BiTraDER Trading Rules

A report to Electricity North West Limited as part of the BiTraDER project

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1 Executive summary

Curtailable connection arrangements are increasingly being offered by Distribution Network Operators (DNOs) to new customers. This is a way of providing a timely connection without waiting for completion of network reinforcement. This type of connection carries a curtailment obligation, which can reduce their attractiveness. As a consequence, connections can be delayed, with low carbon renewable energy sources amongst those affected.

Under the governance of Ofgem's Network Innovation Competition 2021, the BiTraDER project, led by Electricity North West, is developing high level trading rules that could enable peer to peer trading of curtailment obligations between assets connected to the same constraints on the distribution network. Having the ability to trade should encourage more renewable resources to accept curtailable connections, increasing availability of flexibility and thereby reducing whole system costs.

1.1 Project background

There has been an increase in requests by customers to connect low carbon, renewable energy sources to the distribution network. To avoid the need for expensive, time-consuming and disruptive network reinforcement, DNOs have introduced curtailable connection arrangements for customers.

By accepting curtailable connections, customers can connect to the network at potentially lower cost and quicker than if their connection was non-curtailable.

With a curtailable connection, the customer is essentially agreeing to operate flexibly within the limits of real-time network capacity and face the risk of curtailment, known as a 'curtailment obligation'. This risk often disincentivises customers from accepting a curtailable connection, which can delay the uptake of renewable energy sources.

Given the context outlined above, the BiTraDER project seeks to explore the following overarching question:

- Is there a way that curtailment obligations can be transferred, via peer-to-peer trading, from a party seeking to avoid curtailment to a party that is able to take on a curtailment obligation?

As a BiTraDER project team member, AFRY is leading on the development of conceptual trading rules. This document presents a proposed framework for curtailment obligation trading arrangements.

1.2 Approach overview

AFRY initially conducted a literature review to ensure BiTraDER builds on learnings from previous work in similar areas. This was based on desktop research of relevant case studies to help inform the development of the trading rules.

AFRY also reviewed in detail the current Electricity North West curtailment process to understand the context within which the trading of curtailment obligations needs to be framed.

To develop the trading rules, AFRY considered several market design choices across a set of building blocks. The building blocks are combined to create the overall trading arrangements. The building blocks focused on the key design questions, providing the foundations and structure of the overall market design.

Trading of curtailment obligations as envisaged in the BiTraDER project is an innovative concept, without an established prototype model to follow. Therefore, a range of assumptions and simplifications have been made to provide an initial framework within which to explore the concept of the trading rules.

1.3 Current curtailment process

Currently, Electricity North West uses a 'curtailment index' to determine the order for curtailment, referred to as the master merit order. Each customer is assigned a curtailment index based on the security of supply, i.e. how often an asset is likely to be curtailed, and the voltage level where the asset is connected.

This master merit order is constructed so that customers with a higher curtailment index are further up the merit order (and therefore more likely to be curtailed).

When a constraint is active, the Active Network Management (ANM) system works down through the merit order curtailing customers until the constraint is resolved. As customers with curtailable connections are situated at the top of the merit order, they will be the first to be curtailed.

When an asset is curtailed, its curtailment index is decreased by the number of hours or MWh it has been curtailed.

1.4 Trading rules summary

A summary of the key building blocks explored for the trading rules, plus associated questions and high level decisions, are shown in Exhibit 1.1. More details on the decisions are contained within the document.

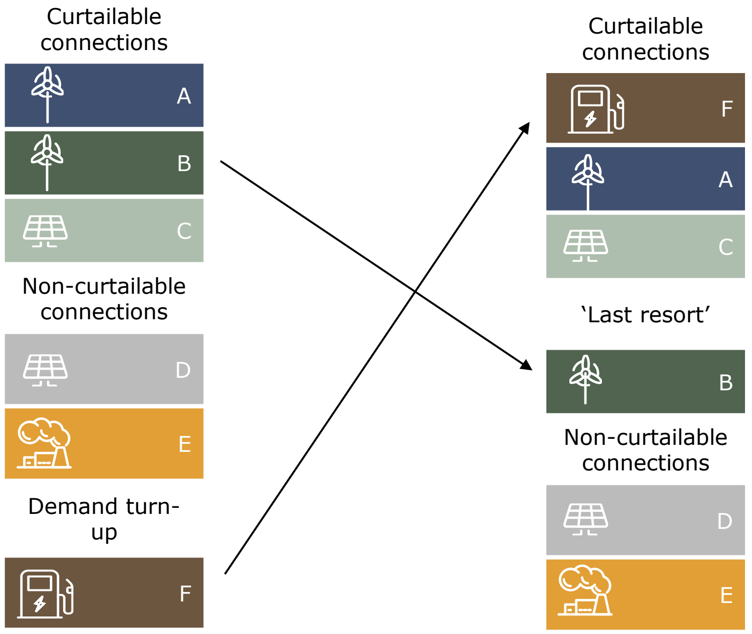
Exhibit 1.1 – Key building blocks and associated questions

Building blocks	Questions	Current decision
Market process and timeframes	What are the timeframes for the market and associated processes/communications?	Day-ahead market with a single auction.
Product definition	What is the nature of the product being traded between parties?	Trading curtailment obligations.
Participant qualification	Which types of participant are eligible to trade as buyers and/or sellers and what are the prerequisites?	Curtailable connections can participate as buyers, and non-curtailable connections as sellers.
Network requirements	What information will be provided to the customer concerning the network situation and how will the different impacts on the network be accounted for?	All assets able to resolve the constraint will be treated equally.
Merit order trading principles	How are the position of the parties in the merit order affected by the trading?	See Exhibit 1.2.
Payment structure and trade matching	What is the basis of payments from buyers to sellers and how are the trades matched?	Both 'Availability and utilisation payments' and 'utilisation payments only' will be explored in the trials.
Volume traded	What is the basis for defining volume traded from the perspectives of buyers and sellers and different resource types?	Utilisation payments will be made for the volume curtailed against a self-declared baseline.
Dispatch and delivery	What are the instructions given by the DNO to the participants in the event of curtailment and how is delivery monitored?	Instructions given by Electricity North West.
Settlement	What is the basis for determining and settling payments between trading parties? What would be the impact on curtailment index?	Buyer's curtailment index is updated if the associated seller is curtailed.

The merit order trading principles are illustrated in Exhibit 1.2 with a potential constraint linked to excess generation. The original merit order list for curtailment is shown on the left. This has the curtailable connection sites

(A, B and C) at the top. These are followed by the non-curtailable connection sites (D and E). Also included, as this is an excess generation related constraint, is a site capable of demand turn up (F).

Exhibit 1.2 – Merit order trading principles



Party B wishes to reduce its risk to potential curtailment. Through trading, Party B (the buyer) successfully trades with, and so secures reduced risk of curtailment from, Party F (the seller) i.e. B transfers its curtailment obligation to F.

The revised merit order following trade is shown on the right. As a consequence of trade, F moves to the top of the merit order, and B moves below all other curtailable connections, and above non-curtailable connections.

The process for the trading and the proposed trading rules design are summarised with the key steps below:

1. In advance of trading, parties will need to be registered on the BiTraDER platform and have functionality to be able to receive a signal from the ANM system.
2. The look-ahead will provide information concerning any expected constraints on the network for the 48 hours ahead, with information specified in hour blocks. For each identified constraint, this will include a list of assets connected to that specific constraint.
3. The master merit order and the look ahead list are sent to the BiTraDER platform.
4. The BiTraDER platform will filter the master merit order list to produce a merit order specific to the constraint. Anyone registered on the platform will be able to see details on the constraint.

5. Curtailable customers can then submit bids based on the amount they are willing to pay to reduce their risk of curtailment, i.e. move down the merit order. Non-curtailable customer can submit offers based on the amount they are willing to accept to increase their risk of curtailment i.e. move up the merit order. These bids and offers can be submitted up to gate closure in day-ahead timescales.

6. Following gate closure, trade matching will occur for each half hourly settlement period for the following day. The traded master merit order, re-shuffled based on the traded position of the customers, will be sent back to the ANM system. There could be a different traded merit order for each half hourly settlement period.

7. When a constraint occurs, the ANM system will send a signal to the first customer on the traded merit order to turn-down / turn-up and will then, as necessary, work its way down the traded merit order until the constraint is resolved.

8. After the event, settlement will occur:

    a. If bids/offers include an availability payment, buyers will pay matched sellers for availability regardless of whether constraint actions were taken. Although if constraint actions are taken and the seller does not respond in line with the trade, it forgoes some or all of the availability payment.
    b. If constraint actions are taken, buyers will pay matched sellers who were constrained a utilisation fee based on the response provided by the seller. The response will be compared to a self-declared baseline provided by the seller.

    All payments will be conducted via a market operator.

1.5 Conclusion

AFRY, together with the project partners, have designed the first layer and high-level principles of the rules for peer-to-peer trading of curtailment obligations, with simple examples to highlight how this can work. The next step is to apply these rules in trials to get feedback from customers and test the trading rules under different scenarios.

2 Introduction

This section provides brief context for the BiTraDER project and for the trading rules development component.

2.1 Flexibility context

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. To avoid the need for expensive, time-consuming and disruptive network reinforcement, DNOs have introduced curtailable connection arrangements for customers.

Where a customer accepts a curtailable connection to the network, the DNO can then curtail that customer's output/offtake to help resolve constraints on the network. This is known as a 'curtailment obligation', and the details of the curtailment is captured in the customer's connection agreement making it a contractual obligation or liability. In return for accepting these obligations, customers connect to the network at lower cost than if their connection was non-curtailable.

However, owing to the commercial risk associated with accepting a curtailable connection (i.e. the risk of not being able to operate normally), many customers are hesitant to accept the DNO's offer of a curtailable connection, preferring instead a non-curtailable connection to the network without the type of curtailment obligation referred to above.

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. Therefore, they are much less likely to accept a curtailable connection. This has the effect of potentially delaying connection of new renewable energy sources, which may frustrate progress towards net zero.

Longer-standing connections do not tend to have curtailment obligations as part of their connection agreements. However, they may have flexibility in their operations and, at times, be open to curtailment. This opens up the opportunity for the concept of transferring curtailment obligations from curtailable connectees to non-curtailable connectees. This could lessen the commercial risk of curtailable connections for newer connectees and, with a trading mechanism in place to facilitate the transfer, provide a revenue source for parties with non-curtailable status.

2.2 Project aims and methodology

2.2.1 Project aims

Given the context outlined above, the BiTraDER project seeks to explore the following overarching question:

- Is there a way that curtailment obligations can be transferred via peer to peer trading from a party seeking to avoid curtailment to a party that is able to take on a curtailment obligation?

More specifically, the project's aims are to:

- investigate, develop and trial an innovative method enabling trading of curtailment obligations;
- reduce barriers for the uptake of renewable energy sources and provide choice for connected customers (to de-risk their connection and opportunity for new revenue streams);
- introduce new sources of flexibility and encourage use of flexibility, promoting an increasingly important feature of network operations and reduce whole system costs; and
- enable DNOs to meet the challenge of net zero, making flexible connections more attractive by offering more choice, and therefore avoiding carbon intensive reinforcement associated with traditional firm connections.

This specific deliverable from the BiTraDER project focuses on the potential trading rules to allow for transfer of curtailment obligations. The trading rules developed through the project and described in this document are intended to provide an initial framework for trading arrangements. The expectation is that this initial framework will be adjusted and refined in the future. If the BiTraDER project indicates that the trading framework concept has positive potential, then the rules themselves can be formalised to allow them to be enacted in practice.

2.2.2 Methodology and content

During the project, time has been dedicated to reviewing how curtailment currently works and the associated mechanics. A literature review has also been conducted to understand if other projects with some aspects of similarity could inform the development of the trading rules for BiTraDER. The key insights from these activities are detailed in Section 3 of this report.

For the market design choice, AFRY used a tried-and-tested process to develop and select market designs which consists of the main following steps:

- define the long term objectives and design principles;
- outline the future for which the market design must scope;
- define building blocks and options;
- understand pros and cons;
- create 'strawman' (high-level designs) that explore alternative philosophies;
- select and refine a market design; and
- reporting and dissemination.

The objectives identified for this market are for it to ensure cost-efficient provision of curtailment through bilateral trading to maintain system security in the context of a zero-carbon system. When assessing the pros and cons of different options, the following sub-objectives, relating to the trading processes and outcomes, were considered:

- practical: deliver ease of implementation and ongoing operation;
- transparent: certify visibility of participation, values and trade process/outcomes;
- efficient: provide incentives for economically efficient behaviour and outcomes and limit free-rider effects; and
- fair: support fair outcomes for participants.

Market design choices made so far in the project are detailed in Section 4, which highlights the main decisions taken, summarises the considerations undertaken and identifies the pros and cons of the different options.

To illustrate how the proposed trading rules work, a range of trading examples have been created – see Section 5. The approach starts with a simple example to explain the concept of the trading and then builds to provide refined examples illustrating different complexities.

Throughout the project, a set of simplifications have been adopted to provide simplicity for the rules to aid their accessibility. These are detailed Section 6, alongside a set of known limitations of the proposed arrangements identified by the group.

3 Current curtailment context and insights

This section introduces a number of concepts relevant for the Electricity North West curtailment process and the framework for curtailment at present. Additionally, it highlights insights gained from our review of other innovation projects with similar focus areas.

3.1 Key concepts and definition

To provide context for curtailment obligation trading, some key concepts of relevance to the Electricity North West curtailment process are presented here.

3.1.1 Connection types

Customers can broadly choose between two types of connection:

- **Curtailable – under system normal conditions:** A connection where the agreement is that the site's import and/or export can be reduced when the network is operating normally, to help resolve constraints. As constraints tend to occur during peak generation or peak demand periods, these customers risk being curtailed multiple times per year. Curtailable connections are assigned a **curtailment index**, as described in Section 3.1.4.
- **Non-curtailable – under system normal conditions:** A connection where the agreement is that the site's import and/or export cannot be reduced, when the network is operating normally, to help resolve constraints. Given this, these connections have a lower risk of being curtailed than curtailable connections, under system normal conditions.

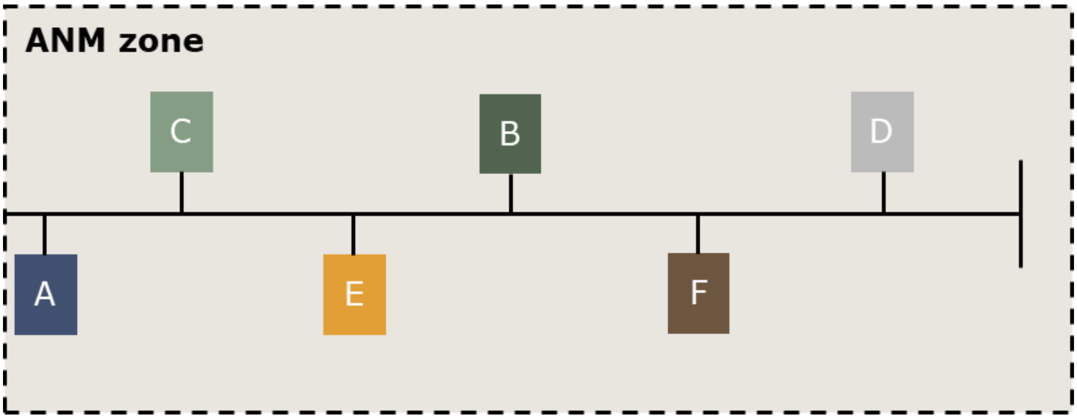
All connections to the network have some risk of being curtailed or disconnected from the network due to a number of factors: faults, maintenance, transmission constraints, thermal overloads, voltage issues, high fault levels, safety requirement, etc. A customer's level of curtailment risk is generally defined by the 'security of supply' they have agreed to through their connection agreement, as outlined above.

3.1.2 Active Network Management

Active Network Management (ANM) systems are used to continually monitor network limits and, in the event of issues on the system, to instigate some network control response. The ANM system directly controls, or issues instructions to, assets such as generators, storage devices, controllable demands etc., to alter their operation.

The network is divided into different ANM zones and the ANM system ensures each zone stays within operational ratings.

Exhibit 3.1 – Example ANM Zone



3.1.3 Merit order

The ANM system holds a master merit order list, which sets out the order in which resources are to be dispatched when a network constraint has been detected. All assets are registered in the master merit order and can be called upon to solve a constraint.

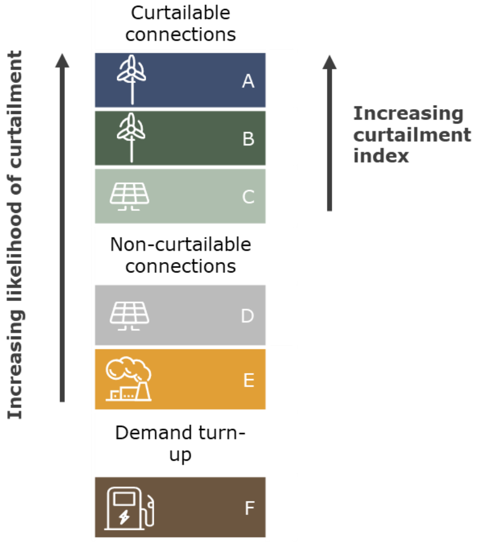
In Electricity North West, the master merit order is common for the entire system as opposed to a merit order list per constraint.

When a constraint occurs, the ANM system uses the master merit order list along with the network connectivity to only dispatch instructions to those assets which can alleviate the constraint.

3.1.4 Curtailment index

The master merit order is constructed based on each connectee's curtailment index. The curtailment index is based on the security of supply, i.e. how often an asset is likely to be curtailed, and the voltage level where the asset is connected. The higher its curtailment index value, the further up the stack the asset will sit as reflected in Exhibit 3.2. In this example, Parties A, B and C, with curtailable connections, sit at the top of the list. A is positioned the highest as it has the highest curtailment index value. Parties D-F have non-curtailable connections and are therefore lower down the merit order list.

Exhibit 3.2 – Example Merit Order in case of excess generation



The curtailment indices used to construct the merit order is determined from connectee's 'contracted curtailment index' plus both their 'actual curtailment or tally' and their 'adjusted curtailment index'. These terms are defined below:

- contracted curtailment index: 'trigger' or max curtailment stated in the connection contract. This is provided as a percentage of time curtailed and number of days over a rolling six-years period;
- actual curtailment or tally: duration of curtailment experienced by the party to date; and
- adjusted curtailment index: this is used to determine the merit order and is the contracted curtailment index minus the actual curtailment.

When a party with a curtailable connection gets curtailed for a duration of X % of time by Electricity North West, the above are adjusted as follows:

- the contracted curtailment index is a fixed value and does not change;
- the actual curtailment or tally gets incremented by X%; and
- the adjusted curtailment index gets decremented by X%.

The master merit order list is then updated to reflect the new curtailment indices. Due to the decrement of the adjusted curtailment index, a party that was previously curtailed could move to a lower position, depending on the curtailment indices of the other parties. A lower position in the merit order will decrease the risk of the party being curtailed in the next curtailment event.

If the average actual curtailment or tally over a six-year rolling period reaches the contracted curtailment index, Electricity North West will investigate and develop a range of options to resolve the constraint by other means.

3.2 Current context for curtailment

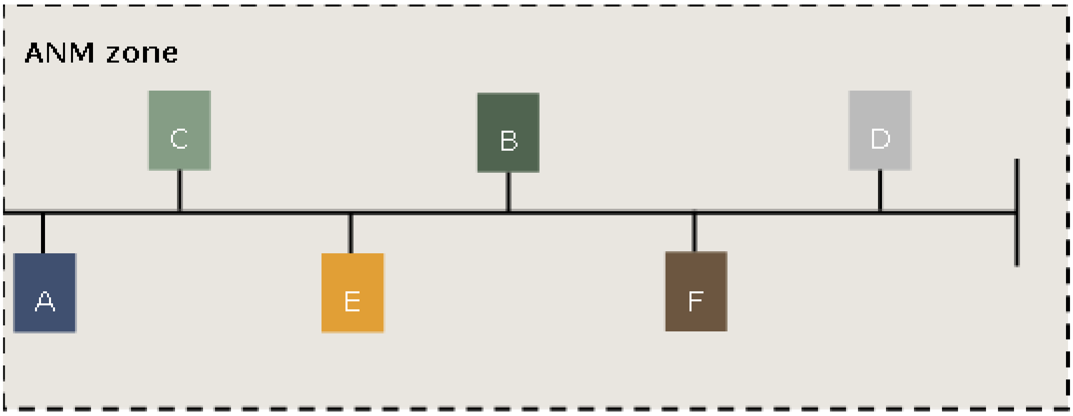
The actions taken to determine curtailment can broadly be split into three phases (based on timescales) after the registration of the different parties:

- run-up to curtailment;
- during curtailment; and
- post-curtailment.

These phases are considered in turn below.

3.2.1 Run-up to curtailment

Exhibit 3.3 – ANM zone illustration

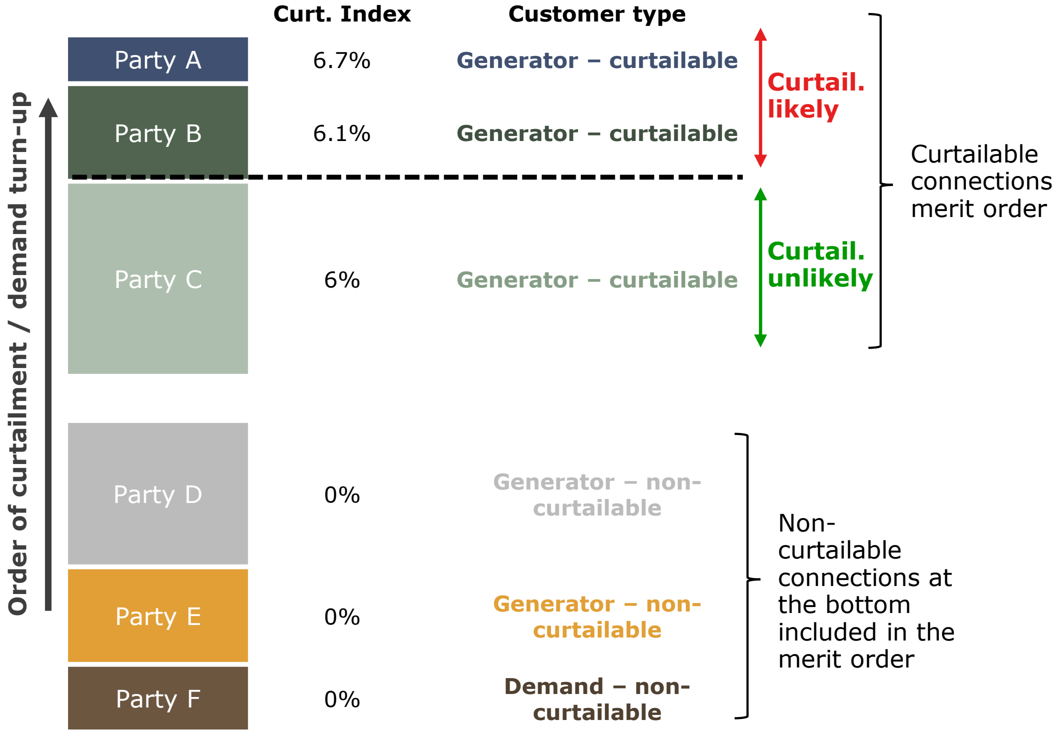


Ahead of time, the ANM system performs a 'look ahead' up to 48 hours ahead to predict likely constraints in one-hour blocks. The 'look ahead' currently uses historical data and predictions based on inputs such as weather data. The output includes a prediction of the magnitude of curtailment required.

Additionally, the system holds a merit order of connected customers and the threshold to which they can be curtailed. The look ahead and merit orders are updated every hour on a rolling basis.

Exhibit 3.4 provides an illustration of a merit order produced from the above processes. The example is for a constraint in a system normal scenario where generation exceeds demand.

Exhibit 3.4 – Merit order before constraints



The merit order for curtailment consists of two tranches:

- curtailable customers (Parties A, B and C), who are at the top of the merit order ordered by curtailment index (from high to low); and
- non-curtailable customers (Parties D, E and F) appear below the curtailable customers in the merit order. Alongside the merit order, the look ahead also provides an 'at risk' level (black dotted line) where curtailment is likely to reach.

If this constraint were to materialise, it can be resolved by reducing generation export or increasing demand import. Based on the merit order, generation decrease can be provided by curtailable connections i.e. Parties A, B and C, who would be curtailed in that order based on curtailment index values. As long as the system remains in normal conditions and does not enter abnormal conditions, Parties D, E and F will not be affected.

3.2.2 During curtailment

Exhibit 3.5 illustrates what happens if the predicted constraint occurs, with 3MW of curtailment required to resolve it.

Exhibit 3.5 – Merit order during curtailment

		MEC	Curt. Index	Post curt.	Customer type
1	~~Party A~~	1MW	6.7%	0MW	Generator – curtailable
2	~~Party B~~	2MW	6.1%	1MW	Generator – curtailable
3	Party C	4MW	6%	4MW	Generator – curtailable
4	Party D	3MW	0%	3MW	Generator – non-curtailable
	Party E	2MW	0%	2MW	Generator – non-curtailable
	Party F	1MW	0%	1MW	Demand – non-curtailable

If the ANM system detects a network issue which requires curtailment action, it starts to work through the latest merit order list (filtered as necessary for the specific constraint).

In this case, the process starts with Party A. The ANM system sends a signal to Party A to reduce output, with Party A then expected to action this. In this example, curtailment of Party A alone is not sufficient to resolve the constraint. Therefore, the ANM system moves down the merit order and issues an instruction to Party B for it to curtail its output too. In this example, curtailment of Party B combined with the curtailment of Party A is sufficient to resolve the constraint.

If an instruction does not elicit a response (or an adequate response) the ANM system continues to work down the merit order issuing instructions until the required level of response needed to alleviate the constraint is delivered.

3.2.3 Post curtailment

Exhibit 3.6 illustrates what happens after the curtailment actions described in the previous section.

Exhibit 3.6 – Merit order post curtailment

Rank	Party	Curt. Index	Customer type
1	Party A	6.56%	Generator – curtailable
2	Party C	6.00%	Generator – curtailable
3	Party B	5.96%	Generator – curtailable
4	Party D	0%	Generator – non-curtailable
	Party E	0%	Generator – non-curtailable
	Party F	0%	Demand – non-curtailable

Once a curtailment event has occurred, the adjusted curtailment indices of the curtailed parties are updated to reflect this. This may mean that the merit order changes for the next constraint event.

If, in the example in Exhibit 3.6, Parties A and B had been curtailed for 12 hours (for illustration purpose), the adjusted curtailment index of both Parties A and B will reduce by 0.14% (12hrs/8760hrs in a year), to 6.56% for Party A (6.7% - 0.14%) and to 5.96% for Party B (6.1% - 0.14%). Party B then falls below Party C in the merit order.

Note the contracted curtailment index i.e. 8% for Party B will remain during the duration of the connection agreement. The adjusted curtailment indices are used internally by Electricity North West.

3.3 Literature review

To ensure BiTraDER builds on learnings from previous work in similar areas, AFRY conducted a literature review in Summer 2022. This was based on desktop research of relevant case studies to help inform the development of the trading rules. Specifically, the literature review focused on projects that:

- were market based;
- focussed on flexibility at the distribution network level; and
- involved some element of peer to peer trading.

The rest of this section focusses on learnings from the five projects shown in Exhibit 3.7. For more details on these projects, see Annex A.

Exhibit 3.7 – Five case studies exploring market design for flexibility trading in the distribution networks

	Location	Objectives	Outcome (market design element)
Energy Exchange	UK Power Network	**Market design** solutions for customers with a **flexible connection** to **reduce renewable curtailment**	- One detailed market design from five initial market designs (including both peer-to-peer and DSO-DER) - Excel simulation - Feedback from stakeholders
Transition	Scottish and Southern Electricity Network	Design, develop, demonstrate and assess the **tools, data and system architecture** to implement **DNO to DSO transition**.	- Peer-to-peer export / import capacity and peak management (DSO-DER trading) trialed in Oxfordshire - Several documents / methodologies have been produced and trialed
ENA open networks[1]	GB	Explored framework for **trading 'curtailment risk'** and **possible rules**	- A document outlining four trading principles, key considerations and potential rules for trading 'curtailment risk' - Trialed in 'war games'
TraDER	Orkney islands	Develop, integrate and scale a **flexibility exchange** on the Orkney islands	- Demand turn-up trialed on the Orkney islands - Market facilitated transactions between two wind turbines and 100+ local demand assets (flexible heating)
NODES	Europe	Provide an integrated marketplace with the goal of creating **value for flexibility providers** and incentivise investments in flexibility.	- NODES is an independent market operator established in 2018. Joint venture between the Norwegian Utility and Agder Energi, and the European power exchange Nord Pool - This has been tested in several projects across Europe

[1]. See footnote below

3.3.1 Literature review insights

Through the literature review, AFRY identified four key messages useful to the BiTRaDER project:

- There is **existing work in this area which can be built upon**. To ensure consistency across the GB DNOs where possible, existing projects in GB should be built upon.
- **Technical ability and regulation are key considerations** in market design. It is therefore important that the project considers the technical feasibility of the market design with Electricity North West's systems.
- **Lack of value and complicated concepts are key barriers to entry** for participants in flexibility markets. The market design should therefore

[1] The work done by Work Stream 1A, Product 6 (WS1A P6) and Non-Access SCR working groups, which WS1A P6 builds upon.

be kept simple and the trades should be designed to produce value for participants.

— **Baselining is difficult**, particularly for demand. If baselining is required, it could therefore be beneficial to start from previous project work in this area.

3.3.2 Existing work

Across the DNOs, a lot of work has been done in similar areas. Key points to consider for the BiTraDER project are shown in Exhibit 3.8.

Exhibit 3.8 – Existing work from current projects to build upon for the BiTraDER project

WHAT	PROJECT	DETAILS	BITRADER ACTION
Principles on potential **market framework**	ENA open networks / non-access SCR working groups	Four **trading principles** for **curtailment risk trading** have been developed, along with potential rules – **transparent information sharing**, ability to **maintain network continuity**, **visibility** of potential trading opportunities, and **transparent trading arrangements.**	Consider these in market design rules
Terms & rules of flexibility trading	Transition	Developed **Basic Market Rules** for all flexibility trading and **peer to peer trading terms sheet**. The peer to peer trading sheet is specific to the market design in this project. Stakeholder feedback has been given for both.	Consider using the basic market rules in market design, and adapting and building on peer to peer trading sheet.
Baselining	Transition NODES	The Transition project has developed a **tool for baselining** which can be applied to other projects. Similarly, the NODES project has also used baselining.	If we do need a baselining methodology, we should start from these tools.

3.3.3 Technical limitations

Several projects mentioned technical limitations being key drivers in the project and final market design:

— In the TraDER[2] project, the abilities of the ANM dictated the market design, and meant they were unable to trial changing the curtailment queue order.

— Energy Exchange[3] did not progress to trials. A report was prepared on the significant technical challenges in deploying market based curtailment management in the existing flexible connections zones in the Eastern Power Networks region. This led to the project to exploring one type of curtailment – planned outages in a different region.

[2] Project TraDER Project summary and lessons learned, Catapult Energy Systems, October 2021, https://es.catapult.org.uk/report/project-trader/
[3] Energy Network Innovation Process Annual Project Progress Report Document, Energy Networks Association, July 2022, https://smarter.energynetworks.org/projects/nia_UKPN0052

3.3.4 Value and simplicity are key to removing barriers for entry

Both the Transition and the Energy Exchange projects recognised value and simplicity as being key to reducing barriers to entry for flexibility markets on distribution networks.

The Transition[4] project found that the income from some of the flexible services was insufficient to cover personnel costs associated with participation. This was particularly the case for customers with low capacities (such as EV chargers). Similarly, a price cap of £300/MWh applied to the flexibility markets may have limited market attractiveness. The Energy Exchange[5] project also found that many customers asked about the potential value of the scheme, and mentioned that this would be a key driver in their decision to get involved.

Both the Transition and the Energy Exchange projects received feedback, around keeping the market simple. These comments included feedback that:

- There was a lack of knowledge around flexibility and flexible connections. This may limit participation and meant that market-based mechanisms could quickly become complex. To minimise barriers to entry, markets should be designed as simply as possible.
- Non-traditional market participants will not have time or resource to understand complex market concepts. These participants may therefore need a route to market. Similarly, customers who don't make decisions on a regular basis expressed an interest to outsource real-time commercial optimisation to a third party (i.e. aggregator).
- Complex contractual documents led to a high cost to review these. Customers did not necessarily have resources with a high level of market knowledge to do this.

The above learnings have been considered while developing the trading rules, as follows:

- While evaluating different market design choices, we have ensured simplicity and value of the market are key considerations in all areas.
- The project partners have had ongoing discussions to understand the technical abilities of the ANM and ensure the trading rules are designed within these boundaries.
- The complexity of baselining was a key consideration when designing the rules around the volume traded (Section 4.2). However, it was decided that the benefits of comparing the volume against the baseline outweighed the complexity of baselines. During discussions around baselining methodology, we have reviewed the Open networks work on baselining, developed as part of the TRANSITION project.

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[4] Transition & Project Leo, Market Trials Report (Period 1), April 2022, https://ssen-transition.com/reports/transition-and-leo-report-trail-period-1-to-ofgem/
[5] Energy Exchange: Market-Based Curtailment Management Initial Market Design, April 2020, UKPN, https://innovation.ukpowernetworks.co.uk/projects/energy-exchange/

4 Market design choices

This section presents details of market design choices that collectively create the foundation for arrangements to allow peer to peer trading of curtailment obligations. Additionally, it highlights some of the thinking conducted during the project in respect of different potential design choices.

4.1 Overview

Our methodology involves the consideration of market design choices across a set of building blocks. The building blocks combine to create the overall trading arrangements.

These building blocks focused on the key design questions, providing the foundations for, and structure of, the overall market design. Exhibit 4.1 introduces the building blocks and the questions that relate to each of them.

Exhibit 4.1 – Building blocks and associated questions

Building blocks	Questions answered
Market process and timeframes	What are the timeframes for the market and associated processes/communications?
Product definition	What is the nature of the product being traded between parties?
Participant qualification	Which types of participant are eligible to trade as buyers and/or sellers and what are the prerequisites?
Network requirements	What information will be provided to the customer concerning the network situation and how will the different impacts on the network be accounted for?
Merit order trading principles	How are the position of the parties in the merit order affected by the trading?
Payment structure and trade matching	What is the basis of payments from buyers to sellers and how are the trades matched?
Volume traded	What is the basis for defining volume traded both from the perspectives of buyers and sellers and for different resource types?

Building blocks	Questions answered
Dispatch and delivery	What are the instructions given by the DNO to participants in the event of curtailment and how is delivery monitored?
Settlement	What is the basis for determining and settling payments between trading parties? What would be the impact on curtailment index?

In the remainder of this section, we present and detail the choices made for each of the building blocks. For most of the building blocks, several options were available from which to select a preferred solution. Some of these have an impact on the other building blocks due to the intricacy of the choices. An overview of the considerations undertaken, with pros and cons, that led to a specific choice is provided when relevant. Examples of how the resultant trading rules could work are provided in Section 5.

A summary of the key steps in terms of the identified market design is described below:

1. In advance of the trading, parties will need to be registered on the BiTraDER platform and have functionality to be able to receive a signal from the ANM system.

2. The look-ahead will provide information concerning any expected constraints on the network for the 48 hours ahead, with information specified in half-hour blocks. For each identified constraint, this will include a list of assets connected to that specific constraint.

3. The master merit order and the look ahead list are sent to the BiTraDER platform.

4. The BiTraDER platform will filter the master merit order list to produce a merit order specific to the constraint. Anyone registered on the platform will be able to see details on the constraint.

5. Curtailable customers can then submit bids based on the amount they are willing to pay to reduce their risk of curtailment, i.e. move down the merit order. Non-curtailable customer can submit offers based on the amount they are willing to accept to increase their risk of curtailment i.e. move up the merit order. These bids and offers can be submitted up to gate closure in day-ahead timescales.

6. Following gate closure, trade matching will occur for each half hourly settlement period for the following day. The traded master merit order, re-shuffled based on the traded position of the customers, will be sent back to the ANM system. There could be a different traded merit order for each half hourly settlement period.

7. When a constraint occurs, the ANM system will send a signal to the first customer on the traded merit order to turn-down / turn-up and

will then, as necessary, work its way down the traded merit order until the constraint is resolved.

8. After the event, settlement will occur:

   a. If the bids/offers includes an availability payment, buyers will pay matched sellers for availability regardless of whether constraint actions were taken. Although if constraint actions were taken and the seller does not respond in line with the trade, it forgoes some or all of the availability payment.
   b. If constraint actions are taken, buyers will pay matched sellers who were constrained a utilisation fee based on the response provided by the seller. The response will be compared to the self-declared baseline provided by the seller.

   All payments will be conducted via a market operator.

Further details are provided below for different building blocks.

4.2 Market timeframes and processes

Question: What are the timeframes for the market and associated processes/communications?

The frequency of market operation is an important design choice. Options for a particular delivery window include a single market process, a multi-stage market process or a continuous market process. The level of active participation required for trading increases as the options move from a single process towards a continuous process, with the latter likely to require active 24/7 trading.

In the interests of simplicity and practicality for the potential market participants, a single market process for a particular delivery window is suggested as the basis for the market. This is considered to be particularly appropriate while the market is in its early phases with limited familiarity for the participants. This choice also avoids creating entry barriers for participants who do not already have advanced trading operations.

In addition, the timeframe of trading is an important design choice i.e. how far ahead from the delivery window will trading take place. Several options were considered e.g. having the trading month ahead, week ahead, day-ahead, or within the day.

In order to decide the most convenient timeframe, the following aspects were considered:

— Information availability and accuracy: What information is available at the time of trading? How accurate are forecasts for constraints? How accurate is a participant’s baseline? (Discussed in Section 4.8.)

— Pricing: What information is needed by the participants to trade and price accordingly?

Longer forward trading timeframes, such as month ahead, raise issues in terms of information availability e.g. the look ahead for constraints is only performed 48 hours ahead. It is also more challenging for participants to form views of their own situation and hence their need for curtailment obligation offset or ability to take on an obligation. Therefore, bidding will be more difficult or at least more influenced by uncertainty.

Within-day timescales offer improved certainty in terms of requirements and capabilities. However, this increases the requirement for active involvement from participants within a day, potentially increasing the burden of trading.

As a result, a day-ahead timeline is suggested for trading. This offers benefits of generally good forecast availability at the day-ahead stage relative to forward timeframes, while managing the administrative burdens of trading relative to intraday timescales. This is also consistent with views provided by customers. Discussions with customers signed up to the project emphasised the importance of arrangements that minimise the time needed to participate in trading. This is also in line with learnings from the literature review, which emphasised putting a priority on simplicity.

Another reason to hold the auction at the day-ahead stage is to align with other GB power markets. We understand that participants will likely be involved in other markets and would potentially like to optimise their revenues streams. Discussions with customers, particularly emphasised by customers with battery assets, highlighted a preference for day ahead auctions, with timings compatible with GB day-ahead electricity markets[6]. As a seller, customers will also need to submit a baseline of their intended generation/demand, which can be linked to their GB day-ahead electricity market positions.

It is, therefore, proposed that the window to submit bids and offers for the BiTraDER auction should remain open after the results of the GB day-ahead electricity markets are released, to allow customers to make more informed decisions on their bids and offers in BiTraDER.

In Exhibit 4.2, a trading timeline is presented for a particular delivery day with two different dimensions shown:

- the merit order dimension in brown; and
- the trading dimension in blue.

In this, the following nomenclature is used for timescales:

- Delivery Day (D): This is the day being traded for and during which curtailment may be undertaken.
- Trading Day (D-1): This is the day on which trade for Delivery Day D is undertaken i.e. at the day-ahead stage.

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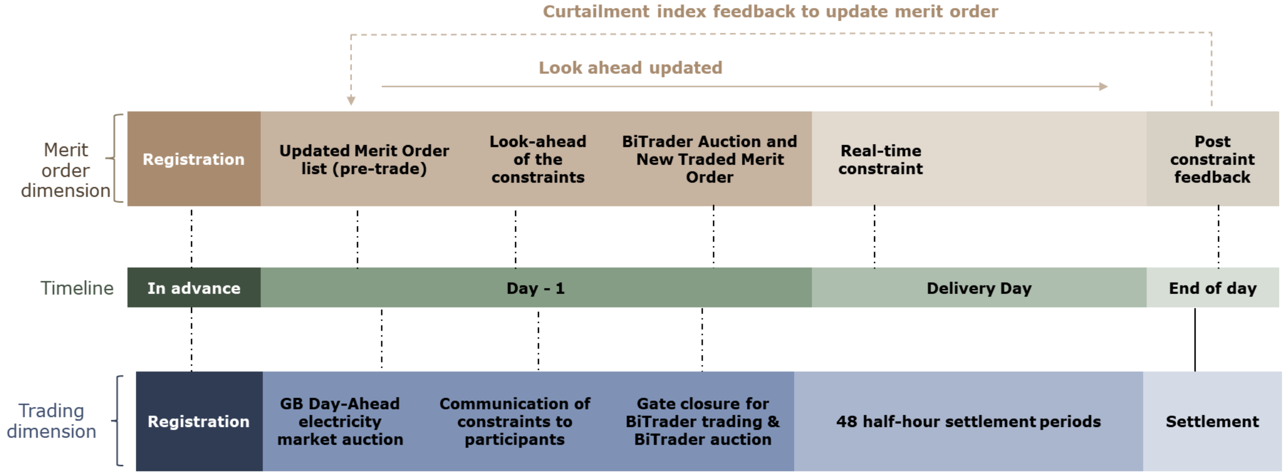
[6] The GB day-ahead market operated by NordPool closes at 9:50am for the next day (https://www.nordpoolgroup.com/497dea/globalassets/download-center/rules-and-regulations/product-specifications-gb-18.04.23.pdf). The GB day-ahead market operated by EPEX closes at 9:20am for the next day (https://www.epexspot.com/en/gb-market-post-brexit). These are the timings for GB markets following the UK's EU Exit process. The European single day-ahead market closes at 11:00am (UK time).

Exhibit 4.2 – Market process and timeframes



In advance of trading, the different parties will need to be registered and satisfy a certain number of criteria to participate in trading (Section 4.5).

On the Trading Day (D-1), the master merit order for the Delivery Day (D) will be updated based on settlement of the curtailment actions from the previous day. Once the GB day-ahead electricity market auction results are published, the latest results from the look-ahead in respect of potential constraints for the Delivery Day (D) will be communicated to the relevant participants.

With information about potential constraints on Delivery Day (D) provided, participants will submit their bids and offers to buy /sell curtailment obligations in respect of Delivery Day (D). Gate closure for submission will be during the Trading Day (D-1), i.e. at the day-ahead stage, at which point an auction will take place based on the bids and offers submitted. The exact timing of gate closure and the auction will be tested and agreed through the trials. Assuming trading occurs, this will lead to an updated merit order.

When/if a constraint manifests on the Delivery Day (D), this new traded merit order will be used to inform the curtailment action.

Following the completion of the Delivery Day (D), settlement occurs. This starts with parties being informed who needs to pay what to who and how curtailment indices will be updated. Subsequently, payments will then be made in accordance with settlement outcomes and curtailment indices will be updated.

4.3 Product definition

Question: What is the nature of the product being traded between parties?

The core intent of the product is to permit trading of curtailment obligations and, in so doing, changing the relative positions in the master merit order list. This works as follows:

- From a buyer's perspective, this involves transferring a curtailment obligation to another party, thereby reducing the risk of being curtailed in the case of a constraint.
- From a seller's perspective, this involves accepting the curtailment obligation of another party thereby increasing the risk of being curtailed in the case of a constraint.

Parties accepting a curtailment obligation need to be able to deliver a response that helps the system, i.e. sellers must be capable of providing a change of behaviour, compared to an initial intended position, that would help alleviate the constraint. For example, sellers must be able to reduce generation or increase demand in real-time for an excess generation constraint. More details are provided in Section 4.8 regarding the volume traded.

In this context, further proposed product definition features are as follow:

- The product will be expressed in MW change compared to submitted intended generation/demand profile over a period of time e.g. change of 1MW for half an hour.
- In terms of product granularity, 50kW units for each half hour settlement period are initially proposed for trading. This granularity has good compatibility with the sizing of the connected sites and is significant in terms of impact on the network. However, this will be revised and tested and during trials.
- Parties can trade partial capacities in 50kW blocks e.g. a 500kW unit can seek to trade 200kW (as four separate 50kW blocks) if it wishes.

These features can be amended if required, following the trials and customer engagement, as there is limited impact on other building blocks.

4.4 Network requirements

Question: What information will be provided to the customer concerning the network situation and how will the different impacts on the network be accounted for?

The trading arrangements need to be clear in terms of:

- the scope of the constraints intended to be covered;
- the treatment of the potential for different sites to have different electrical impacts on the system (e.g. due to locational differences); and
- information provided to customers.

In terms of scope, the focus of the trading arrangements will be on steady state constraints only. This means that trading will not cover post-fault constraints. There were two main reasons for excluding post fault constraints:

- First, to keep the arrangements as simple as possible for participants. As post-fault constraints are by their nature unpredictable, seeking to trade for them would add uncertainty and complexity for participants. This is in line with the insights of the literature review to simplify when possible.
- Second, steady state constraints represent the bulk of constraints on the network compared to post-fault constraints. It was decided that the BiTraDER trading rules concepts should first be tested on the most representative cases, especially where extending the scope adds complexity. If considered appropriate, the scope can subsequently be extended to consider other cases (such as inclusion of trading for post-fault constraints).

Trading for post-fault constraints can, therefore, be considered once experience from initial market operation is obtained.

The treatment of different electrical impacts of sites on a particular part of the network will also be handled via a simple solution, at least initially, to limit the complexity of the arrangements. While a constraint in one location may not deliver the same system impact as an equivalent MW constraint in another location, the trading arrangements will assume initially that all participants linked to a particular constraint have an equivalent impact on resolving the constraint. That is, that all participants in a particular part of the system are, in the initial phases at least, treated equally and have an effectiveness factor equal to 1. More electrically accurate effectiveness factors can be considered once experience from initial market operation is available.

To facilitate trading using the proposed trading arrangements, the DNO will need to provide the following information, as a minimum, to the market platform:

- details of the likely constraint(s), including location and potential size (MW);
- the master merit order list; and

- the list of customers able to resolve the likely constraint(s). This list in combination with the master merit order list will allow the creation of a constraint filtered pre-trade merit order list.

This will support identification of the need / opportunity to trade for all participants.

The trials may identify further information which, if provided, could encourage more participants in the market. Any further information identified will be highlighted in future reports.

4.5 Participant qualification

Question: Which types of participant are eligible to trade as buyers and/or sellers and what are the prerequisites?

Two main characteristics are relevant for establishing eligibility to participate in the market as a buyer or seller:

- type of connection i.e. curtailable connection or non-curtailable connection; and
- technology capability i.e. generation with turn-down/turn-up capability, demand with turn-up/turn-down capability.

The potential to be a buyer or a seller is also influenced by the driver of a potential constraint i.e. is it linked to an excess generation event or an excess demand event.

Across these dimensions, multiple buyer-seller combinations are available. Eight core use cases were identified in Deliverable 1 of the BiTraDER project, as shown in Exhibit 4.3:

- **Buyers**: Parties with curtailable connections. In an excess generation constraint, a buyer is expected to be a generator (or battery seeking to export) with a curtailable connection. In an excess demand constraint situation, a buyer is expected to be a demand site (or battery seeking to import) with a curtailable connection.
- **Sellers**: Parties with curtailable or non-curtailable connections. In an excess generation constraint, a seller could potentially be a generator with a curtailable or non-curtailable connection that agrees to reduce its generation or it could be a demand turn-up with curtailable or non-curtailable connection that agrees to increase its demand. In an excess demand constraint, a seller could potentially be a demand customer with a curtailable or non-curtailable connection that agrees to reduce its demand or it could be a generator with curtailable or non-curtailable connection that agrees to increase its generation.

Exhibit 4.3 – Participant qualification as buyer and seller use cases

	Cases	Buyers		Sellers
Excess generation	1	**Generation** with **curtailable** connection	Excluded	**Generation** with **curtailable** connection providing **generation turn-down**
Excess generation	2	**Generation** with **curtailable** connection		**Generation** with **non-curtailable** connection providing **generation turn-down**
Excess generation	3	**Generation** with **curtailable** connection		**Demand** with **curtailable** connection connection providing **demand turn-up**
Excess generation	4	**Generation** with **curtailable** connection		**Demand** with **non-curtailable** connection connection providing **demand turn-up**
Excess demand	5	**Demand** with **curtailable** connection	Excluded	**Demand** with **curtailable** connection providing **demand turn-down**
Excess demand	6	**Demand** with **curtailable** connection		**Demand** with **non-curtailable** connection providing **demand turn-down**
Excess demand	7	**Demand** with **curtailable** connection		**Generation** with **curtailable** connection providing **generation turn-up**
Excess demand	8	**Demand** with **curtailable** connection		**Generation** with **non-curtailable** connection providing **generation turn-up**

Since the publication of Deliverable 1, the project partners have further refined these eight use cases to six use cases by removing use cases 1 and 5 from Exhibit 4.5. These two use cases depict situations where the seller's connection type is equivalent to the buyer's, i.e.:

- In the case of an excess generation constraint, a curtailable generation connection selling generation turn-down that could also be curtailed in the same direction as the buyer.
- In the case of an excess demand constraint, a curtailable demand connection selling demand turn-up that could also be curtailed in the same direction as the buyer.

In these situations, the seller could also be a buyer which introduces limited value and several negative externalities, including those below:

- This creates an incentive to sell services which do not help to resolve the constraint compared to the pre-trade conditions. This could occur if a curtailable seller sells turn down but would have been curtailed in the pre-trade merit order anyway i.e. without trade happening.
- Trades with curtailable connections as sellers may negatively impact non-trading parties, depending on the original position of the seller in the merit order. A trade between two curtailable parties as depicted in Section 4.6 could result in the non-trading party ending up in a higher position in the merit order compared to pre-trading, creating a significant negative externality for the non-trading parties.

As a result, curtailable connections with curtailment obligations in the same direction as the buyer are not included as potential sellers initially. This restriction on seller participation can, however, be reviewed once insights from initial market operation are obtained. This means six out of the eight use cases shown in Exhibit 4.3 will be initially tested. These cases are expected to reflect the main use cases in the future.

Further requirements identified for sellers are:

- they must be connected to the same identified constraint on the same part of the system as the buyer;
- they must be able to receive dispatch signals from the Electricity North West Network Management System;
- they must be able to provide a useful action (i.e. either turn-up or turn-down relative to a self-declared baseline) to resolve the constraint within agreed timescales (a fast response expected to be specified) following receipt of the dispatch signal; and
- they must have half hourly metering.

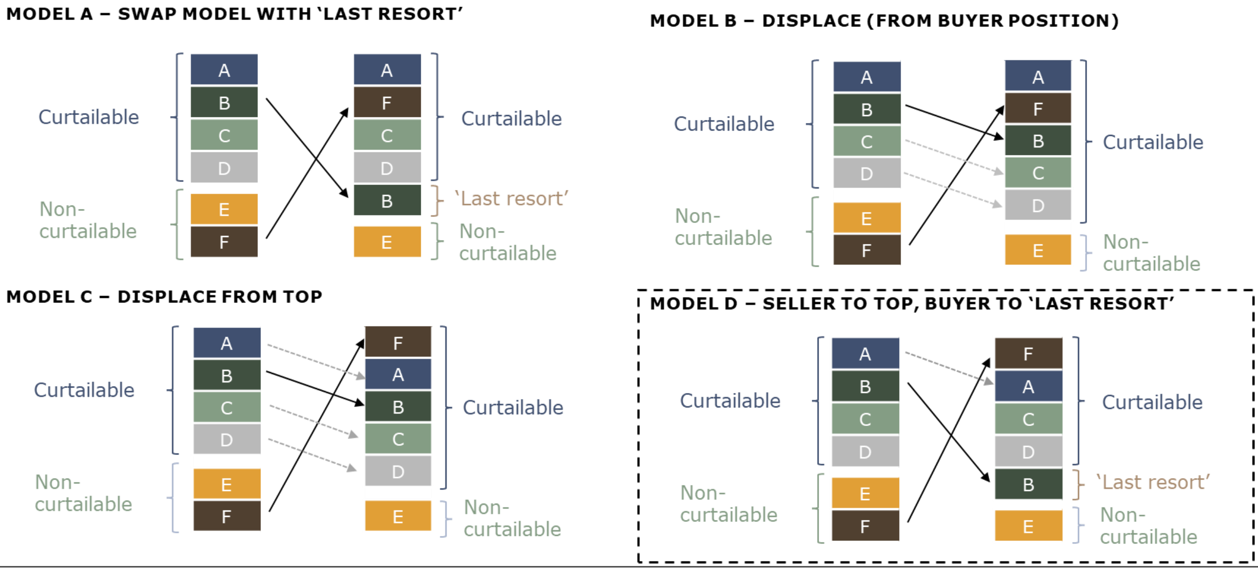
4.6 Merit order trading principles

Question: How are the positions of the parties in the merit order affected by the trading?

There are several approaches for defining how trading will alter a party's position in the merit order list. Four different models were analysed. These are introduced below, supported by illustrative examples presented in Exhibit 4.4.

- **Model A - Swap**: Seller takes original position of buyer. Buyer moves to a 'last resort' position beneath curtailable parties and above non-curtailable parties.
  In the example, F takes the position of B and B goes to the 'last resort'.
- **Model B – Displace from buyer position**: Seller takes original position of buyer. Buyer is below the seller, one position down the list from its original location (as are all parties originally below the buyer).
  In the example, F takes the position of B, pushing B down a place below F. As a result, all other curtailable parties below B shift down a position (in this example C and D).
- **Model C – Displace from top**: Seller moves to the top of the list, with all parties, including the buyer, shifting down a position.
  In the example, F goes to the top, all the other curtailable parties go down by one position, including B.
- **Model D – Seller to top, buyer to 'last resort'**: Seller moves to the top of the list. Buyer moves to a 'last resort' position beneath curtailable parties and above non-curtailable parties.
  In the example, F goes to the top making A drop down one position. B goes to into the last resort block. Other parties do not change position.

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



Consideration of the pros and cons of the different models is summarised in Exhibit 4.5.

Exhibit 4.5 – Summary pros and cons of the different models

Model	Pros	Cons
Model A – Swap	— Simple concept to understand and only one trade required for the buyer. — No free rider effect as no other parties are affected by the trade. — Last resort means no adverse impacts from trading on non-curtailable parties. connections not involved in trades.	— Difficult for sellers to understand where they will end up in the stack as this depends on the buyer position, which makes it harder to price.
Model B – Displace from buyer position	— Better suited to managing some potential externalities e.g. 'nested constraints' explained further below.	— Customers between the buyer and the seller in the original order benefit from 'free-riding'. This creates an incentive for buyers to wait for parties at the top of the stack to trade as those lower may benefit from this trade. — Several trades are necessary for a buyer to 'get out' of curtailment, which adds complexity to trading and pricing. — As for model A, difficult for the seller to price.

Model	Pros	Cons
Model C – Displace from top	— Better suited to managing some potential externalities e.g. 'nested constraints' explained further below. — Clearer proposition for the seller, as it knows it will go to the top, which makes pricing easier and provides more certain value potential. — To some extent, sellers can control where they will end up in the stack – the lower they bid (compared to the other sellers), the higher they will be.	— All customers above the seller benefit from 'free-riding'. This creates an incentive for buyers to wait for the customer at the top of the stack to trade as those lower may benefit from this trade. — Several trades are necessary for a buyer to 'get out' of curtailment, which adds complexity to trading and pricing.
Model D – Seller to top, buyer to 'last resort'	— Simple concept to understand and only one trade required for the buyer. — Clearer proposition for the seller, as it knows it will go to the top, which makes pricing easier and provides more certain value potential. — To some extent, sellers can control where they will end up in the stack – the lower they bid (compared to the other sellers), the higher they will be. — Last resort means no adverse impacts from trading on non-curtailable connections not involved in trades	— Some parties can benefit from free riding and some externalities appear such as nested constraint situations.

Overall, following extensive consideration by the project team of the pros and cons of the options, the preferred model is Model D – Seller to top, buyer to 'last resort'.

When there are multiple sellers, all sellers will go to the top of the merit order, ordered by their utilisation offers (lowest offers first). This ensures that those with the lowest short-run marginal cost of curtailment are the first to be curtailed, leading to efficient dispatch of curtailment.

When there are multiple buyers, all buyers will go below all other non-trading curtailable connections (but above the non-curtailable connections). These will be ordered by their utilisation bids (lowest bids first).

4.7 Payment structure and trade matching

Question: What is the basis of payments from buyers to sellers and how are the trades matched?

There are several possible approaches for: structuring payments between buyers and sellers; matching trades based on submitted prices; and determining the price paid by the buyer to the seller from the submitted bids and offers.

We considered three options for structuring payments: payments based on the availability of an asset; payments based on utilisation of the asset; or a combination of both. Following engagement with customers, we decided not to continue with availability only payments as an option. Customers stated that that detailed information around the risk of curtailment occurring would be required to allow them to price an availability only payment. This detailed information is not currently available.

We have explored two options for determining the price paid by the buyer to the seller:

- **Pay as bid / offer:** The price paid is the price submitted by the buyer (pay as bid) or seller (pay as offer) for the matched trade. The price paid will be different for each of the matched trades.
- **Pay as clear:** All successful trades will pay the same price. This price is determined by the clearing price of the auction (i.e. where the demand (bids) and supply (offers) curves cross.

From the above options, we have developed three designs which will be tested as part of market trialling:

- 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); and
- 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).

The feedback from customer reflected a preference to have both utilisation and availability payment. From the trading point view, a single part bid is easier to understand and implement than a two part bid so the aim is to start with the simpler version i.e. option A, and then to move to options B1/B2 later in the trials.

4.7.1 Options explored

Options A, B1 and B2 are set out in more detail below.

4.7.1.1 Option A: Utilisation only

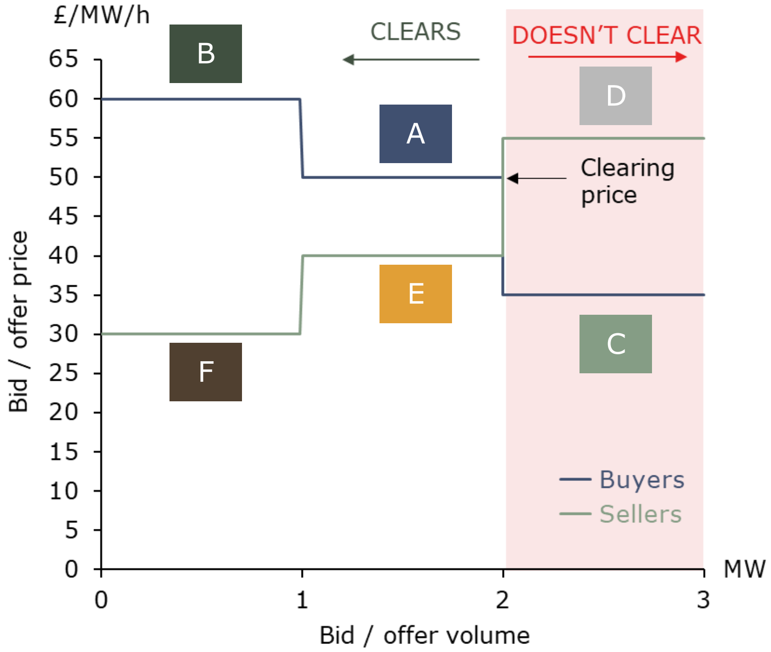
Under Option A, buyers and sellers only submit one price component as part of their bid/offer; a utilisation payment in £/MW/hour. This payment will only be paid if the seller is asked to change its output due to a constraint.

Trade matching and clearing price determination are set out in Exhibit 4.6. Bids (from buyers) are sorted from highest to lowest and offers (from sellers) are sorted from lowest to highest. The buyer with the highest willingness to pay is then matched with the seller with the lowest offer. This continues, working down bid prices and up offer prices until either bids or offers are exhausted or until there is no remaining bid with a price higher than (or equal to) a remaining offer.

The price paid is 'pay as clear' and is determined by the bid of the marginal trade match. The clearing price could either be the marginal bid, the marginal offer or somewhere in-between. For the trials, the clearing price will be the marginal bid, as shown in the Exhibit 4.6. This was chosen as it is the option which results in the highest payment to sellers to encourage more sellers into the market.

Under this mechanism, all the parties get a surplus / discount compared to what they were initially willing to offer/bid except for the marginal bidder.

Exhibit 4.6 – Offers and bids matching algorithm



4.7.1.2 Option B: Availability and utilisation

In both variants of option B, buyers and sellers submit two-part price bids and offers consisting of an 'all-in' price (availability + utilisation) and the separate availability payment component.

The bids will consist of:

- the maximum 'all-in' price, which corresponds to the maximum total price a buyer is willing to pay, summing availability and utilisation payment components, to avoid curtailment; and
- the maximum availability payment.

Similarly, the offers will consist of:

- the minimum required 'all-in' price, which corresponds to the minimum total price a seller needs to be paid, summing availability and utilisation payment components, to take on a curtailment obligation; and
- the minimum required availability payment.

The trade algorithm then matches bids and offers based on two-part prices. The matching processes for options B1 and B2 are set out below.

Option B1: Matching based on buyer's highest total bid and seller's lowest availability

In option B1, the matching process is as follows:

- First, the trading algorithm will sort bids based on their 'all-in' price (availability + utilisation) from highest to lowest.
- Then, for the highest 'all-in' bid, qualifying offers will be identified (if two bids are equal, the asset higher up in the curtailment queue gets matched first). Offers qualify if:
  - the buyer's 'all-in' bid (availability + utilisation) ≥ the seller's 'all-in' offer; and
  - the buyer's maximum availability bid ≥ the seller's required availability offer.
- Of the qualifying offers, the matching algorithm will pick the offer with the lowest required availability payment first. If there are multiple offers with the same availability price, the matching algorithm will pick the offer with the lowest 'all-in' price.
- Once the highest 'all-in' bid is matched, the process is then repeated for the next highest bid and the remaining offers. This process repeats until no more bids and offers can be matched.
- Under this option, payment is a combination of pay as bid and pay as offer. Sellers get paid the 'all-in' price as bid by the buyer, but the availability price as offered by the seller. The utilisation payment is therefore the buyer's 'all in' bid minus the seller's availability offer.

Option B2: Matching based on Buyer's highest total bid and Seller's lowest total bid

In Option B2, the structure is similar to Option B1 except that the offers are ordered by the lowest 'all-in' price. Differences to B1 are highlighted in **bold**.

- First, the trading algorithm will sort bids based on their 'all-in' price (availability + utilisation) from highest to lowest. Then, for the highest 'all-in' bid, qualifying offers will be identified (if two bids are equal, the asset higher up in the curtailment queue gets matched first). Offers qualify if:
  - the buyer's 'all-in' bid (availability + utilisation) ≥ the seller's 'all-in' offer; and
  - the buyer's maximum availability bid ≥ the seller's required availability offer.
- Of the qualifying offers, the matching algorithm will pick the **lowest 'all-in' offer first**. If there are multiple offers with the same 'all in' offer, then the matching algorithm will pick the offer with the lowest **availability** price.
- Once the highest 'all-in' bid is matched, the process is then repeated for the next highest bid and the remaining offers. This process repeats until no more bids and offers can be matched.
- Under this option, payment is a combination of pay as bid / pay as offer but it is different from option B1. Sellers get paid the **'all-in' price and the availability price as offered by the seller**. The utilisation payment is therefore the **seller's 'all in' offer minus the seller's availability offer**.

4.7.2 Pros and cons of the different options

The key pros and cons between options A and B are shown in Exhibit 4.7.

Exhibit 4.7 – Pros and cons of the different options described in Section 4.7.1

	Pros	Cons
Option A	— Trade matching is a simple concept to understand. — Having a market based solely on a utilisation payment reduces some of the externalities in the case of nested constraints (Section 6.2.2). — Clearing price allows for price discovery.	— Does not incorporate an availability payment, which (based on customer feedback) may discourage some sellers from participating in the market.
Option B	— Availability and utilisation payment included. Customer feedback has suggested an availability payment would help more sellers participate in the market.	— Trade matching more complicated to understand. — Trade matching does not always produce the optimum matching of trades. The lowest cost seller may not always clear, and trade matching may not lead to the greatest societal value from all trades being extracted[1].

Notes: 1. Having an indication of the probability of a constraint occurring could improve the trade matching under option B.

Customer feedback suggested it was important to include an option with an availability payment, therefore we will trial both options.

4.8 Volume traded

Question: What is the basis for defining volume traded both from the perspectives of buyers and sellers and for different resource types?

There is a need to define the basis of the volume traded for the curtailment obligation and what this means for all parties.

The expectation is that buyers will only seek to buy a volume up to its expected generation/offtake position. That is, it will not expect to buy volume to cover any headroom between its expected position and its maximum export/import capacity. For example, if the buyer is a generator only expecting to generate 1MW of its 4MW capacity, it would only need to buy 1MW as this is the generation at risk of curtailment.

From the seller's perspective, we identified three options for the action required when a constraint occurs:

- 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.

One question that highlights the key difference between options 1 and 2 compared to option 3 is: Can sellers be rewarded without actively changing their behaviour?

In option 3, sellers that do not intend to, or cannot generate at the time of the constraint are able to sell their non-curtailable status without actively helping alleviate the constraints. For example, if a generator has a 3MW connection, but is only planning to generate at 2MW, then it could, in theory, sell the extra 1 MW headroom up to its maximum export capacity that it is not intending to use. As the generator was not intending to generate that 1MW, selling the 1MW means that the generator is being rewarded without changing its behaviour. This is considered to be an inappropriate outcome, which could frustrate system operation and the efficacy of the trading arrangements. Therefore, option 3 has been ruled out.

The key differences between option 1 and option 2 are the timing of the information and the impact on the potential change of import/export at the time of the constraint.

Option 1 requires minute by minute metering to provide information on real-time import/export and the extent of any change in behaviour. It is unlikely that a non-curtailable connection has this granularity of metering and requesting it would mean significant investment for the customer. As we envisage sellers participating in the market on an ad hoc basis we will not request minute by minute metering. Option 1 has therefore been excluded.

Option 2, our preferred option, avoids the need for the level of metering associated with option 1 as it relies on a declared baseline to define trading volumes and measure performance. The project team reviewed the Open Networks options for baselining and for this market[7].

The seller's baseline will be self-declared. This baseline should be a single figure for each settlement period representing the expected generation/demand across that settlement period. More details are provided in the Annex B.1.

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[7] Flexibility Baselining Tool – User Guide, Open Networks, April 2022, https://www.energynetworks.org/industry-hub/resource-library/on22-ws1a-p7-flexibility-baselining-tool-user-guide-(25-mar-2022).pdf

4.9 Dispatch and delivery

Question: What are the instructions given by the DNO to the participants in the event of curtailment and how is delivery monitored?

After trading has taken place, the merit order for the trading day will be updated. The updated merit order will be used to instruct assets to resolve any constraints that occur as per the process described in Section 3.2 A practical example of this process is provided in Section 0.

Half-hourly metering will be used to assess the delivery of the action by the seller. It will allow an understanding of what the generation/demand of the seller was, during the settlement period they traded for, compared to the instructions sent. For example, if the instruction to a generator was to drop by 1MW compared to a 2MW baseline, the generator should reduce their output by 1MW for the half-hour settlement during the constraint. The half hourly metered reference point used for the settlement should therefore show 1MW*0.5h=0.5MWh.

4.10 Settlement

Question: What is the basis for determining and settling payments between trading parties? What would be the impact on curtailment index?

There needs to be an understanding of what happened to the different parties during the constraint to determine who pays what and how the curtailment index of the buyer is affected. Different scenarios can occur, as detailed in Annex B.2, when taking account of more complex situations such as nested constraints.

4.10.1 Availability payment

4.7.1.10A successful buyer will pay its matched seller an availability payment (if applicable), regardless of whether the curtailment occurred.

During the constraint, it is possible that the seller under-delivers and in this case one of a number of actions can be taken:

1. Do not adjust the availability payment, penalise the seller by reflecting the under-delivery in the utilisation payment.
2. Use a pre-defined threshold to consider whether or not there has been under-delivery e.g. if 50% or more of the instruction has been followed, the seller gets the full availability payment, below that level the seller is considered to have failed to deliver and does not get the availability payment.
3. Pro-rata the availability payment compared to the instructed action e.g. if the seller delivers 0.5MW instead of the 1MW instructed for 10min, the seller gets 50% of its availability payment for the full settlement period;

Action 1 is easy to implement but rewards sellers by paying them for availability with no guarantee that they would be able to provide a useful action at the time of the constraint. Therefore, this option was discounted.

Action 2 avoids some of the pitfalls of the first action but requires the threshold to be pre-defined and the resulting choice may be difficult to objectively justify.

Therefore, action 3 was chosen as the best choice. If a seller over-delivers, the availability payment will be capped at the instructed action i.e. there is no bonus for over-delivering.

4.10.2 Utilisation payment

If the traded seller is curtailed during the settlement period, the matched buyer would need to pay a utilisation fee4.7.

The value of the utilisation payment will be linked to the curtailment duration of the seller during that settlement period as well as the scale of the action compared to the seller's self-declared baseline, capped at the initial volume bought by the buyer.

For example, if the buyer buys 1MW for a 30-minute settlement period and the seller gets curtailed by 0.8MW for 15 minutes compared to their baseline, the buyer would pay 40% (15min/30min *0.8MW/1MW=0.5*0.8=40%) of the agreed utilisation payment (which is based on 1MW, in this case, of curtailment for a full settlement period).

4.10.3 Curtailment index update

The duration and scale of the curtailment would also be reflected in the curtailment index of the buyer. At the end of the delivery day, the curtailment index of the buyer would be reduced by the amount the seller was curtailed.

A practical example of how the curtailment index would be updated is provided in the Section 5.2.3.

4.10.4 Seller baseline

Another component to consider is the accuracy of the baseline of the seller. This is important because assessment of the delivery of the instructed actions is based on change relative to the submitted baseline rather than real-time change. This means accuracy of the baseline is important as this may result in overselling as explained in Section 6.2.3. To avoid this issue, routine checks would be put in place to compare actual generation/demand to the submitted baseline. In case of systematic overselling, some actions/penalties could be taken.

4.10.5 Counterparty

It is anticipated that all settlement, including money transfers, would be handled by a third-party such as a market operator. One of the BiTraDER outputs would be the clarification of who this party could be.

5 Trading examples

This section provides examples to illustrate how the trading rules could work from the participants point of view and highlights the mechanics of the trades in different situations. These are based on the proposed trading arrangements outlined in the previous Section.

5.1 Presentation of scenario examples

A variety of examples can be used to illustrate how the trading rules could work in different cases. Some of the dimensions that vary by example include:

- Nature of the constraint: Is it an excess generation/excess demand? What is the depth of the constraint?
- Customers: What are the customer types based on their connection types and respective technologies?
- Forecast accuracy: How accurate are the participants’ baselines and the constraint look ahead?
- Network reality/eligibility of participants to resolve the constraint: What is the configuration of the network chosen for the example? Are parties eligible to the constraint?
- Appetite for trading: How many participants may there be and how do their respective bids/offers compare?
- Action of participants: Do participants commit to actions as instructed by the DNOs?
- Payment structure: What is the payment structure being used? E.g. option A or option B as illustrated in the previous section.

To build up examples, we first focus on a simpler example to illustrate how the underlying principles of the trading rules could work and then create variations from this initial example as illustrated in the following Exhibit 5.1.

Exhibit 5.1 – Matrix of examples

	Example 1: Simple example to illustrate the trading concepts with utilisation payment only (Option A)	Example 2: Example with availability payment (Option B)	Example 3: Example when seller actions differ from baseline /instructed action
Nature of the constraint(s)	One constraint of excess generation of 3MW happening at 2pm on a Tuesday for 30 mins	As for example 1	As for example 1
Customers on the network	A, B: Windfarms curtailable C: Solar curtailable D: Solar non-curtailable E: Gas non-curtailable F: Demand turn-up	As for example 1	As for example 1
Forecast accuracy	Generation and demand equivalent to self-declared baselines Constraint happens in line with the forecast	As for example 1	One seller overestimates its generation compared to its baseline
Action of participants	In line with what the DNO instructs	As for example 1	One seller under delivers
Network reality/eligibility to resolve the constraint	All the parties are eligible	As for example 1	As for example 1
Size of participants	All parties are 1MW size	As for example 1	As for example 1
Payment Structure	Option A: Utilisation only	Option B: Availability and utilisation	Option A/Option B

5.2 Example 1: Simple example to illustrate the trading concepts with utilisation only (Option A)

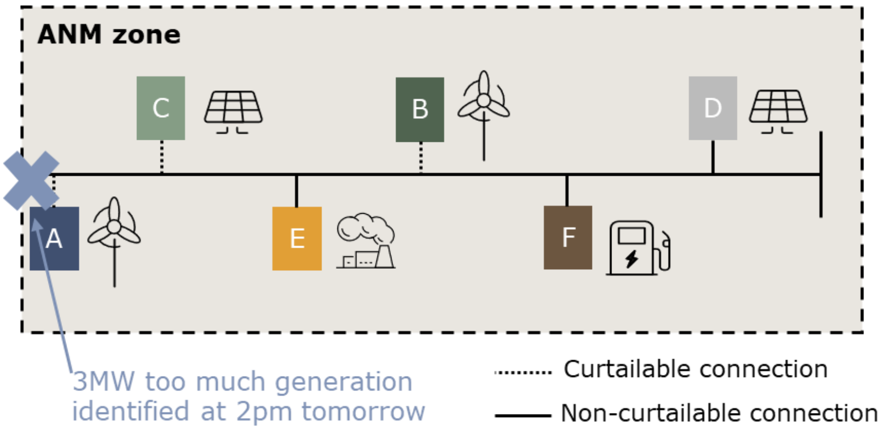
5.2.1 Before the constraint

On Monday, the look-ahead for the coming 48 hours identifies a potential 3MW excess generation constraint, forecast to occur on Tuesday at 2pm in a specified ANM zone. Eligible participants are as illustrated in Exhibit 5.2.

In this example, we assume each generator (A, B, C, D, E) has a 1MW capacity and can reduce their capacity by 1MW to resolve the constraint. F is a demand turn-up asset that can provide an increase of 1MW. The eligible participants are:

- Party A: Wind power plant with a curtailable connection;
- Party B: Wind power plant with a curtailable connection;
- Party C: Solar power plant with a curtailable connection;
- Party D: Solar power plant with a non-curtailable connection;
- Party E: Gas power plant with a non-curtailable connection; and
- Party F: Demand turn-up with a non-curtailable connection

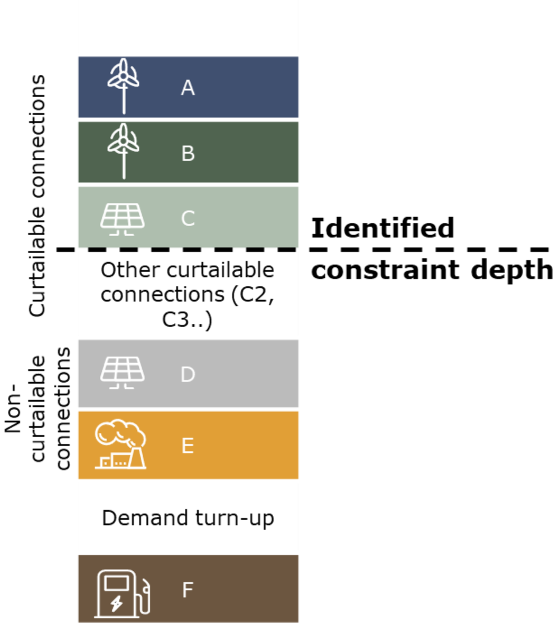
Exhibit 5.2 – Constraint identified by the DNO



The constraint identified by the look-ahead is communicated to the participants via the BiTraDER platform, along with the pre-trading merit order. Information provided to participants includes the depth of the constraint and the parties likely to get curtailed as illustrated in Exhibit 5.3

Without trading, A, B and C are identified to be curtailed if the constraint binds as forecasted based on the pre-trade merit order:

Exhibit 5.3 – Initial merit order before any trading



- A, B and C are at the top of the initial pre-trade merit order as these assets have curtailable connections. A has a higher curtailment index than B, and B higher than C.
- D, E and F are below these assets as they have non-curtailable connections.

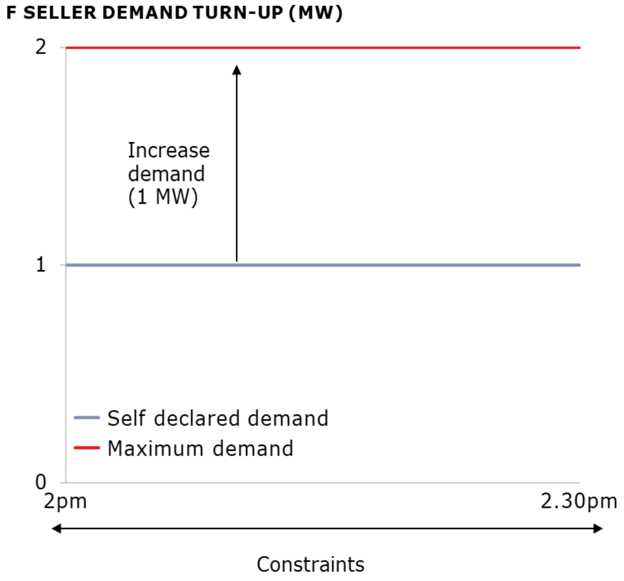
With this information provided, the trading platform opens to A, B, C, D, E and F, as these assets are all connected to the constraint. As per the participant eligibility criteria in Section 4.4:

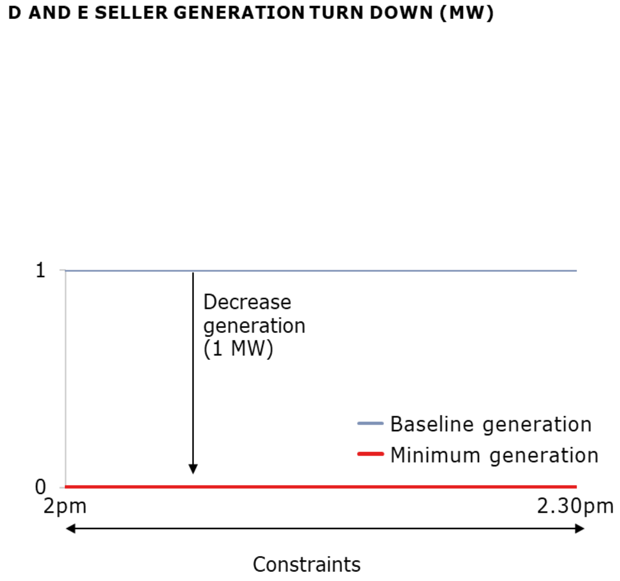
- A, B and C can participate as buyers as these assets have curtailable connections; and
- D, E and F can participate as sellers as D and E have non-curtailable connections and F is demand turn-up.

To participate in the trading, sellers need to submit their expected generation/demand during the settlement period and how much they are willing to change their behaviour to alleviate the constraint to the best of their knowledge.

In this example, D, E and F are willing to participate. As shown in Exhibit 5.4, parties D, E and F submit a baseline of 1MW for the 2-2.30pm settlement period and can sell up to 1MW. For D and E this would mean decreasing generation by 1MW (same baseline submitted on the right), and for F increasing demand by 1MW (on the left).

Exhibit 5.4 – Example self-declared demand/generation by the seller





In this example, A, B and C are willing to participate as buyers and D, E and F are willing to participate as sellers and submit bids and offers shown in Exhibit 5.5.

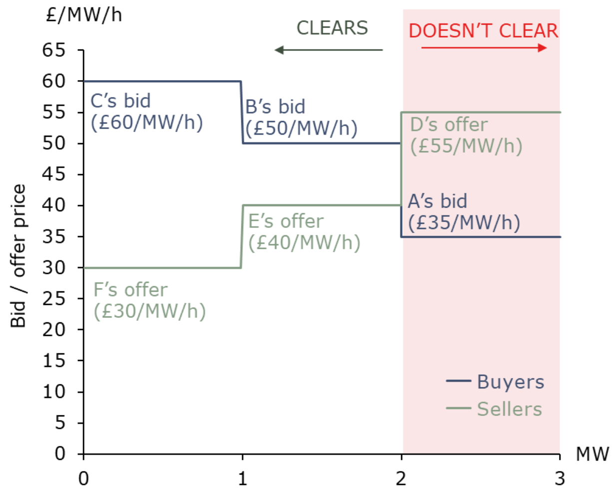
Exhibit 5.5 – Bids and offers submitted with payment structure Model A

Customer	Eligible buyer / seller?	Capacity Buying MW	Utilisation bid £/MW/h
A	Buyer	1	35
B	Buyer	1	50
C	Buyer	1	60
Customer	**Eligible buyer / seller?**	**Capacity selling Mw**	**Utilisation offer £/MW/h**
D	Seller	1	55
E	Seller	1	40
F	Seller	1	30

Under the utilisation only payment model (option A), the trade matching algorithm determines the successful matched trades, and a clearing price. This is achieved by deriving a demand curve and a supply curve from the bids and offers. For the demand curve, all eligible bids are stacked from high to low and for the supply curve, all eligible offers are stacked from low to high. The clearing price, where the supply and demand curves cross, is the lowest cleared bid submitted by a Buyer. This is illustrated in Exhibit 5.6.

Exhibit 5.6 – Clearing algorithm

SUPPLY AND DEMAND CURVE



The following results would be communicated from the clearing algorithm:

— C and B clear as buyers;

— F and E clear as sellers;

— D and A were unsuccessful in trading;

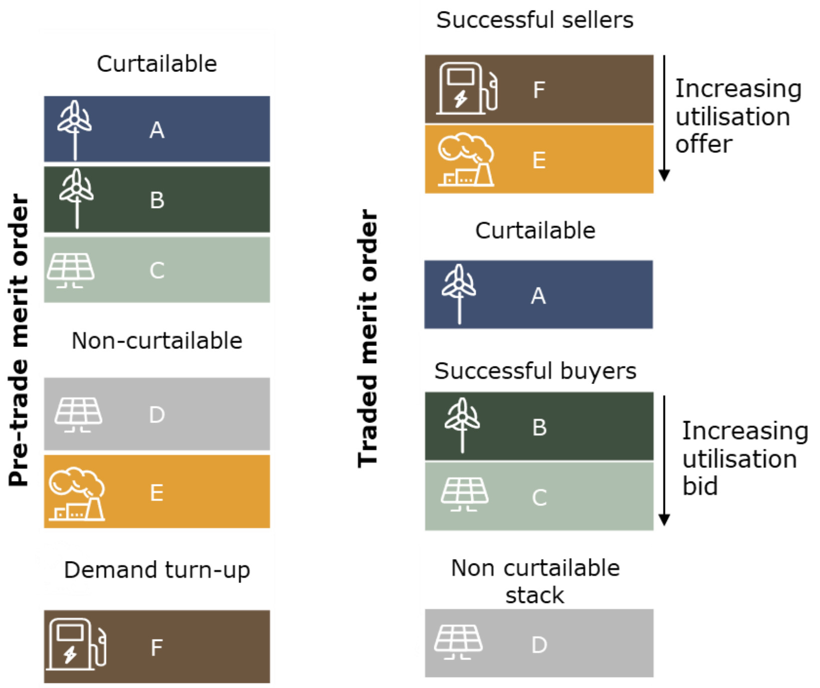
— C is matched with F; B is matched with E; and

— the clearing price is £50/MW/h (corresponding to B's bid).

This is a pay as clear market, so £50/MW/h is the utilisation price used for all successful trades.

Following the trade, the pre-trade merit order is changed to produce the traded merit order illustrated in Exhibit 5.7.

Exhibit 5.7 – Traded Merit order



The merit order has been sorted as follows:

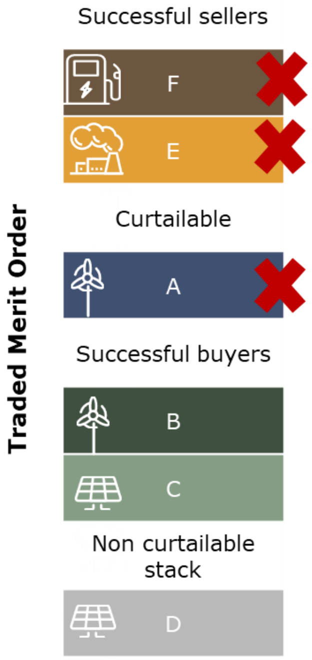
- F and E are successful sellers. These customers therefore move to the top of the merit order. F sits head of E as it offered a lower utilisation price.
- C and B are successful buyers and so move below all other customers with a curtailable connection, but above non-trading / unsuccessful customers with a curtailable connection (D in this case). B sits ahead of C as it has a lower utilisation bid.
- A was not successful in trading, so remains in between the sellers and the buyers, and may still be curtailed.
- D is non-curtailable and was unsuccessful in trading, so it will remain at the bottom of the merit order.

5.2.2 During the constraint

The traded merit order is sent back to the ANM to determine the order of the curtailment actions if the predicted constraint occurs.

In this example, the constraint occurred as predicted, and 3MW is needed to alleviate this either by reducing generation or increasing demand. F, E and A are curtailed.

Exhibit 5.8 – Traded merit order and curtailment during constraint



The following instructions would be sent, based on the merit order depicted in Exhibit 5.8:

- F is first asked to increase its demand by 1MW;
- E is then asked to curtail its generation by 1MW (effectively going to 0MW); and
- A is asked to curtail its generation by 1MW as it would have been in the case without trading (although it is third in line for curtailment rather than first as a consequence of trading).

With these three actions respected by the different parties, the constraint is alleviated and there is no need for further action.

B and C therefore generate the 1MW they bought without being curtailed during the 30 mins, whereas F, E and A follow the instructions until the end of the trading window or the constraint ends (in this case at the end of the trading window).

5.2.3 After the constraint

After the constraint, settlement occurs based on the utilised volumes, which are determined based on the scale of the party's response to an issued instruction relative to its self-declared baseline.

In this example, both sellers received an instruction to modify their behaviour by either increasing their demand of 1MW (F) or reducing their generation by 1MW (E), which they both did for 30 minutes. Both buyers (B and C) avoided being curtailed as they would have been without trading. Settlement would be as follows:

- C was matched with F, and so C pays F £25 (£50/MW/h*0.5h*1MW) for the volume F was curtailed;
- B was matched with E and so B pays E £25 (£50/MW/h*0.5h*1MW) for the volume E was curtailed;
- C's curtailment index is updated based on the volume F was curtailed e.g. 0.5MWh;
- B's curtailment index is updated based on the volume E was curtailed e.g. 0.5MWh; and
- A's curtailment index is updated based on the volume it was curtailed e.g. 0.5MWh.

5.3 Example 2: Example with availability payment (Option B)

Example 2 is used to illustrate the differences between payment structure option A and option B presented in section 4.7 and the implications for the participants. The rest of the trading is the same as Example 1.

5.3.1 Bids and offer submitted

In this example, rather than submitting a utilisation payment only, buyers and sellers submit a two-part bid made up of an availability and an 'all in' bid / offer, as shown in Exhibit 5.9. The 'all in' bid / offer represents the amount the asset will have to pay / be paid if curtailment occurs for a full hour and volume (i.e. availability + utilisation payment).

Exhibit 5.9 – Bids and Offers submitted under Option B

Customer	Eligible buyer / seller?	Capacity Buying MW	Avail* bid £/MW/h	'All in' bid £/MW/h
A	Buyer	1	20	100
B	Buyer	1	15	150
C	Buyer	1	10	200
Customer	**Eligible buyer / seller?**	**Capacity selling MW**	**Avail* offer £/MW/h**	**'All in' offer £/MW/h**
D	Seller	1	30	75
E	Seller	1	10	100
F	Seller	1	5	50

Note: *Avail = availability

5.3.2 Matching of the trade

The trading algorithm matches the trades as shown below:

— C is the bidder with the highest 'all in' bid. This is the first bid to be matched. E and F are both qualifying offers for C. D is not a qualifying bid offer as D's availability offer > C's availability bid. Of the qualifying offers, F has the lowest availability payment. C and F are therefore matched.

— The trading algorithm then moves onto the bidder with the next highest 'all in' bid. In this case, B. The only remaining qualifying offer is E.B and E are matched.

— The trading algorithm then moves onto A.

— There are no remaining qualifying offers for A. D is the only remaining offer, and D's availability offer is greater than A's availability bid. Neither A nor D are matched.

The results are summarised in Exhibit 5.10.

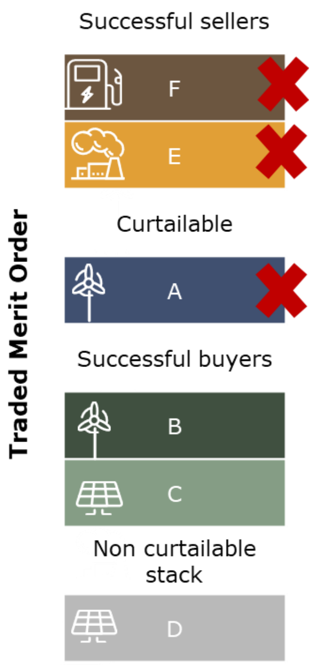
Exhibit 5.10 – Matched Bids and Offers submitted under Option B

Buyer	Avail* bid	'All in' bid	Seller	Avail* offer	'All in' offer
C	10	200	F	5	50
B	15	150	E	10	100
Didn't match – unsuccessful in trading					
A	20	100	D	30	75

5.3.3 Settlement

Similar actions to Example 1 were taken during the constraint as shown in Exhibit 5.11:

Exhibit 5.11 – Merit order traded and curtailment during constraint



- successful in trading are paid / pay the availability payment based on the seller's offers (regardless of whether curtailment occurs unless in the case of full/partial non-delivery).
- As both F and E are making 1MW available for 1 settlement period (i.e. 30mins), C pays F £2.50 (£5/MW/h*1MW*0.5h) and B pays E £5 (£10/MW/h*1MW*0.5h).
- As F and E were curtailed, C and B pay the 'equivalent utilisation' price, based on the 'all in' price bid by the buyers and the availability offered by the seller.
- C pays F £195/MW/h (C's 'all in' price less F's availability price) for the volume curtailed.
- B pays E £140/MW/h (B's 'all in' price less E's availability price) for the volume curtailed.

As under example 1 and payment structure option A, Parties A, B and C get their curtailment indexes updated.

5.4 Example 3: Example when seller actions differ from baseline/instructed action

Example 3 is used to illustrate what happens when a seller either under-delivers compared to the instruction sent or when a seller's generation at the time of the constraint differs from the submitted baseline.

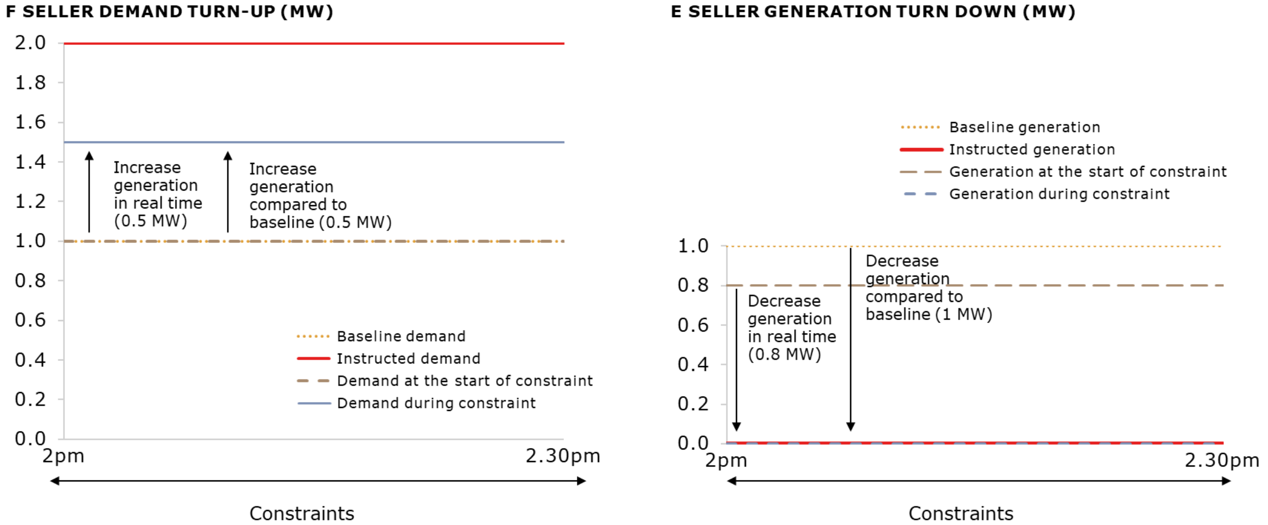
5.4.1 Situation

In this example, the situation remains the same as Examples 1 and 2, except for the real time generation / demand and delivery of the sellers E and F:

- Seller F's demand is at 1MW (as submitted as the baseline) at the start of the constraint. However, when instructed to increase demand by 1MW compared to its baseline (to 2MW), it only increases demand to 1.5MW.
- Seller E is generating at 0.8MW at the start of the constraint instead of the 1MW baseline but respects the instructions sent to go down to 0MW.

The behaviours of E and F are illustrated in Exhibit 5.12.

Exhibit 5.12 – Seller behaviours during the constraint



5.4.2 Settlement

This change in behaviour impacts settlement between C and F. As F has under-delivered and provided only half of the action it has sold i.e. increasing the demand by 0.5MW instead of 1MW, C pays F:

- the utilisation payment based on the volume delivered, £12.50 (£50/MW/h*0.5h*0.5MW). This is half of the utilisation payment received under example 1. C's curtailment index is also decremented based on the volume delivered and so is decreased by 0.25MWh; and
- under payment structure option B, C also pays F an availability payment. As F has under-delivered by 50%, the availability payment is decreased by 50%. C therefore pays F £12.50 (£5/MW/h*1MW*50%*0.5h).

The settlement between B and E does not change compared to examples 1 and 2. E's generation was different from its baseline at the start of the constraint, but the instructed action was respected compared to its baseline i.e. decreasing generation to 0MW for the full settlement period. The buyer B pays the full 1MW utilisation payment to E and gets its curtailment index decremented for the full 1MW.

The example provided here shows that under the current trading rules design, sellers would be penalised if they under-deliver in respect of their ability to change compared to their baseline i.e. if they do not fulfil the required instruction when being called upon. Note that the under-delivery of the seller could result in parties further down the merit order being curtailed to resolve the constraint.

On the other hand, unintentional inaccuracies[8] of the baseline forecast would not be penalised as long as the instructed actions compared to the baseline are respected to alleviate the constraints. This can raise limitations in the trading rules which are detailed in the Section 6.2.3.

[8] If a party is found to systematically be submitting inaccurate forecasts, this behaviour will be penalised.

6 Limitations and further steps

This section presents the simplifications taken during the project and the identified limitations associated with the proposed trading rules. The next steps for the project are then summarised.

6.1 Assumptions

Trading of curtailment obligations as envisaged in the BiTraDER project is an innovative concept, without an established prototype model to follow. Therefore, a range of assumptions have been made to provide an initial framework within which to explore the concept of the trading rules. The assumptions, as well as potential improvements and associated impacts on the rules, are summarised in Exhibit 6.1. These were all discussed in detail and agreed as part of project team discussions.

Exhibit 6.1 – Summary of assumptions taken and impact on the trading rules

Category	Assumption taken	Potential improvement	Building block Impact
Participants ability	Partial curtailment to be assumed possible for all participants for the rules.	N/A	N/A
Probability	Probability of constraint occurring is not currently available.	Include probability of constraint occurrence in the pre-trade information release and in matching algorithm.	Information for trade payment structure and trade matching.
Constraints traded	Post fault constraints have been excluded from the trading scope initially.	Post fault constraint included in trading.	Scope of constraints and settlement.
Participant scope (1)	Pre-emptive actions are excluded and all the participants must be able to respond within an agreed timescale (fast response expected).	Include pre-emptive actions as an option for trade.	Participant qualification, settlement.
Participant scope (2)	Curtailable connections with curtailment obligations in the same direction as the buyer, excluded from being sellers.	Allow curtailable connections with curtailment obligations in the same direction as the buyer to be sellers.	Participant qualification, merit order trading principles.
Effectiveness factor	All parties can trade a MW for a MW i.e. all MW are equivalent regardless of the position in the network.	Take account of effectiveness factors in trading.	Network requirement, volume traded, payment structure and trade matching.

The below provides further explanations on the assumptions that are expected to have the greatest impact:

- **Participant scope (1):** Opening the trading to participants that are not able to respond within a few minutes, and will therefore need to take the action before the constraint occurs, could provide a greater pool of sellers e.g. demand turn-up with slow response time. The actions taken pre-emptively by a seller could prevent the triggering of a constraint and therefore provide a useful service to the buyer. However, taking an action pre-emptively raises issues:
  - When no constraint occurs during the traded window, it is difficult to know whether the pre-emptive action prevented the constraint or the look ahead forecast was inaccurate.
  - Pre-emptive actions could also potentially create issues in the opposite direction e.g. if demand turn up acts pre-emptively for an excess generation constraint, this could create an excess demand constraint.
  - From the buyer perspective, this would mean paying both utilisation and availability payments when being matched with pre-emptive action regardless of whether the constraint happens.
- **Participant scope (2):** Allowing curtailable connections with curtailment obligations in the same direction as the buyer to participate as sellers could increase the liquidity of the market. However, this could introduce significant externalities to the chosen model D (Section 4.6). For example, buyers would still move below the curtailable connections that have not traded. This new position for the buyer could be below the initial position of the seller. Two negative consequences are identified as a result:
  - There could be a high incentive for curtailable connections to sell their services without actually helping to resolve the constraint compared to the pre-traded conditions. This is because the curtailable sellers could have potentially been curtailed anyway without trading.
  - Trades with curtailable connections as sellers may affect non-traded parties, depending on the original positions in the merit order. A trade between two curtailable parties (under model D) could result in the non-trading party ending up in a higher position in the merit order compared to pre-trading, creating a significant negative externality for the non-trading parties.
- **Effectiveness factor:** Currently, the trading rules assume all eligible participants have an equal impact on relieving a constraint. In reality, the ability to relieve a constraint will depend on factors such as the participant's location on the network. Including effectiveness factors for each participant could lead to more efficient use of resources for curtailment as they could be used to calculate effective volumes traded. However, this adds complexities for trading and for the network with a need to calculate all the different effectiveness factors.

6.2 Known limitations

With the market design choices made, a number of limitations are still known to exist. The main limitations/externalities currently identified fall into the following categories:

- free rider effect;
- nested constraints;
- over-estimating baseline; and
- over-declaring ability.

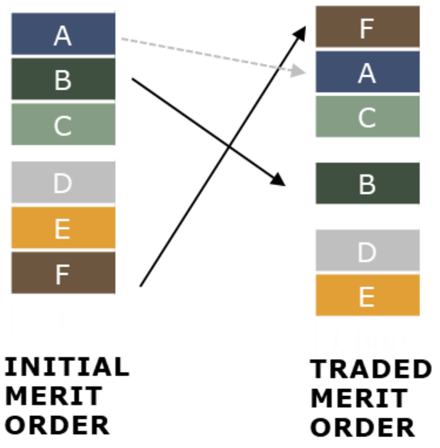
More details are provided below for each of the identified limitations.

6.2.1 Free rider effect

The trading arrangements create the potential for positive externalities for non-trading curtailable parties. In the example depicted in Exhibit 6.2, B trades with F, resulting in F going to the top of the merit order. As a result, A has benefited from the trade by moving down by one place in the merit order even though A has not traded.

In the case where the curtailment required is only 1MW, only F will get curtailed and A would have avoided curtailment for free.

Exhibit 6.2 – Merit order traded with the model D



However, it should be noted that:

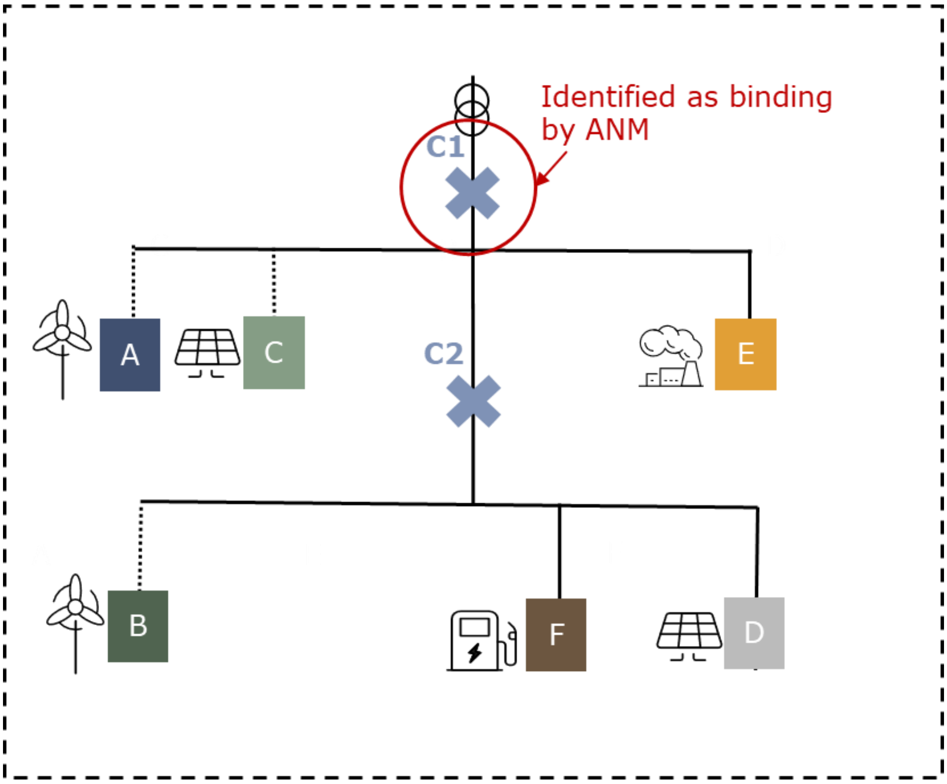
- the position of C has not changed as this party only benefits the curtailable parties with an initial position above the buyer;
- the free rider effect is linked to the number of trades validated; the more buyers that try to benefit from the free rider effect, the fewer trades occur and therefore the effect is reduced; and
- it is impossible to know ahead of trading the number of successful trades and the associated parties - hence, the buyer will have more certainty of avoiding curtailment by trading its way out from curtailment obligations rather than relying on the free rider effect.

6.2.2 Nested constraints

As demand and generation increases on the network, the number of constraints will increase and this is likely to lead to more 'nested constraints'.

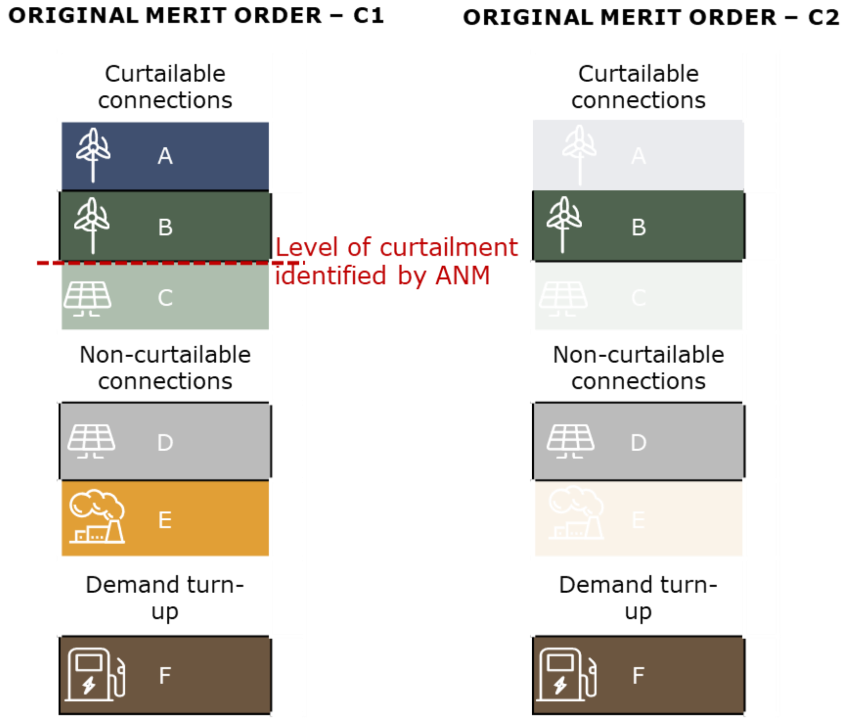
Nested constraints can be represented and simplified as in Exhibit 6.3which shows two constraints, C1 and C2, predicted to occur at different levels of the network.

Exhibit 6.3 – Nested constraint example



If constraint C1 occurs, all parties can help to resolve the constraint (as shown in the merit order on the left in Exhibit 6.4). However, if constraint C2 occurs, only parties B, F and D can help to resolve the constraint. This is shown with the filtered merit order on the right in Exhibit 6.4.

Exhibit 6.4 – Nested constraints C1 and C2 Merit orders



This situation presents two types of potential issues:

- the seller is not useful for resolving both constraints; and
- the seller can receive payment if curtailed in response to a constraint that its matched buyer could not have responded to.

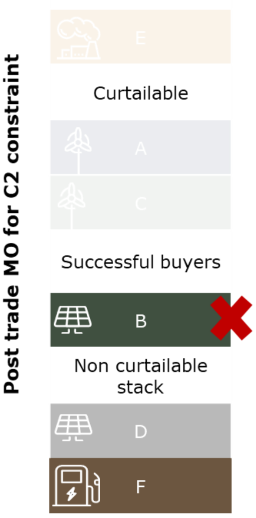
6.2.2.1 Seller not useful

Based on the potential for constraint C1 to occur, B wants to buy its way out of curtailment and E is willing to be paid to reduce its generation. The clearing algorithm results in B and E being matched. E goes to the top of the merit order and B moves down above the non-curtailable connection.

During the traded settlement period, constraint C2 binds, and not constraint C1, with a depth of 1MW. As there is only one master merit order (Section 3.1.3), trades conducted mainly with the intent of altering exposure to constraint C1 will impact the order of curtailment for C2. The traded merit order used for C2 is therefore shown in Exhibit 6.5

Exhibit 6.5 – Nested constraints C2 Merit Order (when the Seller is not useful)

REAL-TIME CURTAILMENT, C2 IS BINDING RATHER THAN C1



In this case, the seller cannot help to alleviate the constraint. Even though B has traded with E, B is getting curtailed as neither E, A or C can help solve the constraint C2.

This creates issues for the buyer, and potentially other non-trading parties:

- **Buyer:** Despite trading, B has not avoided curtailment. In the payment structure which includes an availability payment, B will still have to pay an availability payment to E, despite the fact that B did not avoid being curtailed and E could not help with the binding constraint.
- **Other non-trading parties:** If there had been other curtailable connections which could help alleviate C2, B would have moved below them in the merit order after the trade. In the event of C2 occurring, these non-trading parties will therefore get curtailed first, ahead of B. The trading has therefore increased their chance of being curtailed.

However, it should be noted that:

- Buyer B would not pay F the utilisation fee, as F was not used. The impact is therefore limited in the utilisation only payment structure;
- the parties curtailed in this situation (if not the seller) will have their curtailment index updated to reflect this, which could move them down the merit order for future constraints;
- if constraint C2 is known to be very likely to occur, there could be ways to restrict the eligible sellers to be D and F only, thereby excluding E from being a seller e.g. if this becomes a recurrent issue; and
- if trading per constraint was available in the future, this would no longer be an issue.

6.2.2.2 Buyer off the hook for the constraint

In the same configuration of the network described above, with constraints C1 and C2 constraints and the same forecast, a different issue is presented if C is matched with F.

Again, the C2 constraint binds rather than C1. Exhibit 6.6 shows how the new merit order during the constraint.

Exhibit 6.6 – Nested constraints C2 Merit Order (when Buyer is off the hook)

REAL-TIME CURTAILMENT, C2 IS BINDING RATHER THAN C1

If C2 occurs rather than C1, F would get curtailed as shown in Exhibit 6.6. C would still need to pay F the utilisation payment for this, even though C was not 'on the hook' for this constraint. B also benefits from this trade as part of the free-rider effect mentioned before.

However, it should be noted that:

- as compensation for paying F, C gets its curtailment index decremented which could avoid C getting curtailed next time if this leads to C moving further down the merit order; and
- as in the previous case, if there was a possibility to trade for a specific constraint, then this outcome would not happen. Filtering of participants could help avoid these situations (but may limit liquidity).

6.2.3 Over-estimating baseline

Sellers systematically over / under declaring their baselines could result in sellers getting paid for more than they have delivered as the turn down / up is assessed relative to the baseline.

For example, a seller submits a baseline of 2MW, corresponding to its maximum capacity, even though it is intending to generate 1.5MW. When the constraint occurs, it was instructed to drop to 0MW. The seller will then be paid based on the volume drop compared to the baseline, i.e. 2MW, rather than the more accurate 1.5MW. Paying based on the self-declared baseline, and not penalising participants for inaccuracies in their forecast, is proposed to incentivise greater participation from sellers who might be reluctant to participate if their baseline forecast is uncertain. However, the potential for intentional over / under-declaring baselines is a consequence of this decision.

To alleviate this issue, we propose:

- a clear expectation for participants to submit honest baselines; and
- regular ex-post monitoring and reporting of the comparison between metered data and baselines to ensure that an asset is not systematically over- / under-declaring its baseline.

6.2.4 Over-declaring ability

For a seller which provides a turn-up service, there could be issues with over-declaration of their ability to get a higher availability payment e.g. a demand turn-up with a 5MW connection could declare they would be able to provide 5MW when in reality they could only provide 3MW. This will only be apparent if the asset is called to deliver its turn-up. At this point, they will lose all, or part of, the availability payment.

This may incentivise customers to over-declare their ability to receive a higher availability payment and accept the risk that they may lose some of it if called upon.

However, it should be noted that:

- if a utilisation payment only market is chosen, there will be no incentive to over-declare ability as the payments will only be based on what the assets actually deliver; and
- this will be monitored during the trials, and further rules to discourage this behaviour may be developed if required.

6.3 Further steps

This document provides the first layer and high-level principles for trading rules, with simple examples to highlight how they can work.

As explained above, some assumptions have been made and limitations identified. Alternative options can be considered further once practical experience of using the initial design has been obtained.

To gain the practical experience on how the trading rules work and get further feedback from customers, the project team will conduct a series of trials:

- Mini Trials;
- Simulation Trials; and
- Network trials.

The trials plan will be included in the BiTraDER "Trials Plan, Trading Rules and Initial Specification Report" and the aims of the trials will include:

- explaining the trading rules and receiving feedback from the participants;
- exploring the different options of payment structure as described in Section 4.7 to support a design choice decision;
- understanding the impacts of nested constraints highlighted in Section 6.2.1 from the participants perspective;
- exploring the constraint border effect i.e. when a constraint is binding over two consecutive trading windows and the merit order changes between each window; and
- defining further aspects of the trading rules e.g. exact time of trading, block size etc.

Other aspects to be explored once learning from the BiTraDER project is obtained include:

- post fault constraints;
- the impact of effectiveness factors on trades;
- the interaction of curtailment obligations trading with the Electricity System Operator services; and
- understanding how aggregators could be included.

Annex A Literature review

A.1 Case studies

This section gives a summary of the five case studies explored as part of the literature review. These were Energy Exchange; Transition; TraDER; the ENA Open Networks project; and the NODEs market. Most of these case studies are projects located in Great Britain. Projects in Great Britain were found to provide the most insight for the following reasons:

- GB is considered to be one of the more advanced markets in distribution network flexibility. To our understanding, all ANM systems have been developed for the GB market to date. This is partly led by the TOTEX style incentive scheme giving DNOs an incentive to find innovate methods for building assets in GB.
- The set-up of the market and the split between distribution and transmission is not the same across all markets.

A.1.1 Energy Exchange[9]

UK Power Networks (UKPN) ran the Energy Exchange project from 2019 - 2021 to develop and test market-based approaches for managing curtailment of generators connected to the network through flexible connections. The status quo for UKPN was to curtail based on a Last In First Out (LIFO) basis.

This explored five different market design options, one of which was chosen to be taken forward with a detailed market design, stakeholder engagement and market simulation. The option taken forward was Distribution System Operator (DSO) curtailment. In this market design, the Distributed Energy Resource (DER) submits an offer for curtailment which is then used by the DSO to determine an order of curtailment, based on the £/MWh offer price.

Feedback on the market design for this project provided some useful insights which should be considered in the BiTrader market design:

- Stakeholders mentioned the requirement to keep the market design **simple** as complexity is a barrier to entry. Some customers weren't aware of flexible connections. Undue complexities in the market design should be avoided to ensure participants can actively engage in the market.
- UKPN use a 'sensitivity factor' to account for different curtailment requirements for the same constraint, based on network location, to ensure **efficient curtailment**. BiTrader could consider deploying a similar factor to ensure curtailment is efficiently used.

[9] Energy Exchange: Market-Based Curtailment Management Initial Market Design, UKPN, April 2020 & Energy Exchange – Detailed Market Design (ICE Commitment 7.20.1), July 2020, https://innovation.ukpowernetworks.co.uk/projects/energy-exchange/

- Some customers are likely to outsource real-time commercial decisions to **aggregators**. BiTrader should consider how aggregators can participate in markets (e.g. considering how can generators in different locations be aggregated).
- There are trade-offs that will need to be made depending on the **commodity traded**. Trading energy and access rights both have complications – energy around baselining, and access rights around the regulatory framework. These should be considered in BiTrader's market design decisions.

A.1.2 Transition

Scottish & Southern Electricity Networks (SSEN) are leading the TRANSITION project. TRANSITION is designing, developing and demonstrating the operations of Distribution System Operator (DSO), informed by the Electricity Network Association (ENA) Open Networks Project.

The project includes physical trials of local energy flexibility and the facilitation of new markets, such as peer to peer trading. Two peer to peer markets are being explored – import / export capacity trading and offsetting, where one market actor in a constrained area agrees to increase its demand ahead of another market actor in the same constrained area increasing its generation by the same amount.

Several documents / methodologies have been developed for the Transition project, some of which may be transferrable to the BiTrader project. Using these documents as a starting point where possible ensures the market design remains transferrable across DNOs.

- **Basic Market Rules[10]:** A set of Basic Market Rules was developed for all services being trialled. BiTrader could consider whether these can feed into the Market Rules developed for the BiTrader project, taking into account learnings from the war games and trials run by the TRANSITION project.
- **Peer to peer trading term sheet[11]:** A peer to peer trading term sheet was developed for the trials. This was specific to the services trialled. However, many terms are transferrable, and the BiTrader team should consider whether this can feed into the detailed market rules for the BiTrader project.
- **Baselining tool[12]:** A baselining tool was developed, which has been adopted by ENA Open Networks Project (ON-P WS1A Products 7). If the market trading rules for BiTrader requires baselining, this tool should be explored.

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[10] Market Rules Development Initial Variant, February 2020, SSE & Origami, https://ssen-transition.com/reports/market-rules-development-phase/
[11] P2P Termsheet version 2.0, 9th June 2022, https://ssen-transition.com/wp-content/uploads/2022/06/P2P-Termsheet-v2.0.pdf
[12] https://ssen-transition.com/get-involved/baselining-for-the-trials/

A.1.3 TraDER[13]

TraDER aimed to demonstrate a new market design potential by introducing a flexibility exchange to enable trading between buyers and sellers on the distribution network. This was trialled on the Orkney islands.

The project trialled two products:

- **Demand turn-up:** Curtailed generators and demand assets in the same region can trade with each other. This is a reactive market whereby a generator can contract with demand to turn-up when they have been instructed to curtail.
- **ANM flex:** Aims to enable wider participation of distribution level assets in providing downward flexibility to ESO ancillary services. Currently the ESO prohibits assets in ANM zones from contracting to provide ancillary services. TraDER developed mechanisms for enabling these assets to access ancillary services.

Initially, it was also planned to trial **Curtailment Queue Management**. This enables generators in a constrained area to trade their position in a curtailment queue. This was planned to be both ahead of time and breakpoint trading (close to real-time).

However, the Curtailment Queue Management system was not continued because the ANM system was unable to make changes to the curtailment queue stack and due to limited diversity of asset types on the Orkney islands. The technical abilities of the ANM system impacted the market design in this project:

- The Curtailment Queue Management Product was not continued largely because the ANM was unable to change the queue order.
- Limited visibility of the curtailment and no forecasting meant that the demand turn-up market was limited to a reactive market. This caused issues such as cycling. Generators stop paying for demand turn-up because they had been removed from the curtailment queue, without visibility as to whether the curtailment has been reduced due to wider changes on the system or the procured demand turn up.

The ANM systems used by the DNOs are different, meaning that the technical restrictions for this project may not be technical restrictions in other projects. However, this shows the importance of understanding the technical limitations of the ANM in the BiTrader project, and the role this might play in the market design.

A.1.4 ENA Open Networks

Through the Electricity Networks Association (ENA), the electricity system operator and network operators formed a working group under the governance of the Open Networks project to progress on the issues identified in the Ofgem Significant Code Review (SCR).

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[13] Project Trader Project Summary and Lessons Learned, Catapult Energy Systems, October 2021, https://es.catapult.org.uk/report/project-trader/

An industry led Access Working Group identified four principles for trading non-firm distributed generation curtailment obligations[14]. These are shown in Exhibit 6.7, along with the considerations and potential rules. These should be considered in the market design for the BiTrader project.

[14]. Combined report for 'The Trading of Non-firm distributed generation curtailment obligations', and 'The Exchange of Access Rights between Users'
Product 1 and 2, ENA Industry-led Access Rights Allocation Group 2019, January 2020, https://www.energynetworks.org/industry-hub/resource-library/trading-of-non-firm-dg-curtailment-obligations-and-exchange-of-access-rights-report.pdf

Exhibit 6.7 – ENA framework for enabling curtailment obligation trades

Trading Principle	Key considerations	Potential Rules
Transparent information sharing	— Generators will need information to value curtailment obligation. — DNO must know new curtailment order to give effect to it.	— DNO must make information available about a constraint (MW / MWh, times and network conditions). — DNO must publish process to determine which generators curtail under each plausible scenario. — Parties who have traded must provide the DNO with details of the trade including parties, extent, and time period.
Ability to maintain network continuity	— For network stability, the DNO needs to ensure the asset taking on the curtailment obligation can comply. — Sensitivity factors used.	— DNO must pre-authorise generators wishing to trade (i.e. ensuring included on the ANM system). — MW reduction agreed must have equivalent impact on constraint as MW reduction from generator with curtailment obligation.
Visibility of potential trading opportunities	— Participants will need to be able to determine what opportunities for trading are available under the same constraint. Generators will need to 'opt in' to comply with data privacy and confidentiality.	— Generator's wishing to participate must opt-in. — Platform must provide details on whether parties are offering to increase or bidding to decrease a curtailment obligation; parameters around potential trade; their sensitivity factor; and their bid / offer price.
Transparent trading arrangements	— Define and publish parameters including time period and end to trading window. Need to consider ANM technical restrictions in both of these. — Trading parties need to comply with competition law and procurement rules. Non-trading parties should not be adversely affected.	— Trades must be defined in time periods. — Trades can take place at any point between X and Y before the time it will take effect.

Source: Energy Networks Association, Industry-led Access Rights Allocation Group 2019, Combined report for 'The Trading of Non-firm distributed generation curtailment obligations' and 'the Exchange of Access Rights between Users' Product 1 and 2, January 2020

A.1.5 NODES

NODES was established in 2018 as a joint venture between Norwegian Utility and Agder Energi, and the European power exchange Nord pool[15]. NODES is an independent market operator which aims to provide an integrated marketplace with the goal of creating value for flexibility providers, and incentivising investments in flexibility. NODES has been tested in many real projects across Europe such as:

- Mitnetz case: The German DSO (Mitnetz) used NODES to trade with an industrial park to reduce curtailment of renewables.
- NorFlex: Large-scale demonstration project in Norway. Multiple flexible service providers were invited to provide flexibility to the DSO. This includes aggregating this flexibility for use by the TSO.
- Intraflex: Project in Great Britain. NODES platform used to facilitate trading closer to real time (from a few days ahead to 90 mins before).
- Sthlmflex: Regional market in Stockholm. NODES will operate a near-term flexibility market and long-term availability contracts.

NODEs facilitates the purchase of LongFlex and ShortFlex. LongFlex allows DSOs to secure flexibility for the future via an availability payment. ShortFlex allows DSOs to buy flexibility required at the best price, based on the flexibility service providers that have registered on their platform. NODEs settles the transactions between the two parties.

[15] As of December 2021, Agder Energi is the solar owner of NODES market and technology.

Annex B Building block details

B.1 Volume traded

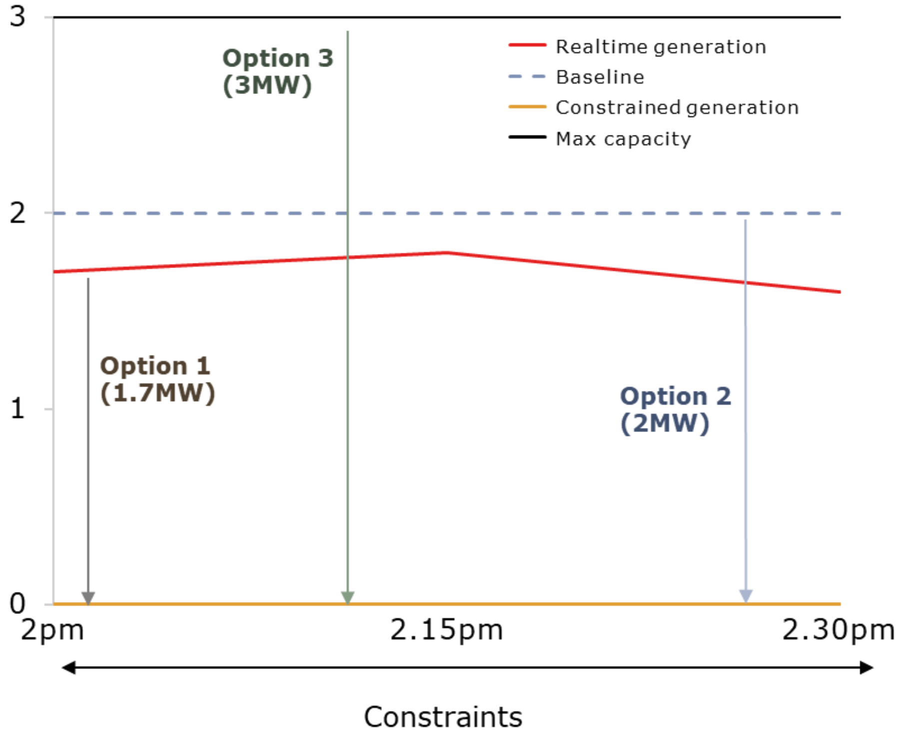
Further details are provided here regarding the choices in respect of the volume traded, as described in Section 4.8.

From the seller's perspective, we identified three possible options for the action required when a constraint occurs:

- 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; and
- Option 3: selling the right to export/import based on the seller's capacity.

These options are illustrated in Exhibit B.1.

Exhibit B.1 – Seller volumes options for a generator



In this example, the look ahead identifies that an excess generation is expected between 2pm and 2.30pm. In this context, a seller F with a non-curtailable connection and a maximum capacity of 3MW (solid black line) is willing to get curtailed to 0MW (solid yellow line) in exchange for utilisation/availability payment.

Based on the information available at the time of trading, a baseline of 2MW was submitted by F indicating its expected generation level during the anticipated constraint (dotted blue line). At the start of the constraint, F is generating 1.7MW (solid red line).

Based on the different options, the volume traded would be different:

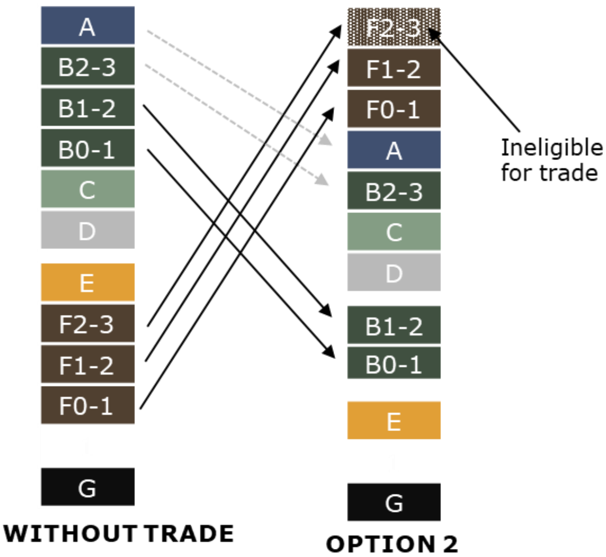
— under option 1, based on the right to export, F could sell 3MW, equivalent to its maximum capacity;

— under option 2, based on the baseline, F could sell 2MW, equivalent to the reduction from 2MW to 0MW from its baseline; and

— under option 3, based on its generation in real time, F could sell 1.7MW, equivalent to the reduction from 1.7MW to 0MW based on its generation in real time at the start of the constraint.

With option 2, assuming all the blocks represent 1MW for simplification, the merit order would change as shown in Exhibit B.2.

Exhibit B.2 – Merit order traded for option 2



B would buy the curtailment obligation to be able to generate at 2MW; (B0-1 and B1-2) tranches would go at the bottom of the curtailable connections, below D and above E, a non-curtailable generator. The tranche B2-3 would not be traded.

The 3MW of capacity of F would go at the top of the merit order with the capacity between 2 and 3MW (F2-3) ineligible for trade/reward. In case of the constraint happening and F curtailed to 0MW, F would receive the payment for its two first tranches (F0-1) and (F1-2).

B.2 Settlement and nested constraints

Further details are provided here linking the settlement market choices described in Section 4.10 with the limitations related to nested constraints highlighted in Section 6.2.2.

When looking at settlement, different eligibility cases are possible for the buyer and the seller linked to the constraint:

- Buyer can either be 'on the hook' or 'off the hook' for the constraint. If the buyer is 'on the hook', it would be on the filtered list of the merit order for the constraint that happens i.e. reducing its generation/demand would help alleviate the constraint.
- Similarly for the seller, it can either have been able to help solving the constraint if needed or not be able to solve the constraint e.g. due to location to the network.

Following the updated merit order, buyers and sellers can be either curtailed or not curtailed by the DNO. This result in a matrix of potential cases depicted in Exhibit B.3, which encompasses the situations identified in the nested constraints section.

Exhibit B.3 – Merit order eligibility and scenario constraints

		Buyer 'on the hook' for the constraint		Buyer 'off the hook' for the constraint	
		Buyer curtailed	Buyer not curtailed	Buyer curtailed	Buyer not curtailed
Seller can help solve the constraint	Seller curtailed	Case A	Case B	N/A	Case C
	Seller not curtailed	N/A	Case D	N/A	Case E
Seller can't help solve the constraint	Seller curtailed	N/A	N/A	N/A	N/A
	Seller not curtailed	Case F	Case G	N/A	Case H

Ignoring the case of under-delivery, the availability payment (if part of the payment structure) would always be paid in all these cases. However, for the utilisation payment, two elements need to be looked at; whether the buyer needs to pay the seller and whether the curtailment index of the buyer is being decremented. This varies according to the different cases presented here:

- Case A: Under the Model D for the trading principles, this should be a marginal case as this would mean that the constraint gets deep enough to start curtailing 'non-curtailable' connections. In the event this happens, the buyer would still need to pay the seller but would get its curtailment index updated twice as compensation for the seller getting curtailed plus the buyer also gets curtailed.
- Case B: The main anticipated case is case B where the buyer is on the hook for the constraint and avoids its curtailment while the seller counterparty gets curtailed. In that case, the buyer pays the utilisation fee to the buyer as anticipated and gets his curtailment index updated once.
- Case C: This can happen if another constraint arises rather the one anticipated by the buyer and the seller e.g. a nested constraint. The seller, as it moves up in the merit order and is 'eligible' for the alternative constraint, gets curtailed. Our approach is that the seller should be paid for being curtailed, hence the buyer should pay even though it was not 'on the hook' for the constraint in the first place. As a compensation, the buyer gets its curtailment index decremented thereby making it less likely to get curtailed the next time.
- Cases D, E, H, G: In all these cases, none of the parties get curtailed. Therefore, there would be no payment for utilisation and the curtailment index of the buyer would not be updated.
- Case F: This can happen for a nested constraint where the seller cannot help to solve the constraint and the constraint goes deep enough to still result in the buyer being curtailed. In this case, the buyer would not pay the utilisation payment as the seller did not provide a useful service. This should be a limited case as some filters should apply for the seller to be 'useful' for the most likely constraints.
- N/A: This represents all the impossible cases under Model D trade matching principles e.g. if the buyer and seller are both eligible for the constraint, then the seller should always be above the buyer in the merit order and be curtailed first, hence it is impossible to have the buyer curtailed and not the seller.
- Cases C and F have some externalities embedded that are discussed in more detail in Section 6.2.2.

Annex C Glossary

Exhibit C.1 – Glossary of key terms

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
Aggregators	Organisations that contract with a number of smaller organisations and use the collective capacity to trade in the flexibility market
'Buyer'	Party buying the ability to transfer their curtailment obligation to another connectee and accept a more favourable position in the merit order list
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 index	A forecasted maximum cap value of curtailment a connectee should expect to see during the course of a year. This is used to rank the merit order stack
Curtailment obligation	The requirement for a connectee to provide curtailment. The specific details of this requirement will be stated in their connection agreement
DNO	Distribution Network Operator - An organisation that owns, operates and manages the electricity infrastructure that distributes electricity from the transmission network operated by the ESO, to end users (commercial and domestic properties). These regional companies are natural monopolies and are therefore regulated by Ofgem
ESO	Electricity 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. ESO is a natural monopoly in the flexibility market, acting as a neutral facilitator
Flexible services	Services purchased from a flexible service provider to provide demand turn down, and demand turn up to alleviate network constraints. These services are used to defer and avoid reinforcement, as well as to allow other customers to connect faster and cheaper to the network and can be provided from demand or generation
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
Merit Order List	A list of connectees in a specific order for the ANM system to action
Non-curtailable connection	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)
Peer to peer trading	Trading between connectees, independent of the DNO or ESO
'Seller'	Party selling the ability to accept a curtailment obligation from another connectee, within the limits of their connection agreement

TABLE OF EXHIBITS

Quality control

Roles	Name	Date
Authors	Simon Bradbury, Gauthier Le Traon, Katie Potter	13/06/2023
Approver	Simon Bradbury	13/06/2023
QC	My Ly Yip	13/06/2023

Document control

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Version	Date	Comments
v300	13/06/2023	Initial release
V400	28/06/2023	Final version

ÅF and Pöyry have come together as AFRY. We don't care much about making history.

We care about making future.

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