SP Electricity North West

BiTraDER

Deliverable 8

Final Report

September 2026

Version

Version	Date	Author	Status	Comments
V1.0	17/07/2026	Christopher Greenfield	First draft	For review
V1.1	28/07/2026	Christopher Greenfield	Second draft	Updated following peer review
V1.2	21/09/2026	Christopher Greenfield	Third draft	Updated following peer review

Approval

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Glossary

ANM	Active Network Management - The use of distributed control systems to continually monitor network limits and provide signals to curtailable connections or flexible services to modify outputs in line with these limits.
API	Application Programming Interface
BAU	Business As Usual
BESS	Battery Energy Storage System
CB	Circuit Breaker
CBA	Cost Benefit Analysis
CEM	Common Evaluation Methodology – Framework which compares the cost of asset-based solutions against flexible alternatives
CHP	Combined Heat and Power gas generator
CI	Curtailment Index – Determines the order for curtailment
CLA	Constraint Look Ahead – A forecast from the ANM system of future localised network constraints
CMZ	Constraint Management Zone – An area of the network where ANM is used to manage local constraints
Connectee	Any individual or company connected to the electricity distribution network
Constraint	A demand greater than network ratings or voltage outside statutory limits. In this definition demand is used in the context of the load on the network (including generation).
Curtailable connection	Connection arrangements which allow Electricity North West to signal, in real time, a curtailment of demand or generation when there are network overloads or restrictions affecting the network local to the connectee whilst the network is operating in an intact, system normal state. Connectees will generally be given a curtailable connection where offering a non-curtailable connection would require network reinforcement which has cost and time implications on them being connected

Curtailment	The turning off, or down, of a connectee's import or export to alleviate a constraint based upon contracted and agreed principles of available capacity
Curtailment obligation	The requirement for a connectee to provide curtailment. The specific details of this requirement will be stated in their connection agreement
DFES	Distribution Future Electricity Scenarios – Long term forecasts of electricity uptake based on different future societal and economic scenarios
DNO	Distribution Network Operator – An organisation that owns, operates and manages the electricity infrastructure that distributes electricity from the transmission network operated by NESO, to end users (commercial and domestic properties)
Demand connection	An asset that is connected to the distribution network and requires import supply
Demand increase (flexible service)	A connectee providing a flexible service where the outcome is an increase in demand (this could be provided by either generator reducing export, or a demand connectee increasing import within their maximum import capacity limits)
Demand reduction (flexible service)	A connectee providing a flexible service where the outcome is a reduction in demand (this could be provided by either generator increasing export within their maximum export capacity limits, or a demand connectee reducing import)
EHV	Extra-High Voltage – 132,000 / 33,000 volts
ENA	Energy Networks Association
Flexibility	The modification of generation injection and/or consumption patterns, on an individual or aggregated level, often in reaction to an external signal, to provide a service within the energy system
FMAR	Flexibility Market Asset Register – A proposal by Ofgem to standardise flexibility market participant asset registration
FSP	Flexible Service Provider
HV	High Voltage – 11,000 / 6,600 volts
kW	Killo-Watt
LIFO	Last In First Out – Curtails the most recently connected customer first and earliest connected last

LV	Low Voltage – 415 / 230volts
Merit order list	A list of connectees in a specific order for the ANM system to action
MOMS	Merit Order Management System – A key component of the ANM system to handle merit order lists
MW	Mega-Watts
NESO	National Energy System Operator – An organisation that monitors, controls and actively manages the power flows on the electricity transmission network to maintain a safe, secure and reliable electricity supply. NESO is a natural monopoly in the flexibility market, acting as a neutral facilitator
NIA	Network Innovation Allowance
NIC	Network Innovation Competition
NMS	Network Management System
Non-curtailable	Under system normal conditions, a connection which is planned and operated such that it should not be curtailed; however, it may be curtailed in the event of the loss of any one or more elements (e.g. an overhead line route, a transformer, an underground cable)
PPA	Power Purchase Agreement – A contract in which a generator such as a solar or windfarm agrees to sell electricity to a buyer at an agreed price over a set period
RES	Renewable Energy Source
SCADA	Supervisory Control and Data Acquisition – Operational IT system to monitor and control remote assets
SP ENW	Scottish Power Electricity North West
TRL	Technology Readiness Level – Used to assess progress of technology throughout a project
UI	User Interface

Executive Summary

This report is the eighth deliverable for the BiTraDER (Network Innovation Competition) NIC project which is being delivered by SP Electricity North West (SP ENW) and its partners. The aim of this report is to explain the project progress to date, including an overview of each work package and the findings from the finalised Cost Benefit Analysis (CBA).

This is the final deliverable report for the BiTraDER project and the overall lessons learned throughout the project will be discussed and collated to inform the recommendations for implementing the project into Business As Usual (BAU).

It builds upon the previously delivered and published report for the BiTraDER project:

1	BiTraDER Customer Engagement and Trading Scenarios	30/11/22
2	BiTraDER Trials Plan, Trading Rules and Initial Specification Report	30/06/23
3	BiTraDER Trading Platform Design	03/09/24
4	BiTraDER Architecture Build Lessons Learned Report	10/03/25
5	BiTraDER Simulation Trials Report	28/05/25
6	BiTraDER Network Trials Report	29/05/26
7	BiTraDER Functional Specification	30/06/26

The main objective of the BiTraDER project is to demonstrate how access to a neutral market allows connected resources to trade their obligations bilaterally, encouraging more of them to offer flexible services, increasing availability of flexibility and thereby reducing whole system costs.

The project is due to end on 31/07/26, and the learnings and outcomes will continue to be disseminated until the end of 2026. The aims, objectives and all deliverables outlined within the full submission document have now been met.

Outcomes of the Project

The BiTraDER project demonstrated that a bilateral market for trading curtailment obligations is both technically feasible and attractive to industry participants. The project evolved from a conceptual design into a fully functional market capable of supporting registration, trading, performance verification and settlement. This was tested through simulation and live trials which validated its operation in a real-world environment.

Key findings show that customers value the ability to manage and transfer curtailment risk, particularly renewable generators seeking to optimise network access and revenue opportunities. The project also highlighted the importance of strong stakeholder engagement, market transparency and sufficient liquidity to support effective price discovery and participation.

The BiTraDER platform was successfully integrated with existing DNO ANM systems, demonstrating the capability to exchange network and dispatch data across operational platforms.

Participants stressed the need for future market arrangements to align with existing wholesale, balancing and ancillary service markets to maximise participation, liquidity and overall market effectiveness.

Main Conclusions

BiTraDER successfully met its objectives, demonstrating that a bilateral curtailment trading market is both viable and attractive to participants. The project demonstrated peer-to-peer trading through a series of live network trials which validated the operational processes required to enable the market.

The project showed that bilateral trading can improve network utilisation, provide customers with greater flexibility in managing connection arrangements and help defer traditional network reinforcement. The CBA indicates that these benefits could grow significantly as flexibility requirements and market participation increase.

While challenges were identified around liquidity, transparency, price discovery and dispatch arrangements, participants still viewed the concept as credible and compatible with existing operational practices.

Overall, BiTraDER has established a strong foundation for future local flexibility markets, demonstrating how bilateral curtailment trading can benefit network operators, flexibility providers and connected customers while supporting wider decarbonisation objectives.

Further details on the learning outcomes and conclusions from the project can be found in section 13.

1 Introduction

As part of the UK's journey toward net zero, Distribution Network Operators (DNOs) are experiencing an increase in requests by customers to connect low carbon, renewable energy sources to the network. These connections can cause network constraints which are usually resolved through expensive, time-consuming and disruptive network reinforcement.

As a more cost-effective solution, DNOs have introduced curtailable connections and flexible services which, when used alongside advanced network automation algorithms such as Active Network Management (ANM), can control the customer's generation or demand output in real-time to resolve constraints.

Curtailable connections allow customers to connect to the network without the need for traditional reinforcement. Therefore, these connections are lower cost and can be delivered within shorter timescales than a 'non-curtailable' connection. When accepting a curtailable connection, a customer accepts the obligation to curtail their asset's export or import, in response to a request from the DNO, under certain network conditions. This is referred to as a 'curtailment obligation' and the specific details are stated in the customer's connection agreement.

Although these connections are lower cost and quicker, many customers are hesitant to accept them due to the inherent risk of being curtailed, and the associated commercial risk. Instead, some customers prefer to pay more and wait for a non-curtailable connection with negligible risk of being curtailed. In the case of low carbon generation such as solar, owing to the high capital investment required to establish the facility in the first instance, customers need certainty of a high in-service utilisation factor, meaning they are particularly sensitive to the risk of curtailment and much less likely to accept a curtailable connection.

Additionally, customers can provide a 'flexible service' to the DNO by agreeing to increase generation output, or reduce demand, at times defined by the DNO in exchange for remuneration. Owing to the long-term commitment associated with a flexible service contract, some customers are similarly hesitant to offer this. The commitment can be perceived as a barrier if customers are unable to meet the contract requirements over a prolonged period (i.e., a year).

BiTraDER seeks to allow new and existing customers to mitigate the risks associated with curtailment obligations by enabling customers to trade their curtailment obligations bilaterally. BiTraDER will also provide an opportunity for customers to participate in flexibility on an 'ad hoc' basis, removing the risk associated with long term contracts and boosting liquidity in the market.

2 Overview of BiTraDER

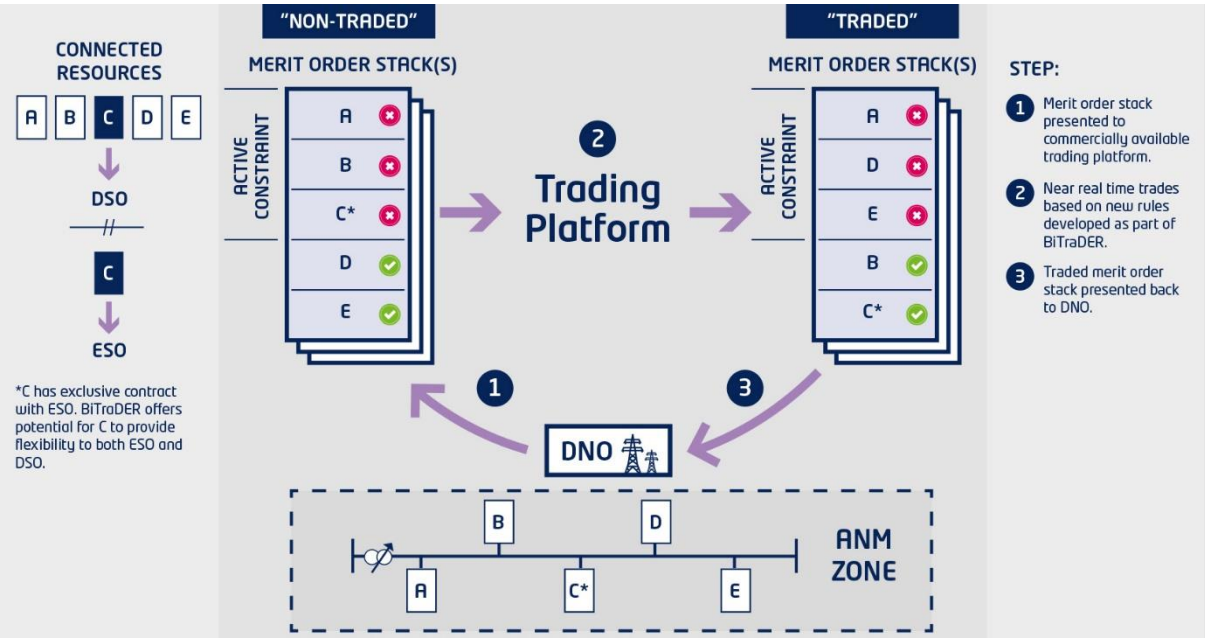
The objective of the BiTraDER project was to investigate, design, build and trial, a brand new and highly innovative market allowing resources connected to the distribution network to trade their curtailment obligation bilaterally.

The project assessed current and future customers' appetite for bilateral trading. This included understanding the data requirements to support operation of the market, designing the interfaces needed to present all necessary information to the trading platform, developing the bilateral market

trading rules determining what is and isn't a valid trade, exploring the market's ability to operate in near real-time, and determining the functionality required to return the output of the market to the DNO and National Energy System Operator (NESO) systems for execution in real time.

BiTraDER is designed to facilitate independent trading, therefore SP ENW will provide the necessary information to the market and receive the output of the market after close of trading. The project has examined the role of the market administrator and who might be best placed to operate the market in BAU. Figure 1 shows the high-level illustration of the trading process as per the BiTraDER full submission document.

Figure 1 BiTraDER illustrative method



BiTraDER has been completed in six phases, over a four-year period:

1. *Customer engagement* – engagement and recruitment of customers to inform the design of the trading rules and platform, during the design phase, and to participate in trading during the simulation and live trial phases.

2. *Design* – development of the core trading scenarios, market principles and trading rules, including validation and practical challenges associated with enabling trades. Design of the trading platform and end to end data architecture, considering cyber security and other associated risks. Capture of the technical requirements and the interface considerations for integrating the trading platform with the SP ENW systems.

3. *Build* – build and test of the trading platform and data architecture using the outputs of the design phase. The acceptance criteria for testing were developed during the design phase.

4. *Simulation trials* – a series of tests were run using simulated network models and customer assets, allowing customers to participate in simulated trading of their curtailment obligations.

Following the simulation trials, a 'stage gate' provided the opportunity to ensure that the plan for implementation of the live trial was both reasonable and deliverable within the constraints of the approved project. Should the project pass the stage gate we will move to the live trial phase, otherwise we will progress immediately to project closedown and BAU transition.

5. *Live network trials* – a live trial of trading covering a specific area of the SP ENW network, including the curtailment of assets connected to our network.

6. *Closedown and BAU transition* – analysis of the costs and benefits of BiTraDER and the production of a closedown report for dissemination. Develop the process for transition to BAU, provide training to internal planners and operational engineers on all new codes of practice, and publish a functional specification for BiTraDER.

3 Customer Engagement

Customer engagement was a key undertaking throughout the project and it was a necessity to ensure the market could be robustly tested. At the start of the project, the appetite for BiTraDER was unclear, with the only certainty being that the number of distribution network constraints is increasing and a potential need for a more localised flexibility option may be of some benefit.

The initial customer outreach set out to introduce interested stakeholders to the BiTraDER concept. Through an online customer webinar, followed by an in-person workshop, a total of 17 organisations, who manage or own a diverse range of asset portfolios and with experience of curtailment signed up to provide their input.

Learnings were however limited, since most attendees had no direct experience managing curtailable assets. Few also had direct experience in the trading, though useful conversations were had on payment structures, timelines and a desire for market transparency, which helped to inform the initial set of trading rules. Furthermore, conversations on the integration of existing assets helped to provide early insights into the potential design of the trading platform.

A postworkshop survey was requested for attendees to fill out and provide any further details that were missed at the workshop. Following review, a 1-2-1 call was set up with a selected few customers to further understand the integration requirements with the trading platform.

What did prove difficult was maintaining the engagement following this initial contact and this was reflected in the lower number of attendees at workshop than signed up. This ultimately was a key theme throughout the project. It was relatively simple for stakeholders to take a keen interest and gain an understanding of how BiTraDER could help them. However, mobilising stakeholders to attend events and provide meaningful input was challenging, even though the cost of attending such events was reimbursed by the project.

This theme is not unique to BiTraDER and is common on other innovation projects. The reality being that existing BAU activities will likely take precedence over an uncertain innovation activity that may not materialise fully for 5 – 10 years, so the challenge of continuing engagement on innovation will remain.

Despite this challenge, throughout the project a small but committed group of participants did continue to be engaged and their contributions helped drive the outcomes that were needed, and at the time helped inform the first draft of the trading rules report.

Following the initial engagement, it was decided that these initial set of trading rules should be tested prior to them being implemented into the trading platform. This would be done through the mini trials workshop which required additional customer outreach. The workshop was promoted on a LinkedIn post and was shared on all the partners' pages.

This was followed by an opportunity for any new interested customers to attend a pre workshop session. The aim of this was to provide an overview of the project and clarify customers understanding prior to the event.

To improve engagement, the outreach was carried out well in advance of the workshop and factors such as location, duration and style were identified to improve chances of attendance.

The workshop itself was attended by seven organisations. It was highly successful and was attributed to the active engagement of key industry stakeholders in helping the project team gain an understanding of how the BiTraDER market could work.

As opposed to the previous workshop, the attendees had a more diverse range of asset portfolios and connection agreements to help drive additional discussions and insights. What was seen as particularly helpful was ensuring attendees were briefed on the subject and clarifying beforehand what exactly was needed from them on the day, which helped drive the engagement.

The outcome from the mini trials workshop helped shape a finalised version of the trading rules and platform design. A post workshop survey was again handed out afterwards, with a view to securing interest in the attending the next phase of trials, the simulation trials.

There was strong interest from the mini trial attendees to attend the simulation trials. This was reaffirmed with an email response a few months after the trials. To supplement attendance, another LinkedIn post was released to target new organisations, and it was from this LinkedIn post that another key organisation joined for the simulation trials.

An introductory meeting was held prior to the simulation trials. These trials took place over a series of months and the timing of events was critical to enable them to work effectively. So, a clear, concise message of what the trials where and expectations from participants was vital.

After each trade, a virtual session was arranged to discuss the trade outcomes and provide more information on each scenario. This was designed to assist participants in understanding how a successful trade was matched and different intricacies in the way the market works. In addition, the project team wanted to ensure the necessary support was available if needed.

Finally, once all the scenarios were complete, a final workshop was held to conclude the trials, with outcomes shared amongst the participants. The simulation trials provided a vital opportunity to test the platform interface, settlement requirements and the performance verification element in a controlled environment, separate from the live network.

Since these trials covered a period of months, continued engagement throughout was required to maximise the outcomes. This was again a challenge. Some customer notified the team stating that they did not have capacity to stay involved in the trials due to competing priorities. This is an understandable reality and, in some cases, affected the quality of the trades. For instance, on occasion the project team had to supplement bids and offers themselves to get a trade match in certain scenarios. Whilst this did decrease realism of the trade, it helped participants to understand how a trade was matched.

The overall customer engagement throughout the simulation trials was successful, owing to a select group of participants who were committed to the project. Useful insights were developed including further refinement of timings of a trade, conversations about different baselines and importantly how trials could be improved further in preparation for live network trading.

The potential benefits of progressing past the project stage gate to the live network trials were clear. The engagement continued to be positive and stakeholders valued what the project team was trying to achieve. This message was effectively relayed to Ofgem and approval to progress was granted.

One of the requirements for the live network trials was that participants needed to be connected within the SP ENW network. Unfortunately, this meant that some of the more engaged participants from the simulation trials, would not be able to attend who were connected elsewhere across GB.

Getting sufficient connected assets in the same area of the SP ENW network to participate in the live network trials was a particular challenge and proved difficult from a customer engagement perspective, not through lack of technique or will, but due to low liquidity of available assets.

The engagement was conducted through two different routes – local universities and Electron's FSP register. One-to-one calls were arranged with each potential participant to discuss the project and what was required to take part. If an asset was considered suitable, then participants were invited to register onto the trading platform.

Suitable scenarios could be determined once the number of assets signed up was adequate. An introductory workshop was arranged for the participants to gain further understanding of the project and timeline.

The live network trials ran over a period of two weeks. Unlike the simulation trials, the project team took more of a hands-off approach to test the price discovery element of the market. There were no supplementary trades from the project team to enable matches. Simply having real assets operating together within existing markets under a single constraint zone would be enough to test the will of participants to enter BiTraDER.

Since asset outputs were expected to be adjusted, adequate compensation was requested, not just payback for the BiTraDER trade, but also extra incentives for participating. This was iterated and agreed through a short set of terms and conditions, stating what would be paid both for participating and for adjusting output. Each participant had different requirements, so the contracts had to be agreed separately with each organisation's legal team. This did cause some minor delays to the start date of the trials but was necessary to secure participation.

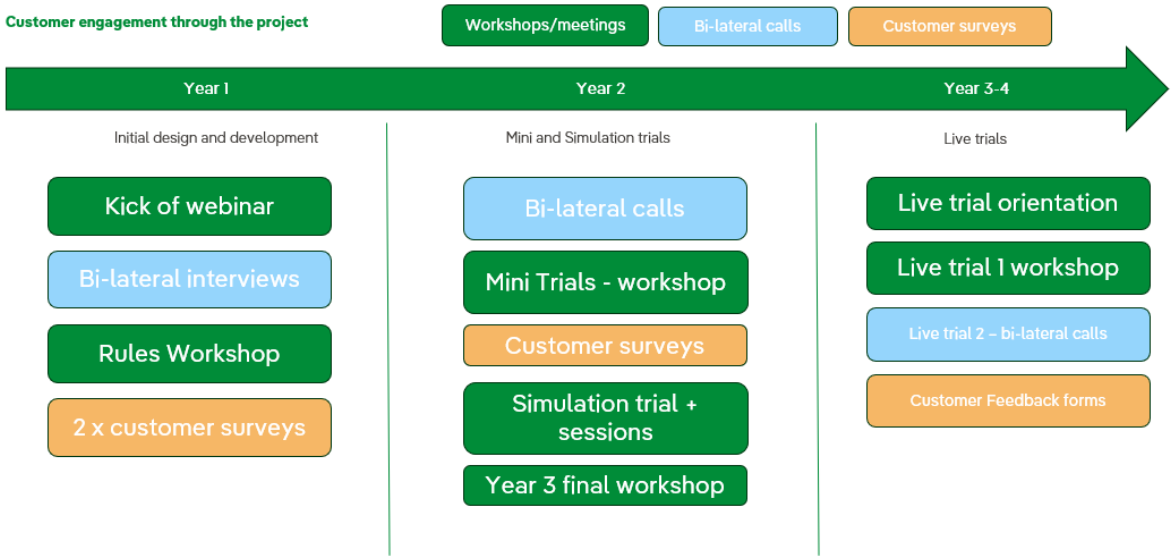
Once again, feedback forms were requested following the trials. Critically some of the more engaged organisations supported the project team with further 1-2-1 sessions to provide more detailed feedback which could feed into the final review of the trading rules and development of the qualitative element of the CBA.

Greater transparency of trading was desired to gauge an understanding of what bids or offers were needed to be submitted to secure a match. More certainty of revenue from the guarantee of a constraint occurring was also brought up. This could be helped by adding a probability element to each constraint. There was hesitance in dispatching assets in real time, mainly due to participants not having the required functionality, and without additional investment to enhance their control systems, instructions had to be sent through a scheduled dispatch email. Though it was stated that the upfront cost to upgrade the functionality in BAU would be worth it if the revenue potential was clear.

Through positive customer engagement, robust feedback was obtained to provide the necessary output to help quantify the potential benefits in BAU. This was a challenging project to keep customers engaged, but through continuous recruitment, active dissemination across the industry and suitable means of communication, ensured the requirements were met.

The engagement journey throughout the project is visualised below in Figure 2:

Figure 2 Customer engagement journey



The initial round of customer engagement can be explored further in deliverable 1: BiTraDER Customer Engagement and Trading Scenarios.

4 Active Network Management

The ANM system at SP ENW is an element of the Schneider Electric Network Management System (NMS). The NMS system is used to manage, operate, control and optimise the network remotely from a central control room. As more embedded demand and generation is added to the network, the system is becoming more active, with consumers managing their own supply and demand. The embedded generation exports into the network at lower voltage levels, causing two-way power flows across the system, associated with voltage swings and uncertain profiles of true demand.

The levels of renewable demand and generation are forecast to increase to accommodate the transition to electric heating and transport. Hence, a significant number of network assets are anticipated to have their ratings exceeded. Associated with this, therefore are significant levels of reinforcement. High enough, that to accommodate the extra capacity from renewable assets in certain cases results in delays to connection as the reinforcement programme builds.

SP ENW does not want to be a barrier to adding additional renewable connections onto the network to help to achieve net zero targets. The ANM system acts as a buffer to enable the existing capacity to be used in such a way that the system remains stable and within its limits. It achieves this through control and optimisation of existing network components and assets. However, only those connected assets that were energised following the exceedance of capacity of the network asset has the facility to be curtailed through a flexible connection agreement.

The Supervisory, Control, And Data Acquisition (SCADA) system integrates with the network model so that there is visibility of power flows at the transformer incomer and Circuit Breakers (CBs). This facility is available at all Extra High Voltage (EHV) and High Voltage (HV) substations and is being rolled out across Low Voltage (LV) substation feeders through retrofitted monitoring devices. Any connected asset on a flexible connection is required to have power monitoring data at the site

installed. The visibility of power flows, combined with a full impedance model of the network enables the NMS to perform load flow calculations.

Over time, a picture of the historical load profile of substation is built. The ANM system can use this to forecast on a short-term basis into the future where network constraints will occur. Specifically, up to 48 hours in advance, with a prediction obtained for each hour. This is known as the Constraint Look Ahead (CLA). Along with the constraint identification, it determines which network components and connected assets are available to help solve the constraint. Then, if the constraint occurs in real time, the required components and assets will be utilised.

The ability of the ANM system to manage the constraint removes the need to reinforce the network immediately and increases the overall utilisation of existing capacity. Other benefits include:

- *Reduced disruptions (e.g. road closures)*
- *Cheaper bills for customers (potentials in the long run)*
- *Generates revenue for flexible service providers*
- *Better quality of supply (faster restoration time during faults / outages)*
- *Increased security of supply by faster switching*

The ANM system can be thought of as an autopilot for the operation of the distribution network, helping to quickly manage supply and demand, keeping the system within its required limits. It is highly adaptable and scalable to future network needs and integrates directly with other components within the NMS system for greater control.

One other benefit is the direct integration with NESO, through the shared operational data exchange. This can be used to effectively coordinate distribution level constraints with further upstream constraints on the transmission network, a key use case for BiTraDER.

4.1 Merit Order Management System (MOMS)

A key component which works alongside the ANM but acts as a standalone system is the MOMS. This system is what provides the order in which assets can be curtailed. This order depends on the security of supply given in the connection agreement and a curtailment index value. For instance, an initial group of assets could provide the mitigation measures for a constraint under system normal. Then a second group of assets could provide additional support for a first circuit outage.

The order in which the groups of assets are curtailed is the curtailment index value. This differs from a Last In First Out (LIFO) stack and helps to provide fairer curtailment and clearer investment signals. Once an asset is curtailed, the index value gets decremented and reduces the chances of it being curtailment in the future for the same constraint.

Since the MOMS system is not directly part of the ANM system, it can be used to pass merit order information to the ANM system or pass them externally to a market platform.

Once the ANM CLA has identified a potential constraint, should this materialise in real time, it will request the merit order list from MOMS. The ANM system will curtail the applicable assets associated with the constraint in the order that the MOMS system shows. After the constraint, MOMS calculates the new curtailment index and reorders the list. Considering BiTraDER, in between the look ahead report and constraint occurring in real time, the merit order list can be passed to a market platform. This list could effectively be changed, so if an asset wanted to reduce their risk of curtailment they could pay to move further down the list. When the constraint occurs in real time, they would avoided curtailment and could continue to operate in their chosen market.

The CLA list being up to 48 hours in advance, enables day ahead trading opportunities to reduce risk of curtailment. The overarching system is shown below in Figures 3 and 4:

Figure 3 Internal architecture

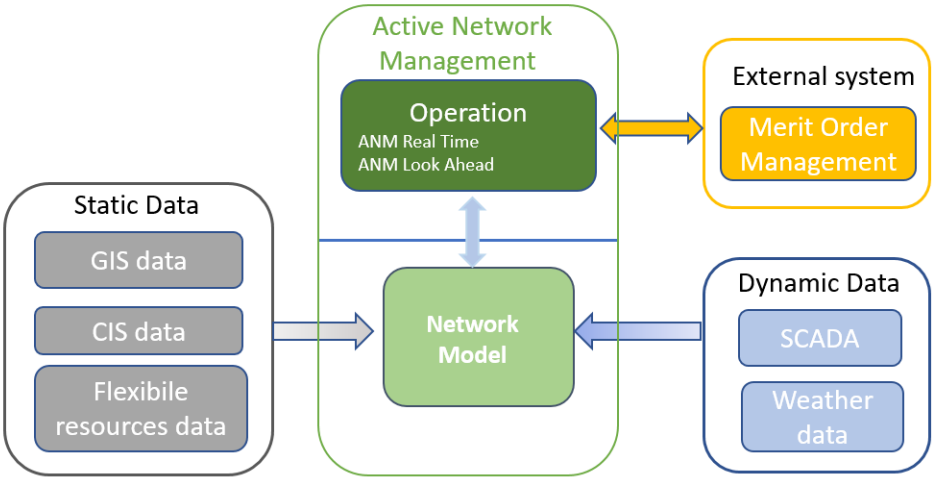
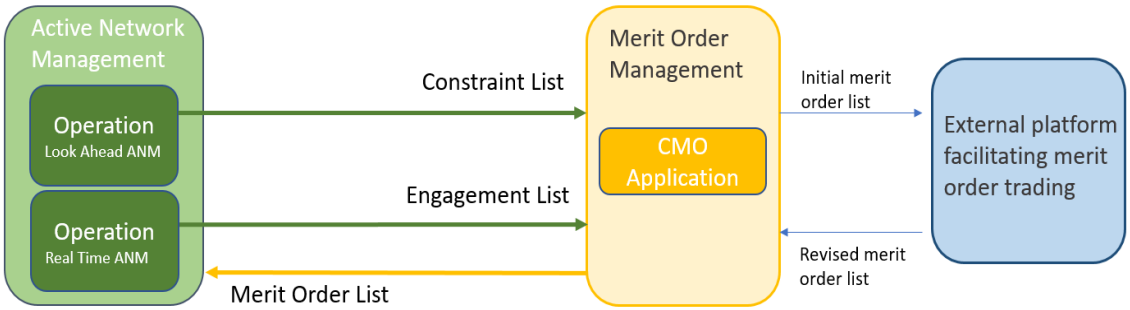


Figure 4 ANM / MOM data flows



Work was undertaken throughout the project on the MOMS system to accommodate BiTraDER. Since the ANM and MOMS were still in the test phase, there was plenty of flexibility to adjust, update and test MOMS.

The contract operation types were defined including the IDs which needed to match between ANM and MOMS. In addition, a unique identifier was added to show whether an asset is signed up to BiTraDER. A timestamp was added to each merit order list and the facility to send the list back and

to from ANM every half hour was setup. The facility to send a merit order list back and to from the trading platform was also setup.

The amount of time allocated to carry out the MOMS enhancements was ample and the system was upgraded by the SP ENW IT operations team. What proved more difficult was having the ANM system fully operational. The go live date for the ANM system was towards the latter end of the project and the ability to adjust the software was more limited as this needed to be agreed with Schneider Electric. The work on commissioning the ANM system was external to BiTraDER, and so the ability to ensure that the system was ready to operate during the trials phase was out of the project team's hands.

At the time the project started, it was anticipated that the ANM system would be operational, so the extra delays at first brought the ability to carry out the trials into question. Fortunately, it was fully operational by the time of the live network trials. However, owing to the low number of connections under a constraint management zone, the ability to for a BiTraDER trade to be executed in real time was not possible. Though a handful of assets were available, they were dispersed across the SP ENW network.

To overcome this problem, a virtual network was created in the NMS test system, with all trial assets connected. This enabled the full end-to-end trials to be carried out. These had to be carefully coordinated with the operational IT teams at SP ENW, as only one instance of the ANM test system could be open.

Aside from the ANM system itself being operational, the number of constraints on the SP ENW network currently is low. Whilst this is predicted to increase in the future, it does limit the liquidity of using BiTraDER at this time.

5 Trading Rules

The trading rules built upon the recommendations from the initial customer engagement and a review of the existing operational markets. Since trading of curtailment is a new concept, the market design was bespoke, especially in relation to the trade matching process. The market was built up in several building blocks which each considered a set of options.

The design had to work alongside the capabilities of the ANM system and how SP ENW manages the merit order stack, so certain elements were chosen to complement these components.

For instance, the ANM CLA function has 48 hours forecast capability. Hence the timing of a trade submission could be no longer than 48 hours. Effectively, an asset could submit a trade shortly before the point of delivery, however it was decided that the market would be implemented as day ahead. This provided good forecast capability, whilst managing the administrative burdens of trading relative to intraday timescales.

The challenge when creating the rules was to ensure effective alignment with the other markets so that customers could optimise their revenue streams. Sellers in BiTraDER would position themselves in the day ahead electricity markets typically in the mornings as the trade windows close. Keeping the BiTraDER trade window open during this time would be important to allow

sellers to make the most informed decision on which market to operate in and what baselines they would operate at.

One drawback of the day ahead trading is that assets who operate intraday will be excluded. This was noted in the trials by storage assets which trade on the day and earn money from arbitrage and balancing services. Although these assets could operate in BiTraDER, a better opportunity post BiTraDER gate closure could become available. This could risk non-delivery in BiTraDER or certain participants unwilling to participate in market full stop. As a result it was decided that the timings of the trade window should be kept under review as the BiTraDER market develops to maximise the liquidity of assets available for trading. An alternative option of a 'continuous trading window' (e.g. up until the point of delivery) was discussed during the project, but it was decided that this would increase the complexity of the market and may impact on participation levels within the trials.

Another important consideration is what constitutes as a buyer or a seller. Assets can be classed as either curtailable or non-curtailable. However, security of supply must be considered. A constraint under pre-fault system normal may have certain groups of curtailable buyers, and a further constraint under post-fault system abnormal may have a different group of curtailable buyers. Therefore, a buyer can be classed as an asset which has a curtailable element of their connection agreement under a certain level of security of supply scenario which can be reduced to free up capacity at time of excess demand or generation.

The buyers trade with sellers, which have a non-curtailable element in their connection agreement for a certain security of supply, who will adjust their capacity to offset the need for the buyers to curtail. Consideration was given for curtailable-to-curtailable trades but was discounted given the way the merit order list changes following a trade, which could end up with a non-trading party in a higher position in the merit order list inadvertently. However, during the trials, an expression for curtailable-to-curtailable trades was proposed. If this was to be taken forward, the current merit order trading model may need to be revisited. This particular use case would be suitable if there were lots of buyers and should be considered again as the number and type of network assets changes in the future.

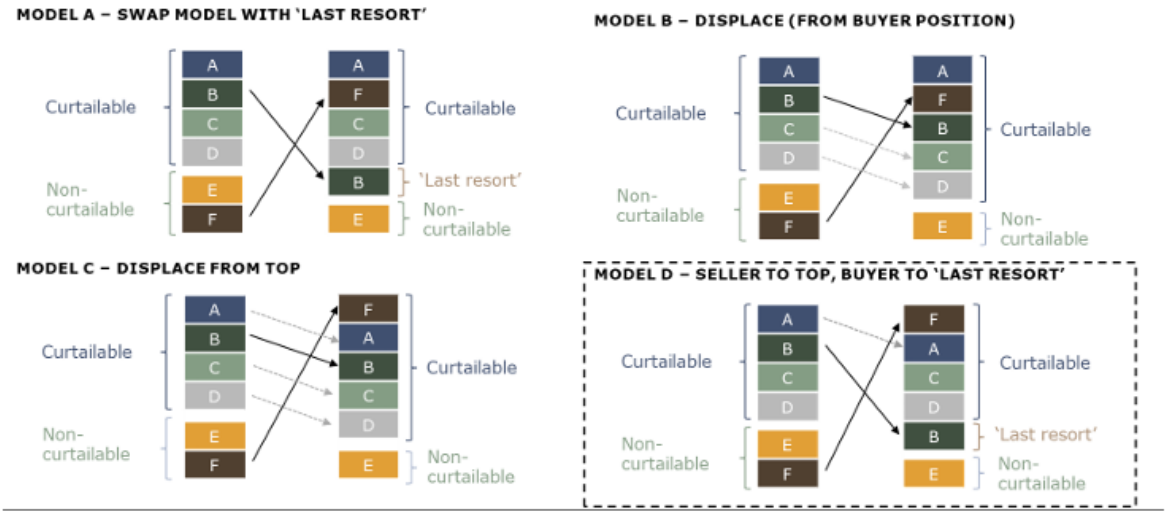
When a trade takes place, the buyer moves to a 'purgatory' or last resort position. This is not a non-curtailable position but sits just above the non-curtailable list. It can be considered as the least risk curtailable position. The seller moves to the top of the curtailable list and is first in line to be curtailed.

Several other options were considered and can be visualised in Figure 5:

- *Model A - Simple swap approach where the seller takes the original position of the buyer, whilst the buyer moves to the last resort position.*
- *Model B - Displace from buyer position approach where the seller takes the original position of the buyer and the buyer moves one position below the list from its original position.*
- *Model C - Displace from top approach where the seller moves to the top of the list, with all parties including the buyer shifting down a position.*

Figure 5 Merit order rearranging options

Exhibit 4.4 – Potential models for changing positions in the merit order



One main reason why model D was taken forward is that it more straightforward for the seller to understand. They will know they will be first in line and at most risk of being curtailed, whilst the buyers know they will be at the least risk of being curtailed. The unavoidable disadvantage is that some non-trading parties can benefit from a free rider effect - however, no curtailable party whether trading or not, will be in a worse off position.

As stated above, for certain discounted trading options such as curtailable-to-curtailable trades or nested constraints, a different approach may be more favourable. But this depends on the aim of the market. As liquidity in BiTraDER matures, it may be necessary to revisit the reordering process.

For payment structures, utilisation and availability payments were considered, either individually or a combination of both. During the trials, the utilisation only payment was tested and then additionally with an availability payment. Trial participants much favoured the pricing structure, which included an availability payment. This is because in BiTraDER, the constraint is not necessarily guaranteed. It is a prediction from the ANM CLA and so, up until the constraint occurs, there is always a chance that a seller could prepare for participation without getting paid, or a buyer could still be curtailed even though they have traded. The availability payment compensates for this.

The element of unpredictability is a challenge. Organisations want certainty over revenue and more detailed constraint information to make more informed decisions. One of these options is adding in a percentage chance of the constraint occurring, based on more detailed short term forecasting information. This would facilitate easier pricing of what is allocated to the availability and utilisation payment, and this is something that could be considered as an addition when BiTraDER is rolled out into BAU.

When considering volume traded, the expectation was that buyers would seek only to buy a volume up to its expected generation / offtake position. For sellers, three options were considered:

- *Option 1: Ability to reduce / increase electricity generation / demand in real time compared to the generation / demand at the time of the constraint.*

- *Option 2: Ability to reduce / increase electricity generation / demand compared to a baseline.*

- *Option 3: Selling the right to export/import based on the seller's capacity.*

Option 2 was the preferred option as it was considered the easiest from a metering perspective, as it relies on a self-declared baseline to define the trading volumes and measure performance. The baseline is a single figure for each settlement period that represents the expected demand or generation across each period.

The baseline was a challenge, particularly for renewable assets. This was related to the day ahead element, with certain trial participants such as battery assets uncertain as to what their output would be the next day. The baseline methodology was designed to follow the standard Energy Networks Association (ENA) baselining tool and additional options may be updated as the project transitions to BAU.

5.1 Final Review

The original BiTraDER Trading Rules Report was published in 2023. Since the publication of this report a significant amount of work has been undertaken on the project.

A final review of the trading rules was undertaken to ensure that any learnings from the trials were taken account of and implemented into the final trading rules. This was focused on a review of the potential impact of nested constraints and alternative payment structures. The full review can be seen in Annex A of the Cost Benefit Analysis report.

5.1.1 Nested Constraints

As demand and generation increase on the network, the number of constraints will increase, and this is likely to lead to more nested constraints. The following issues were identified to arise from nested constraints:

- *Sellers not useful: Despite trading there is the potential that a buyer would not avoid curtailment. In the payment structure which includes an availability payment, the buyer will still have to pay an availability payment to the seller, even though the buyer did not avoid being curtailed and the seller could not help with the binding constraint.*

- *Buyer off the hook for the constraint: It is possible that the buyer would still need to pay the seller the utilisation payment even though the buyer was not 'on the hook' for a specific nested constraint.*

To understand the continued impact of this issue, an internal workshop was setup. The outcomes of this are set out below.

It was decided that it remains acceptable that nested constraints are not formulised within the trading platform at this stage. This is due to the low risk of occurrence and subsequent impact on the operation of the market.

However, to ensure this remains the case it will be important to continue to monitor the following assumptions:

- *Trades are only allowed for those constraints which are identified by the CLA between a sub-set of parties who can solve that constraint.*
- *Utilisation payment is only made if the seller is called on to deliver (and actually delivers).*
- *There is no need to withhold the availability payment if the seller was unable to deliver due to a nested constraint (different rules for non-delivery).*
- *The curtailment index for the buyer is updated to reflect any delivered curtailment which is delivered by the seller on its behalf.*

As BiTraDER is moved to BAU, it will be important for the impact of nested constraints to be monitored, including ongoing feedback from industry stakeholders to ensure solutions are put in place where necessary.

5.1.2 Alternative payment structures

The accepted and rejected 'pricing structures' discussed in the trading rules have been reassessed based on further stakeholder discussions and trial outcomes.

Three options were explored for determining the price paid by the buyer to the seller:

- *Option A: utilisation payment only (pay as clear)*
- *Option B1: availability and utilisation payment with matching based on buyer's highest total bid and seller's lowest availability (pay as bid / offer)*
- *Option B2: availability and utilisation payment with matching based on buyer's highest total bid and seller's lowest total offer (pay as bid / offer)*

Following further detailed review and engagement with trial participants, it was decided that the trading rules for the platform design and subsequent trials would be based on:

- *Buyers: Submit an availability and utilisation price – based on the maximum they are willing to pay. Bids are ordered by the 'all in' bid (availability and utilisation) price and the higher the 'all-in' price the greater the possibility of matching.*
- *Sellers: Submit an availability and utilisation price – based on the minimum they are willing to pay. Offers are then prioritised based on the lowest 'utilisation price' first and then the*

lowest 'all-in' price. Offers are then accepted if the required availability is less than the maximum buyer availability price and the all-in offer is below the buyer 'all-in' price.

5.1.3 Additional Market Design Choices

In addition to the bid / offer structure, a review of other market design choices discussed during the trial period has been considered. These choices are linked to ability of participants to accurate understand the value of participating in the BiTraDER market at any point in time. These were raised with the intension of mitigating the risks linked to the levels of liquidity.

As part of the initial trading rules design the gate closure was set in the morning of the day prior to the 'constraint day'. The intention here was to give participants sufficient time to make necessary operational changes to reflect a new position in the curtailment merit order. This timing was validated in the trials, with participants expressing an interest for the gate closure in the morning.

During the initial trading rules development, it was assumed that the participant bid and offers should be private (except in the case of a bid / offer match) to protect strategies and commercial positions. However, as part of the trials it became evident that there were significant differences in the pricing strategies being operated by the different participants. This was driven by the different operations of participants and their interaction with other markets (e.g. both energy and ancillary).

Given that this design choice had not been explored in depth and the case for change not convincingly made, it was decided not to change the rules for the trials on a forward-looking basis. However, as a mitigation it was decided that at the end of each trial day, the participants bids and offers on an anonymised basis would be shared. This had a significant impact on the future trials as it helped prices to converge over each period, helping participants to submit realistic trades.

Going forward it is recommended that this design choice is considered in more detail prior to BAU roll-out. Initial discussions with participants identified advantages linked to the ability to understand other participant positions and increase the chance of matching while the liquidly improves. But both the potential commercial impacts as well as potential unintended consequences on the market in the long term remain a risk and must be considered in more detail and in consultation with all participant groups, before any change is made.

6 Trading Platform

The BiTraDER trading platform is an extension of the ElectronConnect flexibility market platform. This is the platform that SP ENW use for their local flexible services market. When an asset wants to provide a flexible service, it can sign up via the ElectronConnect platform where it can then view the range of flexible service requirements available to provide. Opportunities are available multiple times per year and once a contract is awarded, the DNO will pay the asset for providing that service.

Should a service be required, the ElectronConnect platform has the capability to receive an instruction from the DNO and dispatch that asset accordingly. The instruction from the DNO for a real time constraint comes through the ANM and MOMs system. Hence, there is considerable overlap between some of the functionality required for flexible services and for BiTraDER.

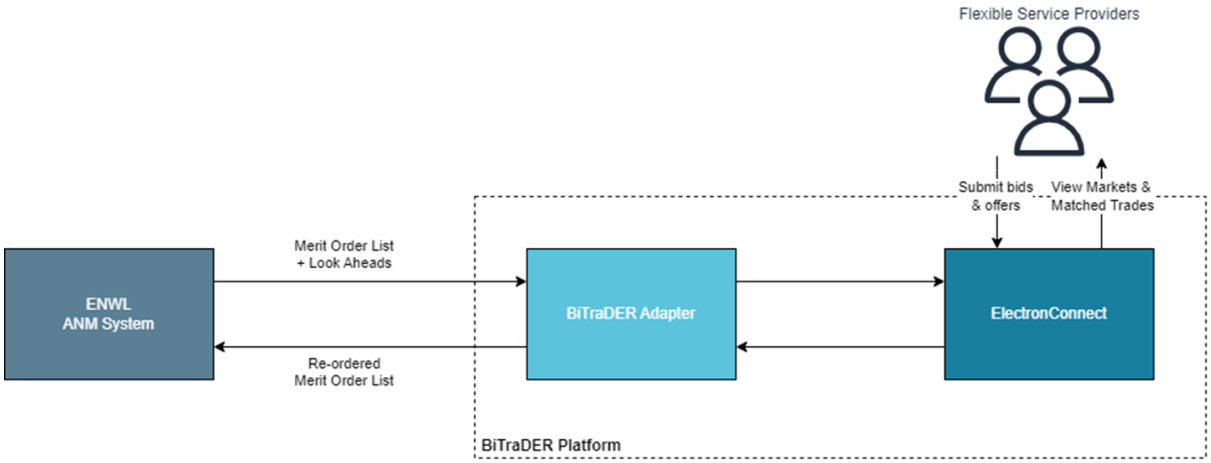
The ElectronConnect platform has been designed to be capable of operating numerous markets with different configurations simultaneously and supports the end-to-end flexibility trading lifecycle including:

- *Provider and resource registration and user management processes*
- *Commercial and technical pre-qualification processes*
- *Flexibility requirements sign-posting process*
- *Bid / offer submissions process and trade matching*
- *Rules-based market coordination*
- *Dispatch instructions*
- *Performance measurement and verification process*
- *Invoicing and settlement process*
- *Data analytics and reporting*

These elements are used to support the operation of BiTraDER, along with a unique adapter, which facilitates the additional BiTraDER functionality, such as CLA filtering, merit order list reordering and the interface between the DNO systems and the ElectronConnect platform.

The high-level architecture is shown below in Figure 6

Figure 6 BiTraDER platform architecture



The BiTraDER adapter was developed to encapsulate the business logic specific to BiTraDER and the integration with the DNO systems. Specifically, the BiTraDER adapter:

- *Receives and validates the MOL and the CLA data from the ANM system*
- *Identifies the potential market participants and their corresponding trading opportunities to buy or sell curtailment obligations under a specific constraint*
- *Instructs ElectronConnect to create the constraint-specific day-ahead peer-to-peer markets for BiTraDER*
- *Processes the resulting trades to re-order market participants position in the MOL and recalculate the size of their curtailment instructions*
- *Exposes the re-ordered MOL to the ANM system.*

The BiTraDER adapter also relies on the ElectronConnect Platform. Using the ElectronConnect Platform, BiTraDER market participants:

- *Register their assets*
- *Browse the trading opportunities related to their assets*
- *Submit bids or offers depending on if their asset is covered under one of the constraint-specific markets*
- *View the results of the trades they participate in.*

The BiTraDER adapter was built up over a seven-month period. Since certain components in the build were required to be integrated with the DNO systems, the functionality was demonstrated to the project team to ensure that it met the requirements.

6.1 Systems Integration

Prior to the build phase, there were multiple meetings between the BiTraDER platform developers and the operational IT teams at SP ENW to ensure that the system architecture was agreed. Thus, collaboration was necessary to avoid delays and ensure a more seamless integration between the two systems.

The trade matching algorithm was developed based on the agreed approach in the trading rules. Each bid or offer consists of an availability price and a utilisation price, which are added together to calculate the total bid or offer price. Bids and offers are matched based on the total price (availability plus utilisation) and the availability payment.

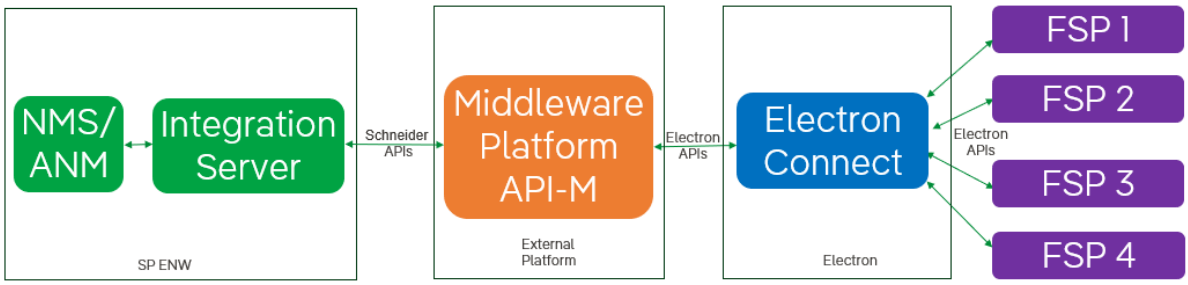
Functionality was demonstrated through a series of test trades. These were similar types of scenarios which would be used during the trials. The test data list was transferred from the DNO ANM and MOMs systems through an Application Programming Interface (API).

Once received, the platform could sort through the data and develop constraint specific trading opportunities that could be presented on the user interface (UI). The project team submitted theoretical trades to demonstrate different scenarios to test out the full capabilities of the trade matching algorithm.

Provided there was a matched trade, the newly reordered merit order list was sent back to the DNO systems via an API.

The integration architecture is shown below in Figure 7. The SP ENW integration server is separated from the ElectronConnect environment through a middleware platform which acts as an airgap for cyber security purposes. It also acts as a gateway between the Schneider APIs and Electron's APIs, which are both platform specific.

Figure 7 Systems integration architecture



The coordination to test out the functionality in stages allowed potential issues to be quickly identified and addressed, reducing the risks of setbacks further down the line. Demonstrations at the end of each stage validated that the agreed requirements were met and provided evidence to progress to the next stage.

Robust design documentation prior to the build phase provided an invaluable reference source for explaining the design rational. This was particularly valuable since BiTraDER contains novel trades rules and complex, evolving domain knowledge.

6.2 Development Approach

Certain components that were necessary in the live network trials were not necessary in the simulation trials, so the platform was built firstly to enable the simulation trials and then further development was required to enable the live network trials. For the live network trials, the additional functionality of dispatching of real assets and the settlement process needed to be agreed.

The trade verification process would ensure that all agreed trades remain valid on the day of dispatch. This step was crucial because the network topology may change after a trade has been agreed. The verification process checks that sellers can still provide a useful service to buyers and confirms whether trading counterparties are still connection to the same part of the network.

During simulation trials, participants were dispatched via email. For the live network trials, the real time dispatch functionality was required. Whilst this capability was already embedded within the ElectronConnect platform, updates to business logic was required to enable the dispatch module to identify which BiTraDER seller assets were eligible for dispatch.

Furthermore, additional requirements were identified from the live network trials that would need to be implemented into the platform prior to BAU transition.

This includes the ability for market participants to view anonymised bid and offer information to support effective price discovery and improve the likelihood of successful trade matching. Also, the ability to adjust positions as the market conditions evolve by resubmitting a bid or offer for a given constraint would help to improve the accuracy and relevance of the information used during trading.

Participants additionally requested to be able to submits trades per half hourly period of a constraint to give more flexibility and better reflect the value of assets that have short run time or variable capacity. For assets with fixed capacity or those that have stable price strategies, automatic bid and offer submission could help reduce the operation effort to participate in the market each day. Similarly, an automatic opportunity notification could alert participants whenever a new trading opportunity is available.

Further details on the development of the trading platform can be found in deliverable 3, BiTraDER Trading Platform Design, deliverable 4, BiTraDER Architecture Build Lessons Learned Report, and deliverable 7, Functional Specification.

7 Trials Phase

The trials were conducted in phases and designed to test certain components of the market. After each phase, time was built in to update the design and adjust the strategy of implementation following user feedback. The trials were vital and used to validate the interim models of the trading platform and ultimately enable the development of the final functional specification.

There were three stages of trials, all of which are in the project plan, including the mini trials which were an additional testing stage added into the original submission.

Mini trials: A one-day workshop held on January 31, 2024.

Simulation trials: Ran from October 2024 to January 2025.

Live network trials: Ran over two weeks in December 2025

The main aim of the mini trials was to test the early models of the trading rules, whilst the simulation trials were aimed at testing the user interface. The live network trials focused on testing the full end-to-end process, with trades mirroring those to be expected in BAU.

At the time of the mini trials workshop, the build had not yet started, with the only outputs available being a first draft of the trading rules and an early design of the platform. The mini trials were not in the project plan, but given the complexity of the trading rules, with the numerous options being considered, it was deemed necessary to validate some of the market rules which were proposed to be taken forward.

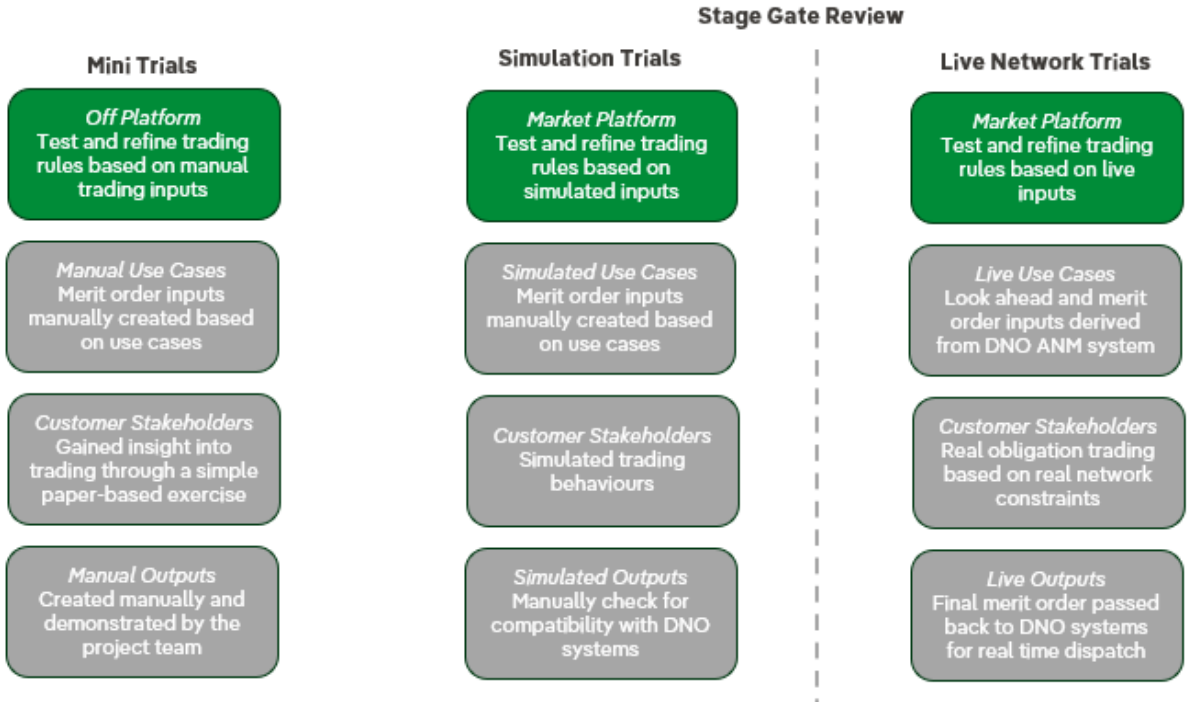
Since no trading platform was available, the trades were based on manual trading inputs and use cases. Through practical demonstrations and paper-based exercises, a handful of participants were able to gain an understanding of the different elements of the market rules considered. This understanding was vital in providing the project team with the initial feedback that was needed prior to progressing to the build stage.

Following the build of the trading platform and integration with the SP ENW systems, trial participants were invited to take part in the simulation trials. This was the first time that the user interface of the platform could be tested. Trades were based on simulated inputs that were developed manually in a test version of the ANM system. Although trading behaviours were somewhat unrealistic, due to the use of fabricated assets and simplistic element of the simulations, participants again gained further understanding of how the market worked and what the project team were trying to create and achieve.

A stage gate was put in place at the planning stage to act as a break if the live network trials were deemed unfeasible or unnecessary. However, the need for testing of trades in a live environment was considered necessary and a request was made to proceed past the stage gate and onto the live network trials.

Unlike the other trials phases, the live network trials were based on live inputs from the ANM system, and participants could trade real money for real network constraints with their own assets. This was a significant step up from the simulation trials and was designed to test the full end-to-end process of BiTraDER. An overview of the trials phases is shown in Figure 8.

Figure 8 BiTraDER trials phases



7.1 Mini Trials

To demonstrate the principles of a network constraint, two simplified paper-based network models were created, a HV network and EHV network. From these models, it was easy to show for instance, the locations where a constraint could occur, and demonstrate the principles of how it occurs.

On these models, a series of theoretical scenarios were devised in which constraints could occur, caused by a handful of fabricated assets. These set of assets were designed to reflect realistic connections on the SP ENW network and included both curtailable and non-curtailable assets.

The six scenarios were as follows:

- *Scenario 1 — Simple case using utilisation-only payments*
- *Scenario 2 — Scenario 1 repeated with updated merit order*
- *Scenario 3 — Simple case using two-part pricing*
- *Scenario 4 — Scenario 3 repeated with updated merit order*
- *Scenario 5 — Network topology change*
- *Scenario 6 — Constraint magnitude larger than expected*

Each scenario was designed to test an element of the market rules that needed validating and devised to ensure participants gained maximum understanding of how market works.

A fabricated asset was assigned to each participant and a profile ID card of the asset, an example of which is shown in Figure 9 was handed out. Secondly a constraint notification card and associated bid / offer submission card, shown in Figures 10 and 11 were handed out.

Figure 9 Profile ID card

Profile ID:Yellow	
Constraint ID	Scenario 1
Asset Type	Commercial demand
Contract Type	Non-curtailable demand
Position	Seller
Service	Demand turn up
Import Value (MW)	6
Trade Value	Turn up by a maximum of 4MW

Figure 10 Constraint ID card

Seller Trade Notification:Yellow	
Constraint ID	Scenario 1
Curtailment window	08:00 - 08:30
Constraint size (MW)	16
Direction	Export (too much generation)
Number of buyers in the MOL	4
Sum of buyers MWs in the MOL	16
Market information	
Market information	Load shifting
Price (£/MWh)	£35

Figure 11 Bid / offer submission card

Seller Offer Submission:Yellow	
Constraint ID	Scenario 1
Curtailment window	08:00 - 08:30
Service	Demand turn up
Forecast import volume (MW)	6
Trade volume (MW)	4
Availability price (£/MWh)	Enter value .....
All-in price (£/MWh)	Enter value .....

A new set of cards were handed out for each scenario so participants could have an opportunity to be both a buyer and seller and experience trading with different technology types.

To demonstrate the outcome of the trades, participants lined up in the room in the order of the original merit order list. They were then instructed to move to a new position in line with the outcome and the feedback from participants was positive.

Key insights include:

- *Preference for two-part pricing with an availability payment.*

Baselining Concerns

- *Storage asset owners highlighted issues with day-ahead baselining.*

- *Many preferred on-the-day baselining using outturn metering.*

Market Liquidity Concerns

- *Participants noted that BiTraDER is a new market with likely limited liquidity as the market starts up.*

The availability payment was strongly preferred as this compensated for the uncertainty of the constraint occurring and helped incentivise sellers to prepare for providing a response.

Depending on the technology type, some participants struggled to understand what trades to submit. This understandably is due to the new market and the limited background information on previous trades or other market conditions. Participants who owned storage assets were concerned about baselining day ahead, since some of their actual assets commonly operate in the intraday market.

The liquidity concern was a common issue throughout the trials and is a challenge for all new markets which are being setup. In BAU, there needs to be sufficient liquidity available for trades to match.

The outcomes from the mini trials enabled the project team to develop the finalised set of trading rules and commence the building of the platform. Further details of the mini trials can be found in deliverable 2, BiTraDER Trials Plan, Trading Rules and Initial Specification Report.

7.2 Simulation Trials

The functionality was built into the trading platform to enable a set of simulated constraints, sent from a test version of the ANM system. Likewise with the mini trials, the assets provided to participants were fabricated. Though, instead of trading manually, each asset was pre-registered onto the trading platform and participants were given login details to view their asset, see trading opportunities and submit bids or offers.

Trading was tested through 10 simulated constraints, as shown in Figure 12, which were designed to expose participants to a wide range of network and market conditions. Specifically, the key variables were whether a constraint occurs or not and how the magnitude and timing of a constraint could affect the trade outcome.

Figure 12 Simulation trial scenarios

Constraint	Scenario	Magnitude	Timing
1	HV feeder import constraint	2 MW import	Full period
2	HV feeder export constraint	3.5 MW export	Full period
3	Severe weather import constraint	5 MW import	Full period
4	Severe weather import constraint with CI update	Less than expected	Full period
5	Severe weather export constraint	4.6 MW export	Full period
6	Severe weather export constraint with CI update	No constraint	N/A
7	BSP topology change export constraint	10 MW export	Midway through period 1 → midway through period 2
8	BSP planned interruption import constraint	8 MW import	Midway through period 1 → midway through period 2
9	Nested import constraints	2 MW import (downstream only)	Full period
10	Nested export constraints	5 MW export (downstream only)	Full period

Each simulation was structured so that a CLA report would be sent to the trading platform on the first and third Monday of the month. The trading window was open for two hours, with the actual constraint occurring the next day. During a trade window, the project team was on hand for an optional drop-in session to allow participants to ask questions whilst preparing their trades. Following the constraint, a post trade meeting was organised to announce the result of the trade and explain the outcomes, along with a further group discussion on BiTraDER concepts.

Throughout the simulation trials, participants were introduced to different mechanism underpinning BiTraDER:

Curtailment Index (CI)

- *How CI decrementing reduces future curtailment risk for buyers who trade.*

Multiple Contracts in the Merit Order

- *How assets can hold different contracts under different security-of-supply conditions.*

Look-Ahead Verification

- *How predicted constraints are validated on the day.*

Varied Constraint Timing

- *For constraints that start / stop mid-period.*

Nested Constraints:

- *How upstream / downstream constraints interact and how buyers are compensated.*

Whilst users did find the platform intuitive, several points emerged about the realism and practicality of the simulation environment.

Simulation Format vs. Real-World Complexity

- *Participants felt the simulation was too simplistic, limiting their ability to apply real-world operational expertise. Guide prices were introduced to help, but this anchored prices and reduced realism.*

Liquidity and Participation Challenges

- *With only seven participating businesses, and many facing competing BAU priorities, liquidity was limited—especially with biweekly trades.*
- *Some trades had to be supplemented by SP ENWL and Electron staff, which helped generate complete examples but reduced the authenticity of market conditions.*

Implications for Live Network Trials

- *Each participating asset will be analysed to create a "perfect hindsight" market model, enabling realistic background price signals and operating conditions. This was idea gained from the post trials workshop.*
- *Additional customer engagement is needed to understand required market data, historical price information, and participation barriers.*

Crucially, the need to test real world trading was important to gain the required outcomes needed for the project. Only real money changing hands would encourage maximum participation in the market. This would be crucial to see how assets operate in BiTraDER, and value the market compared to other operational conditions on a given trading day.

Another critical element to keep the outcomes robust was the attendance of participants. Whilst there was clearly an interest in trading during the trials, BAU activities did take precedence, and so for some scenarios, liquidity of the trades was low and additional submissions were needed from the project team to ensure there were matches. This further reduced the realism and again bolstered the need to progress to live trading.

Further detail on the simulation trials can be found in deliverable 5 BiTraDER Simulation Trials Report.

7.3 Live Network Trials

The live network trials marked the first opportunity to test the full end-to-end BiTraDER market under real network conditions with real money involved.

The primary aim was to understand realistic trading behaviours, including how participants price bids and offers, what limits their trading capacity, and what barriers they encounter.

To enable this, significant upgrades were made to both the BiTraDER trading platform and the live ANM system, alongside targeted customer recruitment within the SP ENW licence area.

The platform, built on ElectronConnect was expanded to support live operations. Enhancements included:

- *Dispatch functionality, allowing the market operator to issue, update, and stop instructions, with participants acknowledging via webhook URLs.*
- *Performance verification, using ENA-standard settlement methodology to calculate delivery performance minute-by-minute.*
- *Capability enabling assets to opt-out of trading partial volumes—important because some generators can only operate at full output or off.*
- *Production-standard user permissions, data security and customer data back-up procedures.*
- *Updated user guides for baseline uploads, meter readings, and dispatch handling.*
- *Settlement remained off-platform to allow rapid testing of different methodologies.*

The difference between the live network trials and simulation trials is that the assets participating needed to be in the SP ENW licence area and covered under a Constraint Management Zone (CMZ) in the ANM system.

As anticipated, the number of assets on existing flexible connections was insufficient to create an 'ideal' live trading scenario. The main reason for this is that SP ENW have an extremely low level of curtailment annually.

It was therefore necessary to strike a balance between running the 'ideal' scenario with live flexible connections and one which could still test and weigh up the benefits of live asset trading.

By utilising existing assets that could be temporarily operated as flexible connections, the requirements to determine whether trading in BiTraDER is suitable could be tested.

Two approaches were taken to identify existing assets willing to participate in the trials. Firstly, SP ENW utilised its existing contacts across the region's universities, reaching out to four institutions.

Following discussions with estate teams and a review of their assets and power infrastructure, it became clear that there was a lack of volume that could be traded to support meaningful trades. Typical assets included chillers and heating systems, capable of only small trades up to a few of hundred Kilowatts (kW). In addition, there was a reluctance to change the output of these assets during term time which restricted trial windows.

As a result, this approach was not taken forward. However, Lancaster University with its larger rural campus, offered more suitable assets that could be utilised including a large wind and solar farm.

The second approach involved contacting existing assets listed on Electron's Flexible Service Provider (FSP) register.

Unlike the universities, these providers were more commercially focused and already had experience in operating assets in existing flexibility markets. This was more successful with five businesses expressing interest in exploring BiTraDER as a means of generating additional income and reducing curtailment risk. Their portfolios included assets in the range of Megawatts (MW), providing sufficient volumes to enable suitable trades.

It was important to understand in detail the capabilities of the assets in each of the FSP's portfolios to gauge whether they would be suitable for the trials.

The project team set up a 1-2-1 meeting with each FSP, along with Lancaster University to explore specific use cases for different asset types and how they could benefit from participation in BiTraDER.

Once the benefits of participating were clear, Electron's asset registration form was distributed. Participants then selected sites they believed were suitable and available for the trials. The form captured key asset details including information on how each asset could operate flexibly for example the level of capacity it could provide for turn down or turn up services.

Some of the FSPs operated as asset owners and some managed the assets on behalf of the owners. In the latter case additional time was required to secure permission from the owners before those assets could be included in the trials.

The project team discussed compensation with each participant, outlining both a general incentive for taking part in the trials and additional incentives linked to individual trial events. These included covering any costs incurred when assets were dispatched, ensuring participants were fairly rewarded for their involvement.

With all registration forms submitted, suitable trading scenarios could begin to take shape. However, the selection of assets available were not located within the same area of SP ENW's network. As noted earlier, the 'ideal' live trading scenario would involve assets under a single CMZ.

To address this, an additional allowance was introduced that incorporated a degree of simulation whereby the assets selected would need to be connected virtually onto a test network to create an artificial CMZ. This approach was considered acceptable because although the assets were not physically situated on the same part of the network, the trading behaviours of the participants would

remain consistent. Crucially, the main outcome of assessing whether the BiTraDER market could operate in BAU could still be achieved under these conditions.

With the assets chosen, two scenarios were devised which incorporated both an import and export constraint. These both had a good mix of technology types including batteries, solar, wind and gas peaking plants with constraint volumes of over 20MW anticipated.

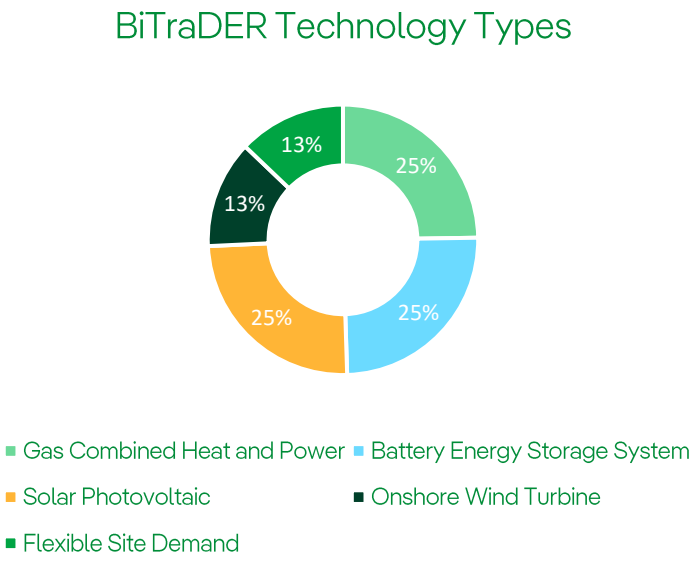
The assets mainly operated within the wholesale and NESO markets but some also had contractual Power Purchase Agreements (PPAs). The scenarios centred on the use case of keeping renewable buyers connected whilst curtailing non-renewable sellers.

Since the buyers were on theoretical flexible connections, the decision was made to not physically dispatch the asset, rather send an email confirmation letting them know that they would be curtailed or they have avoided curtailment should they have been on a true flexible connection.

Sellers on the other hand were required to dispatch if capable to do so. Though some sellers did not have the capability for real time dispatch, so opted instead to have a scheduled dispatch via email. In many cases an hour notice was suitable, but it was noted that this is longer than the real time dispatch that was designed for the BiTraDER market.

The live trials were conducted with the involvement of five participants, who collectively operated eight grid-scale assets. The specific technology classifications for these assets are illustrated in Figure 13.

Figure 13 BiTraDER technology types



Throughout the two-week trial period, 12 constraints were identified by the BiTraDER platform and presented to participants for bidding. From these identified constraints, successful matched trades were achieved in three instances as shown in Table 1.

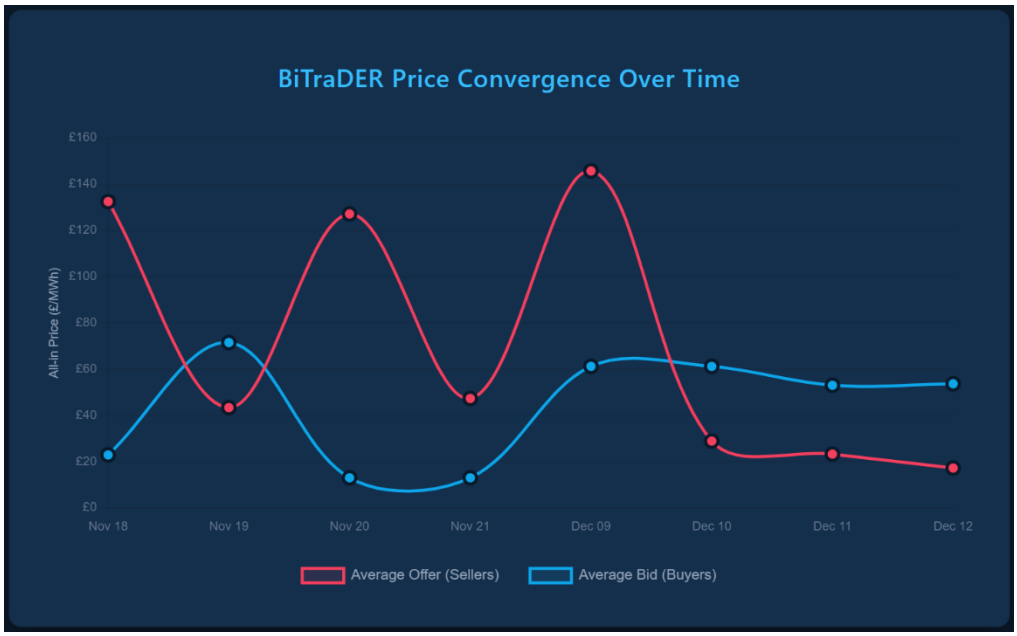
Table 1 trial results

Predicted Constraint Size (MW)	Predicted Constraint Length (hrs)	Actual Constraint Size (MW)	Actual Constraint Length (hrs)	Seller Asset Utilisation (MW)	Delivery as % of Constraint Size
16.5 Import	1	8.25 Import	1	10	121%
20.3 Import	3	20.3 Import	3	12.6	62%
20.3 Import	3	20.3 Import	4	3.9	19%

A convergence of bid and offer prices was observed over the course of the trials, as shown in Figure 14.

This trend is attributed to participants refining their pricing strategies in response to market activity and other participant's submissions. Consequently, a higher volume of matching was recorded in Week 2 relative to Week 1. This increase was further facilitated by strategic adjustments made to the market bidding window timings.

Figure 14 Trade convergence

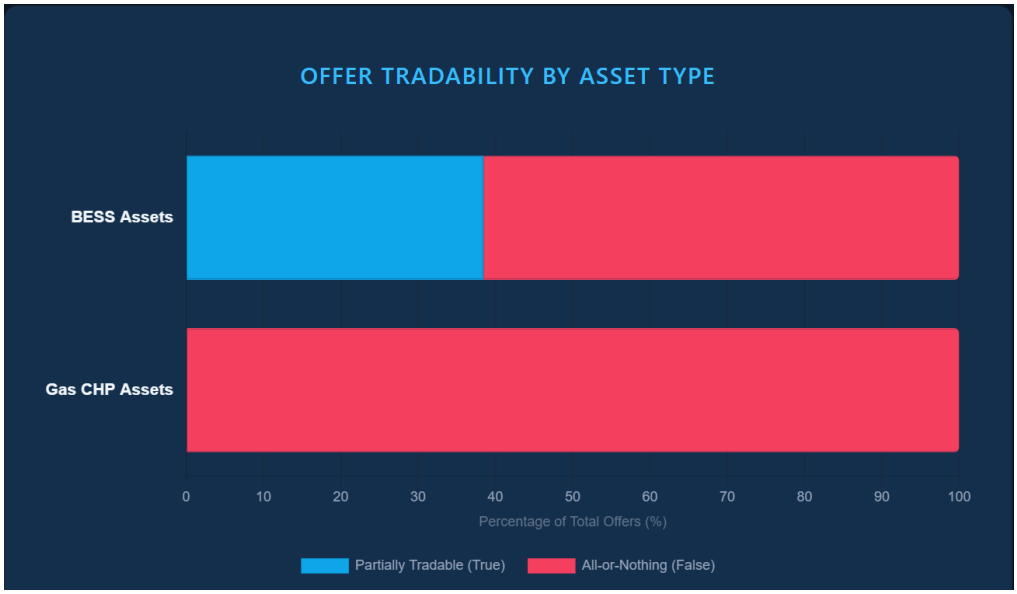


Many BiTraDER sellers decided to opt out of partial volume trading, as shown in Figure 15.

Although this feature was originally implemented to accommodate assets with binary operational profiles, such as Gas Combined Heat and Power (CHP), it was adopted across other asset classes. Participants indicated that the novelty of the market created challenges in calculating opportunity

costs; requiring the full offer volume to be confirmed served as a risk management tool to mitigate this uncertainty. As a result, this feature was utilised by Battery Energy Storage System (BESS) assets for 62% of offers.

Figure 15 Offer tradability by asset type



Significant variation was noted in the cleared all-In price as seen in Figure 16. This was primarily influenced by the buyer's specific commercial model and the timing of the constraint. In alignment with the intended market design, cleared availability prices remained significantly lower than cleared utilisation prices. This confirms that sellers were successfully incentivised to minimise availability pricing to increase the probability of a successful match.

Figure 16 Trade price variation



Participants highlighted the importance of transparency within the market. They expressed a desire for visibility of all bids, including unsuccessful bids to help understanding the opportunity cost and potential revenues that could be made in what remains a developing market.

There were also suggestions to increase bid flexibility. For instance, participants proposed allowing split-volume bids at different price levels, enabling more tailored bidding strategies.

Concerns were raised regarding uncertainty within the market. In particular, the unpredictability of real-time constraints and the short notice periods for activation were viewed as drawbacks. Most participants indicated a preference for receiving at least one hour's notice before activation.

Participants clearly wanted revenue certainty. Mechanisms that enable value to be secured earlier, such as availability payments or other scheduled flexibility products, were considered more attractive than purely real-time opportunities.

Regarding dispatch arrangements, most participants favoured receiving an email in advance of a constraint to confirm that an asset would be dispatched. This differs from the designed mechanism which requires assets to respond in real time via an API. Consequently, most of the assets involved in the trials would not currently be ready to participate in BiTraDER under BAU arrangements.

Participants reported uncertainty around price formation and noted that the lack of clarity regarding what constitutes a successful trade made it difficult to determine appropriate submission prices. This challenge was amplified by the peer-to-peer nature of the BiTraDER market, which differs from more traditional operator-led markets.

The trial also highlighted the diverse approaches taken by participants. Differences in technology types, industries, business models, and operational priorities resulted in varied pricing strategies, which in turn limited the number of matched trades during the trial period.

Despite these challenges, participants generally expected price formation and trading outcomes to improve under BAU conditions. Greater market liquidity and a broader range of participating assets were thought likely to increase the frequency of successful trades.

However, participants identified several competing markets that currently take precedence over BiTraDER. Wholesale markets, the Balancing Mechanism, and reserve services were all cited as higher-priority opportunities when allocating asset availability.

Nevertheless, participants generally felt that BiTraDER could be incorporated into existing operational processes without significant additional effort, provided that market transparency continues to improve and the market reaches a greater level of maturity.

Further information on the live trial outcomes can be found in the BiTraDER live trial outcomes and proposed platform enhancements report.

8 Cost Benefit Analysis

Since the submission of the original business case in 2021, the need for the deployment of flexibility to mitigate distribution network congestion has increased alongside the continued decarbonisation of the power system.

There is widespread agreement that new forms of distribution connected demand and generation will trigger a need for substantial and expensive network capacity upgrades. However, the flexibility inherent in these distributed energy resources could deliver substantial cost savings and wider benefits to connected customers.

During the period since the original business case submission there has been an increasing focus on local flexible services; including:

- *Increased need to understand local constraints through stakeholder engagement for the development of the RIIO price controls and Distribution Future Electricity Scenarios (DFES), including use of the Common Evaluation Methodology (CEM) to identify the need for flexibility; and*
- *Further development and coordination of flexibility products led by the ENA, alongside the launch of the Flexibility Market Asset Registration (FMAR) system to reduce administrative burden of multiple registration.*

These changes have increased the importance of flexibility markets, such as BiTraDER.

The CBA provides a review of the outcomes from the BiTraDER project. This includes a qualitative assessment supported by a quantitative assessment (where possible) recognising that a robust process will be vital in satisfying Ofgem's requirements for the evaluation.

This assessment is based on Ofgem best practice and has been designed to be robust and credible whilst also ensuring that it is both proportional and practicable given the information available.

8.1 Qualitative Assessment

The qualitative assessment draws on the stakeholder feedback and discussions across the development of the project. The learnings from the design of the trading rules and the outcomes of the trials identify no clear insurmountable barrier to entry for all participant types. The trial identified initial trades between curtailable Renewable Energy Sources (RES) and non-curtailable carbon intensive participants enabling the continued operation of RES assets, thereby reducing the level of RES curtailment and overall emissions.

The results from the trials identified a strong interest in the market from participants. The changes made to the trading rules (e.g. pricing options, timings of bid / offer submissions etc.) and platform functionality led to an improved experience for participants, and it is expected that further learning will be identified as the market moves to BAU.

The main concerns for the participants remain the transparency of prices in the market and the likely level of liquidity. During the trials this led to gaps between the prices submitted by buyers and sellers to take part in in the market. This concern was increased due to the different strategies and priorities of the participant types based on the different demand / generation technologies (e.g. between renewable generators and carbon intensive assets).

Unfortunately, the trials were unable to provide a view of whether these concerns would be addressed overtime due to low customer numbers and large simulation component that was used. However, as mentioned previously, the liquidity is expected to increase, leading to greater diversity of technology types and participants which should make trades more likely.

The approach to baselining will remain under review. Preferences were made during the trials, and it was agreed that this aspect would continue to be examined in the post-trials / pre-BAU period. As part of this we would consider work undertaken in other innovation projects alongside the best practices identified by the ENA and latest guidance from Elexon.

Finally, the trials showed that those participants operating in flexibility markets would be keen to take part in BiTraDER. And those with flexibility contracts would be willing to interact with the BiTraDER market on an ad-hoc basis.

8.2 Quantitative Assessment

The quantitative assessment provides an update on the original business case to ensure that it remains relevant. This includes updating the potential benefits identified in 2021 including reduction in load related expenditure, reduced curtailment and improving coordination with NESO.

The assessment is reflective of the benefits and drivers for BiTraDER. Using the initial full submission proposal as a starting point we have reviewed inputs to ensure all quantitative data has been updated to reflect the market changes since 2021. At the same time, we have ensured that the approach is reflective of the learnings from the trials.

All assumptions used in the calculations are based on validated data and credible assumptions – in line with Ofgem best practice. In general, conservative assumptions have been chosen in recognition of the uncertainty of future benefits forecasts.

A description of the benefit categories, and the calculation approach for each, is presented in Tables 2 and 3.

Table 2 Benefit categories

Benefit	Explanation
Reduced curtailment of RES [Financial and Carbon]	BiTraDER will enable a more economic selection of resources for curtailment, expected to lead to a reduction in curtailment of RES generation with flexible connections, replaced by curtailment of non-RES generation. The increase in RES generation at the expense of non-RES generation will lead to benefits in relation to the reduction in CO_2 emissions.
Optimised curtailment of non-RES [Financial]	A more economic selection of parties for curtailment will also bring a benefit on the curtailment of non-RES resources, as curtailment is applied to lower cost resources. BiTraDER will give the opportunity for non-RES participants to optimise the timing of curtailment e.g. the potential to avoid being curtailed at certain times.
Reduced generation investment [Financial]	As the BiTraDER market matures it has the potential to both reduce the levels of peak demand and maximise the output from the existing connected generation capacity. This has the potential to reduce the levels of additional (new) generation capacity that is necessary to deliver system adequacy.
Reduction in load related expenditure [Financial]	Through the optimisation of curtailment, BiTraDER has the potential to facilitate increased flexible connections on the distribution network for the same level of network capacity. This can lead to a limited deferral of the need for load-related expenditure as assets (e.g. existing substations) close to peak capacity need to be upgraded later or to a lesser extent.
NESO interaction [Financial]	By allowing more efficient trading of curtailment, BiTraDER has the potential to release flexible resources. This may allow these resources to free up capacity and offer services to both NESO and other DNO flexibility services, resulting in reduced NESO balancing service costs. This benefit will be dependent on the strategy and operation of the connected resources.

Table 3 Benefit categories, calculation approach

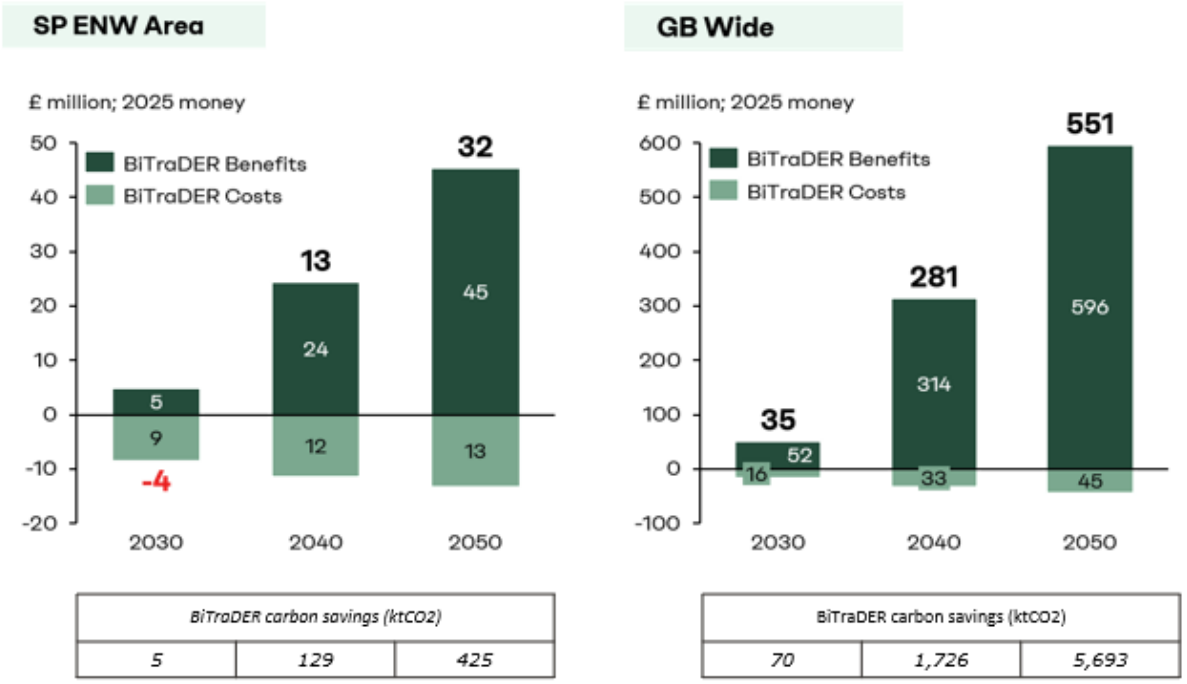
Benefit	Calculation approach
Reduced curtailment of RES	The approach allows for a realistic representation of expected curtailment benefit which is realized via a shift of curtailment from RES operators to non-RES generators. While costs for non-RES curtailment rise slightly as a consequence, this is more than offset by reductions in RES curtailment costs. In this case we have first calculated the reduction in RES curtailment and subsequent increase in non-RES curtailment (MWh) by the respective cost of RES / non-RES curtailment (£/MWh).
Optimised curtailment of non-RES	
Reduced generation investment	The benefit realised through the use of distribution connected assets being able to reduce peak demand so that it can replace a small amount of new generation capacity the system would otherwise need to procure via the Capacity Market This is based on a calculating the reduced capacity market action (kW) and de-rating factor and multiplying by the value of capacity (£/kW).
Reduction in load related expenditure	To quantify this benefit, we have assumed that a small share of the Base case investment requirement will be avoided in each year. In practice, this benefit might grow over time until the market reaches maturity. This is based on the demand forecasts to identify when each primary and BSP substation is expected to reach its firm capacity and the least cost option to solve the constraint (£million).
NESO interaction	To quantify this benefit, we assume that in both the Base and Method cases, a share of flexible resources are able to offer services both to the NESO and DNO. The additional share in the Method case compared to the Base case is expected to deliver financial benefits. The total financial benefit is calculated by estimating the utilisation of these additional resources by the NESO (ultimately in MWh) and multiplying by an assumed cost saving (£/MWh) compared to the alternative balancing resources.

The quantitative assessment reveals that after netting off costs of operating BiTraDER, the scheme generates a cumulative total of £32m in benefits in the SP ENW region by 2050. At GB scale, these modelled benefits reach £551m.

In addition, emissions modelling shows that in the SP ENW region, 425ktCO2 are avoided within the same time period (in addition to the financial benefits associated with emission savings). At GB level, the savings reach 5,693ktCO2.

These values are shown in Figure 17.

Figure 17 Total net benefit



The financial benefits of BiTraDER are driven primarily by reduced generation investment and avoided curtailment of renewable generation, both of which increase significantly over time as the market matures.

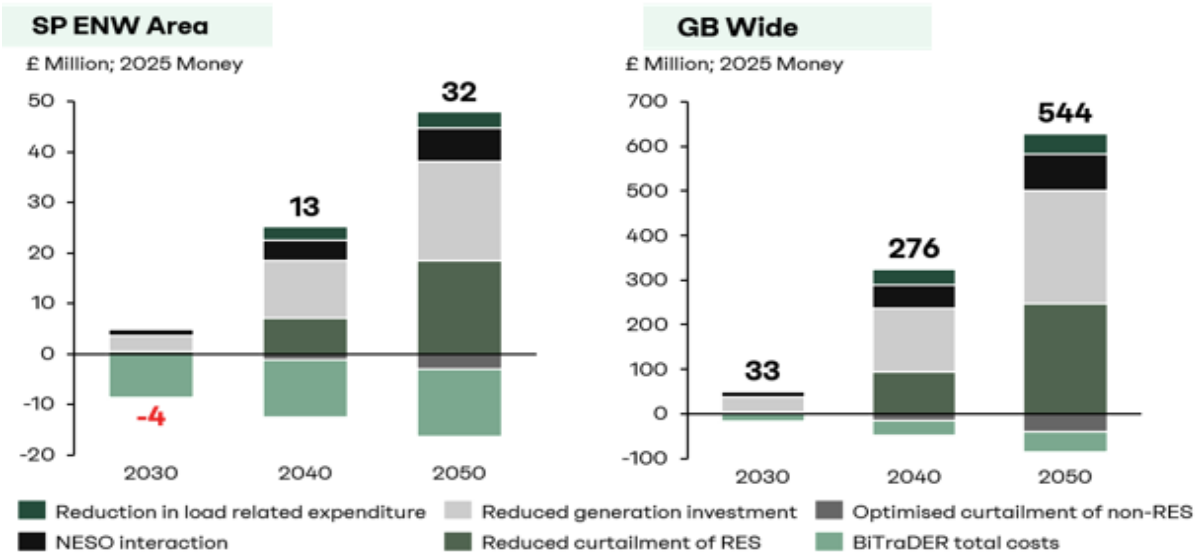
Additional benefits arise from enhanced NESO interactions and, to a lesser extent, deferred load-related network expenditure, which materialises only in later years.

These gains are partially offset by increased curtailment of lower-cost non-RES generation – reflecting an intentional shift towards more efficient system operation – as well as upfront and ongoing platform costs.

Overall, while net benefits are initially negative at SP ENW scale due to early investment requirements, they turn positive over time and deliver substantial long-term value, with materially larger gains when scaled to GB level.

These breakdown of benefits by category are shown in Figure 18.

Figure 18 Total net benefit by category

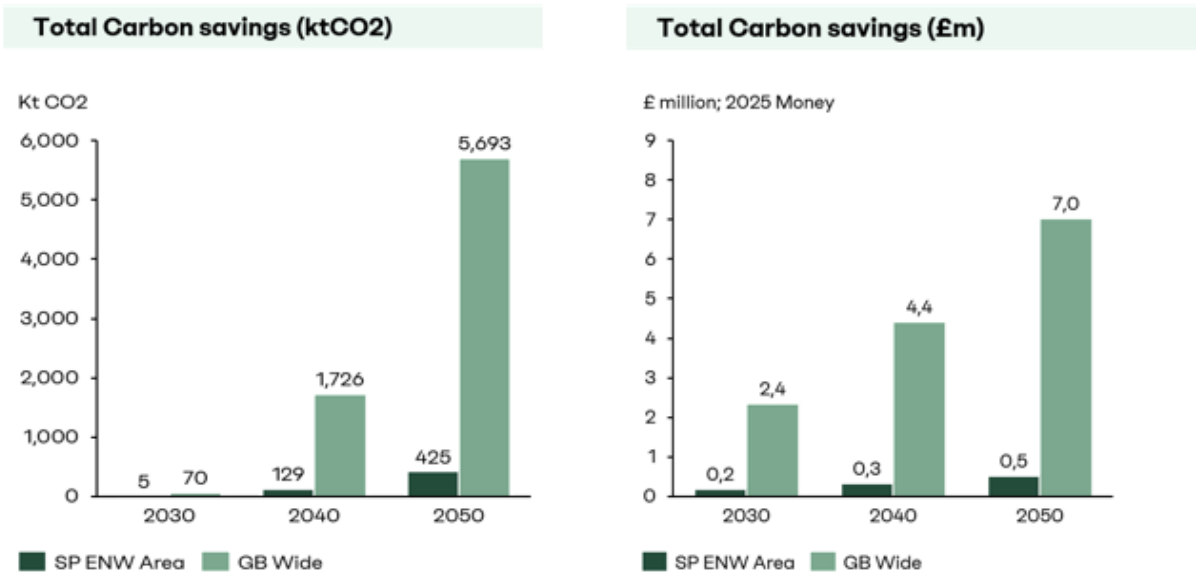


Beyond financial gains, BiTraDER is expected to improve the utilisation of RES, displace fossil generation and generate carbon benefits.

Avoided emissions are estimated assuming that avoided RES curtailment leads to higher non-RES curtailment, and this is calculated using the CCGT emission factor (320kgCO2/MWhel) .

In addition to the emissions volume, the implicit financial benefit of avoided carbon emissions is calculated, using DESNZ's latest "Traded carbon values used for modelling purposes".

Figure 17 Carbon benefits



The full CBA assessment report can be found here.

9 Required modifications to the planned approach during course of project

The project plan was continually monitored, reviewed, and updated in line with the regular project progress meetings. These discussions captured any changes to existing project risks, as well as any newly identified risks and issues.

The project scope evolved through stakeholder engagement and trial learnings. Mini-trials were introduced early in the programme to test market design and price discovery, while trading rules and platform functionality were iteratively updated based on participant feedback and industry developments.

For the simulation trials, the project initially planned to integrate directly with a live ANM environment, however, to reduce delivery risk and enable earlier testing, an ANM orchestrator was developed. This allowed market processes, trading rules, system interfaces and participant behaviours to be tested and refined before progressing to live operation.

It was found that the live network trials trading window was more than adequate to obtain the learnings required from the project. This was condensed down from the original plan for the trials to last over a period of months. This gave the project team more time to prepare for the live network trials, generating more accurate outcomes and allowing for more time afterwards to discuss robust conclusions with the participants.

10 Significant Variance in Expected Costs

The NIC governance document (June 2017) Appendix 2 states that the licensee is to describe if any parts of the project ended up costing more or less than expected (+/- 10%). This occurred in the labour, IT, 'payments to users', and other budgets.

There has been a notable underspend on IT payments from the following cost categories:

- *Interface design to ENWL systems - 58% underspend (£318,000)*
- *Interface build to ENWL systems - 48% underspend (£354,000)*
- *Application integration – 100% underspend (£107,750)*

The primary reason for the IT underspend came from the fact that the trials were conducted using an internal test component of the ANM system. Unlike the live ANM system, which would have incurred substantially higher costs from the manufacturer, the internal test environment offered greater flexibility, allowing modifications to support a wider range of tests. This approach proved far more cost-effective, as the adaptability of the internal system enabled adjustments at each stage of the trials. As different use cases and asset types were explored, the system could be tailored accordingly, maximizing the value of the trials. Hence the overall cost reduction in this category can be attributed to efficiency savings.

There has been a notable underspend on the payments to users payments from the following cost categories:

- *Payments to users (customer engagement) - 100% underspend (£111,547)*
- *Payments to users (flexibility payments) - 93% underspend (£268,000)*

The customer engagement payments were added to compensate participants for coming to events and workshops throughout the project including the trials. This would cover participants cost of travel and payback for time away from BAU activities. However, it became clear that participants in most cases opted to neglect any request for compensation. It is thought that the time and cost of administering the invoices to receive the payment would not be high enough to justify participation. This and given the fact that the project could add value to the businesses in other ways, for example access to early participation and network opportunities may be seen as an incentive itself without the need for further payment. Hence, the budget in the category has a large underspend.

The flexibility payments compensated the live network trial assets for adjusting their output following a trade. This structure was broken down further into a participation payment and a further curtailment payment. This incentivised participants to submit trades and support liquidity during the trials. The reason for the high underspend was that given the live network trial period was only two weeks, the number of trades combined with the number of assets did not require the level of payments in the budget. Originally, it was anticipated that the live network trials would be run over a longer period, but it was deemed that following the two-week period, the learnings that could be obtained from the participants had reached a maximum. This therefore left a large underspend, but since all requirements were met, could be justified.

The 'other' cost category had an underspend on accommodation consisting of the following:

- *Other - accommodation - 37% underspend (£40,000)*

This was due to an office change for SP ENW innovation staff mid-way through the project. Since the new office is more cost effective, this has resulted in less money being spent than anticipated.

Finally, the 'labour' cost category had an underspend on the technical author consisting of the following.

- *Labour – functional specification for BiTraDER (technical author) 100% underspend (£87,804)*

It was originally thought that the functional specification would be written by a technical third party, but it became clear that this was not required and the expertise utilised by the project team would suffice in delivering the requirements.

The remaining cost categories were largely within budget as expected. The project does still have some final invoice payments to be made and final accounts to be approved prior to formal finance closure.

11 Legal Documents

As part of the project, three legal templates have been prepared and can be used as a guide to create a final set of legal documents between each of the parties once the project enters BAU.

The three documents can be accessed from the links below:

- *the proposed Contract Structure*
- *a set of skeleton terms and conditions that the Market Operator may want to have in place with the participant in BiTraDER*
- *an addendum to the skeleton terms and conditions dealing with the specific DNO aspects (with regards to supplementing the participant's connection agreement) that will need to be in place directly between the DNO and the participant*

11.1 What the documents cover

The contract structure sets out all the contractual relationships that are contemplated in being required as part of any BAU rollout of BiTraDER.

The skeleton terms and conditions are explained in more detail within the general drafting notes on the first page of this document. These terms and conditions are proposed to be entered into between the Market Operator and the BiTraDER participant via a click acceptance mechanism within an online portal.

The addendum is explained within the general drafting notes on the first page of this document. Fundamentally, this addendum acts to supplement the participant's connection agreement with the applicable DNO to allow the trades via BiTraDER to operate correctly in accordance with the applicable connection agreement. It is important to note that, when giving instructions or notifications to the participant, the DNO will not be contacting the participant directly as such. Instead, the functionality of the BiTraDER platform will need to enable the DNO to issue these instructions or notifications to the participant via the BiTraDER platform, which can be covered in the contract between the DNO and the Market Operator.

11.2 What the documents do not cover

Evidently from the proposed Contract Summary, not all contractual elements contemplated are included within the Documents. There are no drafts of any agreement between the DNO and the Market Operator, the platform licence agreement between the Platform Operator and the Market Operator or the EULA between the Platform Operator and the participant in BiTraDER.

In terms of the agreement between the Platform Operator and the Market Operator, we have included within the skeleton terms and conditions some elements in blue highlight that we consider may be relevant to this agreement. The last two of the documents we have not prepared (the platform licence agreement and the EULA) would, we propose, be prepared by the relevant

Platform Operator (although some pointers are in green highlight within the skeleton terms and conditions).

12 Data Access Details

All project reports and associated document are published and stored on the SP ENW website as per previous links.

The Innovation data sharing policy is also available on the SP ENW web site: Our data sharing policy

The SP ENW policy is:

We will make available on our website any aggregated network, consumption or other relevant data pertaining to a particular innovation project trial. This is in line with Ofgem's governance on projects funded under the NIC and the Network Innovation Allowance (NIA).

Due to the high volumes of data produced by the different innovation project trials, we will only publish the latest available data i.e. data from the current month for each relevant trial.

Previous months' data will be made available if the party requesting it can demonstrate that release of the data is in the interest of electricity consumers. For data protection purposes this data may be subject to anonymisation and/or redaction.

The contact detail for further information is included on the webpage linked to above and is "innovation@enwl.co.uk".

The SP ENW innovation team can also be contacted at:

SP ENW Innovation, Linley House Dickinson Street, Manchester, M1 4LF

13 Learning Outcomes and Conclusions

13.1 Learning Outcomes

The BiTraDER project has successfully demonstrated that a bilateral market for trading curtailment obligations is both technically feasible and attractive to industry participants. Throughout the project, the concept evolved from an initial theoretical market design into a fully integrated platform capable of interfacing with the DNO and FSP systems, supporting participant registration, market operation, performance verification and trade settlement processes. The successful completion of simulation and live network trials has provided valuable evidence on how such a market could operate in a BAU environment.

A key learning from the project is that participants recognise value in the ability to manage curtailment risk. Connected customers increasingly seek flexibility in how they manage network access rights and wish to optimise participation across multiple revenue streams. The ability for a customer to transfer curtailment risk through a market mechanism was viewed positively, particularly by curtailable renewable generation owners and operators.

The project also demonstrated that effective customer engagement is critical to the development of innovative flexibility markets. While there was considerable interest in the concept of BiTraDER, maintaining sustained engagement over a multi-year project proved challenging. Competing operational priorities often limited the availability of participants, particularly during the trials. Nevertheless, a core group of highly engaged stakeholders provided valuable feedback that shaped the market design, trading rules and platform functionality.

Another important learning relates to market transparency and liquidity. Participants consistently highlighted the importance of understanding market conditions, competitor pricing strategies and the likelihood of successful trade matching. The trials indicated that limited liquidity could create uncertainty around price discovery, leading to significant variation in bidding behaviour. Greater transparency of market information and increased participant numbers are therefore expected to be important prerequisites for successful long-term market operation.

The project also demonstrated that the technical architecture required to facilitate bilateral trading can be successfully integrated with the existing ANM and MOMs system. The exchange of CLA information, merit order data and dispatch instructions functioned as intended, validating the proposed architecture. This represents a significant achievement given the complexity of integrating multiple operational systems.

Finally, the trials highlighted the importance of aligning new market arrangements with existing electricity markets. Many participants actively operate in wholesale, balancing and ancillary service markets and therefore assess BiTraDER opportunities against alternative revenue streams. Future market development must continue to consider how participation can be made compatible with these existing commercial arrangements to maximise liquidity and participation.

13.2 Technology Readiness Level (TRL)

At the start of the project, the TRL was assessed at level 6. The expectation was that by the end of the project, this would increase to level 8, which would correspond to a BAU ready solution. The outcomes of the project have validated TRL level 8 compliance, given the robust testing of the market through the trial stages. Through the live network trials, customers have traded in a BAU environment, expressing understanding of outcomes and a desire to see BiTraDER as a live operational market.

The systems to enable the market have been developed and successfully integrated, enabling data to be exchanged between the DNO and the trading platform, with the underlying market rules built into the platform.

The final set of functional specifications have been developed and designed to enable integration across other licence areas, and the CBA has shown this value through extrapolation up to GB wide.

13.3 Project Replication

The market can be replicated to other DNOs who have flexible connection customers who may wish to trade curtailment obligations. Whilst the underlying market mechanisms remain the same, SP ENW recognise that its control system is unique in sourcing its NMS system from Schneider

Electric. Hence additional integration with other DNO ANM systems will be required, along with ensuring that the merit order change principles are applicable to that system. For instance, the merit order stack at SP ENW is based on a curtailment index, whilst some other DNOs across GB have stacks based on a LIFO arrangement.

It is anticipated that integrating the market into other DNO systems will involve a technical review of the merit order trading principles and thorough testing of data transfer. It is difficult to estimate the costs of this as they will likely vary between each system and DNO.

13.4 Planned Implementation

The ANM system at SP ENW is a live system and actively managing flexible connection contracts. The logic within the MOMs system has been updated to handle the exchange of BiTraDER specific data with the trading platform, and the functionality has been updated so that the merit order list can be updated following peer-to-peer trading.

Regarding the BiTraDER trading platform, the functional improvements required for transition to BAU have been documented in deliverable 7, Functional Specification. These updates reflect some of the recommendations gained from the trials and will ensure the market, once operational meets its objectives.

At this time on the SP ENW network, the number of network constraints and subsequent flexible connections is still low and hasn't increased to the level anticipated at the start of the project. The implication of this is that the liquidity of trades at this time would not be enough to justify the transition to BAU.

However, the usefulness of BiTraDER is evident for licence areas for that may be seeing high levels of constraints now or in the future. For SP ENW, that case is for the future and BiTraDER remains a strong solution for when the forecasted uptake of renewable demand and generation start to cause an uptake in network constraints.

13.5 Conclusions

BiTraDER has successfully met its core objectives and demonstrated the viability of a bilateral curtailment obligation trading market at distribution level. The project has shown that market participants are willing to engage with the concept and that suitable governance, system architecture and operational processes can be established to facilitate trading. The successful completion of the live network trials represents the first practical demonstration of this market concept under real-world conditions.

The project has also shown that bilateral trading has the potential to improve network utilisation and support the transition to a more flexible energy system. By enabling participants to trade curtailment obligations, network capacity can be used more efficiently, providing customers with greater options for managing their connection arrangements while reducing the need for traditional network reinforcement. The CBA indicates that these benefits could become substantial as market participation grows and flexibility requirements increase over time.

While the project identified several challenges, none were considered fundamental barriers to implementation. Issues relating to liquidity, market transparency, baseline methodologies, price discovery and dispatch arrangements are all capable of being addressed through further market development and industry engagement. Importantly, participants generally considered the market concept credible and capable of being incorporated into existing operational processes.

The trials also reinforced the expectation that flexibility will play an increasingly important role in facilitating the connection of low-carbon technologies. As the number of flexible and ANM connections grows across GB, the potential value of mechanisms such as BiTraDER is expected to increase. Consequently, the project has established a strong foundation for future deployment and further development of local flexibility markets.

Overall, BiTraDER has demonstrated that bilateral curtailment trading can provide benefits to network operators, flexibility providers and connected customers whilst supporting wider decarbonisation objectives. The project has therefore delivered significant learning for the electricity industry and provided a practical framework upon which future flexibility market developments can build.

13.6 Next Steps

Although the project has now concluded, several opportunities have been identified to further enhance the concept and prepare it for wider BAU deployment.

Firstly, continued industry engagement will be required to validate the market design with a broader range of participant types and asset technologies. Focus should be placed on understanding the requirements of storage providers, renewable generators, demand-side response providers and aggregators to ensure that future market arrangements support the widest possible participation.

Secondly, platform functionality should continue to evolve in response to participant feedback. Enhancements identified during the trials include increased transparency of market prices, automated bid and offer submission, the ability to resubmit trades as market conditions evolve, half-hourly trading opportunities and enhanced participant notifications. These developments would improve usability and support greater market efficiency.

As the market matures, additional consideration should be given to more advanced market design features such as the treatment of nested constraints, alternative pricing mechanisms and enhanced baseline methodologies. While these issues were not considered barriers during the project, they may become increasingly important as participation levels and trade volumes increase.

From a network operations perspective, ongoing coordination between DNO systems, ANM platforms and flexibility market platforms will remain essential. Future deployment should seek to leverage developments in flexibility market standardisation, including emerging industry initiatives designed to simplify participation and reduce administrative burdens for market participants.

Finally, the learnings from BiTraDER should be shared more widely across the electricity industry to support future flexibility market development. The project has generated significant insight into the interaction between curtailment obligation trading, local flexibility services and participant

behaviour. These lessons can inform future policy, market design and operational practices as the electricity system continues its transition towards a smarter, more flexible and lower-carbon future.

14 Peer Review

Scottish & Southern Electricity Networks

Christopher Greenfield, Innovation Project Manager
SP Electricity North West
Linley House Dickinson Street,
Manchester
M1 4LF

04 August 26

BiTraDER Close-Down Report – DNO Peer Review

Dear Chirstopher,

I write to following you request for Scottish and Southern Electricity Networks (SSEN) Distribution to undertake a Peer Review of the SP Electricity North West BiTraDER NIC funded project.

I can confirm that we have undertaken this review and consider that the Close-Down Report to be clear and understandable and contains sufficient detail and information to enable a DNO, not closely involved with the project, to make use of the learning generated to implement the solutions developed within our BaU operations.

Should you wish to discuss anything further or have any additional requirements that you need to address in respect of the project, please do not hesitate to contact me.

Yours sincerely,

Frank Clifton
Innovation Manager

Inveralmond House, 200 Dunkeld Road, Perth PH1 3AQ ssen.co.uk

Scottish and Southern Electricity Networks is a trading name of: Scottish and Southern Energy Power Distribution Limited Registered in Scotland No. SC213459; Scottish Hydro Electric Transmission plc Registered in Scotland No. SC213461; Scottish Hydro Electric Power Distribution plc Registered in Scotland No. SC213460; (all having their Registered Offices at Inveralmond House 200 Dunkeld Road Perth PH1 3AQ); and Southern Electric Power Distribution plc Registered in England & Wales No. 04094290 having their Registered Office at No. 1 Forbury Place 43 Forbury Road Reading RG1 3JH which are members of the SSE Group www.ssen.co.uk

Appendix 1 - BiTraDER Dissemination log

Date	Activity	Audience
10/12/21	Award of funding announcement in company newsletter	All SP ENW employees
19/01/22	Award of funding announcement in stakeholder newsletter	All SP ENW registered stakeholders
27/01/22	Project overview article in company magazine	All SP ENW employees
24/06/22	Announcement of project start in stakeholder newsletter	All SP ENW registered stakeholders
13/07/22	Power Responsive Seminar	All registered attendees (approx. 200)
21/09/22	EnergyXNorth	All registered attendees (approx. 75)
29/11/22	Energy Innovation Summit 2022	All registered attendees
14/12/22	SP ENW DSO Functions: Data and Flexible Services webinar	All registered attendees
19/04/23	SmartEn – Distributed Flexibility: Maximising Local Optimisation	All registered attendees
19/06/23	Meeting with European Commission – DG Comp	Damien Columb Matt Wieckowski
20/06/23	Eurelectric – Eurelectric Power Summit: Private Roundtable	All registered attendees
18/07/23	Weather and Climate Research for highly renewable power systems – University of Bristol	All registered attendees
12/09/23	Newsletter update sent to all signed up customers	All BiTraDER participants / customers

Date	Activity	Audience
29/09/23	LCP Delta published blogpost and posted on LinkedIn. Blogpost included an update on the project progress and a call for new customers to sign up to be involved in the project	LinkedIn audience
01/11/23	Energy Innovation Summit 2023	All registered attendees
06/12/23	Project overview and progress video used at the SP ENW stand at the Innovation Summit uploaded to the SP ENW website and YouTube.	SP ENW website / YouTube audience
07/12/23	Presentation to ENA ANM Curtailment Working Group	All WG members – DNOs and NESO
05/02/24	Project update LinkedIn post from Electron following the mini trials.	LinkedIn audience
09/02/24	Article in Connect – SP ENW's weekly internal comms newsletter about mini trials workshop	All SP ENW employees
12/02/24	LinkedIn post about the mini trials.	LinkedIn audience
19/04/24	121 BiTraDER project overview with NGED	NGED employee who attended the meeting
15/05/24	Article on flexibility markets in Modern Power Systems magazine	Modern Power Systems magazine readers
21/05/24	Presentation on BiTraDER at Utility Week Live	Attendees on the flexibility stage at UWL 2024
14/08/24	LinkedIn post on the simulation trials to update on the project and recruit new customers	LinkedIn audience
23/08/24	Presentation to ENA ANM Curtailment Working Group	All WG members – DNOs and NESO
29/10/24	Energy Innovation Summit 2024	All registered attendees
12/11/24	LinkedIn post on simulation trials following first successful trade	LinkedIn audience
26/06/25	Presentation on BiTraDER at Connecting Projects to the Grid Conference	Conference attendees

Date	Activity	Audience
03/07/25	Presentation on BiTraDER at Reforming Grid Connections Conference	Conference attendees
06/11/25	Energy Innovation Summit 2025	All registered attendees
02/12/25	BiTraDER Press Release	All article readers
07/07/26	BiTraDER Project Dissemination Day	All registered attendees
11/08/26	BiTraDER Learnings Blog	LinkedIn audience