TRANSITION & PROJECT LEO

Market Trials Report (Period 1)

April 2022

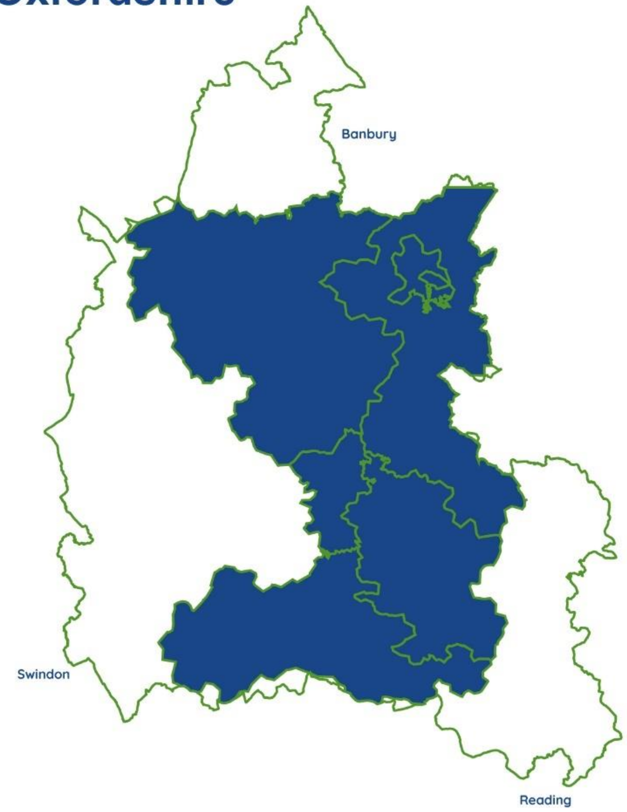
transition
Moving to a smart future

LEO Local Energy Oxfordshire

Our flexibility market trials are;

- Being run in areas across Oxfordshire
- A unique collaborative programme of trials bringing two key energy innovation projects together
- Trialling new innovative markets and commercial approaches, smart systems and platforms in a real world environment
- Running across 7 bulk supply points and 13 primary sub stations areas
- Open to businesses across the trial areas able to offer flexibility services
- Unique opportunities for peers to trade spare connection capacities between each other

Oxfordshire



Executive Summary

Net Zero and the energy transition are key terms used frequently in the media and general conversation, but what does this really mean on the ground, and how can such a huge ambition as to be Zero Carbon by 2050 be realised? Although there are many technologies being invested in, from using hydrogen for heating[1], to utilising Carbon Capture and Storage (CCS) and revolutionary generation technologies, the majority of this transition is going to happen through electrification and will be dependent on electricity networks.

Ofgem had the foresight to sponsor the TRANSITION project 4 years ago to work out how to adapt and make the most effective use of electricity infrastructure as we move from a steady state world of predictable demand profiles supplied from a central resource, to one of distributed energy resources combining generation and demand flexibility through varying and non-traditional resources. At the outset, the TRANSITION programme was tasked with exploring the market and technology elements of flexibility within the electricity system and was joined a year later by the Innovate UK sponsored LEO (Local Energy Oxfordshire) project which brought a more holistic representation of the overall energy system, including the participants and people who will be needed to truly test and develop the concepts necessary to achieve the project goals.

LEO Local Energy Oxfordshire

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As part of these projects there has been considerable learning from setting up and running flexible services. These services have been divided into DSO-Procured Services and DSO-Enabled services, in line with our consultation on what the users of a market would find most beneficial.

Setting up the trials has involved the development of two IT systems, one the Neutral Market Facilitation platform to be market facing and advertise the need for flexibility. The other the Whole System Coordinator which looks at bringing together the need for flexibility derived from Power System Analysis (PSA) tools, and identify which participants are able to supply the correct level of flex on demand.

The first set of Trials ran for 17 weeks, with 69 events, 18 assets, over 3 Bulk Supply Points (BSPs). The trials have predominately tested the ability of an asset to deliver a set amount of flexibility at a set time. There are 3 trial periods that last until January 2023 and this is the report of the findings of the first trial period from November 2021 to February 2022.

[1]Future Energy Scenarios in five minutes, published by National Grid ESO July 2021

Vehicle to Grid Charging

The main technologies being tested were battery and Vehicle to Grid (V2G) in the Sustain Peak Management market, at a week ahead time frame where 540kWh were dispatched across the period. The time of these events spanned from 15:00 to 19:00 with the end-to-end process being fully developed and represented. This includes massive developments in areas such as baselining and settlement, documentation of end-to-end processes through the Neutral Market Facilitator (NMF) and Whole System Coordinator (WSC) into the Power System Analysis (PSA) tools that analyse the network needs. The TRANSITION project brings flexibility procurement closer to real time than current arrangements. The week ahead procurement market is the one that has been explored in these trials, with market orchestration set out to allow day ahead, and within day in subsequent trials.

A route to market for all those who want to participate in flexibility markets is a key goal of the project. The LEO partners have potential assets for flexibility from across Oxfordshire from libraries, run of river hydro and V2G. All have different levels of understanding of the energy industry and the learning curve to produce a skilled body of people across Oxfordshire has been huge. Contracts for flexibility have been explored through the trials, with the ENA Flexibility Services Agreement (FSA) a starting point. There has been varying success with signing up participants within the consortium, with feedback focusing on the complexity of the agreements and that they are devised for larger players in the market and aggregators and suppliers rather than individuals and assets. Overall there has been more interest from the LEO consortium in the peer to peer services than in providing flexibility to the DSO. In Trial Period 2 we bring in small aggregators and will be testing complexity and reliability through third party route to market.

The prices paid for flexibility have been worked on a Willingness to Pay (WTP) and Willingness to Accept (WTA) basis with a ceiling price of £300/MWh split into an availability and utilization price. Part of the challenge for DSO services from the trials, is that the use of assets for DSO services alone has not proved to be attractive to participants. There are likely to be three potential options for flex market participants; in a locally constrained area, DSO services may only be possible, in a less constrained area stacked services where appropriate, and where there is no local constraint and full flexibility can be provided to ESO markets.

Clear routes to market are key for large scale uptake, and at the moment the market is most accessible for larger generators and batteries for whom energy is the first concern. These are followed by those who manage many small assets via aggregation such as Nuvve. Domestic households and small businesses who are interested in taking part in the trials have limited access unless they are part of a larger portfolio of aggregation. The supplier on the project has fed back that there is no opportunity for them to take part in the trials. Testing different routes to market has been carried out using two platforms Piclo and NMF directly. This gave participants an option as to which platform or route would be preferred, at this stage in the project there was no real preference, but this should be more prevalent in later trial periods. The NMF gives one point of contact between the DSO for constraint management, and potentially multiple platforms from specialist aggregators for EVs or Heat, locational aggregators such as local communities, or platforms carrying out an intermediary role such as Piclo. The NMF represents one place where all these different solutions can be optimised.

There have been many challenges around the enablement of Demand Side Response (DSR) through the project, one of which has been baselining. The baselining product used in 69 events has proved successful and enabled the settlement rules to be tested based on the amount of flex that has been delivered. The V2G sites have been useful in learning about the behaviours and other factors affecting when an asset is available to be used, for example the timing of charging the vehicle can be affected by the link to its tariffs.

In order for Flex to be useful for a DSO there needs to be a measure of the amount of market liquidity there is behind a particular part of the network. Liquidity indexes have been developed to enable a view of how much flex is available. This is key to giving confidence to embed flex markets as an alternative to reinforcement at closer to real time considering the amount of time it takes to build a new piece of network which is the only alternative open to a DNO. Things to be discovered and linked to the liquidity index would be the percentage of procurement at different timescales such as Season, Week, Day Ahead depending on the DSO's risk appetite.

Other indices include a reliability index where assets in a particular area would be assigned a value based on their historic ability to deliver, this would help the DSO to procure the right amount of flex to satisfy a constraint without having to over procure. The competition index is of less value until there are more assets participating in the trials but would eventually give an idea of the likelihood on an asset being successful in flex markets at a particular point.

All market data from these trials is being collated by the University of Oxford in line with the open data ideals of the project. The market reports have been developed from outputs from the NMF using Python and Power BI to produce basic reports to communicate the market interactions.

The technological learning from the project in terms of forecasting has been vast. The first part of the trials have concentrated on the Market fundamentals of running a flexibility market. Looking at asset recruitment, building relationships in Oxfordshire, and then how these assets and people behave within a market environment. In order to test these market relationships, the concept of forecast and scheduled events has been developed. Scheduled to test the behaviour of a market and forecast to test the integration of technical Power System Analysis into the project. Further work includes development of forecasts from weather data enabling greater accuracy as constraints move nearer to real time.

The project crosses over between constraints from background demand growth from already connected assets, and the ability to connect new assets. The ability to connect new assets is an output from the project, once some of the learning has been adopted as to how to manage the network at the local level using flexibility with confidence. Until this has been proven, the network will be designed to the outside limit case for any connection. These trials build confidence in the level of delivery at the very local level.

The consortium of partners on the LEO project has enabled learning across the end to end energy system. Having reached out to industry bodies such as The Association for Decentralised Energy (ADE) we have engaged with over 40 organisations to participate in the trials, of which 12 have gone through the company qualification process and 5 have signed the FSA, and 5 have multiple assets ready to participate in Trial Period 2.

This first report gives a flavour of the challenges overcome in setting up a local market for flexibility and produces key learnings and recommendations for each area.

Key Impacts for DSO Implementation

Planning and Network Development

- For most of the participants in the LEO consortium energy is not their main business focus, and communicating and understanding the requirement for Flex has been hard for non-industry people, so there is a role for intermediaries to simplify the proposition
- Although the longevity of the market for flexibility based on deferred reinforcement could be limited due to the forecast rate of increase in demand, there is added value in optionality for scheduling work with the rate of uptake of LCTs likely to be across a similar time frame and building access to ESO markets.
- Forecasting constraints in closer to real time (week ahead) has brought forward modelling techniques to reflect weather impacts and up to date network topology.
- For the small sample size of V2G in the project, it offers an erratic source of flexibility, influenced by behaviours and tariff structure. However, if scaled up could provide a useful source of flexibility in close to real time for the network.
- The data from the network is more robust at higher voltages, than at the lower voltages, with connectivity, and monitoring required to inform the need for efficient provision of flexibility.

Market Development

- Through detailed engagement on the trials, it has been found that smaller organisations, such as specialist aggregators, are keener to participate in flexibility markets than larger suppliers.
- Working with the LEO partners, a baselining tool has been successfully trialled, tested and delivered, with payments made into participants accounts based on the assumptions in the model.
- When working to establish a new market at distribution level for flexibility, the market for the LEO partners has had limited participation with prices at £300/MWh, so prices are to be increased for the next trial period.
- The provision of a central neutral market platform, managed by the DSO, with satellite platforms providing an interface has been successful, proving that multiple platforms could be used as customer interfaces but only one setting the auctions.

Operation of Flexibility Services

- Through work with the LEO partners it has been found that enabling demand side response in assets such as buildings, and making inflexible sources, such as solar, flexible is relatively expensive, technically demanding and resource heavy for short duration contracts.
- Although there are some larger institutions in the LEO consortium, the legal documentation for DSO services is complex, pointing to the benefits of an intermediary to manage these relationships.

- Within the LEO consortium, during the first trial period, Market Participants were equally interested in exploring Peer to Peer traded products as participating in alleviating network constraints.

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1 Introduction

When TRANSITION was conceived in 2017, the legally binding commitment to Net Zero by 2050 was yet to be announced and two concepts fundamental to the aims of TRANSITION were to be explored:

- the energy trilemma (the interplay between energy security, energy equity and environmental sustainability of energy systems) the pace of which has increased since the establishment of Net Zero 2050.
- the move from Distribution Network Operator (DNO) to a Distribution System Operator (DSO) which manages the electricity system more holistically and proactively and strives to find the right balance between flexibility for deferment of reinforcement locally, and balancing energy nationally.

Since 2017, significant progress has been made. The UK has produced a legally binding requirement to achieve Net Zero and published a strategy to deliver it[2]. The UK was joint 4th in the 2021 rankings for the energy trilemma[3]; and the transition from DNO to DSO has progressed significantly over the last five years under the stewardship of the Energy Networks Association Open Networks Project (ON-P)[4].

Based on the outputs of the ON-P, TRANSITION's aim is to inform the design requirements of a market interface (Neutral Market Facilitator, NMF), a network interface (Whole System Coordinator, WSC), develop the roles and responsibilities within the marketplace, develop the market rules required for trials, and implement and test these by means of a programme of trials in Oxfordshire.

Project LEO (Local Energy Oxfordshire) is an important step in understanding how new markets can work and improving customer engagement. It is part funded by Innovate UK under the Prospering from the Energy Revolution Programme and will demonstrate a county-wide Smart Local Energy System (SLES) to maximise economic, environmental and social prosperity for the region. This has involved establishing a market platform that enables local flexibility providers to understand how new services can maximise the utilisation of the electricity distribution network at minimal cost and provide best value for all connected to the network. Alongside this, understanding the functions that are natural monopolies and those that can operate in a free market.

The TRANSITION project was born of an industry-focussed approach to explore the technological and market solutions for the issues that need to be solved around the energy transition. The LEO project takes that technical and market knowledge and adds the people and academic insight to the same issues, allowing for a much greater and holistic learning about the whole system in a real commercial and behavioural environment. The projects are conducting joint trials to maximise the outputs from

[2] UK Government Net Zero Strategy, published by HM Government October 2021
[3] World Energy Trilemma Index 2021, published by World Energy Council 2021; ranked UK as 4th best overall performer (level with Finland) (19th for energy security, 9th for energy equity and 10th for environmental sustainability).
[4] Five Years ON, published by Energy Networks Association 03 March 2022

testing and developing local flexibility markets in Oxfordshire during three Trial Periods[5]. The area for this trial period includes; six individual areas with 94 devices monitoring the low voltage network for Distributed Energy Resources (DERs), and these are mapped in Figure 1.

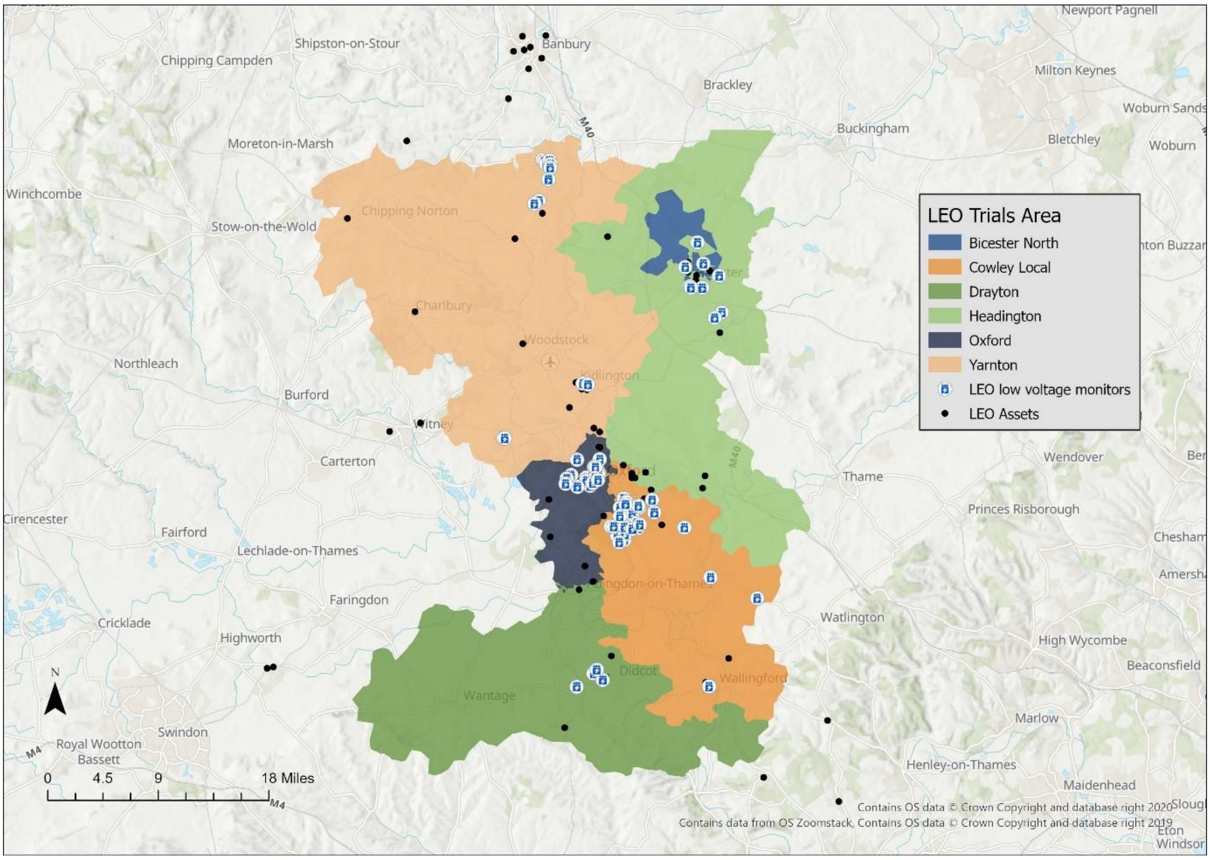


Figure 1 : LEO trial area, installed monitoring and DERs

The joint approach to trials has identified three services to be delivered that either support the network (DSO-Procured) or improve the efficient use of existing capacity (DSO-Enabled). These are given below along with a description and the reason for inclusion.

Table 1 - Summary of DSO-Procured and DSO-Enabled Services

Service	Description of Service	Reason for Inclusion
DSO-Procured Service		
Sustain Peak Management (SPM)	A market participant delivers flexibility to the DSO to reduce the load on a critical asset (such as a transformer) that is forecast to become overloaded due to excess demand.	Test processes and systems for the procurement of a DSO service. Procurement is at season ahead, week ahead and day ahead with at least 12 hours' notice of delivery.
DSO-Enabled Services		
Exceeding Maximum	Two market participants in a network area with limited (or no) spare export capacity	Test processes and systems for the procurement of a new service between

[5] Trials Plan version 3, published by LEO and TRANSITION February 2021; TP1 (Nov-21 to Feb-22), TP2 (May-22 to Sep-22), and TP3 (Nov-22 to Feb-23)

Service	Description of Service	Reason for Inclusion
Export Capacity (EMEC)	trade a portion of their export capacity for an agreed period without affecting the network. The Buyer can increase their export level, but the Seller must reduce their export level.	market participants. Trading is week ahead with the service available as specified in the trade.
Exceeding Maximum Import Capacity (EMIC)	Two market participants in a network area with limited (or no) spare import capacity trade a portion of their import capacity for an agreed period without affecting the network. The Buyer can increase their import level but the Seller must reduce their import level.	Test processes and systems for the procurement of a new service between market participants. Trading is week ahead with the service available as specified in the trade.

With the services defined and understood, a joint trial plan was developed and is summarised in Table 2.

Table 2 - Summary of Joint Trial Plan

Parameters		Trial Period 1
Time Frame		01-Nov-21 to 28-Feb-22
Duration (Weeks)		17
Service Group	**DSO-Procured**	**DSO-Enabled**
Service Type	SPM	Trading export or import capacity
On / Off Market Platform	NMF and Piclo Platform	Offline (4 auctions) & NMF (3 auctions - EMEC only)
Contracted DERs	Community Based Battery (16kW) V2G Chargers across three sites (13 units @ 6kW)[6]	Hydro station (440 kW) Primary School (Community Based Battery (16kW) and rooftop solar PV (28kW)) Community building with rooftop solar PV[7]
Scheduled/ Forecast	Scheduled	Scheduled
Service Window	1500 – 1900	0000 – 2400
Service Days	Mon – Fri	Mon - Sun
Auction Type	Week Ahead	Week Ahead
Substation	Bicester North, Cowley and Oxford	Cowley
Total Auctions	41 (23 on NMF and 18 on Piclo)	7 (4 offline and 3 on NMF)
Total Events	69	4 (no physical delivery)

The joint trial plan also detailed the planned auctions and delivery events for one DSO-Procured service and one DSO-Enabled service using a variety of contracts and how buyers and sellers would interact

[6] The V2G Chargers are across 3 locations; residential (6kW; unused to a variety of technical issues); commercial (36kW); and educational (36kW).
[7] Capacity unavailable due to commercial confidentiality.

with the market (Neutral Market Facilitator (NMF), Piclo, or offline) with increased complexity as the trials progressed. The NMF is set up as the natural monopoly system allowing it to deal with conflict management, constraint forecasting and constraint mitigation direction. This is summarised in Table 3.

Table 3 - Overview of DSO-Procured and DSO-Enabled Services tested during trials

Item	DSO-Procured (peak management)	DSO-Enabled (trading export and import capacity)
Platform	3-weekly sprints alternating between two platforms (tested the functionality of each platform and provided market participants experience of them each); • NMF (marketplace between DSO and market participants)[8]. • Piclo (an independent marketplace for trading flexibility used to run auctions in conjunction with NMF)[9]. The NMF transferred all auction information to and results from Piclo and conducted interaction with the WSC.	Auctions were run on one of the following; • To 31-Jan - manual auctions running replicate NMF functionality • 1-Feb onwards - NMF to test functionality of trading export capacity. There was no physical usage of the service as parties were familiarising themselves with processes and usage.
No. of Auctions	41	7
Contracts	Flexibility Services Agreement; NMF Terms and Conditions (T&Cs)	Peer-to-Peer (P2P) Termsheet; NMF T&Cs; Temporary Capacity Variation Notice (TCVN)
Data Collected	• auction details (location, volumes requested and offered, prices and DER types) • changes to DER availability • delivery instructions • metered data for verifying delivery	• auction details (location, capacity requested and offered and prices) • network issues that affected usage • metered data for comparing actual import / export delivery against revised allowances through BaU processes
Market data analysis	Market data analysis focused on the market liquidity by area, price variation and delivery success across participating DER types and routes to market	Market data analysis focused on the agreed trade terms (export or import capacity, price and duration).

Data has been collected from the market platforms and the following sources:

- monitors on the low voltage network installed within the trial area;
- metering at site level where DERs are installed;
- metering directly connected to the DER; and
- participants during TP1 trials and during formal feedback sessions.

[8] What is the Neutral Market Facilitator (NMF) Platform, published by TRANSITION
[9] The UK's leading independent marketplace for flexible energy systems, published by Piclo

Due to the unique range of experience offered by the diverse LEO consortium, the key findings from the first trial period were organised into themes for DSO-Procured and DSO-Enabled services. The recommendations from this report will inform the development of the Local Flexibility Market and the detailed approach for future trial periods to maximise project outcomes. This will allow TRANSITION to continue to provide ongoing feedback to and inform the Open Networks project (ON-P).

In parallel with the first trial in Oxfordshire, SSEN and ENWL have been developing the plan for a set of simulated trials covering parts of the Greater Manchester network. These simulations will allow the project to explore aspects of flexibility that would not be possible within a real trial, such as emergency operating conditions, or the impact of the mass adoption of low carbon technologies. Simulations will start in summer 2022. Some initial activities have already been completed, including testing the interoperability of various IT systems and power systems modelling software platforms.

This report focuses on the first trial period and fulfils TRANSITION Ofgem Project Direction, Reference 6 (Trials Stage 1; Completion of one stage of Trials).

2 Routes to Market

To ensure a just transition and enable participation in flexibility markets and the energy transition more widely, clearly defined and well understood routes to market need to be developed. As the first trial period was focussed on those assets that could be brought to the market by the LEO partners, there was direct engagement with asset owners and a specialist aggregator, with routes to market for a supplier planned for Trial Period 2. These two approaches will develop learning from both routes to market, helping to inform the market structure and consumer engagement roles of the DSO, Supplier, and Aggregator roles going forwards.

2.1 Alignment of Services and Products

The focus was to 'Learn by Doing' for DSO-Procured and DSO-Enabled services through the entire end-to-end process from advertising the need (auction) through baselining and measurement of delivery (verification), and then settlement.

As part of our market conceptualisation over the course of the next 2 trial periods we aim to trial the interaction between different timelines for different services. During Trial Period 1, the three services (peak management and trading export or import capacity) were trialled across a week ahead timeline as detailed in Table 4. There were 35 Week Ahead auctions for Peak Management for delivery the following week.

Table 4 - Services and Products during first trial period

Service	Product (timeline)		
	Season Ahead	Week Ahead	Day Ahead
Peak Management	×	✓	×
Trading Export Capacity	×	✓	×
Trading Import Capacity	×	✓	×

2.1.1 Summary of the SPM Week Ahead Auctions

Sustain Peak Management auctions focussed on three network areas where potential market participants indicated they had available DERs. The capacity requested through auctions for SPM was restricted to that of available DERs to determine the effect on behaviour. Two types of DER expressed an interest in participating in auctions: a community battery and multiple Vehicle to Grid (V2G) chargers managed by an aggregator. Auction delivery periods were from 0.5 hours to 2 hours, with the full period 15:00 – 19:00. Details of auctions and the outcomes are summarised in Table which indicates that 50.6% of the Total Capacity Requested was Offered (748.28kW requested versus 378.8kW offered).

Table 5 - Summary for all Week-ahead auctions for SPM in TP1.

Substation name	Completed auctions	Aggregate Capacity Requested (kW)	Aggregate Capacity Offered (kW)		Number of contracts		Aggregate Capacity Delivered (kWh)	
			Battery	V2G	Battery	V2G	Battery	V2G
BSP C	10	196.32	-	73.4	-	6	-	48.54
BSP A	14	500.24	208	71.6	13	8	493.25	
BSP B	11	51.72	-	25.8	-	8	-	
Total	35	748.28	208	170.8	13	22	493.25	48.54
NMF	19	385.88	128	76.6	8	11	493.25	47.86
Piclo	16	362.40	80	94.2	5	11	181.34	0.68

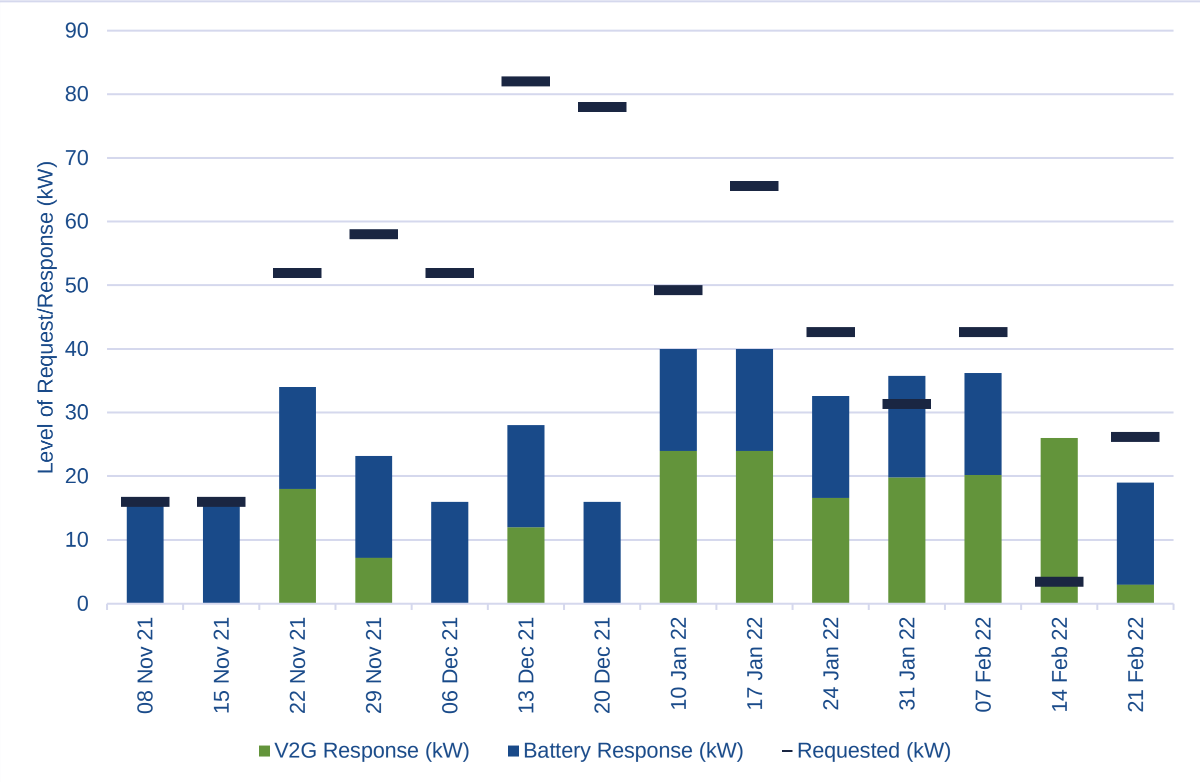


Figure 2 : Response by DER type against requested capacity

DER Availability

In relation to the availability of DERs, both DER types demonstrated similar performance;

- There were no periods of unavailability for the Community Battery
- A V2G charger can only provide flexibility when an EV is connected, and this is affected by driver behaviour. As these were new V2G chargers, drivers did not always charge their EVs as expected. This resulted in a total of 220 hours of declared unavailability out of 436 contracted availability hours across all SPM auctions.

Price Variation

Market participants for SPM varied the Availability Price and Utilisation Price, based on an assumed number of deliveries during the week. The DSO determined those Offers to accept within a maximum Total Contract Value (TCV) of £300/MWh using the actual number of deliveries. This meant some market participants exceeded this TCV; these Offers were accepted to gain the experience of the market. This is illustrated in Figures 3 and 4.

Figure 3 : No. of offers made in auctions and the outcome

As can be seen from Figure 3, market participants have explored a variety of price combinations from Utilisation Price only to exceeding ceiling price and price stabilisation (17-Jan 2022 onwards).

Figure 4 : Utilisation Price vs Availability Price

2.1.2 Summary of the Export Capacity and Import Capacity Week Ahead Auctions

To maximise learnings, the trial plan was developed to vary selected factors (initiator of the trade, whether the trade was initiated by the buyer or seller of capacity and whether the trade was for Export Capacity or Import Capacity) to ensure the end-to-end process was appropriate and to allow market participants to gain experience of varying their price strategies.

Details of sites that participated in the testing of auction stages and their interest in Export Capacity or Import Capacity are provided below.

Table 6 - Details of sites participating in DSO-Enabled services

Site	DERs	Trading Export Capacity	Trading Import Capacity
Community Centre	Rooftop Solar PV	✓	×
Primary School	Rooftop Solar PV and Battery	✓	✓
Sandford on Thames	Run of river hydro	×	✓

Auctions for Capacity Exchange were held a week prior to delivery and were held in two ways;

- To 31-January 2022 - operated using a manual processes and exchange of emails to deliver the sequence and content of exchanges that need to occur for this service. This helped market participants to explore a variety of price strategies and refine their resourcing and approvals.
- From 1-February 2022 – from the success of the manual process testing in the first half of the trial period we were able to move to automated Export Capacity Exchange functionality through the NMF platform for simulated events.

The key learnings and recommendations for future trial periods are summarised in the table below.

Table 7 - Learnings and Recommendations for Alignment of Services and Products

Key Learnings	Recommendations
Market participants chose to focus on week ahead rather than season ahead due to increased learning opportunities.	Aim to reformat auctions so DERs can be used in more auction products in future trial periods, increasing liquidity and learnings.
There were 2 types of market participants which resulted in low liquidity and the need for a wider variety of DER types, especially aggregators.	Increase the number of market participants and range of DER types to participate in future trial periods to provide greater market liquidity across a wider range of services and additional data for analysis. For example through customer value propositions for market stimulation as part of RIIO ED2
The two market platforms worked well together representing a central market and a satellite market, but it needs further testing.	Test the market platforms with an increased number and type of DSO-Procured and DSO-Enabled services and a wider range of market participants and DERs.
Improvements are required to three areas of the market platforms; (i) training and documentation, (ii) user experience, and (iii) functionality errors in the market platforms.	Improve; (i) the training and documentation, (ii) the user experience, and (iii) functionality errors in the market platforms to improve the overall experience for market participants.
To maximise market and learning opportunities, DERs need to be able to participate in different auction products.	Consider the ability of DERs to allocate their capacity across auctions for different timescales or services to increase learning opportunities.
The unpredictable behaviour of the EV users and when they will be connected to the V2G chargers has been challenging, resulting in high unavailability.	Increase the number of V2G events and consider the impact of scaling up the results of behaviours and market signals.

2.2 User Experience of Market Platforms

Two platforms provided a route to market for Local Flexibility Services. The NMF platform operated as a centralised market for the procurement and delivery of peak management and trading of export and import capacity services. The Piclo Flex platform operated as a satellite market and interacted with the NMF via APIs, developed during the project, for the procurement and delivery of peak management only. The trading of import capacity was delivered through manual processes only during this trial period.

Feedback from the market participants on the market platforms is summarised below.

Table 8 - Learnings and Recommendations for User Experience of Market Platforms

Key Learnings	Recommendations
The role of each platform is understood but there is a lack of distinction between them and how they would apply in BaU.	Clarify the role of each platform which would be a natural monopoly and which would be more suited to a free market approach.
The development of the NMF platform has been an agile iterative process through the trials, which has led to varying degrees of ease of use.	Consider how to; (i) improve the user experience for future developments and making the NMF platform easier to use and (ii) provide visibility of NMF platform updates through the established project sub-groups and / or in-platform pop-up bubbles or notifications.

Improve the training on the NMF platform.	Consider the provision of topic-based training for the NMF platform that address specific audience needs through either a comprehensive manual and / or a series of short instructional videos by expert users rather than platform developers.
The NMF platform does not encompass the entire end-to-end process, could be more automated to reduce scope for user errors.	Future NMF development should consider; greater automation across the end-to-end process, P2P settlement and verification process for all parties and include inbuilt methods to help users navigate and use the platform.
The Piclo Flex platform needs further development to match some of the NMF capability, including EMEC and EMIC services, if it is to act as a satellite market.	Future Piclo Flex development should consider; greater automation across the end-to-end process, including functionality for P2P auctions and additional APIs for dispatch notifications with the NMF and market participants.
Testing a single market platform during the trials would reduce the burden on trial participants but need to test different routes to market.	Consider if more platforms can be trialled during TP2 or TP3 to inform future market preferences design and potential integration of Local Flexibility Markets.

2.3 Contractual Documents

There are four legal documents that govern contractual arrangements for the Joint Trials:

- The Flexibility Service Agreement (FSA) – an enabling agreement that defines the general terms and conditions on which a provider agrees to provide DSO-Procured services to a DSO[10].
- Peer to Peer (P2P) Termsheet – an enabling agreement that defines the general terms and conditions on which two parties trade DSO-Enabled services[10].
- Neutral Market Facilitator (NMF) Platform Terms and Conditions – an agreement that details the terms and conditions on which parties agree to use the market platform (NMF) and to trade DSO-Procured and DSO-Enabled services consistent with the FSA or the P2P Termsheet.
- Temporary Capacity Variation Notice (TCVN) – SSEN approval to a buyer of EMEC or EMIC so they can enter into a trade to temporarily increase the import or export capacity of a site.

Feedback on the above has been collected using a variety of means (i.e., tailored workshops, document reviews, ongoing stakeholder engagement, questionnaires and face-to-face interviews with trial participants) and consolidated to determine the key contractual barriers to market participation. The Key Learnings and Recommendations will be used to develop the contractual arrangements prior to TP2.

2.3.1 Feedback on contractual documents

The key contractual barriers identified from the consolidated feedback are mapped against each of the four legal documents in Table 9 and Table 10. The orange cells below indicate where a barrier has been identified.

[10] Specific contractual arrangements are completed through the flexibility market.

Table 9 - Key contractual impacts

Contractual barrier	FSA	P2P Term-sheet	TCVN	NMF Platform T&Cs
Length of document / process				
Complexity				
Issues with specific terms of contract				
Lack of visibility				
Unclear how contracts relate to one another				

Contractual barriers experienced were dependent on the organisation type and the level of market knowledge within the organisation:

- Lack of market knowledge increased the review period (alternatively a high level of market knowledge reduced the review period);
- Organisations without legal resources either took a risk-adjusted view and reviewed contracts internally (without seeking a formal legal review) or outsourced the legal review (at substantial cost).

Table 10 - Summary of positive feedback, shown by the green cells, received for documents

Positive Feedback	FSA	P2P Term-sheet	TCVN	NMF Platform T&Cs
Easily understood through simple language		YES		
Concise document		YES		
Comprehensive coverage of terms	YES			YES
Key information communicated to participants	YES	YES	YES	YES
Applies to DSO-Procured and DSO-Enabled services				YES

Specific comments on the agreements that are worth noting included:

- A number of points in the **FSA** could become a barrier to entry, particularly for smaller organisations, including:
  - It is very long (55 pages) and complex (based on industry-standard contract);
  - the requirement for unlimited liability;
  - the audit burden for organisations with DERs that have low levels of flexibility;
  - the need to sign the FSA to participate in Market Stimuli Packages (MSPs) which are specific payment structures to stimulate the market.

- The **P2P Termsheet** was commended for being short and simple to understand, although it required further detail on the dispute mechanism.

- The **NMF T&Cs** was considered to be fit for purpose with the right balance of length and complexity.

- The **TCVN** application form was relatively short and simple to complete although there was duplication of process across documents and the application process is not easy for third parties who are not signatories to the connection agreement, which may provide a barrier to entry. The duration of the TCVN review process (~65 Business Days) was criticised (Trial Period 1 was 17 weeks), although the TCVN process is aligned to regulated BaU processes.

2.3.2 Learning and Recommendations for contractual documents

The above feedback provides learning on the existing suite of contractual documents and indicates improvements that would make DSO-Procured and DSO-Enabled services more attractive to a wider range of market participants (including those with relatively low levels of market knowledge or those with DERs that have low levels of flexibility). The suite of contractual documents will be reviewed between the trial periods, and recommendations are summarised below.

Table 11 - Learnings and Recommendations for Contractual Documents

Key Learnings	Recommendations
Most contractual processes were seen as slow and complex, and the length of the contract and the level of complexity had implications on the level of resources required and the cost of review.	Simplify language used throughout the suite of contractual documents and simplify and shorten contracts (particularly FSA) whilst ensuring contracts are not compromised on legal accuracy.
The requirement to sign the FSA to participate in the (Market Stimuli Packages) MSPs increases the overall complexity of this route to market which was designed to be simple.	Consider simplifying the MSPs and whether they can be contracted without the need to sign the FSA.
Drafting of the FSA was biased in favour of the DSO making the contract less attractive to potential market participants.	Consider providing an independent review of the FSA to reduce the legal burden on individual organisations and reduce the bias towards the DSO.
It is unclear how the P2P Termsheet fits with other contracts.	Develop resources to define the purpose of each contractual document and how they relate to one another.
It is unclear how well the contractual processes would suit aggregators.	Obtain feedback from new market participants (particularly aggregators) on the suitability of the contracts for an aggregator / intermediary, including in relation to risk and reward.
Participants favoured the ability to sign the contracts on the NMF.	Enable the viewing and acceptance of contracts through the NMF platform.
The duration of the TCVN application process may present a barrier to market participation.	Consider whether TCVN process could be shortened and if it has to follow the BaU timescales.

All comments and recommendations from TP1 have been documented in a register to ensure they are considered during the review prior to TP2. Work is currently underway to address a number of the recommendations above to reduce the contractual barriers faced by future participants.

2.4 Routes to Market for Non-Traditional DERs

An additional 20GW of combined short-term storage and DSR will be needed to reduce the capacity of low carbon generation needed to meet emission targets[11] this excludes the level of flexibility to reduce locational network constraints (although there would be some overlap). This will require the involvement of new market participants (Small and Medium Enterprises, public organisations, communities and domestic premises), all of whom want to avoid the burden of understanding the market and involve new DERs (e.g. smart charging of electric vehicles and heat pumps combined with heat storage, all connected at low voltage and available for short periods throughout the day).

The trials involved;

- New market participants that were unfamiliar with flexibility markets and sought new opportunities (local authorities, charities and an EV aggregator) with no understanding or experience of DSO-Procured and DSO-Enabled services.
- New DER types that had not previously been used for the delivery of services (library air conditioning, community battery and electric vehicles)

Analysis of the market data for the services is presented in Section 4.1 Start Up Market Indices. - Formal feedback was received from the market participants to examine any barriers and / or their DERs and also to discuss issues of fairness and equity. This is important to a number of those organisations[12] especially as the financial benefits will be relatively low and the non-financial benefits can be more important. This work builds on the 'Smart and Fair' concepts established with the Centre for Sustainable Energy.

Table 12 - Learnings and Recommendations for Routes to Market for Non-Traditional DERs

Key Learnings	Recommendations
Need to define what non-traditional market participants and DERs are, as they will require a different approach.	Define non-traditional market participants and non-traditional DERs and look for mechanisms to incentivise energy efficiency.
Non-traditional market participants will often not have the time or resources to understand flexibility services and flexibility markets.	Consider how to assist them with knowledge sharing and consideration of routes to market, services and likely DERs in a summarised and easily digestible format.
Establishing the amount of flexibility available from smaller non-traditional DERs can be challenging.	Identify where specific support is required and how this may be provided internally or explore the use of trusted intermediaries / aggregators.

[11] Smart Systems and Flexibility Plan 2021: Appendix I - Electricity System Flexibility Modelling, published by DBEIS July 2021

[12] Whitepaper: Vision on the inclusion of small (under 7kW) flexibility from the grid edge and its role in Future Energy System, published by LEO 24-Nov-21

Key Learnings	Recommendations
Providing flexibility from non-traditional DER could have an adverse impact on customers or staff (particularly for DSR).	Emphasise the benefits of providing even a small amount of flexibility from their DER.
Contractual arrangements are too complex and costly to review for the level of flexibility involved.	Consider alternative routes to market and/or simpler forms of contracts.
Some non-traditional participants are motivated by the wider social value such as carbon savings.	Demonstrate additional value beyond revenue and include these in market reports.
Non-traditional market actors may require different routes to market (inc. platforms).	Thoroughly test the different routes to market (inc. platforms) for different market actors and DERs.

3 Social and Behavioural Impacts

3.1 Identifying the Social and Behavioural Aspects to Participation

Feedback on the key social and behaviour issues experienced by participating and potential Market participants has been collected throughout TP1 via the various sources shown in Table 13 to identify any significant trends. Orange cells below indicate the source identified the barrier; a grey cell indicates it did not.

Table 13 - Key social and behavioural barriers

Social and Behavioural Issue	Recruitment Engagement	V2G Barriers Report[13]	Feedback from Partners	Ecosystem Workshop
Lack of knowledge about flexibility and the wider industry	[orange]	[orange]	[orange]	[orange]
Lack of skilled resources	[orange]	[orange]	[orange]	[orange]
Lack of perceived benefit	[orange]	[orange]	[orange]	[orange]
Behaviour of customers affects the viability of Trial participation	[grey]	[orange]	[orange]	[grey]
Mixed attitude to risks and innovation	[grey]	[orange]	[orange]	[orange]

This feedback has provided the following learnings and recommendations which should be considered to address the key social and behavioural barriers throughout future trial periods and beyond.

Table 14 - Learnings and Recommendations for Identifying the Social and Behavioural Issues for Participation

Key Learnings	Recommendations
A lack of knowledge about flexibility and the wider electricity industry was identified as a barrier.	Review and revise training materials ahead of next trial period and provide targeted sessions to increase knowledge.
The lack of skilled resource within organisations is a major and ongoing barrier to participation, particularly DER enablement and legal reviews.	Provide case studies on the enablement of DERs and aim to reduce contractual barriers to participation (see Section 0).
Financial benefits of participation in trials is low (see section 7.1) and they are largely driven by non-financial benefits (environmental, learning).	Review price for DSO-Procured services and develop a simple business case to identify and quantify the benefits of participation.

[13] Vehicle to Grid (V2G) Barriers and Opportunities: a capability approach, published by LEO December 2021

Key Learnings	Recommendations
Some organisations highlighted that there was limited support / motivation within their wider organisation to participate in trials.	Help market participants understand how trials can support their organisational values and objectives to increase support / motivation.

3.2 Simplification of Concepts and Language

Projects LEO and TRANSITION have taken an innovative and simple approach to how the complexities of the projects and market trials are explained to their wide target audience. 'Plain English' has been used to simplify the key terms and concepts of the Trials throughout all communication channels, e.g. the LEO Website[14], social media and news releases. Animations[15], diagrams[16] and infographics have also been used to make content more accessible. This approach has received positive verbal and written feedback from both within the projects and from wider stakeholders:

"Whilst there is a good level of general understanding about energy efficiency and the impact this has on carbon and climate in organisations with the people we have engaged with, this isn't true for energy flexibility. Project LEO's Plain English approaches and "explainer" animations have been really helpful tools for engagement" - ***Ruth Harris – Oxford City Council***

A largely iterative approach to this work has been taken, with products and language being constantly refined in response to feedback. This is captured in Table 15.

Table 15 - Learnings and Recommendations for Simplification of Concepts and Language

Key Learnings	Recommendations
An innovative and simpler approach to communication and engagement is key when working with an audience not well versed in the subject.	Animations have been particularly well received and should be continued to be used through other trial periods.
The time required to educate people who do not know what flexibility is, why it is necessary, and its benefits are should not be underestimated.	Prepare an engagement plan for potential market participants and engage with them far in advance of the next trials.
Communicating complex concepts in a way that is accessible to all audiences is vital to this project's success.	Keep the website updated with clear, easy to understand explanations and diagrams for complex concepts.
Using language targeted to the audience you are communicating or engaging with and present information in a way that is meaningful to them it critical to getting the message across.	Continue to use language targeted to the audience and consider how best to get the message across. Revise the LEO Glossary further for an external non-industry audience.

[14] LEO website
[15] Animation for Sustain Peak Management, LEO website
[16] Diagram for Market Stimuli Packages, TRANSITION website

Key Learnings	Recommendations
The language used in the Flexibility Services Agreement has been identified by the project as a barrier to participation (see Section 0).	The language used in the Flexibility Services Agreement should be simplified where possible to overcome this barrier to entry.
Project LEO reports, even those that are of a more technical nature, often have elements that may be of interest to a non-technical audience.	Summarise points from Project LEO reports in Plain English and share these through various communication channels.

4 Market and Technical Risk for Flexibility Provision

Both Market and Technical Risk for the delivery of flexibility need to be well understood and explored. As part of our first start up trial period both areas have been addressed as follows.

4.1 Market Start Up; Reliability, Liquidity, and Availability Indices

As markets at distribution level are being trialled, an easy measure of the maturity of those markets has been developed through three market indices summarised in Table 16.

Table 16 - Indices that measure the maturity of a Local Flexibility Market

Index	Definition	Scoring
Competition	Reflects the concentration of a market using the relative market share of individual organisations (maximum of 10,000) HHI Score[17]	• score for an individual organisation is the square of their relative market share[18] • low score indicates a more competitive market • high score indicates a less competitive (monopolistic) market
Liquidity	Reflects the granularity of demand to the supply	• below 1 - supply is less than demand • Equal to 1 - supply equals demand • above 1 - supply is greater than demand
Reliability	Reflects the risk to the market if one DER is not available or fails to deliver split by asset type.	• 100% - all supply purchased is delivered • below 100% - not all supply purchased is delivered and may need to purchase more than demand to ensure a secure market

The trials varied several factors to collect more meaningful data for the above indices, e.g. the demand for SPM auctions was varied from 60% to 150% of the aggregate capacity of all registered DERs in a BSP at the time of the auction.

4.1.1 Competition Index

The Competition Index helps understand the ideal market route for participants to ensure a cost-effective price for both providers and the DSO. A ceiling price (£300/MWh) was used to limit the cost of purchasing SPM to the DSO due to the lack of competition. All participants were paid the ceiling price if the level of supply in an auction was less than demand requested.

The level of competition in the auctions for DSO-Procured services for all three BSPs were analysed and is illustrated in Figure 5. The findings can be summarised as follows:

[17]https://www.ofgem.gov.uk/sites/default/files/2021-08/CfEC_review_2021_publication_final.pdf
The Herfindahl-Hirschman Index (HHI) is a commonly accepted measure of market concentration. It is calculated by squaring the market share of each firm competing in a market and then summing the resulting numbers. It can range from close to zero to 10,000

[18] An organisation with a relative market share of 41% would have a competition index of 1,681 (41x41)

- The market at each BSP displays behaviour of limited competition duopoly or monopoly. This behaviour was expected during TP1 due to the limited number of organisations participating in auctions for DSO-Procured services for the BSPs consisting of organisations involved in project LEO. Third party organisations are being recruited for involvement in TP2.
- The limited number of assets indicates there may be potential barriers to entry. This was borne out by feedback received on participation in Local Flexibility Markets ,conducted at the end of TP1.
- The Competition Index is high throughout TP1 indicating a concentrated DSO-Procured services market based on a few dominant providers of flexibility.
- the price ceiling remains the most cost-effective means to deliver SPM and provide participants with market certainty.

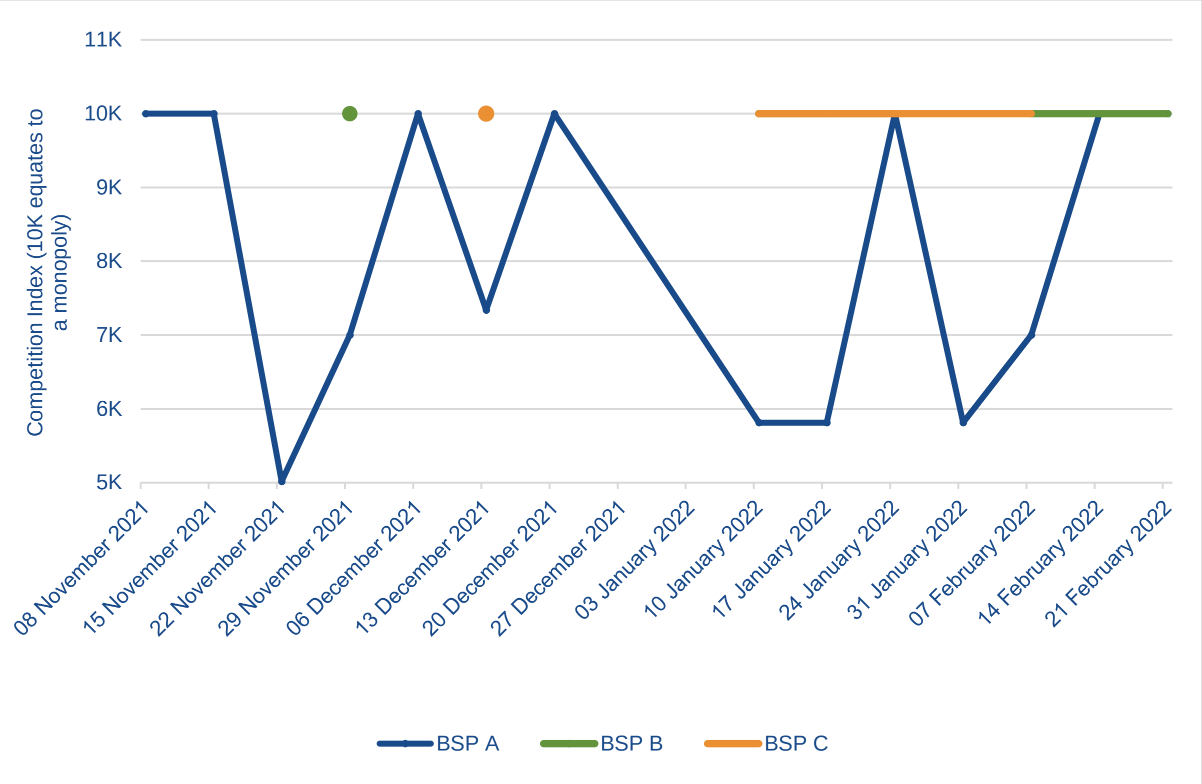


Figure 5 : Competition Index for DS-Procured services market

4.1.2 Liquidity Index

The Liquidity Index helps understand the efficiency of the flexibility market behind a BSP, in meeting or exceeding the DSO requirements. If supply meets demand, the DSO is able to manage the network using flexibility. If the supply of flexibility is less than the demand (Liquidity Index is less than 1), the market is illiquid and need to be stimulated to drive up liquidity. When the Liquidity index is 1, the supply of flexibility equals demand.

During TP1, the requested flexibility for each auction was equal to, or lower than the available flexibility for each BSP. The results are illustrated in Figure 6.

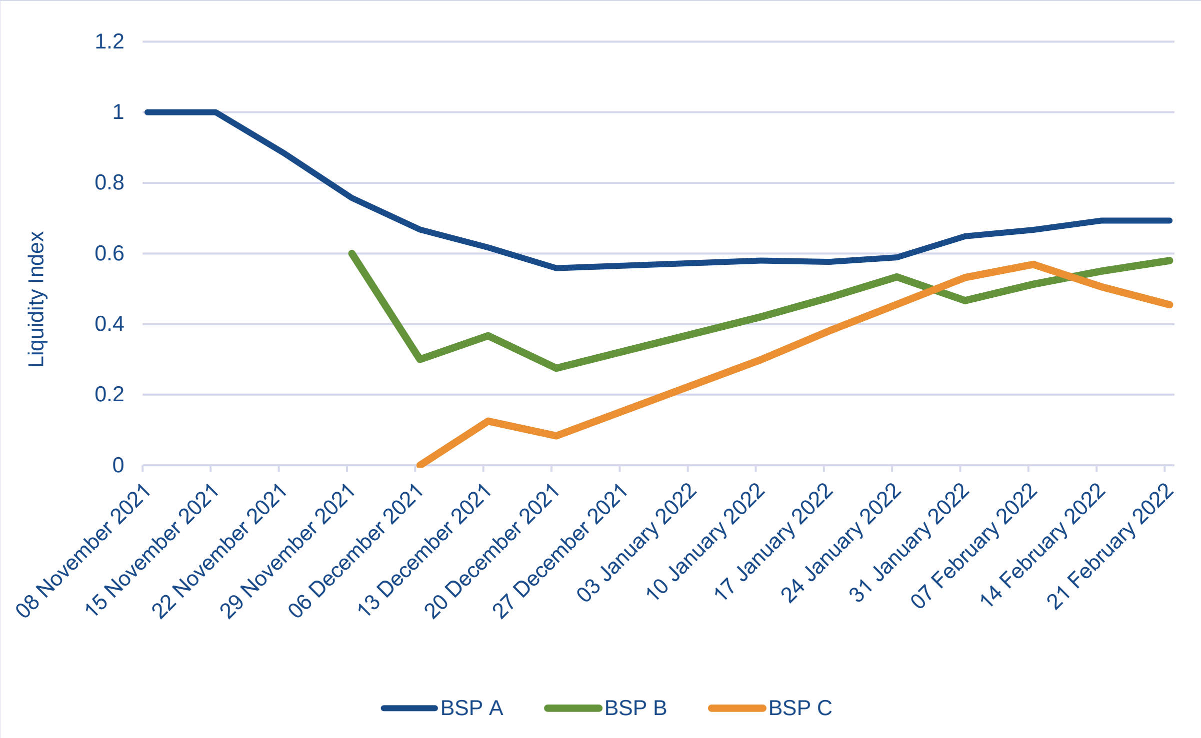


Figure 6 : Liquidity Index for the DSO-Procured services market

The findings can be summarised as follows:

- BSP A had the highest Liquidity index as it was the BSP where supply most met demand.
- Even with the demand artificially changed, the supply was never greater than the demand (the Liquidity Index was never above 1 at any of the BSPs).
- The variation in Liquidity Index across BSPs was primarily due to the large variation of actual DER Flexible Capacity, e.g. electric vehicle charger (V2G) not being in use due to driver requirements.

4.1.3 Reliability Index

The Reliability Index helps understand the reliability of an individual DER, a particular DER type, and of supply in meeting demand. This includes the ability of the asset to forecast when it is likely to be unavailable.

Figure shows the Reliability Index (as a percentage) for the four DERs available during TP1; Community Battery and the three V2G Chargers (V2G1, V2G3 and V2G4). The findings can be summarised as follows:

- the DER reliability is dependent on the DER type and its normal use.
- the Community Battery had a high Reliability Index as it is a static DER and is also used to optimise behind the meter solar.
- the V2G Chargers had a lower Reliability Index with higher variance as they are connected to mobile DERs, and availability is dependent on driver behaviour.

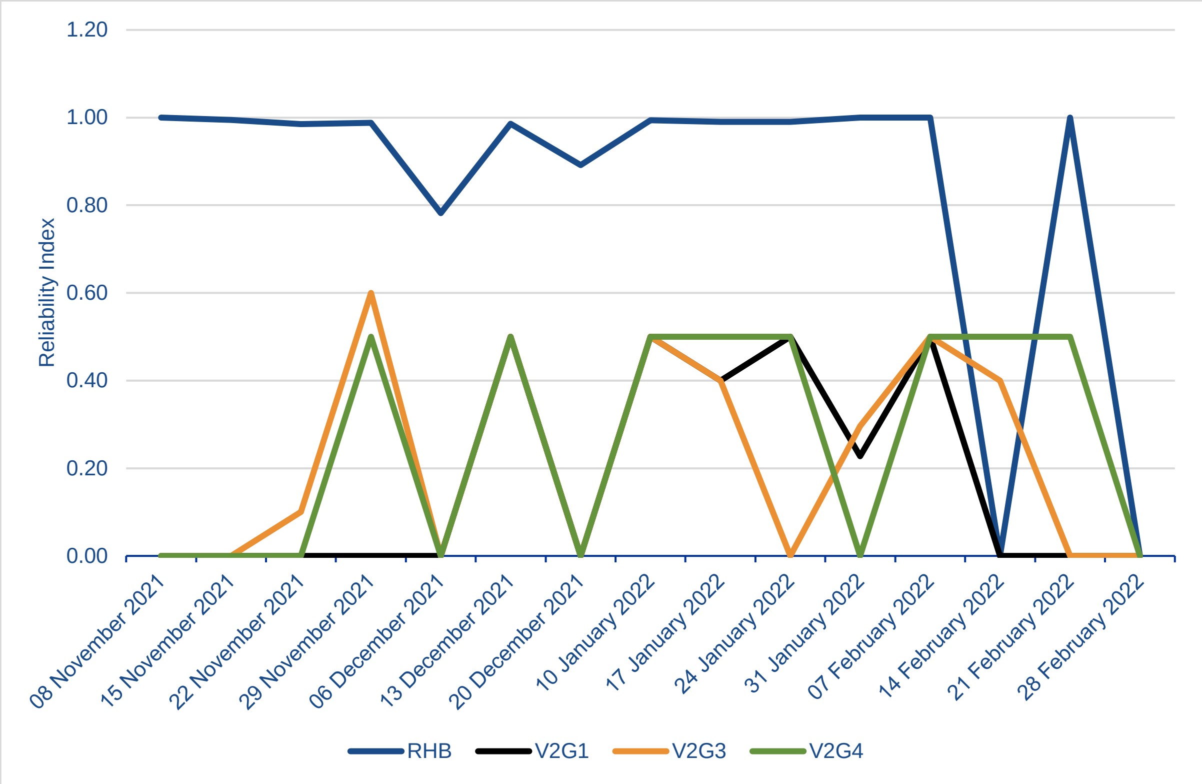


Figure 7: Reliability Index by Asset for the DSO-Procured services market

The distribution of the Reliability Index for different DERs is shown in Figure 8, 9 and 10.

- The Community Battery has a reliability level from 78% to 100% with 85% of uses at close to 100% (see Figure 8) indicating it is more likely this DER would have delivered the SPM service.
- V2G chargers (as shown in Figure 9) demonstrate a reliability level between 10% to 60% with the highest frequency falling at approximately 50%, indicating the DSO would have to procure twice the demand level to ensure the reliable delivery of the flexibility. Despite the lower reliability index, installations of V2G chargers are increasing and the reliability is likely to increase with a greater density of charge points.
- It should be noted that during TP1, the dispatches were scheduled, and dates known in advance so the reliability of delivered energy will therefore be weighted towards available.

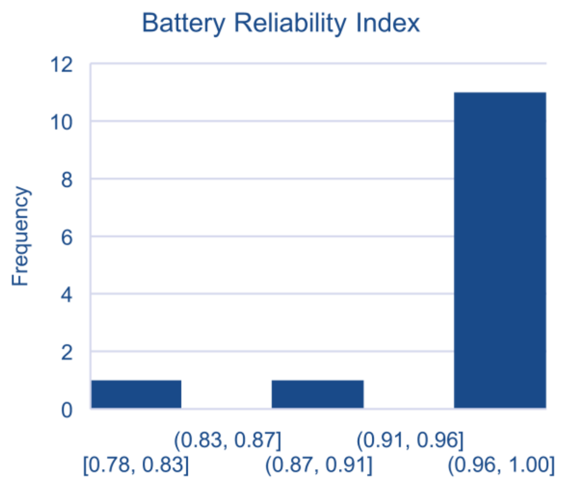


Figure 8 Battery Asset Reliability Index

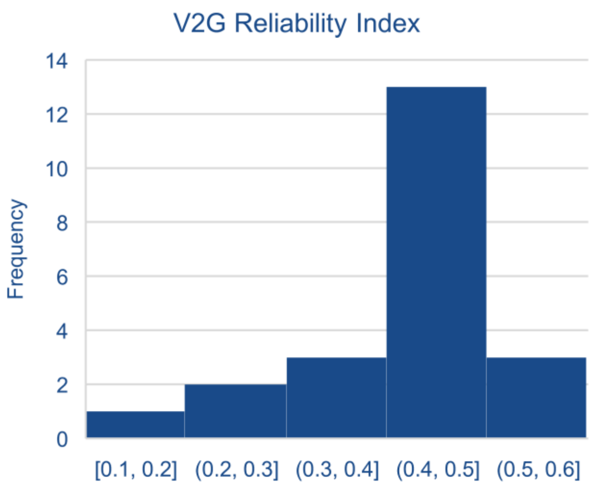


Figure 9 Vehicle to Grid Asset Reliability Index

A single Market Reliability Index using the individual DER Reliability Index values is illustrated in Figure 10 with a reliability level between 10% and 100% across 18 deliveries. The weighted average Reliability Index is 72%, giving an indication of required procurement levels, although this is driven by the Community Battery reliability at the high end of the distribution of results. Whilst this is not a high level of robustness, this should increase as more DERs participate in the market.

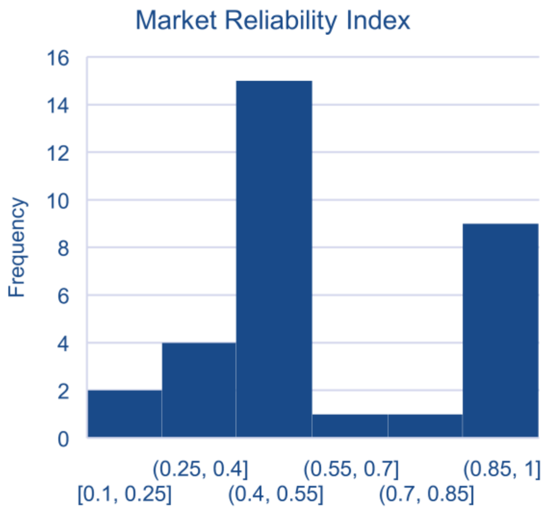


Figure 10: Reliability Index for DSO -Procured services markets

4.1.4 Learning and Recommendations on Market Start Up Indices

A framework has been developed to measure the maturity of a DSO market for flexibility, and the key learnings are summarised in Table 17[19].

Table 17 - Learnings and Recommendations for Reliability, Liquidity, and Availability Indices

Key Learnings	Recommendations
The DSO-Procured services market is operating at near monopoly levels	Increase the number and range of companies and DERs participating in TP2. For example with a customer value proposition for market stimulation as part of ED2.
Price may be affecting the attractiveness of the market. The significant increase in energy prices may affect the market attractiveness during TP2.	Consider increasing the price ceiling[20], not having a price ceiling and revamping the Market Stimuli Packages[21].
Contract term and limited range of services may affect market attractiveness and performance of DERs.	Increase the range of service and consider a range of season ahead, week ahead and day ahead markets to suit a wide range of DERs.
Need to reduce the effect of non-delivery and improve Reliability Index.	Consider whether DSO procures more supply than required and / or providers hold reserve to avoid contractual penalties.
External factors (e.g. EV user behaviour, relative size of DERs and weather) affect the level of delivery	Determine effect of external factors on level of delivery across the day and with different delivery notice periods from services.
Poor market attractiveness may be affected by no opportunity to stack services	Introduce ability to stack services (including price management and trading services and using DSO-Enabled Services to support delivery of DSO-Procured services) to determine effect on market attractiveness.

4.2 Market Start Up: Flex Delivery and Unavailability

4.2.1 Flexibility for DSO Procured Services

This section draws out the risk of using flexibility to secure the system in close to real time including the risk of under delivery, risk of unavailability using the Utilisation Fraction Metric. Several of these risks are mitigated through the contractual arrangements with participants.

[19] In the table, CI = Competition index, LI = Liquidity Index and RI = Reliability index.
[20] TRANISTION Commercial Arrangements . TRANSITION website
[21] Market Stimuli Report TRANSITION website

Table 18 - Risk of Delivery (per DER type)

		Sum of Flex Energy Delivered (kWh)	Sum of Flex Energy Instructed (kWh)	Average of Utilisation Fraction	Average of Utilisation Fraction Capped
	Battery Total:	**493.2**	**488.0**	**101%**	**97%**
Battery	11 Nov 21	16.0	16.0	100%	100%
	16 Nov 21	16.1	16.0	100%	100%
	18 Nov 21	15.8	16.0	99%	99%
	23 Nov 21	15.8	16.0	99%	99%
	25 Nov 21	15.8	16.0	99%	98%
	30 Nov 21	15.8	16.0	99%	98%
	02 Dec 21	15.9	16.0	99%	99%
	07 Dec 21	9.1	16.0	57%	57%
	09 Dec 21	15.9	16.0	100%	99%
	15 Dec 21	15.8	16.0	99%	99%
	17 Dec 21	15.8	16.0	99%	99%
	22 Dec 21	12.8	16.0	80%	80%
	23 Dec 21	15.8	16.0	99%	99%
	11 Jan 22	15.8	16.0	99%	99%
	12 Jan 22	18.0	16.0	113%	100%
	18 Jan 22	31.6	32.0	99%	99%
	20 Jan 22	31.8	32.0	99%	99%
	25 Jan 22	9.5	9.6	99%	98%
	27 Jan 22	14.4	14.4	100%	100%
	01 Feb 22	16.3	16.0	102%	100%
	04 Feb 22	16.2	16.0	101%	100%
	08 Feb 22	32.0	32.0	100%	100%
	09 Feb 22	46.2	32.0	145%	100%
	21 Feb 22	32.4	32.0	101%	100%
	24 Feb 22	32.4	32.0	101%	100%
	V2G Total	**48.5**	**72.0**	**117%**	**37%**
V2G	20 Jan 22	48.7	7.2	677%	100%
	27 Jan 22	-0.9	10.0	71%	50%
	01 Feb 22	9.9	19.8	52%	52%
	15 Feb 22	-3.9	3.0	-129%	0%
	18 Feb 22	0.1	26.0	1%	1%
	23 Feb 22	-5.5	6.0	-91%	0%
	Grand Total	**541.8**	**560.0**	**105%**	**82%**

As part of the contractual arrangements market participants have the option to declare their asset unavailable. Understanding the risk of unavailability is critical to informing procurement strategies for DSO Flexibility Markets. Unavailability lowers the amount of Flexibility available to be instructed by a DSO to deliver and therefore over-procurement may be required to mitigate the risk of unavailability. As shown in the Table 19 the unavailability percentage varied between the DER types. The V2G technology had a significantly higher unavailability than the fixed battery, which is expected as the V2G relies on vehicles that may or may not be present at the time the flexibility is required depending on vehicle use. Whereas the fixed battery unavailability is only dependant on state of charge. Given the Flexibility Service trialled in TP1 had a sufficiently long notice period, the state of charge and hence unavailability of the fixed battery may have been substantially easier to manage. Unavailability is a risk to the DNOs ability to have sufficient flexibility to mitigate a constraint, but also to the Service Provider as this results in reduced payment under the Availability Price mechanism in the FSA.

Table 19: Risk of Unavailability per DER type

Row Labels	Average Response Quantity (kW)	Sum of Total Availability (Hours)	Sum of Total Unavailable (Hours)	Average of Percentage Hours of Unavailability (%)
Battery	16.00	260	0	0%
V2G	7.76	436	234	54%
Grand Total	10.82	696	234	34%

The responses gathered from the LEO partners highlighted further perceived risks to participation in the Trials, these included:

- Procurement restrictions around buying Flexibility Services.
- Operational risks around maintaining BaU requirements whilst ensuring DERs are capable of meeting the Flexibility Service requirements.
- Interface risks where multiple platforms are communicating and passing critical information via APIs and other processes.

4.2.2 Flexibility DSO Enabled Services

- DSO-Procured non-delivery could lead to Network impact, whereas the DSO-Enabled non-delivery may result in revenue shortfall against predictions and the business case alongside network impact.
- As Oxfordshire is a congested network, DNO approval is needed for any trials that exceed a participant's Import or Export Capacity. If there is a risk to the security of the network, then these trials are unable to take place.
- In TP1, there were two participating Service Providers in the DSO-Enabled services. Part of the learning from these trials for Peer to Peer services is the ease or otherwise of finding a peer with whom to exchange capacity.

4.2.3 Learning and Recommendations on Market Start Up Flex Delivery and Unavailability

Table 20: Key Learnings and Recommendations for Market Start Up Flex Delivery and Unavailability

Key Learnings	Recommendations
Varied auction timeframes and flexibility services with shorter dispatch notices may affect DER unavailability. For example, the V2G Charger unavailability may be significantly improved at the day ahead stage where there is more certainty in vehicle requirements.	Auction risks need to be tested in later Trial Periods using a mixture of week ahead, day ahead and within day auctions. Also to investigate the impact of scaling up from the results of the V2G trials.
Under delivery is likely to affect procurement strategies. Early data indicate that the delivery performance of DERs may not be as expected.	Further testing in later Trial Periods is required to better understand procurement strategies across a range of DER types and Flexibility Services. Consideration should also be given to delivery in the opposite direction to the request i.e., increasing demand during a demand reduction service and how this impacts payments and incentives in other settlement periods or events during a contract.
Unavailability is likely to affect procurement strategies. Early learning indicates that unavailability is likely to be linked to DER type.	Further testing in later trial periods is required to better understand unavailability across a range of DER types, auction timescales and Flexibility Services.
DSO-Enabled services share similar risks to DSO-Procured but also have some unique risks associated with these services (TCVNs etc).	The risks in DSO-Enabled services need to be further tested with more trades and an increased number of participating market participants.
The end to end process is dependent on clear and timely communication processes which can be further complicated with the addition of third-party platforms and interfaces.	The communication processes need to be robust and clearly defined so that information handling does not restrict or prevent the effective operation of Flexibility Markets.
Organisational governance has been found to restrict procurement and participation in the market.	Work with organisations to demystify the market and gain greater participation.

4.3 Technical Start Up; Market Platform Development, Automation, Monitoring

The technical challenges in a project of this size can be divided into areas such as forecasting the need for flexibility, advertising the need, delivering that flexibility and validating the delivery, through settlement. This section concentrates on the advertisement of need, flex delivery and verification with the identification of need covered in Section 8.1.1. The main areas are;

- Market platform development, employing an agile iterative approach building on the ability to run auctions, and the collection of meter data for baselining, delivery verification and settlement.
- DER control and delivery, including the automation of the control of DERs to deliver services and the collection and submission of metering data for baselining and delivery verification.
- Network monitoring, specifically the effect of service delivery on network loading at various points on the local LV network.
- Congested Network challenges when running trials to increase capacity on a network, where capacity is limited,

4.3.1 Agile Market Platform Development

Using the 'Learn by Doing' approach, agile methodologies for the project are being developed. These have resulted in the successful implementation of 2 APIs between the Piclo Platform and the NMF which is an industry first between a DSO procurement platform and a third-party platform, enabling tests of different market models. There were two challenges to be overcome in relation to the ongoing development of the NMF and Piclo platforms: training for participants new to market platforms and the concept surrounding them, and the development of automated processes between platforms.

Training was an ongoing commitment as the functionality of the platforms changed on a regular release cycle with two particular issues raised that are currently being addressed:

- The release cycle meant that there was a lag between an appropriate user manual that reflects the latest functionality.
- Training was often delivered shortly after the user acceptance testing, which meant that it was often delivered by a member of the development team. This was not ideal for the market participants who had a very basic understanding of the NMF platform.

The status of the platforms at the beginning and during TP1 is summarised in Table 21.

Table 21 - Functionality of Market Platforms

Functionality	NMF	Piclo Flex
DER Registration	**Before TP1**	**Before TP1**
Advertise auction for DSO-Procured service (peak management)	**Before TP1**	**Before TP1**
Advertise auction for DSO-Enabled service (trading of export and import capacity)	**During TP1**	**Future work**
Receive auction offers	**Before TP1**	**Before TP1**
Notify market participants of contract outcomes	**Before TP1**	**Before TP1**
Notification of changes to availability of assets	**Before TP1**	**Future work**
Schedule and instruct assets	**Before TP1**	**Future work**
Issue STOP instructions	**Future work**	**NA**
Data collection for baselining and delivery verification	**During TP1**	**NA**
Data verification	**Future work**	**NA**
Issue of Settlement Report	**Future work**	**NA**
Performance indices and reporting	**Future work**	**NA**

4.3.2 DER Control and Delivery

Although the process from instruction to delivery is becoming more automated, the Community Battery and the V2G chargers were manually scheduled and automatically dispatched by the market participant. The hydro station that was expected to participate in TP1 was unable to do so due to delays in third party technical works (third party unable to travel due to COVID restrictions) and water levels.

All deliveries were measured using metered data and one of two baseline methodologies[22] recommended by the ENA[23],[24]. The historic data method uses data from over the previous 8 weeks with an on the day adjustment to allow for any changes to the baseline, e.g., changes in temperature or underlying demand (Same Day Adjustment). The nomination method uses a day ahead forecast submitted before 1700 the day before delivery. Figure 11 illustrates the delivery from the community battery (using historic baseline with Same Day Adjustment).

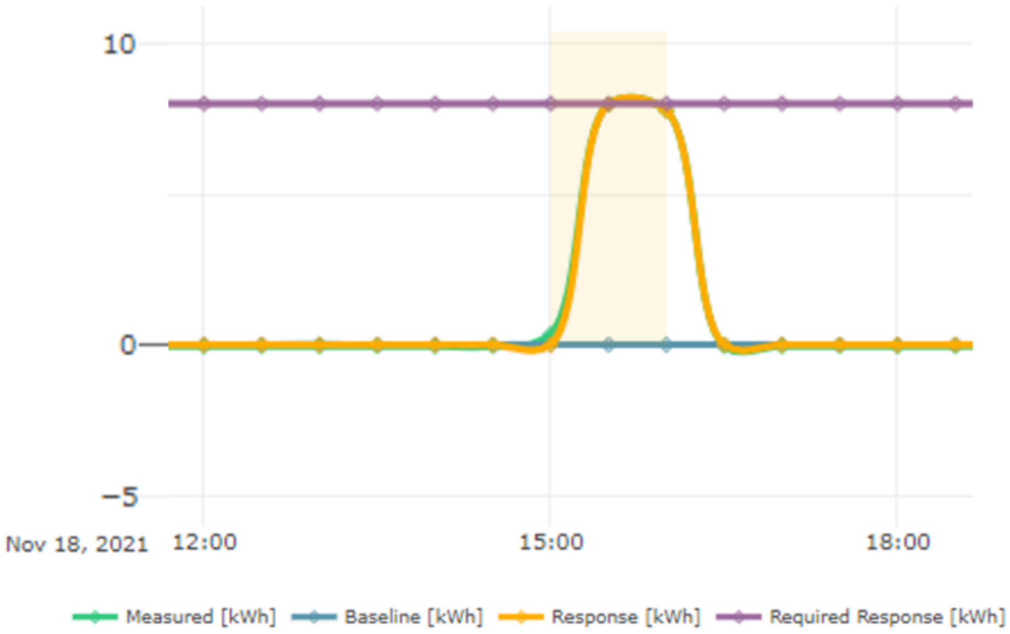


Figure 11: Illustrative delivery from community-based battery

- The target response (purple line) is 16kW (8kWh in each Settlement Period). Delivery is fully successful in a Settlement Period (shaded yellow) if more than 7.6kWh (95%)[25].
- The baseline (blue line) is -0.04kWh in SP1 and -0.05kWh in SP2.
- The event day adjustment (green line) is the change from the baseline; none for event.
- The metered response (yellow line; 7.98kWh and 7.77kWh; difference between baseline and event day adjustment); 0kWh at all other times.
- The actual response (8.02kWh; 7.82kWh) was successfully delivered in both settlement periods.

[22] Baselining for the trials, TRANSITION website
[23] Technical Specification Baseline Methodology Verification Tool WS1A Product 7 version 1, published by ENA June 2021
[24] Open Networks WS1A P7 Baseline Methodologies Final Report Version 1.1, published by ENA February 2022
[25] Payment, TRANSITION website

Figure 12 illustrates the delivery from the V2G charger using a historic baseline with Same Day Adjustment[26].

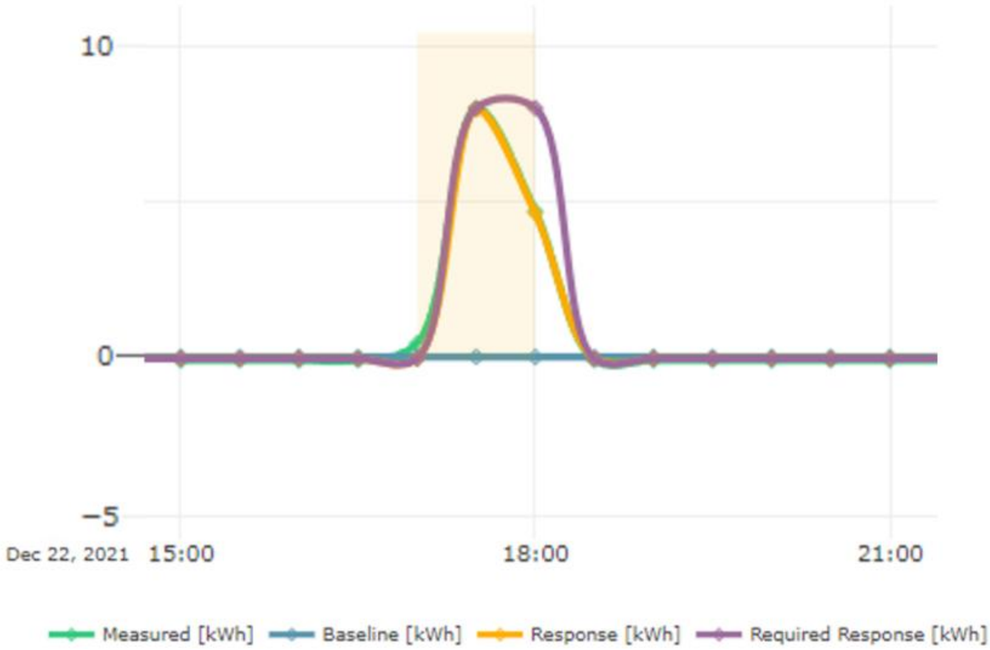


Figure 12: Illustrative delivery for EV Charger

- The target response (purple line) is 16kW (8kWh in each SP). Delivery is successful in a SP if more than 7.6kWh (95%).
- The baseline (blue line) is -0.05kWh in each SP.
- The event day adjustment (green line) is the change from the baseline; none for event.
- The metered response (yellow line; 8.01kWh and 4.71kWh; difference between baseline and event day adjustment); 0kWh at all other times.
- The actual response (8.06kWh; 4.76kWh) was successfully delivered in SP1 but not in SP2.

4.3.3 Network Monitoring

The effect of service delivery from DERs connected directly to the network was monitored at the LV side of secondary substations and on their individual feeders using a low cost substation monitor (Eneida Deepgrid One). The data from the device can be downloaded from a central database for analysis and serves two main purposes;

- enables the DNO to determine the effect of service delivery from DERs on the local network and on network performance.
- creates a data resource for areas of the network not previously monitored at LV which could be used to identify and verify real time network issues and faults.

[26] Note that this event was a deliberate under-delivery

In total 130 LV monitors will be installed in Oxfordshire, to date there have been 94 units installed (see Figure 1) with the remaining planned for installation throughout 2022.

An example of using the LV monitoring to test how the delivery of a flexibility service affects the total load on a substation is provided below. A battery connected to one LV feeder from a substation was asked to deliver 16kW from 1700-1900 hours on 20-Jan-22, shown in orange. The delivery was separately verified using DER metering and the historical baseline with Same Day Adjustment. The data detected on the substation feeder (power) prior to, during and after the delivery period is provided in Figure 13

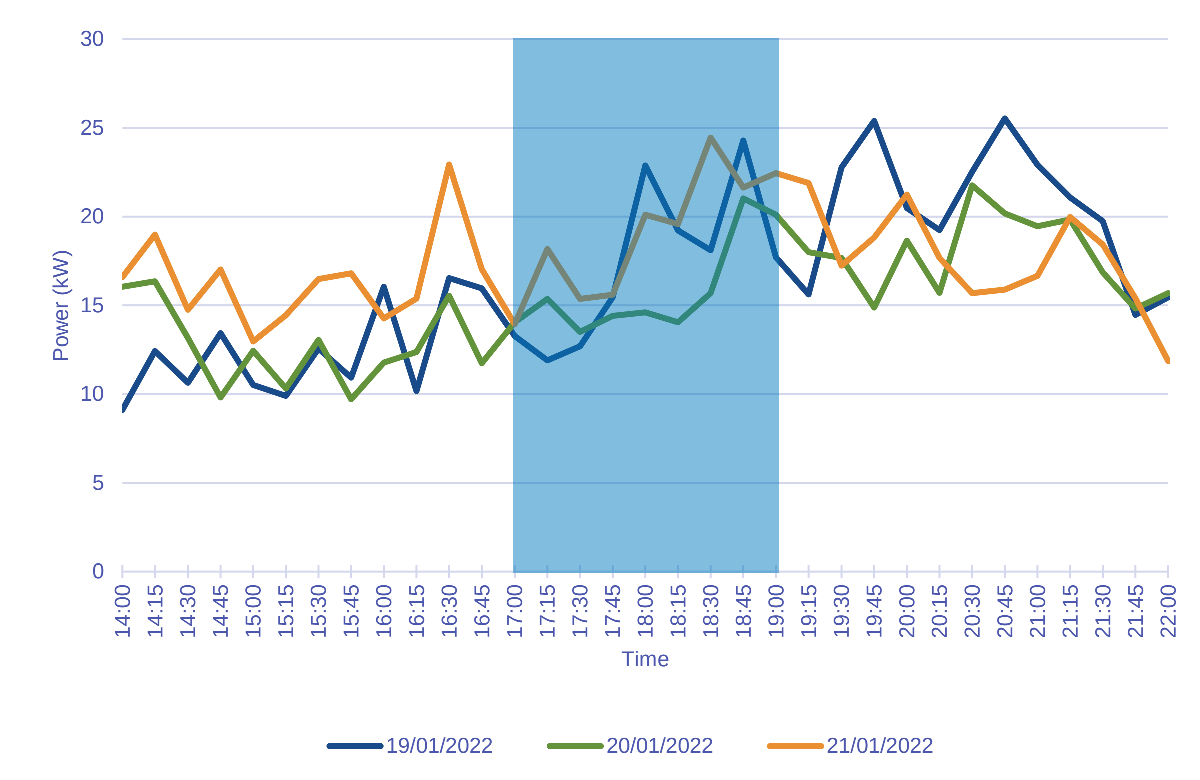


Figure 13: Effect of service delivery on LV feeder (power)

Comparing the load for the event day (20-Jan-22) compared to adjacent days there is no observable difference in the power or energy on the feeder or the power any phase as a result of the delivery of the flexibility service. Possible reasons for this include:

- other asset on the feeder between the site and the monitor could have changed their activity, e.g., increased their demand or decreased their generation which may make the effect of the DER service delivery.
- there are other DERs and devices on the site behind the MPAN. The other DERs could have increased demand as the battery discharged and masked the effect.
- volume of flexibility dispatched during TP1 relative to the feeder capacity was low therefore undetected at the LV monitor.
- The population size on the LV network is too low to be able to display probabilistic effects.

4.3.4 Trialling a DSO Enabled Service

During TP1, one of the market participants identified an opportunity to achieve an early connection for one of its leisure sites that had benefitted from the installation of heat pumps. A new substation was required to accommodate the load, but the partner identified a short-term MIC trade between their site and four other sites that would enable an earlier connection whilst the substation works were being completed. This would have been a significant achievement for the project but discussions with the BaU team identified that one of the existing underground cables could not accommodate the additional load, even with the proposed trade.

Whilst this was a good learning, trades for exceeding existing import and export capacity may be limited by existing connections equipment and the local network infrastructure.

4.3.5 Key Learnings and Recommendations on Technical Start Up; Market Platform Development, Automation, Monitoring

Table 22: Key Learnings and Recommendations for Technical Start Up for Market Platform Development, Automation, Monitoring

Key Learnings	Recommendations
The project was designed to have market participants using the NMF who already have experience of energy markets such as aggregators and larger generators. Through LEO and enabling Demand Side Management, those needing to use the NMF have needed more detailed documentation and training.	Concentrate on providers who are already familiar with the energy industry alongside providing easy to engage with material for the less well informed.
Quality of data provided by market participants is variable at times.	Review the data checking tool and insist on market participants using it prior to submitting data for verification.
Testing the baseline tools on a wider range of DER types would confirm its accuracy. There is an issue with the application of the baseline methodologies to V2G and similar new DERs.	Encourage a wider range of DER types to participate in the markets so the baseline models can be tested, reviewed and revised. Consider the key requirements of an appropriate baselining method for V2G and similar new DERs.
When installing the LV monitors it was confirmed that not all secondary substations have a socket for the LV monitor voltage connector.	When a new LV monitor installation is triggered (either through asset registration or request from LEO partners), arrange a site visit to check the fuse holder.
The timing to verify the detailed requirements for the interface between the Piclo platform and the NMF did not allow sufficient time for detailed design, testing and training.	For future interface the detailed requirements need to be confirmed and shared earlier to allow a successful deployment.
The ramp-up time required for the community battery to reach the requested capacity had to be accounted for to ensure it was available at the beginning of the delivery period.	DER control strategies should account for the ramp-up time to ensure that the DER is delivering at the required capacity at the beginning of the delivery period.
Some DERs do not have their own connection agreement.	Consider how such DERs can participate in future markets.
There may be physical limitations that prevent trading import or export trading.	Consider how best to reflect a check for physical limitations prior to EMEC or EMIC trading.

5 Gaming

The efficient operation of a Smart Local Energy Market requires fair and equitable access for all with standards of behaviour for market participants in the auction and delivery to minimise the scope for gaming.

Gaming is likely to be prevented through three routes.

- A set of basic market rules (BMR)[27] that govern how the market should operate, provide guidelines for the expected behaviour of market participants, and provide guidance in relation to conflict resolution and new DSO-Enabled services. The rules aim to encourage an open market and reduce gaming opportunities and, although not contractually binding, can impose sanctions. The rules were developed by TRANSITION and tested during several market simulation events attended by a variety of stakeholders, including other DNOs.
- Contractual arrangements that govern the relationship between the parties (NMF Platform T&Cs, FSA and P2P Termsheet).
- Potential detection of gaming behaviour utilising analytics and AI in more mature markets.

Following TP1, the continued appropriateness of the market rules were considered during feedback sessions to determine whether a robust application would have prevented gaming opportunities. These sessions were held with market participants to identify gaming opportunities in a variety of areas and determine whether they remained fit for purpose. The following working definition of gaming was used during a scenario-based review of gaming opportunities;

"***gaming is deliberate behaviour designed to give an unfair advantage to one or more parties or to manipulate the market to benefit one or more parties***".

The output from the feedback sessions is summarised in Appendix C and will be used to inform the development of TP2, the market rules and the contractual arrangements.

5.1 Gaming Learnings and Recommendations

In general, the combination of the market rules, contractual arrangements and the operation of the Market Platform mean many gaming opportunities have been engineered out. The Key learnings and Recommendations are summarised in Table 23.

[27] Market Rules Development Initial Variant version 1, published by TRANSITION February 2020

Table 23 - TP1 Outcomes from Feedback on Gaming

Key Learnings	Recommendations
The market rules developed earlier in the project need to be refreshed.	Organise workshop prior to or at the beginning of TP2 and use the Market Rules to review market behaviour.
There are some opportunities for gaming that are not adequately addressed.	Aim to address remaining gaming opportunities prior to the start of TP2, especially availability of auction reports.
Availability has been varied to address forecasting uncertainty of DERs which could affect security of the network.	Consider approach for market participants to change capacity and who is best placed to hold reserve capacity to maximise opportunity for DERs whilst minimising risk for DSO. Clarify rules for Availability Notices issued after a DER has been asked to deliver a service.
The baselining approaches could be refined for batteries and DERs that require preconditioning.	Consider how to improve and trial alternative methods of baselining for DERs that require preconditioning.
There is scope for manipulation of data from source.	Consider how to reduce scope for data manipulation.
Longer term contracts could be cancelled to gain advantage in a shorter term contract.	Consider measures to address this issue.
Those trading DSO-Enabled services can still exceed their revised capacity.	Consider how to best address this and understand if the BaU processes can help.
Parties involved in DSO-Enabled services are unable to verify the behaviour of the counterparty and whether they are gaming.	Explore the sharing of MPAN data between trading counterparties, and develop methods for detection and prediction of gaming activity. Look at the need for regulatory powers for enforcement.
The gaming opportunities of stacking services is uncertain, especially cost reduction measures which are not considered in other work.	Consider how best to address these issues and test stacking of services during TP2.

6 Commercial – DSO

The DSO is tasked with ensuring a safe, secure and reliable network, delivering the electricity required for the energy transition in a cost-effective way through the provision of flexibility. As part of this work the cost benefit analysis of flexibility provision sets prices that can be paid for flexibility as part of the market.

6.1 Flexibility Services Benefit

Within the Oxfordshire area 16 network locations, 6 BSPs and 10 Primary Substations, were each assessed for reinforcement costs as if there was a transformer capacity issue. An artificial reduction in capacity available was applied on each substation to create a near overload situation, i.e. a 20 MVA transformer currently loaded at 14.7 MVA would have its rating artificially reduced to 15MVA.

The cost benefit analysis from the 2020 ENA Common Evaluation Methodology Tool for Network Investment Decisions[28] was used to assess the Net Present Value (NPV) of deferring large CAPEX expenditure associated with network reinforcement and comparing it to the alternative (Flexibility market) scenario. It was run assuming utilisation costs only and assumes perfect Market operation.

The data was assessed to look at the marginal value of flexibility on a year-by-year basis, this is then divided by the flexibility needed to calculate the maximum utilisation cost. This is also described as the DSO's "Willingness to Pay" (WTP) for Flexibility as an alternative to reinforcement.

The model could be improved to include societal impacts, carbon, losses and customer interruptions, customer minutes lost and any fixed cost for operating the Flexibility Markets. The methodology could also be expanded to include the lost value through constraints preventing local flex participants trading fully in national markets.

The average availability and utilisation prices bid into the auctions for the three BSPs (BSP A, B & C) were used to derive the net benefit of the Flexibility solution at these locations against the baseline cost of reinforcement. For each substation the analysis was run against the five Distribution Future Energy Scenarios (DFES) published in December 2020[29]. Results are shown for the Leading the Way scenario[30] and assumptions were made for the availability and utilisation volume requirements based on the load growth of this scenario. The Leading the Way scenario was chosen as project participants are highly engaged in acting to reduce and manage their energy consumption.

[28] Flexibility services, ENA website

[29] Distribution Future Energy Scenarios 2020 Southern England licence area Results and methodology report Final version, published by Regen and SSEN 11 December 2022

[30] In the Leading the Way scenario, consumers are engaged and active in improving energy efficiency with a mix of solutions.

6.1.1 Cost Benefit Analysis

Figure 14 shows the price ceiling value of flexibility (in £/MWh) or WTP per MWh of utilisation over a year and how price changes over a 10-year deferral. The values vary greatly over all three BSPs, ranging from £378/MWh to £6179/MWh in year 1. This is consistent with the nature of Local Flexibility Markets as the demand and need for reinforcement will be based on the changing topology and demands of the local network. For the Leading the Way scenario, all three BSPs show a steep decline in the WTP over a period of 4 years as the value of Flexibility decreases year-on-year as the forecast peak demand increases.

However, the WTP presented here does not account for other societal impacts, such as reduction in carbon emissions, customer interruptions and reduction in curtailment of renewables, which should increase the WTP as they are likely to be additional benefits. The value of flexibility in initial years is high, potentially opening an initial route to Market for unconventional DERs. The value of WTP looks to sharply decrease after 3 to 5 years which can look particularly dramatic over time due to the high initial prices. In some cases, the value of flexibility based on the WTP is still 'competitive' in absolute terms but looks low in relative terms.

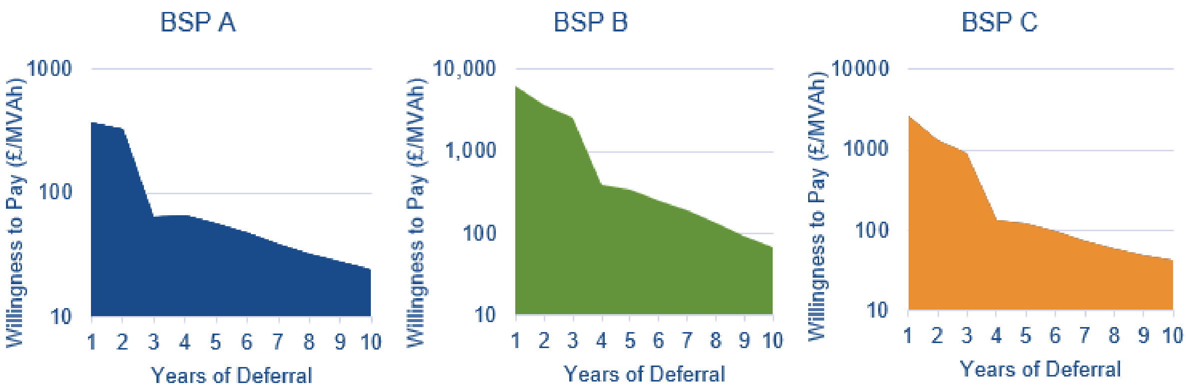


Figure 14 Willingness to Pay from the NPV Cost Benefit analysis of reinforcement deferral (for Leading the Way Scenario), graph payment axis in logarithmic scale

Table 24 below shows the average availability and utilisation price from TP1, including Offers not accepted, across the three BSPs. The average Total Contract Value (TCV) for the auction Offers at each BSP was calculated based on an average utilisation of 3 hours per week. Offers over the price ceiling were accepted to test DER delivery during TP1 and, as such, all three values are slightly higher than the price ceiling set for SPM service (£300/MWh).

Table 24 - Average Flexibility Prices from the auctions run at the three BSPs in TP1

BSP	Average Availability Price /(£/MW/h)	Average Utilisation Price /(£/MWh)	Average Total Contract Value /(£/MWh)
A	31	105	311
B	37	70	317
C	38	62	317

These values were then used in the ENA Common Evaluation Methodology Tool to evaluate the cumulative net benefit for each additional year of reinforcement deferral across all three BSPs and the results are shown in

Table 25 below gives the optimal number of deferral years for each BSP, based on this cost benefit analysis and the associated WTP at that year. The table also shows the maximum WTP or the initial price ceiling and the maximum value of Flexibility at the BSP based on the optimal deferral year.

Table 25 Optimal number of deferrals years and value of Flexibility for the three BSPs in TP1

BSPs	Optimal no. of deferral years	WTP at optimal no. of deferral years £/MWh	Max WTP £/MWh	Maximum value of Flexibility
A	1	378	378	£71,159
B	5	336	6179	£292,146
C	4	136	2670	£154,704

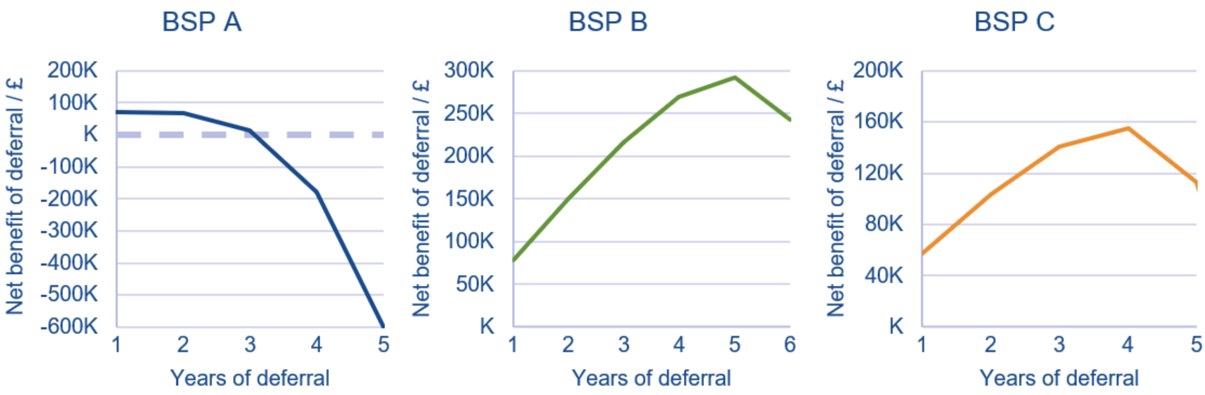


Figure 15 Cumulative Net benefit of deferral against a baseline of Traditional Reinforcement

From Figure 15 it can be seen that;

- the WTP value for BSP A (£378/MWh at 1 year deferral) is similar to the Total Contract Value for peak management (£311/MWh), when the cumulative net benefit of the Flexibility Market is calculated with a high cost after 3 years of deferment.

- the WTP for the first 5 years at BSP B and BSP C was significantly higher (£2670/MWh to £6179/MWh). Therefore, the net benefit of a flexibility market against the cost of reinforcement is high. The cumulative benefit drops after years 4 and 5 respectively but remains a significant advantage.
- after 5 years, the BSP B net benefit is ~£300k and at BSP C the net benefit ~£150k.

The varying levels in benefit across these BSPs show that a low benefit in one local market can be negated by the high benefit in another to support the fixed resourcing cost for the Local DSO Flexibility Markets. The outcomes of the net benefit methodology can be used to demonstrate the potential outcomes across a range of scenarios and allows the DSO to explore the potential value that could be realised in the future as a result of decisions taken now.

Further deferred costs of reinforcement at lower voltages, such as the replacement of 33kV overhead lines (OHLs) with 33kV underground cables can be included in the cost benefit analysis of Flexibility versus reinforcement. For example, additional cable costs were incorporated based on expected constraints in the Local Oxfordshire area for each BSP.

Figure 16 and Figure 17 show the WTP for BSP A and BSP B with the addition of deferred replacement of cables; there were no similar constraints for BSP C.

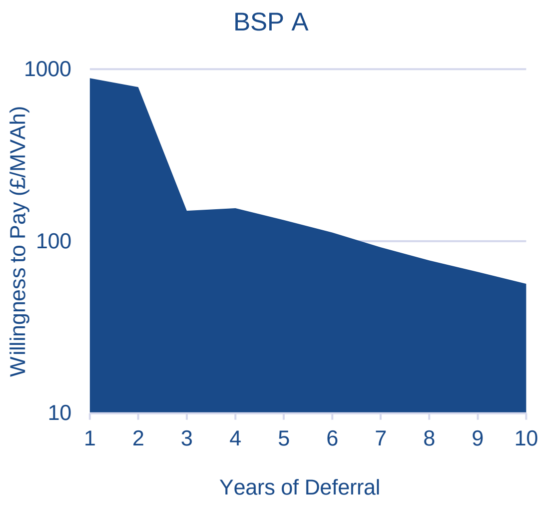


Figure 16: Willingness to Pay from the NPV Cost Benefit analysis of reinforcement deferral with replacement 33kV cables at BSP A

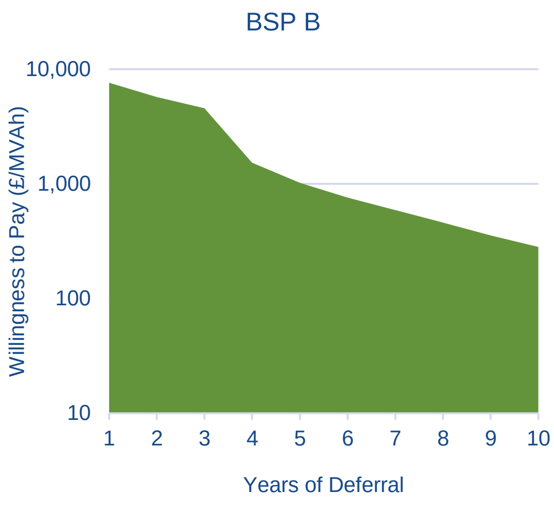


Figure 17: Willingness to Pay from the NPV Cost Benefit analysis of reinforcement deferral with replacement 33kV cables at BSP B

The WTP for BSP A, when the cost of cable replacement at 33kV Network level was included, shows a doubling in the WTP value compared to Figure 14. This is due to the BSP A having three OHLs that would require replacement. In comparison BSP B, which has a lower need for Flexibility and requires one cable replacement has shown a less significant increase in the WTP. It should be noted that these cost-based analyses use generic indicative costs to produce an indicative WTP for the Oxfordshire area and needs development for use in decision making. Using the cost benefit analysis highlights those networks with a higher need for flexibility cannot be based on reinforcement for a transformer overload. It must reflect the possible need to replace cables at lower network levels which would be required as the local demand increases as we move to a world with consumers opting for electrification of heating and EVs.

6.2 Key Learnings and Recommendations for TP2

The auctions held in the first trial period at the three BSPs have allowed TRANSITION to test the Flexibility Market at a price ceiling and determine if this price for Flexibility offers a cost-effective solution against traditional CAPEX solution. The following learnings and recommendations were found.

Table 26 - Key Learnings and Recommendations on the Flexibility Services Benefit analysis

Key Learnings	Recommendations
Flexibility Markets can offer a significant benefit, but this is dependent on large CAPEX being deferred and a low Flexibility requirement to meet peak demand. The lower the reinforcement cost and the greater the Flexibility need, the lower the benefit will be for the Flexibility Market, as with BSP A.	Results are shown for the Leading the Way scenario and assumptions were made for the availability and utilisation volume requirements based on the load growth of this scenario. These will need to be reviewed to deliver a more reflective assessment of the Flexibility need , including the position of the asset and the voltage at which it is connected.
The Willingness to Pay varies significantly over the different networks and in several areas is over £1000/MWh.	An increase in the price ceiling is warranted by the analysis, but the frequency of the events need to be taken into account This should be reviewed to attract more participants and allow the project to better test the cost benefit on Flexibility at different price points, while assessing its wider benefits.
Just as the willingness to pay varies over the different network topologies, so will the benefits from Flexibility.	Future analysis should include the impacts of; losses, emissions associated with losses, emissions changes from using the DER Flexibility, customer interruptions, customer minutes lost and the fixed Market operation costs. Furthermore, combining the benefit over several of the network areas will give the DSO a more cohesive understanding of the Flexibility Market benefit.
This is a network centric cost-based benefit analysis based on reinforcement and does under value the need for Flexibility, which once enabled in an asset can be used to further optimize against Tariffs, PPAs and Wholesale Markets	Explore further and long-term revenue streams (i.e. service stacking and balancing), and whole electricity system value to reducing peak load, engaging with project partners to share DER commercial optimization models
The analysis concentrates on the higher voltages, BSPs, 33kV and Primary Substations.	Carry out similar analysis for LV, secondary substations and 11kV to assess the compound benefit of flexibility at different voltages in the system.

7 Commercial – DER

The relationship between the DER and the DSO is crucial in helping to establish a market for flexibility. The participants who hold DER are wide and varied, and our work with project LEO has shown that the sustainability credentials of helping to decarbonise are sometimes a more influential factor than commercial factors. However, as we are investigating a market for flexibility as part of the TRANSITION project, we have concentrated on the commercial viability of providing flexibility to the DSO, and Peer to Peer capacity exchange.

7.1 Comparing and Contrasting Different DER Types

In a fully functioning market for flexibility at distribution level, the DSO would expect there to be a diverse range of different DERs to call upon with different characteristics. Part of the work of the LEO Trials is to test which sorts of DER are most suitable for which services, and how the financial incentives need to be structured to provide investable business propositions for participants. As part of the trials we have found that organisations have commercial sensitivities regarding the sharing of their bespoke financial models, the inputs and the outputs. Discussions with individual participants identified unique modelling aspects of specific DERs and the non-financial factors that were considered. For TP1, the outputs from each participant will be used to determine; (i) the economics of delivering Peak Management Services from different DERs and (ii) the practicalities and benefits of delivering SPM using a variety of DERs and EMEC and EMIC using a variety of sites.

7.1.1 Comparison of Costs for DER Type

Typically, when pricing the value of Flexibility, organisations consider any Capital Expenditure (CAPEX) costs, ongoing Operational Expenditure (OPEX) costs and margin Figure 18 shows the types of costs typically incurred by each DER type when participating in a Flexibility Market and identifies those costs considered by LEO partners during TP1.

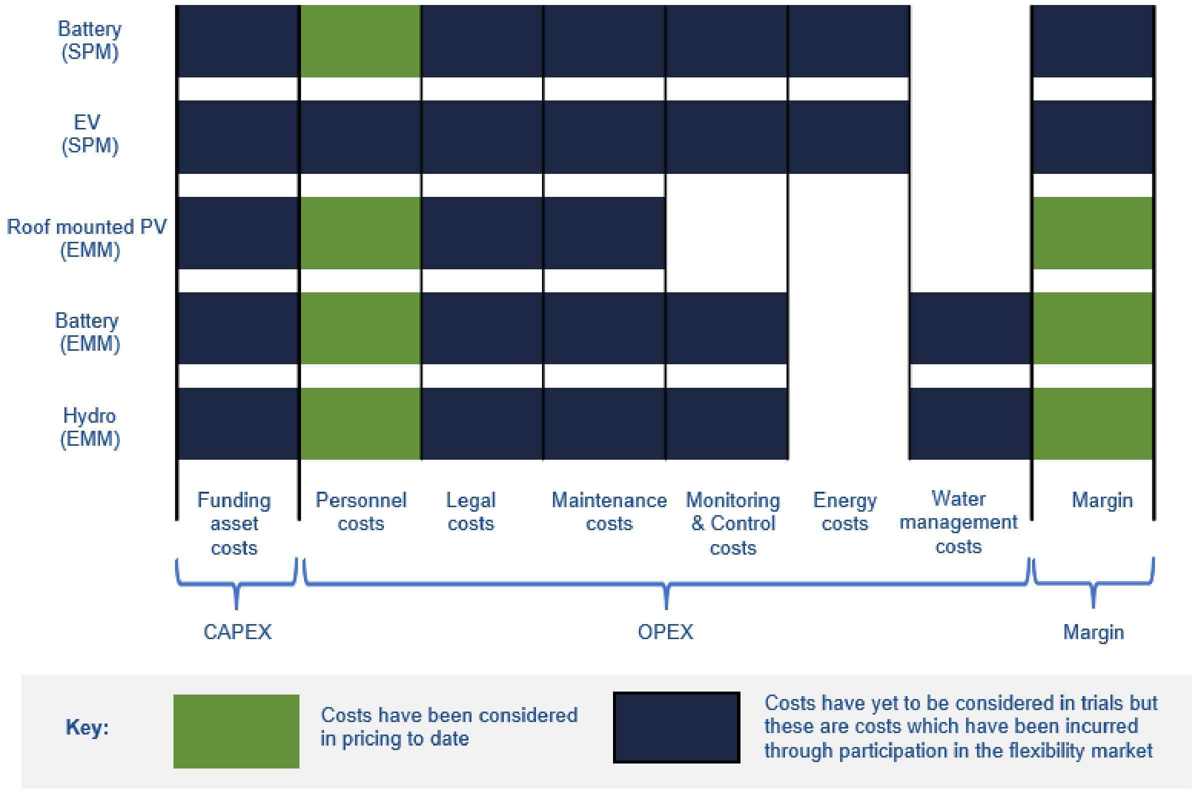


Figure 18 : Comparison of costs to be considered for different DER types (See Appendix A for glossary comprising definitions of each cost type)

As shown above, different costs will be attributed to different DERs and Services. For example, energy costs were the main consideration for the EVs participating in SPM, and personnel costs were the main consideration for the battery, whereas those participating in EMEC and EMIC only considered personnel costs and margin due to the nature of the Service.

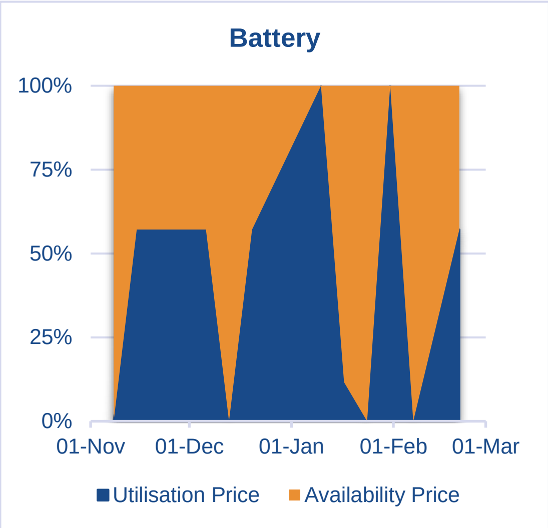
7.1.2 Comparison of Baselining for DER Types

There were a number of issues associated with baselining for peak management;

- DERs that have a predictable pattern of usage or sufficient historic data can reduce errors in the baseline, e.g. a battery co-located with solar PV that has a regular charge / discharge cycle will be easier to baseline than new EV chargers being used for flexibility due to unknown vehicle patterns.
- DERs that need pre-conditioning may breach the baselining methodology, e.g. a battery that needs to charge between providing two different services.
- DERs that already deliver a benefit, e.g. charge management, will struggle to prove delivery of a service, even though their behaviour contributes to reducing demand; this loss of stacking benefit may harm the provision of flexibility.

7.1.3 Utilisation and Availability Payments

DSO-Procured services are contracted through an auction process with the price split between Availability Price and Utilisation Price[31]. Figure 19 illustrates the split between Availability Price and Utilisation Price during TP1. The prices for both DERs were varied and, in general, the battery was able to support different pricing strategies (including all Utilisation Price or all Availability Price) due to the higher certainty of delivery. The V2G chargers were more uncertain due to vehicle patterns and, as their pricing strategy matured towards the end of TP1, the share of the Availability Price increased above the Utilisation Price (a lower risk approach as there is less dependency on the number of Utilisation hours).



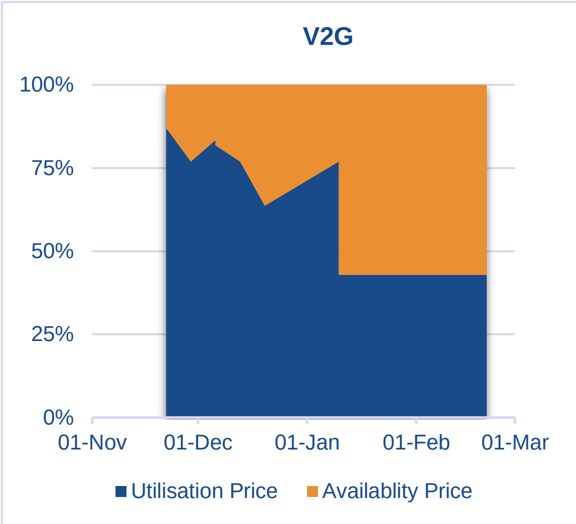


Figure 19 : TP1 auction prices for Sustain Peak Management service shown as percentage split between availability and utilisation at auction per asset type

7.1.4 Market Liquidity and Perceived Value of Services

During our start up Trial Period, there was not much competition, consequently, prices for SPM were at or near the ceiling price throughout the Trial Period (as shown in Figure 20).Even at the ceiling price, participants found the income from peak management (less than £100 for the trial period) were generally insufficient to cover personnel costs associated with participation (although these were expected to reduce through automation). This is where there is the aspiration to move away from individuals accessing the markets manually to more automated systems with the benefit of working at scale across multiple markets with standard customer propositions. It is uncertain whether the income from service provision in a liquid market would be higher if there were multiple flexibility services which may affect the market attractiveness to DERs with lower levels of flexibility, although the ability to stack services would have a positive effect.

[31] Payment | SSEN Transition (ssen-transition.com)

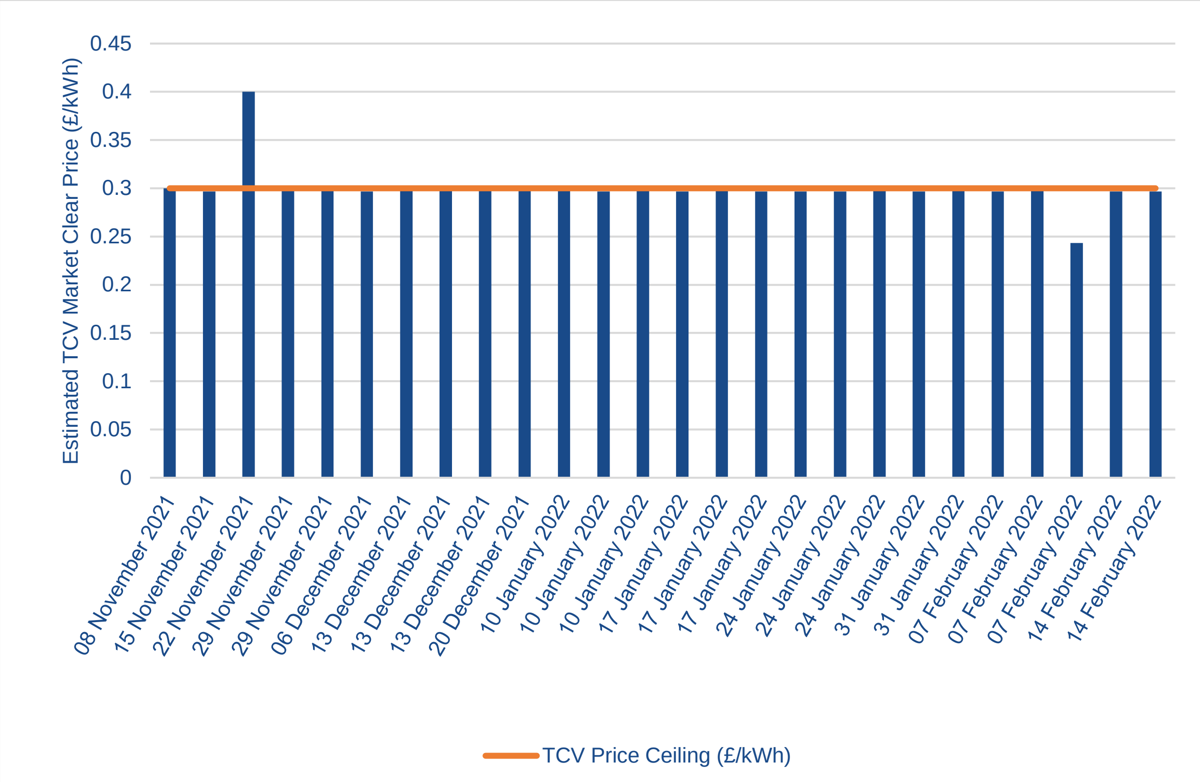


Figure 20 : TP1 Estimated Total Contract Value (TCV) prices for Peak Management

For EMEC AND EMIC services, learnings around pricing are to be gauged in the next trial period, the two organisations taking part in the TP1 market were driven by sustainability rather than profit and transactions were therefore made with zero price. More participants are expected in later trial periods to increase liquidity and commerciality of services.

The following points were noted on the ***financial benefits*** of participating in the TP1:

- The Flexible Capacity of a DER has a large impact on the cost effectiveness of a Service, e.g., at £300/MWh, a 6kW EV charger will receive an income of £1.80/hour from DSO-Procured Services. To make a 6kW economically viable, flexibility would need to be provided for a range of services (see Figure 20). As previously stated, the energy costs were the main consideration for the V2G chargers participating in SPM. Although this service was stacked with a Time of Use Tariff, a doubling of energy costs for one site at contract renewal made it uncompetitive to continue.
- The fixed costs of participation are disproportionately high for DERs with lower levels of flexibility on a £/kW basis. Variable costs are scaled by size and easier to recover.

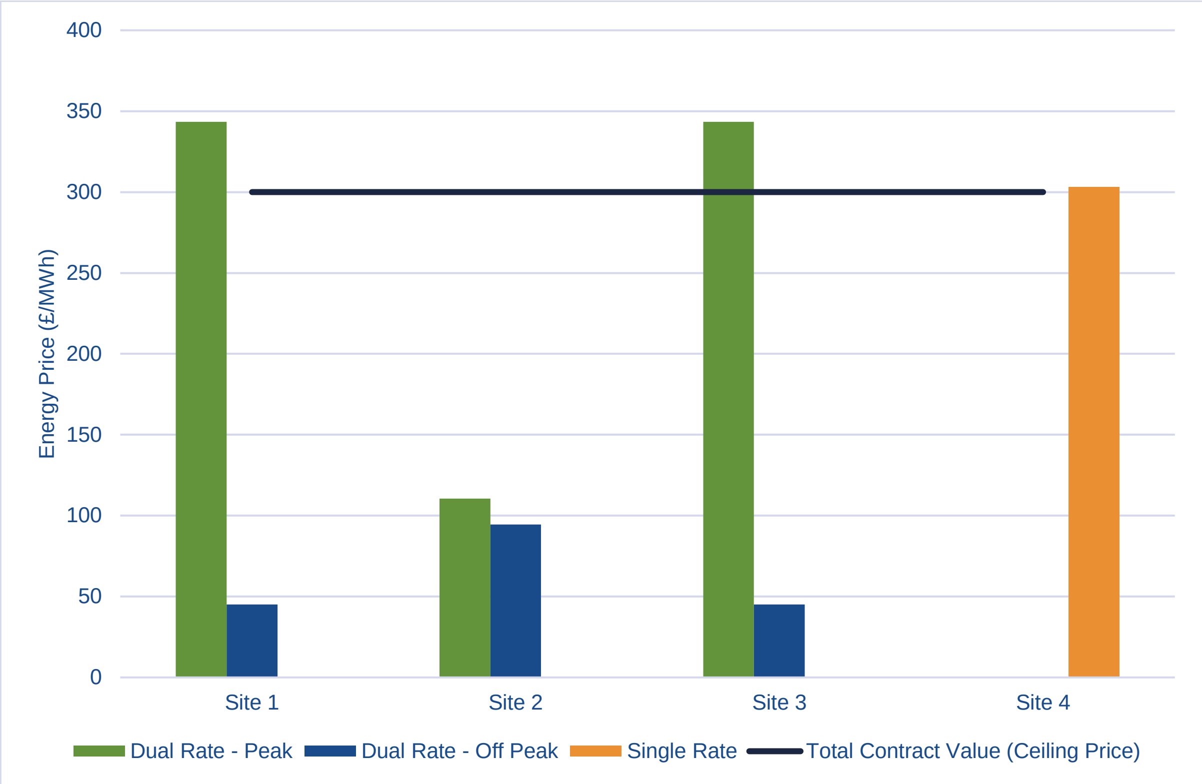


Figure 21: Tariffs at V2G charger sites against ceiling price

Participants noted a range of ***non-financial benefits*** from participating TP1, these included:

- Experience, e.g. better understanding of assets and their capabilities
- Learning, e.g. participation in future trial periods and benefits to the network
- Future benefits, e.g. reduction in carbon intensity by enabling additional renewable generation

7.1.5 Key Learnings and Recommendations for TP2

Market liquidity was low during TP1 with limited types of DERs and organisations. The key learnings are summarised in Table 27.

Table 27 - Outcomes from Feedback on Comparing and Contrasting DER Types

Key Learnings	Recommendations
There may be a barrier to entry for DERs with low levels of flexibility if the market price for SPM is insufficient to recover all fixed and variable costs. To make commercially viable, SPM needs to be stacked with other services (i.e. Behind the Meter services, DSO services, ESO services or a combination of all).	Participants should explore the impact of service stacking on revenue and attractiveness of Services. The impact of increased experience and automation[32] on revenue and economic feasibility of participation should be explored.
Some Services and timeframes are better suited to some DERs more than others. For example, due to Time of Use tariff, it seems that V2G chargers may not be best suited to the SPM service. Moreover, predictable DERs may suit season-ahead markets; whereas DERs which are difficult to forecast may be better suited to the day-ahead markets.	Participants should continue to explore which Services and timeframes (i.e., day-ahead and season-ahead). are best suited to their DER as further options are available to be explored throughout TP2 including scaled flexibility provision
Some baselining methodologies are better suited to some DERs more than others.	The project should continue to determine the most suitable baselining methods for different DER types to inform TP2 and beyond.
Some participants highlighted that their business was more interested in the Trials from a carbon savings point of view and many participants were motivated by their organisation's internal commitments to Net Zero.	The non-financial benefits of participating in the Trials (including carbon reductions) should be explored to encourage future participation.
For EMIC and EMEC services, learnings around pricing are ongoing, however the value of EMEC AND EMIC was found to be generally sufficient to cover participation costs and margin. Market liquidity was low during TP1; to inform how the market would operate in reality, the project would benefit from more commercially minded organisations participating in EMEC AND EMIC.	Participants should explore alternative pricing structures. For example, participants could explore calculation of margin as a percentage of revenue. Testing the pool route with multiple participants will provide learnings around pricing strategies and market competition.
The prices paid for SPM availability varied between DER types, with EVs demonstrating significantly higher unavailability (i.e., submitting more Unavailability Notices) than a fixed battery due to driver behaviour.	Rules for Unavailability Notices are to be reviewed ahead of TP2. Participants should consider the impact of any changes on commercial viability for various DER types.

7.2 Comparing and Contrasting different Holistic Business Models

Hypothetical value propositions were created for each of the Low Carbon Hub (LCH) DERs by considering their values framework, known as the "4 Ps":

- Planet: protecting our warming planet with a better energy system
- People: engaging and involving people in creating a better energy system

[32] It should be noted that automation has a capital cost that requires high asset utilisation to recover.

- Prosperity: generating collective wealth
- Perception: being transparent and a trusted partner; sharing knowledge and expertise openly

Value propositions were devised for each of LCH's asset-service combinations. An example for the Market Trial in which a hydro generator buys MEC from a school (see Figure 22).

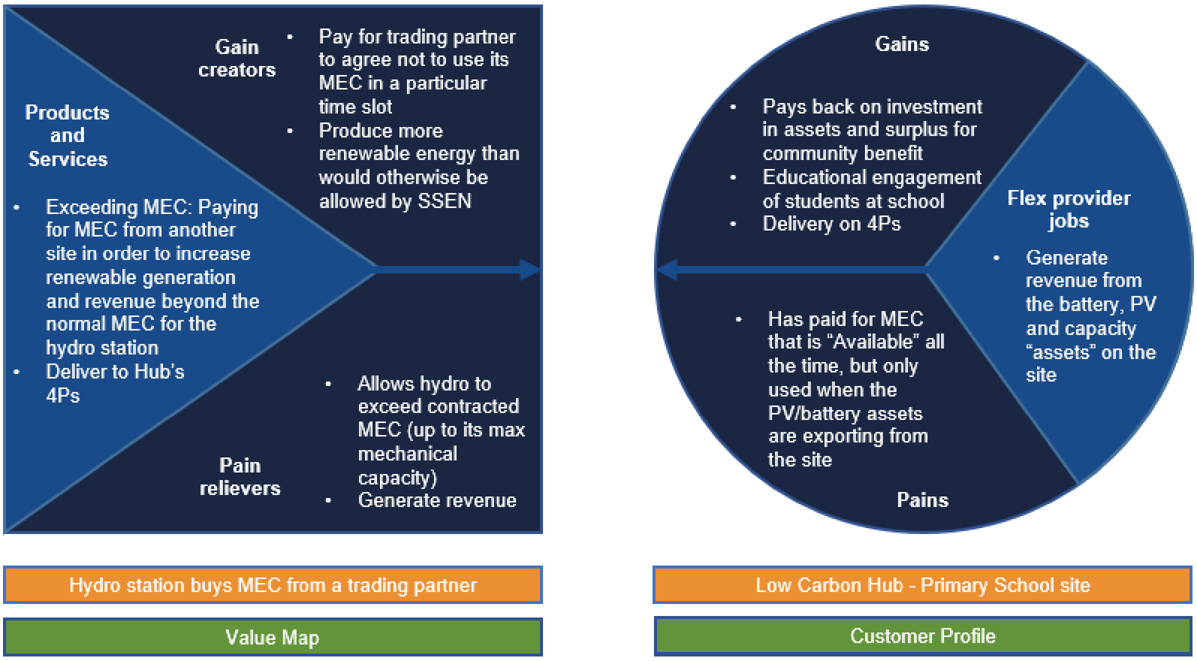


Figure 22 : Proposition Canvas for a MEC trade between a Hydro generator and a School

This is a LCH-centric framework; however, it is considered a suitable starting point to assess the significance of wider value creation and the extent that this could enable investment in a DER. The key learnings from this exercise are shown in Table . During TP1, there were limited assets and data available to inform analysis. Recommendations from this analysis will be used to develop a more rigorous analysis in TP2, in particular how to assess the costs and benefits of stacking services and assessing the business case for delivering Flexibility Services from an aggregated and optimised set of DERs.

7.2.1 Key learnings and recommendations on different Holistic Business Models

Table 28 - Key learnings and recommendations on different Holistic Business Models

Key Learnings	Recommendations
Buying MEC for hydro generator provided minimal value to LCH as it represented an addition to a core operating model (generation) which itself is limited by seasonal weather and technical capacity.	Assess whether monetary value from the delivery of services could be shared with other parties – for example the hosts of LCH assets.

Key Learnings	Recommendations
Reputational value may be created for LCH if the host of a DER (e.g., a local primary school or council) can demonstrate its enabling role in local decarbonisation. There may also be an educational benefit if LCH were to help these organisations understand how their DERs may be used to provide Flexibility Services.	The extent to which this provides significant additional value in terms of the local communities' (and organisations') perception of LCH could be investigated. Explore a combined business model for the Community Battery and school.
The asset-service combinations trialled in TP1 do, potentially, create value beyond pure financial benefits. This is highlighted by the fact that LCH and the Council chose not to charge for their trades.	Assess the value propositions for asset-service combinations that don't include LCH assets.
The financial business case will be important context for interpreting wider benefits.	The full financial analysis is also required to inform the interpretation of more holistic considerations.

8 Technical - DSO

8.1 Learnings from the Development of the WSC-PSA

The following are key to the development of the more advanced capabilities of a DSO:

- forecasting of demand and generation patterns within the operational timeframe;
- Power System Analysis (PSA) and network modelling; as well as
- Whole System Coordination (WSC).

The main progress on these topics within LEO / TRANSITION TP1 has focussed on Forecasting and PSA (as summarised below), with limited learnings delivered to date on the WSC.

8.1.1 Operational Forecasting - Methodology

The key steps used to deliver the TP1 operational forecasting solution are outlined below:

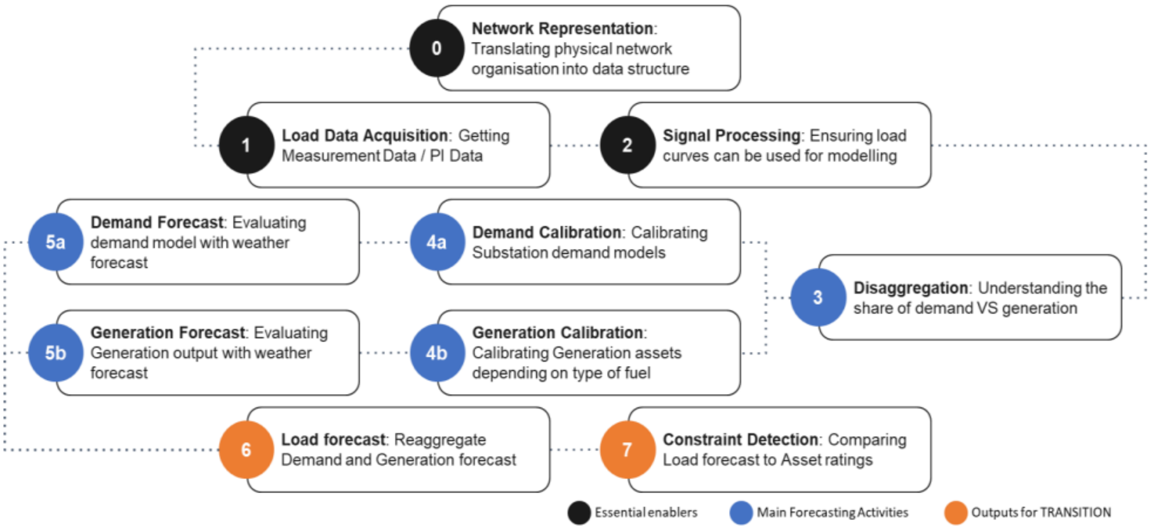


Figure 23: Key Steps to developing the operational forecasting solution, summarised from a report by SIA partners and SSEN[33]

This process might be summarised as:

- Gathering historical system net demand, generation and network topology, and weather data
- Disaggregating the system/network demand and generation into their underlying signals
- Training forecasting models on these underlying signals
- Re-aggregating the outputs of those trained underlying forecast models for flexibility market analysis when applied to expected near term weather trends
- Forecasting specific individual generators, as well as forecasts of demand at 11kV feeder, Primary Substation and BSP level

[33] TRANSITION-Load-Forecasting-Dissemination-Report-Final-V3.pdf (ssen-transition.com)

8.1.2 PSA Network Model Development

A detailed report[34] on the development of the network model outlines the key steps and inputs as summarised here:

- An integrated digital model of the electricity network, covering Extra High Voltage (EHV) and High Voltage (HV) (plus a simplified representation of Low Voltage (LV)) was developed from various sources[35]
- Generation, demand, switching configurations, asset ratings data, etc. were added to this model
- Representations of DERs registered to participate in the Flexibility Market was included
- The development of this model was conducted so that model inter-operability between different tools could be ensured
- The model was stress tested and further calibrated with respect to previous system studies around key snapshot operating points (e.g. winter peak studies)

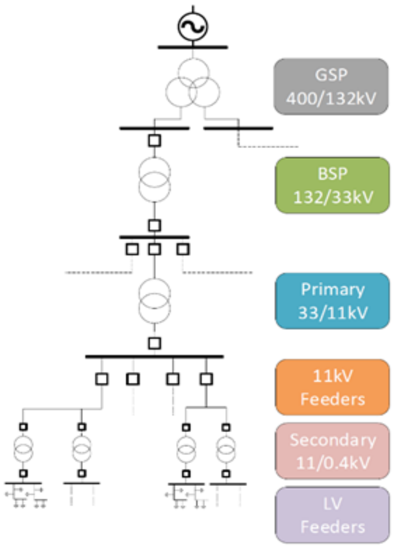


Figure 24: Representation of Network

The modelling focused in particular on the 6 BSPs that form part of the trial area of interest with separate models being developed for each BSP. A version of these models was then ready for transfer / upload to the WSC for support of the Flexibility Market Trials.

8.1.3 Analysis and Results

Operational Forecasting

The models were trained based on a certain 'calibration timeframe' segment of historical data, and then applied to a separate 'test timeframe' segment of historical data. Various metrics were applied to the performance of the calibration, for the expected forecast points. An example plot of the forecast Mean, Absolute, Percentage, Error (MAPE) metric is shown in Figure 25 for the Primary substations in the LEO / TRANSITION trial area. The performance of the demand models at Primary substations is well within acceptable levels, all below a MAPE of 20% (indicated by the orange line).

[34] Whole System Coordination Requirement Specification version 10, published by CGI and SSEN November 2019

[35] The EHV system model was sourced from System Planning models and the HV network model came from the outputs of another internal SSEN project Connectivity+

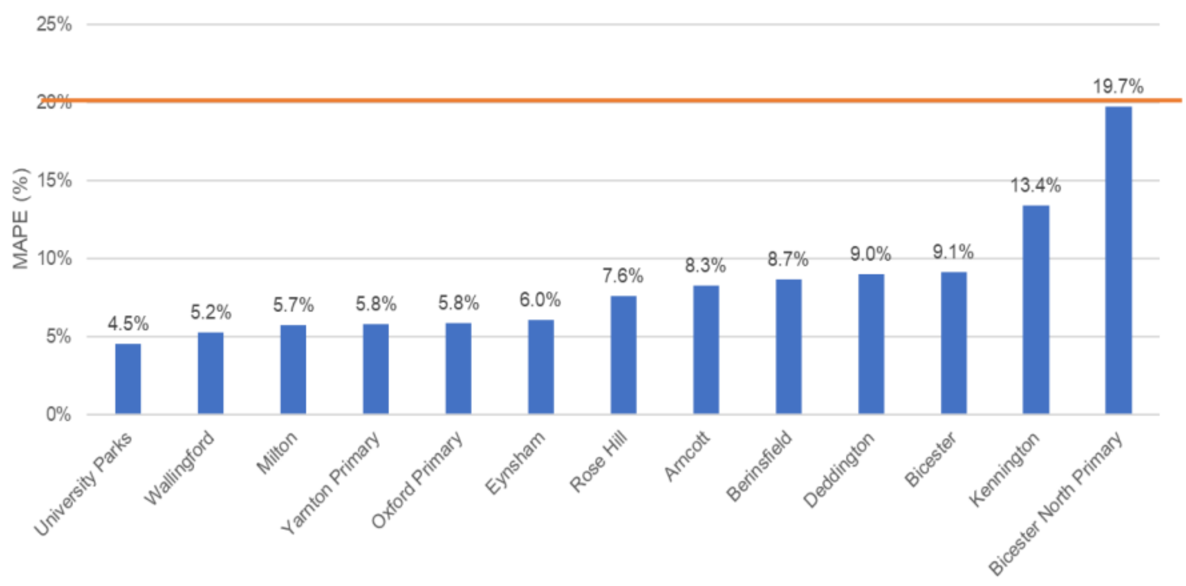


Figure 25: Mean, Absolute, Percentage, Error (MAPE) metric performance for the Primary substations in the LEO / TRANSITION trial area

PSA Network Model Development

Sample diagrams of the resultant voltage profile on the nodes within the Bulk Supply Point A (BSP) model is contained in the image below. As all the voltages are within reasonable ranges, this graph indicates that the PSA model that was developed converged and functioned generally as expected, providing confidence that it is ready for the application within the Market Trials.

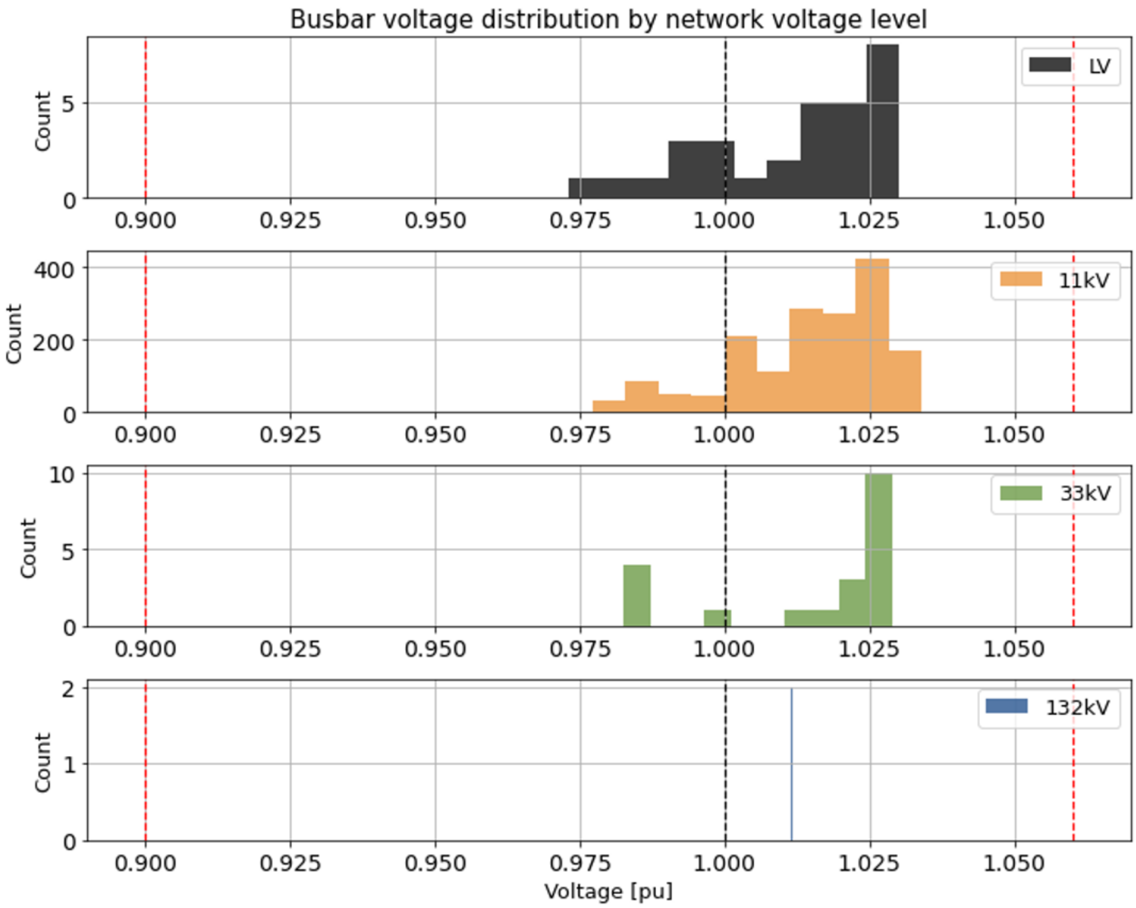


Figure 26: voltage profile on nodes within the BSP A model in a winter peak loading scenario

8.1.4 TP1 Outcomes

The key learnings and recommendations detailed in Table 29 will be used to:

- further improve the design of the systems and tools required for these DSO functions both within the lifetime of LEO / TRANSITION, and for the roll-out of DSO functions within BaU;
- provide insights into the datasets and data management processes required to support these tools in the future; and
- further inform and improve the planning for additional Flexibility Services in Trial Periods 2 and 3 in relation to these technical modelling and analysis matters.

Table 29: TP1 Learnings and Recommendations on Forecasting

Key Learnings	Recommendations
Good quality historical system data measured at substations is key to drive forecast model fitting performance - including network visibility and data from all voltage levels (EHV, HV and LV)	Connection to real-time or near real-time data measurements is essential to validate the quality of the forecasts. It also provides an opportunity to improve demand forecasts, capturing deviations from historical behaviours as the network evolves. This was especially valid in 2021, as load in 2020 was heavily impacted by the Covid-19 pandemic. Integrating this functionality would form a real improvement to the Load Forecasting solution implemented at the time of this report. It is planned to explore this in Trial Period 2 with a further development of the Sia forecasting platform.
Historical network connectivity data availability is just as important as historical net demand and generation measurements to adequately match consumption levels with connection arrangements for LV and individual phase connection.	
The identification of generators connected to the network, at all levels, is important to operate an accurate disaggregation, thus developing good demand models, even if few or no measurements are available for lower levels of the network	
Forecasting of Renewable Energy Sources is possible, and the use of reliable weather data is essential to drive quality of the forecasts	Procuring reliable weather data on a high temporal and locational resolution is essential to produce accurate forecasts of weather driven generation such as solar and wind.
Forecasting of non-renewable dispatchable generators is more challenging when only considering weather data and temporal parameters. Other variables, such as price signals, would be required to improve the performance of the models	Further analysis of other factors that contribute to the change in generation profile by non-renewable generators is needed. Especially those driven by market signals.
Probabilistic forecasting allows the representation of uncertainty which is critical in the operational time horizon. The use of weather ensembles enables this probabilistic view	Using probabilistic forecasting multiple scenarios of the network constraints could be produced giving the participants a measure of the potential risk/benefit.
The design of a simple, user-friendly forecasting dashboard interface is required to ensure suitable adoption of operational forecasting, and support decision-making processes	The forecasting dashboard could also incorporate advanced features, such as an API. This would allow queries from external parties that want to access data on the network constraints, giving them a chance to plan ahead and ultimately facilitating their participation in flexibility markets.
Automation of data collection and processing of alignment between network connectivity and measurements would be beneficial to scale up the Load Forecasting Solution that was deployed in this Oxfordshire region pilot study, to a full distribution network area	Standardising processes for data collection when commissioning network changes and upgrades is required. Ultimately there is a requirement for machine readable historical data of network connectivity that can be matched to the historical network data.

Table 30: TP1 Learnings and Recommendations from PSA Model Development

Key Learnings	Recommendations
Integrated PSA network models that represent various voltage levels in the system are important to support flexibility market analysis and in particular consider the contribution from assets connected lower down in the network.	The EHV and HV PSA model developed to date has been used in the TP1 and will be further used in future TPs to support the quantitative modelling required for the flexibility market trial events.
Developing the PSA models that are compliant with the Common Information Model (CIM) format is desirable to ensure inter-operability and compatibility of different data sources across different software systems and tools.	The network modelling to date has taken a simplified approach to LV modelling, (e.g. representing all LV feeders as one node, and ignoring technical issues like 3-phase modelling and phase imbalance etc). Later Trial Periods will explore more detailed LV models for our Trial Areas, in particular focussing on some of the Smart and Fair Neighbourhood (SFN) zones
The 11kV system CIM files exported from SSEN's Connectivity+ project will be constantly evolving, as the physical network changes – improved processes for version control will be useful in future.	Exploring the option of automating the CIM file "bundling" process of 11kV feeders into groups as part of Primary substation area, would be beneficial to speed up the overall model development process, and will be explored further in TP2
The process of converting and pre-processing these CIM files into network models that are usable by a PSA software tool, like PowerFactory, needs to be as automated as possible to allow for constant updates.	Workflows for processing CIM files need to be properly documented and standardised so that they are reproducible and automated in future iterations

Appendix A Glossary of Terms

The Glossary of Terms for the LEO project can be found here.

Additional Terms used by the TRANSITION project can be found here.

The Terms and Definitions produced by the Open Networks Project can be found here.

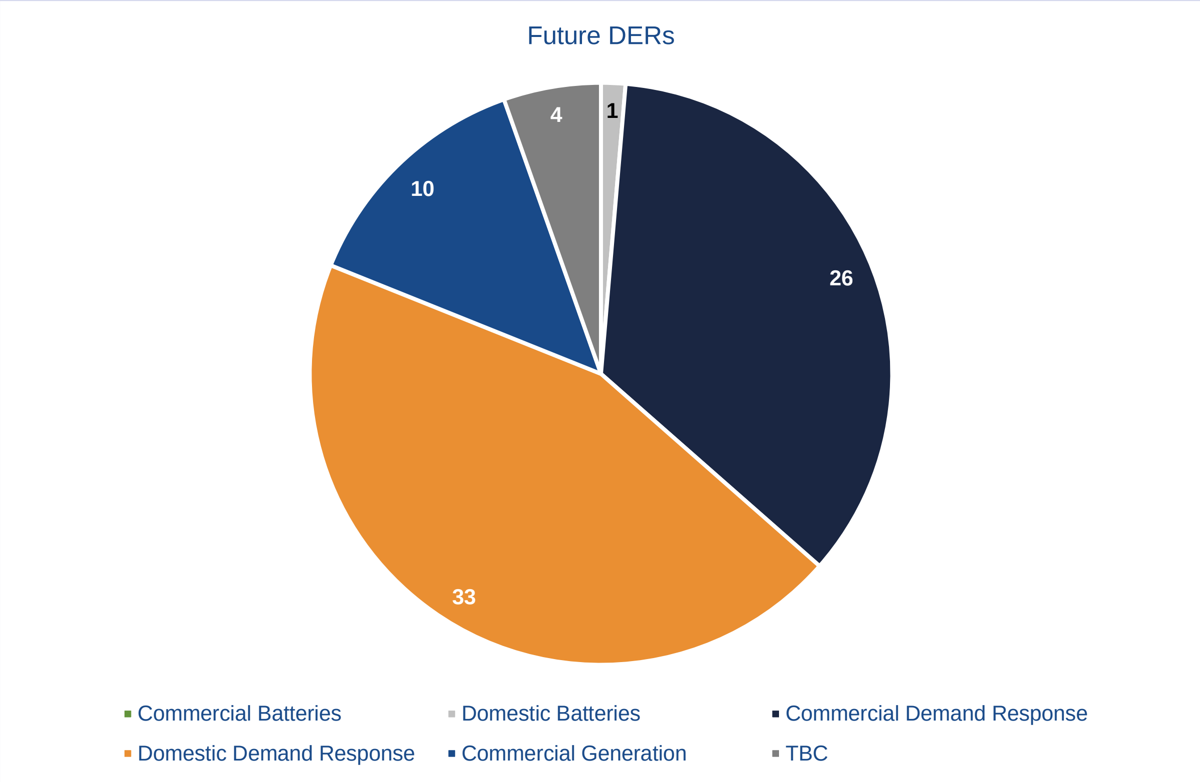
There are some terms used in this document that do not yet appear in the Glossary of Terms. Working definitions are provided below:

Term	Definition
Bulk Supply Point (BSP)	A point on the transmission network, generally at 132kV level, where electricity is delivered to the DNO for delivery through its distribution network to users' premises.
Common Information Model (CIM)	A standardised file format, used as means to transfer data between different systems in a standardised manner.
Distributed Energy Resource (DER)	A Demand Asset, Generation asset or Storage asset connected to the Distribution Network that may be able to provide Flexibility.
Distribution Network Operator (DNO)	The organisation that owns, operates and maintains the Distribution Network in one of 14 regional areas that delivers electricity to industrial, commercial and domestic users on behalf of Electricity Suppliers.
Distribution System Operator/Operations (DSO)	The functions and services needed to run a smart electricity distribution network in the interests of all Consumers / Prosumers. DSO functions will be delivered by a range of parties.
DSO-Enabled Services	Flexibility Services that are not procured by the DSO but that are traded between two peers on the network. In TRANSITION these are the trading of export capacity or trading of import capacity on a Peer-to-Peer basis. Although not procured by the DSO, it plays a role in enabling these to occur.
DSO-Procured Services	Flexibility Services that are procured directly by the DSO with the purpose of supporting the local distribution network in some way.
Exceeding MEC / MIC	To go above the contractually agreed maximum amount of electricity (expressed in kW or kVA) permitted by the DNO to be exported from your site (Maximum Export Capacity, MEC) or imported to your site (Maximum Import Capacity, MIC).
Extra High Voltage (EHV)	For the purpose of these trials Extra High Voltage is 33kV.
Energy Costs	The electricity costs associated with the delivery of Flexible Service. Particularly for storage assets – for example, the main cost incurred for electric vehicles was the electricity costs associated with charging the vehicle before and after service.
Flexibility Services Agreement (FSA)	The Flexibility Services Agreement **(**FSA) is the legal contract between the DNO and the provider of Flexibility Services. It sets out, amongst other things, the terms of the trades, the expectations on both sides and any penalties for non-delivery of service. The TRANSITION FSA is based on an industry standard template developed through Open Networks.
Funding Asset Costs	Capital expenditure (CAPEX) associated with funding and enablement of DER to participate in flexibility markets.
High Voltage (HV)	For the purpose of these trials High Voltage is 11kV.

Term	Definition
Legal Costs	Costs associated with legal reviews. During TP1, most significant legal costs were associated with reviewing of the trial contracts, particularly the FSA due to its length.
Low Voltage (LV)	For the purpose of these trials Low Voltage is anything below 1,000V.
Maintenance Costs	Costs associated with any maintenance of a DER during participation in Flexibility Services.
Margin	The difference between the income from service and the amount of money required to produce it.
Monitoring & Control Costs	Costs associated with monitoring and metering of DER and any control required to dispatch its Flexibility.
Net Zero	We will have achieved 'net zero' when the amount of greenhouse gas we produce is no more than the amount being taken away.
Neutral Market Facilitator (NMF)	The TRANSITION Neutral Market Facilitator (NMF) is an IT platform that will in many cases automate the processes required around the procuring of flexibility services and will be connected to a number of other systems such as Forecasting and Power System Analysis tools. It has been developed to be transparent and non-discriminatory and has a key role in establishing markets for Flexibility Services. It can be used by those selling a Flexibility Service to; • find requests for those wishing to buy Flexibility Services; • submit responses to requests for Flexibility Services; • find if their response has been accepted or not; • find the instruction to deliver a Flexibility Service; • provide updates or changes to the availability of their DER; • find other instructions from the DNO/DSO; and • share their data to verify delivery of a flexibility service
Peer-to-Peer (P2P)	In the context of our trials, this means either a generator, storer or user of electricity who enters into a DSO-Enabled trade, with one peer being the seller and one the buyer. To do this both peers must be connected at the same point on the distribution network.
P2P Services	Flexibility Services traded between market participants (but not the DNO, DSO or ESO although any one of these entities may enable the trade) and includes DSO-Enabled Services.
P2P Termsheet	The P2P Termsheet contains the contractual terms both parties agree to comply to in order to trade spare capacity.
Personnel Costs	Staff costs associated with participation in market, including pricing and interaction with the NMF.
Power Systems Analysis (PSA)	Assessments of the power flows and voltages on the electricity network using different demand and generation scenarios. PSA studies can be done across all timeframes, from long-term years-ahead for system planning, weeks/months-ahead for maintenance scheduling, down to the very short term for assessing the present network flows in real-time. The objective of PSA is generally to make sure that electricity network stays within allowable performance criteria for current and min/max voltages.

Term	Definition
Service Stacking	The ability of a market participant to deliver more than one service in the same or adjacent half hour periods usually in multiple markets (i.e. DSO services, P2P services, ESO services) as a means of maximising revenue streams.
Smart Local Energy Systems (SLES)	A Smart Local Energy System is one where local and national energy infrastructure, people/communities, and technologies work together in an intelligent integrated way to make, move, store, sell, use and conserve energy locally. A successful SLES creates value to the community it serves and should respond to the community's objectives.
Smoke Test	A series of tests used to check if the functionality of a system, from individual blocks to the entire system, work as expected. They are used to build confidence that systems and processes being used work as expected.
Sustain Peak Management (SPM)	A flexibility service most often used in 'winter tea time' situations in which the demand for electricity is predictably at its highest. Incorrectly managed this can create stress on parts of the electricity network. To prevent this, the DSO can procure this service some time ahead of need which can be provided by either an increase in generation, decrease in demand, or call on locally stored power in batteries.
Temporary Capacity Variation Notice (TCVN)	A notice that permits a temporary increase in either the maximum import capacity or maximum export capacity of a site. It is provided by the DNO to the party who wants to exceed their export or import capacity and may include some limitations.
Trial Period	The TRANSITION / LEO market trials are running in three calendar periods as follows; • TP1 started in October 2021 and ran until February 2022 • TP2 starts in May 2022 and runs until September 2022 • TP3 starts in November 2022 and runs until February 2023 The breaks between these three trial periods allow us to consolidate our learnings and use these to influence the plans for the next trial period. Each trial period will be testing the markets for a different set of flexibility services as well as increasing in their complexity as new technical and commercial elements are introduced.
Water Management Costs	Costs incurred with moving and storing water (particularly for river hydro) to enable DER to participate in flexibility service.
Whole System Coordinator (WSC)	The Whole System Coordination (WSC) is an IT tool that integrates data from a variety of different sources to quantify the requirements for network flexibility across different timeframes.

Appendix B List of DERs and status



Appendix C Output from Gaming Workshop

The output from the feedback sessions is summarised below and will be used to inform the development of TP2, the market rules and the contractual arrangements.

Scenario	Outcome
Auctions – are there any opportunities which could arise for Market Participants during auction? Could the selection of Responses for either DSO-Procured services or DSO-Enabled service give rise to gaming opportunities?	▪ The DSO has access to information on the relative performance of individual DERs and types of DERs that can be used in their decision making, which is not available to affected market participants. ▪ Reports on NMF auctions are available in real time and can be used to manipulate the market as they are available during an auction and could influence the behaviour of market participants.
Response to an auction Request; is it acceptable for a market participant to submit an auction response relying on a forecast of rain to materialise? The BMR states "Market participants should only offer a DER in a flexibility market to deliver … flexibility services if the DER is expected to be available to deliver the flexibility services".	▪ Many DERs depend on some form of forecasting (weather, demand, or behaviour). ▪ DERs with a low variability due to forecasts would be suited to auction timescales of more than week and those with a high variability would be more suited to shorter timescales (week ahead and within week). ▪ The DSO is affected by the uncertainty of delivery which could affect the security of supply.
Pricing – could market participants manipulate the availability price and / or utilisation price to game the market? The FSA requires a combination of these prices to be submitted which, together with a DSO assumption on the number of uses for a service, is used to derive a total contract value that determines those DERs that may be asked to deliver the service.	This is a possible gaming opportunity in TP1, it was possible for market participants to submit a very low availability price and a very high utilisation price. During the delivery period, the DER availability could be manipulated to avoid delivery. This loophole was closed during TP1. ▪ The TP1 plan included the scheduled delivery times and it was possible to submit a very low utilisation price and very high availability price at the week-ahead stage and change availability close to delivery. The penalties for poor availability mitigate against this action. This situation is unique to the Trials and does not exist in BaU. ▪ In BaU scenarios when events are forecasted outside of trial periods this would not present an opportunity for gaming.
Market Share; could a single buyer or Service Provider dominate the market and manipulate market prices to their own gain? The BMR forbids market abuse or manipulation: "Market participants should not use inside information to manipulate the delivery or price for flexibility services or the flexibility market".	▪ Unlikely to be a gaming opportunity. ▪ If the DSO is the sole buyer for a service, market manipulation is mitigated as the regulatory framework treats CAPEX and OPEX the same which also reduces the desire for the DSO to offer low costs for flexibility. There is a lack of transparency that the additional opportunity value for flexibility as it provides the DSO with a short-term solution until there is more certainty in the future. The DSO will also have a ceiling price for each service and rigid procurement rules with which they will comply. ▪ For other services, there needs to be a willing buyer and seller and. although the buyer may have another unrealistically low price they are willing to pay for the service or the seller has an unrealistically high price they are willing to accept for the service.
Contract Cancellation – could a market participant cancel one contract in favour of another nearer to delivery? If so, would this give rise to gaming opportunities? The FSA	▪ Not a gaming opportunity at present. ▪ This action is not currently prohibited by the FSA (see opposite) but the BMR states: "Market participants have an obligation to deliver a flexibility service in accordance with the contract for that flexibility service."

Scenario	Outcome
allows service stacking if it does not interfere with the delivery of services and provides the right of termination for repeated failures to deliver[36].	▪ The market participant would be prevented from this action at present as the design of the NMF does not currently allow coincident delivery windows to facilitate service stacking.
Unavailability Notices; is it acceptable to submit an Unavailability Notice if a DER cannot meet the full capacity accepted in an auction at all times? The FSA states an Unavailability Notice should be submitted "as soon as reasonably practicable" to inform the DSO that a DER will be unavailable during a particular delivery window for a service[37].	▪ This presents a possible gaming opportunity. ▪ Market participants have used Unavailability Notices to advise of changes to capacity and there is a legitimate concern that DERs relying on forecasting (DERs that rely on water levels or rely on user behaviour) could be penalised for such changes in availability when it is a legitimate operational issue and allows the DSO to take alternative action.
Service Stacking - is it gaming to stack services in the same or adjacent Settlement Periods? The FSA allows service stacking if it does not interfere with the delivery of services and provides the right of termination for repeated failures to deliver.	▪ Market participants may stack services across DSO and ESO markets unless stacking is prohibited for specific service, e.g. STOR is an exclusive service, although work is progressing to share information that would provide visibility of such activities to prevent or reduce conflicts. ▪ There are several situations where the effect of service stacking is uncertain, including; stacking with services that reward a reduction in demand at certain times (TRIA response), stacking DSO-Enabled services to deliver DSO-Procured services and the effect of stacking services on the baseline.
MIC/MEC responses – could the buying or selling of spare capacity be considered gaming? The P2P Termsheet requires buyers and sellers to adhere to the revised import or export capacity (accounting for the effect of the trade).	▪ The buying or selling is not a gaming opportunity but could lead to gaming. ▪ A buyer or seller of spare capacity are allowed to import or export up to their revised capacity (accounting for the effect of the trade). ▪ A buyer or seller who then exceeds the revised capacity would be in breach of the P2P Termsheet (although it is unclear how the other party would become aware of this) and this action would be detected by the DSO under BaU processes (although the timescales are unclear). ▪ The buyer of capacity could resell that capacity through a P2P Service for a higher price. This is explicitly prohibited through P2P Termsheet and the BMR except under extraordinary circumstances and would be captured by the processes within the NMF.
Data, Baselining and Verification – could market participants manipulate their metered data to increase revenue or game the market? Missing data is addressed in the FSA, under certain conditions[3636].	▪ This is a potential gaming opportunity. ▪ Market participants could deliberately manipulate data used to determine the baseline or the level of delivery to increase revenue or mask poor performance. ▪ The baselining mechanisms do not adequately account for preconditioning of some DERs (typically batteries, electric vehicles, storage hydro and thermal DERs), particularly where the preconditioning occurs near delivery and would not occur except for the delivery of the service. Batteries present a challenge where

[36] Flexibility Service Agreement Schedule 5 Paragraph 2, clause (h)(iii), published by TRANSITION 23 August 2021
[37] For further details of the Unavailability Notices submitted during TP1, see section 0

Scenario	Outcome
	they can change from charging to discharging within seconds and this could provide a false indication of the flexibility delivered. ▪ The FSA allows the DSO to conduct an audit of data (and they receive MPAN data) and the BMR provides sanctions in the event of manipulation. ▪ Standardised metering could help mitigate potential gaming issues but this could become a barrier to entry for DERs with lower levels of flexibility.