Routes to Market Overview

Gary Howorth

Institute of Energy and Environment

Electronic and Electrical Engineering

University of Strathclyde, Glasgow

November 19, 2021

Summary

Key to any assessment for a Virtual Power Plant (VPP) is the prices that one would expect to achieve in the various markets. There are a number of markets that a potential VPP can sell into or buy from and in the future would include:

- Longer term Storage /Flexibility Markets associated with Transmission (currently exists under the UK STOR" arrangements)
- Longer term Storage /Flexibility Markets associated with Distribution (Evolving trial systems set up - see Piclo flex (https://picloflex.com)
- Day ahead and real time sales of Power between producers (APX andN2EX trading market places – currently available)
- Real time flexibility market at distribution or local level (future market)
- Frequency response services (e.g. FFR) and other ancillary services
- And Bilateral markets between participants.

The Current markets are evolving and regulators including Ofgem are looking to make market access for services like flexibility easier to access. Historically balancing markets have been focussed on providing flexibility or imbalance services via the transmission network but Flexibility at the distribution market level is still evolving with several pilot markets such as Piclo Flex being made available. Real time markets at the distribution level do not currently exist, but it is anticipated that they will.

Ultimately a VPP owner will be required to access these various markets to monetize its assets and generate revenues. This will require contractual arrangements as well as communication technologies to transfer data to the appropriate parties. VPP owners can communicate with the markets and the system operator (National Grid ESO in the UK). VPP owners can connect with these markets and system operator directly or indirectly (via Energy/Supplier/Retailers or Aggregators) through a variety of mechanisms and are shown diagrammatically below.

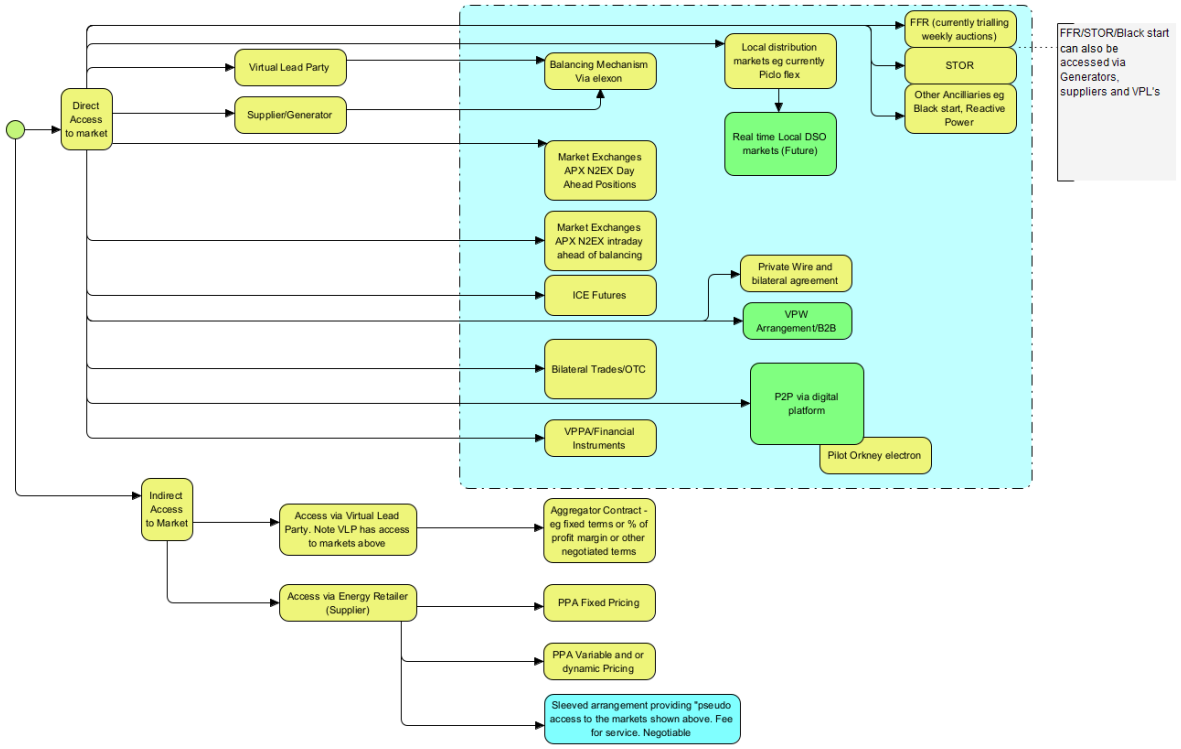


Figure 1: Routes to different markets

This short report summarizes the current operation of the power markets and provides useful links . Various methodologies including the use of Virtual Private Wires , Sleeving arrangements , Virtual or financial PPA's, PPA's, Virtual Lead Parties, Suppliers (Energy Retailers), and the use of Trading (Futures markets) are discussed.

Implications for VPP Use-Cases

As detailed in the main sections of the report, various markets can be entered directly or indirectly via third parties. There are minimum thresholds for direct entry into the various markets (around 1MW-3MW) as well as "joining fees" for certain markets[1]. Entering directly will require that the participants have many agreements with various third parties such Exelon, the DSO/DNO, National Grid and so on and will be required to have "approved" communications links that supply data to and from these various parties. Entry through a third party will preclude the need to have these agreement and links as the third party deals with this. In theory, one agreement could cover many markets providing a "wrapped ancillary flexibility contract" that has access to many different markets.

[1]£14,000 to be a full member of an exchange like APX.

Initial thoughts from the research and analysis of these markets indicates that:

- If a VPP/asset owners are risk adverse or very small (in MW terms) they would probably want to enter market indirectly. That is, let the supplier/aggregator take the risk and structure contract to enable that if you can.
- If value stacking i.e. entering many markets, participants will need to enter many agreements and have lots of communication pathways under the direct option. Costs for entry are in region of £1500-3000/year (2021) and potentially £5 -15,000 entry fee for certain markets.
- Local Distribution markets will become more real time over time but when?
- Participants will probably need to risk manage if entering the market directly – everyone else does!.
- Many of the current UK markets for flexibility/balancing are Pay as bid (2021) not pay as clear. Market prices are cleared prices and represent a maximum. This may change.
- There are minimum thresholds that need to be met to participate in some of these markets eg. Balancing Mechanism >=1 MW tranches (1,2,3 MW…)

Note a companion report provides a summary and analysis of prices achieved in the various markets.

Abbreviations

ANM	Active Network Management
APX	Amsterdam Power Exchange
BEIS	Department for Business, Energy & Industrial Strategy
BETTA	British Electricity Trading and Transmission Arrangements
BM	Balancing Mechanism
BRP	Balancing Responsible party (usually an energy retailer)
BSC	Balancing and Settlement Code
BSP	Balancing Services Provider
BSUoS	Balancing Services Use of System Charges
BMU	Balancing Mechanism Unit
CCGT	Combined Cycle Gas Turbine
CfD	Contract for differences
CHP	Combined heat and power
CPX	Capital Expenditure
CUSC	Connection and Use of System Code
DER	Distributed Energy Resources
DG	Distributed generation
DNO	Distribution Network Operator
DSM	Demand side management
DSO	Distribution system Operator
DSR	Demand side Response
DUOS	Distribution use of Service charge
EHV	Extra High voltage
ENA	The Energy Networks Association
ESO	Electricity System Operator
EU ETS	European Union Emissions Trading system
FFR	Firm Frequency Response or Fast Frequency repsonse
FITs	Feed in tariffs
HV	High Voltage
ICE	Intercontinental Exchange
IDNO	Independent Distribution Network Operator
IRR	Internal rate of Return
LIFO	Last in First Out
LMP	Locational Marginal Pricing
LSE	Load Supplying entity
LTDS	Long Term Development strategy
LV	Low Voltage
MPAN	Meter Point Administration Number
MV	Medium Voltage
NETS	National Electricity Transmission System (NETS)
NG	National Grid
NG ESO	National Grid ESO

NPV	Net Present Value (NPV)
OCGT	Open Cycle Gas Turbine
OFGEM	Office of Gas and Electricity Markets.
OPX	Operating Expenditure
OTC	Over the Counter
P2P	Peer to Peer
PPA	Power Purchase Agreement
RIIO	Revenue = Incentives + Innovation + outputs
RO	Renewables Obligation
ROC	Renewables Obligation Certificates
ROS	Renewables Obligation Scotland
RPZ	Registered Power Zones
SHET	Scottish Hydro-Electric Transmission Limited
SO	System Operator
SPEN	Scottish Power Energy Network
SPTL	Scottish Power Transmission Limited
SSE	Southern and Scottish Energy
STOR	Short term Operating Reserve
TO	Transmission Operator
TSO	Transmission System Operator
TUOS	Transmission use of Service charge
VER	Variable Energy Resource
VLP	Virtual Lead Party
VPP	Virtual Power Plant
VPPA	Virtual Power Purchase Agreement
VPW	Virtual Private Wire

1. Introduction

Deciding how to sell and selecting the right route to market is essential to the success of any product or service. Different routes to market will suit different kinds of assets producing different products/services e.g. Hydrogen vs electricity and involve different risk and rewards. In the case of a Virtual Power Plant (VPP) it is not a simple case of picking one market over another but to understand that having access to switch between markets may be more valuable than any one market. There are costs (financial and other resources) to joining a marketplace and needs an assessment of whether having access to additional markets is worth the cost of joining them. This can be likened to having an option. If the cost of the option far outweighs its value, then the market should not be accessed.

Assessment of the VPP value will take account of the value of these markets , the costs of access and will eventually enable us to determine the best setup for a particular use-case . Eg use-case one may suggest access to an electricity Day ahead markets and hydrogen markets only but use-case 2 may suggest a different commercial set up. This is for future work after assessment of the values later in the project.

In terms of the use-cases on the SIES project , there are three key energy vectors or markets to consider but it is important to realise that within any one of vectors there may be more than one market. Typically, this is along temporal lines (e.g. Day ahead intraday real time) but may markets may also be structured for specific types of assets and their ability to dispatch in a certain manner eg Frequency response vs longer term balancing. In this project. The energy vectors or markets are (see Figure 2):

- Heat
- Power (Electricity)
- Hydrogen

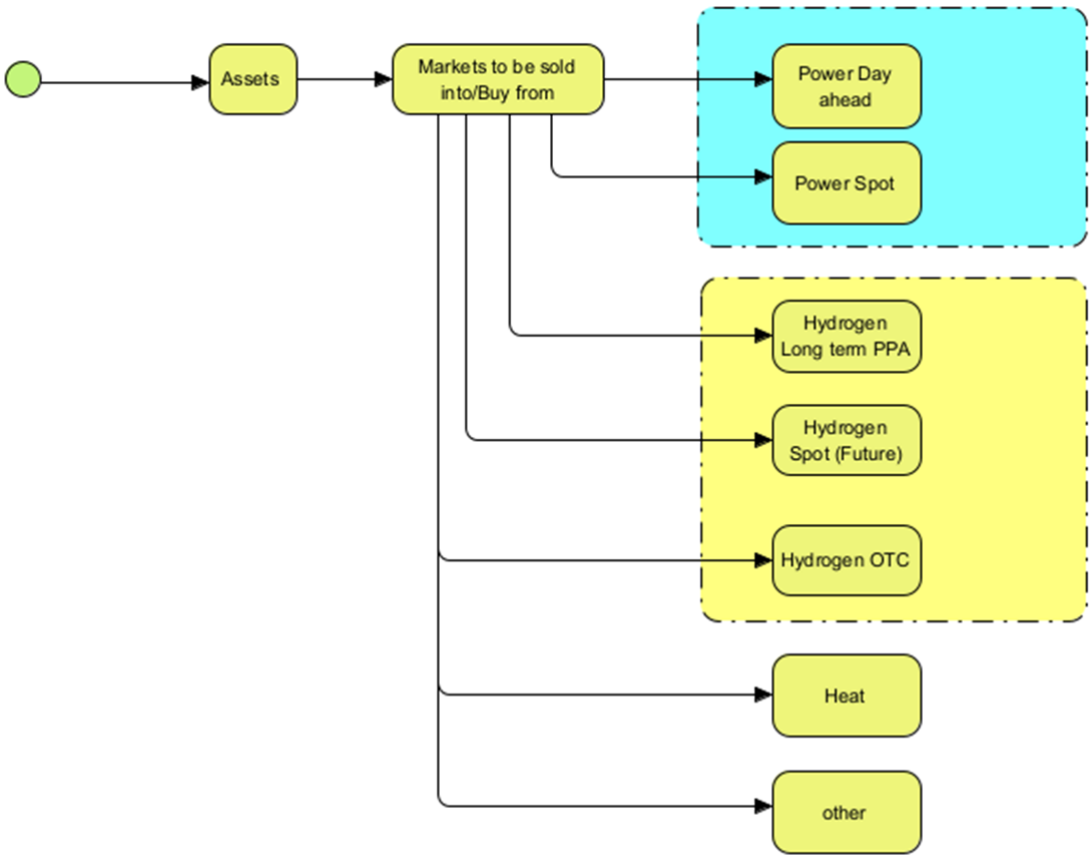


Figure 2: Access to different markets over different timescales

Note this report will focus on power markets only. But in more complicated VPP use cases other markets such as Hydrogen will need to be considered.

2. Current Power & Future Markets

The UK and European power markets have been evolving over the last 30 years and current markets and are still changing. A high-level representation of the current UK market is shown in Figure 3. Historically power has been generated at large centrally dispatched power stations connected to the transmission grid. Power was then directed to lower voltage level distribution systems (66KV and below[2]), where distribution network operators (DNO's) delivered the power to end consumers (industrial commercial and domestic). They managed the network to ensure safety, disconnecting loads as required and charged consumers for their services.

[2] Some distribution systems have parts of their network that operate above these levels.

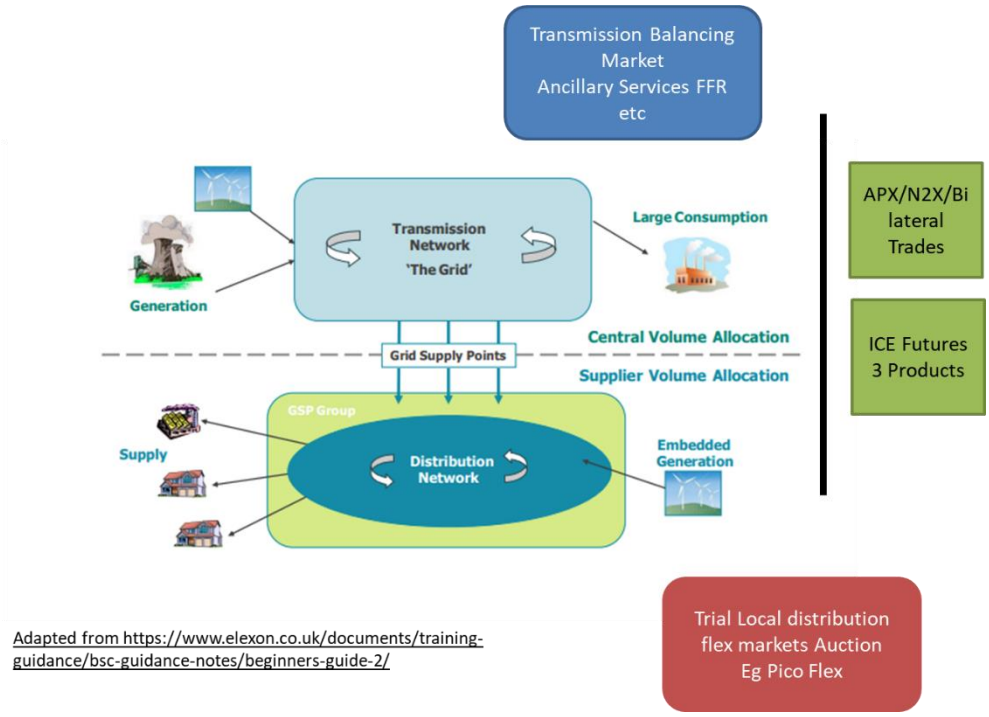


Figure 3: Current UK power markets

Historically, system balancing has occurred at the transmission level with those services managed by National Grid Electricity System Operator (NG ESO) /Elexon. With the addition of renewable resources, distributed energy resources[3] (DER's)/ Embedded generation to power systems, especially at the distribution level , the system has become more complex and requires different methodologies to manage it. DNO's are evolving into organisations that not only manage the network but coordinate and optimise two-way flow for assets connected to their local network – and hence are known as Distribution system Operators (DSO's)[4] when operating in this mode. Included in this evolution is the concept that consumers could help to manage the system by providing flexibility either from their domestic sources of generation such as PV or batteries. It also has the benefit of negating potential costly upgrades to the transmission and distribution networks .

To facilitate interaction between, potentially, millions of Distributed Energy Resources and manage the coordination issues, it is also necessary to develop aggregation models. According to the English Oxford Dictionary aggregation is defined as "the formation of a number of things into a cluster". In a

[3] Small units connected to the distribution grid with possible two-way flow of electrical power. Common examples of DERs are Distributed Generators (solar, wind) battery storage, electric vehicles (EV) and active demand response (load that can change its consumption to provide flexibility to the system).
[4] Note in Europe DNO's are known as DSO's

comparable way, an aggregator is defined as “a company that negotiates with producers of a utility service such as electricity on behalf of groups of consumers”. In this way aggregator companies[5] take millions of volume-cost bids from homes, businesses and other DER’s, packages those bids into larger bid units and submits those bids to a Transmission system Operator (TSO), Distribution System Operator (DSO) or some hybrid organization that manages flexibility markets on behalf of TSO and DSO [1].

For the interested reader (https://www.elexon.co.uk/documents/training-guidance/bsc-guidance-notes/beginners-guide-2/) provides a good overview of how the UK system as is currently configured.

To facilitate the provision of flexibility at the local level, independent markets have been developed. These flexibility markets allow smaller players including aggregators /VPP’s to provide such flexibility, although currently these UK local DSO based markets do not operate in real time but use auctions. There is currently therefore a market at the transmission level and the distribution level, albeit the distribution focussed market is less well developed.

The UK market uses exchanges (e.g. APX and N2EX) and bilateral or over the counter (OTC) trades to affect trades in the UK market. Generators and suppliers use the exchanges to buy/sell their power output. This is discussed more fully below, where a description of trades and their link to the balancing market is made.

2.1. Development of Current Markets

Further market development is ongoing, and markets are moving towards being more real time. The exact nature of the shape of these markets in years to come is currently unclear, and whether there will be one overall market for both transmission & distribution systems or whether the markets will remain separate or there will be, multiple markets for flexibility is unclear (see Figure 4). Note that in the current arrangements, National Grid ESO (a legally separate entity that is still part of the National Grid Group) performs the ESO role, but in January 2021, Ofgem recommended to the Government that the ESO role is delivered by a body that is fully independent of National Grid.

[5] Note a Virtual Power Plant (VPP) owner is essentially an aggregator.

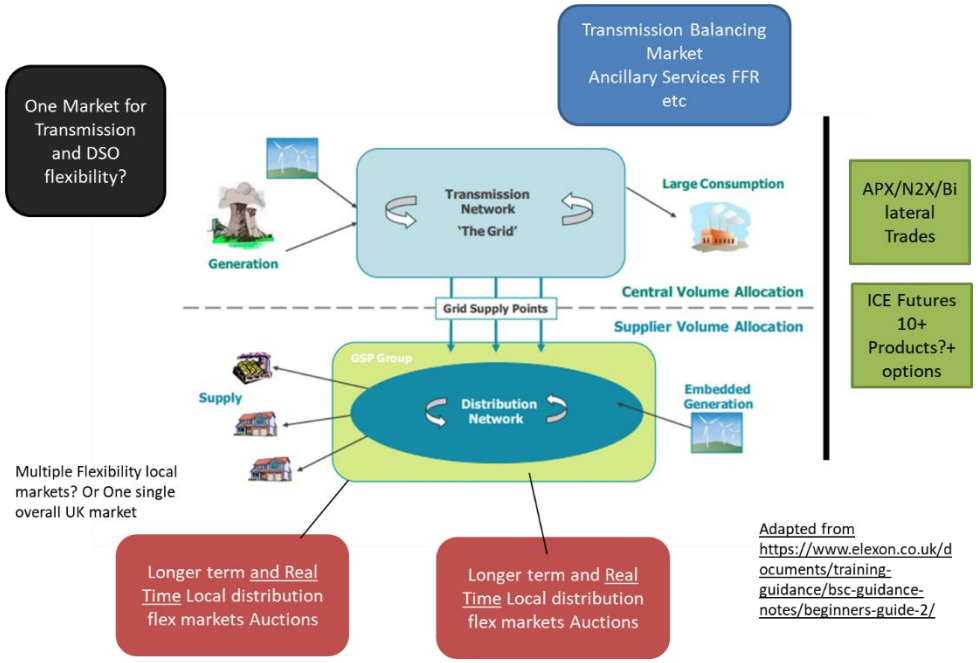


Figure 4: Future power market

Futures markets like ICE in the UK allow users to hedge their positions with the purchase of future's products. There are currently three products in the UK market (the UK spark spread, UK base and UK peak products). Like other markets e.g. PJM in the US (https://www.cmegroup.com/trading/energy/global-power-futures.html& https://www.theice.com/energy/power) we would expect UK futures markets to develop to provide additional products like options to help manage a more complex market as it evolves.

2.2. Trading Arrangements Market Operation in UK Power

The transmission operator and the future DSO's need to plan for system operation hours before actual dispatch and need to balance the system in real time as they have always done. Methodologies for balancing the system typically use an Optimal Power Flow (OPF) approach to dispatch the system. This approach is used in Australia, Norway PJM[6](https://www.pjm.com/) in the USA and historically the UK. In these markets participants, provide the system operator (TSO) and the DSO with volumes (MWh) and price bids for the next 24 hours. The system operator uses OPF based models to minimise system costs[7] taking account of power flow constraints and losses. This involves a new non-linear optimization and provides the operator with a dispatch plan and clearing prices for the market. The wholesale price or clearing prices may be derived for particular zones, regions or actual nodes on the system. Locational Marginal pricing (LMP) using nodes and is used in

[6] Pennsylvania New Jersey and Maryland.
[7] Using the marginal cost bids provided to them as part of the Day ahead market managed by the TSO/SO.

the PJM system. The UK is moving to a half hourly bidding system although there are some systems that bid at 15 minutes and even five minutes[8]. This is essentially a day ahead market. Power participants have to provide data in advance before an agreed gate closure time in the UK ie 11:00 am for dispatch between 23.00 and 22.59 the next day.

However, the UK is now what is known as a self-dispatching system. Buyers of power (known as supplies/energy retailers) and sellers of energy (generator/producers) interact by agreeing bilateral contracts (or by using over the counter contracts) or via market exchanges such as APX and N2EX. They form financial transactions to buy and sell vias these various exchanges. The buyers/sellers have to provide the TSO (NG ESO) with the dispatch volumes agreed between them including the locations. This is performed electronically. It is unclear whether they give the TSO contractual information associated with the commercial agreement i.e. the price. After gate closure the TSO balances the system using an OPF model and dispatches it to minimise system costs. Is not clear exactly what the system costs are as in this calculation as they may not have been provided to the system operator. A more traditional OPF Calculation would involves the marginal costs of the units provided to them via their own system. Note that that the current self-dispatching system produces similar results to that that would be obtained using a standard OPF methodology using marginal bid costs. Note the TSO has total control of the system after gate closure and provides sellers buyers with final dispatch plans (Day ahead). For each half hour, known as the Settlement Period, companies can trade up to 1 hour beforehand.

3. Imbalance Volumes

Because demand projections rely on weather forecasts, changes in weather, along with system outages, congestion and other issues, results in changes in the planned day head schedule. The TSO has to make short term changes to balance the system for deviations from the Day ahead planning schedule hour by hour[9]. In the UK self-dispatching system sellers can use the market exchanges (APX, N2EX) to balance their short term (Intraday trading) by buying or selling volumes as required.

Participants can also use the futures markets to further hedge their positions.

[8] LMP or 5-15 minute bidding may eventually be used in the UK.
[9] Note this is likely to be for shorter time periods in the future

Ultimately in a very short term (minutes, seconds) the system will still need to be physically rebalanced. National Grid ESO uses a variety of sources such as batteries and existing generation to balance the system and calculate balancing prices in real time using an OPF methodology. Bids and offers are provided by market participants. This Balancing mechanism is managed by National Grid ESO and Elexon. When participants (Balancing Responsible Parties – usually Suppliers/Energy Retailers) have imbalances over the day charges are made for balancing the system at the clearing price (known as the System Price) as determined above (including admin charges). The average period from Settlement Day to payment day is 29 days and over the period losses may cancel out gains. Elexon requires participants to post collateral for the usual amount associated with balancing over the 29 period. The value of the collateral will fluctuate with historical prices and the activity of a particular balancing participant. (https://www.ofgem.gov.uk/sites/default/files/docs/2002/03/528-elexon.doc).

4. Markets & Routes to Revenues

Using the research on the markets for our use-case, a route to market diagram has been constructed (Figure 5) and provides an overview of the routes to market for a potential VPP owner and can be subdivided into direct and indirect channels. A VPP using a "Direct channel" buys/sells/interacts directly with the various markets that are to be described shortly. Participants using "Indirect access" essentially access the same the same markets via a third party. That would typically be via a supplier (Energy Retailer) or a VPP/Aggregator e.g. Ecotricity, Flextricity Next Kraftwerke[10] who provide such access for a fee. That is, the Supplier gives generator the ability to access the balancing mechanism and potential balancing mechanism revenues without the generator being required to hold a generation licence or have its asset registered as a Balancing Mechanism Unit (BMU)[11].

[10] Currently in Europe only

[11] They are registered via the Supplier or VLP (Aggregator) as a secondary BMU

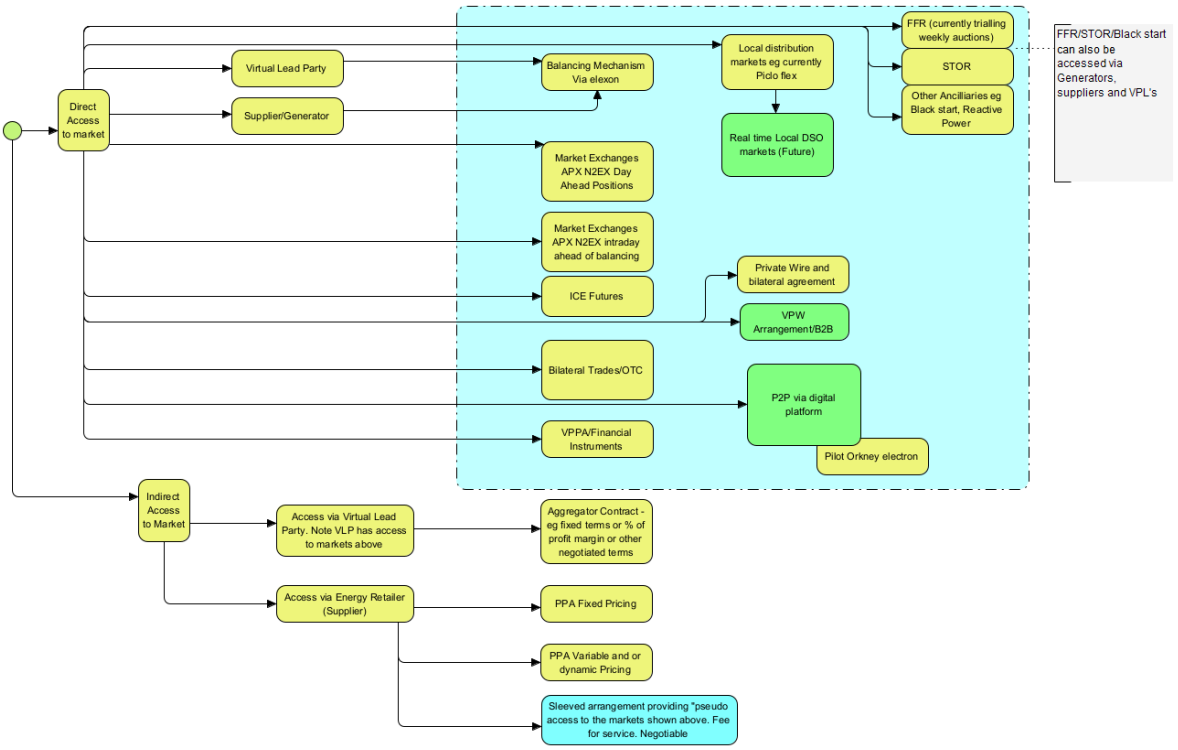


Figure 5: UK routes to market

Using Figure 5 as a guide, this section provides a short commentary on the various markets identified in the UK power system. Links to various documents providing more details can be found in appendix 2. Although not specifically labelled on Figure 5, National Grid ESO provides a forward "trading" service /market to allow users to provide balancing services at specific locations for a number of years. Note a forward market deals in physical volumes which are expected to be delivered but a futures market is purely financial.

4.1. Balancing Mechanism

The Balancing Mechanism, or BM, is the main mechanism used by National Grid ESO, to balance electricity supply and demand close to real time at the transmission level. When the TSO predicts that there will be a discrepancy between electricity production and demand during a certain time period, it may accept a 'bid' or 'offer' from a market participant to either increase or decrease generation (or consumption). The operation of the BM relies on the flow of data and information between the TSO and market participants. This happens in real time to ensure that system balance is

maintained. The TSO specifies the interfaces that must be used for these processes, to comply with in the Balancing and Settlement Code (BSC).

The process of the Balancing Mechanism is as follows:

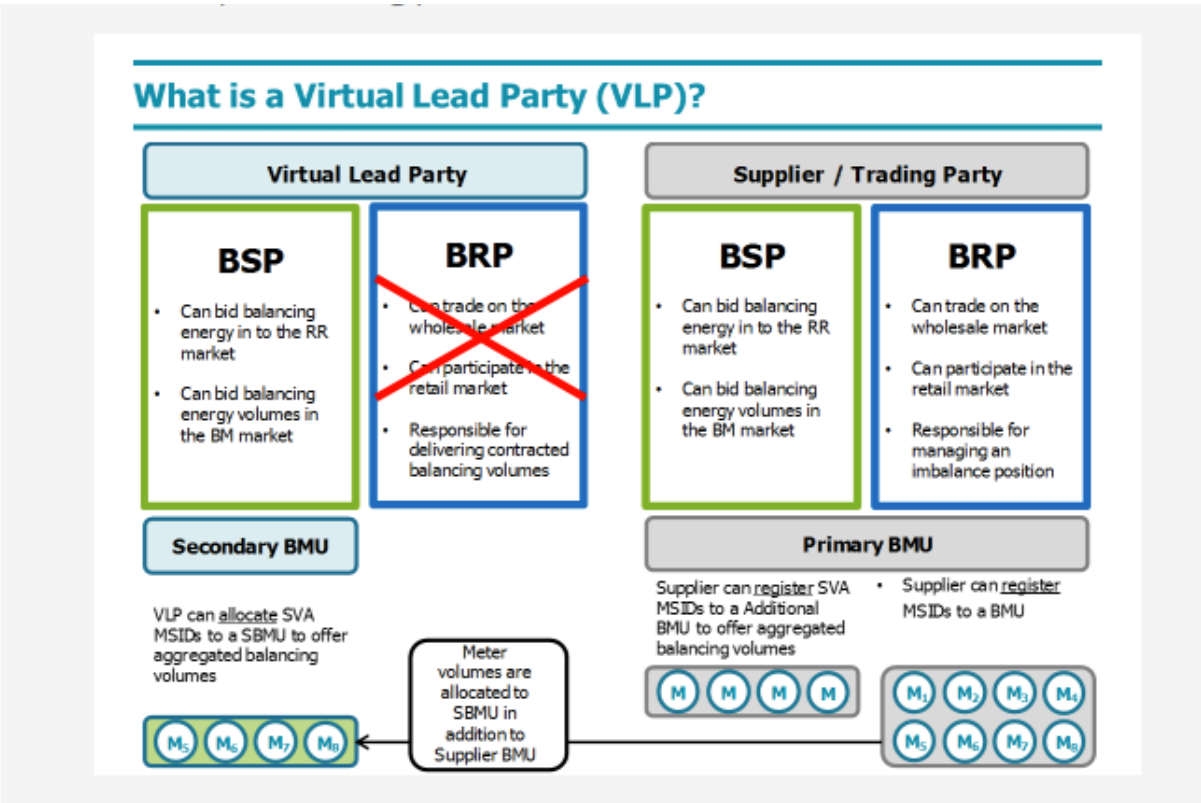
- Each generator provides a detailed specification of the characteristics of its Balancing Mechanism Units (BMUs), its generation assets e.g., ramp rates. In December 2019 NG ESO lowered the minimum threshold to take part in the BM from 100MW to 1MW, which has allowed small and aggregated units to provide power to the grid, particularly in regional networks.
- As described previously each generator bids into the day-ahead market. After the day-ahead auction results, the market generator knows which bids have been accepted where and when.
- Then the intraday trading process starts, in which the generators buy and sell power with other market participants on the exchanges (APX exchange).
- Trading activity up to gate closure must be notified to the market operator, market via Elexon. These trades, submitted as Electricity Contract Volume Notifications (EVCNs), establish the position for each generator up to gate closure. Participants can submit up to ten Bid- Offer Pairs for each Balancing Mechanism Unit.
- Before gate closure, the planned dispatch of the power generation asset, is sent to the Electronic Data Transfer (EDT) system of the TSO. The dispatch pattern is the Final Physical Notification (FPN) and consists of a series of points. The points contain the levels of production (in MW) at each half-hour, and all other minutes where there is a change in the speed of ramping up or down. The points are the official schedule of the generation asset.
- After gate closure, the TSO is responsible for maintaining system balance. The prices at which the TSO may vary the production of generation assets after gate closure, are submitted by the generators via bids and offers in the balancing market. This is in effect the flexibility that generators are offering to the system. The variations in production and supply are reconciled and settled through Elexon's Central clearing System. An important distinction between the BM and the wholesale spot markets is that all participants are 'paid as bid' not paid the price of the marginal provider of energy.

The UK TSO uses the Balancing Mechanism as the primary means to balance the system at the transmission level. However, they also use other mechanisms provided as ancillary services by

market participants. These include the Firm Frequency Response (FFR) service, the short term operating reserve (STOR), Fast Reserve (FR) and Black Start. See below.

4.1.1. Virtual Lead Party (VLP)

Exelon and Nation Grid introduced the concept of a virtual lead part to allow enable Aggregators to enter the market more easily. .The role of a VLP and how to enter the market is set out in https://www.elexon.co.uk/documents/training-guidance/bsc-guidance-notes/virtual-lead-party-vlp-entering-the-market/. V



Note BSP – Bulk Supply Point

“Whilst the VLP route to the market opens up access to the Balancing Mechanism for smaller participants and aggregators, it does not provide access to day-ahead and intra-day trading (EPEX Spot) and for smaller distribution connected assets, access must still be achieved by either acquiring a supplier license or partnering with an existing supplier.”

https://www.enegen.co.uk/content/generation/National-Grid-Wider-Access.shtml

VLPs, like other BSC Parties are required to provide credit collateral for trading charges and gain SVA qualification. They will also need to interact the Supplier volume allocation Agent (SVAA – currently CGI - https://www.cgi.com/uk/en-gb) 12.

Unlike suppliers , VLP's do not need to pay 'use of system' charges (TNUos & DUoS). VLPs also gain from the simplification of the communication protocols (EDT and EDL) with the Balancing Mechanism with the introduction of APIs rather than fixed line Multiprotocol Label Switching (MPLS) lines.

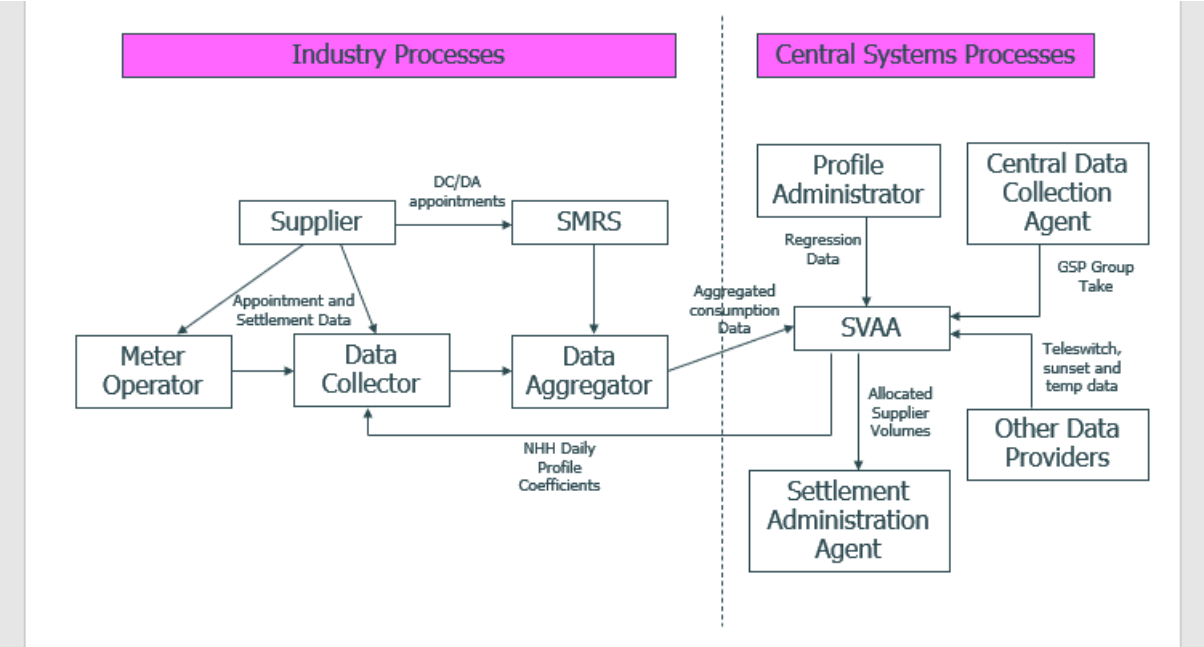


Figure 6: Supplier Volume Allocation (SVA) process

5. Costs of Participating in the Balancing Market.

The costs of the various markets are summarised in Table x below in section 2 but are summarised below.

[12] They calculate supplier volumes , manages market data, provides non half hourly profiles, etc.

Table 1: Summary of costs for entering and participating in various markets

5.1. Distribution Flexibility Market: Piclo Flex Example

Piclo flex (https://picloflex.com) is an example of an independent digital marketplace for flexibility services based around the distribution system. It was set up to provide an independent open online platform to support the efficient connection of decentralised embedded generation. Six DNO's and National Grid are participants in this system. The platform is known as Piclo flex and can be accessed by those companies that have flexibility assets or intending to develop flexibility assets by registering on their site. It provides an information portal of upcoming flexibility competitions congestion areas etc. In a 2019 trial, some 4442 megawatts of assets proposed their services in the active competitions on the system, but only 116 megawatts of that qualified for use. The current system provides data and visualisations of areas of the grid where flexibility services are required and gives details on upcoming competitions auctions . The platform aims in the longer term aims to provide a transparent view of flexibility services, its value and to allow smaller users e.g. ~10 kilowatts to connect to local distribution services and provide the flexibility in the years to come. It is essentially a one-way system where the DSO requiring such flexibility advertises for services. Currently competitions look for flexibility for a number of months throughout the year and over a number of years and for specific time slots during the day. Prices for such flexibility appeared to range from £2 to £3500/MWh and participants can be paid both a commodity and a capacity charges e.g. they will be paid for the megawatts on standby and for the actual MWh that they deliver or a combination of both. In the longer term it is likely that Piclo Flex will transition to a more real time local flexibility market. There are other pilot sites performing similar functions around the UK.

Providers have to register their flexible assets, enabling them to qualify for and take part in competitions. It is free to use (2021). It is an example of a local distribution based flexibility market although the platform runs competitions for multiple DSO's and the TSO. Scottish Power Energy Networks (SPEN) is one of the DSO's that runs its competitions on the platform and is the DSO associated with the use-cases at E-T-C and Myres Hill. There are currently (2021) over 1,400 DSO flexibility competitions live on Piclo Flex for Flexibility Providers to win contracts from (https://blog.piclo.energy/post/6520542139789312 00/top-tips-for-participating-in-dso-flexibility).

Frequently asked Questions can be found at >> https://support.picloflex.com/article/75-spen-spring-2021-competitions.

Note that there are other platforms like flexible power that SPEN also interact with.

In summary key points for these types of flexibility auctions are:

- Auctions market are run yearly/half yearly for flexibility at certain locations for next 4-5 years. Typically looking for flex at specific locations for 2-4 hours during certain times of the day for ceratin months.
- The DSO's e.g. SPEN via the Piclo flex platform, run competitive tenders yearly (around March) for flexibility at the local distribution grid level. Tenders close early July with award in September[13]. For certain services (Secure) there is a minimum threshold for bids (this appears to be DSO dependent. WPD in one of their trials has facilitated the participation from loads as small as 600w.
- Note that the services are predefined and Piclo Flex provides guidance on what the tariffs should be e.g. premium rates vs lower rates. Providers have to prequalify (Flexibility Prequalification services document). The pre-qualification process is split into two parts: The first to assess company specific information (e.g. financial information like; Can this organisation pay its debts as they fall due (within the meaning of Section 268 Insolvency Act 1986) and the second to assess the suitability of the proposed flexibility asset.
- Key: Piclo Flex do not require exclusivity so participants can value stack with other services (assuming the flexibility agreement allows this). Providers are required to declare availability a week ahead during the contracted service window thereby confirming the provision of service. If, due to network requirements, the weekly schedule is not accepted , particpants can divert those resources elsewhere.
- Piclo Flex uses a "Pay as bid" market - in competition results doc all pay as bid or fixed
- To take part in tenders participants need register on the Piclo Flex website. Registration requires the submission of company-specific data. They assess this data and accept or reject the company. Only accepted companies can submit bids. Assets are uploaded onto the Piclo Flex platform and technical and locational information provided as part of a Questionnaire. Piclo Flex then accepts or rejects assets as appropriate
- Dispatch and settlement via a portal using an API system
- Participants can only bid from assets already connected and from those in development

[13] Based on last tender March 2021.

- MWs/MVARs can be offered in smaller volumes with either a single price or a variety of prices i.e. a stack of volumes at different prices offered.
- After a bid for flex is accepted participants need to sign up to a flexibility services agreement. Should services not be provided, in part or in full, an adjustment may apply. The terms for such adjustment will be included in the Flexibility Services Agreement.
- PicloFlex can reject bids if not commercially suitable or if there are not enough bids. After bid the DSO makes a technical assessment of such bid which takes about 10+ weeks to contract award. Intention to enders are posted around one month before the auction. (flexibility procurement services Document march 2021 v1) Note that the DSO (SPEN in this instance) is setting aside 6 weeks to perfrom technical assessments of the offers!

5.2. STOR

Historically Short Term Operating Reserve contracts – were procured by the National Grid ESO via a competitive tender process 3 times per year for delivery of STOR volumes within 20 mins. Some contracts still exist. The minimum requirements for participating in STOR include:

- Offering a minimum of 3MW generation or steady demand reduction (can be aggregated)
- A maximum response time for delivery of 240 minutes following instruction, although National Grid ESO typically contracts for 20 minutes or less.
- The ability to deliver the contracted MW for a continuous period of not less than two hours.
- Being able to deliver at least three times per week.

(http://powerresponsive.com/wp-content/uploads/2021/04/NG_MEUC-book-2021.pdf)

Since April 2021 STOR has procured its services through a daily pay-as-clear auction process. The auction closes at 05:00 for service delivery the following day 05:00-05:00 [2]

5.2.1. Participating in STOR

Interested parties should contact commercial.operation@nationalgrideso.com. Pre-qualification requirements are to be fully compliant and tested for the Platform for Ancillary Services (PAS)[14] or live in the Balancing Mechanism (BM).

[14] The Platform for Ancillary Services (PAS) programme, includes updating the Service Provider and Contracts Management platform, the Ancillary Services Dispatch Platform (ASDP) and the Settlements platform.

Providers will need to sign up to the Services Terms

Non-BM Providers will need to complete and return a STOR Data Template which captures the unit's technical and operational details.

Once this has been completed National Grid ESO will issue approval which then allows. providers to participate daily Auction on the Auction Platform [2].

5.3. FFR

There are several markets currently available for providers to offer frequency response services to National Grid ESO:

- The Mandatory market – open only to large transmission connected generators who have signed up to the various network codes as Balancing Mechanism Units. (not applicable to SIES use-cases).
- Firm Frequency Response (FFR) market – open to all providers and tendered monthly. Not it is expected that these will be replaced with near real time markets in the form of Dynamic containment (DC), Dynamic Regulation(DR) and Dynamic Modulation (see below)
- The weekly frequency response auction trial – a temporary trial of a new approach to procurement.
- Dynamic Containment (DC post fault service)) (launched in Oct 2020 on the EPEX trading platform) – the first of a new suite of three faster-acting frequency response products that the ESO is transitioning to.
- Two other services (Dynamic Modulation (pre fault – 1 second response time 30 min requirement) and Dynamic Regulation (pre – fault 10 sec response time 60 min requirement) are due to be rolled out in Spring 2022[15]. The are two sub products associated with DC, DCL (low freq) and DCH (high freq). The new services will also be unbundled into high and low frequency products. DM/DR services will only initially for BM units[16] [3].

[15] National Grid ESO currently out for consultation. DR will be released first
[16] Non-BM's will be brought into the system later.

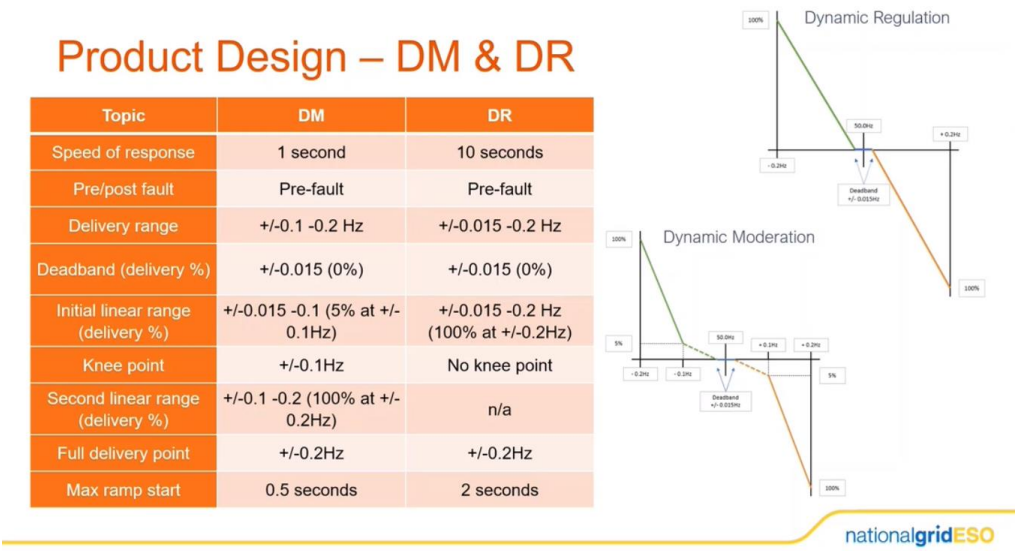


Figure 7: Dynamic modulation & regulation products [3][17]

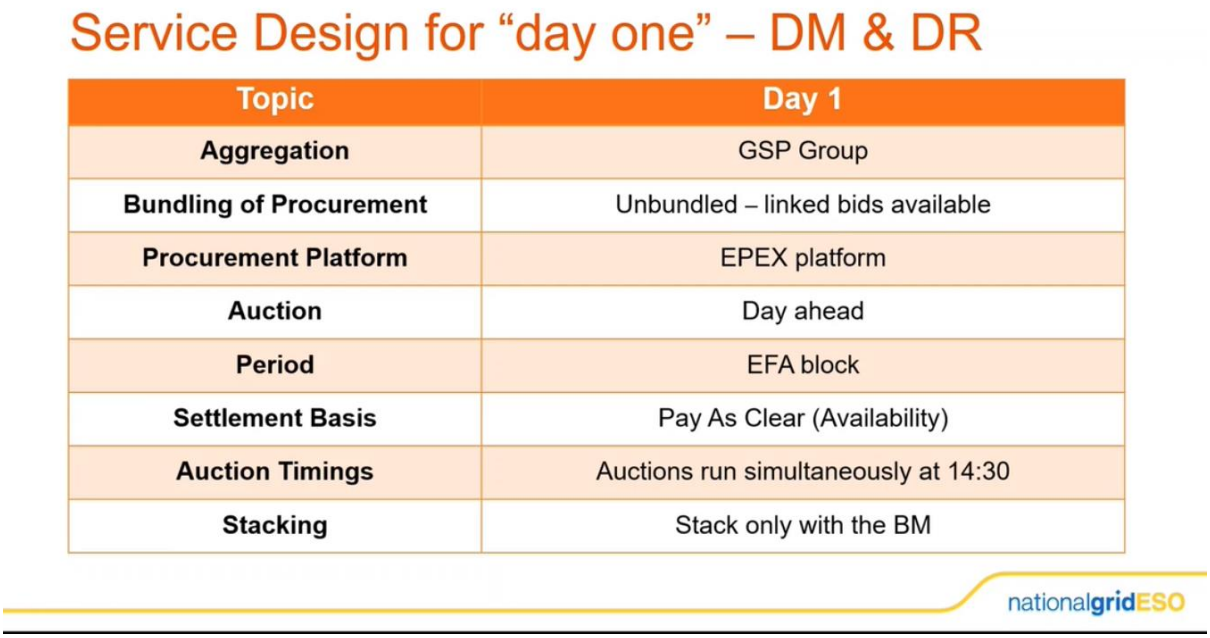


Figure 8: Dynamic modulation & regulation products [3]

[17] EFA blocks -Electricity Forward Agreement blocks (see [4])

- Also four reserve products to be developed.
- National Grid are taking a learning by doing approach for new products using an agile approach developing a minimal viable product (MVP).
- Aggregators will be able aggregate services to the Grid Supply Point (GSP Group) point for the DR/DM services[18] and to the Grid supply point for DC. National Grid have recognised the need to incorporate assets at the distribution level !
- Can value stack DC/DM/DR with the balancing market. But Dynamic markets may not be stacked together e.g. DC with DR etc

FFR has historically been procured through a monthly electronic tender process. Once service providers succeed in the pre-qualification assessment and sign onto a framework agreement, they will be provided with a login to the electronic tender platform. Providers must have:

- suitable operational metering;
- pass the FFR pre-qualification assessment;
- deliver minimum 1MW response energy;
- have the capability to operate (when instructed) in a frequency sensitive mode for dynamic response, or change their MW level via automatic relay for non-dynamic response;
- communicate via an automatic logging device; and
- be able to instruct and receive via a single point of contact and control where a single FFR unit comprises of two or more sites located at the same premises.

Having considered the quality, quantity and the nature of the services, National Grid ESO will accept the most economical tenders Providers will also need to test their assets in accordance with the NG ESO testing procedures

Standard contract terms can be found at [5] .

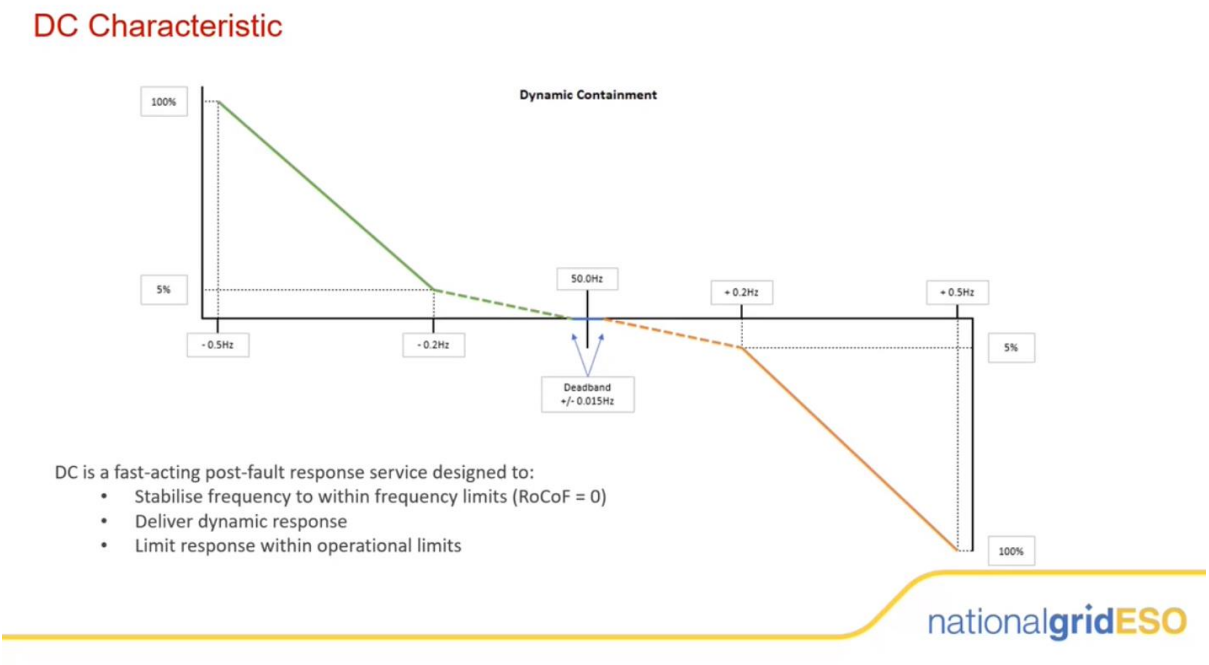
[18] Still under consultation for DM DR and reserve services

- At the moment providers typically tender for an availability fee is generally submitted by and hence the total cost of the contract is the MW x number of hours allocated to the service (£/MW/h).

Note the cost of a tender can be made up of:

- Availability fee (£/MW/h)
- Window initiation fee x forecast hours of nomination (£/Window)
- Nomination fee x forecast hours of nomination ((£/hr) - a holding fee for each hour used within FFR nominated windows).
- Where appropriate, response energy price x volume of response energy delivered ((£/MWh) - based upon the actual response energy provided in the nominated window). [6]

Dynamic containment (day ahead procurement for next 24 hours) was launched in



5.4. Other Ancillaries e.g. Black Start/Restoration Services

Black start refers to the series of actions necessary to restore electricity supplies to customers following a total or widespread partial shutdown of the GB Transmission and Distribution Systems. Black Start requires transmission substations to be re-energised and reconnected to each other in a controlled way to re-establish a fully interconnected system.

National Grid ESO requests services for Black start around one year in advance using a tender requests for a number of years in the future (typically 3 years). Providers are paid an availability Price of £/start. In the 2020 Auction eight providers were accepted at a total cost of £53.8m for circa 11GW – which is an average price of £ 2445/MWh assuming a 2 hour service and 1 start. Note it is possible to provide other balancing services alongside Black start, as long as doing so does not interfere with the providers ability to deliver such services. A high level summary**19** of assets types are given in [7]. Note some embedded gas-based generation is providing such services. Where there is enough competition for services market prices will be determined by the auction using Pay as Bid or alternatively using cost plus or alternative costs (see [8]).

Trials have been caried out by DSO's(e.g. SPEN) to see if renewable or other embedded assets could be used to energise the circuits and substation. DSO's may look to procure Black Start services. Black start services from Hydrogen based Fuel cells have been proposed for micro grids. [9, 10].

Another option is to use battery storage, such as forms part of Siemens' Siestart system which uses battery storage along side gas turbines [11] to energise the grid .

To discuss the provision of restoration services to the transmission system providers should contact commercial.operation@nationalgrideso.com

5.5. Virtual Private wire (VPW)

If a physical wire was built from generation site to a demand site 10 miles away and used to supply electricity under a commercial arrangement or for free (if the owners of the sites are the same), then this would be known as private wire arrangement. There would be no need to connect to any of the markets discussed in these documents. The Virtual Private Wire (VPW) concept is similar but uses existing distribution (and potentially transmission in a few cases). No entry or exit charges

[19] Tender results in August 2020

would be paid but some form of recompense would be needed to paid for the use of the distribution system. These costs would be lower than connecting in the usual way so, TUOS and DUOS costs would be saved. E.g. a potential use case would be to connect Myres Hill to E-T-C site (both the same owners) assuming enough capacity exists in the distribution system. Note actual flows from one site to another would not necessarily occur. [12] provided an outline of potential business models in 2007 and was further studied in [13, 14] In a more recent paper commissioned by the Advanced Renewables connections group[20] some business models and contractual arrangements are laid out for providing a VPW service at the local level [15].

5.6. Peer to Peer (P2P)

P2P refers to the arrangement where individual users or customers interact with each using an independent market exchange or digital platform. Uber or AirBnB are well known examples of peer to peer networks. In a first of its kind , Electron have used a Peer to Peer trading platform in the Orkney's in Scotland in a two-year trial, known as Project TraDER. The system delivered almost 24,000 peer-to-peer trades between local wind turbines and homes, as well as providing flexibility services into a national transmission market [16]. This type of market is not currently available to VPP's in the area of the Use-cases but the use of P2P platforms would be expected to grow and may prove to be valuable as they are likely to save costs (eg TUOS and DUOS) similar to that of a VPW.

6. Indirect routes To Market: PPA's , Sleeving, CfD's

Participants can buy and sell power to a variety of markets but at its simplest users can contract with an energy supplier/retailer or an aggregator via a power purchase agreement (PPA) which typically provides the user with fixed prices indexing with RPI or other terms. The supplier provides access to the various markets through its contractual agreements and relationships and its communication pathways i.e. electronic communication with the TSO (National Grid Electricity Supply Operator (ESO)), where prices are variable but provides a fixed price[21]. The Supplier therefore takes the risk that prices will be lower if buying from a producer and therefore will charge a premium for taking such risk. Other contract types have been seen including time of day pricing[22], Dynamic prices

[20] This builds on the University of Strathclyde work in references [13, 14]
[21] The user has an indirect relationship with the actual markets
[22] Details cannot be provided because of Confidentiality

reflecting flexibility/Balancing market prices and so on. Note that Octopus Dynamic pricing tariff use the 3 pm APX Exchange clearing prices

Where participants are provided with access to market fluctuations through a third party such as supplier this is known as sleeving. The supplier takes the energy directly from the power producer and "sleeves" it to the buyer at its point of intake, for a fee[23]. Note the supplier typically charges the generator/participant either a transaction fee or a % of profit made for each trade it executes. Note the participant may also perform these actions through an aggregator/VPP owner. In the case of an aggregator/VPP owner they are known as a Virtual Lead Party (VLP) if transacting with NG ESO's Balancing market

Historically renewable projects could sell their electricity on favourable terms under the UK renewable electricity incentive schemes. They have been replaced by the Contract for difference (CfD) auctions (see below).

Participants are also able to generate revenues via bilateral trades.

An important secondary offering of some routes to market via suppliers/aggregators is the ability for a generator to access the balancing mechanism and potential balancing mechanism revenues without the generator being required to hold a generation licence / have its asset registered as a BM Unit. Essentially this is an indirect route to this market.

As discussed In the case of aggregators the National Grid ESO/Elexon have made it easier for such aggregators to provide flexibility to the Balancing mechanism or market by becoming allowing aggregators to join as the Virtual lead party.

This is commonly achieved by the VLP assigning a generator's asset as a secondary BMU. VLP's must bid a minimum of 1 MW into the Balancing mechanism, but are allowed to aggregate several assets to achieve this. An analysis of current aggregator contracts indicates that suppliers are typically provided with either fixed prices or charges a percentage of the prices received from the market (ie a margin).

Third parties can also be used to access Ancillary Services provided by National Grid or others in the future. Flexible generation/storage projects may want to rely on more complex 'value stack' revenue streams. With direct entry , with generators/VPP owners would be required to enter into numerous framework contracts and competitions to create the revenue stack.

[23] The supplier could sell directly to end markets or to other suppliers or groups of end users with which they have relationships

It would be possible for Energy Suppliers/Aggregators to simplify the revenue stack using “simpler” contractual structures that provide all or some of those revenues ,through their third party agreements a “wrapped ancillary services and Capacity Market solution”. This contracting solution is not without its challenges, particularly if an asset developer requires project financing, as the asset owner may potentially be exposed to the supplier’s aggregated assets position and therefore its credit and performance risk.

6.1. Drawbacks of Indirect Access through third Parties

Energy customers and small generators can access the Balancing mechanism via licensed suppliers or utilise the Virtual lead Party (VLP) route to access the Balancing Market. However, existing suppliers and even VLP’s, may own competing forms of flexibility, so they may have an incentive to trade their own flexibility first.

Suppliers and VLP’s will also charge for this service – thus eroding some of the benefits of direct entry.

7. Power Purchase Agreement (PPA)

A PPA is a contract between a producer and a seller to buy/ Sell electricity over a power grid connection. It involves a physical power delivery over a grid, but may be at a variable or a fixed price dependent upon the agreement.

A Sleeved PPA is also a contract for physical delivery that involves three parties rather than two where the third part acts as an intermediary and in the UK is typically a supplier. It involves using the suppliers existing arrangements to gain access to generators or demands (with the appropriate commercial arrangements already in place) and to provide that power via the supplier company for a fee. Known as a sleeving fee. It may have the advantage in some cases that if power is curtailed that said supplier will purchase power from elsewhere. The intermediary energy retailer/utility company ”Supplier” handles the transfer of money and energy between the real markets and the energy producer.

A sleeved agreement or PPA could also involve access to balancing market prices (for a fee) without the need to directly connect to the actual market.

8. Virtual PPA's (VPAA)

A Virtual PPA (or financial PPA) is a financial contract and does not include any physical powers flows. A contract for difference (CfD) is an example of such as contract. VPPA is essentially a fixed for float swap where the buyer receivers or pays a fixed price whilst the issuer of the swap takes on a floating power price in the market. VPPA's are very similar to physical PPAs' financially, but they differ in that physical power is not required – hence no grid connection is required. Note that Virtual PPAs may have more onerous accounting reporting requirements as they could be seen as financial derivatives.

9. Generator and Supplier costs (TUOS and DUOS)

The costs of transmission and distribution including power losses are accounted for by charges in the Transmission use of system (TUOS) and (DUOS) charges in the UK. In the case of Transmission (see refs for more details) the ESO (National Grid) perform an economic assessment of the costs of moving power from one zone to another using a DC linear power flow model. Tools to calculate charges can be down loaded from the distribution companies or from the ESO by asking for permission. Generators are charged according to their Transmission Entry Capacity and .Suppliers are charged based on actual demand. All tariffs are based on which geographical zone Users are connected to. Essentially an entry and exit charge

TUoS tariffs are published annually by 31 January and take effect from 1 April each year. these charges apply to Generators/Suppliers Directly connected Transmission demand and certain Embedded Generators. Where assets are connected at the distribution level the Distribution company normally deals with these costs – ie they are passed on.

10. Futures Markets (Exchange)

Futures markets in the EU and UK are less well developed than the USA where users access to some 40 to 50 products versus 3 in the UK. Option products are not currently provided in the UK markets for power. With the inability to use multiple futures products there is a higher risk of seeing basis

risk in applying futures products for hedging that is the risk associated with a perfect match either in location terms or timing. The use of the future market to hedge against losses will be discussed in future work.

The APX or Amsterdam power exchange operates three markets / exchanges in the Netherlands, the United Kingdom and Belgium and is owned by EPEX Spot (https://www.epexspot.com/en). Members have full, access to the markets but can trade both on their own account, and on behalf of other companies (indirect). Only companies can become members of EPEX SPOT. A list of members can be found here (https://www.epexspot.com/en/exchangemembers), but members can be categorized as banks, DNO/DSO's, trading companies , energy retailers, aggregators, VPP owners and so on. Examples of companies trading directly as member on the exchanges includes Centrica EDF EON Ecotricity, Flextricity, Scottish Power SSE , National Grid and Next Kraftwerke.[24]

ICE is the largest market place in the world and in the UK provides futures products for hedging and for speculative traders. Most of the volumes are associated with that trading is associated with the front months[25] with some contracts for longer time periods out to 3-5 years.

Contract types for European markets are limited when compared with the USA markets[26] The current UK futures market only offers three products and no option products. These are summarised in table x below

11.Bibliography

[1] G. Howorth and I. Kockar, "Do we need a new architecture for simulating power systems? A position paper," 2018.

[2] National Grid ESO. (2021, 1 Oct). *STOR – How to participate*. Available: https://www.nationalgrideso.com/industry-information/balancing-services/Reserve-Services/Short-term-operating-reserve/How-to-participate

[3] National Grid ESO, "Response and Reserve Webinar ", ed, 2021.

[4] Neil Weaver, "EFA: how does the EFA day work?," vol. 2021, ed, 2021.

[5] National Grid ESO, "Firm Frequency Response Tender Rules and Standard Contract Term," 2019, Available: https://www.nationalgrideso.com/document/154151/download.

[24] This is not an exhaustive list.

[25] Earlier months

[26] For example there are no options products.

[6] National Grid ESO, "Assessment Principles – Firm Frequency Response," 2020, Available: https://www.nationalgrideso.com/document/153946/download.
[7] National Grid ESO, "Black Start – Competitive Procurement Event Northern," 2020, Available: https://www.nationalgrideso.com/document/174951/download.
[8] National Grid ESO, "Black Start Strategy and Procurement Methodology 2021/22," 2021, Available: https://www.nationalgrideso.com/document/191636/download.
[9] R. Steinberger-Wilckens, J. Radcliffe, P. E. Naser Al-Mufachi, A. V. A. Dodds, O. Jones, and Z. Kurban, "THE ROLE OF HYDROGEN AND FUEL CELLS IN DELIVERING ENERGY SECURITY," 2017.
[10] M. Gardener, "Hydrogen Energy Storage: Experimental analysis and modeling, US Dept of Energy

" 2014, Available: https://www.energy.gov/sites/default/files/2014/08/f18/fcto_webinarslides_h2_storage_fc_technologies_081914.pdf.
[11] Power Magazine, "Siemens Energy wins its first black-start battery storage project for power generation in the U.S.," ed. Power Magazine, 2021.
[12] Dave Miller, "Virtual Private Networks," 2007, Available: https://www.ofgem.gov.uk/sites/default/files/docs/2007/09/ce-electrics-paper---virtual-private-networks.pdf, Accessed on: 5 Jun 2021.
[13] S. Gill, M. Plecas, and I. Kockar, "Coupling demand and distributed generation to accelerate renewable connections: Options for the accelerating renewable connections project," 2014.
[14] S. Gill, M. Plecas, I. Kockar, F. White, A. Maybury, and J. Gutierrez, "Options for the Accelerating Renewable Connections project," 2014.
[15] Community Energy Scotland, "'Linking Local Power and Local People': A Review of potential commercial arrangements for facilitating 'Virtual Private Wire' grid connections," 2017, Available: https://www.spenergynetworks.co.uk/userfiles/file/ARC_Learning_Report_Potential_Commercial_Arrangements_for_Virtual_Private_WireSystems_Feb_2017.pdf, Accessed on: 1 Jun 2021.
[16] Catapult Energy Systems, "First-of-a-kind neutral market platform trades flexibility between local and national markets in the Orkney islands," ed, 2021.

Appendices

Appendix A1 Balancing Mechanism(BM) and Exchange Data Sources

Data on wholesale electricity market activity can be found on the following links:

Supply and Demand Data/Balancing Market Reports

BM reports data and downloads Exelon: https://www.bmreports.com/bmrs/?q=help/about-us

Gridwatch: https://www.gridwatch.templar.co.uk/

National Grid ESO Datasets : https://data.nationalgrideso.com/search

Exchange prices

APX UK: www.apxgroup.com/market-results/apx-power-uk/dashboard/

N2EX: www.n2ex.com/marketdata

Forward Exchange Prices

NASDAQ: www.nasdaqomx.com/commodities/markets/marketprices

The ICE: www.theice.com/marketdata/reports/ReportCenter.shtml#report/

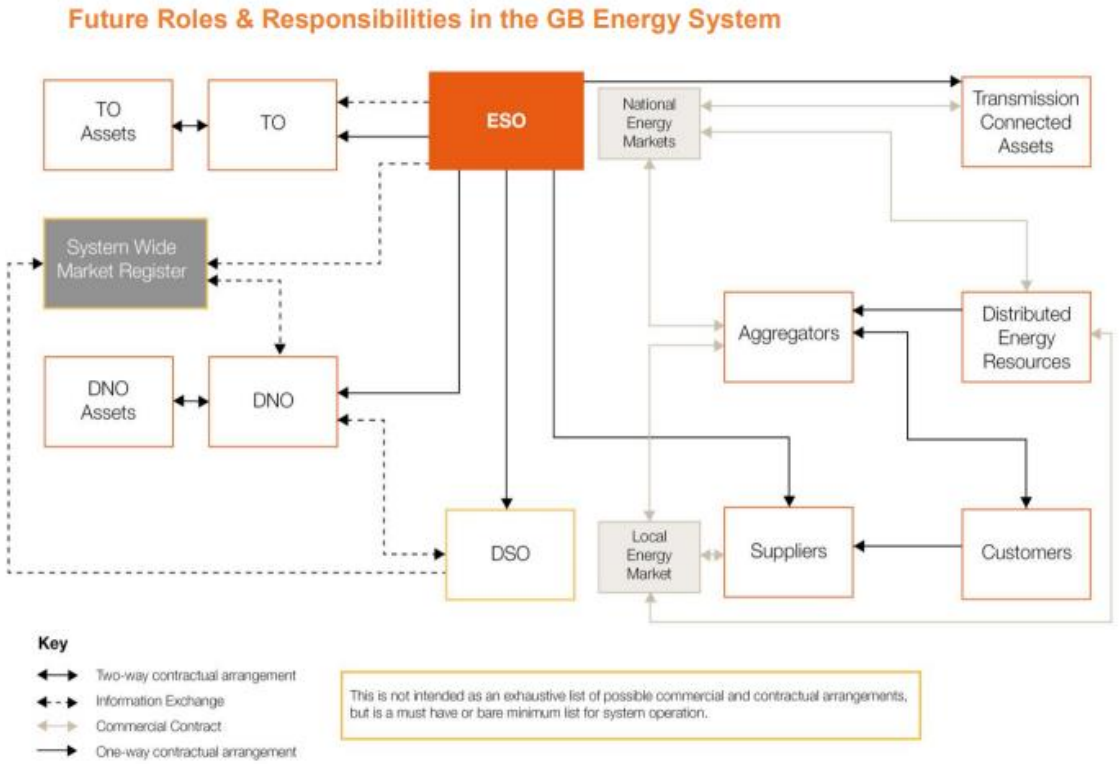
Over-the-Counter (OTC) prices - London Energy Brokers' Association (LEBA):
www.leba.org.uk/pages/index.cfm?page_id=41&title=uk_power_prompt

Appendix A2 Useful documents

- The Electricity Trading Arrangements A Beginner's Guide: https://www.elexon.co.uk/documents/training-guidance/bsc-guidance-notes/beginners-guide-2/
- Balancing Mechanism Wider Access -Guidance on Joining NG ESO: https://www.nationalgrideso.com/industry-information/balancing-services/balancing-mechanism-wider-access
- Connection and Use of System Code (CUSC) – UK Transmission: https://www.nationalgrideso.com/industry-information/codes/connection-and-use-system-code-cusc-old?code-documents=&page=0%2C1&search=
- Balancing and settlement code Elexon : https://www.elexon.co.uk/bsc-and-codes/balancing-settlement-code/
- FFR National Grid Roadmap 2017 – New Products and rationale: https://www.nationalgrideso.com/sites/eso/files/documents/Product%20Roadmap%20for%20Frequency%20Response%20and%20Reserve.pdf
- Connections use of system and metering services SPEN: https://www.spenergynetworks.co.uk/pages/connections_use_of_system_and_metering_services.aspx
- Transmission Network Use of System (TNUoS) Charges https://www.nationalgrideso.com/industry-information/charging/transmission-network-use-system-tnuos-charges#tnuos-tariffs
- Roles and Responsibilities in the Provision of Flexibility: Energy UK: https://www.energy-uk.org.uk/publication.html?task=file.download&id=6798#:~:text=Balancing%20Responsible%20Party%20(BRP)%20%E2%80%93,fiscally%20responsible%20for%20its%20imbalances.
- Ofgem glossary : https://www.ofgem.gov.uk/sites/default/files/docs/2019/09/000_-_working_paper_-_summer_2019_-_glossary_final.pdf
- Renewables Obligation - https://www.ofgem.gov.uk/environmental-and-social-schemes/renewables-obligation-ro
- A Guide to EDT, EDL and CT with National Grid 2016 https://www.nationalgrideso.com/document/95736/download
- A guide to Balancing mechanism Units Elexon (Includes how to register and timimgs) https://www.elexon.co.uk/operations-settlement/balancing-mechanism-units/

- BSC Insight: Overall Costs of Balancing system and analysis Elexon: https://www.elexon.co.uk/article/bsc-insight-increasing-costs-for-balancing-the-gb-system/
- Use of System (UoS) and Virtual Lead Party (VLP) https://www.nationalgrideso.com/industry-information/connections/use-system-uos-and-virtual-lead-party-vlp
- Firm Frequency Response Interactive Guide National Grid https://www.nationalgrid.com/sites/default/files/documents/Firm%20Frequency%20Response%20%28FFR%29%20Interactive%20Guidance%20v1%200_0.pdf
- Data for Ancillary Services: https://data.nationalgrideso.com/data-groups/ancillary-services
- Balancing Services Descriptions, NG ESO: https://www.nationalgrideso.com/industry-information/balancing-services
- How does the Balancing Mechanism work? Flextricity: https://www.flexitricity.com/how-does-balancing-mechanism-work/
- Monthly Balancing Services Summary 2018/19 NG ESO: https://www.nationalgrid.com/sites/default/files/documents/MBSS_July_2018.pdf
- Settlement Calander Balancing Market Elexon: https://www.elexon.co.uk/operations-settlement/balancing-and-settlement/
- EPEXSPOT (APX) Clearing (Good description of process of clearing): https://www.epexspot.com/en/basicspowermarket
- Piclo Flex April 2021 Support Document for Flexibility competition : https://support.picloflex.com/article/53-competitions
- Case study on uk power networks auctions for flex Picloflex: https://piclo.energy/publications/Piclo+Case+Study+-+UKPN+-+July+2020+-+Release.pdf
- Virtual Lead Party Entering the market: https://www.elexon.co.uk/documents/training-guidance/bsc-guidance-notes/virtual-lead-party-vlp-entering-the-market/
- SPEN Jargon Buster https://www.spenergynetworks.co.uk/userfiles/file/Jargon%20Buster.pdf
- BSC Agents, Elexon: https://www.elexon.co.uk/documents/training-guidance/bsc-guidance-notes/bsc-agents/

Appendix A3 Physical Data and Communication Links



https://www.energy-uk.org.uk/publication.html?task=file.download&id=6798#:~:text=Balancing%20Responsible%20Party%20(BRP)%20%E2%80%93,fiscally%20responsible%20for%20its%20imbalances.

Appendix A4 Glossary

Transmission Operator (TO): There are 3 TO organisations responsible for maintaining and monitoring transmission power networks across the UK. National Grid Electricity Transmission plc (NGET), Scottish Power Transmission Limited and Scottish Hydro Electric Transmission plc operate the national networks which pull together the segmented distribution networks and transmission-connected generation assets. TOs own and maintain the network assets but play no role in balancing, as this sits with the Electricity systems Operator (ESO – National Grid ESO).

Electricity systems Operator (ESO – National Grid ESO): The ESO is responsible for operating the entire UK power system to ensure optimal flow of energy across the network. This role is fulfilled by a part of National Grid Group (National Grid ESO) and there are a large number of aspects to that role including efficient planning and delivery of transmission investment and acting in the role of the Electricity Market Reform (EMR) delivery body.

Balancing Responsible Party (BRP): The BRP role is typically taken on by energy suppliers, who hold responsibility for ensuring they have purchased enough energy to provide for the demand created by their customers. Failure to accurately predict the amount and timing of their customers' energy usage can result in imbalances on the system as supply and demand fall out of alignment. If resolving this issue requires action from the ESO, the supplier is held responsible for the cost of resolving the issue. The ESO establishes contracts with a number of parties ahead of time to ensure that they have a range of options suited to their situational needs. This enables them to act quickly to resolve the imbalance, leaving resolving the costs of their actions until the situation has passed.

The balancing responsible party (BRP) is a market participant who is responsible for ensuring they have purchased enough energy to provide for the demand created by their customers

Aggregator – An organisation which collates various energy resources to create a single, larger flexibility asset, as set out in Ofgem's open letter on the design of arrangements to accommodate independent aggregators in energy markets.

Distribution Network Operators (DNO): These organisations are responsible for maintaining and monitoring distribution networks (pipes and wires) as defined by the Distribution Licence. There are 14 distribution network areas operated by seven DNOs across GB. DNOs are responsible for ensuring that distribution networks are able to deliver for the needs of those in their respective geographical area. DNOs are responsible for investment and innovation across their networks and coordinate with Ofgem and National Grid in those areas.

A DNO or Distribution Network operator manages the network and diverts flows from the transmission grid to end users. It is somewhat a passive role. DNO's in the UK are in the process of transitioning to DSO's (Distribution System Operators) who in addition to managing the network look to optimise the network to manage local storage and distributed assets with the view to making the system more "smart" using digital technologies and active network management (ANM) the rest of Europe, the DSO is the generic term for a company that performs a role equivalent to that of a DNO in the UK, but it does not necessarily mean they are "smart". Both manage congestion on the network.

Balancing Services Provider (BSP) : A range of balancing services are offered through existing markets in GB, with each body signed up to offer a service counted as a Balancing Services Provider. At current, BSPs have relationships with National Grid, as the ESO, and the third parties contracted by the ESO as part of the management of those markets. The typical format of the relationship is a contracted service being establishes, which the ESO then calls upon for balancing the system to operate at optimal levels.