow for Flexible Power can be seen below. Events for the proceeding week were discussed and chosen and confirmed each Thursday. Once scheduled, the suppliers were made aware of when the event days were. Fifteen minutes before the event was set to commence, a notification was sent to each supplier to be ready to deliver their services. 15 minutes after this, a notification to start was sent and two hours later a command to stop was also sent, shown in Figure 5.

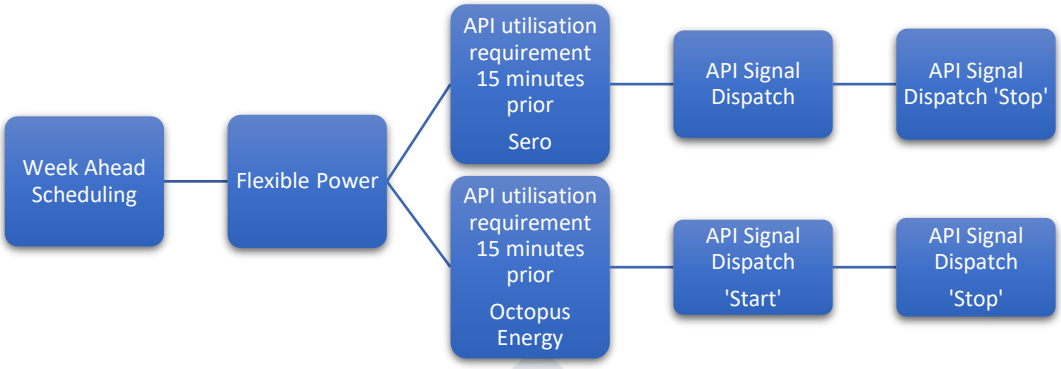

Figure 5 Flexible High level flow diagram.

The fundamental developments that were needed prior to trial one beginning from the DNO to the supplier were thus:

- Flexible Power account creation
- API Build
- Start and end signal confirmation
- Full end to end Testing

The first trial period started on 13th December 2022, so the project team were mindful to have tested and have everything in place prior to having any form of participant involved. Testing took place for both suppliers and comprised of simple verification of the API signals to full end-to-end testing. As Octopus were utilising their existing Kraken Flex platform, a process that they use already within Flexible Power, only validation of this was required. This was also duplicated for Sero but with added testing on their developments that were carried out in the lead up to trial one. Testing took place within the first two weeks of December 2022. The process for this was to observe the signals being received by each supplier via an organised virtual meeting and completion of test books and plans. Further details of the trial one testing can be observed in Appendix D.

6.1.2. Technical Specification Overview - Octopus Energy

The following information provides an overview of the technical integration between DNO and supplier, and between supplier and customers for Octopus Energy for trial one.

Customer cohorts

Octopus Energy Customers were split into two commercial arrangements, Pay as you go ("pay per event") and Pay in advance ("pay monthly"). Customer recruitment was carried out in a two stage process, registration of interest and then agreeing to relevant T&C, depending on whether a customer was eligible for aggregator control of their heat pump during the trial. Customers were split equally and randomly between the two commercial arrangements after the registration of interest stage, though there was a lower number of conversions to full onboarding in the Pay per event group, resulting in unequal final numbers for each group:

Pay per event:	174 customers
Pay monthly:	193 customers

Customer technology type "aggregator control" represented a small number of customers and was not split between commercial arrangements, with all "aggregator control" customers placed in the Pay monthly group.

All customers had heat pumps as their main source of home heating, smart meters reporting home electricity consumption at half-hourly granularity and were located withing the National Grid distribution area. Customers were additionally rewarded for their participation in trial surveys, interviews and focus groups, but were not permitted to participate in the NGESO Demand Flexibility Service (DFS). This was notable for Octopus Energy customers in particular as the Octopus Energy DFS product, Saving Sessions, was heavily marketed to a customer base that would otherwise have included EQUINOX participants. Customers were permitted to choose between EQUINOX and Saving Sessions (or other DFS products) but were not permitted to rejoin EQUINOX if they exited the trial.

Customer technologies

Customer technology was initially captured in two groups, "customer control" and "aggregator control". The majority of Octopus Energy customers in EQUINOX trial one fell into the "customer control" group. As the trial proceeded and information was

gathered from customers, it became clear that there were was a further distinction to be made within the "customer control" group, separating out customers as "customer control – at home" vs "customer control – app control".

Customer control- at home

These customers were unable (or unwilling) to control their home heating settings remotely and someone had to be physically present in the home in order to change the heating settings or turn the heat pump on or off. From feedback in trial one, we know that this home control could range from a central thermostat to individual thermostatic controls on radiators in each room. As well as being home when an EQUINOX event starts, someone had to be at home when the EQUINOX event ended, in order to put the heating settings back to the desired temperature.

Customer control- app control

Remaining in full control of their own heating, this group of customers were able to change the settings on their heating while they were away from home, typically via a mobile app. This could, but did not always, include setting schedules in advance so that their heating would automatically turn down for an EQUINOX event. Customers used a range of commercially available technologies for this approach, including both manufacturers' controls and third party systems. These customers experience an increased convenience in carrying out EQUINOX events, as comparted to the "manual control" group.

Aggregator control

In the aggregator control group, customers agreed to third party control of their heat pump, which was limited to enacting EQUINOX events. In this case, the third party was their energy supplier (Octopus Energy), in other scenarios, aggregator control could be provided by a third party other than their energy supplier.

Aggregator control customers retained override capabilities during EQUINOX events and furthermore could opt-out of events in advance if they did not want to participate in a particular EQUINOX event for any reason. Independently of whether or not the third party was automating the day-to-day scheduling of their heat pump, these customers had the convenience of not needing to act in order to participate in each EQUINOX event. It is thought that this increased convenience may have facilitated additional participation in EQUINOX events across the trial period, though the sample size was too small to be conclusive.

Technical performance requirements

To facilitate participant engagement at the scale of up to 1000 customers, existing customer management solutions within Octopus Energy were used to create bulk, personalised emails and to collect customer feedback and information through surveys. Customer-initiated contact came through the normal customer support channels (phone, email, socials) and was handled by Energy Specialists with prior knowledge of the project.

Customer invitations and on boarding to the project happened in this way, supported by resources hosted on the Octopus Energy website, including FAQs and Terms and Conditions for the project. Data management for customers on boarded to the EQUINOX trial was handled by an in-house Data Science team. Customer withdrawal from the project could be initiated through any of the normal customer support channels and was enacted manually, removing the customer from further trial messaging and trial data collection. Separation of withdrawn customers' data from trial results was enacted manually, in accordance with GDPR best practice. As part of this process, customers onboarded to EQUINOX trial one were marked ineligible for other demand flexibility services and did not receive direct invitations to participate in Octopus Energy's Saving Sessions product (part of ESO's DFS product).

Customers with eligible heat pump models were additionally invited to participate in EQUINOX as part of the Aggregator control technology group. Automation of EQUINOX events for these customers was managed by Octopus Energy's Kraken platform, via the Octopus heat pump control product. Interested customers were able to onboard for this service via the Octopus Energy website and once registered, were manually assigned to the EQUINOX trial. Customer support was provided by Product Specialists as well as by Energy Specialists with prior knowledge of the project.

EQUINOX event operations

EQUINOX events were initiated by National Grid via the Flexible Power platform, a business as usual (BaU) system for DNO procurement of demand flexibility. Octopus Energy's Kraken platform used the existing API connection to Flexible Power to receive dispatch signals immediately preceding EQUINOX events, initiating automated turn off for registered Aggregator control group of heat pumps for the indicated event period.

All other customers, in both of the customer control groups, did not receive automated intervention. Heat pump turndown/turn off for these groups was enacted by each customer, in accordance to their own preferences and the particulars of their own heating system. For both commercial arrangements, customers in all technology groups were notified in advance of an event by email.

At the end of an EQUINOX event, all customers received an email with a link to the post-event survey, which asked customers to report on their comfort during the event and their length of participation.

Customer settlement

In the Pay monthly commercial arrangement, customers were paid credits to their Octopus Energy account towards the beginning of each winter month, in advance of subsequent events.

Customers in the Pay per event commercial arrangement were paid credits into their accounts following each event, depending on their length (of time) of participation in the event. Customer participation was largely self-reported and based on feedback for the post-event surveys.

All customer settlements were carried out within existing systems on Octopus Energy's Kraken platform.

High level architecture diagram for EQUINOX events

Figure 6 below shows the data flows between NGED, Octopus Energy and the customer and an overview of the technical architecture for Octopus Energy customers participating in the Aggregator control technology type in EQUINOX trail one.

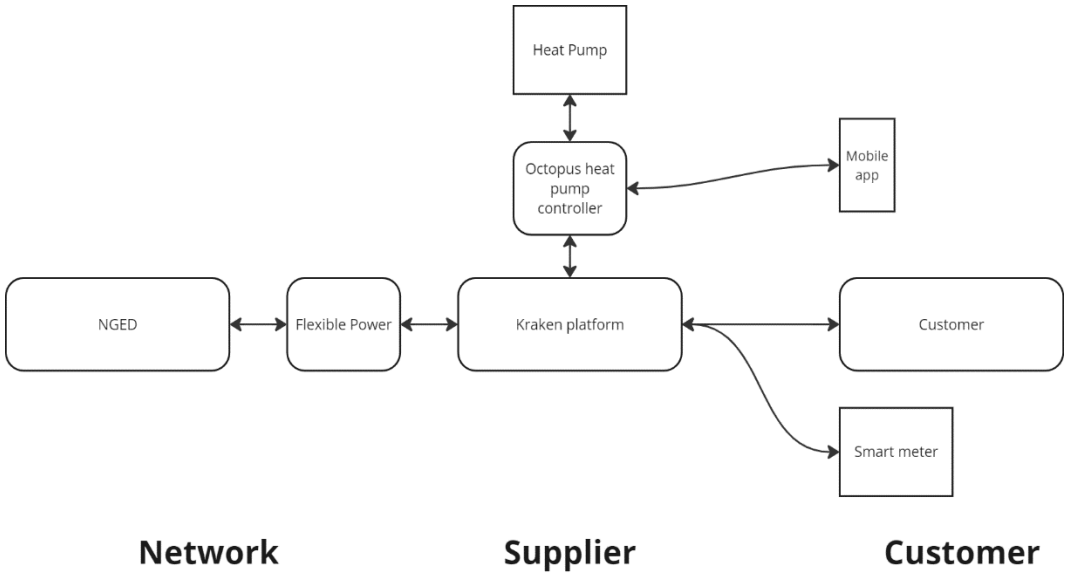

Figure 6 Octopus Energy high-level data flow

Utilising BaU systems in order to mimic market conditions wherever possible, flexibility signals were initiated by NGED via the Flexible Power platform, sending a dispatch signal to Octopus Energy's Kraken platform and indicating the particulars of an event. Within the Kraken platform, an event dispatch was enacted via the Octopus heat pump controller, turning down the status of that device to "off", for the event period. Customers could view this change on their mobile app and could enact an override during the event via controls in the app or on the home thermostat. At the end of an event period, each device as returned to its pre-event status, "on".

6.1.3. Technical Specification Overview - Sero

The following sections provide an overview of the technical integration between DNO and supplier and between supplier and customers for Sero controlled homes for trial one.

Background & Assumptions

Sero's role in EQUINOX is to link their participating homes which can facilitate heat pumps being remotely switched on and off during the trial, to effect remote switching, to manage the customer experience, and to provide operational and behavioural data to illustrate results. For trial one, key understandings and assumptions included:

- Three events occurred each week during the pilot, each switching heat pumps off from 5pm – 7pm for all participating homes.
- There was a pre-trial phase in November, which allowed testing of the operational process with a smaller number of homes.
- Each Wednesday a meeting determined the switching schedule for the coming week and that was communicated to Sero by email from NGED.
- In the interests of not prejudicing the behavioural response to switching, the schedule for the week was not communicated to residents in advance
- On-the-day event notification was received from NGED through the Flexible Power Platform, and occurred up to 15 minutes before a switch was required. Sero requested that this be made at least two hours prior to accommodate any manually instantiated switching necessary.
- Sero provided both a manually instantiated as well as programmatically instantiated remote switching, in order to accommodate any automated system failure or to effect and override.
- It was possible for a resident to opt out of an individual switching event. The proposal was calling the Sero Help Desk during the trial.
- "Off" meant switching the heat pump off, rather than issuing a command to power down.
- Sero did not make any mitigating adjustments to the resident's heating schedule to offset the potential effects of the switch off (such as pre-loading the hot water tank or boosting heating).

The purpose of this section is to lay out the technical and operational methodology through which Sero achieved remote switching of heat pumps as part of the Direct Load Control Save as You Go elements of the first trial of the EQUINOX project as portrayed in Table 7. Key outcomes that are discussed below are the approach, event notifications and instruction flow, mitigation plans that were placed for manual intervention and residential opt outs.

Participating Properties

Sero initially proposed to recruit households from their implementation at Parc Eirin, near Cardiff, where residents are accustomed to living with a heat pump-enabled property managed by Sero. However, these properties operate a Sero Building Energy Engine (BEE) developed in partnership with a third party and the timescales for making changes to effect remote switching would not be entirely within Sero's control.

Sero therefore opted to recruit properties from their newer Aspen Grove (Eastern High) development, which allowed system changes to be solely controlled by Sero due to their own ownership and development of the BEE in these properties. Aspen Grove is a mixed development of houses and flats spanning private owner occupancy and social tenancy. Homes were still under warranty with Wates home builders and social homes were provided in partnership with Cardiff City Council.

Event Notification and Instruction Flow

The following subsections show how both an automated and manual remote switching mechanism was introduced. The high-level instruction flow can be seen in Figure 7.

Heat Pump Off/On Automated

- NGED send an API push to tell Sero that the Off event window can start
- The IES API receives the pre-defined message and forwards to IOT Core
- A service in IOT Core will:
    - Lookup the profile of homes included in the pilot
    - Translate the NGED signal to a "Heat Pump Off" message and send to ONLY the pilot homes' BEEs
    - Start a cron timer for 2 hours
    - At cron timer expiration, send a "Heat Pump On" message to ONLY the pilot homes' BEEs
- The BEE will receive the messages to turn off / on the heat pump. Write to the MODBUS register to turn off / on at the appropriate time.
- The heat pump will turn off all features apart from data reads and access (low power consumption)
- Validation for the first stage of the pilot will be to log into the MasterTherm dashboard and check the off status has been registered

Figure 7: High-level instruction flow

Heat Pump Off/On Manual (Backup)

If, for any reason, there was a failure in the end-to-end path for automated heat pump "off" and "on" signalling, Sero were able to revert to a manual method. Options for the manual method are seen below in preferential order:

- Sero remotely log into the BEE and send the command to disable the heat pump for each pilot home.
- Sero log into the MasterTherm dashboard and manually disable the heat pump for each pilot home.

Resident opt outs

The residents were able to opt out by calling the Sero service desk. A manual method to re-enable the heat pump via the BEE, to ensure state is maintained was also put in place. This simply allowed the BEE to revert to normal operational mode. All calls and actions to opt a resident out were able to be recorded to ensure that there was a consistent data representation of the impacts, both automated and manual.

Technical Methodology

As per the event notification flow, the main preference was to automate the signal through to heat pump activity, which was built without scale in mind, to prove the outcomes of the pilot. Manual overrides were preferred to opt a resident out, which gave the benefit of ensuring that the opt out is deliberate and not a mistaken action.

Services that were developed to support the above:

- NGED specific API endpoint for signalling
- Profiling (RBAC) for the homes that ensured the signals only affect participant homes
- Service to translate the signals into the “heat pump off/on” internal messages
- Firmware updated for the BEE to enable “heat pump off” and “heat pump on” modes

Data for events were stored within Sero’s Google cloud environment and were shared with NGED to validate the pilot outcomes. These data points were shared manually for the first tranche of the pilot.

6.1.4. System Performance - Trial One

Trial one held a total of 22 ‘EQUINOX’ events across December 2022 – March 2023 with a total cumulative participation of 386 participants. This was split between Octopus Energy (368) and Sero (18). Of the 18 Sero participants and three Octopus participants, who are aggregator controlled, there was a 100% participation rate with 630 hours of flexibility delivered. Over those events, each dispatch signal to start and end the event was received and actioned correctly for both suppliers.

It was identified, early in the trial that the Sero system acted ahead of the event time when dispatching customers. Flexible Power operates on notifying the FSP 15 minutes prior to dispatch of their flex. In this case, the Sero Building Energy Engine (BEE) system saw that as an ‘operate’ signal and for their pools events were seen as 16:45-19:00 rather than 17:00-19:00. This was an identified development area and was rectified on the lead up to trial two.

On average, the manual customer group achieved a participation rate of 84% throughout the duration of the trial with minimal dropout throughout.

6.2. Trial Two

6.2.1. Aims and Goals

Trial two represented an opportunity to gather learnings from trial one and evolve the applied methodology and approach for heat pump flexibility going forward. As trial one created a good foundation both commercially and technically, the focus for trial two was put on the developments needed to get closer BaU. Like trial one, Flexible Power was utilised in the same way as for trial one but with some added capability, as described below.

As the commercial arrangements were updated significantly for trial two, they drove the majority of the changes that took place between each trials technical integration. Throughout the trial-planning period, it was identified that some of the technical requirements to be implemented had to change slightly due to the route the commercial arrangements were taking. This caused no issue, only slight amendments.

As shown in the Trial Two Commercial Arrangements section above, three underlying variables were tested for trial two:

- Notice period
- Payment method
- Time of day

Once the variables were confirmed within the commercial arrangements, the resulting action was to identify the work needed from a technical standpoint in order to accommodate the three variables. The high-level needs can be seen in Table 12 below:

As there had been numerous developments between trial one and trial two, in addition to on boarding a new energy supplier, the same strategy behind the testing regime for trial one was adopted. Testing was carried out for each individual supplier on the week commencing 23rd October 2023. The duration varied from each supplier but was in the range of one day to one week. Due to the developments that had been made, testing was more detailed and thorough compared to the previous trial. For example, with there being two different groups involved, due diligence had to be carried out on making sure the correct signals were sent to the right group without effecting the other, and vice versa.

Some issues were identified when testing with Sero. The first event that was to be tested was correctly scheduled but was not accepted within the Flexible Power portal. This resulted in Sero not being able to receive their first test signal in the morning. This was rectified for the next test signal, for control group B of which Sero correctly received but failed to reduce the in-home set point. This was addressed over two days by Sero's developers where two bugs were identified and addressed. A new test date was confirmed and on the 30th October 2023, Sero correctly received start and stop signals for each control group where the anticipated in-home set points were achieved.

The whole test plan documents for both trial one and trial two can be found in Appendix D.

Table 12: Technical requirements needed to accommodate trial two variables

Trial Two Variable	Technical Additions Required
Notice period	Additional Meterable Units (MUs) and Dispatch Groups (DGs) required per supplier
Payment method	Additional Meterable Units (MUs) and Dispatch Groups (DGs) required per supplier
Time of day	N/A

The fundamental requirement on the technical side was to create a way to differentiate between participants in differing payment groups. Due to there being a further two groups in each commercial arrangement (for control purposes) MUs and DGs were the sensible option to take. These event participants to be grouped to their representative group. These are already utilised within Flexible Power and therefore required little time to build and develop.

Scottish Power Energy Retail on boarding

Scottish Power Energy Retail (SPERL) are an energy supplier that have been recruited to deliver EQUINOX events for trials two and three. They have been involved since the tail end of trial one and have since contributed towards the trial analysis, new commercial arrangements and have had to develop their own technical methodology in order to accommodate their customer pool. Their technical integration has been slightly different to the other suppliers as a third party aggregator will be acting on their behalf. This enables the project to generate more learning around how technical integration can link between multiple parties. Their technical arrangements can be seen later in the document.

The following sections provide an overview of the technical integration between the DNO and suppliers that include both the, in-home automation, and customers cohorts. Each supplier's solution requirements are included in addition to the high-level architecture, test plans, and test results (located in appendix D).

6.2.2. Technical Specification Overview – ScottishPower

Solution and methodology overview

ScottishPower customers participating in the EQUINOX trial will do so via the ScottishPower Power Saver App, designed to tell customers when EQUINOX events are happening and allowing them to visualise the rewards they have earned. The back office of this App is integrated with Flexible Power to enable receiving and sending of event signals and information.

The ScottishPower Power Saver App is available under ScottishPower's author on the App store on both iOS and Android. The ScottishPower Power Saver App is fully branded as ScottishPower, with the technical solution being provided via a 3rd party service provider. ScottishPower contracted a 3rd party who own a smart energy platform which has been developed specifically to make demand-side response (DSR) events available to domestic customers by receiving signals when the grid may be experiencing peak demand constraints, subsequently notifying customers to shift their demand. The customer interface is App based, whereby users are rewarded points for reducing load by turning off appliances and devices at these peak times.

ScottishPower and the 3rd party (via a services contract) will meet the requirements of EQUINOX Trial 2.

The following sections detail how the process works, and can be seen in Figure 8 below and also within Appendix D.

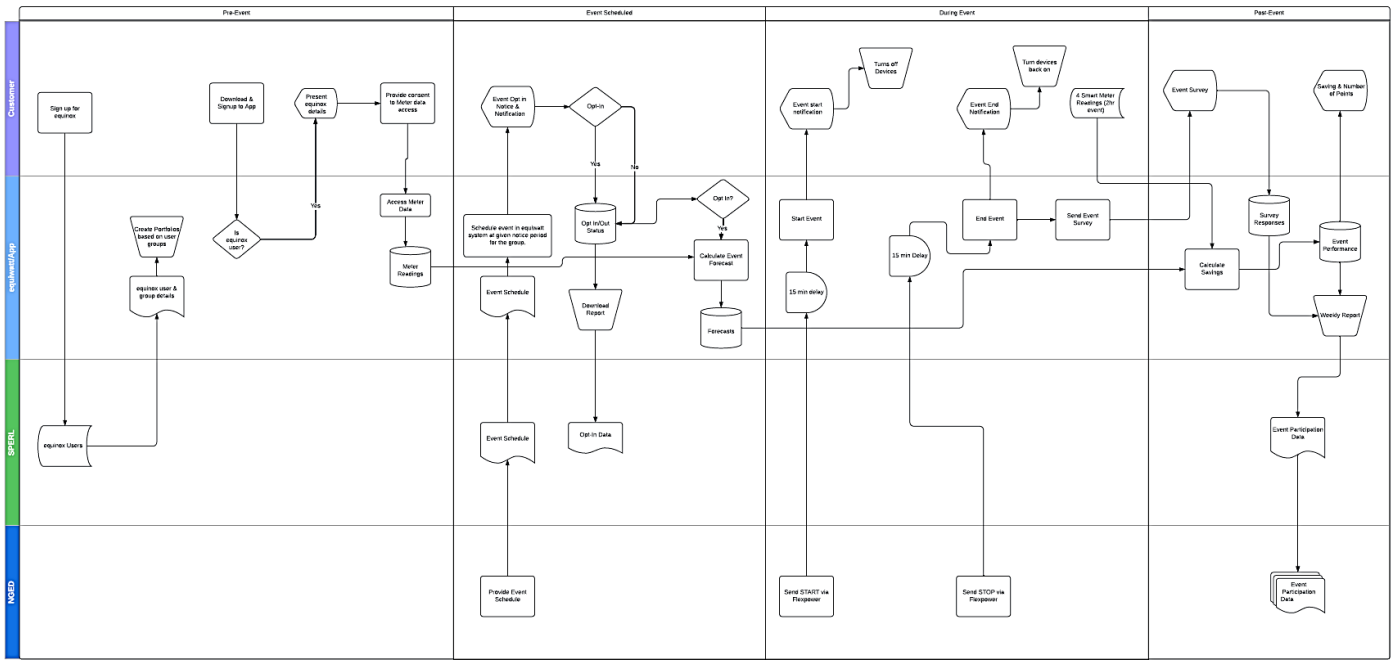

Figure 8 ScottishPower Architecture Diagram

6.2.3. Trial Preparation

The following activities were carried out prior to the beginning of trial two.

Customer recruitment and participation eligibility

ScottishPower identified a group of customers for EQUINOX participation, by analysing eligibility according to several factors:

- ScottishPower supply in NGED distribution area
- Heat Pump ownership indicator
- Consumption
- Smart meter installation
- Level of communication from smart meter
- Communication preferences and consents

These customers were split into several recruitment pots according to type of smart meter and communication preference. Each recruitment pot received an initial communication and a follow up communication. Customers are asked to register via a Landing Page where recruitment data is stored safely and securely as per our polices.

ScottishPower review the applications received through the sign-up page to confirm that the applicants are eligible to participate in the trial. Suitable applicants are subsequently invited to accept the trial terms and conditions via an email.

Allocation of customers to control groups as required by the Trial

Due to the smaller nature of ScottishPower's recruitment pot for Trial two (16 customers), all ScottishPower customers participated within the same commercial arrangement group (M1 or M2, to be defined). However, the customers were split into two control groups. The methodology to define these control groups looks to split customers evenly by incorporating available data on geography, customer type, vulnerability flags, technology type and consumption habits.

App launch

The ScottishPower Power Saver App has been launched on the App stores available for iOS and Android and will sit under ScottishPower ownership and authorship within the App store. App reviews and comments will be monitored and responded to by ScottishPower.

6.2.4. Pre-Events

The following actions take place once customers have been recruited, before live events begin.

Customer on boarding process

ScottishPower provide the list of EQUINOX customers to the 3rd party by secure data transfer in table 13 below:

Table 13 ScottishPower EQUINOX Customer List

user_email	mpan	verified_address	Meterable unit ID/Group
example@example.com	100000000000	No 3, Example Street, NE8 4JE	

Upon the receipt of the customer list, the 3rd party perform necessary checks on Smart Meter connect-ability, MPAN & address matching. Once data is checked, it is uploaded to the platform backend, ready for users to sign up and identify themselves within their App.

Customer Registration

Customers were asked to download the ScottishPower Power Saver App. They were asked to input their email address, where an automatic OTP verification code is sent to the customer for validation. Once this code has been received by the customer and input into the App, the customer's email address is validated and the customer can continue with the on boarding process.

Customer Data Retrieval

Any user signing up to the ScottishPower Power Saver App using details in the aforementioned customer list, will be deemed an EQUINOX user and they will be asked to consent to their MPAN and address being used to access their Smart Meter data.

Once the customer has completed this process, the customer's smart meter data will be retrieved from the DCC, ready for Trial forecasting and baselining.

Flexible Power integration

Both ScottishPower and the 3rd party have access to view Flexible Power. The 3rd party have integrated with Flexible Power's API to view Meterable Unit and Dispatch Group information, as well as receive Start/Stop signals on ScottishPower's behalf.

The aforementioned control groups, will be grouped together in Flexible Power under the assigned Meterable Unit IDs.

Event scheduling

The following section covers the actions triggered by the event schedule.

Receiving event schedule

National Grid notify ScottishPower (and other project partners) via email every Wednesday afternoon with regards to the events scheduled for the following Monday to Friday period. ScottishPower will share this information with the 3rd party to enable customer notifications to be scheduled.

Customer event notification

Upon receiving the schedule of events for the following week, the 3rd party schedules the series of App push notifications (copy written by ScottishPower) according to what control group (Meterable Unit) the event is for, on what day, at what time and with what notice period. The effectiveness of App notifications will be measured throughout the Trial, with the option of email communications as an alternative method.

For events where the customer will receive notice of an event either day ahead or morning of, ScottishPower may send an event reminder via push notification in the ScottishPower Power Saver App. The effectiveness of these reminders will be measured throughout the Trial and the process may be amended to ensure optimal participation.

Within the ScottishPower Power Saver App, the customer will also receive a live countdown to the next event, once the event has been scheduled and notified.

Customer opt in

When a customer is notified of an event, regardless of the notice period, they will be asked to actively opt in to the event via an "opt in now" button in the App. This will be registered and will form part of the participation data to be analysed as part of the Trial and will help shape future participation forecast models. If a customer does not opt in to the event, but it seems they have participated by providing a turndown, they will receive rewards.

Baseline calculation

As agreed amongst project partners, ScottishPower will follow the industry recognised baseline approach of P376, in line with other similar flexibility schemes such as National Grid ESO's Demand Flexibility Service. This baseline will be used to later calculate the customer reward for turndown.

6.2.5. Event operations

The following sections include detail on the operational triggers and actions when a live event starts. This process applies to all events throughout the Trial period (subject to process improvement).

Event start

As required by National Grid, START signals will be consumed directly via the START signal on the Flexible Power API as a real time signal for the start of each event. The notification to START signal will be launched 15 minutes before the real event start time, therefore a 15 minute delay is introduced to ensure the event starts on the hour. When this START signal is received via the Flexible Power API, the customer will see an "Event: Live" status in the ScottishPower Power Saver App. This marks the start of the event and is when the customer is expected to turn down their Heat Pump.

Event end

Similarly to the Event start mechanism, STOP signals are sent via Flexible Power to mark the end of an event, again accounting for the 15 minute time lapse. This STOP signal will trigger an "event has now ended" message to the customer in the App. No event results appear at this stage.

Event survey

Upon the completion of the event, a post event survey will be sent to the customer. The mechanism for the survey is a push notification, which sends the customer to an embedded link in the ScottishPower Power Saver App, where they can answer the post survey questions as per the EQUINOX requirements.

6.2.6. Post Event

The following activities take place after each event.

Smart meter readings

Smart meter readings are collected for the two hour time slot as per the active event received via START and STOP signals. A meter reading will be collected for each half hour of the two hour event window.

Savings calculation

The smart meter readings are used to compare against the baseline to calculate the kWh difference. The turndown reward is calculated using this kWh difference and the relevant price per kWh defined by the EQUINOX project partners as per the type of event (i.e. notice period) and commercial arrangement.

ScottishPower customers see this monetary value translated as points in the App. The points maintain their monetary value and can be accumulated and redeemed against a series of rewards as per the customer's choice.

The timing of when this calculation is done is dependent on when smart meter data is received. However, the platform is set up to do this calculation automatically once the data has been received.

Data analysis & reporting

ScottishPower receive participation data on a weekly basis. ScottishPower also receive the aggregated metering data and baseline information to supply to National Grid, to allow them to carry out a baseline comparison as part of project analysis. The frequency of this data exchange will be monthly (unless requested more frequently) as seen in Table 14.

Table 14 ScottishPower data reporting format

event	mpan	period	meter_group	opt_in_time	baseline	reading

6.2.7. Launch and testing

The following includes detail about the testing process and launch of the ScottishPower Power Saver App.

Flexible Power Testing

Flexible Power testing was carried out prior to launch to ensure START and STOP signals are received via the API integration. This was carried out by creating a fictional event. These START/STOP signals then correctly triggered the correct customer notification.

App soft launch

Prior to UAT testing, ScottishPower employees had access to a beta version of the ScottishPower Power Saver App for pre-testing purposes. This allowed any issues to be identified early on and mitigates any risks of full UAT testing failing.

UAT Testing

User Acceptance Testing (UAT) was used to ensure the technology adheres to requirements and behaves correctly when tested in "real life" scenarios. The testbooks and test plans are visible in Appendix C.

The UAT document in Appendix C provides a reference on how the app should behave when a user tries to sign up and connect their smart meter in a step-by-step manner with a pass/fail confirmation, which determines the working of any clicked option on the screen. The document includes expected behaviours of the App screens and process as a benchmark for the pass/fail confirmation.

There were four main test scenarios included in the UAT process, designed to cover the end to end process. These are shown below in table 15:

Test 1: Control Group A – Customer sign up and smart meter connection process, event holding screen

Test 2: Control Group B – Customer sign up and smart meter connection process, event holding screen

Test 3: Control Group A – Flexible Power pre-scheduled event, event START/STOP trigger, customer notifications

Test 4: Control Group B – Flexible Power pre-scheduled event, event START/STOP trigger, customer notifications

Various tests may be carried out under each test scenario

The UAT process took four days in total, with initial test scenarios being run in the first two days, with Day three and Day four scheduled for resolutions to be put in place for any bugs raised throughout the first two days of testing. Day three and four also provided the opportunity for additional iterations of each test scenario to be carried out to ensure resolutions meet requirements. The below matrix outlines the key stakeholders involved in testing each scenario, and when this was carried out.

Table 15 UAT Process Plan

	Test scenario 1	Test scenario 2	Test scenario 3	Test scenario 4
3rd party App Developer	Day 1	Day 1	Day 2	Day 2
SP Digital Tester	Day 1	Day 1	N/A	N/A
SP Smart Solutions Lead 1	Day 1	Day 1	Day 2	Day 2
SP Smart Solutions Lead 2	Day 1	Day 1	N/A	N/A
NGED Lead	N/A	N/A		

Approval and sign off

The App was only launched when Flexible Power Testing was signed off by NGED and ScottishPower signed off UAT testing.

6.2.8. Technical Specification Overview – Octopus Energy

The following information provides an overview of the technical integration between DNO and supplier, and between supplier and customers for Octopus Energy for trial two.

Customer cohorts

Octopus Energy Customers will be split into two groups for each commercial arrangements (M1 and M2), creating M1A, M1B, M2A and M2B. These A and B designations refer to customers who will experience events on different days. When group A events are called (customers in M1A and M2A) then the group B customers will not be contacted, and so will continue their usual behaviour and act as a control group for that event. In the following weeks, group B customers will be called on and group A customers will not be contacted. Across the trial period, each group will be invited to a similar number of events across a similar range of temperatures. Understanding the consumption of non-event customers during an event period will contribute to increased accuracy of post-trial analysis.

The four groups comprise roughly equal numbers of customers, segmented on location, technology type and electricity tariff type. All customers will have heat pumps as their main source of home heating, smart meters reporting home electricity consumption at half-hourly granularity and be located in the National Grid distribution area. Customers in EQUINOX will be additionally rewarded for their participation in trial surveys but are not permitted to participate in other demand flexibility services during the EQUINOX trial period.

Customer technologies

EQUINOX trial two captures the customers' heat pump "technology type" as one of three different levels of automation. From least to most automation, customers are separated into "customer control - at home", "customer control - app control" and "aggregator control". The majority of Octopus Energy customers in EQUINOX trial two fall into the two customer control technology types.

Manual customer control

Customers are unable (or unwilling) to control their home heating settings remotely and someone must be physically present in the home to change the heating settings or turn the heat pump on or off. From feedback in EQUINOX trial one, we know that this home control can range from a central thermostat to individual thermostatic controls on radiators in each room. As well as being home when an EQUINOX event starts, someone must be at home when the EQUINOX event ends in order to put the heating settings back to the desired temperature.

Remote customer control

Remaining in full control of their own heating, customers with remote control are able to change the settings on their heating while they are away from home, typically via a mobile app. This can, but does not always, include setting schedules in advance so that their heating automatically turns down for an EQUINOX event. Customers use a range of commercially available technologies for this approach, including both manufacturers' controls and third-party systems.

There is an increased convenience for these customers, which may facilitate additional participation in EQUINOX events across the trial period.

Aggregator control

In the aggregator control group, customers agree to third party control of their heat pump, which is limited to enacting EQUINOX events. In this case the third party is their energy supplier (Octopus Energy).

Aggregator control customers retain override capabilities during an EQUINOX event and furthermore can opt-out of events in advance if they do not want to participate in a particular EQUINOX event for any reason. Independently of whether or not the

third party is automating the day-to-day scheduling of their heat pump, the customer has the convenience of not needing to act in order to participate in each EQUINOX event. It is thought that this increased convenience may facilitate additional participation in EQUINOX events across the trial period.

Technical performance requirements

To facilitate participant engagement at the scale of up to 1000 customers, existing customer management solutions within Octopus Energy are used to create bulk, personalised emails and to collect customer feedback and information through surveys. Customer-initiated contact came through the normal customer support channels (phone, email, socials) and was answered by Energy Specialists with prior knowledge of the project.

Customer invitations and on boarding to the project happened in this way, supported by resources hosted on the Octopus Energy website, including FAQs and Terms and Conditions for the project. Data management for customers on boarded to the EQUINOX trial was handled by an in-house Data Science team. Customer withdrawal from the project could be initiated through any of the normal customer support channels and was enacted manually, removing the customer from further trial messaging and trial data collection. Separation of withdrawn customers' data from trial results was enacted manually, in accordance with GDPR best practice. As part of this process, customers on boarded to EQUINOX trial two were marked ineligible for other demand flexibility services and did not receive direct invitations to participate in Octopus Energy's Saving Sessions product (part of ESO's DFS product).

Customers with eligible heat pump models were additionally invited to participate in EQUINOX as part of the Aggregator control technology group. Automation of EQUINOX events for these customers was managed by Octopus Energy's Kraken platform, via the Octopus heat pump control product. Interested customers were able to on board for this service via the Octopus Energy mobile app and once registered, were manually assigned to the EQUINOX trial. Customer support was provided by Product Specialists as well as by Energy Specialists with prior knowledge of the project.

EQUINOX event operations

EQUINOX events were initiated by National Grid via the Flexible Power platform, a business as usual (BaU) system for DNO procurement of demand flexibility. Octopus Energy's Kraken platform used the existing API connection to Flexible Power to receive dispatch signals immediately preceding EQUINOX events, initiating automated turndown of registered Aggregator control group heat pumps for the indicated event period and for the indicated customer group (control group A or control group B, depending on the event).

All other customers, in both the manual customer control and remote customer control groups, did not receive automated intervention. Heat pump turndown was enacted by each customer, in accordance to their own preferences and the particulars of their own heating system. For M1 and M2 commercial arrangements, customers in all technology groups were notified in advance of an event by email or by app notification.

At the end of an EQUINOX event, all customers from that event group (A or B) received an email with a link to the post-event survey, which asked customers to report on their comfort during the event.

Customer settlement

To maximise data availability from smart meter readings, the customer settlement process was carried out at least four days after each EQUINOX event. Where a customer had opted in to an event, their settlement was calculated as:

(predicted consumption - observed consumption) * pay rate (p/kWh) = settlement amount (£)

Settlement was calculated on a per half-hour basis, for each half-hour of the EQUINOX event, and no penalty was applied to the customer for negative settlement amounts (where observed consumption was greater than predicted consumption). The p376 baseline method was used to calculate predicted consumption and observed consumption was provided by smart meter readings. The pay rate for each customer varied per event, depending both on their pay group (M1 or M2) and the notification

period of that event. Where smart meter readings were not available at the time of settlement calculation, customers were paid the average amount that others in their commercial arrangement were paid for that event.

Settlement amounts were calculated on a per customer basis and paid as credits onto their energy account. This process (calculations and payment) was carried out within existing systems on Octopus Energy's Kraken platform.

High level architecture diagram for EQUINOX events

Figure 9 below shows the data flows between NGED, Octopus Energy and the customer and an overview of the technical architecture for Octopus Energy customers participating in the Aggregator control technology type in EQUINOX trial two.

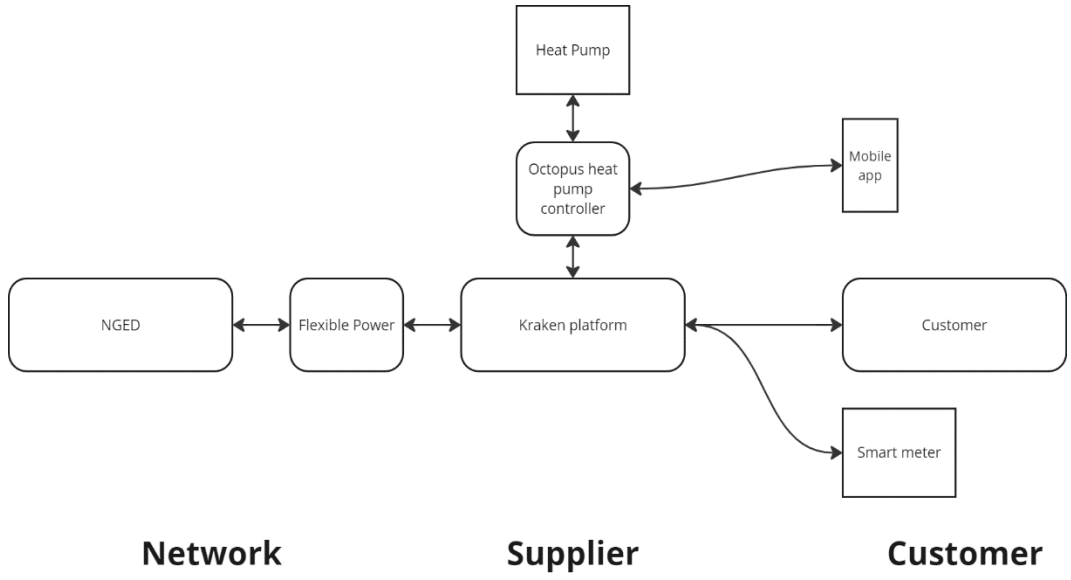

Figure 9 Octopus Energy high-level data flow

Utilising BaU systems in order to mimic market conditions wherever possible, flexibility signals were initiated by NGED via the Flexible Power platform, sending a dispatch signal to Octopus Energy's Kraken platform and indicated the particulars of an event (time and flexibility zone). Within the Kraken platform, an event dispatch was enacted via the Octopus heat pump controller, turning down the set point temperature for that device, for the event period. Customers could view this change on the Octopus Energy mobile app, and could enact an override during the event via controls in the same app. At the end of an event period, each device was returned to its pre-event temperature set point; home electricity consumption was measured by the smart meter and was reported to Octopus Energy from the following day, according to normal industry practice.

The connection from Octopus Energy's Kraken platform to NGED's Flexible Power is able to convey aggregated smart meter data for the Meterable Unit(s) that were dispatched in response to an event, but for trial purposes this feature was not used in EQUINOX trial two. This process is in regular use for procurement of distributed domestic flexibility, enacted via electric vehicles.

6.2.9. Technical Specification Update – Sero

The following section outlines the updated technical arrangements that have been put in place for Sero during trial two.

Key understandings and assumptions

Key understandings and assumptions upon which this section is based include:

- Two events will occur each week during the pilot, each adjusting set point temperatures for all participating homes.
- Communications notice periods will vary dependant on the participant profile per home, with the following schedules:
    - Phantom events – No notice
    - Customer informed 2 hours ahead of event
    - Customer informed on the morning of event
    - Customer informed a day ahead of event
- In the interests of not prejudicing the behavioural response to events, the schedule for the week will not be communicated to residents in advance
- On-the-day event notification will be received from NGED through the Flexible Power Platform, and will occur up to 15 minutes before the event.
- Sero will need to provide both a manually instantiated as well as a programmatically instantiated set point change, in order to accommodate any automated system failure or to effect and override.
- It must be possible for a resident to opt out of an individual event. Sero proposes that this be effected by calling the Sero Help Desk during this trial, or by utilising the in-home “heat advance” button
- Setpoints will be dropped to 12˚ C to ensure the event setpoint is lower than a selectable setpoint in the resident app.
- Sero will also ensure that hot water is charged during the cheap tariff window prior to the event

Purpose

The purpose of this section is to lay out the updated technical and operational methodology through which Sero will achieve remote setpoint changes as part of the Direct Load Control elements of the second trial of the EQUINOX project. Key outcomes expected from this section includes agreement of approach, including any phasing of the approach that might be necessary to meet trial two homes commitments.

Participating Properties

Sero proposes to recruit properties from the same Aspen Grove (Eastern High) development as in trial one, the site has had more residents move in, increasing the pool for selection. Aspen Grove is a mixed development of houses and flats spanning private owner occupancy and social tenancy. As this development is currently rolling out, the pool of houses available to participate continues to grow, although the growth during the trial will not be significant beyond the figures shown below. Homes are still under warranty with Wates home builders and social homes are provided in partnership with Cardiff City Council, who will each be consulted in addition to individual residents to secure participation.

Sero had tentatively proposed to include Gwynfaen, another in progress development project with Sero BEEs and controlled heat pumps. However, due to the slow turnaround of the build phase, these homes have been ruled out for trial two.

Event Notification and Instruction Flow

The following subsections show how both an automated and manual remote setpoint change will be introduced. Figure 10 shows the high-level instruction flow for Sero for trial two. Blocks indicated in red, orange, and green represent developments, adaptations and existing capabilities respectively.

Figure 10: Sero high-level instruction flow for trial two

The trigger to start EQUINOX event activity within Sero is by way of an API call from Flexible Power into the Sero external API. Two participant groups are defined within trial two, with different event windows per group. The API call from Flexible Power will signify the start of the event and will identify which participant group to trigger by way of a meterable unit identifier.

Sero has expanded the development of the home selector service, which was built for trial one, to cater for multiple profiles. This allows us to categorise and match the individual homes that are participating into the two distinct participant groups. The meterable unit identifiers received in the API call are mapped to the appropriate participant group and subsequent event activity is only implemented against that group of houses.

The schedule builder is a new development for EQUINOX trial two. This “service” takes a snapshot of the current customer schedule (start, stop times and set point) and stores this for reversion after the event. The service then builds a schedule for the event itself based on the API call timings; this schedule includes the event window start and stop time, and then setpoint for the event, which will be set to 12˚ C)

A new development for trial two is the “app block”. This service blocks signals from the customer app from impacting or overriding the existing schedule, during the event. User commands sent via the app to boost heating, hot water or to update the existing set point will not be sent through to the BEE, giving us more control over how the resident triggers an “opt out”. Once the app is blocked, the event schedule is forwarded to the Building Energy Engine (BEE) with the participating homes.

The BEE replaces its current schedule with the event schedule and will hold the set point of the home to 12˚ C during the event. At the expiration of the event window, the app block is notified by the schedule builder service to “unblock”, restoring full control of the home to the resident.

The schedule builder service also looks up each homes previous schedule “snapshot”, i.e. the residents original schedule, and sends that to the BEE. The BEE overwrites the existing schedule with the reverted resident schedule, effectively returning it to Business As Usual operation.

Our data science team, using data that has been cleansed and categorised by the internal tool “DOVE”, performs post analysis.

At any time during the event, the resident has two options to Opt out of the existing event:

- A phone call into the Sero customer service team. The team will use our Home Management System (HMS) to deselect the home from the existing event. This will trigger the schedule builder service to kick in as though it is the end of the event for that specific home.
- Pressing the in-home dial, which already has a function, when pressed, to set the current set point to the current temperature +1˚ C. This will immediately remove the home from the trial, activating the heat pump.

Resident opt outs

The residents can opt out by calling the Sero service desk or pressing their in-home heating control dial. We will have a manual method to reset schedules via our management platform (HMS). This will simply reapply the resident schedule into the BEE to return to normal operational mode. All calls and actions to opt a resident out will be recorded to ensure that we have a consistent data representation of the impacts, both automated and manual.

Technical Methodology

As per the event notification flow, our preference is to automate the signal through to heat pump activity, which will be built without scale in mind, to prove the outcomes of the pilot. Manual overrides are preferred to opt a resident out, which gives us the benefit of ensuring that the opt out is deliberate and not a mistaken action.

Services to be developed to support the above:

- NGED specific API endpoint changes, to add meterable units, for signalling
- Profiling (RBAC) for the homes to ensure these signals only affect participant homes in the appropriate participant group, i.e. the “home selector”
- A service to build schedules that correlate to the agreed setpoint and to the start and stop times sent in the NGED API call, i.e. “schedule builder”
    - This also has the add-on service which sends the appropriate event schedule, and resident schedule, as described in the event notification and instruction flow.
- A service which prevents the user accidentally opting out by boosting heating or hot water, i.e., the “app block”
- Adjustments to DOVE to cater for the per home kWh analysis as required in the commercial models for trial two

Data for events will be stored within Sero’s Google cloud environment and will be shared with NGED to validate the pilot outcomes. These datapoints will be shared manually for the first tranche of the pilot.

6.3. Cyber Security

The following section outlines the cyber security requirements that have been in place for each of the trials. Although Flexible Power is a part of National Grid, due diligence has been carried out, and existing practices have been captured for full clarity.

6.3.1. Sero

Sero is working towards fully complying with ISO27001/2 ISMS. Thus, Sero will process acquired information and handle data to satisfy ISO27001 and NCSC CAF guidance.

To satisfy legal and compliance requirements:

- Sero will create an anonymised list of selected properties for the project EQUINOX trial to be used in the automation system
    - Access to the list will be controlled for a pre-specified user list.
    - System auditing will be enabled to record and capture any changes to the list.
- The automation process will run in a secured GCP environment under its-own CloudRun instance.
- The automation process will receive the trial signals in a secure & controlled manner.
- The signals coming from the NGED will go through a validation process before submitting into the automation process
- The trial home sensor information will be captured centrally in Seros' time series information repository.
- Then the sensor information for the predefined trial properties for the specific period will be extracted and transformed into NGED data requirements
- The transformed data will be submitted to the NGED via Flexible Power API.

Any PII and sensitive information has been normalised before transmitting to external parties.

A data exception has been required to transmit information from Sero Information Security Comity (ARB-ISC).

The following text provides information on how Sero's systems are cyber compliant, audit history and a high-level overview of the processes carried out within Sero as seen in Figure 11 .

Cyber Compliance

- The device and consumption event data of properties are stored securely in access-controlled resources within the Google Cloud Platform (GCP) environment.
- The event data only stores operational necessary identifiable information.
- The API endpoints are PEN tested annually by an external third party. Moreover, these systems are internally PEN tested multiple times by internal security testers.
- Sero is working towards ISO 27001/2 accreditation and has already started this process.
- Furthermore, Sero is planning to comply with the NCSC CAF.

Audit History

- The last external PEN test was carried out at the beginning of October 2023 due to the migration from google to AWS.
- An external AEGIS security assessment was carried out in September 2022 as a precursor to the ISO 27001/2 accreditation.

Integration detail

Figure 11 illustrates how a property (BEE) communicates with the Sero services and how Flexible Power connects to Sero APIs with HMAC authentication.

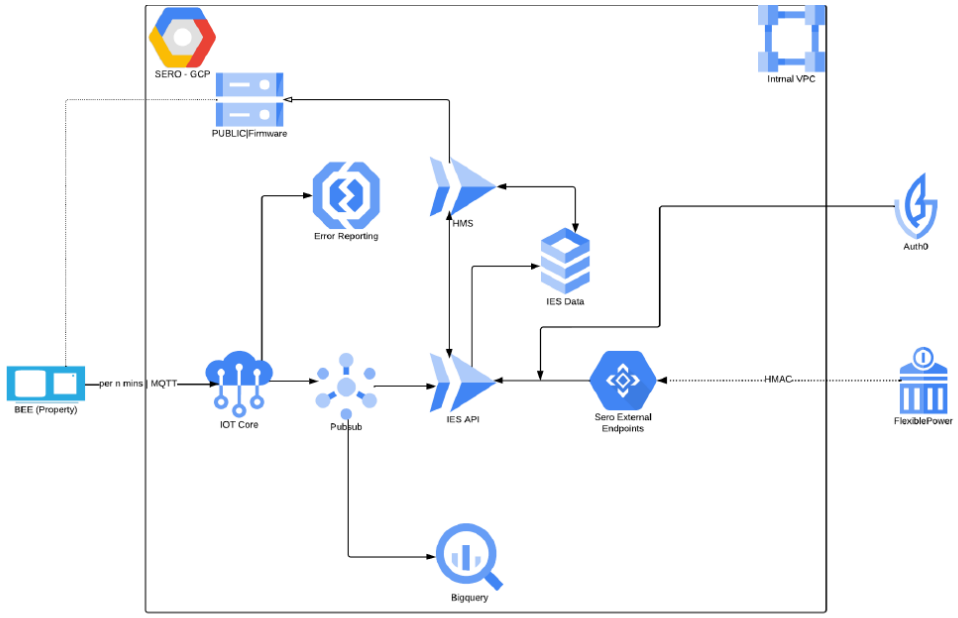

Figure 11: Sero High-level architecture of the Edge/IoT/Sero application with Flexible Power

6.3.2. Octopus Energy

Octopus Energy Ltd. and KrakenFlex follow industry best practices to ensure the security of their systems. They meet any regulatory obligations, for example the Information Security obligations in SEC Section G (which is aligned to ISO 27001), as well as the industry standards such as SOC 2 (KrakenFlex's parent company Kraken Technologies is SOC 2 Type 1 certified). Any AWS infrastructure and services is designed and maintained by KrakenFlex in line with AWS Well-Architect Framework including the Security Pillar.

6.3.3. ScottishPower Energy Retail

At ScottishPower, we are committed to managing the risk and the cyber security of our networks and information systems, helping to ensure the confidentiality, integrity and availability of personal data and information. As we continue to manage risk and security, we must ensure that our outsourced partners do the same. We recognise that there can be different ways of meeting the required data security standards and will therefore be flexible where that is appropriate, however a three part cyber security assessment was required to assess data security arrangements as part of our ongoing assessment of network and data security. This evaluation follows the process defined in the Corporate Security Third Party Management Standard Operating Procedure. The requirements and outcomes are included below in table 16:

Table 16 ScottishPower Cyber Security Requirements

PART 1: INITIAL CYBERSECURITY REQUIREMENTS	Outcome
Certifications	
Cyber Insurance	OK, no further action required
Data Loss Prevention	
How data loss prevention controls protect information from loss or theft. In particular any Email monitoring, Web Restrictions and blocking of any Removable media channels (USB etc)	OK, no further action required
End-User Security	
Anti-malware solution and how this is kept up to date	OK, no further action required
Patching solution - How all servers, databases and applications are patched regularly	OK, no further action required
Network Security	
Penetration tests in the last 12 months	OK, no further action required
Infrastructure scan for common vulnerabilities and policy for remediating detected vulnerabilities	OK, no further action required
Additional Security	
Two factor authentication/multi factor authentication	OK, no further action required
Incident Management	
Incident Response Plan specifically for Cyber Security Incidents/Breaches	OK, no further action required

PART 2: TECH/INFORMATION SECURITY REQUIREMENTS	Outcome
Certifications	
ISO27001 Information Security Management System	OK, no further action required. Copy of certification to be provided.
Cyber Essentials (Plus) Self CertifieC	OK, no further action required
PCI-DSS CertifieC	OK, no further action required
Any other relevant certifications	OK, no further action required
Data Loss Prevention	
Physical access to our Data Centres if required	OK, no further action required

Access to our Corporate Network/Infrastructure if required	OK, no further action required
End-User Security	
Security features of your desktops / laptops estate - Full disk encryption for removable assets - "Hardened build" to conform to security best practice - Control of local administrator rights? - Tracking non-compliances to your standard build	OK, no further action required
Network Security	
Network security mechanisms to prevent cyber attacks / DDoS / loss or breach of data / ransomware	OK, no further action required
Employees using their own equipment	OK, no further action required
Connection to Scottish Power systems or data via a remote network connection	OK, no further action required
Current network protection (eg firewalls, intrusion detection, 2FA) to protect the proposed VPN	OK, no further action required
Data Security	
How data will be securely transferred	OK, no further action required
How data is stored, transfered and handled	OK, no further action required
Encryption	OK, no further action required
Data Location	
System data-backup storeage	OK, no further action required
Supply Chain Management	
Level of security assessment of additional 3rd parties	OK, no further action required
Assurance activities of suppliers	OK, no further action required
Incident Management	
Notification as soon as practicably possibly of any network and information security incident(s) that could affect the confidentiality, integrity and availability of data and services	OK, no further action required
24 hour Security Operations Team (SOC/CSIRT etc)	OK, no further action required
Responsible business representative/team who handles Cyber Security incidents both inside and outwith standard working hours (Bank holidays etc)	OK, no further action required
Education and Awareness	

Cyber Security training and awareness	OK, no further action required

PART 3: CLOUD SERVICES REQUIREMENTS	**Outcome**
Data Processing	
Data processed through the cloud based service	OK, no further action required
Cloud Outsourcing	
Outsourced Cloud service	OK, no further action required
Cloud outsourcing data protection and information security policies	OK, no further action required
Security compliance accreditation's and certifications	OK, no further action required
Encryption	
How cloud hosted data will be encrypted in transit and at rest: Data at rest - AES256, 3DES etc Data in transit - SFTP, HTTPS etc	OK, no further action required
Access Management	
Access to data/systems hosted on the cloud	OK, no further action required
Access management to cloud	OK, no further action required
Multi-factor authentication	OK, no further action required
Performance Management and Monitoring	
Evidence of the Cloud Service Provider compliance against specific cloud hosting guidelines. At the time of writing these include: •Cloud Security Alliance •European Institute of Standards & Technology (ENISA) •National Institute of Standards & Technology (NIST)	OK, no further action required
Method, frequency and associated reporting of vulnerability assessments conducted on cloud services.	OK, no further action required

Data Protection

ScottishPower will remain the Data Controller at all points throughout the process. The ScottishPower Privacy Policy will apply. Data Protection due diligence has been carried out to ensure the 3rd party meet ScottishPower's Data Protection requirements.

Due diligence

As with any suppliers, ScottishPower has conducted a compliance and due diligence check ahead of working with the 3rd party on the EQUINOX project. This report includes the following results:

Dow Jones Risk Center checks – No issues noted for company or CEO

UK Companies House Review – No issues noted

6.3.4. Flexible Power

Flexible power has been subjected to cyber security testing services. The following information concerns testing that was carried out on:

- www.flexiblepower.co.uk
- demo.flexiblepowerportal.co.uk

Reliance acsn, who are specialists in IT security management, were tasked to carry out the testing services. Table 17 shows the following tools that were used to conduct the Cyber Security Testing Sevices:

Table 17 Tools used to conduct the Cyber security testing services

Tool	Version	Summary	URL
Nmap	7.91	A TCP/UDP port scanner	https://nmap.org/
Nessus	10.0.1	A vulnerability scanner	https://www.tenable.io
Burp Suite Professional	2021.10.3	A web application vulnerability scanner and intercepting proxy	https://portswigger.net/

Below is a high-level summary of the findings:

- Overall, both applications are well designed and implemented, with the API's utilising role-based access controls to protect routes and calls. The infrastructure appeared to be fully patched at the time of the assessment, suggesting that even during the development and testing, patches are applied in a suitable timeframe. While there are several positive areas, there is still some room for further improving the security posture.
- The applications appear to be reliant on the web framework to cleanse user input on rendering the page, rather than performing the validation prior to submission, which could lead to Cross Site Scripting attacks, should the framework become vulnerable. It is recommended that the user input is validated before allowing it to pass to the API. Validation should also be performed on all functionality, and not left as a client-side decision, as this led to the consultant being able to re-enable the functionality to delete and modify data. It should however be noted that the developers confirmed this was due to different functionality being requested by clients, and therefore may not exist on the non-demo systems.
- With regards to protection of data in transit, the application server's TLS offerings were noted to be in line with best practice, and the only deviation was the inclusion of triple-DES ciphers on the permitted cipher list. This is a simple remediation task and disabling these ciphers should not affect access from existing clients, although a thorough evaluation should be performed before and after implementation.

6.4. Learning from developing Technical Integration Methods

The work carried out so far on the technical integration has allowed us to gather valuable learning that can be applied to future aspects of the project. The points below have been generated from a mix of trial one planning, delivery and building up to trial two. They are summarised by the following points:

- **Individual approaches are needed with the technical design rather than a cooperated approach**: in order to integrate with multiple energy suppliers and home management systems, individual approaches were need to be taken to create a successful integration design. Due to the network interaction being standardised via an API, this ensures that there is no impact on trial management.
- **Technical aspects have to be tailored to suit the commercial arrangements**: There were a few ideas that were shared post trial one for what the technical design should pursue for trial two. These, if implemented would have affected the commercial arrangements and in turn had to be re visited.
- **In place contingency needed:** When planning work for software development teams, contingency needs to be in place for any features expected to be developed for other initiatives as other project/BaU can mean their priorities change.
- **Baselining analysis for settlement needs to be a manual process:** a key aim for trial two will be to compare the baselines used in trial two (supplier) to the baseline that would've been applied (Flexible Power) in a BaU scenario. Normal settlement is carried out through aggregated smart meter data sent from the supplier to Flexible Power via API. Although this has already been used in BaU, it cannot be done when payments are being made to the customer from the supplier perspective. This is because the data sent through the API will be reported on and in turn creates in accuracies. The solution is to send the aggregated smart meter as a .csv format to so that a manual process can be applied to establish the potential difference in payments when using two differing baselines.
- **Certain parameters need to be set in order to receive the correct instruction:** in order to dispatch an event with no notification, the dynamic service has had to be incorporated into the trial design. Suppliers need to have certain parameters selected within their flexible power account in order to receive notifications to dispatch their flexibility.
- **Completely turning off a heat pump isn't the best solution:** During trial one, it was discovered that for the majority of automated customers, a spike in demand was seen at the end of the trial. This was mainly due to the heat pump being completely off during the whole event. It then required more energy than it saved during the session. The smart use of set points will be utilised for trial two to analyse whether this is a legitimate mitigation solution.

6.5. Next steps and trial three

Although not confirmed for trial three, there is currently an early understanding of the requirements that are necessary to continue the evolvement of the work done in EQUINOX. The eventual aim is to prove heat pump flexibility is viable, economical and to provide both customer and network benefits.

Aspects that are yet to be proven within the first two trials that are commonplace within Flexible Power is the use of clustering and matching of the network requirements to actual delivery. The clustering piece can be linked to the current usage of CMZs, and can only be carried out on sufficient trial numbers in a given area that is a CMZ. There are potential alternatives for this if the trial numbers are insufficient to fill a CMZ through simulated CMZs. Ultimately, wider heat pump uptake will allow a greater chance to gain sufficient potential trial participants in CMZs.

Fundamentally, the delivery from the FSP will need to match the network requirement in order to achieve the most economical system. This was something that was discussed for trial two, however, it contraindicated the aim of delivering statistically relevant results via use of control groups. Increased reliability for predicting the kWh impact of heat pump flexibility was prioritised in trial two.

Trial three therefore, will want to capture a trial that is as close to BaU as possible. The current technical requirements are sufficient enough to incorporate the above so it is anticipated that little additional development will be needed. Developments that are identified will be highlighted and captured in future deliverables.

Appendix A: Acronyms

API	Application Programming Interface
AWS	Amazon Web Service
BaU	Business as Usual
BEE	Building Energy Engine
CMZ	Constraint Management Zone
DER	Demand Energy Resource
DFS	Demand Flexibility Service
DG	Dispatch Group
DNO	Distribution Network Operator
DSO	Distribution System Operator
DSR	Demand Side Response
ENA	Energy Networks Association
EQUINOX	Equitable Novel Flexibility Exchange
ESO	Electricity System Operator
FSP	Final Submission Pro forma
GCP	Google Cloud Platform
GDPR	General Data Protection Regulation
HMS	Home Management System
HP	Heat Pump
IOT	Internet of Things
kWh	Kilowatt hour
LCTs	Low Carbon Technologies
MPAN	Meter Point Administration Number
MSID	Mobile Station Identifier
MU	Metering Unit
NEA	National Energy Action

NIC	Network Innovation Competition
NPg	Northern Powergrid
ON	Open Networks
PEN Test	Penetration Test
PIN	Period Indicative Notice
PQQ	Pre-Qualification Questionnaire
RIIO	Revenue = Incentives + Innovation + Outputs
SPEN	ScottishPower Energy Networks
SPERL	ScottishPower Energy Retail
SSEN	Scottish and Southern Energy Networks
ToU	Time of Use
UAT	User Acceptance Testing
WMCA	West Midlands Combined Authority

Appendix B: Commercial heads of terms between suppliers and customers

Octopus Energy

Trial one

General

These Terms and Conditions apply to the EQUINOX heat pump trials provided by Octopus Energy (the "Trial"). By entering the Trial, you agree to be bound by the following terms and conditions:

1. The Trial will be run by Octopus Energy Limited, a company registered in England and Wales with registered number 09263424 and registered office 33 Holborn, London, EC1N 2HT ("Octopus Energy", "we", "us").
2. The Trial is run by Octopus Energy as part of a wider OFGEM Network Innovation Competition (NIC) consortium project, EQUINOX, in partnership with National Grid Electricity Distribution (NGED), SP Energy Networks (SPEN), ScottishPower, PassivUK, Welsh Government, West Midlands Combined Authority (WMCA), Sero, National Energy Action (NEA) and Guidehouse ("Partners") (though to be clear, the Partners are not a party to the Terms and Conditions).
3. These terms and conditions, together with any specific information or rules set out in any communications relating to the Trial, are the Trial rules ("Rules") and apply to this Trial. By entering this Trial, you are agreeing to comply with these Rules and any other applicable instructions.
4. Octopus Energy reserves the right to cancel or amend the Trial and/or the Rules without prior notice. We'll make sure that we post any changes to the Rules on our website so you can see them.
5. In the event of any dispute regarding any aspect of the Trial, the decision of Octopus Energy shall be final and no correspondence will be entered into.
6. These Trial terms and conditions are separate to the terms and conditions for the supply of electricity and gas that you will have with Octopus Energy and will not affect your rights and obligations under those terms.

Service Participation

7. There is no entry fee and no purchase necessary to enter this Trial. Entrants must be 18 or over. Only residents that fall within the distribution network of National Grid Electricity Distribution (NGED) are eligible to take part in the Trial.
8. To be eligible for the Trial, you must:
    1. Be a current electricity customer of Octopus Energy;
    2. Have a working smart meter which has been sending us 80% of half-hourly readings for the last 20 days;
    3. Have at least a full day's worth of half-hourly readings;
    4. Opt-into the Trial by completing the required pre-trial questions as sent by email to your Octopus Energy account email address;
    5. Own and use a heat pump as the primary method of heating your home (and this heat pump must not be shared with any other residence(s));
    6. Have consented to, and not remove your consent for, giving us half-hourly meter reads;
    7. Participate in surveys in the timeframes requested of you, including longer periodic surveys asking about your experience in the Trial and in more frequent, brief surveys after trial events and

8. Comply with these Terms & Conditions at all times.

9. Participation in this Trial makes you ineligible for any demand flexibility services being provided by Octopus Energy or another supplier (including but not limited to Saving Sessions).

10. The Trial period will start at 00:01 on Monday 30th October 2023 and will end at 23:59 on Tuesday 30th April 2024. Participation in the Trial will not entitle you to participation in further trials that may be run after this period.

11. There will be at least 15 turn down windows ("Events") between Monday 30th October 2023 and Tuesday 30th April 2024. You will be invited to no more than 25 Events in the Trial. Customers will be able to decide which of the Events they are invited to that they participate in. Prior to each Event, we will attempt to send you a notification of the Event window and the available payment per kWh turn down (the "Incentive"). The Incentive is not fixed and may be different for each EQUINOX Event.

12. To be eligible for payment, you must opt-in to the Event before it begins, and reduce electricity import as measured by your smart meter compared to a "Baseline" during any of the half-hours of the Event window.

13. You will be paid the Incentive for each half-hour of the Event that you turn down. We will use our reasonable endeavours to credit your account with your Incentive within 14 business days of each Event.

14. We will calculate your Baseline using the BSC P376 'Utilising a Baseline Methodology to set Physical Notifications' without an in-day adjustment. The Baseline is the average consumption for the same period(s) over up to 10 days of your recent smart meter history, excluding days where an Event has taken place.

15. In the event that we're unable to pull your meter readings to calculate your usage from any of the Events, we'll work it out using an average across all Event participants. EQUINOX is focusing on heat pump flexibility and asks that heat pump turndown is the only action taken for an Event. If the turndown achieved in an Event is deemed to be beyond fair usage (that obtainable via the heat pump alone) then the Incentive may be limited to an amount matching your heat pump electrical load. If turndown persistently exceeds fair usage, we reserve the right to remove you from the Trial.

16. If at any point throughout the Trial you are no longer eligible to participate, we reserve the right to remove you from the Trial. Similarly, if your smart meter becomes disconnected, if you no longer use your heat pump as the primary method of heating your home or if you move house, we reserve the right to remove you from the Trial.

17. By entering the Trial, you warrant that all information submitted by you is true, current and complete. If any information you submit is found to be fraudulent or incorrectly completed or if Octopus Energy has reasonable grounds to believe that you have breached any of the Rules, Octopus Energy reserves the right to disqualify you from the Trial.

18. Octopus Energy will not be liable to reimburse any expenses incurred with entering the Trial. Octopus Energy does not accept liability for any equipment malfunction that occurs during the Trial.

19. If at any point you wish to opt-out of the Trial, please email hello@octopusenergy.com and we will remove you.

20. If you exit the Trial or are removed from the Trial for any reason you will not be eligible for any further payments from the Trial.

Data Protection and Privacy

21. Octopus Energy's privacy policy shall apply to any data collected in connection with the Trial and can be found on our website at http://octopus.energy/privacy.

22. The Trial is provided by Octopus Energy as part of an OFGEM NIC Consortium project, in collaboration with Partner companies. By entering the Trial you agree that, for the purpose of administering surveys and for analysing results of the Trial, Octopus Energy may provide your contact details (name, email, postcode), information about your residence

(including but not limited to property type, generalised location, presence of other low carbon technologies or heating technologies), information about your household (including but not limited to Priority Services Register (PSR) status (yes/no), perceived cold vulnerability, EPC rating, occupancy) and half hourly electricity consumption, baseline and reduction data to Guidehouse and National Energy Action (NEA). You will be given an opportunity to opt-out of non-aggregated data sharing for this purpose. This data will be governed by the privacy policies of each Guidehouse and NEA, which can be obtained from them directly.

23. By entering the Trial you further agree that, for the purpose of administering the Trial, Octopus Energy will share your Meter Point Administration Number with National Grid Energy Distribution (NGED).
24. The results of the Trial belong to Octopus Energy and to Partners in the EQUINOX consortium. As part of the Trial, we will be required to share anonymised, aggregated data collected during the Trial with the EQUINOX Consortium to analyse results coming from all of the Partners contributing to the Trial. By entering the Trial you agree to your information being used as such.
25. Octopus Energy may contact you to invite you to participate in further studies within the trial, run by Partners. Any agreement that you choose to enter into with Partners will be governed by their Privacy Policies and is separate from Octopus Energy.
26. Octopus energy in its sole discretion reserves the right to withdraw or vary the Rules and/or any offer made in connection with them in order to comply with the decision of any relevant judicial or regulatory body and shall not be held liable to any entrant for so doing.

Sero

Trial one

1. By signing up to the EQUINOX trial, you agree we will collect information from you which will be used to carry out the trial and analyse the results of the trial. This information will include:
    - Name, email and postcode
    - Information about your home including the property type, location, and whether you have a heat pump and how many people occupy the property
    - Consumption data including half hourly electricity consumption data.
2. Sero's privacy policy shall apply to any data collected in connection with the trial. A copy of our privacy policy can be found here.
3. To analyse the impact of EQUINOX, we will be required to share anonymised and aggregated data which we collect during the trial with the other partners of the trial. All partners are listed here. By signing up to EQUINOX, you agree to us sharing your data for these purposes.
4. If you withdraw completely from EQUINOX, which you can do at any time, we will stop collecting your data, but we will still process any data collected prior to the date you left the trial. We will only process this data in an aggregated and anonymised form (so you cannot be personally identified) for the purposes of analysing the results of the trial.
5. In addition to sharing the aggregated and anonymised data with project partners, we need to share your consumption data with Guidehouse (one of the trial partners). Guidehouse will use the information to verify the results of the trial. The data shared with Guidehouse will not be aggregated but it will still be anonymised (which means we will not share your name or contact details with Guidehouse).
6. You can ask us to stop sharing this data at any time by contacting us on hello@sero.life. If you have any questions about how your data will be processed during the trial, please contact us on hello@sero.life
7. We may need to remove you from the trial if your smart meter is disconnected, if you no longer use your heat pump to heat your home, or if you move house. We will let you know if we need to remove you from the trial.
8. We may need to suspend or cancel the trial and if we do, we will let you know. We will not be liable to you for any expenses you incur in connection with the trial, or any payments you would have received had the trial continued.
9. The results of the trial belong to us (and the other partners) and by agreeing to take part in the trial, you agree to comply with any applicable instructions we give you in relation to the trial. If you do not comply, we reserve the right to remove you from the trial.

Trial two

1. By signing up to the EQUINOX trial, you agree we will collect information from you, which will be used to carry out the trial and analyse the results of the trial. Information provided in this survey will be shared
2. By signing up to EQUINOX, you agree to us sharing your data with Guidehouse and National Energy Action (NEA) for the following purpose.
3. This information will include:
    - Name, email (To be invited to participate in trial surveys)
    - Postcode (For trial analysis)
    - Information about your home such as the property type, location, and information about your heating system. (For trial analysis)
    - Energy consumption data including half hourly electricity consumption data, Data from your B.E.E. (For trial analysis)
    - Tariff information. (For trial analysis)
    - Your Priority services register status (if you have answered yes to the previous question) (For trial analysis)
    - Your home ownership status (For trial analysis)
4. We will also be required to share anonymised and aggregated data which we collect during the trial with the other partners of the trial. All partners are listed here.
5. Sero's privacy policy shall apply to any data collected in connection with the trial. A copy of our privacy policy can be found here.
6. If you withdraw completely from EQUINOX, which you can do at any time, we will stop collecting your data, but we will still process any data collected prior to the date you left the trial. We will only process this data in an aggregated and anonymised form (so you cannot be personally identified) for the purposes of analysing the results of the trial.
7. You can ask us to stop sharing this data at any time by contacting us on hello@sero.life. If you have any questions about how your data will be processed during the trial, please contact us on hello@sero.life
8. We may need to remove you from the trial if your smart meter is disconnected, if you no longer use your heat pump to heat your home, or if you move house. We will let you know if we need to remove you from the trial.
9. We may need to suspend or cancel the trial and if we do, we will let you know. We will not be liable to you for any expenses you incur in connection with the trial, or any payments you would have received had the trial continued.
10. The results of the trial belong to us (and the other partners) and by agreeing to take part in the trial, you agree to comply with any applicable instructions we give you in relation to the trial. If you do not comply, we reserve the right to remove you from the trial.

ScottishPower

ScottishPower Equinox Terms & Conditions

General

These terms and conditions govern Scottish Power's trial of the Equitable Novel Flexibility Exchange ("Project EQUINOX") to allow customers to be rewarded for altering their heating choices during peak times (the "**Trial**").

The Trial will be run by SCOTTISHPOWER ENERGY RETAIL LIMITED, a company registered in Scotland (Company number: SC190287) and having its registered address at 320 St. Vincent Street, Glasgow, Scotland, G2 5AD ("**ScottishPower**");

The Trial is part of Project EQUINOX, funded by Ofgem's Network Innovation Competition ("**NIC**") and led by National Grid Electricity Distribution ("**NGED**"), in partnership with ScottishPower Energy Retail, Scottish Power Energy Networks, PassivUK, Welsh Government, Sero, National Energy Action ("**NEA**"), Octopus Energy and Guidehouse (the "**Partners**").

By participating in the Trial, you agree to comply with the following terms and conditions (the "**Trial Terms**") and any other communications given by ScottishPower as part of the Trial. These Trial Terms are separate to the terms and conditions for the supply of electricity that you have with ScottishPower and your rights and obligations under those terms are not therefore affected by these Trial Terms.

ScottishPower reserves the right to amend these Trial Terms at any point and the decision of ScottishPower will be final in the event of any dispute regarding any aspect of the Trial or The Trial Terms.

Trial Eligibility

To be eligible for the Trial:

- Your electricity supply must be with ScottishPower

- Your electricity supply point must be within the distribution network of National Grid Electricity Distribution (NGED)

- A heat pump must be the primary source of heating in your home and this heat pump should not be shared with any other domestic homes

- Your electricity meter must be an Electricity Smart Meter (as defined in the Smart Energy Code)

- You must consent to your Electricity Smart Meter providing us with half-hourly meter reading data

- Your meter must have communicated read data for a minimum of 80% of the [960] half-hour periods in the previous 20 days and must have communicated at least one full day, consisting of 48 contiguous half-hour periods commencing midnight, of half-hourly consumption data.

- We may issue participation surveys from time to time throughout the Trial to learn about your experience, and you must agree to participate in such surveys and to complete them within any relevant specified timeframes.

- Comply with these Trial Terms at all times

You must also agree not to participate in any other Demand Flexibility Service being provided by ScottishPower or any other supplier for the duration of the Trial period.

Trial Details

The Trial will start at 00:01 on 30th October 2023 and shall pause at 23:59 on 15th December 2023. The Trial will then resume at 00:01 on 8th January 2024 and end at 23:59 on 30th April 2024. There may be further trials that run after this period, however participation in this Trial will not automatically entitle you to participation in further trials.

There will be a minimum of 15 turn down windows ("**Events**") during the Trial and a maximum of 24 Events. Project EQUINOX Events will each take place between 4-8 pm. This timeframe corresponds to evening peak electricity demand in the UK.

The notification period for Events will vary throughout the Trial to simulate different needs of the grid at different times. You will receive a notification between 2 – 24 hours prior to the Event. Payment amounts for participating in Events will also vary based on notification time. As set out in the onboarding communications, you will earn rewards throughout the Trial based on your participation in Events and surveys.

If at any point throughout the Trial you are no longer eligible to participate, we reserve the right to remove you from the Trial. Similarly, if your Electricity Smart Meter becomes disconnected, if you no longer use your heat pump as the primary method of heating your home, or if you move home, we reserve the right to remove you from the Trial.

By participating in the Trial, you warrant that all information submitted by you is true, accurate and complete. If any information you submit is found to be incorrect, or if ScottishPower has reasonable grounds to believe that the Trial Terms have been breached, ScottishPower reserves the right to remove you from the Trial immediately.

ScottishPower will not be liable to reimburse any expenses incurred with entering the Trial and ScottishPower does not accept any liability for any equipment malfunction that may occur during the Trial.

You will not be able to remain in the Trial if you move house or change energy supplier during the Trial.

If at any point during the Trial you wish to opt-out, please email spsmartcities@scottishpower.com and we will remove you from the Trial.

If you exit the Trial or are removed for any reason, you will not be eligible for any further payments from the Trial.

Trial Participation and Payment

To participate in the Trial, you must download the application provided by our partner Equiwatt (the "**App**") and accept the App Terms & Conditions. ScottishPower will send you a notification via the App in advance of each Event. You will be able to decide which Events you participate in, however please note that you cannot earn rewards for Events you did not participate in.

After participating in an Event, you will be rewarded with points in the App. You can redeem your points against a series of rewards. Please visit the Rewards section of the App for more details. Any points not redeemed against the rewards within 6 months may be lost. Average heat pump customers can earn points worth up to £50 by participating in this Trial. The final amount you earn depends on various factors, including how many Events you opt in to, the amount of

energy your heat pump uses during Events compared to the amount of energy your heat pump normally uses, your participation in additional surveys, etc. Payment amounts may vary across the Trial according to the notice period and Trial group you are assigned to.

A fair and reasonable usage policy will apply, which means rewards will be based on turndown, measured according to your smart meter readings and capped based on the maximum heat pump system electrical consumption (kWh) over a 2 hour period for your make and model.

Data Protection and Privacy

ScottishPower's Privacy Information Notice shall apply to any personal data processed by ScottishPower in connection with the Trial. This policy can be found here.

The Trial is provided by ScottishPower in collaboration with project Partners. [You may be invited to participate in further research run by Guidehouse. By entering the Trial you agree to ScottishPower sharing your personal data with Guidehouse, for the purposes of administering surveys and analysing the conclusions of the Trial. This information includes but is not limited to:

- contact details (name, email address, phone number and postcode)

- information about your residence (property type, generalised location, presence of other low carbon technologies, how you heat your home and hot water)

- information about your household (occupancy, Priority Services Register status)

- half-hourly electricity consumption, including baseline and reduction data

Guidehouse have their own privacy policy which applies to their use of your personal data and which can be obtained from them directly.

ScottishPower is providing this Trial via an App in partnership with our provider Equiwatt who will process your personal data. You must accept the Terms and Conditions in the App when you download it in order to be able to continue participating in the Trial.

By participating in the Trial you understand that, for the purpose of administering the Trial, ScottishPower will share your Meter Point Administration Number (MPAN) with National Grid Electricity Distribution (NGED).

When you download the App, you will be able to view the Privacy Policy applicable to the App.

The results of the Trial belong to ScottishPower and to the other Partners in Project EQUINOX. As part of the Trial, we will be required to share anonymised, aggregated data collected during the Trial to analyse results with all Partners.

Appendix C: List of Domestic Flexibility Payment Schemes Considered During Development of Trial One Commercial Arrangements

Scheme	Who	When	Type	On	Earned per customer	Peak reduction	More details
Power Move[1]	Ovo Energy	2022/23	Drop to	Whole house	Up to £100 (£20/ month Nov-Mar)	Aim: reduce 4-7pm from 19% to 12.5% daily	Customer gets £20 every month it reduces average proportion of electricity consumption between 4-7pm below 12.5% of daily total
Saving Sessions[1]	Octopus Energy	2022/23	Turn down	Whole house	Up to £100	N/A	£4 per customer per event (assuming 1kWh turn down across ~25 events (1-2/week)
Viflex	Viess-mann (GER)	2022/03	Turn off	Heat pump	€120 sign up; €0.10/kWh for DLC reduction – up to €200-400/yr	N/A	Single heat flow tariff offered to consumers from ViShare tariff plan; current electricity prices for participants are €0.61-65/kWh, plus €8-11 monthly charge (varied by location); HP turned off for max 2 hours per day; customers define eligible blocking times for DLC
LEO	SSEN	2022/23	Turn down	Heat pump	£300 for DLC HP flex across winter	N/A	Only 3 homes; also free home retrofit assessment (£350) and retrofit cost up to £750 covered
Energywise	UKPN	2015-16	Efficiency	Whole house	£14/year energy saving	N/A	Energy saving: customers access smart meters, affordable energy saving devices, energy saving advice

Energywise	UKPN	2017-18	Turn-down	Whole house	£6.24/year TOU £37/year (£3-111) critical peak rebate	-2.2% evening peak, +22.2% weekend peak for TOU	TOU: free electricity on Sat/Sun between 9-5 Critical Peak Rebate: bill rebate if consumption reduced during DSR events. Credit of 10 units/ unit energy reduction in consumption relative to consumption recorded in previous equivalent days
SAVE	SSEN	2018	Drop-to	Whole house	Max £20 (first 6 weeks) Max £50 (final 6 weeks)	-4.2% (first 6 weeks), -7.1% (final 6 weeks).	Customers paid for every hour (in 4 hr periods every weekday) they stayed below custom kWh threshold (0.2, 0.5 or 1 kWh). 10p/h first 6 weeks, 30p/h final 6 weeks
Windy Day Fund	Octopus Energy/ SPEN	2022	Turn-up	Whole house	£5 average, £73 max	20 MWh shifted from peak hrs (3.3MWh avg)	6 events - 5:30-7:30am, 7:30-9:30pm; 24 hour notification period; if household +10% energy, credited back all energy used in event. If +100% extra, credited double the amount used
Powerloop	Octopus Energy	2020-21	Turn-up (sort of)	V2G	£30/month	N/A	One-off payment for having vehicle plugged into their charger and were available for the V2G service between 4-7pm at least 12 times
RPP	London Hydro (CAN)	2018-19	Turn-down	AC	$100 ($25 at start, $75 at end)	Up to -47% in CPP events	36 1-hour critical peak pricing (CPP - /kWh rate 10 time higher than slightly discounted TOU off-peak rate) evening peak events (1 yr)
APP	Alectra (CAN)	2015-16	Turn-down	Heat/ cool	Winter costs down 9-27% ($38-246); summer 0-10% ($1-50)	-2kW for max flex settings; -0.1kW for max comfort	DR savings delivered by participants varied depending on conservation setting selected. (from max flex to max comfort); CPP 11-14 times higher than slightly discounted off peak rate; 2 hrs + warning prior to CPP; CPP 4 hours max
Energywise Home	Duke (USA)	2016	Turn-down	Heat strips/ HW	$25 sign up; $25 bill credit per appliance per year	-2.77 kW per heat strip; -0.4kW per water heater	10 events for 78 participants; >90% respondents unaware when DLC events occurred

Appendix D: Technical Integration Testing

Sero trial one test plan

Test criteria	Life App - Pass/Fail	HMS – Pass/Fail	Comments
The list of BEE's is filtered to match the equinox trial in HMS	NA	Pass	Working as expected
The state of the heat source associated with each BEE will be displayed in the list of BEEs engaged in the equinox trial.	NA	Pass	Working as expected
If the BEEs do not have a heat pump status, the status will be Unknown.	NA	Pass	Working as expected
If a BEE is a part in the Equinox Trial, the BEE information page will display the EQ status.	NA	Pass	Working as expected
Request to turn off the heat pumps for home in trial: When the heat pump status is ON and the BEE is online, and an authorized user sends a request to turn the heat pump OFF. The heat pump is turned off.	Pass	Pass	Manual resource sent command to turn OFF the heat pump and worked as expected
Request to turn ON the heat pumps for home in trial: When the heat pump status is OFF and the BEE is online, and an authorized user sends a request to turn the heat pump ON. The heat pump is turned ON.	Pass	Pass	Manual resource sent command to turn ON the heat pump, all the schedules kicked in as expected.
When an unauthorized user sends a request to switch ON/OFF the heat pumps included in the Equinox trial, the status should remain unchanged, and the request attempt is logged.	Pass	Pass	Request initiated as a malicious (unauthorized)user to turn ON/OFF the heat pump and there was no change in the heat pump status and the request attempt was logged.
If a BEE is not participating in the equinox trial and is online, and a request to change the status is sent, the heat pump status remains unchanged.	Pass	Pass	Manual resource sent command to turn ON the heat pump, there was no change in the heat pump status. worked as expected

Request to turn off the heat pumps for home in trial: When the heat pump status is ON and the BEE is offline, and an authorized user sends a request to turn the heat pump OFF.	Pass	Pass	Alerts are now being sent over Slack when the BEE is offline.
When the heat pump is turned off and the current temperature is lower than the target temperature, and the user attempts to send a heating boost request, the current set point is returned if the request cannot be fulfilled.	Pass	Pass	Tried to send a heating boost request when the heat pump was OFF, and the request was not fulfilled
When the heat pump is turned off and the current temperature is lower than the target temperature, and the user attempts to send a heating hot water request, the Life App looks like boost has worked but then will sync and show the boost isn't on	NA	NA	Currently not supporting hot water requests
When the heat pump is turned off and the current temperature is lower than the target temperature, and the user attempts a manual override request, then no new set point is created	Pass	Pass	Did a manual override request when the heat pump was offline, and the heating status was shown as ON in the HMS dashboard and the new set point was also displayed in the heating page, but the heat pump was not turned ON.
When the heat pump is turned off and the current temperature is lower than the target temperature, and the user attempts to send a heating schedule request then the Schedules remain in place ready for when the heat pump is on	Pass	Pass	Heating schedules did not kick in when the heat pump was OFF,
When the heat pump is turned off and the current temperature is lower than the target temperature, and the user attempts to send a hot water schedule request then Schedules remain in place ready for when the heat pump is on	NA	NA	Currently not supporting hot water requests
When the heat pump is turned off and the current temperature is lower than the target temperature, and the user attempts to send a heat pump in pre-heat phase when call comes	Pass	Pass	Working as expected

in then turning heat pump off while turning off pre-heat event			
When the BEE goes offline during the trial end and if it is less than 150 mins after the trial end then the heat pump remains OFF	Pass	Pass	Manual resource initiated the Offline test, and worked as expected
When the BEE goes offline during the trial end and if it is more than 150 mins after the trial end then the heat pump is set to ON	Pass	Pass	Manual resource initiated the Offline test, and worked as expected
If the BEE loses power during the trial before the heat pump is ON, when the power is returned to the BEE then the heat pump status is turned ON	Pass	Pass	Manual resource initiated the test, and when the BEE was back the schedules kicked in successfully.

22-12-12_EQUINOX SERO Testbook.xlsx

Octopus trial one testing

equinox_connectivity_test_results.csv

Sero trial two testing

23-10-30_EQUINOX SERO Test plan.xlsx

Octopus trial two testing

20231030 EQUINOX trial two test results.cs

SPERL trial two testing

Equinox Consolidated UAT Re

ScottishPower EQUINOX Full Flow Di

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