Project FUSION

FUSION Interim Trial Learnings Report

Date of document 22.03.2022

SCOTTISHPOWER

Contents

Executive Summary

INTRODUCTION

Project FUSION has prepared this document to report on the progress and the intermediate learnings from phase 1 of the FUSION trial which commenced on 09th Sep 2021, as well as to communicate next steps.

This document should be read in conjunction with other FUSION publications and particularly the FUSION' Interim Trial Learnings Report #1, which was published in October 2021.[1]

OVERALL TRIAL LEARNINGS [2]

The FUSION trial is now fully operational, and flexibility is being dispatched in both St. Andrews and Leuchars areas. In phase 1 of the trial, the network congestion events are simulated almost daily to allow the trials to respond to those events using flexibility.

Phase 1 of the FUSION trial started in September 2021 and the following statistics provide a snapshot of progress (at the time of writing):

- 162 FlexRequests have been issued by the DSO;
- Power in the FlexRequests ranged from 5-500kW with a median of 200kW;
- 217 FlexOffers responded to these requests at an average price of £0.46/kWh;
- 54% of FlexOffers were followed up with a FlexOrder;
- 102 FlexRequests were followed up by at least one FlexOrder;
- 16.3MWh of flexible energy was realised; and
- Total utilisation payments amounted to £4810.

The trial showed that:

- Aggregators were able to respond to FlexRequests with at least one offer in 94% of cases.
- Aggregators successfully delivered FlexOrders from the DSO in 75% of cases.
- The incentive for delivering on FlexOrders is largely attributable to the Monthly Performance Adjustment Factor (MPAF) that is calculated as a function of an aggregator's performance in delivering FlexOrders and directly impacted aggregators' monthly availability payment.
- Aggregators FlexOffer prices closely approximated their contracted price caps.
- Aggregators were more likely to over-deliver power than under-deliver: on average, aggregators realised 187% of the ordered power. The reason for this is a combination of the type and number of flexible assets in each aggregator portfolio as well as the penalties associated with under-delivery. FUSION will seek to address this in Phase 2 by adjusting the penalties in the FSA.

Aggregators have also provided the following qualitative insights from their experience in phase 1:

---

[1] https://www.spenergynetworks.co.uk/pages/fusion.aspx#tablist1-tab4
[2] Please refer to Sections 3, 5 and 6 for further detail

- The standardisation of the FSA makes it easier for aggregators to implement from a system and commercial point of view, however the penalties imposed by the FSA on non-performing assets in phase 1 of the FUSION trial was considered too high.
- The overall experience with the UFTP and FUSION is user-friendly, even for aggregators with less experience in trading, to facilitate participation in flexibility markets. The automated bidding and settlement processes that USEF offers are extremely beneficial for smaller assets, which would otherwise have higher proportional management cost. However, penalties for non-delivery and long-term availability contracts make participation very difficult for smaller assets, where a market mechanism with a framework contract would be much better.

OpusOne observed that implementing a concept which has not been trialled before carries an inherent level of uncertainty. Some of the challenges they encountered included the following:

- Planning timescales were very tight and a more agile software approach would have facilitated the process.
- With data sharing being key to innovation projects, the trial itself would have benefited from more agile and fluid data sharing by all stakeholders throughout the process.
- The trial would have benefited from more testing rounds especially between OpusOne and SPEN to ensure that both teams are fully familiar with the platform and that progress was made in the right direction.
- OpusOne sees an opportunity for FUSION to further align with SPEN's BAU activities, which will be considered in phase 2 of the FUSION trial.

TRIAL LEARNINGS PER OBJECTIVE [3]

Project FUSION partners agreed on a set of learning objectives for the FUSION trial. The following provides a status update on the progress to date against each objective:

Cost Benefit Analysis (CBA)

The aim of the CBA was to evaluate the feasibility, costs, and benefits of implementing a common flexibility market framework based on the open USEF model to manage local distribution network constraints and to support wider national network balancing requirements. At the time of writing the analysis is still ongoing, but work is progressing according to schedule with preliminary outputs expected in May 2022.

Commercial Mechanisms

One of the aims of Project FUSION is to explore the commercial mechanisms that USEF offers to encourage consumer participation. Refer to Section 4 of this report for full analysis of this objective. The key conclusions of analysing this objective to date based on feedback from participating aggregators are as follows:

- Engaging with customers to educate them about flexibility markets remains a key barrier.
- USEF proposes standardisation of the interaction between aggregator and flexibility provider platforms and flexibility services. Therefore, even though there are multiple different routes to market (aggregator platforms, flexibility platforms and direct), USEF enables onboarding to be streamlined through standardisation.
- Two of the largest commercial barriers for flexibility service providers and aggregators which limit participation in flexibility markets are:

[3] Please refer to Section 4 for further detail

    - Challenges in defining, and adhering to, a business case to support businesses participating in the market through an aggregator; and
    - Achieving diversification in flexibility portfolio through ensuring the pool of domestic flexibility is large enough to minimise the impact to customers and aggregators.
- Domestic customers face most barriers to participation due to the inherent complexity in trying to forecast their energy usage and effectively control their assets. Furthermore, the strict performance adjustment factors (penalties) used in the FSA in phase 1 threatened to reduce the rewards for customers, further reducing their willingness to participate.
- The utilisation incentive should be increased in phase 2 to reduce barriers to participation.
- Data processing presents a huge challenge for aggregators, particularly those with large numbers of small customers.
- One aggregator noted that the notifications sent to customers were originally sent as FlexRequests (sent before response is accepted/ordered by the DSO) however, customers found this confusing and, as such, the aggregator switched to using FlexOrders to increase the accuracy of the notifications. To release the availability burden, notifications should be defined and agreed as acceptable to customers; generally, longer timescales (i.e. day ahead) are preferred to minimise impact to customer. All notifications need to be passed to the aggregator in sufficient time to inform the end customer.
- Tiered markets (combination of short- and long-term markets) benefit the aggregator. These markets provide more certainty around availability of flexibility and are much easier to onboard new assets into the market on an ongoing basis. In addition, they provide the financial security of long-term markets. FUSION is testing both long-term and short-term market elements.
- Basing a large proportion of flexibility payments on stated capacity six months ahead of time detracts from participants' ability to, and disincentivises them from, offering any available capacity closer to real time if they cannot meet the stated capacity. This is due to service providers and aggregators more likely declaring unavailability to avoid utilisation penalties as they are unable to meet the capacity requirements set at the contract. In short term markets, their capacity commitments would be dynamic so they would likely bid their real time capacity into the auction. In principle, committing to providing capacity 6 months ahead of time will act as a barrier to demand side engagement for any participant who is not a specialist DER investor / operator. (Gridimp)
- The USEF Free Bids mechanism is beneficial in that it provides more opportunity for revenue through enabling additional revenue outside of long-term contracts. (Orange Power)

D-programmes & baselining

D-programme (or D-prognosis) is a forecast that the aggregator provides day-ahead to the DSO, this forecast contains the net load or generation of each aggregator portfolio per congestion point. This forecast is submitted before flexibility trading, which means that it does not include DSO service delivery. USEF designed D-programmes for two purposes – 1) serving as baseline to quantify flexibility delivery and 2) providing visibility to the DSO for their own forecast as well as having the visibility on the flexibility amount that they could request from aggregators. In this report, we have analysed the effectiveness of D-programmes in satisfying each of these use cases through quantitative analysis and insights from FUSION trial participants and the DSO.

Regarding the use of D-programmes to improve DSO forecasts:

- FUSION has identified a way in which the DSO could conceivably integrate D-programmes into substation load forecasting to improve accuracy. To test this, however, the aggregator would need to communicate real time sub-meter data, which could be costly.

- The current DSO substation forecast is relatively accurate (estimated 2-3% of error) and therefore further reducing the error would have a small impact on the flexibility activations day-ahead. However, the D-programmes and other type of information (such as asset type, capacity, etc) could add significant benefit by improving the accuracy of lower-voltage forecasts, especially those below 11 kV, which are outside of the scope of the FUSION trial.
- Therefore, because of the limited value of attempting to improve forecast accuracy at 11kV and above, instead of attempting to integrate D-programmes into DSO forecasts, phase 2 will aspire to analyse the forecast accuracy at different times and how this affects the flexibility that needs to be requested by the DSO, and thus costs. For example, what would be the difference in flexible power and DSO costs if flexibility is ordered week-ahead/day-ahead compared with what is needed real-time? Can the difference be attributed to the forecast error?

Regarding the use of D-programmes as baseline:

- During phase 1, aggregators have successfully shared D-programmes, via the UFTP protocol, with the DSO. The DSO has successfully visualised the D-programmes on the FFP and used them for flexibility ordering, quantification and settlement.
- The accuracy shown by the D-programmes varies per portfolio type. The accuracy has consistently improved throughout the trial in every portfolio. Despite the improvement, the overall accuracy of the D-programmes is relatively poor when compared to what is typically regarded as a "good" or "acceptable" baseline[4]. It is worth noting the portfolios are relatively small, which makes them generally more difficult to forecast than larger, more diverse portfolios.
- Aggregators have praised the simplicity and inclusivity of D-programmes and regard them as one of the best features of USEF. A suggested improvement is to allow for D-programme intraday updates to be used as baselines to enhance their accuracy.
- As next step, project FUSION will aspire to compare the performance of D-programmes against other alternative baselines (historical and meter before meter after) to provide further insights on ENA baselining assessment for DSO flexibility products.[5]

Free Bids

USEF defines free bids as flex offers which aggregators send in response to a flex request from the DSO, that are either outside of their contracted availability window or above their contracted power capacity. This objective aims to analyse whether the use of free bids would save costs for DSO and benefit the aggregator by allowing them to bring additional non-firm capacity to the market (e.g. residential). Due to limitations on data, this report focuses on the pricing of free bids as well as the qualitative view of trial participants and feedback regarding the experience using free bids.

- Free bids have been successfully provided by aggregators in response to flexibility requests for periods outside of the availability window. However, the request was perceived by one of the aggregators as being somewhat ambiguous and they suggest to explicitly indicate in the message itself that the DSO is requesting free bids.
- Aggregators offered free bids close to or at the price cap. Aggregators stated that with the exceptionally high prices that the energy crises caused, it was not viable to offer free bids at

[4] This definition and criteria is based on the report "Baselining the ARENA-AEMO Demand Response RERT Trial" https://arena.gov.au/assets/2019/09/baselining-arena-aemo-demand-response-rert-trial.pdf

[5] https://www.energynetworks.org/industry-hub/resource-library/open-networks-2020-ws1a-p7-baselining-assessment-report.pdf

the contracted price cap. This situation seems to have impeded the normal market functioning that the FUSION trial expected.

- Aggregators regard free bids as a beneficial mechanism to allow for more non-firm capacity (e.g. residential assets) to be brought to the market, which in turn would result in more liquidity for the DSO. One of the aggregators, that has residential assets, was able to deliver twice the contracted available capacity and free bids provide a mechanism for them to be remunerated for activating that extra capacity when requested by the DSO.
- Aggregators believe that the participation of free bids could result in a lower overall flexibility cost for the DSO since they could spread their costs into many more assets. To evaluate the veracity of this hypothesis, FUSION is considering increasing the price caps on free bids in Phase 2 (i.e. a discretionary utilisation ceiling price) to reflect the current energy prices and to assess whether that results in more cost-effective offers from aggregators.

Sub-metering arrangements

This objective aimed to compare and contrast the use of MPAN data versus the use of sub-meter data for service delivery validation and settlement purposes. Due to lack of access to MPAN data during the trial, this assessment focussed on qualitative insights from the aggregators.

In phase 1 of the FUSION trial, flexibility validation was performed exclusively using sub-meter data for all congestion points and participating aggregators. Some of the assets, such as CHPs and EVs, had an integrated sub-meter. Whereas for other residential assets the sub-meter was installed by the aggregators. Based on aggregators' experience with sub-metering arrangements, both aggregators suggest that they prefer the use of sub-metering versus connection point meters in flexibility services:

- Sub-metering offers better resolution and visibility of asset behaviour
- Sub-metering allows for more informed control of assets
- Forecasting at asset sub-meter level is more straightforward because aggregators do not have visibility of the rest of assets behind the main meter.
- Access to MPAN data for residential connections is not available to non-supplier aggregators.

Market Co-ordination Mechanism (MCM)

The USEF MCM facilitates flexibility trading and consists of five phases – contract, plan, validate, operate and settle. During the trial, the contract phase was populated at the procurement stage whereas the phases from 'plan' to 'operate' were conducted day-ahead and intraday. This report analyses:

1. the *fit* of SPEN's DSO flexibility operations (i.e. business-as-usual) with the USEF MCM;
2. the *experience* of aggregators using MCM features such as FlexReservationUpdates and D-programmes intraday updates;
3. the *reliability* of flexibility dispatched through portfolio bids and asset bids.
4. The conclusions are based on quantitative analysis of trial data and feedback from the trial participants and DSO insights:
    a. All five phases of the USEF MCM have been successfully trialled in phase 1.
    b. SPEN BaU flexibility process is still at an early stage and USEF MCM could contribute to the development of a more consolidated approach.
    c. FlexReservationUpdates are, according to aggregators, a beneficial function for enabling them to manage their portfolios and avoid conflicts with the delivery of other services. However, SPEN BaU expressed a concern that, because DSO services are fully stackable, the added value from FlexReservationUpdates may be limited.

d. Aggregators perceive limited value to D-programme intraday updates because they do not serve as updated baselines, but just offer an update to the DSO on the latest forecasted behaviour of the aggregated load.

e. Regarding reliability of portfolio bids against asset bids, the trial results indicate that reliability of portfolio bids is higher than asset bids by 4%. The portfolio bids consisted, in the most part, of residential assets.

USEF Flexibility Trading Protocol (UFTP)

In the FUSION trial the interaction between SPEN (DSO) and the aggregators has been formalised through the USEF Flexibility Trading Protocol (UFTP). The scope of this learning objective was to quantify the UFTP implementation costs for SPEN and the aggregators, assess their respective user experiences of the UFTP, consider the applicability of UFTP to the wider GB industry, assess potential cost savings that can be realised through the use of this standardised protocol and identify barriers and challenges to its implementation.

The conclusions of the assessment of the UFTP objectives are:

- The cost and implementation effort for aggregators was considered low to medium. One of the aggregators considered the effort of implementation lower than for other platforms such as NGESO's marketplace. The other aggregator considered that the effort of implementation was higher than for the one needed to communicate with BaU platform, but this additional effort was commensurate with the additional functionality realised. The effort for OpusOne was considered high as they had to develop a new platform and incremental changes to their existing platform were not sufficient.
- Aggregators and OpusOne highlighted a number of benefits of UFTP associated with the automated UFTP processes, the use of D-programmes, the inclusivity of UFTP even for new participants, the bidding process and the streamlined MCM.
- The benefit of standardisation for the wider industry and for the aggregators, in particular, was recognised by all interviewees, as the use of multiple platforms would create additional burden for market participants.
- Although aggregators suggest that UFTP is fit-for-purpose for GB and the Energy Networks Association (ENA) products, OpusOne has identified several functionalities that it considers the current version of the UFTP may not satisfactorily address. For example, UFTP does not have the ability to integrate with network models and is not designed for settlement of availability payments.
- A number of improvements have been suggested by the aggregators and OpusOne (see section 4.8.3). These improvements will be considered and assessed by project FUSION to understand if they can be accommodated in phase 2 of the trial. Some of these improvements have already been discussed with Shapeshifter so that the UFTP can be modified.

NEXT STEPS [6]

Two primary objectives for phase 2 are:

a) to simulate events that more closely resemble real grid congestion issues; and

b) if possible, dispatch flexibility that alleviates real network congestion, as opposed to simulated congestion.

---

[6] Please refer to Section 7 for further details

(Editorial note 27/04/22: Both of these objectives were successfully achieved in April 2022 within the first month of Phase 2 having commenced. More detail will be provided in the ITLR#3 report due Oct 2022).

The next steps for phase 2 are:

1. To simulate events closer to real conditions in phase 2 we will ingest real forecast data and exclusively modify the maximum power threshold at substation or feeder level, instead of modifying the forecasts (as in phase 1).
2. Project FUSION will aspire to study the rebound effect: analyse meter data and linking this data to the types of assets that deliver flexibility with the help from the aggregators to calculate the rebound effect at meter, feeder and substation level.
3. FUSION will aspire to test the use of partial activations: USEF offers the possibility for aggregators to add partial activation in their FlexOffers. This means that aggregators give the DSO the option to choose, for example, 50% or 100% activation of the offered flexibility.
4. FUSION trial will aspire to test the use of intraday flexibility trading: USEF encourages DSOs and aggregators to iterate the 'plan' and 'validate' phase as needed up to the 'operate' phase (i.e. real time).

ENA Collaboration: In phase 2, project FUSION will collaborate with Energy Networks Association (ENA) Open Networks project (ONP) Workstream 1A Product 5 (WS1A P5) to develop a report which will quantify the impacts of the primary rules with regard to conflict management and co-optimisation of DSO and ESO flexibility services.

1. Introduction

1.1. OVERVIEW OF PROJECT FUSION

Project FUSION is funded under Ofgem's 2017 Network Innovation Competition (NIC), to be delivered by SP Energy Networks in partnership with the following project partners: DNV (formerly: DNV GL), Origami Energy, Imperial College London (academic partner), SAC Consulting, The University of St. Andrews, and Fife Council.

Project FUSION represents a key element of SP Energy Network's transition to becoming a Distribution System Operator, taking a step towards a clean, smart and efficient energy system. As the electricity system changes from a centralised to decentralised model, it enables a smarter and more flexible network to function. Project FUSION is trialling the use of commoditised local demand-side flexibility through a structured and competitive market, based on a universal, standardised market-based framework; the Universal Smart Energy Framework (USEF). USEF provides a standardised framework that defines products, market roles, processes and agreements, as well as specifying data exchange, interfaces and control features. The purpose of USEF is to accelerate the transition to a smart, flexible energy system to maximise benefits for current and future customers.

FUSION will also inform wider policy development around flexibility markets and the DNO-DSO transition through the development and testing of standardised industry specifications, processes, and requirements for transparent information exchange between market participants accessing market-based flexibility services. Ultimately, FUSION will contribute to Distribution Network Operators and all market actors unlocking potential and value of local network flexibility in a competitive and transparent manner. In doing so, FUSION aims to contribute to addressing the energy trilemma by making the energy system more secure, more affordable and more sustainable.

1.2. USEF OVERVIEW

The USEF framework aims to facilitate effective coordination across all the different actors involved in the electricity market by providing a common standardised roles model and market design while describing communication requirements and interactions between market roles. USEF turns flexible energy use into a tradeable commodity available for all energy market participants, separated from (but in coordination with) the traditional electricity supply chain, to optimise the use of resources. USEF focuses on explicit demand-side flexibility, in which prosumers are contracted by the aggregator to provide specific flexibility services using Active Demand and Supply (ADS) assets. USEF acknowledges but does not provide detailed considerations for implicit demand-side flexibility or peer-to-peer energy trading.

To facilitate the transition towards a cost-effective and scalable model, the framework provides the essential tools and mechanisms which redefine existing energy market roles, add new roles and specify interactions and communications between them. In addition, the USEF standard ensures that all technologies and projects will be compatible and connectable to the energy system, facilitating project interconnection, hence fostering innovation and accelerating the smart energy transition. By delivering a common standard to build on, USEF connects people, technologies, projects and energy markets in a cost-effective manner. Its market-based mechanism defines the rules required to optimise the whole system, ensuring that energy is produced, delivered and managed at lowest cost for the whole system and effectively for the end-user. The USEF framework provides:

- a standardised common framework designed to be implemented on top of current energy markets such as wholesale, retail and capacity markets.

- A description of the flexibility value chain (FVC) involving new and existing market players and giving a central role to the aggregator in facilitating flexibility transactions.
- A roles model and interaction model to enable the implementation of different business models and interactions between actors

A market design described by the Market Coordination Mechanism (MCM) which sets out the phases and interaction requirements for flexibility transactions. The MCM provides all stakeholders with equal access to a smart energy system. To this end, it facilitates the delivery of value propositions (i.e. marketable services) to various market parties without imposing limitations on the diversity and customisation of those propositions.

Detailed communication and markets access requirements taking into considerations privacy and cybersecurity issues.

The USEF was initially developed by the USEF Foundation. In 2014, the USEF Foundation was inaugurated to accelerate the establishment of an integrated smart energy market which benefited all stakeholders, from energy companies to consumers. USEF was an early mover, a combined force of parties and professionals with a shared goal. Together they explored new territories to help unlock and structure the future market and, as a result, many elements of USEF can now be found in standardisation and harmonisation policies at both national and European level.

In 2021, 7 years later, the work of the USEF Foundation was therefore considered complete and USEF Foundation had ceased to exist by 1 July. To safeguard the legacy of the USEF foundation, the USEF framework, including the UFTP protocol (recently rebranded to Shapeshifter) is being maintained by the GOPACS organisation. The Shapeshifter protocol has also been adopted by the Linux Energy Foundation, offering a platform for the maintenance and support of the protocol.

1.3. BACKGROUND TO THIS DOCUMENT

Project FUSION commenced in September 2018. Since then, a number of significant milestones and preparatory activities have been completed, culminating in the commencement, in September 2021, of the live FUSION trials, which marked the first deployment in GB of a USEF-compliant flexibility market.

1.4. PURPOSE OF THIS DOCUMENT

Project FUSION has prepared this document to report upon the progress, implementation and interim learnings from Phase 1 of the FUSION trial which commenced on 9th Sep 2021, as well as to outline the planned next steps for trial Phase 2.

This document provides an overview of:

5. The background of the trial design and its operation to date, including an overview of flexibility providers and flexibility assets that have been participating in phase 1, the detailed service requirements and the trial cases that have been simulated.
6. The analysis of the trial operation to date, key statistics on delivered flexibility, prices, flexibility offers and orders;
7. Assessment of delivery against agreed objectives for the FUSION trial phase 1;
8. Learnings from stakeholders and participants in the FUSION trial phase 1;
9. FUSION's current progress with stakeholder engagement and
10. Next steps for phase 2 of the trial, which is planned to commence in April 2022.

2. Trial design & Operation

This section provides an overview of the FUSION's phase 1 trial design and operation. It describes the main roles and responsibilities, the type of flexibility services that were procured and activated in phase 1, the type of flexibility providers and assets participating in the trial, as well as the test cases that were simulated.

2.1. ROLES AND RESPONSIBILITIES

FUSION partners agreed on the FUSION USEF Implementation Plan, covering the flexibility services and the USEF roles that the trial seeks to test. Table 2-1 sets out the roles included in the trial and the market parties responsible for performing them.

Table 2-1: USEF roles in the FUSION trial

USEF Role	Inclusion in FUSION trial	Performed by	Comments
Distribution System Operator (DSO)	Yes	SP ENERGY NETWORKS	
Electricity System Operator (ESO)	No	n/a	
Prosumer	Yes	DERs owners contracted by participating aggregators	
Active Demand Supply (ADS)	Yes	DERs managed by participating aggregators	
Aggregator	Yes	Flexibility providers: Engie and Orange Power	Selected Through industry engagement and tendering process
Supplier	No	n/a	
Capacity Service Provider (CSP)	No	n/a	The aggregator can also be active in the capacity market, but the trial will not test the interactions with this role

Constraint Management Service Provider (CMSP)	Yes	Flexibility providers: Engie and Orange Power	Through industry engagement and tendering process
Balancing Services Provider (BSP)	No	n/a	The aggregator can also be active in balancing products, but trial phase 1 will not test interactions with this role
Balance Responsible Party (BRP)	No	n/a	The aggregator can also be active in wholesale trading, but trial phase 1 will not test interactions with this role
Common Reference Operators (CRO)	Yes	SP ENERGY NETWORKS	
Meter Data Company (MDC)	Yes	SP ENERGY NETWORKS	SP ENERGY NETWORKS will take this role by default
Allocation Responsible Party (ARP)	No	n/a	Wholesale settlement is out of scope for trial phase 1

2.2. FLEXIBILITY SERVICES

This section provides a high-level description of the available DSO flexibility that was procured in preparation for phase 1 of the trial for each of the DSO congestion management zones.

2.2.1 DSO Flexibility Services

Three DSO Services were procured in the two selected locations for trial phase 1:

- Sustain Peak Management: A service to provide the DSO with a planned reduction in demand or increase in generation in advance of a forecast capacity constraint at peak time, e.g. reducing the loading on a transformer during tea-time peak.
- Secure DSO Constraint Management (pre-fault): A service to provide the DSO with an immediate reduction in demand or increase in generation during a planned outage of one or more critical assets on in the event of network disturbances to maintain security standards and avoid any customer minutes lost.
- Dynamic DSO Constraint Management (post-fault): A service to provide the DSO with an immediate reduction in demand or increase in generation following an unplanned outage of one or more critical assets to maintain security standards and avoid any customer minutes lost.

2.2.2 Location of Flexibility

The project trial area of East Fife is defined as the network area supplied by the primary substations at St Andrews and Leuchars. This area was selected because both recent load growth and the integration of distributed generation have led to localised network constraints which FUSION was designed to alleviate.

As such all flexible units, including distributed energy resources (DERs) and flexible assets, are located within the area that is normally supplied by St. Andrews primary substation and Leuchars primary substation. More information on the postcodes served by the St. Andrews and Leuchars can be found in the FUSION Flexibility Services Requisition (FSR) for each location. [7] [8]

2.2.3 Detailed service requirements

The flexibility requirements for each location have been published in the FSR document and are summarised below.

Table 2-2: Flexibility Requirements in St. Andrews

		Response Type*						
Ref	Year	Demand (kW)	Generation (kW)	Period	Days	Service Window	Service Type	Duration (mins)
1	2021	-250	250	Oct - Dec	Mon - Fri	09:00 – 10:30 11:00 – 13:00 15:00 – 17:00	Sustain Peak Management	60
2	2021	-250	250	Jul-Sep	Mon - Fri	09:00 – 10:30 11:00 – 13:00 15:00 – 17:00	Sustain Peak Management	60
3	2021	-250	250	Oct - Dec	Mon - Fri	14:00 – 16:00	Secure DSO Constraint Management (Pre-fault)	60
4	2021	-250	250	Jul – Sep	Mon - Fri	14:00 – 16:00	Secure DSO Constraint Management (Pre-fault)	60
5	2021	-250	250	Jun - Dec	Mon - Fri	14:00 – 16:00	Dynamic DSO Constraint Management (Post-fault)	60

*a positive value represents an increase in demand or export; negative is the opposite

[7] FSR Leuchars: FUSION_Flexibility_Services_Requisition_Leuchars_SP ENERGY NETWORKS.pdf (SP Energy Networksergynetworks.co.uk)
[8] FSR St. Andrews: FUSION_Flexibility_Services_Requisition_St_Andrews_SP ENERGY NETWORKS.pdf (SP Energy Networksergynetworks.co.uk)

Table 2-3: Flexibility Requirements in Leuchars

		Response Type*						
Ref	Year	Demand (kW)	Generation (kW)	Period	Days	Service Window	Service Type	Duration (mins)
1	2021	-250	250	Oct - Dec	Mon - Fri	09:00 – 10:30 11:00 – 13:00 15:00 – 17:00	Sustain Peak Management	60
2	2021	-250	250	Jul-Sep	Mon - Fri	09:00 – 10:30 11:00 – 13:00 15:00 – 17:00	Sustain Peak Management	60
3	2021	-250	250	Oct - Dec	Mon - Fri	14:00 – 16:00	Secure DSO Constraint Management (Pre-fault)	60
4	2021	-250	250	Jul – Sep	Mon - Fri	14:00 – 16:00	Secure DSO Constraint Management (Pre-fault)	60
5	2021	-250	250	Jun - Dec	Mon - Fri	14:00 – 16:00	Dynamic DSO Constraint Management (Post-fault)	60

*a positive value represents an increase in demand or export; negative is the opposite

Project FUSION has developed additional service requirements which have been specified within the Flexibility Service Agreements (FSAs) between the aggregators and SPEN.[9] These additional service requirements are described below:

1. Maximum Response Time: This parameter depends on the service. Sustain Peak Management, Secure DSO Constraint Management (pre-fault) and Dynamic DSO Constraint Management (post-fault) have a maximum response time of 17 hours, 30 minutes and 15 minutes respectively.
2. Minimum Sustain Time: 60 minutes
3. Metering requirements: Minute-by-minute metering is required to monitor the provision of the flexibility services aggregated in 30-minute intervals for data sharing purposes.

[9] Flexibility Service Agreement (FSA) template: Flexibility_Services_Agreement_Template.pdf (SP Energy Networksergynetworks.co.uk)

4. Metering point: The metering point can be at asset level (i.e. sub-metering) or at boundary level (i.e. the main meter between the Site on which the Distributed Energy Resource (DER) is located and the SPEN network).
5. Baseline for measuring delivery: A nomination baseline is used for the settlement of the delivered flexibility. As per USEF terminology, the D-programme which is issued before the Flexibility Offer is used as baseline.

2.2.4 Flexibility providers and flexible assets

The following table provides and overview of aggregators' assets at each congestion point.

Table 2-4 Overview of Assets at Each Congestion Point

Congestion Point	Aggregator Name	Asset type - technology	Capacity (kW)	Asset flexible rating (kW)	Ramp-down (min)	Ramp-up (min)
St Andrews primary	Orange Power	Electric Vehicle Chargers and Solar	305	305	1	1
St Andrews primary	Orange Power	Combined Heat and Power (CHP)	35	35	5	5
St Andrews primary	Orange Power	CHP	50	50	5	5
Leuchars primary	Orange Power	Electric Vehicle Chargers	291	291	1	1
St Andrews primary	Engie & Gridimp	CHP	238	238	5	5

2.3. OPERATION

This section presents the overview of the test cases simulated during the trial phase 1 period. Although there was no real congestion affecting any of the substations,[10] the cases were designed so that flexibility would be dispatched by simulating a number of plausible scenarios. Within each use case there are a number of test cases depending on the day-ahead and intraday forecast of the substation load.

The first subsection below describes the test cases that were simulated and tested throughout the trial phase 1 period. These explain the logic that the DSO follows to trade flexibility, i.e. to request flexibility from the aggregators and then order it if it is required (i.e. issue a FlexOrder). In the second subsection, we present some statistics on the number of events simulated per test case

[10] In phase 1 of the live trials, all congestion has been simulated. Alleviation of real congestion will be introduced in phase 2 of the trials, which commence in April 2022.

and distribution of requested power during operation. It is worth noting that the simulations were executed according to a schedule that was designed to ensure that all test cases were trialled and that a high turn-over of events were achieved to maximise the volume of relevant empirical data generated for subsequent analysis within the boundaries of the contracts.

2.3.1 Overview of use cases and test cases

2.3.1.1 Use case – Secure DSO Constraint Management (pre-fault)

Use case description: There is a need to reduce the demand on a distribution network asset [immediately or at least within the hour] under certain system conditions and at certain times of day for a maximum duration to keep that asset within its operational capability. This could support the network to avoid fault conditions, during both planned and un-planned maintenance work, or where a constraint is forecast, using a DSO-triggered service.

The flexibility required can come from one of three actions that help to reduce demand at the Meter Point Administration Number (MPAN): (1) a reduction in demand, (2) an increase in generation, or (3) discharging a battery.

Test case 1.1 - Secure DSO Constraint Management (pre-fault) - Reserve + Order

To reserve and issue an order for flexibility under the Secure DSO Constraint Management product, the DSO would observe the following preconditions during day-ahead (D-1) and intraday (D) operation:

- Day D-1: The forecast for day D at congestion point Y is below the maximum power profile and peak load occurs between 14:00 and 16:00 on a weekday. The forecast can have inaccuracies; therefore, the DSO uses a lower adjusted maximum power profile to reflect inaccuracies (>3% lower) to consider a potential forecast underestimation. When applying the power profile reduction, the forecast exceeds the profile. This triggers the DSO to send a FlexRequest for day D.
- Day D: The real-time updated intraday forecast shows that the load will be above the maximum power profile sometime between 14:00 and 16:00 on a weekday. This triggers the DSO to send a FlexOrder by selecting the FlexOffers that cover the foreseen excess load.

Test case 1.2 - Secure DSO Constraint Management (pre-fault) - Reserve + no Order

To reserve flexibility under the Secure DSO Constraint Management product, the DSO would observe the following preconditions:

- Day D-1: As per Test Case 1.1.
- Day D: The real-time updated intraday forecast shows that the load will be below the physical threshold between 14:00 and 16:00. The operator does not send FlexOrders.

Test case 1.3 - Secure DSO Constraint Management (pre-fault) - Free bid + Order

To reserve flexibility under the Secure DSO Constraint Management product and to order it during intraday, the DSO would observe the following preconditions:

- Day D-1: The forecast for day D at congestion point Y is below the maximum power profile and peak load occurs outside the availability windows (i.e. weekdays at any time except 14:00 – 16:00 or weekend). The forecast can have inaccuracies; therefore, the DSO uses a lower adjusted maximum power profile to reflect inaccuracies (>3% lower) to consider a potential forecast underestimation. When applying the power profile reduction, the forecast exceeds the maximum power profile. This triggers the DSO to send a FlexRequest for day D.
- Day D: The real-time updated intraday forecast shows that the load will be above the threshold in the next 30 min coinciding with the period in which the FlexRequest was made. This triggers the operator to send a FlexOrder by selecting the FlexOffers that cover the foreseen issue.

Test case 1.4 - Secure DSO Constraint Management (pre-fault) - Free bid + no Order

To request free bids and not activate them under the Secure DSO Constraint Management product, the DSO would observe the following preconditions

- Day D-1: As per test case 1.3.
- Day D: The real-time updated intraday forecast shows that the load will be below the maximum power profile for the coming periods. The DSO does not send any FlexOrders.

Test case 1.5 - Secure DSO Constraint Management (pre-fault) - FlexReservationUpdate

To send the aggregators a FlexReservationUpdate to release them from their availability obligation at a certain day, the DSO would observe the following preconditions

- Day D-1: The forecast for day D at congestion point Y is below the maximum power profile and peak load occurs between 14:00 and 16:00 on a weekday. The forecast can have inaccuracies; therefore, the DSO uses a lower adjusted maximum power profile to reflect inaccuracies (>3% lower) to consider a potential forecast underestimation. When applying the power profile reduction, the forecast doesn't exceed the profile. This triggers the DSO to send a FlexReservationUpdate.

2.3.1.2 Use case – Dynamic DSO Constraint Management (post-fault)

Use case description: There is a need to reduce the demand on a distribution network asset immediately following a network fault, for a maximum duration to keep that asset within its operational capability. This service is unplanned but could be scheduled at times of high network risk.

The flexibility required can come from one of three actions that help to reduce demand at the substation: (1) a reduction in demand, (2) an increase in generation, or (3) discharging a battery.

Test case 2.1 – Dynamic DSO Constraint Management (post-fault) - Reserve + Order

To reserve and order flexibility under the Dynamic DSO Constraint Management product, the DSO would observe the following preconditions:

- Day D-1: The forecast for day D at congestion point Y is below the maximum power profile and peak load occurs between 14:00 and 16:00 on a weekday. The DSO knows that there might be a fault occurring the following day in one of the assets, which might lower the maximum power profile (by >3%). The DSO lowers the maximum power profile to simulate what would happen if the fault occurred. After lowering the profile, the forecast exceeds the maximum power profile showing a deficiency. This triggers the DSO to send a FlexRequest for the following day.
- Day D: Between 14:00 and 16:00 a fault occurs (i.e. the maximum power profile drops) and the DSO immediately sends a FlexOrder to remediate the excess load.

Test case 2.2 - Dynamic DSO Constraint Management (post-fault) - Reserve + no Order

To reserve flexibility under the Dynamic DSO Constraint Management product and to not order it during intraday, there are certain preconditions that the DSO would observe during day-ahead (D-1) and intraday (D) operation:

- Day D-1: As per Test Case 2.1.
- Day D: A fault does not occur, and the DSO does not send any FlexOrder.

Test case 2.3 - Dynamic DSO Constraint Management (post-fault) - Free bid + Order

To request free bids and activate them under the Dynamic DSO Constraint Management product, there are certain preconditions that the DSO would observe during day-ahead (D-1) and intraday (D) operation:

- Day D-1: The forecast for day D at congestion point Y is below the maximum power profile and peak load occurs outside the availability windows (i.e. weekdays at any time except 14:00 – 16:00 or weekend). The DSO knows that there might be a fault occurring the following day in one of the assets, which might lower the maximum power profile (by >3%). The DSO lowers the maximum power profile to simulate what would happen if the fault occurred. After lowering the profile, the forecast exceeds the maximum power profile showing a potential constraint. This triggers the DSO to send a FlexRequest for the following day.
- Day D: A fault occurs (i.e. the maximum power profile drops) and the DSO immediately sends a FlexOrder to remediate the deficiency.

Test case 2.4 - Dynamic DSO Constraint Management (post-fault) - Free bid + no Order

To request free bids and not activate them under the Dynamic DSO Constraint Management product, there are certain preconditions that the DSO would observe during day-ahead (D-1) and intraday (D) operation:

- Day D-1: As per Test Case 2.3.
- Day D: A fault doesn't occur, and the DSO doesn't send any FlexOrder.

Test case 2.5 - Dynamic DSO Constraint Management (post-fault) - FlexReservationUpdate

To send the aggregators a FlexReservationUpdate to release them from their availability obligation at a certain day, under the Dynamic DSO Constraint Management product, there are certain preconditions that the DSO would observe during day-ahead (D-1).

- Day D-1: The forecast for day D at congestion point Y is below the maximum power profile and peak load occurs between 14:00 and 16:00 on a weekday. The DSO knows that there might be a fault occurring the following day in one of the assets, which might lower the maximum power profile (by >3%). The DSO lowers the maximum power profile to simulate what would happen if the fault occurred. When applying the power profile reduction, the forecast doesn't exceed the profile. This triggers the DSO to send a FlexReservationUpdate.

2.3.1.3 Use case – Sustain Peak Management

Use case description: There is a need to reduce the demand on a distribution network asset to keep that asset within its normal operational capability. This could be as a result of a forecast capacity constraint on the asset at a particular time, e.g. to reduce the demand on a critical asset during winter tea-time peak, using a DSO planned service. This service supports the deferral or avoidance of conventional approaches to network reinforcement.

The flexibility required can come from one of three actions that help to reduce demand at the MPAN: (1) a reduction in demand, (2) an increase in generation, or (3) discharging a battery.

Test case 3.1 – Sustain Peak Management - Reserve + Order

To reserve and order flexibility under the Sustain Peak Management product, there are certain preconditions that the DSO would observe during day-ahead (D-1):

- Day D-1: The forecast for day D at congestion point Y is above the maximum power profile on a weekday in a period between any of the timeslots 09:00-10:30, 11:00-13:00 and 15:00-17:00. This triggers the DSO to send a FlexRequest. After receiving FlexOffers from aggregators, the DSO selects the FlexRequest(s) and sends FlexOrder(s) to cover the foreseen issue.
- Day D: The DSO takes no further action as the flexibility is delivered as per the day-ahead FlexOrders.

Test case 3.2 - Sustain Peak Management - Free bid + Order

To request free bids and activate them under the Sustain Peak Management product, there are certain preconditions that the DSO would observe during day-ahead (D-1) operation:

- Day D-1: The forecast for day D at congestion point Y is above the maximum power profile on a weekend or a weekday in a period outside these timeslots 09:00-10:30, 11:00-13:00 and 15:00-17:00. This triggers the DSO to send a FlexRequest. After receiving FlexOffers from aggregators, the DSO selects the FlexRequest(s) and sends FlexOrder(s) to cover the foreseen issue.
- Day D: The DSO takes no further action as the flexibility is delivered as per the day-ahead FlexOrders.

Test case 3.3 - Sustain Peak Management - FlexReservationUpdate

To send the aggregators a FlexReservationUpdate to release them from their availability obligation at a certain day, under Sustain Peak Management product, there are certain preconditions that the DSO would observe during day-ahead (D-1).

- Day D-1: The forecast for day D at congestion point Y is below the maximum power profile on a weekday in a period between any of these timeslots 09:00-10:30, 11:00-13:00 and 15:00-17:00. This triggers the DSO to send a FlexReservationUpdate.

2.3.2 Summary of test cases deployed in Phase 1

Phase 1 of the trial simulated the different test cases at the two congestion points. Each simulation tested how FUSION trial participants (FTPs) responded to the different test cases outlined above. The number of simulations of each test case at each congestion point is shown below (Figure 2-1). The simulation schedule focused on test cases where flexibility is ordered (i.e. test cases 1.1, 2.1 and 2.3) to maximise the volume of empirical data generated where flexibility is delivered. The schedule also ensured that there was data on all the other test cases.

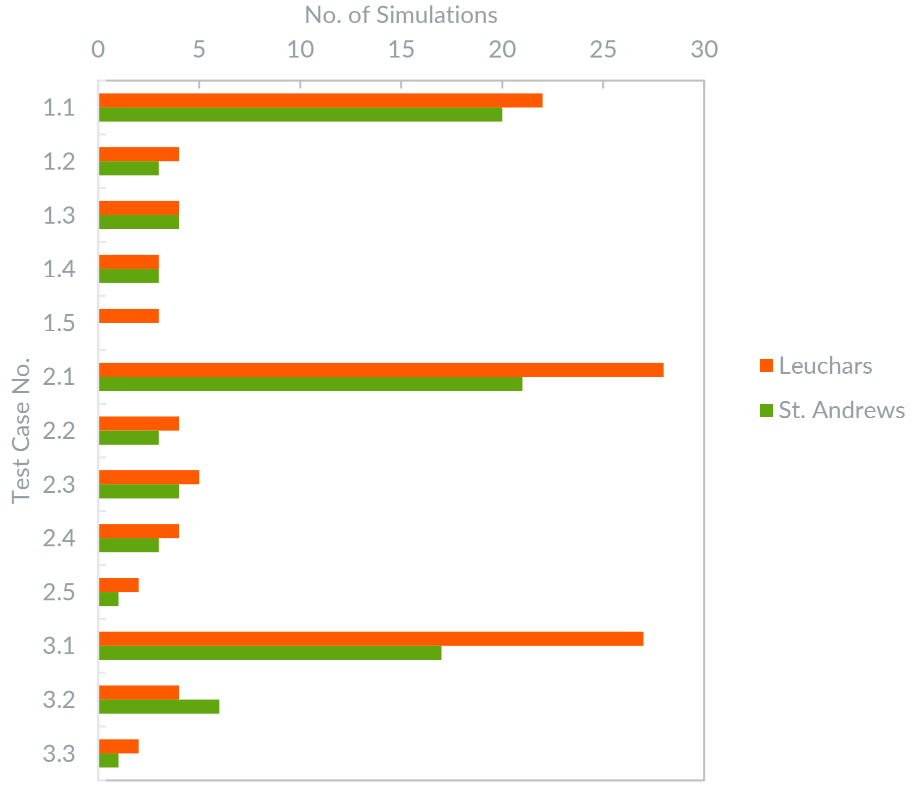

Figure 2-1 Number of Simulations for Each Test Case at Leuchars and St Andrews

The distribution of power requested shows that higher quantities of flexibility were requested at St. Andrews than at Leuchars (Figure 2-2). This is because more flexible capacity was connected at St Andrews than Leuchars, so the trial was able to test out requesting greater amounts of flexibility at this location.

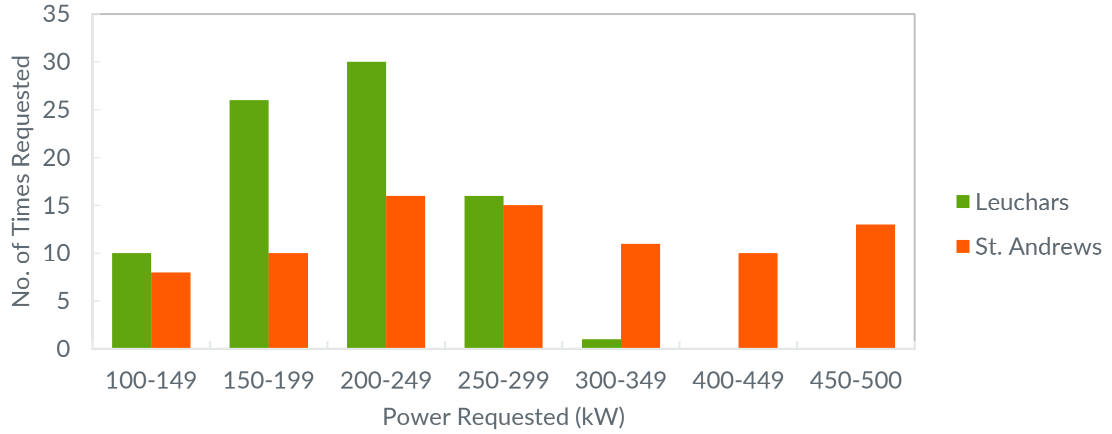

Figure 2-2 Histogram Showing the Range of Power Requested Throughout Analysis Period

3. Trial simulation overview

This section provides an overview of the results from Phase 1 of the trial and offers insights into the delivered flexibility and the observed trends in offers, orders and prices. The section outlines the method used to analyse the available data before looking at three key topic areas: trial summary statistics, delivered flexibility and the relationship between offers, prices and orders. For each topic, we provide the scope of the analysis, the results and the interim learnings and conclusions.

3.1. METHODOLOGY

The analysis has used data covering the trial period between 09/09/2021 and 09/02/2022, which corresponds to the time between when the communication protocols were fully established and a deadline that the project had to impose to be able to complete the analysis in time for the report to be published in April 2022. The data included the following:

1. Meter data - from each aggregator at portfolio level at each congestion point and from the DSO at the substation.
2. Validation Phase Information – including D-programmes, FlexRequests, FlexOffers and FlexOrders.
3. Trial Simulation Schedule – a pre-determined list of the FlexRequests and FlexOrders to be placed. The trial simulation schedule includes the plan for activating the test cases examined in this trial.
4. Settlement Information – showing payments due for delivered flexibility for each event and each aggregator.

The data was downloaded from the FUSION Flexibility Platform's (FFP) central database using a combination of Structured Query Language (SQL) scripts and power query. It was then cleansed to avoid duplicate database entries and post-processed to enable the analysis to be done.

Meter data from aggregators is only available for those days that FlexRequests were issued. As such, the analysis focuses exclusively on those days. The meter data includes the half-hourly imported and exported energy, which is then converted into net average power for each time interval (i.e. Import Energy – Export Energy).

3.2. TRIAL SUMMARY STATISTICS

3.2.1 Scope

The purpose of this section is to provide an overview of the trial's performance to date, describe which services have been used most frequently and give an overview of the volume and scale of simulated events that have been responded by the aggregators.

3.2.2 Results and Analysis

The trial simulated instances of the DSO requiring flexibility at the two congestion points. Each simulation was designed to test how the FUSION trial participants (FTPs) responded to the different test cases outlined above.

A summary of the main characteristics of the trial within the analysis period is shown in Table 3-1. 94% of FlexRequests received at least one FlexOffer, and 55% of offers were followed up with a FlexOrder. The sum of the total flexibility provided, including anything over and above the power in the FlexOrder, is referred to as the realised flexibility. The realised flexibility based on meter readings is 50% higher than the sum of the ordered flexibility. This difference indicates that aggregators were consistently overdelivering on the agreed volume of flexibility. Aggregators were not penalised for over-delivery in the FUSION trials, but neither are they remunerated for the over-delivery.

The reasons for this over-delivery lie in the type of assets used by aggregators: Gridimp operates a CHP plant that is either on or off. It was therefore not possible to tailor FlexOffers to the requested power, which led to over-delivery. In addition, Orange Power confirmed that they added several new flexible assets, which significantly increased their total flexible power (from around 250kW per congestion point to 800kW). The reason for this increase was to reduce the risk of under-delivering, which was penalised in the trial, whereas over-delivery was not. Finally, any inaccuracy in aggregator baselines will have also impacted the percentage of over-delivery. If aggregators underestimate their expected power during the delivery window, this would lead to the trial reporting an over-delivery of flexibility. One of the risks of over and under delivery of flexibility is that it becomes more difficult to counteract the action to neutralize the effect on the system balance (the so-called redispatch); redispatch is a necessary part of any activation of flexibility as part of a constraint management service. This is discussed in more detail in Section 3.4.2.

Table 3-1 FUSION Phase 1 Trial Summary Statistics

Process	Statistic	Value	Comments
FlexRequests	Total number of FlexRequests	162	This number includes FlexRequest revisions.
	Range of FlexRequest Power Requirements	5-500kW	

	Median FlexRequest Power Requirement	200kW	
FlexOffers	Total number of FlexOffers	217	
	Number of FlexRequests with at least one offer	153	
	Average % of Requested Power Offered by FlexOffers	89%	Calculated by summing power in all FlexOffers and dividing by requested power.
	Average FlexOffer Price	£0.46/kWh	
FlexOrders	Total number of FlexOrders	114	
	Total number of FlexRequests followed by at least one FlexOrder	102	
	Median FlexOrder Power	200kW	Calculated per FlexRequest
	% of FlexOffers followed up with a FlexOrder	54%	57% of Orange Power offers at Leuchars, 45% of Orange Power offers at St. Andrews and 64% of Gridimp offers at St Andrews
	Average % Power Required in FlexOrders Delivered by Aggregators	187%	
Overall	Sum of FlexOrder Power	20,300kW	
	Sum of Delivered Flexibility Based on FlexOrders	16,700kW	This only includes FlexOrders that were realised and is capped at the FlexOrder power.
	Sum of Realised Flexibility Based on Meter Reading	24,700kW	
	Total Energy Flexibility Realised	16.3MWh	
	Total utilization Payments for Flexibility Delivered	£4810	Discussed further in Section 3.4.2

3.2.3 Learnings and Conclusions

The volume of flexibility requested, offered and ordered demonstrates that the key aspects of the USEF framework are functioning. The results show that 94% of FlexRequests received at least one offer. Orange Power confirmed that the reasons that some requests to them did not receive an offer were because of For example, in November there was an issue with the software and the switch to daylight savings time, and in January the FlexRequests were missing the Imbalance Settlement Period (ISP), which was due to human error.

Additionally, aggregators successfully delivered FlexOrders from the DSO in 75% of cases. Out of the 36 cases which were deemed unsuccessful, 12 cases did not provide meter data to verify the quantity of flexibility and 24 cases delivered below the minimum flexible power ordered. This is discussed further in Section 3.2.2 but can be partly explained by one of the aggregators having issues with the control of their assets early in the trial.

It is also worth noting that some FlexRequests (18%) were never intended to be followed up with a FlexOrder according to the simulation schedule, which is a feature of the trial design rather than an outcome of it. This accounts for some of the difference between the number of FlexOffers and FlexOrders.

Availability payments are made to aggregators for being available to deliver the contracted Flexibility Service during the service window. The incentive for delivering upon FlexOrders is largely attributable to the Monthly Performance Adjustment Factor (MPAF) that is calculated as a function of an aggregators performance in delivering FlexOrders and has a direct impact on your monthly availability payment. Total payments for energy delivered were £4810, however aggregators were also paid for availability, which will have been based on their MPAF from delivering 83% of the ordered power by the DSO.

3.3. DELIVERED FLEXIBILITY

3.3.1 Scope

The purpose of this section is to outline whether the delivery of flexibility is working as it is intended and to identify patterns and trends in how and when flexibility is delivered. Our analysis looks at a typical example showing the impact of a FlexOrder on the metered net power, percentage of power delivered compared to power ordered, correlation between time of day and flexibility delivered and the effect of notice time between the issuing of a FlexOrder and its delivery. It also outlines the performance of each aggregator at each stage of the validation phase of USEF and examines the impact of the delivered flexibility at the substation level.

3.3.2 Results and Analysis

Our analysis starts with a typical example showing the impact that a FlexOrder had on the net power of each aggregator's portfolio. This example demonstrates that the trial is working successfully by enabling the DSO to reduce load through the issuing of FlexOrders. The example presented below is from Orange Power at the St Andrews congestion point on the 18th of November 2021 (Figure 3-1). Net power at the aggregator's meter dropped from 400kW, which was the net power an hour before the FlexOrder delivery start, to 7kW, and then went back to approximately the same value as it was prior to the FlexOrder. For the rest of the afternoon and evening, the net power followed the D-programme baseline. This is a typical example of realised flexibility in the trial and similar instances have been seen throughout the trial period.

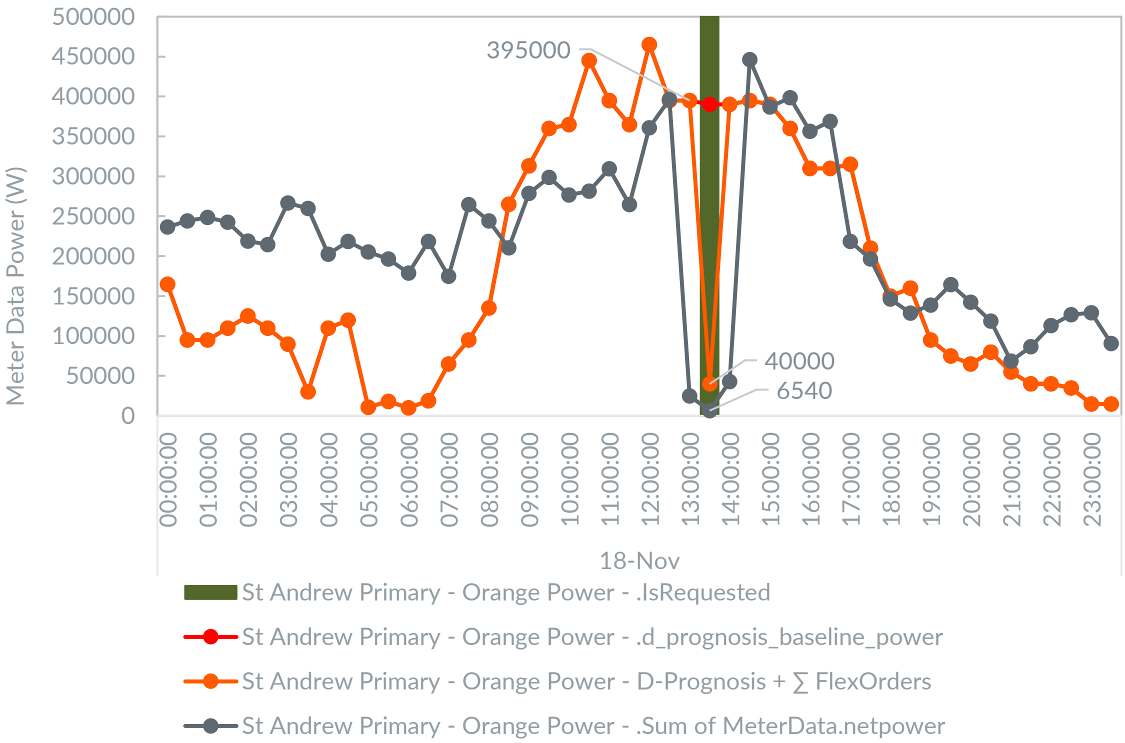

Figure 3-1 Example of FlexOrder Leading to Reduction in Net Power Demand at the Meter on 18/11/21

Our analysis also examined the reliability of aggregators in providing flexibility, by ensuring that their net power demand was reduced when a FlexOrder was issued. Aggregators managed this in 97% of the instances in which a FlexOrder was issued: there were only five occasions (3% of cases) when there was an increase in the net power demand.).

As discussed in Section 3.2.2, aggregators typically over-delivered on the minimum power requirements specified in the FlexOrders (Figure 3-2). This section looks at how that changed throughout the trial period. On average, Gridimp delivered flexibility closer to the power agreed within the FlexOrders than Orange Power (Figure 3-2). In the first two and half months of the trial, Gridimp underdelivered power on several occasions (Figure 3-3), which has reduced their average percentage delivered. The reason for this is that Gridimp had issues with the control of their assets and relied on manual rather than remote activation, leading to errors in the delivery of flexibility. After the 17th of November, Gridimp improved the reliability of delivery and consistently delivered at least 100% of the FlexOrder power.

Orange Power underdelivered on one occasion (Figure 3-4) and overdelivered by more than 300% on three occasions.

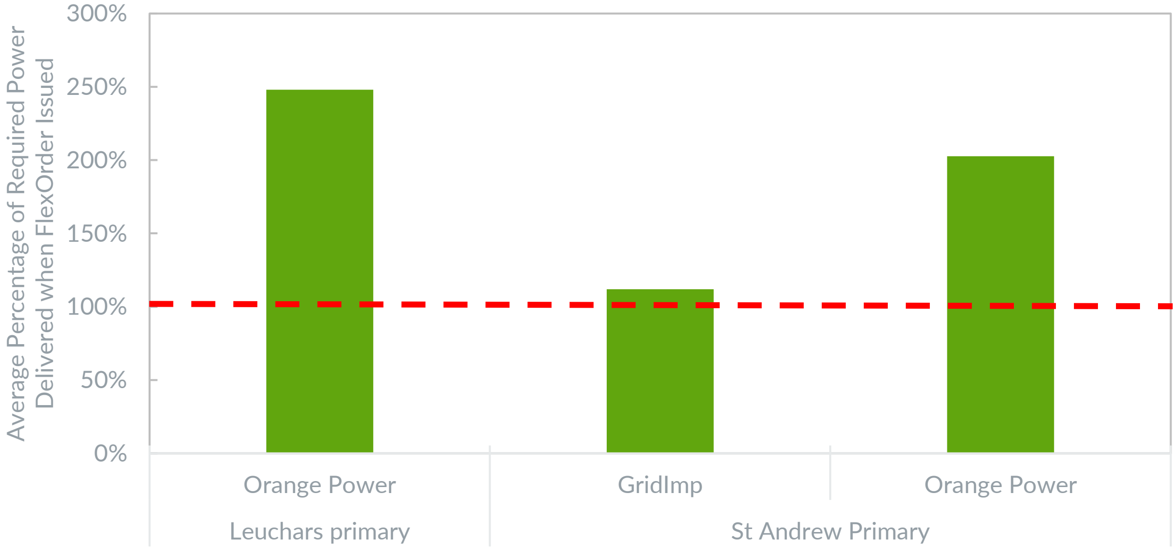

Figure 3-2 Average Percentage of Required Power Realised when FlexOrder Issued

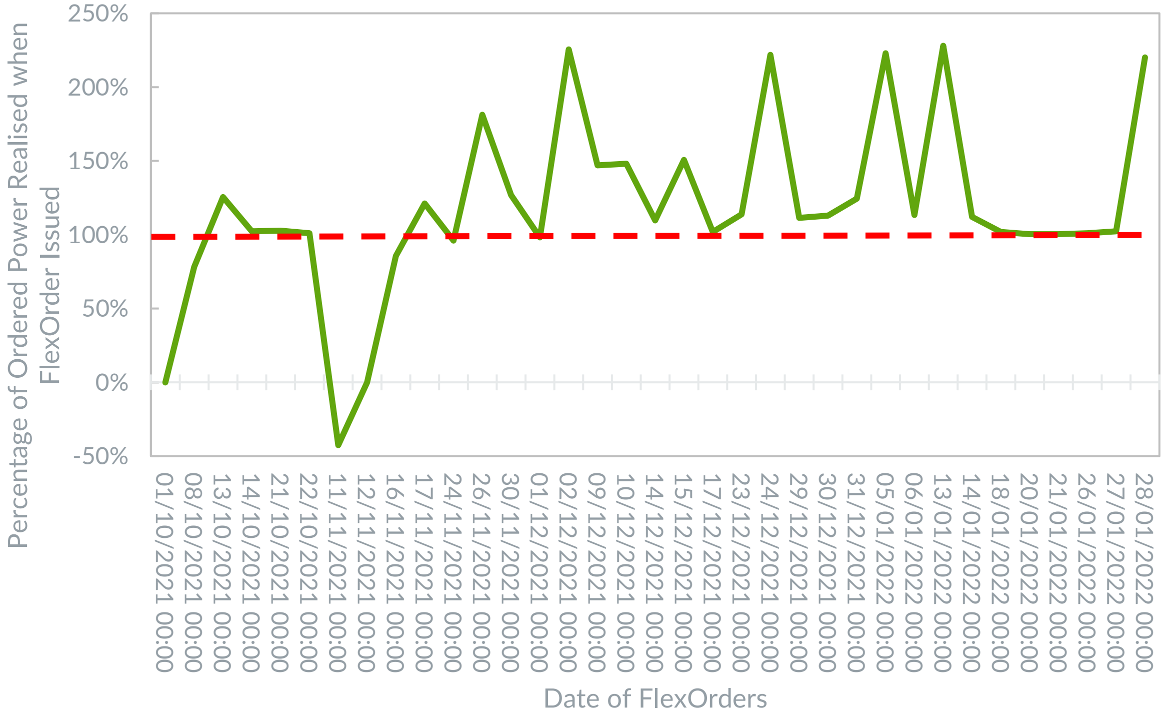

Figure 3-3 Percentage of Ordered Power Realised when FlexOrder Issued to Gridimp at St. Andrews

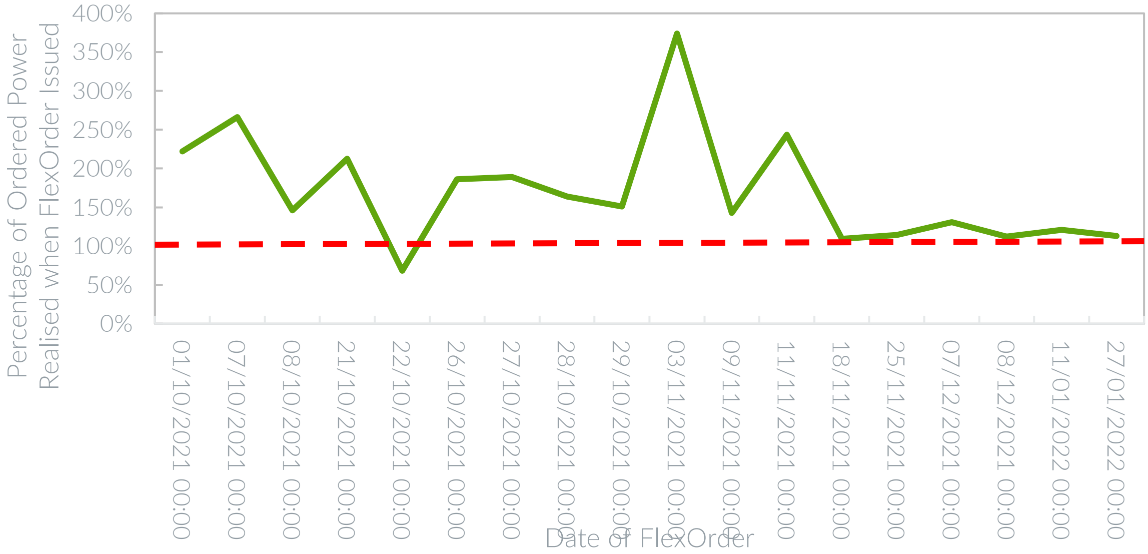

Figure 3-4 Percentage of Ordered Power Realised when FlexOrder Issued to Orange Power at St. Andrews

Our analysis also investigated the correlation between the time of the activation window and the percentage of FlexOrder that was realised (Figure 3-5): The aim was to understand whether aggregators were more accurate at delivering the agreed amount of flexibility at different times of day. Aggregators were more likely to deliver at least 100% of the FlexOrder before 2pm (83% of the time) than after it (73% of the time). It is worth noting that the sample size for cases before 2pm is smaller, as 76% of FlexOrder contained a start of delivery time after 2pm. For larger portfolios of flexibility, the reliability of delivery is an important factor in determining the volume of flexibility that is required. Awareness that his may change throughout the day is therefore a useful insight from the trial.

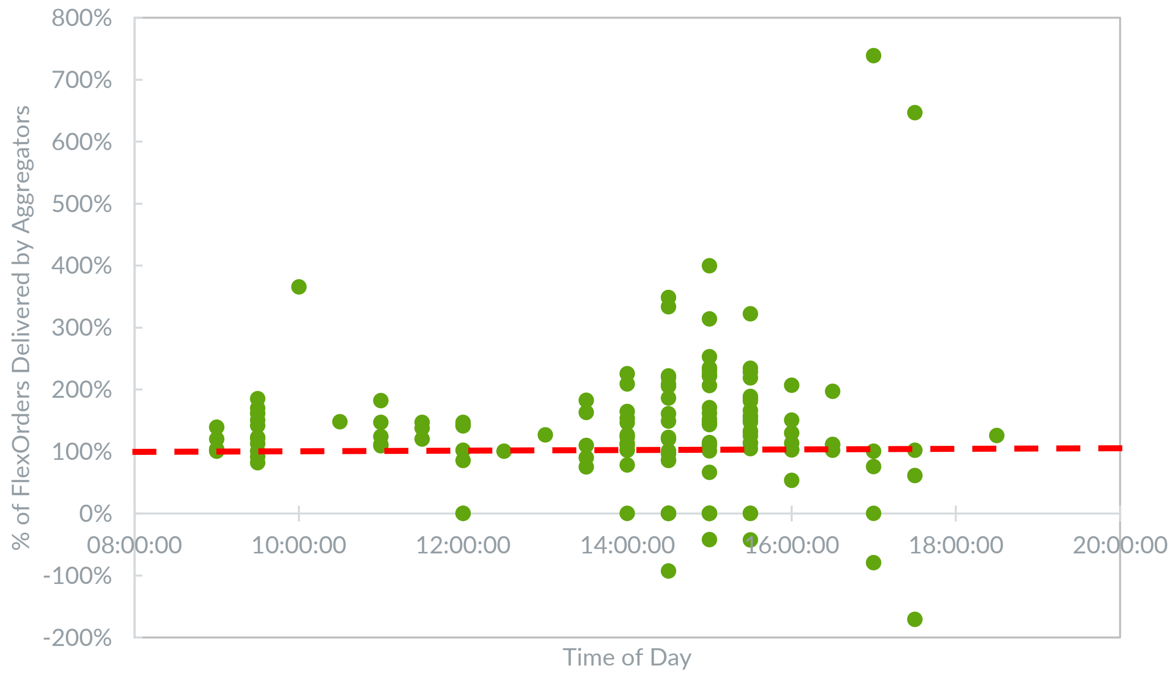

Figure 3-5 Percentage of FlexOrders delivered by aggregators by Time of Day

We also analysed the impact of the notice time between the issue of the FlexOrder and the activation of flexibility. The analysis showed that the notice time between the issue of the FlexOrder and the utilisation had limited impact on the percentage of the FlexOrder that was realised (Figure 3-6), as aggregators may have only been marginally more accurate at delivering the ordered power when they are given more time to prepare. There are several outliers which do not follow this hypothesis; the exact reasons for these are not known yet but will be investigated further in phase 2 of the trial.

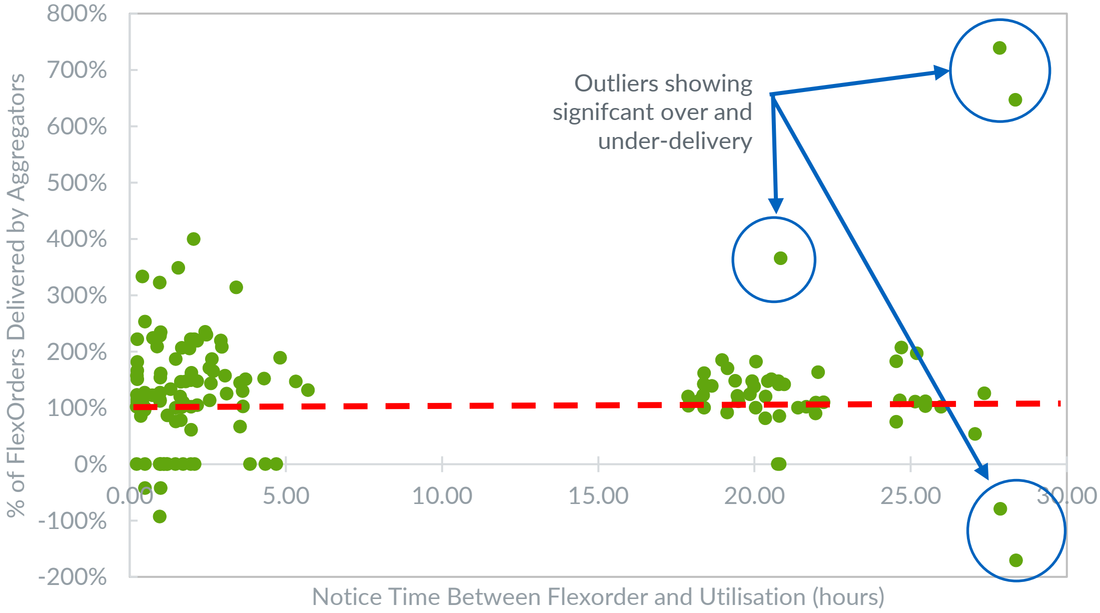

Figure 3-6 Percentage of FlexOrders Realised by aggregators by Notice Time Between FlexOrder and Utilisation

We also looked into a comparison of the volumes of flexibility reaching each stage of the validation phase of USEF (i.e. FlexRequest, FlexOffer and FlexOrder). The aim was to see how much flexibility was converted from FlexRequest into realised flexibility as well as all the stages in between. A summary of this analysis is shown in Figure 3-7.

To clarify the terms in Figure 3-7, the realized flexibility represents the measured difference between the forecasted D-programme and the measured power at the meter. The delivered flexibility is the sum of power that was ordered in a FlexOrder and successfully delivered by the aggregator; overdelivered flexibility is therefore not included in this metric and the power is capped at the FlexOrder power for each time interval.

We find that a greater percentage of the FlexRequests were realised by the aggregator at Leuchars than the aggregators at St. Andrews. The reason for this is because of the types of assets at each congestion point: there were more residential assets and EV chargers at Leuchars which had to be aggregated and are, therefore, less predictable. This increased the realised power compared to the requested power. This reinforces the need to understand the type of assets that are supplying flexibility.

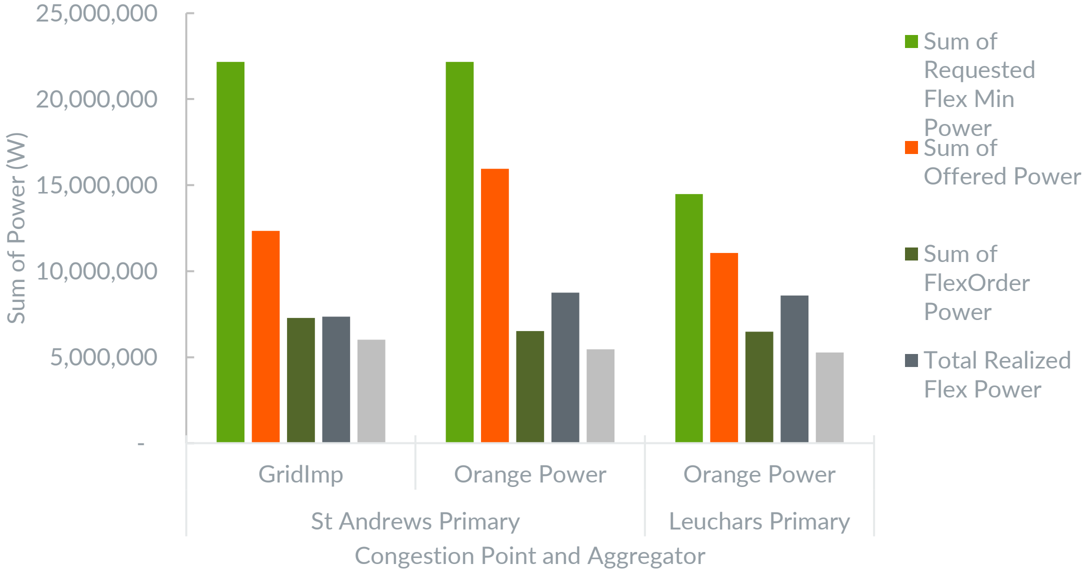

Figure 3-7 Sum of Power Offered, Ordered, Realized and Delivered at Each Congestion Point per aggregator

Finally, we analysed data on the substation load from SPEN to determine the impact that the realised flexibility would have had on the network. The available flexibility is a small percentage of the total load on both substations: the average non-event power of the flexible assets which participated in the trial is 3.0% and 7.7% of the total substation load at St Andrews and Leuchars, respectively. This means that it is not possible to see a tangible impact of the realised flexibility on the substation without scaling the loads.

For the purposes of the trial, the substation load from SPEN has been scaled down and shifted in time so that it coincides with the contract service window and is proportionate to the amount of available flexibility. The theoretical substation load on the 18th of November (the same day as Figure 3-1) is shown in Figure 3-8. The realised flexibility measured from the trial has been subtracted from the substation load during the service window in order to visualise the impact that the flexibility would have had on the peak demand. The results demonstrate that the flexibility can shave peak power output by approximately 5% when orders are enacted by the aggregators.

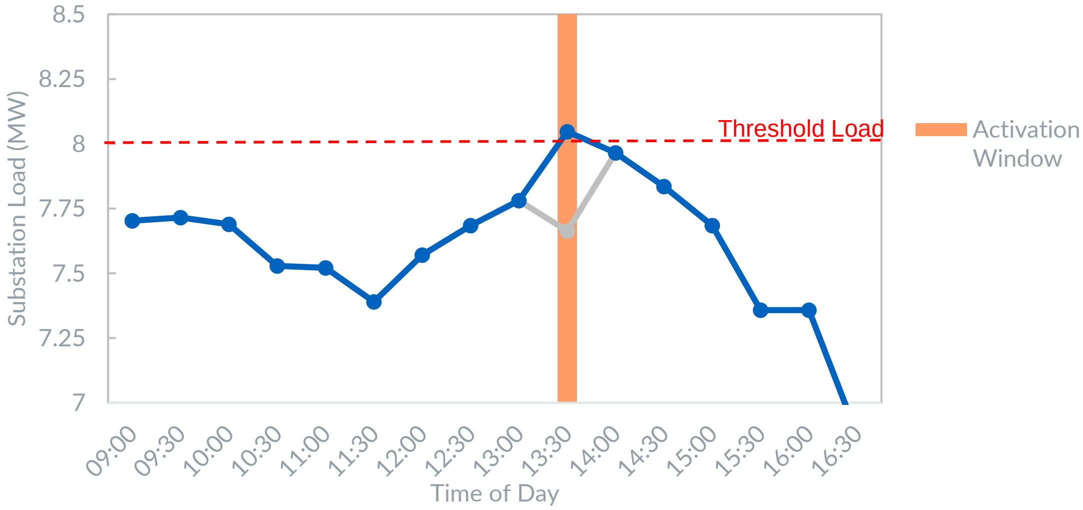

Figure 3-8 Modified Substation Load with Trial Flexibility Applied on the 18/11/21

3.3.3 Learning and Conclusions

Analysis of the D-programme baseline shows that flexibility requests effectively reduce demand at the meter when they are ordered. The over-delivery of flexibility was also explored further in this section, and we found that the accuracy of the realised power compared to the ordered power improved over the trial period for both aggregators. We have also shown the differences in the over delivery of flexibility at the two congestion points. One of the main reasons for this is the different characteristics of the types of flexible assets in each aggregator's portfolio.

Finally, we demonstrated how the sum of flexibility at each stage of USEF validation decreases as the DSO and aggregators communicate with FlexRequests, FlexOffers and FlexOrders. The difference between requested and realised power may appear to be significant (Figure 3-7), however this does not account for FlexRequests which were never intended to be followed up with a FlexOrder in the simulation schedule and the FlexRequests that didn't receive a FlexOffer. When focusing specifically on FlexOrders, aggregators delivered an average of 83% of the ordered power (85% in the first half and 80% in the second half).

3.4. OFFER PRICES AND ORDERS

3.4.1 Scope

The purpose of this section is to provide an overview of the offer prices and their relationship to the test cases and to FlexOrders. Our analysis includes the distribution of offer prices for each aggregator, the relationship between offer power and offer price, the offer prices for each test case and finally the relationship between FlexOffers and FlexOrders. The section provides insights into pricing strategies and describes their impact on whether FlexOffers translate into FlexOrders.

3.4.2 Results and Analysis

Table 3-2 below summarises the contract availability price, the cap on the utilisation price in the contract and the minimum, maximum and average offer price in the trial at each substation by aggregator. Overall, Table 3 2 shows that the offer prices were either very close to or at the contract price caps for utilisation.

Availability payments are made for being available to deliver the contracted Flexibility Service during the service window and the utilisation payments are made for energy that has been delivered when ordered. Table 3-2 shows that the cap on utilisation payments is lower than the availability price which will have informed the aggregators bidding strategy. Due to a combination of this difference and the way that aggregators are penalised on their availability payment for failing to deliver flexibility (through the MPAF calculations, discussed in Section 3.2.3), aggregators are incentivised to offer higher prices to discourage the DSO from activating the flexibility. One explanation for this is that the potential loss in availability payments from being penalised outweighs the possible benefits from utilisation. Therefore, aggregators, who are obligated to offer flexibility, do so at the highest price possible to reduce the possibility of being utilised and running the risk of failing to deliver. However, this suggests that the aggregator was not confident in their ability to deliver flexibility, which is not the feedback that was received. Alternatively, due to the high wholesale price of electricity during the trial, aggregators may have been able to earn more through normal continuation of supplying power to grid; particularly true for CHP plant.

Table 3-2 Contract Availability and Utilisation Prices and Offer Prices from the Trial

Congestion Point/Aggregator	Contract Availability Price[1] (£/kW/hr)	Contract Cap on Utilisation Price[1] (£/kWh)	Minimum Offer Price in Trial (£/kWh)	Maximum Offer Price in Trial (£/kWh)	Average Offer Price in Trial (£/kWh)
Leuchars primary Orange Power	13.5	0.5	0.3	0.49	0.49
St Andrews Primary Gridimp	17	0.4	0.3	0.4	0.40
St Andrew Primary Orange Power	13.5	0.5	0.3	0.49	0.48
Average	n/a	n/a	0.3	0.49	0.46

[1] The values differ by aggregator but are the same for all service windows, notification periods and contract types

Figure 3-9 shows that the offer price of both aggregators was between £0.30-0.50/kWh. There were two occasions where the offer price exceeded the cap on the utilisation price specified in the contract, however following consultations with aggregators these are considered outliers that are not representative of the trial. On 26/11/21, Orange Power submitted two offers with a price of £1 and £1.20 at Leuchars and St. Andrews. These were given a status of "received but does not meet flex option" and not followed up with a FlexOrder. Orange Power then submitted a second offer at both sites at a lower price, although these were also not accepted as they came after the deadline. These prices were due to human error.

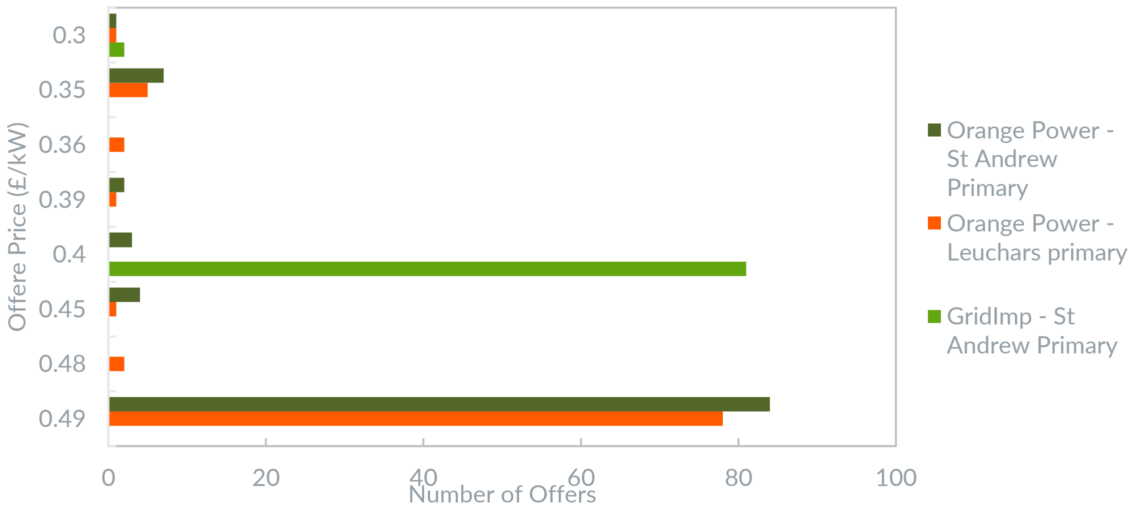

Figure 3-9 Distribution of Offer Prices for Each Congestion Point and aggregator

We also investigated the relationship between the volume of offered power and the offer price. The analysis showed that volumes of offered power had a small effect on the offer price (Figure 3-10). However, there is insufficient data from offers below 100kW to draw firm conclusions.

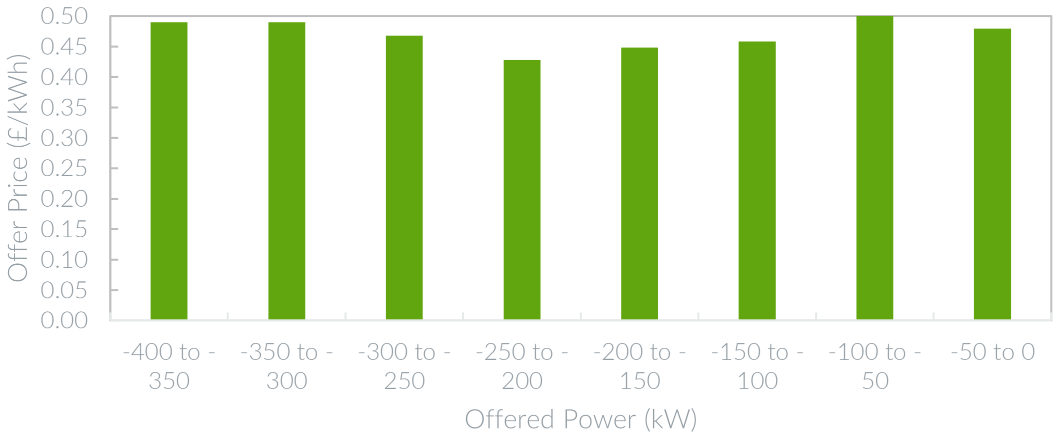

Figure 3-10 Comparison of Offered Power and Average Offered Price

The other element we analysed was the variation in the offer prices between test cases. Our analysis and Table 3-3 show that small variations in offer prices can be observed in test cases with free bids (i.e. test case 1.3, 1.4, 2.3, 2.4 and 3.2). In addition, the offer prices were marginally higher at Leuchars Primary than at St Andrews, which one would expect at the site with no competition. However, this difference is also explained by the fact that the aggregators bid close to or at the contract cap price and Gridimp have a lower cap and only offer flexibility at St Andrews.

Table 3-3 Average Offer Price for Each Test Case (£/kWh)

Test Case	Free Bids (Yes/No)	Leuchars Average Offer Price (£/kWh)	St Andrews Average Offer Price (£/kWh)
1.1	No	0.48	0.43
1.2	No	0.46	0.45
1.3	Yes	0.49	0.44
1.4	Yes	0.44	0.45
2.1	No	0.52	0.46
2.2	No	0.49	0.46
2.3	Yes	0.49	0.45
2.4	Yes	0.49	0.45
3.1	No	0.46	0.43
3.2	Yes	0.46	0.45
Total	-	0.48	0.44

Table 3-4 shows the trend of FlexOffers that were followed up by a FlexOrder throughout the trial. At Leuchars Primary in November, there was a significant drop off in the percentage of FlexOffers realised through a FlexOrder. All rejected offers in November were given a status of "received but does not meet flex option". The reasons behind these rejections are not clear. One of the reasons for the low percentage could be that there were multiple offers of around 250kW which didn't receive an associated offer.

Table 3-4 Percentage of FlexOffer Power Ordered through a FlexOrder

Month	Leuchars Primary	St Andrews Primary
Sep	77%	56%
Oct	38%	61%
Nov	21%	57%
Dec	90%	45%
Jan	60%	48%
Grand Total	59%	53%

3.4.3 Learnings and Conclusions

This section has demonstrated that offer prices have remained relatively constant throughout the trial period and across the different test cases and no real patterns or strategies have emerged regarding the pricing of utilisation. The offer prices were either very close to or at the contract price caps for utilisation.

The price that aggregators are paid for availability is higher than for being activated. One of the reasons for this is likely to be the high wholesale electricity prices at the time of the trial. The other reasons were to cover the capital costs associated with applying USEF and to attract new aggregators to the area to ensure that at least two were able to participate in the trial. The higher availability payments, coupled with the penalties applied to aggregator's payments for failing to deliver (which was established to incentivise delivery), encouraged the aggregators to reduce the risk of failing to deliver by avoiding being activated. The potential loss in availability payments from being penalised outweighs the possible benefits from utilisation. Aggregators may have, therefore, offered as high prices as possible to avoid being activated, which explains why prices in the trial remained close to the price cap. To address this issue in Phase 2, the penalties for under delivery have been relaxed.

The number of FlexOffers that are followed up with a FlexOrder across the different congestion points and aggregators varied within the trial period. One of the reasons for this is that the simulation schedule changes every month, which specifies how many FlexOffers are activated, although this does not account for the low percentage in November.

4. Trial learnings per objective

4.1. COST BENEFIT ANALYSIS

4.1.1 Scope

The aim of this task is to evaluate the feasibility, costs, and benefits of implementing a common flexibility market framework based on the open USEF model to manage local distribution network constraints and to support wider national network balancing requirements. Impact of USEF model on CBA drivers i.e. change in available capacity of flexibility, change in availability of flexibility including change in common mode failures, and change in the size and shape of load recovery will be analysed and impact established. This will be compared with the change in costs for DSO to acquire or activate flexibility and change in absorption of additional renewable energy resources.

The scope of this task within the time period that is covered in this report is to obtain East Fife relevant HV network, load and available trial data.

Two reports will be produced, an initial report and a final report. The initial report, expected delivery in May 2022, will describe benefits in local East Five network of USEF flexibility. The final report will be delivered at the end of the project, expanding the scope to the whole of GB network and comparing with BaU flexibility implementation, including difference in incremental cost of USEF and BaU flexibility implementations.

4.1.2 Methodology

East Fife local network data consisting of node-line connectivity model, transformer, cable, overhead line, switchgear, and protection parameters are provided by SPEN. The conductor type ratings and impedances are provided separately and associated with cables and overhead lines.

Corresponding historical annual HV feeder and primary site profiles are provided by SPEN. Those profiles are used to establish peak demand per each distribution transformer based on transformer rating and corresponding HV feeder peak. In addition, load duration curves are created for use in the network adequacy assessment and contribution of flexibility to security of supply. Range of circuit failure rate is established from Central & Fife district circuit performance data provided by SPEN.

A first set of trial related data is provided and data analysis is in progress.

The Common Evaluation Methodology (CEM) tool will be used to assess merits of deferring network reinforcement by employing flexibility solutions.

4.1.3 Results and Analysis

East Fife local network is supplied from two primary substations, St Andrews and Leuchars primaries. The length of HV circuits is 279 km to which 505 distribution transformers are connected. Table 4-1 provides further details.

Table 4-1 Size of East Fife local network

Parameter	Detail
Primary sites	St Andrews Primary and Leuchars Primary
Distribution transformers	505 transformers rated from 5 to 1000 kVA

HV cables	1426 sections with total length of 110 km
HV overhead lines	703 sections with total length of 169 km
Circuit breakers	88 CBs at GM sites
Sectionalisers	83 sectionalisers at PM sites
PMARs	11 PMARs at PM sites
Fuses	13 fuses at PM sites
Switch fuse	58 swich fuses at GM sites
Switches	301 switches
Switch line	311 at 11 kV and 4 at 33 kV

An annual profile is sorted in descending order and normalised by the peak value. Figure 4-1 shows an example of normalised load duration curve with load factor of 61%.

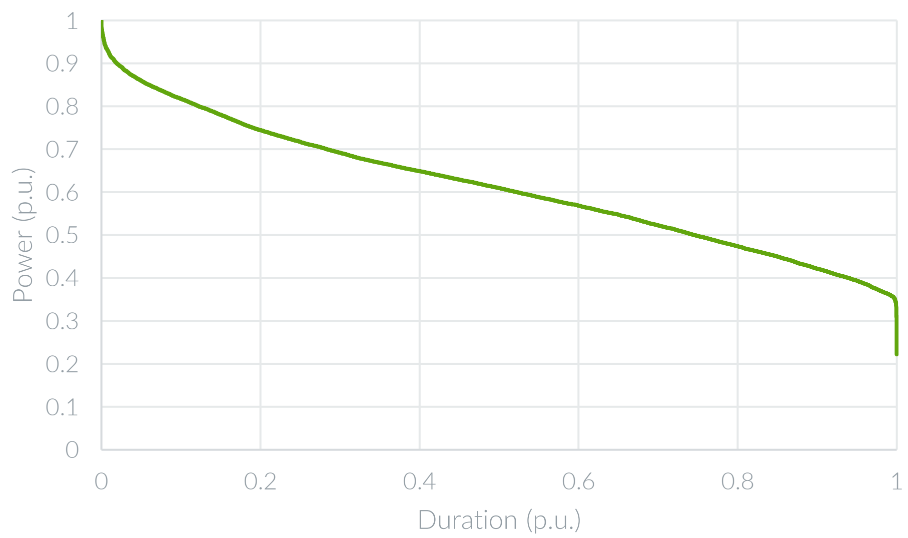

Figure 4-1: Illustration of normalised load duration curve

4.1.4 Conclusions and Learnings

Work on this task is progressing as planned. East Fife local network data, including loading, has been provided. The received trial data are being analysed.

4.1.4.1 Next steps for this objective

Continuous trial data collection and analysis will be conducted. Currently analysis of the first trial data set is in progress to characterise flexibility performance in terms of the shape of demand reduction and load recovery period.

Additional contribution of USEF-based flexibility to security of supply will be calculated by comparing the network reinforcement in BaU and USEF-based flexibility implementation. Potential cost savings from reduced or deferred network reinforcement will represent an additional benefit while increased network reinforcement will represent an additional cost of USEF-based flexibility implementation. Sensitivity analyses will be conducted to establish confidence levels for each flexibility CBA driver.

The option value of USEF-based flexibility will be calculated by adding it to the portfolio of mitigation measures under uncertainty related to the future demand growth.

Impact of the potential GB-wide deployment of USEF-based flexibility will be established by using the current size of the flexibility marked to establish the potential range of size of future flexibility marked. In addition, power system use driven carbon benefits will be calculated.

4.2. COMMERCIAL MECHANISMS

4.2.1 Scope

One of the aims of Project FUSION is an exploration of the commercial mechanisms available to encourage consumer participation, with a particular focus on the effectiveness of USEF. Currently in the market, there is a clear dominance of larger market players. Project FUSION will assess the sufficiency of commercial mechanisms to support providers with lower levels of flexibility and explore how the project could be used to inform the development of such mechanisms.

4.2.2 Methodology

This report focuses on FUSION Phase 1 Objective 1.2: Investigate a range of commercial mechanisms to encourage flexibility from energy consumers' use of multi-vector electrical applications in satisfying overall energy use.

This report will assess the effectiveness of commercial mechanisms in encouraging flexibility from providers (particularly providers with lower levels of flexibility). Initially considering the current market conditions and key barriers for flexibility providers, this report will then provide a summary of the key commercial mechanisms currently available within the USEF framework to encourage participation and provide an assessment of how FUSION could inform their progression.

To inform the above objective, feedback on the above has been collected and summarised in this report. Feedback has been collected using a variety of means, including a series of questionnaires and interview sessions with each of the aggregators participating in the FUSION trials.

4.2.3 Results and Analysis

The series of questionnaires and interviews were undertaken with the two aggregators involved in Project FUSION:

- Orange Power
- Gridimp

The key outputs from the aggregators' responses are summarised throughout this section of the report.

4.2.3.1 Attracting Consumer Participation

Responses from aggregators indicated there are ample routes to market and the route varies for each individual business. Three key routes to market were identified by the aggregators which have been used to date:

1. Business-to-business - Usually a discussion between the aggregator directly with the potential business customer.
2. Domestic (business-to-business) - Typically conversations with hardware companies that represent the main route to residential customers.
3. Direct customers - Usually one of the following routes; advertising opportunities for participation on the aggregator website, transferring existing DSO customers onto platform or via a social media campaign. USEF proposes standardisation of the interaction between aggregator and flexibility provider platforms and flexibility services. Therefore, even though there are multiple different routes to market, USEF enables onboarding to be streamlined through standardisation and achieve this at a lower cost. If USEF is more widely adopted, it will reduce aggregator costs for interacting with market platforms through simplified processes for the DSO, the aggregator and the customer which should increase consumer participation.

4.2.3.2 Barriers

Aggregators were asked the key barriers they faced in encouraging participation. The main barrier identified was around consumer understanding and raising awareness of flexibility. For flexibility markets to grow, consumer understanding and motivation to participate is key. This must be aided through the use of simple language and straightforward processes, all encapsulated in a simple customer proposition, tailored to their needs. Project FUSION will help to inform how best to reach and engage a diverse portfolio of customers.

The key barriers vary depending which route to market is considered:

1. Business-to-business:

The main issues are; understanding the business in order to identify the appropriate use case to support participation in flexibility markets, finding the right decision maker within the business and the development of a clear business case which supports business's participation. Drivers for participation may include Net Zero targets, revenue or taking advantage of unused capacity.

2. Domestic (business-to-business):

Aggregators must ensure there is a substantial pool of domestic flexibility so that the impact on individual customers is mitigated. Diversification will help minimise the impact on the flexibility provider, e.g. for a domestic customer this could be ensuring the temperature of their home remains within acceptable limits to ensure there are minimal implications on their behaviour.

When considering levels of deterministic response (easily forecastable) versus non-deterministic response (difficult to predict), there are several key barriers to recruiting assets with non-deterministic flexibility:

- Aggregators felt that to recruit flexibility from operational plant, generation or storage assets behind-the-meter which are not there for the primary purpose of making money through providing services to the grid or energy market, the barriers to overcome are around incentivising utilisation payments. For customers to be motivated to participate in the markets, financial incentive must be improved.
- For flexibility markets to succeed for domestic customers, it was suggested that capacity is decoupled from the payment scheme. In other words, availability would be removed from the revenue stream to allow for more attractive utilisation incentive. This approach would very much benefit domestic customers.
- To manage the risk of delivery, plentiful resource should be available in contracts. This approach would mean the same incentive is no longer tied to capacity and therefore, should

reduce barriers to participation. To manage the risk of delivery, the DSO should look to having sufficient liquidity to address the issue of certainty of response which would have traditionally been provided by dedicated availability. Alternatively, the DSO should find a new commercial mechanism to unlock participation from non-deterministic plant/assets.

With regards to delivery notifications, these were originally set up as FlexRequests (requests for flexibility sent from DSO to aggregator), however customers found this confusing. To overcome this problem, one aggregator switched to FlexOrders (sent to aggregator with a price which is accepted/ordered by the DSO after aggregator's response to flexRequest has been evaluated). This change increased the accuracy of the notifications, therefore minimising the impact on the customer. Eventually, the platform functionality will enable customers to opt-in and opt-out of notifications on the customer interface.

In order to reduce barriers, notifications should be defined and acceptable to customers. Rather than a use case based approach to determining flexibility requirements, more of a time-based approach should be taken. Customers would prefer delivery notifications to be given well in advance to allow time to respond to a request. For example, one of the aggregators felt that giving notice at day-ahead stage would help to retain more domestic customers. The decoupling of availability and utilisation payments mentioned above should also help to solve this issue. There is undoubtedly a balance which would have to be struck here. If the timescale is too long, there will be too much uncertainty around availability of assets; however, if the timescale is too short, customers will need to respond too quickly. A longer timescale also increases the risk that the flexibility is not required.

Another barrier is related to the data processing requirements:

- Residential consumers include a very wide range of assets which means data handling is a major challenge.
- The current data requirements of 30-minute intervals under UFTP are manageable. However, if markets begin to encourage higher granularity of data and close-to-real-time metering, data traffic and associated complexities will increase significantly. At the moment, this is not a cost-effective exercise for residential aggregators to implement and as such, one of the aggregators is using technical partners to source the data.
- If there are issues around metering data being omitted or misinterpreted, this could result in a poor decision which may negatively impact the aggregator's portfolio. The aggregator is currently working alongside hardware companies to reduce this issue; however, as the number of users increases, the problem grows.
- While not the case in FUSION currently, simultaneous data exchange at a high resolution is a massive challenge, particularly for residential aggregators with high volumes of very small assets.

As a group, domestic customers currently faced the most barriers to participation. Domestic customers are the most difficult to control and forecast; although, this would be helped through automation and scale. Automation is the key to all flexibility markets, particularly when it comes to domestic customers. Furthermore, the strict performance factor reduces the rewards for customers and makes the participation rate even lower. The more domestic customers there are in a portfolio will reduce the impact on any individual customer and increase the certainty of delivery. It is suggested that Project FUSION should consider the development of commercial mechanisms to reduce these barriers and further encourage participation from domestic customers.

4.2.3.3 Market Procurement Timelines

Procurement strategies have differing procurement timelines; aggregators were asked for their opinion on the comparison of long-term and short-term market procurement. The ENA ONP's Flexibility Procurement Timeline uses 6-monthly procurement cycles and the shorter procurement timescales of a USEF approach enable day-ahead and intra-day markets.

One aggregator stated that the optimum procurement timeline would be a mid-term scalable contract. This would ensure similar terms with capacity that could be increased on a quarterly basis (for example) without much negotiation or retendering. This would help aggregators, it was suggested, to scale quickly as their portfolio grows. While a short-term contract would solve this issue; it would add more uncertainty to the revenue long term if aggregators had to invest first to get the control of assets. The aggregator suggested that a mid-term scalable contract would enable providers to easily adjust contracted capacity throughout the year without having to go through the full contractual process. Contracts would be scalable rather than having a fixed capacity which cannot be changed.

Basing a large proportion of flexibility payments on stated capacity six months ahead of time detracts from participants ability to, and disincentivises them from, offering any available capacity closer to real time if they cannot meet the stated capacity. Both sides would lose out on the real time flexible capacity with this approach. However, if capacity commitments are decoupled from the revenue certainty offered by forward contracts, then a commercial case can be made to invest in control solutions to make existing plant able to respond to programs or influence the design specification for behind-the-meter energy generation or storage plant.

Generally, the aggregators felt that a shorter-term timeline would benefit them. Short-term markets allow the aggregator to easily bring new flexibility into the market and it is much easier to make predictions of how much flexibility will be available on a shorter term. In general, short-term markets makes the onboarding of new assets into the market much easier which is one of the significant advantages which can be brought from the USEF market mechanism. It may be that shorter and longer-term procurement timescales would suit a tiered procurement strategy and could be used to address changes in need nearer delivery.

4.2.3.4 Effectiveness of UFTP Free Bids Mechanism

The USEF Free Bids mechanism is a mechanism where the term of the contract is agreed but new flexibility can be added as and when it becomes available. The USEF Free Bids mechanism allows for additional revenue outside of long-term contracts which gives more revenue to uncontracted assets as they join the market. This in turn, means more revenue opportunity for aggregators and makes the recruiting of new flexibility providers easier. Free Bids also allow the DSO to refine their procurement needs nearer delivery and avoid paying availability for the term on longer contracts.

4.2.4 Conclusions and Learnings

Summary of key outputs from questionnaire responses are as follows:

- The engagement of customers and their understanding of flexibility markets remain key barriers.
- Standardisation of processes under USEF makes easier to onboard new assets using a variety of routes to market.
- Two of the largest barriers are the defining of, and adhering to, a business case for participation and diversification to minimise impact to customers and aggregators.
- Domestic customers face most barriers; these customers are most difficult to control and forecast. Furthermore, the strict performance factor reduces the rewards for customers, making the participation rate even lower.
- Utilisation incentive should be increased to remove barriers to participation.
- Data processing presents a huge challenge for aggregators, particularly those with large numbers of small customers. If FUSION trials continue to allow data granularities of greater than one minute, this should not be an issue in the FUSION trials but may be an issue in the BaU environment going forward.

- Notifications should be defined and acceptable to customers; generally, longer timescales (i.e. day ahead) are preferred to minimise impact to customer.
- Short term markets benefit the aggregator – more certainty around availability of flex and much easier to onboard new assets into the market.
- Basing a large proportion of flexibility payments on stated capacity six months ahead of time detracts from participants ability to, and disincentivises them from, offering any available capacity closer to real time if they cannot meet the stated capacity on the long-term contracts.
- Benefit of USEF Free Bids mechanism is that it provides more opportunity for revenue through enabling additional revenue outside of long-term contracts.

4.2.4.1 Next steps for this objective

Summary of any recommendations for future work within this project and for how FUSION could inform the shaping of UFTP mechanisms to encourage participation of assets with low levels of flexibility.

- Consider increasing utilisation incentive for providers to encourage high delivery standards. Decoupling availability from capacity may allow easier commitments of flexibility using the nominated baseline and enable for more attractive utilisation incentive which would very much benefit domestic customers.
- The simulations performed during the trials were scheduled so not truly reflective of reality. In future simulations once the forecasting of events is introduced, it will be important to ensure FlexRequests are as accurate as possible to minimise any impacts on revenue and predictability. In general, increasing the accuracy of the requests will minimise the impact on customers. The accuracy will be improved over time as the market matures and more data is available to inform requests.
- Terms and conditions under the FSA are robust and give the aggregator confidence when signing long term contracts with asset owners. The terms and conditions of the Free Bid mechanism will need to have a similar level of robustness to give aggregators contractual confidence.
- Increased automation is key to the success of flexibility markets. Automation in USEF is very helpful; the possibility to automatically bid and settle small assets is a large benefit.
- Project FUSION should continue to work with aggregators to consider how best to encourage participation of domestic assets and the impact of various commercial mechanisms.

4.3. D-PROGRAMMES

4.3.1 Scope

D-programme (or D-prognosis) is a forecast that the aggregator provides day-ahead to the DSO, this forecast contains the net load or generation of each aggregator portfolio per congestion point. This forecast is submitted before flexibility trading, which means that it does not include DSO service delivery.

USEF designed D-programmes for two purposes – 1) serving as baseline to quantify flexibility delivery and 2) providing visibility to the DSO for their own forecast as well as having the visibility on the flexibility amount that they could request from aggregators. In this section, we will focus on the second purpose of D-programmes. Whereas in Section 4.6, the first purpose – baselining – will be further analysed.

4.3.2 Methodology

For this objective, we will answer the following questions based on interviews with SPEN's flexibility team as well as SPEN's forecasting provider (SIA partners):

- How should D-programmes be integrated in the forecasting process?
- Can D-programmes (inc. varying timing) improve the forecasting accuracy for grid components? Would this lead to less flexibility being activated? How much?
- Is the current mechanism sufficient, or should it be augmented with other information, e.g. contractual information that could be added to the Common Reference Operator (CRO)?

4.3.3 Results and Analysis

During FUSION phase 1 trial, the aggregator has exchanged D-programmes successfully with the aggregator using the UFTP protocol. The DSO was able to visualise them in the FFP. Figure 4-2 illustrates how the DSO visualises D-programmes in the FFP. The D-programmes, represented by the dark blue colour, represent the aggregator's forecasted net load, whereas the grey colour represents the non-aggregator load, i.e. the rest of the load at substation level. During phase 1, the split of aggregator and non-aggregator load has been simply done by subtracting the aggregator D-programme from SPEN's day-ahead load forecast at substation level. Therefore, we are not able to provide qualitative insights on how the D-programmes could be used to improve the DSO forecasting capabilities.

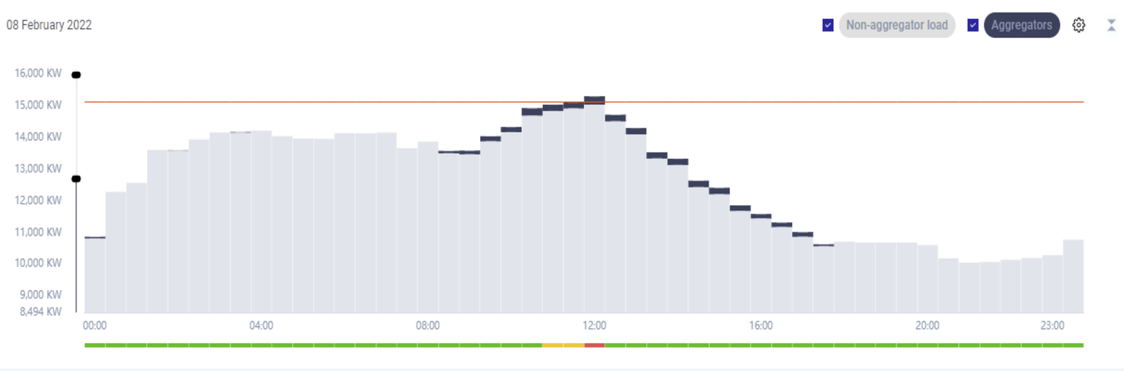

Figure 4-2 DSO Visualisation of D-programmes

To analyse how D-programmes could improve the current forecast, it is necessary to understand how the forecast is built and how accurate it is. The current forecasting methodology predicts the load at substation level up to five days in advance, based on historical measurements. The measurements are updated every half hour and the forecast is enhanced with the latest information. Generation is only accounted separately when there is front-of-the-meter generation. However, in either St. Andrews or Leuchars, there is no such generation. All generation assets for both substations are behind-the-meter and therefore SIA partners suggest that knowing the amount of generation behind the meter, and its type, would be useful to enhance the forecast.

How should D-programmes be integrated in the forecasting process?

During this phase we have not investigated the accuracy improvement, but rather how D-programmes could be integrated into the business forecasting method. D-programmes could be incorporated into the forecast by following this process:

1. Subtracting aggregator sub-meter data (from the flexible assets participating in the trial) to the substation measurements that feed into the substation forecast algorithm.
2. Running the forecast algorithm to forecast the non-aggregator load.

3. Summing up the D-programmes of aggregators active at the substation.

However, there are issues with this approach. Firstly, the sub-meter measurements are submitted the day after by the aggregators, i.e. there is not a real time metering communication. Therefore, the first step would not be possible unless aggregated sub-meter data is communicated real time. Secondly, the current DSO forecast looks into 5 days in advance but the D-programmes are only submitted day-ahead. This means that the forecast would need to include different forecasting methodologies for day-ahead or for longer periods of time.

Can D-programmes (inc. varying timing) improve the forecasting accuracy for grid components? Would this lead to less flexibility being activated? How much?

As mentioned above, in this phase the project has not investigated the accuracy improvements that D-programmes could bring. It is interesting, however, to touch upon the current forecast accuracy for a comparison at a later stage.

According to SIA partners (SPEN forecast service provider), the current substation forecast ranges an error of 2-3%. Based on this percentage, the table below shows a comparison between the forecast mean average error to the average aggregator's load per congestion point.

Table 4-2 Mean Absolute Error of Load Forecast at Substations

	MAE of load forecast at substation	Aggregator's contracted capacity
St. Andrews	252.7 – 357.05 kW	500 kW
Leuchars	46.5 – 69.8 kW	250 kW

The table shows that, on average, the absolute DSO forecast error is around half of the contracted flexibility capacity. Therefore, an improvement of accuracy could, in theory, reduce the activated flexibility power by 252-357.05 kW (~50-70% of the contracted power) at St. Andrews and by 46.5-69.8 kW (~20% of the contracted power) at Leuchars. It is worth noting, however, that the contracted flexibility volumes for this phase are relatively small.

Is the current mechanism sufficient, or should it be augmented with other information, e.g. contractual information that could be added to the CRO?

SIA partners suggested that it would be beneficial to get information on the asset types as well as their capacity to enhance their forecasts. The metering at substation level only specifies the load and the front-of-the-meter generation, whereas all generation behind the connection is hidden for the DSO. Knowing the capacity of distributed PV, or other types of generation would enhance the forecast, not only at substation level, but specially at lower voltages (below 11kV) where the DSO hardly has visibility.

4.3.4 Conclusions and Learnings

1. During phase 1, aggregators have successfully shared D-programmes with the DSO communicating via the UFTP protocol. The DSO has successfully visualised the D-programmes on the FFP.

2. FUSION has identified a way in which the DSO could integrate D-programmes into substation load forecasting. To test this, however, the aggregator would need to communicate real time sub-meter data, which could be costly.

3. The current DSO substation forecast is relatively accurate (estimated 2-3% of error) and therefore further reducing the error would have a small impact on the flexibility activations day-ahead. However, the D-programmes and other type of information (such as asset type, capacity, etc) could greatly contribute for lower voltage forecast, especially below 11 kV, which not part of the FUSION trial.

4.3.4.1 Next steps for this objective

In the next phase of the trial, potential next steps are:

- Based on phase 1 conclusions and because of the limited value, instead of attempting to integrate D-programmes into DSO forecasts, phase 2 will aspire to analyse the forecast accuracy on different times and how this affects the flexibility that needs to be requested by the DSO, and thus costs.
- Analyse forecast accuracy at 11kV feeder and assess the added value of D-programmes at that connection level.
- Explore the applicability of D-programmes in low voltage (LV) forecasting.

4.4. FREE BIDS

4.4.1 Scope

Free bids are flex offers which aggregators send in response to a FlexRequest from the DSO, that is either outside of their availability window or above their contracted power. During phase 1, free bids have been trialled in the following test cases:

- 1.3 Secure DSO Constraint Management (pre-fault) - Free bid + Order;
- 1.4 Secure DSO Constraint Management (pre-fault) - Free bid + no Order;
- 2.3 Dynamic DSO Constraint Management (post-fault) - Free bid + Order;
- 2.4 Secure DSO Constraint Management (pre-fault) - Free bid + no Order; and
- 3.2 Sustain Peak Management - Free bid + Order.

These test cases correspond to free bids because the DSO requests flexibility to the aggregators at times outside their availability windows.

4.4.2 Methodology

For this objective, we answer the following questions based on the trial results and interviews with the aggregators and DSO:

- Which assets can participate in DA/ID congestion management that cannot be considered firm capacity?
- What is the effect on the liquidity / activation prices / DSO costs?
- How can the business case of FSPs operating these types of technologies improve, when they have access to this additional revenue stream? Can we expect that this will lead to more (residential) AGRs participating in DSO products?

4.4.3 Results and Analysis

To evaluate this objective is key to identify the firm and non-firm capacity in each portfolio. In trial phase 1 there were three portfolios with different combination of firm/non-firm capacity:

Gridimp – St Andrews: This portfolio consists of only one asset (a CHP plant) that could be considered as firm capacity. This CHP is on stand-by most of the time.

Orange Power – St Andrews: This portfolio includes two small CHPs that could be considered firm capacity, but the majority of the power comes from residential assets (electric vehicle (EV) chargers, electric heaters, photovoltaics (PV), etc), that are considered non-firm capacity.

Orange Power – Leuchars: This portfolio is composed exclusively from residential assets (EV chargers, electric heaters, PV, etc) that are considered non-firm capacity.

The Orange Power portfolio consists of over 800 kW while it has only contracted 250 kW on availability. This is because this capacity is considered non-firm and Orange Power need to have more capacity available to ensure delivery. As described in section 3.3 Orange Power has often delivered over twice the offered flexibility. This behaviour could have been driven by the high penalties that aggregators could face for under-delivery.

By making use of free bids, Orange Power could get remunerated for activating the extra capacity that is available, and difficult to forecast in the long-term. Orange Power has indicated that they have not started making use of free bids by bidding over the contracted power. However, Orange Power has indicated that making use of these bids could allow them to make use of the additional non-firm capacity and bring more non-firm assets to the market. According to the aggregator, this will also reduce the total flexibility costs. To be able to bring more assets and make use of free bids, the aggregator has suggested to increase the price cap, since the current cap is too low to bring a lot more extra capacity on the basis of only utilisation payments. During the trial, Orange Power has offered slightly lower prices for free bids (outside the contracted availability window) than normal bids as indicated in Table 4-4.

Gridimp has not been able to identify the free bid requests from normal requests, therefore they have been bidding as with normal requests. The aggregator considers it is ambiguous and there should be a clear signal when the DSO sends a free bid request. This is reflected in Table 4-4, which shows the prices offered by the aggregator in both free and normal bids, as both prices are the same. Moreover, Gridimp was not able to offer any extra capacity since they had a single asset. Gridimp has indicated during the interview, that free bids would be very beneficial if there was no price cap or if the price cap would be significantly higher.

In summary, the trial results show that, on average, aggregators have offered a slightly lower price per kW for free bids than for normal bids. However, both aggregators have bid at, or just under, the price cap. Therefore, there is no straight-forward conclusion on the differences between free bids and normal bid prices. The offered power in response to free bids has been 5% lower than the percentage of power offered against the request for normal bids.

Table 4-3 Bid prices in phase 1 on aggregated level

Bid Type	Average Offered Price (£/kW)	Max Offered Price (£/kW)	Min Offered Price (£/kW)
Free Bid	0.44	0.49	0.30
Normal Bid	0.46	0.49	0.30

Table 4-4 Bid prices per portfolio

Congestion Point and Aggregator	Average of Offered Price (£/kW)		Max Offered Price (£/kW)		Min Offered Price (£/kW)	
	Free Bid	Normal Bid	Free Bid	Normal Bid	Free Bid	Normal Bid
Leuchars primary – Orange Power	0.47	0.49	0.49	0.49	0.30	0.35
St Andrew Primary - Gridimp	0.40	0.40	0.40	0.40	0.40	0.30

St Andrew Primary - Orange Power	0.47	0.48	0.49	1.00	0.30	0.35

Table 4-5 Comparison of Ratio of Power Offered to Power Requested

Bid Type	Ratio of Offered Power to Power Requested
Free Bid	65%
Normal Bid	70%
All Bids	68%

4.4.4 Conclusions and Learnings

During phase 1 of the FUSION trial:

- Free bids have been successfully provided by aggregators in response to flexibility requests outside the normal availability window. However, the request was ambiguous for one of the aggregators, which suggests to explicitly indicate that the DSO is requesting free bids or to give more clear instructions.
- Both aggregators believe that free bids are a beneficial mechanism to allow for more capacity to be brought to the market, which in turn will result in more liquidity for the DSO. One of the aggregators, which has residential assets, was able to deliver twice the contracted capacity, and free bids offer the means for them to be remunerated for activating that extra capacity.
- Both aggregators believe that the participation of free bids would result in a lower overall flexibility cost for the DSO since they could spread their costs into many more assets. However, they both suggest that the price cap should be either removed or raised, so free bids can work like a proper market.
- With the current results, the savings from free bids cannot be properly estimated because the bid prices are either very close or at the price cap. To calculate true DSO savings, the price cap should be removed, since the price would not only reflect assets marginal cost but also the market conditions, i.e. the opportunity cost to the aggregator.
- Finally, both aggregators believe that free bids would benefit their business case and facilitate the introduction of more residential flexibility in the market. However, they consider this extra capacity should complement contracted capacity under an availability contract (perhaps with lower capacity) that warranties a constant revenue.

4.4.4.1 Next steps for this objective

As next steps, the DSO savings will be calculated by:

- Collecting data by simulating more free bids test cases;
- Removing/increasing bid prices for free bids; and
- Clearly communicating with the aggregators what are the cases in which the DSO requests free bids.

4.5. SUB-METERING ARRANGEMENTS

4.5.1 Scope

The role of sub-metering in DSO services is largely unexplored. As such, the initial scope of this objective as defined in FUSION's Interim Trial Learnings Report #1 (ITLR#1) was to compare and contrast the use of MPAN data versus the use of sub-meter data for service delivery validation and settlement purposes, considering the experience of and the impact on both the aggregators and the DSO. In more detail, project FUSION seeks understand how the accuracy of the baseline is affected by the use of MPAN or sub-meter data and assess whether sub-metering is more suitable for certain assets increasing the inclusivity of the service.

The scope of this objective has changed since ITLR#1. In phase 1 of the FUSION trial, the flexibility validation was performed using exclusively sub-meter data for all congestion points and participating aggregators. Some of the assets, such as CHPs and EVs, had an installed sub-meter already. Whereas for other residential assets the sub-meter was installed by the aggregators. In addition, project FUSION could not get access to MPAN data. Therefore the scope of this objective was adjusted to assessing the experience of the DSO and aggregators with sub-metering.

4.5.2 Methodology

This objective assessment is based on qualitative information from the DSO and aggregators regarding the use of sub-metering. DNV engaged with SPEN BAU and aggregators through workshops, bilateral discussions, and the provision of questionnaires.

4.5.3 Results and Analysis

SPEN BAU team explained that they only receive MPAN data for the validation and settlement of flexibility services, except for residential assets where only sub-metered data is available. However, they did not have a preference on whether MPAN or sub-metered data is preferred.

Both aggregators suggest that they prefer the use of sub-metering in flexibility services:

- Sub-metering offers better resolution and visibility of the asset behaviour
- Sub-metering allows for better control of assets
- Forecasting at asset sub-meter level is more straightforward
- Access to MPAN data of residential assets is not possible to non-supplier aggregators.

4.5.4 Conclusions and Learnings

The use of sub-meters is preferred by aggregators as it enables better control of assets and provides improved visibility. In addition, there are practical considerations with regard to MPAN data access.

4.5.4.1 Next steps for this objective

Project FUSION will consider whether MPAN data can be accessed in FUSION trial 2, in order to assess the initial learnings objectives.

4.6. BASELINE DESIGN / NOMINATION BASELINE

4.6.1 Scope

DSO products for congestion management typically use historical baselines as a basis for the validation and settlement of the delivery. A recent ENA Open Networks study (Workstream 1A, Product 7 2021) suggests widening up the possibilities for FSPs, by allowing nomination baselines when the default baseline in not sufficiently accurate. The scope of the FUSION trial is to assess the performance of nomination baselines against a number of quantitative and qualitative criteria that are discussed in the "Methodology" section and provide learnings and insights to wider GB industry.

The FUSION trial is using nomination baselines (i.e. D-programmes, see section 4.3) as per prescribed by the USEF framework. Nomination baselines are the forecast of the generation or demand profile of the asset or portfolio if no flexibility activation would take place. This forecast is determined by the Flexibility Service Provider (FSP) and sent to the DSO a predefined deadline (e.g. gate closure). For example, the physical notifications which are used in the Balancing Mechanism belong to the Nomination baseline types. The DNO can then use this profile to calculate the deviation of the metered data from the planned profile. In general, the choice of (a) method(s) to do the forecast is left at the discretion of the FSP.

This section looks at the baseline accuracy, variance and bias of the D-programme submitted by the aggregator to the DSO as well as the aggregator and DSO experience using this type of baselines during the FUSION trial. Accurate, technology inclusive, and simple baselines are an essential part of delivering and quantifying the benefit of flexibility therefore examining the reliability of these baselines.

4.6.2 Methodology

The baseline is evaluated against the following criteria:

- Accuracy: The degree to which the baseline is able to accurately predict energy demand. Variance will be measured by the relative root mean square of the errors (RRMSE), see Equation 4 below. Literature proposes that RRMSE of 10 per cent or less is generally considered to be 'good', and an RRMSE between 10 and 20 per cent is considered to provide 'acceptable' accuracy.[11] Accuracy is typically expressed in variance and bias:
    - Variation (or normalised variance): The degree in which the baseline error varies. Variability will be measured in normalized mean absolute error (see equation 2). In this phase, the analysis will be done only on D-programmes. In phase 2, the aim is to compare D-programme variance against other baseline types for the FUSION trial.
    - Bias: The degree to which the baseline method tends to over- or under-predict the actual metered load of the portfolio. Most programs seek baselines with zero bias; however, baselines characterised by consistent, but minor under- or over-estimates can be acceptable as any residual error will be known and an adjustment factor can be considered. Bias will be measured by the normalized mean bias (see equation 3 below). A zero bias would define a good baseline. In this phase, the analysis will be done only on D-programmes. In phase 2, the aim is to compare D-programme bias against other baseline types for the FUSION trial.
- Simplicity: This criterion reflects the level of effort and the complexity of implementing and operating/using the baseline methodology, including but not limited to collecting the right data, performing the calculation, and communicating D-programmes to the DSO. This criterion also considers the replicability of the baseline by the aggregator. The main principle of simplicity is that the solution is practical, and the effort required is proportionate to the outcome. Therefore, we will evaluate it using:

[11] This definition and criteria is based on the report "Baselining the ARENA-AEMO Demand Response RERT Trial" https://arena.gov.au/assets/2019/09/baselining-arena-aemo-demand-response-rert-trial.pdf

- DSO implementation costs: compare the cost of D-programmes implementation against another baseline methodology e.g. historical; and
- Aggregator cost of implementation: analyse the extra effort that aggregator needs to put into implementing D-programmes next to their BaU cost.

- Inclusivity: The degree in which the baseline is suitable to use for (almost) all technologies. This criterion will be analysed quantitatively based on the input from aggregators, and the diversity of assets contracted in the FUSION trial.

The aspects on integrity (potential for gaming behaviour) and stackability are left out of the analysis.

To assess quantitative aspects, the baseline variability against the measured meter data will be calculated using the normalized mean absolute error (Equation 2), which is derived from subtracting the measured meter power (m_t) from the baseline value (b_t) to get the error (d_t) at each time step (t) (Equation 1). This approach has been selected as outliers have less of an effect compared with using the variance, therefore we feel the normalized mean absolute error is more representative of the general spread of errors, allowing outliers to be addressed separately. The bias will be calculated using the normalized mean bias (Equation 3). Finally, the accuracy will be calculated with the relative root mean square error (RRMSE) (Equation 4), which assesses the error after n values.

$$d_t = b_t - m_t \qquad \text{(EQUATION 1)}$$

$$nmae_p = \frac{\sum_{t\epsilon T}|d_t|}{\sum_{t\epsilon T} m_t} \qquad \text{(Equation 2)}$$

$$bias_p = \frac{\sum_{t\epsilon T} d_t}{\sum_{t\epsilon T} m_t} \qquad \text{(Equation 3)}$$

$$RRMSE = \frac{\sqrt{\frac{1}{n}\sum_{t\epsilon T} {d_t}^2}}{\frac{1}{n}\sum_{t\epsilon T} m_t} \qquad \text{(Equation 4)}$$

The different parameters are calculated on non-event moments and excludes weekends and public holidays.

4.6.3 Results and Analysis

D-programmes (i.e. nomination baseline) have been used for flexibility settlement throughout the phase 1 trial period. This analysis covers the period between October 2021 and January 2022 and D-programmes submitted by aggregators as well as sub-meter data was used to perform the calculations.

The figure below shows an example of a baseline submitted by Orange Power for their portfolio in Leuchars. The baseline is compared to the aggregated sub-meter data of Orange Power's portfolio. In this example, as well as other multiple days, D-programme are more accurate at predicting peak power demand but less accurate at predicting times outside of peak times.

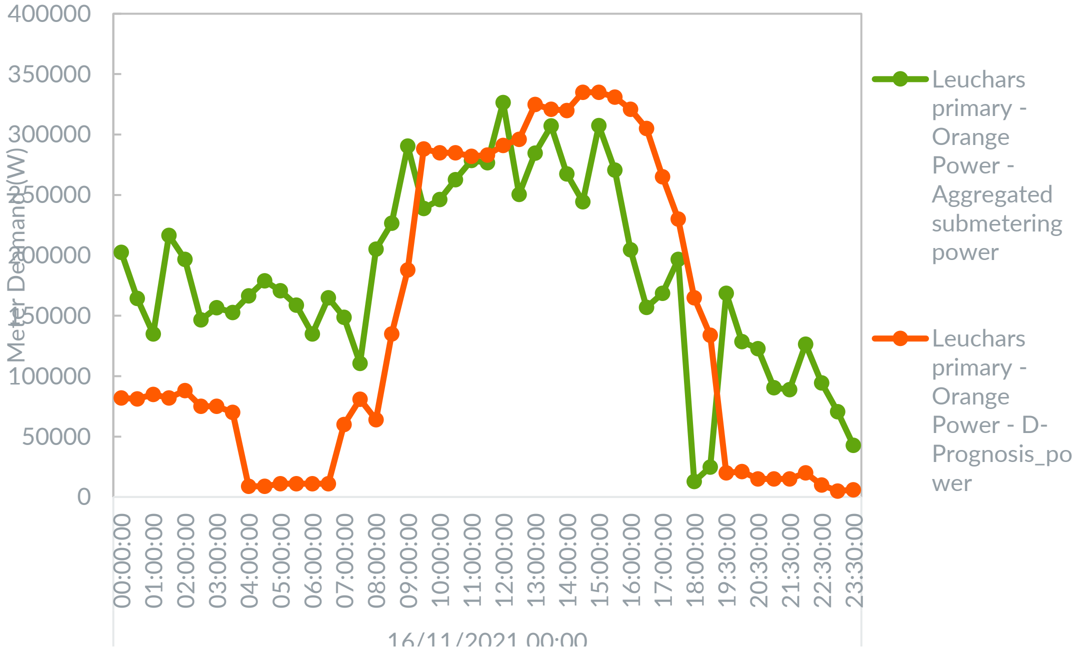

Figure 4-3 D-programme Baseline against counterfactual for Days Without FlexOrders

4.6.3.1 Accuracy

The tables below show the calculation of accuracy, variability and bias for the baselines of each aggregator portfolio from October 2021 to end of January 2022. The overall results throughout the period have been calculated for all non-event times (i.e. the times where no flexibility was dispatched) and for non-event times only limited to service windows (9 am to 5pm).

Accuracy: According to our calculations (Table 4-6), RRMSE ranges –215% to 111% throughout both aggregators' portfolios. As described in the previous section, an RRMSE value for a good or acceptable baseline should be below 10% or 20% respectively. Therefore, the current values indicate a poor baseline accuracy. To explain this, we look further into the individual portfolio characteristics.

- Gridimp – St. Andrews: The portfolio is only represented by one asset, which is a CHP that is on when the district heating provider is not providing heat to its customer. Therefore, the D-programmes rely on the nominations of the customer, and the district heating plans on maintenance or expected behaviour. This means that any type of unexpected events at the district heating plant would affect the operation of the CHP. Gridimp highlighted, for example, a fire that occurred at the district heating plant that triggered the CHP to be on instead of off as they forecasted (and thus submitted in their D-programme). Moreover, the CHP only has 2 modes: on or off, which means that if the D-programme is not accurate, it will be off by 220 kW, which is 100% of the flexible power contracted.

Figure 4-4 shows the baseline for various days in January where this happens. When looking at the accuracy per day of the week, Tuesdays seem to be slightly more accurately predicted than the rest of the week-days. Finally, it is worth noting that Table 4-9 shows that the accuracy in September was significantly worse, which also hampers the overall result. This was due with a delay in the implementation of the controls of the CHP. The RRMSE improved significantly throughout the trial, going up to -87% in January. Overall, Gridimp's portfolio shows the lowest accuracy across all portfolios, at -215%.

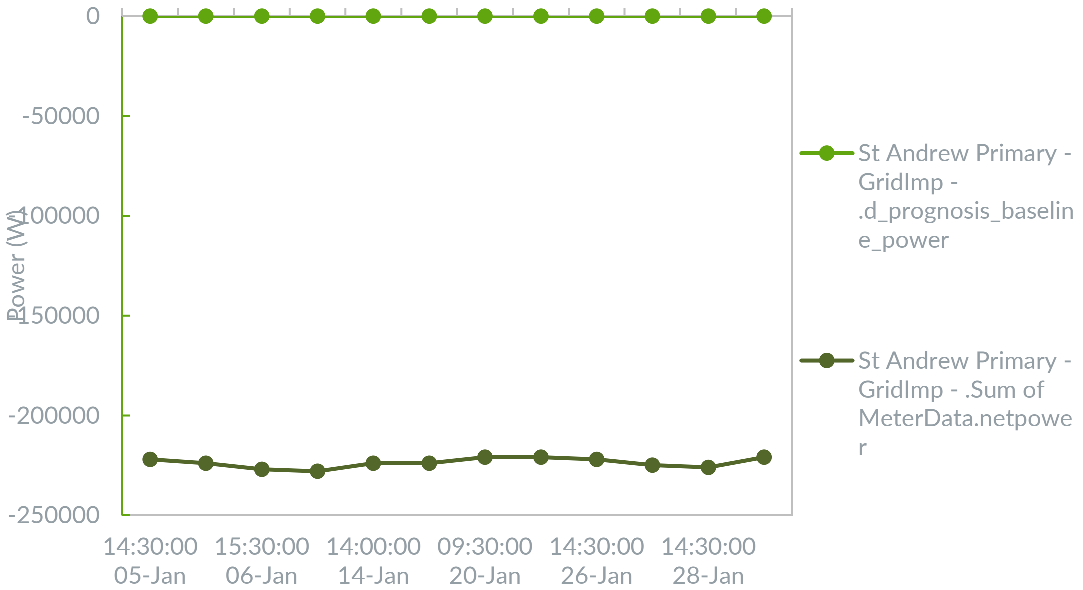

Figure 4-4 Gridimp – St Andrews D-programme vs sub-meter measurements. Note that generation is denoted as negative power.

- Orange Power – St. Andrews: This portfolio is composed of EV chargers, water heaters, and solar PV as well as 2 CHPs. Orange Power's forecasting method consists of forecasts per technology supported by machine learning to include the seasonal factors.
- Even if the overall RRMSE is 81%, Table 4-9 shows how the accuracy has been consistently improving from the beginning of the trial. It started at 137% and in January it went down to 62%. This reflects the improvements that the machine learning technique provided, since it got better the more data it collected. Orange Power that the challenge is with residential assets, where they can barely get 50% of accuracy. Regarding the day of the week, Tuesdays and Thursdays show a much better accuracy than Wednesdays and Fridays. Orange Power also confirmed that the day of the week is a very important element to consider when forecasting because of different daily patterns.
- Orange Power – Leuchars: This portfolio includes EV chargers and other residential assets. Orange Power uses the same forecasting method as for the St. Andrews' portfolio. This portfolio forecast is the most accurate out of all of them, at a 66% RRMSE. The D-programme has also shown an improvement since the beginning of the trial until January, where it got down to 58% RRMSE. Regarding the day of the week, this forecast does not show significant changes by day. The better D-programme accuracy of this portfolio might be because of the fact that there is no dispatchable generation, such as CHPs.

We have also considered the bias metric. The bias shows that both Gridimp and Orange Power (at Leuchars) tend to underestimate the baseline, whereas Orange Power (at St. Andrews) results in 0% mean bias. 0% bias is an ideal result, according to literature. However, when investigating the differences between "all day" and "only service window", Orange Power appears to show a positive bias during the service window, i.e. the D-programme is overestimated.

Table 4-6 D-programme Accuracy per Congestion Point and Aggregator

Congestion Point/Aggregator	Normalized Mean Absolute Error	Normalized mean bias	Relative Root Mean Square Error (RRMSE)
Leuchars - Orange Power	66%	-22%	83%
St Andrews - Gridimp	-107%	-75%	-215%
St Andrews - Orange Power	81%	0%	111%

Table 4-7 D-programme Accuracy of Service Window Compared to the All Non-Event Times

Congestion Point/Aggregator	Normalized Mean Absolute Error (nmaep)		Normalized Mean Bias (biasp)		Relative Root Mean Square Error (RRMSE)	
	Service Window	All time	Service Window	All time	Service Window	All time
Leuchars - Orange Power	65%	66%	44%	-22%	81%	83%
St Andrew - Gridimp	-106%	-107%	-73%	-75%	-207%	-215%
St Andrew - Orange Power	107%	81%	91%	0%	133%	111%

Table 4-8 D-programme Accuracy Metrics by Day of the Week

Day of Week	St Andrews Gridimp			St Andrews Orange Power			Leuchars Orange Power		
	nmaep	biasp	RRMSE	nmaep	biasp	RRMSE	nmaep	biasp	RRMSE
Mon	-87%	-56%	-203%	n/a	n/a	n/a	n/a	n/a	n/a
Tue	-92%	-71%	-179%	69%	-22%	93%	65%	-30%	82%
Wed	-107%	-91%	-226%	120%	23%	165%	71%	-17%	86%
Thu	-130%	-68%	-244%	70%	0%	92%	62%	-26%	76%
Fri	-115%	-82%	-217%	87%	19%	121%	71%	-11%	89%

Table 4-9 D-programme Accuracy Metrics by Month

	St Andrews Gridimp			St Andrews Orange Power			Leuchars Orange Power		
Month	nmaep	biasp	RRMSE	nmaep	biasp	RRMSE	nmaep	biasp	RRMSE
Sep	-384%	14%	-3739%	96%	34%	137%	71%	-23%	85%
Oct	-130%	-130%	-177%	120%	45%	171%	71%	-17%	86%
Nov	-240%	40%	-402%	55%	-14%	69%	52%	-20%	60%
Dec	-73%	-60%	-505%	80%	-37%	97%	81%	-10%	95%
Jan	-87%	-87%	-152%	54%	-33%	62%	49%	-38%	58%

4.6.3.2 Simplicity

The aggregators have indicated that the implementation of D-programmes has required little effort. Aggregators already have forecasting systems in place to forecast and monitor flexibility. Therefore, the forecasting aspect is not a cost that they attribute to D-programmes. The cost would only be associated to the Extensible Markup Language (XML) message to communicate this via UFTP, for which a small effort is required.

The DSO has implemented the capability to receive D-programmes in the FFP, however is not possible to break down the cost of that specific element from the total. This aspect will be more relevant to introduce when comparing D-programmes with other baselines (such as historical) that would need to be calculated by the DSO.

4.6.3.3 Inclusivity

The aggregators participating in the trial have indicated that they are positive about the use of D-programmes since it allows to baseline the diversity of assets in their portfolios. From the data it is also evident that the quality of the D-programmes, regardless off the composition of the portfolio, have been improving each month because the aggregators are allowed to use their own mechanisms to enhance the forecast. The aggregators have indicated, however, that intraday submission of D-programmes would be beneficial to improve accuracy.

4.6.4 Conclusions and Learnings

The FUSION trial has successfully used D-programmes (i.e. nomination baselines) for flexibility delivery quantification and settlement.

- The accuracy shown by the D-programmes varies per portfolio type. The accuracy has consistently improved throughout the trial in every portfolio, whereas the bias and variation have fluctuated. Regardless of the improvement, the overall accuracy of the D-programmes is relatively poor when compared to what literature define as "good" or "acceptable" baseline. It is worth noting the portfolios are relatively small, which generally are more difficult to forecast than bigger portfolios. In addition, the binary forecast nature of Gridimp's CHP drags the D-programme performance down.

- The simplicity and inclusivity have been evaluated highly by the aggregators and some of them define D-programmes as one of the best additions of USEF. An aspect that was suggested is to allow for D-programmes intraday updates to be used in the baseline to enhance the accuracy.

4.6.4.1 Next step for this objective

The next step for this objective is to compare the performance of D-programmes against other types of baselines such as historical and a meter-before-meter-after approach.

4.7. MARKET COORDINATION MECHANISM (MCM)

4.7.1 Scope

During FUSION trial phase 1, flexibility trading was done according to the USEF market coordination mechanism (MCM). The USEF MCM facilitates flexibility trading and consists of five phases – contract, plan, validate, operate and settle. During the trial, the contract phase was done at the procurement stage whereas the phases from plan to operate were conducted day-ahead and intraday. Finally, the settle phase was done once per month.

The different services and test cases have been trialled according to the MCM during phase 1. The scope of this objective is to evaluate the experience of the difference parties using this mechanism as well as the fit to the different services.

4.7.2 Methodology

This objective is evaluated in a qualitative manner through interviews and questionnaires that DNV conducted with aggregators and SPEN. The qualitative analysis covers the following questions:

- How does the USEF MCM fit into DSO day-to-day operations?
- What is the FlexReservationUpdate value to the AGR (by bringing it to other markets)?
- How are assets selected in the BaU situation, what are the expected saving when using a merit order approach?
- Intraday updates: To what extent are D-programme updated intraday before the flexibility has been ordered? To what extent are failures to deliver the ordered flexibility notified ahead of the activation? Does this trigger the DSO to activate more flexibility?
- The topics related to flexibility delivery and reliability are analysed on a quantitative manner. The data used for this exercise covers the period of October 2021 to end of January 2022.

4.7.3 Results and Analysis

SPEN's business as usual process for planning, procuring and dispatching flexibility is at very early stages of deployment. We identified the following phases:

1. Long-term forecasting (5-7 years ahead) to determine long-term grid capacity needs
2. Procure and contract flexibility several years ahead
3. Month-ahead forecast to identify grid needs

4. Month-to-week-ahead utilisation instruction
5. Settlement

The business phases are partly in line with the contract, plan, validate and settle USEF MCM phases. The main differences between both mechanisms are:

- USEF MCM involves an extra role in the contract phase, the Common Reference Operator (CRO).
- USEF MCM can be applied from years ahead to real time, whereas the BaU approach has a disconnection with real time operation and short-term forecasting.
- USEF MCM evaluates uses FlexRequests and FlexOffers to request flexibility daily and creates competition in utilisation prices. SPEN BaU dispatches flexibility long in advance, based on month ahead forecasts, for a fixed fee agreed during contract stage.
- SPEN BaU does not include the contribution of flexible assets to the forecast whereas USEF MCM uses D-programmes.
- SPEN BaU does not apply concepts such as FlexReservationUpdates, free bids, and D-programme updates,
- SPEN BaU baseline is either historical or nomination. Nomination is only considered for generators. USEF MCM uses D-programmes (nomination) as baseline.

SPEN BaU would like to close the gap between long-term and short-term/real time flexibility planning and dispatch. At present, SPEN's ambition is to move to week-ahead planning, and only use real time for post-fault services. However, this exercise is difficult because the control room way of working is completely disconnected from flexibility and there are no processes in place to assess/dispatch flexibility closer to real time operations. Moreover, there is not a lot of liquidity in the market to be able to assess what assets/portfolios to dispatch.

This confirms that SPEN BaU is still at very early stages and needs to further develop its processes. The USEF MCM could help the development of these processes, however, some of the MCM concepts are still far from being applied by the business. For example, FlexReservationUpdates, because the DSO does not consider that this element provides value yet, since they would not pay for flexibility availability if they do not need it.

- FlexReservationUpdates is a USEF concept that allows the DSO to release the aggregator from their availability contractual obligations when flexibility is not needed. In the FUSION trial phase 1, FlexReservationUpdates were sent day-ahead to aggregators in test cases 1.5, 2.5 and 3.3. aggregators believe that FlexReservationUpdates bring significant value to them, since it would allow them:
  - To avoid sending a false alarm to customers if they are not going to be activated
  - To manage their portfolio and make assets available for other use

Intraday D-programme updates after the FlexOrder has been sent are not perceived as useful by aggregators. Intraday D-programme updates before FlexOrder is considered to add value only if the baseline would be updated. Currently, the updated D-programme would only be useful for the DSO to check the expected changes in their forecast. There is no apparent value for the aggregators. This is reflected in the trial results as only on few occasions one of the aggregators has sent updated D-programme.

Finally, this objective looks at the reliability of portfolio-based bids vs asset bids. Until now, BaU has only utilised assets and has had very few activations, even if in the future it will support portfolio bids. Therefore, we do not have enough data to assess the reliability of the BaU process. The USEF framework is based on portfolio bids since the operator does not have visibility of what assets are assigned to each offer. During the FUSION trial phase 1, the aggregators sent flex offers with both portfolios and one specific asset (CHP). Therefore we can assess the reliability of both types of utilisations.

Reliability is calculated as the percentage of successfully delivered FlexOrders. This metric does not take into account over-delivery. As described in section 2.3.2, the overall reliability of delivery is 75%. The full analysis of this figure can be found on that section. Figure 4-5 breaks down the reliability per portfolio. We can observe that overall, the portfolio bids with residential assets from Orange Power showed a better reliability than the asset bid from Gridimp. The average reliability of portfolio bids is 76.3% whereas the reliability for the asset bids is 72.5%. Based on the trial data, this result suggests that portfolio bids are more reliable than asset bids.

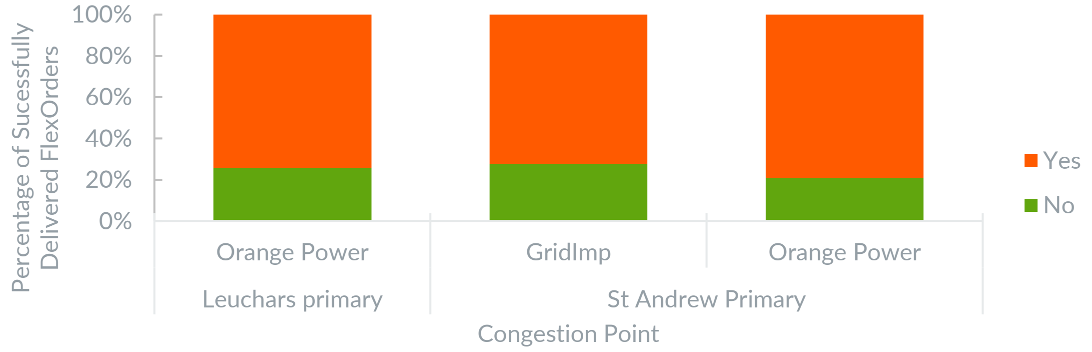

Figure 4-5 Percentage of Successfully Delivered FlexOrders at Each Congestion Point (defined as having a realised power greater than 100% of the FlexOrder)

4.7.4 Conclusions and Learnings

The first phase of the trial has successfully trialled all phases from the USEF MCM.

- SPEN BaU flexibility process is still at an early stage and USEF MCM could contribute to the development of a more consolidated approach.
- FlexReservationUpdates are, according to aggregators, a beneficial function for enabling them to manage their portfolios and avoid conflicts with the delivery of other services. However, SPEN BaU considers that FlexReservationUpdates may not add value because DSO services are fully stackable.
- D-programme intraday updates have not been perceived useful by aggregators because they do not serve as updated baselines, they just as an update to the DSO on the latest forecasted behaviour of the aggregated load.
- Regarding reliability of portfolio bids against asset bids, the trial results indicate that reliability of portfolio bids is higher than asset bids by 4%. The portfolio bids consisted, in the most part, of residential assets.

4.7.4.1 Next steps for this objective

In the next phase we will further explore the synergy between USEF and BaU flexibility processes, in the context of all Energy Networks Association (ENA) services and how the process fit them. Further, the type of assets and bids in the next phase will increase, therefore we will continue to analyse the reliability based on different portfolio bids and volumes. Finally, we will explore with aggregators their benefits when using FlexReservationUpdates when they are active in other services, such as ESO services.

4.8. USEF FLEXIBILITY TRADING PROTOCOL (UFTP)

4.8.1 Scope

In the FUSION trial, the interaction between SPEN (DSO) and the aggregators has been formalised through the USEF Flexibility Trading Protocol (UFTP). The USEF Communication Protocol, formally referred to as the USEF Flexibility Trading Protocol (UFTP), describes the interactions and communication exchange between aggregators and DSOs to resolve grid constraints at distribution level. The UFTP covers all phases in the USEF Market Coordination Mechanism (contract, plan, validate, operate and settle) and is designed to be used as a stand-alone protocol for flexibility forecasting, offering, ordering and settlement processes. More details on the implementation of UFTP and its technical requirements are provided in FUSION's Interim Trial Learnings Report #1, which was published in October 2021.

The scope of this learning objective is to understand and assess the implementation costs of UFTP for SPEN and the aggregators, assess the user experience of SPEN and aggregators when using the UFTP, consider the applicability of UFTP in the wider GB industry, assess potential cost savings that can be realised through the use a standardised protocol and identify barriers and challenges related to the implementation of UFTP.

4.8.2 Methodology

The assessment method of the UFTP objective was qualitative. In order to obtain the required information, DNV engaged with SPEN and aggregators through workshops, bilateral discussions and the provision of questionnaires. The qualitative assessment covered the following topics:

- Qualitative assessment based on AGR and OpusOne (FFP) experience with other flexibility protocols and UFTP
  - Effort required for implementation
  - Advantages of UFTP
  - Areas for improvement
  - Benefits of Standardisation
  - Fit-for-purpose for GB and ENA products
- Creation of a backlog with improvements suggested by DSO and AGR.

4.8.3 Results and Analysis

The responses of one of the aggregators (Gridimp) are summarised below:

Effort required for implementation: Gridimp estimate that the additional effort to implement USEF and UFTP compared to SPEN's BAU requirements was around 6 weeks. The additional effort was mainly linked to USEF requirements for automated bidding, bid acceptance and automated settlement processes.

Advantages of UFTP: Automated bidding and bid acceptance are highly beneficial for the aggregator and wider market. Automated settlement will save a lot of manual time and make market participation easier for smaller assets. Automated trading in the future will allow closer to real time trades and weekend trades, which will bring liquidity to markets benefiting both the DSO and the aggregator.

Areas for improvement:

- The UFTP settlement needs to be extended to include availability payments.
- Gridimp suggested other improvements to the FlexRequest and settlement messages (see section 4.8.3.1).

- Implementation effort could be optimized if certain values were not repeated during the trade message chain (e.g. price and ISP list). The aggregator suggested that UFTP follows the programming principle of "once-and-only-once" so that once information has been agreed it is not re-transmitted. This approach would reduce the number of "non-happy" paths that must be implemented and tested.
- Implementation effort could be optimised if all ISPs were always included singly in the specification, by dropping the duration, this would reduce implementation checks (note that in the practice this was the case as implemented)

Fit-for- purpose: Gridimp suggests that UFTP is fit-for-purpose for wider use in GB and with ENA products.

Benefits of standardisation: Gridimp highlighted massive cost benefits in case of standardisation and the usage of the same flexibility trading protocol by all DSOs, on the basis that it is costly to implement each separate API and to bid and settle small volumes manually. A standard API that includes bidding and settlement is vital for participation of small assets (e.g. 100 kW or less). In addition, using a flex trading protocol that is not GB-specific provides the opportunity for GB aggregators to access markets in other countries.

The responses of the other aggregator (Orange Power) are summarised below:

Effort required for implementation: The experience of the second aggregator with UFTP implementation was different from the first one, because the more code-based UFTP (compared to existing market platform) allowed Orange Power to automate most of the commands and perform fewer manual activities. The additional functions that Orange Power had to implement and the associated effort as perceived by them are:

- D-programme – medium effort, high benefit (discussed below in the advantages)
- Update D-programme after FlexOrder – low effort, low benefit.
- FlexRequest – medium effort, low benefit; under the current trial aggregators do not use the FlexRequest to reflect the availability as the availability contract is fixed.
- In addition, when comparing the cost and effort of UFTP implementation to activities required for integration with NGESO's marketplace, the UFTP implementation cost and effort was considered much lower with limited areas for improvement.

Advantages of UFTP: The most beneficial function is considered the D-programmes which allows aggregators to forecast and update on daily basis. As discussed in Section 4.3, the use of D-programmes are a great alternative to historical baselines. According to Orange Power, D-programmes are fit for the future and would function across different markets like the Balancing Market and DSO flexibility services. It is also very helpful for aggregators to have a dynamic baseline that can be updated on a daily basis.

With regard to the overall experience with UFTP and FUSION trial, Orange Power has suggested that UFTP is sufficiently user-friendly even for aggregators with less experience in trading. Once UFTP is set up the actual trading effort is not high and the cost for a supplier/aggregator to hire a trading team is reduced.

Areas for improvement: According to Orange Power, one of the areas for improvement is the type of penalty that is imposed to non-performing assets. The current agreement penalises the response based on the lowest performing 3 ISP periods per month, which can be very detrimental to the participation of DSR type assets. Although availability should be adjusted to reflect non-performance, the aggregator suggests that the availability should be adjusted more smoothly. Although this improvement is not directly linked to the UFTP or USEF, we report it here as an overall improvement of existing FUSION agreements.

Fit-for- purpose: Orange Power suggests that UFTP is fit-for-purpose for wider use in GB and with ENA products.

Benefits of standardisation: The benefits of a standardised protocol are considered massive by Orange Power on the basis that implementing bespoke communication protocols for each DSO or platform it would require unreasonable costs and effort. In addition, using a flex trading protocol that is not GB-specific provides the opportunity for GB aggregators to access markets in other countries.

We also interviewed OpusOne who developed the FUSION Flexibility Platform (FFP) in order to understand their experience with the implementation of UFTP for the DSO. The summary of their responses is provided below:

Effort required for implementation: According to OpusOne the implementation of UFTP involved significant effort and cost to enable their existing platform to participation in the USEF framework. They had to develop a new platform distinct from their existing OpusOne Flexibility Market Platform. Particularly they had to add functionality for the UFTP messaging, the MCM stages and the encountered problems with the limitations of data models and the creations of a logical network connections model. From all the

Advantages of UFTP: OpusOne recognised the use of MCM stages allow for an improved and streamlined User Interface experience.

Areas for improvement: OpusOne suggested the following areas for improvement:

- Easier process to update and review the UFTP messages. This could be facilitated by having ready-made template for CRO, DSO and aggregator tools
- Improvements in settlement function.

Fit-for- purpose: According to OpusOne UFTP does not fully fit-for-purpose due to a number of factors. For example, UFTP does not have the ability to integrate with network models and is not designed for settlement of availability payments. In addition, UFTP could not accommodate services which are outside load variation (e.g. voltage control or frequency control services), as it is only designed for Constraint Management services.

Benefits of standardisation: In contrast to aggregators the benefits of a standardised communication protocol for a single DSO were not considered significant for OpusOne, on basis that a DSO (or the Flexibility Platform provider) would have to develop the platform regardless of the standardisation and commonality across other markets. They however recognise that higher benefits can be achieved for the wider industry if the same platform is used by multiple DSO and multiple aggregators.

4.8.3.1 Change requests

The current UFTP version does not allow for specifying the service type that the DSO needs in the FlexRequest message. This has an impact in the FUSION trial, since the service type needs to be communicated outside this system. To address this problem, one of the aggregators (Gridimp) created a change request that they presented to the Shapeshifter (former UFTP) technical steering committee. The request was approved and will be implemented in the next release of the protocol in 2022. The change request included the revised FlexRequest XSD message that includes an optional attribute on ServiceType that can be specified by the DSO. For free bids this field would remain empty.

This change request aligns with the direction in which the ENA and DSOs in GB are moving with the different service types.

4.8.4 Conclusions and Learnings

The conclusions of the assessment of the UFTP objectives are:

- The cost and implementation effort for aggregators was considered low to medium. The effort for OpusOne was considered high as it had to develop a new platform, since incremental changes of their existing platform were not sufficient – although this is an observation specific OpusOne.

- Aggregators and OpusOne highlighted a number of benefits of the UFTP associated with the automated UFTP processes, the use of D-programmes, the inclusivity of UFTP even for new participants, the bidding process and the streamlined MCM.
- The benefits of standardisation for the wider industry and for the aggregators, in particular, are recognised by all interviewers as the use of multiple platforms would create additional burden for market participants.
- Although aggregators consider that the UFTP is fit-for-purpose for GB and ENA products, OpusOne identified several functionalities that cannot be addressed within UFTP.
- A number of improvements have been suggested by the aggregators and OpusOne. These improvements will be considered and assessed by project FUSION to understand if they can be accommodated in phase 2. Some of these improvements are already discussed with Shapeshifter so that the UFTP could be modified.
- One of the aggregators sent a change request to modify the UFTP FlexRequest message for it to include a field on service type to align better with FUSION and the ENA direction.

4.8.4.1 Next steps for this objective

The learnings of this objective regarding UFTP improvements and UFTP's suitability for GB and ENA products will be considered by project FUSION and an update will be provided in the next trial learnings report #3.

5. Additional learnings from live trials PHASE 1

This section provides additional learnings from aggregators, OpusOne and FUSION partners. Most of the learnings have been captured under the objectives assessment (Section 4). In an effort to gain further insights, we also took the opportunity to record incidental observations and explore secondary learning objectives outside of those listed above.

5.1. LEARNINGS FROM AGGREGATORS

We asked aggregators about their experience with the Flexibility Procurement Process, the Flexibility Services Agreement (FSA) and any views on barriers customer participation.

Orange Power has indicated that:

- The advantage of the flexibility procurement process for FUSION is that it is a dynamic process, due to the ability to forecast the baseline. One the other hand, the tendering processes is more manual, whilst other tendering processes (e.g. through Picloflex) are algorithm based and more automated.
- The standardisation of the FSA makes it easier for aggregators to implement flexibility contracts from the system and commercial side. However one of the areas for improvement is the type of penalty that is imposed to non-performing assets. The current agreement penalises the response based on the lowest performing 3 ISP periods per month, which can be very detrimental to the participation of DSR type assets. Although availability should be adjusted to reflect non-performance, the aggregator suggests that the availability should be adjusted more smoothly.

- The overall experience with UFTP and FUSION is user-friendly even for aggregators with less experience in trading, increasing participation to flexibility markets. Particularly when considering smaller distributed energy resource (DER) assets, residential assets and/or transport sectors, the signal of FlexRequest could be a useful warning for these assets to decide whether they can opt in or out of the event at day ahead stage, giving them sufficient visibility of what they can or cannot deliver.

Gridimp has indicated that:

- With regards to flexibility procurement processes, using UFTP for offers and settlement is a cost saving for aggregators, which could be also replicated in other procurement processes. For example, they suggest that the existing Picloflex solution could mesh with the USEF contract phase.
- With regards to the FSA improvements, Gridimp is fully aligned with Orange Power that the performance factor is a barrier, and they would like to encourage participation of flex providers by rewarding performance smoothly. The current loss of all revenue after 3 non-performing ISP periods means that Flex Providers may lose money if they subsequently participate after a single dispatch failure; this is a negative outcome both for the flex provider and for the DNO. Instead Gridimp suggests that utilization should be paid for the individual instance, with no effect from monthly availability and no penalty above the minimum threshold of 60% - i.e. 99% deliver doesn't get penalized down. In addition they would like to see availability payments smoothed, either weekly or with more periods considered.
- With regards to USEF contribution to reduce barriers to participation, Gridimp acknowledge that the automated bidding and settlement processes that USEF offers, is extremely beneficial for smaller assets, which would otherwise have higher proportional management cost, so automated bidding and settlement. However, the penalties for non-participation and pre-contracted flex make participation very difficult for smaller assets, where a market mechanism with a framework contract would be much better. For example, Gridimp suggests that they could be contracted to perform within certain criteria and can recruit and offer assets to the market when they are available.

5.2. LEARNINGS FROM OPUSONE

The learnings from OpusOne focus on the implementation of UFTP and particularly the actions that OpusOne had to implement in order to develop and deliver the FUSION Flexibility Platform (FFP):

- As it has also been described in the UFTP objective, the cost and effort implementation of UFTP for OpusOne was much higher than originally planned.
- These costs could have been partially avoided if there was more efficient alignment between commercial specifications and the UFTP.
- In addition, OpusOne suggests that planning timescales were very tight and a more agile software approach would have facilitated the process.
- Another important element raised by OpusOne is that the trial itself would have benefited from increased data sharing among all partners, more agile and fluid data sharing throughout the process. Data sharing is key for innovation projects and is a valid improvement for future activities.
- In addition, the trial would have benefited from more testing rounds especially between OpusOne and SPEN to ensure that both teams are fully familiar with the platform and that progress made to the right direction.
- Finally, OpusOne sees an opportunity for FUSION to further align with SPEN's BAU activities which will be considered in phase 2 of the FUSION trial.

OpusOne's observations are all valid and should be considered not only by FUSION but by other innovations projects as well. Most of the learnings and the challenges that OpusOne phased are driven by the innovative nature of project FUSION: implementing a concept which has not been trialled before has an inherent level of uncertainty.

5.3. LEARNINGS FROM FUSION PARTNERS

Through metering validation work conducted by Origami, it was concluded that the kWh readings taken on site over the time period of interest were in agreement with the metering data provided by aggregators for the same dates. Through comparative analysis of data sent directly from aggregators versus the equivalent data downloaded via the FFP, it was confirmed that both datasets use the same time zone (local time) and align when compared by settlement period. Therefore, there is no impact on settlement.

However, it was noted that the dataset sent directly from Gridimp uses a different timestamp convention to the data exported from the FFP. The raw data timestamp convention used in the data sent from Gridimp aligns with the Elexon timestamp convention of labelling the end of the settlement period; whereas, in the FFP export data, the ISP is converted into a timestamp which indicates the beginning of the settlement period. While there is no impact on settlement, this exercise highlighted the importance of standardisation and transparency in approach when labelling settlement periods and demonstrated that the use of ISP values (rather than timestamps) allows for much more transparent analysis. Due to the aggregated nature of some of the data, this exercise was able to be carried out for one asset only.

6. Stakeholder engagement and wider impact

This section contains the interactions of project FUSION with other initiatives, projects or organisations: TEF projects, ENA ONP, BEIS and Ofgem, and the SPEN BAU Flexibility team.

6.1. INTERACTIONS WITH TEF

Project FUSION is one of three projects that comprise the TEF group of NIC projects, the other two being TRANSITION (SSEN) and EFFS (WPD). Over the past 6 months, all three projects have continued to convene monthly Project Delivery Board (PDB) meetings to share progress updates on the TEF projects, track developments within the Open Networks Project (ONP) and coordinate on what opportunities we perceive might exist for us to add value, independently or collaboratively, to the ONP products.

During each of the monthly PDB meetings, TEF partners have also hosted 'deeper-dive' sessions. These comprise a 1-hour slot at the end of the PDB meeting during which a specific subject area is discussed in detail with participation from subject matter experts. Subjects covered in recent 'deeper dive' sessions include benchmarking, metering and forecasting.

6.2. INTERACTIONS WITH THE ENA ONP

The agreed avenue for interaction between any TEF project and the ENA is the TEF representative (currently Daniel Burke, SSEN) who relays information back and forth between the TEF group and the ONP.

Where possible Project FUSION has sought to align closely with the ENA by, where practicable, adopting and implementing, the best practices that emerge from the ONP and providing feedback on our experiences. This is exemplified by FUSION's adoption and review of various iterations of the Flexible Service Agreement (FSA) that emerged from WS1a P4 and the implementation of the Common Evaluation Methodology (CEM) that emerged from WS1a P1. One current ongoing interaction between Project FUSION and the ONP is focussed particularly on WS1a P5, in which Project FUSION is exploring the potential viability of collaborating with the ENA on a report into primacy rules that would be published in 2022.

6.3. INTERACTIONS WITH BEIS / OFGEM

Project FUSION meets quarterly with Ofgem to discuss project progress and share insights on interim learnings and next steps. In November 2021, Project FUSION presented a 'show & tell' to an audience of 30+ Ofgem representatives, which comprised a presentation of interim learnings and a Q&A session.

6.4. INTERACTIONS WITH SPEN BAU FLEXIBILITY TEAM

Project FUSION meets fortnightly with representatives from SP Energy Networks DSO team to discuss how the two workstreams can cooperate to maximise the value of our operations and learnings to our customers. We also meet every 6-months a part of a wider 'Internal Steering Group' which convenes to ensure that the FUSION project is continuing to align with the strategic objectives of the business and the industry.

6.5. IMPACT ON ED2

Interim learnings from Project FUSION helped contribute to the elaboration of the SP Energy Networks ED2 submission. The key areas of influence comprised the following:

- DSO System Architecture;
- Cost Development; and
- Decision Making Framework (DMF).

7. Next steps

7.1. PHASE 2 TRIAL

As set out above, congestion events in phase 1 of the trial were simulated. During phase 1 the FUSION trial has been modifying the network forecast so that network peaks coincide with the availability periods that the aggregators committed. We took two steps to modify the forecast: 1. scale forecast volume, 2. shift forecast in time.

To simulate the congestion on the network, we also set the maximum power threshold of the substation to the desired level, which created a deficiency between 100 and 500 kW. This approach allowed us to create a series of scheduled events throughout the trial and collect as much data on delivery as possible. However, the simulations did not properly reflect the real grid condition.

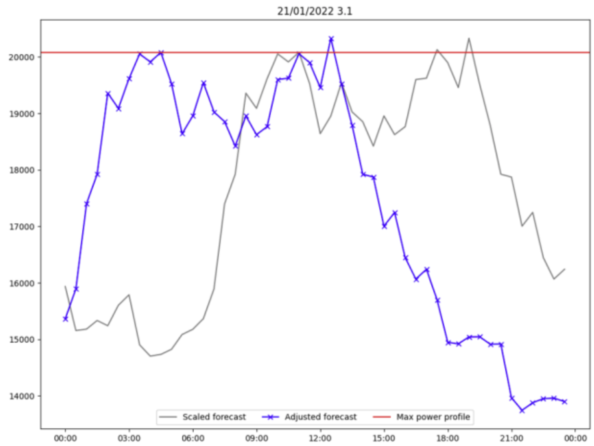

Figure 7-1 Example of phase 1 forecast modification to simulate congestion

Two objectives of phase 2 are:

a. to simulate events that more closely resemble real grid congestion issues; and

b. if possible, dispatch flexibility that alleviates *real* network congestion, as opposed to simulated congestion.

(Editorial note 27/04/22: Both of these objectives were successfully achieved in April 2022 within the first month of Phase 2 having commenced. More detail will be provided in the ITLR#3 report due Oct 2022).

Real congestion is foreseen during the period of St. Andrews' golf tournament and during planned outages. The first of these planned outages is planned to take place in April 2022 ad Project FUSION plans to deliver flexibility to alleviate real congestion during that planned outage event.

For the rest of the trial period, no real congestion is anticipated so we will continue to dispatch flexibility in response to simulates events. To simulate events closer to real conditions in phase 2 we will exclusively modify the maximum power threshold at substation or feeder level, instead of modifying the forecasts (as we did in phase 1). In this way, the original grid forecasted profile will be used and the full functionality of the FFP will be utilised; the FFP will interface with SPEN's network forecast system and update the forecasts every 6 hours.

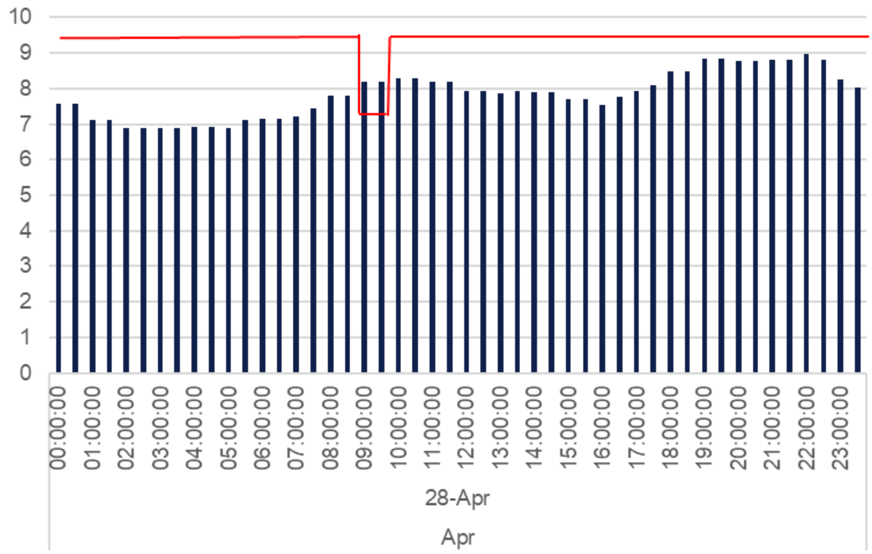

Figure 7-2 Example of phase 2 maximum power threshold modification to simulate a fault

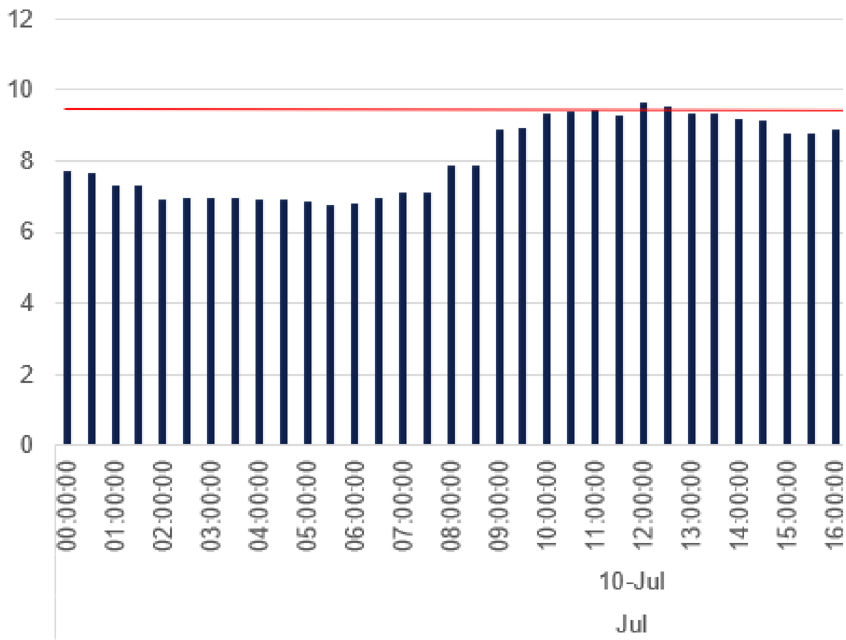

Figure 7-3 Example of phase 2 maximum power threshold modification to simulate congestion

In addition, phase 2 will aspire to trial another three USEF functionalities that were not tested in the first phase:

a. Project FUSION will aspire study the rebound effect. Aggregators will not be able to nominate their rebound effect. Therefore, Project FUSION will aim to analyse meter data and linking this data to the types of assets that deliver flexibility with the help from the aggregators to calculate the rebound effect at meter, feeder and substation level.

b. Partial activations: USEF offers the possibility for Aggregator to add partial activation in their FlexOffers. This means that Aggregators give the DSO the option to choose, for example, 50% or 100% activation of the offered flexibility. This functionality could be interesting from both, aggregator and DSO, perspectives. The aggregator would have more chances of being selected (i.e. their flexibility being ordered) because they will offer more options to the DSO with regards to the flexibility amount. The DSO would potentially be able to match the flexibility order to the flexibility need under current network conditions. For example, the DSO requests flexibility day-ahead when their forecast indicates that there will be a flexibility need of 500 kW. However during intraday, the flexibility need reduced to 200 kW. In this case, if the aggregator offers partial activations, the DSO could order an amount that is closer to 200 kW, instead of 500 kW. Project FUSION will aspire to use partial activations and experience how they work in practice during phase 2.

c. Intraday flexibility trading: USEF encourages DSOs and aggregators to iterate the 'plan' and 'validate' phase as needed up to 'operate' phase (i.e. real time). During the "plan" and "validate" phases, the DSO monitors the need for flexibility, requests flexibility from aggregators, aggregators offer flexibility, and the DSO accepts the offers or not. In phase 1, the "plan" and "validate" phases could iterate only up to day-ahead. However, during phase 1 it was observed that if the grid condition changes during intraday, the DSO was limited to use the flexibility offers that were outstanding from the previous day, and the DSO was not able to issue a flexibility request for a different time or a different power the same day of delivery. Moreover, it is expected that flexibility trading will move to closer to real time timeframes in the future. Therefore, phase 2 trial will explore the possibility to implement this intraday functionality in the FFP, will explore the contractual requirements for intraday flexibility requests with aggregators in the context of the FSA, and will aspire to test functionality for real congestion if possible.

Testing the abovementioned functionalities together with this approach for phase 2 will allow us to;

a. Introduce conditions of real network operation, during which the operator would need to observe network conditions closely to be able to perform flexibility trading and choose the required flexibility service
b. Monitor rebound effect following an activation at substation/feeder level
c. Assess and observe 'real time' changes in the system to request more flexibility if necessary, making use of the intraday flexibility trading functionality
d. Observe day-ahead to intraday changes in the forecast and changes in flexibility needs, as a sequence of forecast accuracy, any event in the grid, or the flexible assets in each congestion point
e. Analyse the use of partial activations and their impact on DSO costs

7.2. COLLABORATION WITH THE ENA

In phase 2, project FUSION will collaborate with Energy Networks Association (ENA) Open Networks project (ONP) Workstream 1A Product 5 (WS1A P5) to develop a report which will assess the impacts of the primary rules with regard to conflict management and co-optimisation of DSO and ESO flexibility services. The work will help DNOs and ESO to understand which primary rules deliver the most efficient outcome for the end consumer, considering a number of factors and impacts on affected parties.

Glossary

Term	Definition
Aggregator (AGR)	A service provider that contracts, monitors, aggregates, dispatches and remunerates flexible assets at the customer side. (USEF terminology)
Availability Payments	Payments made for being available to deliver the contracted Flexibility Service during a specified time period (described as the 'Service Window').
Common Reference (or congestion point repository)	USEF defines the Common Reference as a repository which contains information about connections and congestions points in the network.
Common Reference Operator (CRO)	In USEF, the CRO is responsible for operating the Common Reference. The CRO's role is to ensure the publication of both the DSO flexibility requirements and the associated flexibility assets in each congested point as well as the standardisation of this publication for all distribution areas.
Congestion Management	The avoidance of the thermal overload of system components by reducing peak loads. The conventional solution to thermal overload is grid reinforcement (e.g. cables, transformers). Congestion management may defer or even avoid the necessity of grid investments.
Constraint Management Service Provider (CMSP)	A provider of constraint management services to a DSO or the TSO. This is a USEF role and is not currently used in GB. This role takes on specific responsibilities in communicating and coordinating flexibility transactions with the ESO and DSOs, to ensure effective deployment of flexibility as well as effective management of network constraints. Responsibilities also involve ensuring efficient dispatch of flexibility to maintain the safety and reliability of the networks.
D-programmes	Aggregator forecast of the amount of energy to be consumed or produced at a given congestion point.to be shared with DSOs in congested distribution network areas.
Delivered Flexibility	The term delivered flexibility is used solely for flexibility that meets the FlexOrders. It is the amount of the ordered power that was delivered during the activation window measured by looking at the change in power from the baseline to the meter readings and capping it at the power output agreed in the FlexOrder

Distribution System Operator (DSO)	As defined in DIRECTIVE 2009/72/EC: A natural or legal entity responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.
Flexibility	Ability of an asset or a site to purposely deviate from a planned or normal generation or consumption pattern.
Market Coordination Mechanism (MCM)	The Market Coordination Mechanism in USEF includes all the steps of the flexibility trading process, from contractual arrangements to the settlement of flexibility. USEF splits the flexibility trading process in five phases and describes the interactions between market participants and information exchange requirements in each phase of the MCM.
Prosumer	This role refers to end-users who only consume energy, end-users who both consume and produce energy, as well as end-users that only generate (including on-site storage). (USEF terminology)
Realised Flexibility	The total change in power from the baseline to the meter readings during the activation window.
Settlement Period	The time unit for which imbalance of the balance responsible parties is calculated. In GB is 30 minutes.
USEF Flexibility Trading Protocol (UFTP)	A protocol that describes the interactions for the exchange of flexibility between aggregators (or other flexibility service providers) and DSOs.
Utilisation Payments	Payments made to flexibility service provider for energy delivered as part of a Flexibility Service