DNV·GL

Project Fusion – USEF Due Diligence

SP Energy Networks

Date of issue: 2019-06-19

IMPORTANT NOTICE AND DISCLAIMER

1. This document must be read in its entirety. This document may contain detailed technical data which is intended for use only by persons possessing requisite expertise in its subject matter.

2. This document has been produced from information relating to dates and periods referred to in this document. This document does not imply that any information is not subject to change.

Customer Details

Customer Name:	SP Energy Networks
Customer Address:	320 St Vincent St, Glasgow G2 5AD
Customer Reference:	Project Fusion – USEF Due Diligence
Contact Email Address:	fusion@spenergynetworks.com

DNV GL Company Details

DNV GL Legal Entity:	DNV GL Limited
DNV GL Organisation Unit:	Energy Markets & Technology
DNV GL Address:	30 Stamford Street, London SE1 9LQ
DNV GL Telephone:	+33 20 3816 5879
DNV GL org. No.:	E-NG-N

About this document

Document Title:	Project Fusion – USEF Due Diligence
Date of issue:	19/06/2019
Date of last revision:	19/06/2019

Revision History

Revision	Issue Date	Comments
V1.5	04/04/2019	Draft Report
V1.6	24/04/2019	Updated Draft Report
V2.0	20/05/2019	Draft Final Report
V3.0	19/06/2019	Final Report

for
DNV GL Limited

Prepared by:

Rafiek Versmissen
Director – Energy Markets & Technology

Approved by:

Michael Dodd
Market Area Manager UK & Ireland

Table of contents

GLOSSARY

Active Demand & Supply (ADS)[1]	Energy consuming or producing devices that can be actively controlled.
Aggregator[1]	A service provider that contracts, monitors, aggregates, dispatches and remunerates flexible assets at the customer side.
Aggregator Implementation Model (AIM)[1]	USEF term that describes the relation of the aggregator with the supplier and the Balance Responsible Party (BRP). It covers relevant aspects of aggregation implementation, such as contractual arrangements, imbalance responsibility and transfer of energy.
Allocated volume	An energy volume physically injected or withdrawn from the system and attributed to a Balance Responsible Party, for the calculation of the imbalance associated with the Balance Responsible Party.
Allocation Responsible Party (ARP)[1]	A party that establishes and communicates the actual electricity volumes which are consumed and produced per Imbalance Settlement Period (ISP) within a certain metering area. In GB, this role is performed by the Balancing and Settlement Code Company, ELEXON, for Imbalance Settlement and the Balancing Mechanism.
Balance Responsible Party (BRP)	A market participant or its chosen representative who is responsible for balancing electricity supply and demand of its portfolio in each settlement period.
Balancing Mechanism (BM)	A mechanism used by National Grid Electricity System Operator (ESO), to balance electricity supply and demand close to real time. It is used to balance supply and demand in each half hour settlement period.
Balancing Mechanism Unit (BMU)	Balancing Mechanism Units are the units used under the Balancing and Settlement Code (BSC) to account for all energy that flows on or off the Total System, which is the Transmission System and each Distribution System combined. A BM Unit is the smallest grouping of equipment that can be independently metered for Settlement.
Balancing Service Provider (BSP)	A market participant who provides energy volumes to the TSO for the purposes of balancing the total system. In GB, this role is usually undertaken by aggregators, suppliers or customers directly connected to the transmission network.
Balancing Settlement Code (BSC)	The Balancing and Settlement Code (BSC) is a legal document which defines the rules and governance for the balancing mechanism and imbalance settlement processes of electricity in Great Britain. The BSC is administered by ELEXON, the Balancing and Settlement Code Company.
Capacity Market (CM)	A mechanism designed to increase security of electricity supply by encouraging investment in reliable sources of capacity.
Capacity Service Provider (CSP)[1]	A market participant in USEF that provides adequacy services to either the TSO or the BRP. This term is not used in GB although there are market parties that provide adequacy services in the Capacity Market.
Common Reference Operator (CRO)[1]	In USEF, the CRO is responsible for operating the Common Reference. USEF defines the Common Reference as a repository which contains information about connections and congestions points in the network.
Congestion Management[1]	The avoidance of the thermal overload of system components by reducing peak loads. The conventional solution to thermal overload is grid reinforcement (e.g. cables, transformers). Congestion management may defer or even avoid the necessity of grid investments.
Constraint Management Service Provider (CMSP)[1]	A provider of constraint management services to a DSO or the TSO. This is a USEF role and is not currently used in GB.

1 USEF terminology

Data Transfer Service (DTS)	A regulated centralised communications service which uses common set of industry requirements to facilitate business-critical processes, such as settlement, change of supplier and metering. In DTS, only information about domestic customers is exchanged.
Demand Turn Up (DTU)	A National Grid ESO Restoration Reserve service which has been discontinued. This service requires large energy users and generators to either increase demand or reduce generation at times of high renewable output and low national demand.
Demand-Side Flexibility (DSF)	According to USEF, DSF is flexibility at the customer side, which includes flexible load, generation and on-site storage. DSF is provided "behind-the meter" or "behind the connection". National Grid's DSF definition encompasses the same elements as USEF, however, it also includes storage and generation "for export". This report uses DSF as per USEF's definition.
Demand-Side Response (DSR)	The change in electricity demand in response to a signal, through load shifting, on-site generation and/or use of storage.
Distributed Energy Resources (DER)	Small scale power generation technologies (typically in the range of up to 10MW and including electric energy storage facilities) and larger end-use electricity consumers (e.g. industrial and commercial) with the ability to flex their demand (i.e. demand-side response) that are directly connected to the electricity distribution network.
Distribution and Connection Use of System Agreement (DCUSA)	The multi-party contract between licensed electricity distributors, suppliers and generators in GB concerned with the use of the electricity distribution system.
Distribution Network Operator (DNO)	Company licensed to distribute electricity in GB.
Distribution System Operator (DSO)	As defined in DIRECTIVE 2009/72/EC: A natural or legal entity responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.
Distribution Use of System (DUoS) Charges	Charges levied by distribution network operators on users to recover the cost of operating and maintaining the distribution network.
Energy Contract Volume	A contract between two BSC Parties stating who is buying/selling the electricity and the volume of electricity being traded.
Energy Contract Volume Notification Agent (ECVNA)	A person authorised by a BSC Trading Party to submit an Energy Contract Volume Notification on behalf of the Trading Party.
Energy Networks Association (ENA)	The industry association for operators of gas and electricity transmission and distribution networks in the UK and Ireland.
Energy Service Company (ESCo)	A company that offers auxiliary energy-related services to Prosumers.
Enhanced Frequency Response (EFR)	National Grid ESO dynamic balancing service, where the active power changes proportionally in response to changes in system frequency. This service aims to improve the management of system frequency pre-fault to maintain system frequency closer to 50Hz.

European Network of Transmission System Operators for Electricity (ENTSO-E)	European network of TSOs that represents 43 electricity TSOs from 36 countries across Europe, with a shared objective of both setting up the internal energy market and ensuring its optimal functioning, as well as of supporting the European energy and climate agenda.
Explicit Demand-Side Flexibility (DSF)	Committed, dispatchable flexibility that can be traded on different energy markets (wholesale, balancing, system support and reserves markets).
Fast Reserve (FR)	National Grid ESO balancing service. This service provides rapid and reliable delivery of active power through an increased output from generation or a reduction in consumption from demand sources, following electronic dispatch instructions from National Grid.
Final Physical Notification (FPN)	The level of import or export that a BSC party expects to import or export from the Balancing Mechanism Unit in a settlement period, in the absence of any Balancing Mechanism acceptances from the system operator.
Firm Frequency Response (FFR)	National Grid ESO balancing service. FFR is the firm provision of dynamic or static response to changes in frequency. FFR providers supply a certain amount of power or demand reduction when large frequency variations occur in the system. Dynamic FFR is used to manage ongoing frequency variations. Static FFR is used to address large variations of frequency, usually loss of generation.
Flexibility Service Provider (FSP)[1]	Market participant offering services using flexible resources. In USEF this is either a BSP, BRP, CMSP or any combination of these three roles.
Flexibility Value Chain (FVC)	The potential of demand-side flexibility to create value to multiple participants through several markets and in the form of different products and services.
Flexibility	Ability of an asset or a site to purposely deviate from a planned or normal generation or consumption pattern.
Flexilibility Requesting Party (FRP)	Market participant who buys flexibility from a flexibility service provider either directly or through exchange / market platform.
Frequency Containment Reserve (FCR)	Active power reserves available to contain system frequency after the occurrence of an imbalance. FCR balancing service is the first line of defence against frequency deviations in the grid. Primary reserves respond rapidly (within seconds) and aim to maintain the grid frequency at 50 Hz in Europe.
Frequency Restoration Reserve (FRR)	According to EU Electricity Market Glossary: Active power reserves available to restore system frequency to the nominal frequency and to restore power balance to the scheduled value. There are 2 types of FRR: Automatic FRR (aFRR) and Manual FRR (mFRR).
Grid Supply Point (GSP)	A system's connection point at which the transmission system is connected to a distribution system.
Imbalance Settlement Period (ISP)	The time unit for which imbalance of the balance responsible parties is calculated. Each ISP normally lasts 15, 30 or 60 minutes. In GB, the term Settlement Period is used and lasts 30 minutes.
Implicit Demand-Side Flexibility	Situation when consumers/generators react to pricing signals by increasing or decreasing demand/generation in response to pricing signals. Customers can choose to be exposed to time varying electricity prices or time varying network grid tariffs that reflect the value and cost of electricity and/or transportation in different time periods.

Independent aggregation[1]	Situation where a customer has an agreement with an aggregator to dispatch and market (parts of) its flexibility, whereas this aggregator operates without the consent from or a contract with the electricity supplier of the customer.
Independent Aggregator	A market party who performs the role of Aggregator and is not affiliated to a supplier or any other market participant.
Initial Physical Notification (IPN)	The initial notification made by (or on behalf of) a BSC party, in respect of a Settlement Period and a BM Unit, to the ESO under the Grid Code, as to the expected level of export or import at the Transmission System Boundary, in the absence of any Bid-Offer acceptances at all times during that Settlement Period.
Meter Data Company (MDC)[1]	A USEF role designating a company responsible for the acquisition and validation of meter data, to facilitate the flexibility and balancing settlement processes by making accurate and valid data available to market agents.
Metering System Identifier (MSID)	Identifier associated with each metering point in the distribution system.
Producer[1]	Role responsible for feeding energy into the grid under certain requirements and for facilitating the security of energy supply.
Prosumer[1]	This role refers to end-users who only consume energy, end-users who both consume and produce energy, as well as end-users that only generate (including on-site storage).
Replacement Reserve (RR)	According to European Network Code, Replacement Reserve means the active power reserves available to restore or support the required level of frequency restoration reserve (FRR) to be prepared for additional system imbalances, including generation reserves.
Short Term Operating Reserve (STOR)	National Grid ESO balancing service that provides additional power to National grid when demand on the Transmission Network is greater than forecast or there is unforeseen generation unavailability
Supplier	The role of the Supplier is to source and supply energy to end-users, to manage (hedge) delivery and imbalance risks, and to invoice its customers for energy.
Supplier Volume Allocation (SVA)	The determination of quantities of active energy to be taken into account for the purposes of settlement in respect of supplier BM Units.
TERRE	Trans European Replacement Reserves Exchange (TERRE) is the European implementation project for exchanging replacement reserves in line with the European Guideline on Electricity Balancing. The aim of TERRE is to build the Replacement Reserves (RR) Platform and set up the European RR balancing energy market in order to create a harmonized playing fields for the Market Participants.
Time-of-Use (ToU) Tariff	An implicit demand side flexibility mechanism in which electricity tariffs vary with the time of usage, reflecting the time-varying nature of electricity costs.
Trader[1]	A market party that buys energy from market parties and re-sells to other market parties on the wholesale market, either directly on a bilateral basis (over the counter) or via an energy exchange (day-ahead, intraday).
Transfer of Energy (ToE)[1]	USEF term for a wholesale electricity transaction between the Supplier and the Aggregator, triggered by a Demand Response activation by the Aggregator on the retail side, restoring the energy balance of both the Aggregator and the Supplier (and their BRPs).

Transmission System Operator (TSO)	A physical or legal entity responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity. In GB, the party responsible for the system balance and operability is the Electricity System Operator (ESO), National Grid ESO. Separate parties, the electricity Transmission Owners (TOs), are responsible for investing, building and maintaining their electricity transmission network. This report uses the term TSO when referring to USEF processes and the term ESO when referring to GB processes.
Virtual Lead Party (VLP)	BSC party that only participates in settlement by offering balancing energy. The VLPs are aggregators of Supplier Volume Allocation (SVA) registered units for the sole purpose of participating in the provision of balancing services and are not subject to the same charges and obligations as existing BSC Parties.
Virtual Power Plant (VPP)	The combination of various small size distributed generating units to form a "single virtual generating unit" that can act as a conventional generating unit and is capable of being visible or manageable on an individual basis.

EXECUTIVE SUMMARY

Introduction to Project FUSION

The energy landscape is changing as new possibilities to produce, use, and store energy continue to emerge and evolve. The ongoing uptake of low carbon technologies and rise of distributed generation lead to high growth and variability of load on electricity networks, requiring new solutions and technologies as alternatives to conventional methods of network management. Demand-side flexibility (DSF) is widely recognised as one such alternative method, and although DSF has been tested and deployed by some network operators, the industry is still investigating how to maximise its economic potential.

Project FUSION will demonstrate the feasibility of using local flexible resources to address distribution network congestion issues by making such resources accessible through a universal, standardised market-based framework: the Universal Smart Energy Framework (USEF). FUSION will implement a local, competitive flexibility market based on the USEF framework in East Fife, Scotland. FUSION will inform wider policy development around flexibility markets and the DNO-DSO transition through the development of standardised industry specifications, processes and requirements for transparent information exchange between market participants accessing market-based DSF.

Introduction to the USEF Framework

The Universal Smart Energy Framework (USEF) provides guidelines to build an integrated smart energy future. Its purpose is to accelerate the establishment of an integrated smart energy system which benefits all stakeholders, from energy companies to consumers. Through its work, USEF aspires to contribute to the harmonization of these flexibility mechanisms throughout Europe. USEF's ongoing development is managed by the USEF Foundation,[2] a dedicated core team tasked with coordinating expertise, projects and partners while safeguarding the integrity and objectives of USEF.

USEF aims to facilitate effective coordination across all the different actors involved in the electricity market by providing a common, standardised role model and market design while describing communication requirements and interactions between market roles. USEF turns flexible energy use into a tradeable commodity available for all energy market participants, separate from (but in coordination with) the traditional electricity supply chain, to optimise the use of resources. To facilitate the transition towards a cost-effective and scalable model, the framework provides the essential tools and mechanisms to redefine existing energy market roles, add specific roles and to specify interactions and communications between them. In addition, the USEF standard facilitates project interconnection, thereby fostering innovation and accelerating the smart energy transition.

Due Diligence Methodology

This report documents the findings of a due diligence process of the Universal Smart Energy Framework (USEF) against legal, regulatory and market arrangements governing the GB energy sector.[3] In addition, this report assesses the direction of reform of GB energy policy and regulation, as well as forward-looking industry initiatives like the ENA Open Networks project and assesses the fit of the USEF framework with this direction. The information date for this due diligence is 20 May 2019.

The main purpose of the due diligence is twofold

- To identify whether USEF is fit-for-use in the GB market; and

2 https://www.usef.energy/usef-foundation/

3 www.usef.energy

- To identify innovative elements in the USEF framework that could add value to the current thinking about future market design, and that can be trialled and proven within the FUSION project.

Additionally, the due diligence will point out

- the potential need for adaptations of USEF to make it compliant with relevant GB legal, regulatory and market arrangements; and/or
- the potential need for modifications to the current GB legal, regulatory and market arrangements to facilitate effective flexibility markets.

The USEF framework is developed as an add-on to existing energy market models, principally those based on ENTSO-E principles (European Network of Transmission System Operators for Electricity), to create a level playing field for demand side participation. However, while based on common principles, the interpretation and implementation of market processes and regulations can differ between markets. Moreover, markets differ in the extent to which they are discussing, have discussed, or perhaps even have implemented, aspects of future market design to facilitate demand side participation.

The fit analysis has considered key topics and areas that are essential for implementing a common flexibility market framework based on the open USEF model, and more generally for maximising the value of flexibility for network operators and end-users:

- Flexibility Value Chain and routes to market for flexibility resources;
- Flexibility market organisation, covering new and changing market roles and interactions;
- Design of a flexibility market;
- Detailed requirements to facilitate DSO flexibility transactions;
- Details requirements to access specific flexibility markets; and
- Detailed requirements for privacy, cybersecurity and communications between market participants.

Key Due Diligence Outcomes

The USEF framework proposes arrangements for a smart, flexible energy system of the future in which the trade of flexibility and energy is integrated and coordinated. USEF has been developed in continental Europe and has been tested and validated in many field trials. The content that has been developed, along with the insight gained and hands-on experience, are potentially valuable in the GB market as well.

The due diligence results show that there is a close fit between USEF and both the current market design and the likely direction of future market design in GB. Most importantly, the due diligence has not found areas that could prevent USEF from being implemented in GB. Few modifications will be needed on the USEF side, and a limited set of recommendations to adjust current or (proposed) future arrangements in the GB energy system appear necessary. The results also show that there are several relevant and valuable innovative elements within USEF that could enrich current discussions and views on future market design, both broadening and deepening these views.

Specifically, USEF could add value to GB flexibility market arrangements in the following areas:

- Although there is alignment on key routes in the **flexibility value chain**, USEF describes a greater range of services than those that currently exist in the GB energy system. USEF also proposes ways of facilitating independent aggregation, setting out additional models for Aggregators to access wholesale energy markets, even if they do not have a supply licence or contractual requirements with a licensed supplier. USEF's models enable the wholesale energy settlement of flexibility transactions, as well as the settlement of imbalances imposed upon Suppliers due to activation of demand response by Aggregators.

- USEF proposes a **market organisation** based on clear roles and responsibilities, some of which do not yet exist in the GB energy system. Some of these USEF roles can be said to be in early development in GB, and there are no barriers to such roles being developed in full in the future.
    - USEF defines the role of the Common Reference Operator (CRO), which operates a repository containing information about connections and congestion points in the electricity network, facilitating informed decision making for flexibility sellers and buyers. A CRO role does not currently exist in GB, but a similar functionality is being considered in the ENA ON project, which explores the creation of a System Wide Resource Register.
    - In USEF, the Meter Data Company (MDC) acquires and validates meter data required for flexibility and balancing settlement processes. The MDC role as a single entity facilitates transparency and consistency in the flexibility settlement processes, providing accurate and valid data to market parties. In GB, these activities are split between several entities, including the Data and Communications Company (DCC), which manages smart meter data and communication infrastructure, and other parties covering data validation, information exchange and settlement processes.
    - The GB energy system does not currently recognise USEF's Constraint Management Services Provider (CMSP) as a unique role with specific responsibilities (e.g. towards prequalification, flexibility trading, dispatch, settlement), although there are currently market participants that provide constraint management services to NG ESO and even to DSOs.
- In terms of **market design**, current GB arrangements do not cover the structure and the mechanisms for a functioning flexibility market as defined in USEF. USEF defines operating regimes, functioning as a traffic light mechanism reflecting the status of constraints and congestion in the energy system to inform the (un)restricted trade and dispatch of flexibility. USEF also defines a flexibility Market Coordination Mechanism (MCM) covering interactions between market participants to facilitate effective flexibility transactions. These are areas where USEF could add specific elements and enhance the GB market design to commercialise flexibility and lower overall energy system costs.

  The ENA ON project is working on last-resort mechanisms which will describe the shift from a market-led to a control-led state. Also, the ENA ON has planned to undertake detailed work on operation, measurement, validation and settlement of flexibility. USEF's Operating Regimes and MCM can be used to inform and enhance these deliverables.

  USEF provides a fully-developed market mechanism and detailed roles model, including a central role for the Aggregator in a future energy system. The framework sets out appropriate standards, principles, interactions, and requirements for information exchange between all market participants. In these areas USEF could enhance the work undertaken to date in the ENA ON, by considering the (economic) perspective and potential roles for actors such as Balance Responsible Parties (BRPs), Generators, Suppliers, Aggregators and Customers in coordinating the deployment of flexibility in the energy system.
- USEF defines requirements for **DSO flexibility transactions** such as contractual & regulatory arrangements, pricing, remuneration, settlement and validation processes. All these processes are under development in GB and therefore USEF's proposals could enable effective DSO flexibility transactions. USEF proposes:
    - that Aggregators active in congested DSO areas inform the DSO on planned activations of flexibility (day-ahead and intra-day), as well as on any contracted flexibility capacity. USEF also proposes to extend this obligation to Suppliers for flexibility activated through implicit mechanisms. This information flow facilitates better planning for DSOs and the optimal procurement and dispatch of flexibility.
    - to allow "free bids" under short-term procurement, where there is no contractual obligation to offer the flexibility to the market and flexibility is provided on a day-to-day basis. Free bids allow flexibility

providers a last-minute route to market, at a competitive price to DSOs, maximising the value to both flexibility providers and DSOs.

  - to introduce the concept of re-dispatch to compensate the effect of the local demand response activation on system level, which is essential for managing imbalances that are caused due to flexibility dispatch.

  - a reference architecture for explicit demand-side flexibility from the Prosumer to the Flexibility Requesting Party, which will facilitate the standardisation of interactions between the market platforms and grid management services. A key feature in the USEF architecture is the regulated central data hub, where measurement and validation of flexibility transactions are performed and recorded.

- USEF's proposals for **market access requirements** facilitate Aggregators' ability to maximise the services they can provide:

  - Although stacking of flexibility services is generally possible both in GB and USEF, USEF proposes dynamic pooling of assets, which is currently limited in GB because of complex processes to re-allocate assets/units.

  - USEF proposes that Prosumers can contract with, and be operated by, multiple Aggregators at the same time, although each Aggregator should operate a mutually exclusive set of resources. There are currently no GB arrangements to cover the coordination of multiple aggregators working with a single prosumer, although such arrangements are in development, and could be informed by USEF.

  - USEF considers sub-metering essential for independent aggregation and proposes that Aggregators should be allowed to apply sub-metering for all flexibility services to enable the settlement process. The upcoming BSC modification P375 may allow aggregators/Virtual Lead Parties (VLPs) to install their own settlement sub-metering for flexible assets in the future.

  - In USEF, the Flexibility Requesting Party (e.g. ESO, DSO) defines the baselining methodology for all flexibility services except for wholesale market services. For these services, the regulatory authority (Ofgem in GB) is responsible for defining the baseline methodology for the Transfer of Energy (ToE). In GB, the concept of ToE is not yet in place and therefore a baselining methodology has not yet been defined.

  USEF's seven Aggregator Implementation Models (AIMs) could also add to GB arrangements for the aggregator role, balancing responsibility and settlement of imbalances between market participants. The fit analysis does not recommend AIMs that should be used in GB, but highlights which USEF models are already applied or could be applied in the future:

  - Under current GB arrangements, the equivalent of the USEF Uncorrected Model is applied to aggregators offering ancillary services to the ESO and the USEF Integrated Model is in place where a supplier and an aggregator are combined in a single market party.

  - Under future arrangements in GB, with the introduction of VLPs in the BM and Project TERRE, aggregators acting as VLPs will not be responsible for their balance position. ELEXON will perform perimeter corrections to protect suppliers from the imbalance caused by aggregators/Virtual Lead Parties (VLPs). Elements of these arrangements are similar to USEF's Central Settlement Model and Broker Model, respectively.

  - Ofgem is considering the equivalent of the Corrected Model to solve the energy sourcing issue. This option however, according to USEF, could complicate arrangements in case of residential customers since the remuneration of the supplier would be done through residential customers (the Prosumers).

In addition to identifying areas of added value, it is important to observe that the fit analysis confirms alignment between GB and USEF arrangements for the fundamentals of energy and flexibility markets, such as existing roles and interactions as well as flexibility services and routes to market. The analysis also finds that USEF's guidelines on privacy and cybersecurity mostly align with applicable GB rules, indicating that a USEF implementation in GB would not encounter fundamental barriers in this area. Finally, there are also key elements of alignment in future flexibility market design and the ENA ON project, for instance both USEF and the ENA ON World B propose that the ESO and the DSOs procure flexibility independently from each other and a level of information exchange and coordination will be required. This level of alignment is an expected key finding since both USEF and GB aim to align with ENTSO-E principles as the basis for future flexibility services and market organisation.

Next Steps

The findings from this due diligence are the basis for the next phase in Project FUSION, which involves a public consultation on the USEF framework that will seek GB energy market stakeholders' opinion on a set of proposals to overcome gaps and conflicts between GB arrangements and the USEF framework, as well as to consider innovative elements of the USEF framework to inform future GB market design.

We will analyse the results and recommendations from the public consultation to inform a reference implementation plan for USEF in the GB energy market. This plan will both inform the trial within FUSION as well as the future design of the GB energy system, to be refined over the course of the project and informed by the trial outcomes.

1 INTRODUCTION

1.1 Introduction to Project Fusion

The energy landscape is changing as new possibilities to produce, use, and store energy continue to emerge and evolve. The ongoing uptake of low carbon technologies and rise of distributed generation lead to high growth and variability of load on electricity networks, requiring new solutions and technologies as alternatives to conventional methods of network management. Demand-side flexibility (DSF) is widely recognised as an alternative method, and although DSF has been tested and deployed by some network operators, the industry is still investigating how to maximise its economic potential.

Project FUSION will demonstrate the feasibility of using local flexible resources to address distribution network congestion issues by making such resources accessible through a universal, standardised market-based framework: the Universal Smart Energy Framework (USEF). FUSION will implement a local, competitive flexibility market based on the USEF framework in East Fife, Scotland. FUSION will inform wider policy development around flexibility markets and the DNO-DSO transition through the development of standardised industry specifications, processes, and requirements for transparent information exchange between market participants accessing market-based DSF.

FUSION aims to achieve the following objectives:

- Explore the potential for localised demand-side flexibility utilisation to accelerate new demand connections to the network that otherwise would require traditional reinforcement;
- Investigate a range of commercial mechanisms to encourage flexibility from energy consumers' use of electrical applications in satisfying overall energy use; and
- Evaluate the feasibility, costs and benefits of implementing a common flexibility market framework based on the open USEF model to manage local distribution network constraints and support wider national network balancing requirements;

In addition, through a live trial in East Fife, FUSION will:

- Gain an understanding of the potential use and value of flexibility within geographically local regions to further enhance efficient DNO network management; and
- Demonstrate the proof of concept, and evidence the business case, of commoditised flexibility (locally and for GB) through a USEF-based flexibility market.

1.2 Introduction to the USEF Framework

The Universal Smart Energy Framework (USEF) provides guidelines to build an integrated smart energy future. Its purpose is to accelerate the establishment of an integrated smart energy system which benefits all stakeholders, from energy companies to consumers. [4] Through its work, USEF aspires to contribute to the harmonization of these flexibility mechanisms throughout Europe. USEF's ongoing development is managed by the USEF Foundation,[5] a dedicated core team tasked with coordinating expertise, projects and partners while safeguarding the integrity and objectives of USEF.

The USEF framework aims to facilitate effective coordination across all the different actors involved in the electricity market by providing a common standardised role model and market design while describing communication requirements and interactions between market roles. USEF turns flexible energy use into a tradeable commodity available for all energy market participants, separate from (but in coordination with) the

4 www.usef.energy

5 https://www.usef.energy/usef-foundation/

traditional electricity supply chain, to optimise the use of resources. To facilitate the transition towards a cost-effective and scalable model, the framework provides the essential tools and mechanisms to redefine existing energy market roles, to add specific roles and to specify interactions and communications between them. In addition, the USEF standard facilitates project interconnection, hence fostering innovation and accelerating the smart energy transition.

The USEF framework provides

- a **standardised common framework** designed to be implemented on top of current energy markets such as wholesale, retail and capacity markets.
- a description of the **flexibility value chain** (FVC) involving new and existing market players and giving a central role to the Aggregator in facilitating flexibility transactions.
- a **roles model** and an **interaction model** to enable the implementation of different business models and interactions between actors.
- a market design described by the **Market Coordination Mechanism (MCM)** which sets out the phases and interaction requirements for flexibility transactions. The MCM provides all stakeholders with equal access to a smart energy system. To this end, it facilitates the delivery of value propositions (i.e., marketable services) to various market parties without imposing limitations on the diversity and customization of those propositions.
- detailed **communication and market access requirements** taking into consideration privacy and Cybersecurity issues.

This report will describe all the above elements of the USEF framework in detail and determine their fit with current GB energy market arrangements and regulations.

1.3 The purpose of this due diligence report

This report documents the findings of a due diligence process of the Universal Smart Energy Framework (USEF)[6] against legal, regulatory and market arrangements governing the GB energy sector. In addition, this report assesses the direction of reform of GB energy policy and regulation, as well as forward-looking industry initiatives like the Energy Networks Association's Open Networks project ("the ENA ON project") and assesses the fit of the USEF framework with this direction.

The main purpose of the due diligence is twofold

- To identify whether USEF is fit-for-use in the GB market; and
- To identify innovative elements in the USEF framework that could add value to the current thinking about future market design, and that can be trialled and proven within the FUSION project.

Additionally, the due diligence will point out

- the potential need for adaptions of USEF to make it compliant with relevant GB legal, regulatory and market arrangements; and/or
- the potential need for modifications to the current GB legal, regulatory and market arrangements to facilitate effective flexibility markets.

The USEF framework is developed as an add-on to existing energy market models, principally those based on ENTSO-E principles, to create a level playing field for demand side participation. However, while based on common principles, the interpretation and implementation of market processes and regulations can differ between markets. Moreover, markets differ in the extent to which they are discussing, have discussed, or perhaps even have

6 www.usef.energy

implemented, aspects of future market design to facilitate demand side participation. This leaves the potential for gaps and/or conflicts between USEF and individual market arrangements. Figure 1 below illustrates the fit analysis, where gaps may reflect areas where USEF adds to GB arrangements (1) or areas where GB arrangements add to USEF (3), and conflicts involve areas where USEF and GB arrangements both have a defined, but different, view (2).

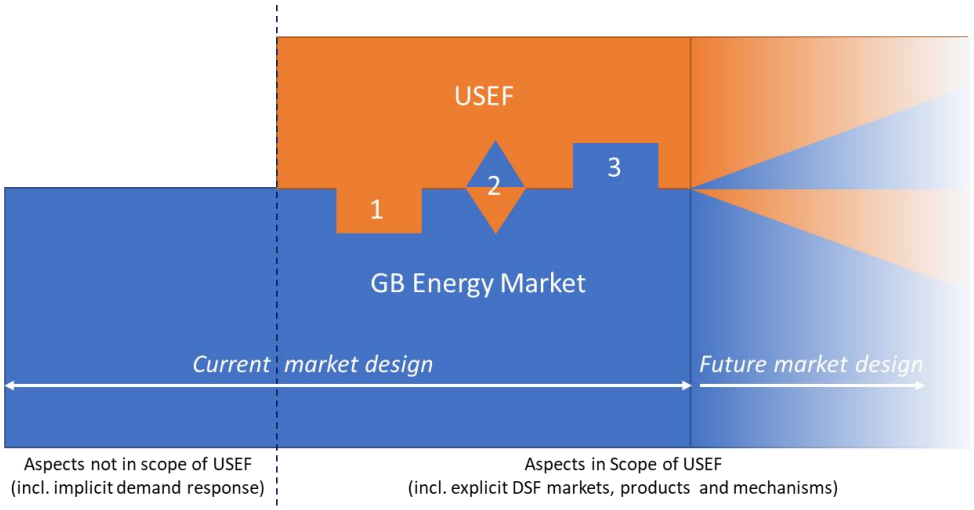

Figure 1: Fit Analysis

In undertaking this due diligence, DNV GL has undertaken desktop research and analysis to map relevant legal, regulatory and market arrangements against specific elements of the USEF framework. In addition, DNV GL has met with relevant GB energy industry stakeholders to inform or confirm parts of this due diligence. The information date for this due diligence is 20 May 2019. The outcome of this due diligence analysis forms the basis for FUSION Deliverable 2: Public Consultation on USEF.

1.4 Report Structure

The remainder of this report is structured as follows:

- Section 2 discusses the flexibility value chain and looks at routes to market for flexibility resources;
- Section 3 discusses flexibility market organisation, covering new and changing market roles and interactions;
- Section 4 looks at the detailed design of a flexibility market;
- Section 5 covers detailed requirements to facilitate DSO flexibility transactions;
- Section 6 assesses the detailed requirements to access specific flexibility markets;
- Section 7 discusses detailed requirements regarding communications between market participants; and
- Section 8 summarises the findings of the due diligence analysis and sets out next steps for a public consultation on the USEF framework.

2 FLEXIBILITY VALUE CHAIN

The concept of "flexibility" in the energy system refers to the ability of consumers and/or generators in the system to adapt their demand for, or supply of, energy in response to system needs. The ability to be flexible in an energy system facilitates the matching of energy production and consumption in a given time period, enabling a variety of benefits, such as cost efficiencies in network operation, avoidance of peak system costs, environmental benefits from reduced carbon emissions and optimisation of end-user processes.

Traditionally, the flexibility in the energy system has come from the supply side being able to respond to fluctuations in energy demand. However, the ongoing electrification of energy demand, combined with the rise of new and smart technologies, has enhanced the feasibility of, and scope for, demand side flexibility ("demand response"). Through deployment of battery storage technology and smarter controls, the load from energy-consuming devices or processes can be varied in response to economic signals or technical requirements. Demand-side flexibility can be deployed through various routes in the energy system to provide benefits to different users based on their needs or preferences. The potential of demand-side flexibility to create value to multiple market participants through several markets and in the form of different products and services is the Flexibility Value Chain (FVC).

This section discusses the FVC according to the USEF framework and compares it against the present and future FVC in the GB energy market, to determine current and future flexibility services and identifies which of them are accessible to (aggregated) demand response services.

2.1 The USEF Flexibility Value Chain

In describing the USEF flexibility value chain, this section refers to typical agents in an energy or flexibility market, reflecting existing business roles commonly accepted throughout Europe and defined by ENTSO-E, the European Network of Transmission System Operators for Electricity. Section 3 provides further detail on how USEF defines these roles and assigns responsibilities to them and compares them against existing and planned roles in the GB energy market.

2.1.1 Central Role for the Aggregator

As discussed above, Demand Side Flexibility (DSF) can create value for multiple customers and stakeholders, including:

- The Prosumer, who can decrease its energy bill by making use of in-home optimisation services;
- The Balance Responsible Party (BRP), who can use flexibility to optimise its portfolio and reduce imbalance costs;
- The Distribution System Operator (DSO), who can use flexibility products for congestion management to defer or avoid investment in grid reinforcement; and
- The Transmission System Operator (TSO), who can use flexibility to ensure system adequacy,[7] as well as in balancing services and for constraint management.

In USEF, Aggregators have a central role in maximising the value and use of demand-side flexibility. Aggregators are responsible for acquiring and accumulating flexibility from Prosumers and offering that flexibility to market participants (e.g. DSO, TSO, BRPs) in commercial transactions as illustrated in Figure 2. The reward that Aggregators receive in return for providing flexibility to market participants is shared with the Prosumers.

7 Note that adequacy might not be responsibility of the TSO, this is subject to the regulations of a specific energy market.

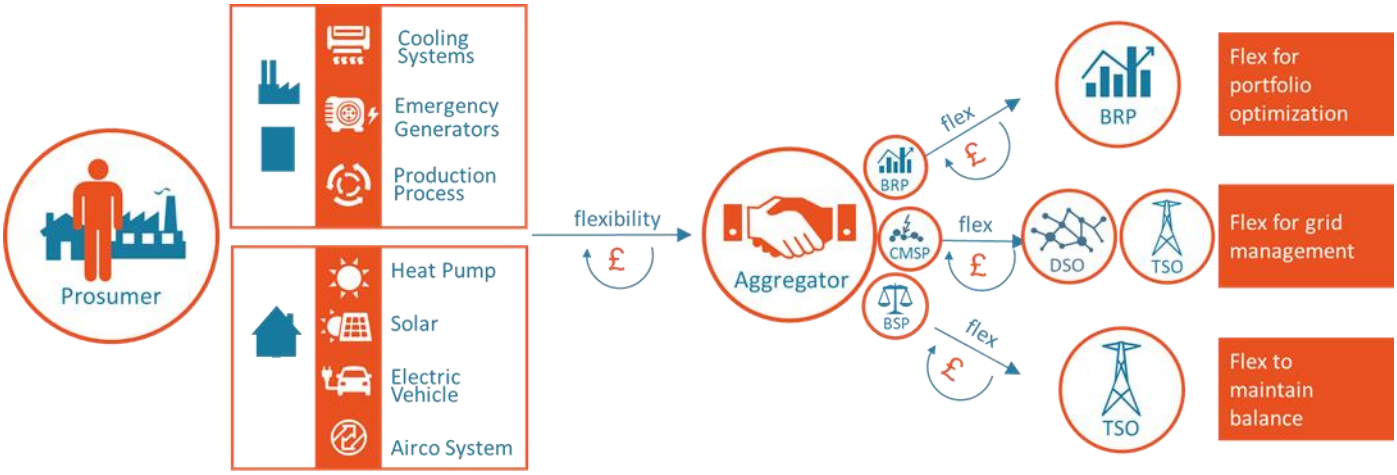

Figure 2: USEF Flexibility Value Chain

Aggregators provide only explicit flexibility services to the TSO, DSOs or BRPs, where flexibility is directly exposed to the market, traded and purchased as a specific product.

The flexibility services offered to the Prosumer can be both implicit and explicit. USEF focuses on explicit demand-side flexibility, in which Prosumers are contracted by the Aggregator to provide specific flexibility services using Active Demand and Supply (ADS) assets. USEF acknowledges, but does not provide detailed considerations for, implicit demand-side flexibility or peer-to-peer energy trading. Section 2.1.2 provides more detailed descriptions of explicit and implicit flexibility services. To maximise the value of explicit flexibility services, the Aggregator can apply value stacking, i.e. providing multiple services from the same portfolio, or even from the same ADS asset(s), potentially to multiple parties. This concept is further explained in section 6.1.1.

In the case of implicit flexibility services, Prosumers are exposed to dynamic prices (or tariffs) across time periods, which incentivise the Prosumer to optimise its energy use. For example, Prosumers can use flexibility to optimise consumption against peak and off-peak prices, or to maximise the benefits of on-site microgeneration. The value of implicit flexibility is reflected in an overall reduction in the Prosumer's energy bill. Dynamic pricing or tariffs are usually set by Suppliers. In the case of dynamic network tariffs, Prosumers react to signals within the tariffs set by the TSO or DSOs to provide implicit demand services.

2.1.2 Explicit flexibility services

Explicit demand-side flexibility involves short-term and long-term bilateral contracts for defined flexibility services, procured competitively in an open market. Figure 3 provides an overview of potential USEF explicit demand-side flexibility services which are classified in four categories:

- Adequacy services;
- Constraint management services;
- Wholesale services;[8] and
- Balancing services.

USEF assigns and defines certain roles for the procurement of each type of flexibility service: Constraint Management Service Provider (CMSP), Capacity Service Provider (CSP), Balance Responsible Party (BRP) and Balancing Service Provider (BSP). Section 3.1.1 describes these roles in detail.

8 Since the delivery of individual wholesale transactions are not verified ("physical settlement"), but only on portfolio (BRP perimeter) level, wholesale trading should be considered as an implicit mechanism. However, wholesale trading by an Aggregator (based on the activation of demand side flexibility) is always accompanied by a transfer of energy that needs to be verified per individual activation. The ToE is therefore the explicit part of wholesale trading by an Aggregator.

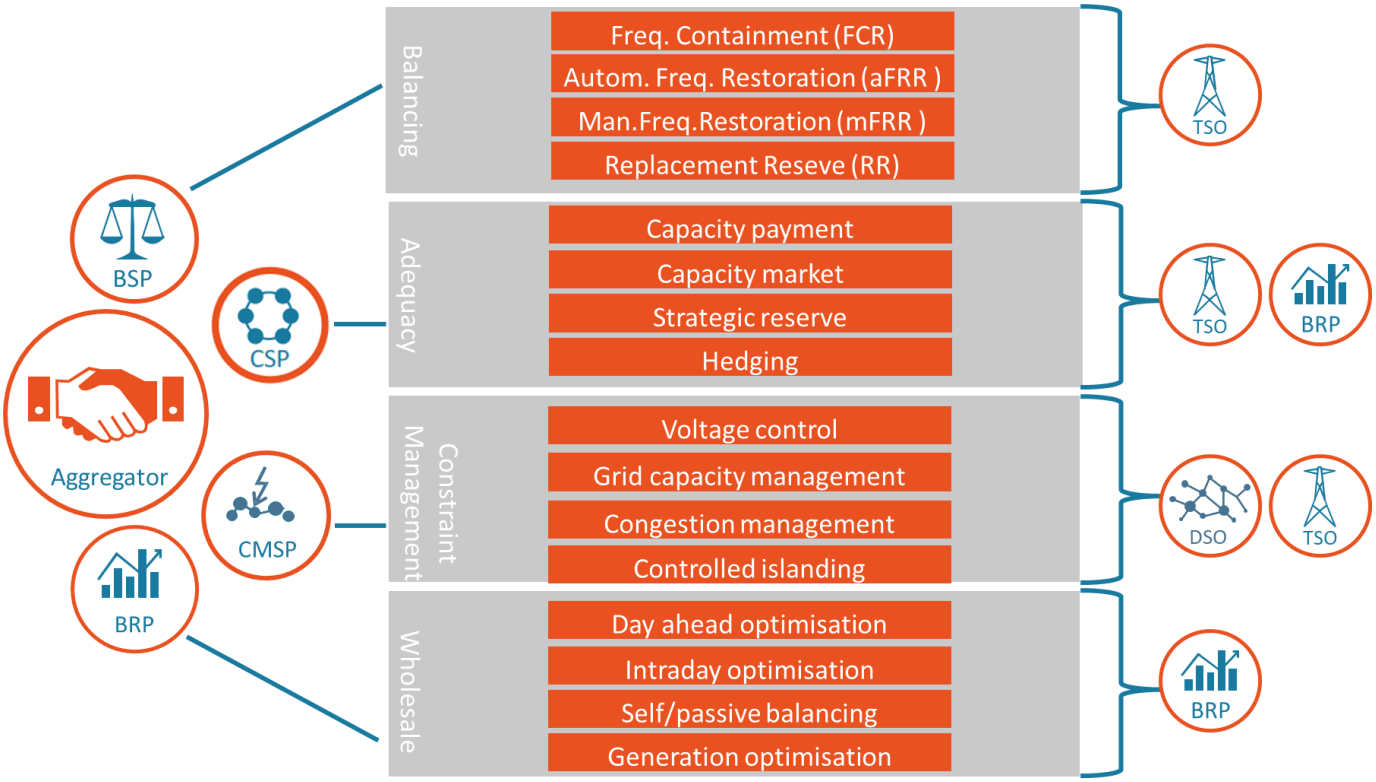

Figure 3: USEF Explicit DSF Routes to Market

2.1.2.1 Balancing services

The purpose of balancing services is to maintain the frequency of the transmission network at 50Hz and compensate for any imbalances between demand and supply that the grid may face. USEF identifies the following TSO balancing services:

- **Frequency Containment Reserve (FCR):** The aim of FCR is to contain the frequency deviation after an incident, it requires a quick response of (milli)seconds.
- **Automatic Frequency Restoration Reserve (aFRR):** Activated by automatic control, aFRR aims to restore system frequency to its 50Hz target.
- **Manual Frequency Restoration Reserve (mFRR):** The objective of mFRR is to reactivate aFRR, and therefore has a longer period between notification and activation, generally longer sustain times and a higher ramp rate.
- **Replacement Reserve (RR):** RR replaces the activated reserves to restore the available reserves in the system.

2.1.2.2 Adequacy services

Adequacy services aim to guaranty the long-term security of supply by ensuring the availability of sufficient generation capacity. Flexibility in the form of distributed generation and flexible load can be used to reduce capacity requirements during peak periods. USEF distinguishes four types of adequacy services:

- **National capacity market:** Capacity markets are classified as centralised or decentralised, depending on the party who is responsible for procuring the capacity. In centralised capacity markets, the TSO is responsible for estimating and contracting sufficient capacity to cover the long-term demand. In decentralised capacity markets, the obligation remains with the Supplier or the BRP of the Supplier. The clearing price is then set by the intersect of capacity demand and supply curves. In the decentralised capacity markets, the Aggregator could participate in the market and offer flexibility to the BRP to reduce their capacity obligations.

- **Capacity payments:** A centralized system of payments for participants offering generation capacity in an energy market.
- **Strategic reserves:** This service fulfils capacity requirements for specific periods. Demand-side flexibility can be used as a strategic reserve that would be managed and activated by the TSO, implying that this DSF is out of the market.
- **Hedging:** A mechanism for the BRP to mitigate price risks associated with volatility in energy demand and supply.

2.1.2.3 Constraint management services

Constraint management services support grid operators in active system management: operating the grid in a more efficient manner whilst respecting all physical constraints.

- **Voltage control:** Voltage control services make use of flexibility to manage voltage levels. The voltage level at locations of (larger) distributed energy resources may exceed the allowed boundaries. By making use of flexibility, load can be activated so voltage does not exceed certain levels and generation curtailment can be avoided.
- **Grid capacity management:** Grid capacity management services use demand-side flexibility to allow DSOs and the TSO to do more effective operational planning. Aggregators can participate in grid capacity management products on a voluntary basis. The main purposes are to defer grid reinforcement, optimise the operational performance of assets, reduce grid losses and increase reliability during planned maintenance.
- **Congestion management:** This service aims to reduce or avert unanticipated (in long-term planning) overload in the system to avoid failure or outage in case of unexpected events. Congestion management is a temporary solution before grid reinforcement can take place.
- **Controlled islanding:** Controlled islanding services use demand-side flexibility to better match demand with local supply to avoid a supply interruption in a given section of the grid, which is caused by faults occurring in another section.

2.1.2.4 Wholesale services

Wholesale services aim to help the BRP to minimise the energy sourcing costs, including imbalance costs, on day ahead and intraday markets. USEF identifies the following:

- **Day-ahead optimisation:** This service aims to shift load from high-price time intervals to lower price time intervals, so that the BRP reduces the sourcing costs of electricity. Demand-side flexibility can be used by BRPs to optimise their day-ahead portfolio.
- **Intraday optimisation:** This service is very similar to day-ahead optimisation but refers to intra-day portfolio optimisation.
- **Self-balancing and passive balancing:** In self-balancing services the BRP uses demand–side flexibility services to reduce portfolio imbalance and avoid imbalance charges. In situations where the TSO compensates BRPs for reducing system imbalance, this is called passive balancing.
- **Generation optimisation:** This service optimises the generation profile of central production units. Central production units are required to respond within minutes by either increasing or decreasing their generation. However, increasing and decreasing generation at short notice reduces the life of the unit. Demand-side flexibility can be a resource to avoid this problem.

2.1.3 Implicit flexibility services

Implicit flexibility services are services provided by ESCOs to assist Prosumers in accessing (and maximising the value of) implicit demand-side flexibility possibilities. The Aggregator can also take an active role in providing

implicit DSF services, although the role of the Aggregator in USEF focuses on explicit flexibility services. Implicit flexibility services include:

- **Time-of-Use (ToU) optimisation:** This service assists the Prosumer to optimise its energy consumption based on the electricity price signals or tariffs. The Prosumer can apply demand-side flexibility to shift their load to lower pricing periods, when the Prosumer is exposed to real time electricity prices (i.e. ToU Tariffs). The use of demand-side flexibility in this case can help the Prosumer reduce its energy bill.
- **In-home self-balancing:** This service enables Prosumers with on-site generation capacity, such as solar panels, or battery storage, to optimise the costs of electricity consumption and generation against market prices.
- **KW_{max} control:** The purpose of KW_{max} control is to reduce the peak load of the Prosumer to save on network charges where they are based on the maximum capacity contracted by the Prosumer.
- **Emergency power supply:** This service involves a Prosumer providing emergency power. The value of this service depends on the circumstances surrounding the Prosumer, grid stability and potential damage caused by grid outage. Demand-side flexibility can enable islanding for emergency power supply, however, this service might incur additional costs.

2.2 GB Flexibility Value Chain – Current and Future

This section focuses on current and future flexibility services and markets that are available for aggregators and demand side response in GB.

2.2.1 GB explicit flexibility services - current

The GB explicit demand-side flexibility services are summarised below and are classified in five groups: Electricity System Operator (ESO) balancing services, ESO adequacy services, ESO constraint management services, DSO flexibility services and wholesale market services.

2.2.1.1 ESO Balancing services

National Grid (NG) ESO is responsible for procuring network balancing services from providers. The purpose of these services is to maintain the grid frequency at (or as close as possible to) 50Hz. Traditionally the NG ESO has relied on wholesale market participants which are registered as Balancing Mechanism Units (BM Units) and must fulfil a minimum power requirement, to procure balancing services. Since 2017 non-BM units can participate in Balancing Services which are called non-Balancing Mechanism (BM) Balancing Services. Non-BM units tend to be smaller generators such as a CHP unit or a small wind farm and sites that provide load response. Non-BM customers can provide Demand-Side Response (DSR) either directly to the ESO, via aggregators or via suppliers. Since aggregators are not registered as BM Units the main route to flexibility services is through non-BM Balancing Services. Recent changes in aggregators' participation in the BM are discussed later in this section (paragraph Balancing Mechanism).

Frequency response services[9]

- **Mandatory Frequency Response services (MFR):** MFR service is a balancing service that provides an automatic change in active power output in response to a frequency change to keep frequency within statutory and operational limits. This service is mandatory for large generators and is not open to DSR. MFR consists of Primary Response service, Secondary Response service and High Frequency Response services.[10]
- **Firm Frequency Response services (FFR):** FFR is the firm provision of dynamic or static response to changes in frequency. FFR providers supply a certain amount of power or demand reduction when large

9 https://www.nationalgrideso.com/balancing-services/frequency-response-services

10 Mandatory Frequency Response, National Grid: https://www.nationalgrideso.com/document/92441/download

frequency variations occur in the system. Participation in FFR is open to all technologies and aggregation is allowed if the technical requirements are fulfilled.

- **Enhanced Frequency Response services (EFR):** This service is similar to FFR, but providers need to respond in one second or less. EFR was procured through a one-off tender in 2016 and is not being actively procured. According to the ESO document "Future of Frequency Response",[11] there are no plans to procure a second round of EFR. This service was open to BM and non-BM providers, as such DSR and aggregators could participate.

Reserve services[12]

- **Demand Turn up (DTU):** In this service demand-side providers increase their demand to manage excess renewable generation and to avoid renewable generation curtailment. The service is an alternative to actions from Balancing Mechanism Units and therefore all participation is demand side. Aggregators who manage the load of their customers can participate in the DTU. The ESO has paused the procurement of this service while they review their restoration reserve products.
- **Short term operating reserve (STOR):** The STOR service provides additional power to National grid when demand on the Transmission Network is greater than forecast. Aggregators participate either by managing generation sources of small non-BM generators or by load reduction of large I&C customers.
- **Fast reserve (FR):** FR is similar to STOR, but differs in that the response requirement is two minutes and the service should be sustainable for a minimum duration of 15 minutes. The service is open to DSR providers and aggregators who manage customers load or generation.

Balancing Mechanism

The Balancing Mechanism is one of NG ESO's main tools to balance electricity and supply close to real time. The Balancing Mechanism is considered as Replacement Reserve product based on USEF classification. It is inherently more flexible than the Reserve Products in continental Europe, since it allows a wider range of price, MW capability and dynamic/performance-related parameters than the specific Replacement Reserve products require. Where NG ESO predicts that there will be a discrepancy between electricity production and demand during a time period, they accept a 'bid' or 'offer' under the Balancing Mechanism from a market participant to either increase or decrease generation or consumption. Until recently, only parties with a BM Unit could participate in Balancing Mechanism. However, the ESO's participation in the Trans-European Replacement Reserve Exchange (TERRE, for details see section 2.2.2) has driven changes in Grid Code and Balancing and Settlements Code (BSC) that aggregators and providers of embedded flexibility to participate in the Balancing Mechanism via the modification of P344, which was implemented in February 2019 and will go live in December 2019. Modification P344 has opened the market entry process for independent aggregators to the Balancing and Settlement Code as Virtual Lead Parties (VLPs).[13] VLPs will not be subject to the same level of charges and obligations as existing BSC Parties, since they will only participate in Settlement by offering balancing energy in TERRE and/or the Balancing Market.[14]

2.2.1.2 ESO Adequacy services

NG ESO ensures the long-term security of supply and generation capacity that delivers the future power needs in the UK. The Capacity Market (CM) was introduced as part of the Electricity Market Reform (EMR) programme to encourage investment in generation capacity. The CM is open to generators as well as DSR. [15] National Grid ESO,

11 Future of Frequency Response, Industry update, February 2019, NG ESO: https://www.nationalgrideso.com/document/138861/download
12 https://www.nationalgrideso.com/balancing-services/reserve-services
13 https://www.ELEXON.co.uk/news/opening-europe-wide-market-electricity-balancing/
14 https://www.ELEXON.co.uk/documents/change/releases/2019-releases/feb-2019-release-p344-terre-overview-of-configurable-item-changes-v1-0-2/
15 https://www.ofgem.gov.uk/electricity/wholesale-market/market-efficiency-review-and-reform/electricity-market-reform/capacity-market-cm-rules

in its role as EMR Delivery Body, administers key elements of the Capacity Market, including the prequalification and auction processes.[16]

Despite being approved by the European Commission (EC) in 2014, the CM is, at the time of writing, suspended following the November 2018 decision by the General Court of the EU.[17] Pending investigation by the EC and engagement with the UK Department of Business, Energy and Industrial Strategy (BEIS), the future of the CM is uncertain. There are two possible scenarios for DSR; DSR might be limited to short term (T-1 auctions[18]) contracts or might be allowed to participate in long term auctions. The UK government will hold a T-1 auction in summer 2019, taking into consideration any potential necessary regulatory changes agreed with the EC. [19]

2.2.1.3 ESO Constraint management services

According to National Grid ESO, a constraint occurs in the system "when the energy is restricted in its ability to flow between two points". [20] To manage the constraint the NG ESO uses transmission constraint management services and reactive power services.

In case of active power transmission constraint management, National Grid requests potential service providers to limit or profile their generation or demand during a specific period. Requirements are identified on an ad hoc basis for certain locations and only certain providers with the required technical capacity participate. The services are not open to DSR or aggregators.

Reactive power services used to control voltage levels across the transmission system. NG ESO ensures that the transmission system is kept under acceptable voltage levels by building assets for Reactive Power and through balancing services when network assets are not available. Two reactive power services exist: The Obligatory Reactive Power Service and the Enhanced Reactive Power Service. Both these services are provided by power stations over 50MW and neither is open to DSR or aggregators. DSR or aggregators do not participate in these services since they are aimed at generators/BM participants.

2.2.1.4 DNO flexibility services

The DNO to DSO transition highlights the need for the DNO to take an active role in the management of Distributed Energy Resources (DER) and DSR at distribution level, to optimise the deployment of these resources both for the distribution network but also, where possible, for the transmission network to support whole system optimisation. Flexibility can be used on the distribution network to defer or avoid investment in network reinforcement, to manage planned maintenance and to manage unplanned interruptions. Project FUSION will demonstrate the feasibility of using DNO flexibility services to address distribution network congestion issues.

In recent years, GB DNOs have started designing and developing the flexibility services for distribution networks, as well as commenced planning on actively using flexibility (outside of innovation projects). At the time of writing, various DNO efforts are underway:

- UK Power Networks (UKPN) launched their second tender for flexibility services competition in February 2019 and they recently announced that their second flexibility tender offered contracts for a total of 18.2MW of power from six companies across eight different locations.[21] [22]
- Western Power Distribution (WPD) has published plans for its first 2019 flexibility services procurement cycle.[23]

16 https://www.emrdeliverybody.com/sitepages/about.aspx

17 http://europa.eu/rapid/press-release_IP-19-1348_en.htm

18 T-1 auction is an auction that is held one year before the delivery year.

19 Tempus State aid judgement (22 March 2019) https://www.emrdeliverybody.com/Prequalification/Advice%20for%20capacity%20agreement%20holders%20and%20capacity%20market%20applicants%20v3.0.pdf

20 Constraint Management Service, National Grid: https://www.nationalgrideso.com/document/92391/download

21 UKPN Flexibility Services Invitation to Tender – 2018/19: https://www.ukpowernetworks.co.uk/internet/asset/9ed338e5-b879-4642-8470-8b90e0a730bJ/Invitation+to+Tender+-+PE1-0074-2018+Flexibility+Services.pdf

22 https://www.ukpowernetworks.co.uk/internet/en/news-and-press/press-releases/UK-Power-Networks-announces-results-of-UKs-biggest-ever-competitive-Flexibility-tender.html#art-top

- Electricity North West (ENW) has asked potential flexibility providers to register their interest in flexibility provision in 2 areas of their network, providing also their flexibility requirements for these areas.[24]
- Northern Power grid (NPg) has launched its Expression for Interest publication in order to plan for a tendering process if appropriate.[25]
- Scottish Power Energy Networks also published its invitation to tender flexibility services for some of their constrained areas.[26]
- Scottish and Southern Electricity Networks (SSEN) has also agreed to procure flexibility and demand-side response services across its entire network rather than just the constrained areas. SSEN has already procured flexibility for 6 sites in their licence areas.[27]

The flexibility services that are considered by DNOs so far involve active power flexibility services, which include pre-fault and post-fault constraint management, and restoration support.

All GB DNOs have registered with the Piclo Flex flexibility platform for either procuring their flexibility services or for trials. Piclo Flex enables DSOs and flexibility providers to find and contract with each other. UKPN and SPEN for example will run flexibility services competitions on Piclo Flex, while all the other DNOs have also registered with Piclo Flex to provide information on where and when they require flexibility services.[28] Piclo Flex's concept is that DNOs publish on Piclo Flex the geographic locations where flexibility is needed, as well as specifications such as type of need, connection, availability and availability window and online auctions take place where flexibility providers bid for contracted capacity. This platform is open to DSR and aggregators and other flexibility providers such as energy suppliers, operators of Electric Vehicle (EV) charging installations and operators of battery energy storage systems (BESS).

2.2.1.5 Flexibility services in the wholesale energy markets

Aggregators in GB can only access wholesale energy markets if they have a supply licence or a contractual agreement with a licensed supplier. The first route is particularly difficult due to the volumes required by the ESO, administrative costs, compliance with electricity licensing codes and registration of a Balancing Mechanism (BM) Unit. The second route is easier, but partnering has to be through a licensed supplier. [29] When considering aggregators' access to wholesale energy markets, however, Ofgem points out that "arrangements to facilitate independent aggregators' participation in energy markets should not build-in stages that require ex-ante consent of a customer's supplier". These arrangements are not in place yet. [30]

---

23 https://www.flexiblepower.co.uk/tools-and-documents

24 https://www.enwl.co.uk/get-connected/network-information/flexible-services/

25 Northern Power Grid, Launching DSO: https://www.northernpowergrid.com/asset/0/document/4686.pdf

26 https://support.picloflex.com/article/35-sp-energy-networks

27 https://www.ssen.co.uk/SmarterElectricity/Flex/

28 https://picloflex.com/

29 Barriers to Independent Aggregators in Europe, University of Exeter, 2019, http://geography.exeter.ac.uk/media/universityofexeter/schoolofgeography/images/researchgroups/epg/Barriers_to_Independent_Aggregators_in_Europe.pdf

30 Ofgem's views on the design of arrangements to accommodate independent aggregators in energy markets: https://www.ofgem.gov.uk/system/files/docs/2017/07/ofgem_s_views_on_the_design_of_arrangements_to_accomodate_independent_aggregators_in_energy_markets.pdf

2.2.2 GB implicit flexibility services - current

In addition to explicit demand-side flexibility service, in GB implicit demand-side flexibility services exist and are open for DSR and aggregators.

Triad Avoidance

National Grid uses Triad to determine Transmission Network Use of Systems (TNUoS) charges for customers with half-hour metering. The Triad refers to the three half-hour settlement periods with the highest system demand from November to February, separate by at least ten clear days. Large industry costumers with half-hour (HH) metered consumption are only charged for the average demand that they consume during these three settlement periods. In this way, they are incentivised to reduce their load at times of high transmission demand.

Aggregators can assist customers in Triad Management by forecasting high demand periods, and managing their large customers' load during these periods, to realise lower TNUoS charges.

DUoS Charge Avoidance[31]

Distribution Use of System (DUoS) charges vary by region as well as by time of day, through a time banding mechanism designed to encourage customers to spread their network usage across the day and avoid network usage at demand peak times. The Common Distribution Charging Methodology[32] is part of the Distribution and Connection Use of System Agreement (DCUSA),[33] and describes how DNOs should allocate distribution charges per customer segment and measurement class.[34] Distribution tariffs are divided in three different time bands – red, amber and green – from higher to lower price per kilowatt/hour. In this way, consumers and generators are encouraged to shift their demand/generation to avoid high price time bands. Aggregators or ESCOs can assist distribution-connected users to reduce their energy bill by optimising their consumption profile according to DUoS charges.

Time-of-Use (ToU) Tariffs

ToU Tariffs have been introduced in GB, allowing consumers to adjust their consumption patterns in a way that they benefit from lower tariffs during certain off-peak periods in a day. In BSC P272 code modification in 2014, customers in Profile Classes 5-8 (generally considered larger, non-domestic customers), should be provided with half-hourly meters by their suppliers, which allows for half-hourly settlement. Following this code modification, suppliers were encouraged to develop dynamic price tariffs for large customers with HH metering. Aggregators in GB assist consumers to optimise their energy use according to their time-of-use tariffs.

In the residential sector, ToU Tariffs have been introduced, but not all suppliers offer them. Green Energy's TIDE tariff[35] and Octopus Energy's Agile tariff are examples of ToU tariffs in the GB market. [36] Ofgem released a consultation on access to half-hourly data for settlement purposes, which discussed half-hourly settlement for small and domestic customers. [37] The final decision – expected in the second half of 2019 – will determine whether HH settlement will be mandatory or customers will have the option of opt-in or opt-out. According to Ofgem, HH settlement will encourage suppliers to develop new dynamic tariffs. Aggregators are also active in offering services

31 DUoS stands for Distribution Use of System

32 Common Distribution Charging Methodology: https://www.dcusa.co.uk/DCUSA%20Document%20Public%20Version/Schedule%2016%20v10.2.pdf

33 https://www.dcusa.co.uk/SitePages/Home.aspx

34 Links to each DNO's charging information are found here: http://www.energynetworks.org/electricity/regulation/distribution-charging/distribution-charges-overview.html

35 https://octopus.energy/agile/

36 https://www.greenenergyuk.com/tide

37 Access to half-hourly electricity data for settlement purposes: https://www.ofgem.gov.uk/system/files/docs/2018/07/access_to_data_for_settlement_consultation_5.pdf

on energy optimisation and self-consumption to domestic customers. For instance, Powervault assists consumers to use more self-generated electricity and shifting from high demand peak times.[38]

DNO flexible connections

Flexible Connections are connection arrangements in which a customer's export or import is managed (often through real-time control) in response to network capacity constraints. Flexible connections do not fall under the implicit or explicit DSF services but are included in the scope of the due diligence report. Flexible connections enable a DNO to connect new customers to the distribution network, even where the required connection capacity would exceed available peak capacity on the network, without having to undertake reinforcement works. This allows a DNO to speed up the connections process, as well as to reduce the cost of new connections (to be shared with the customers), since investments to reinforce the network can be deferred or even avoided. Various types of flexible connections are currently being offered by GB DNOs.[39]

2.2.3 GB future flexibility services

2.2.3.1 GB Balancing Services

The ESO has recently completed a review to improve and simplify balancing services procurement processes and to reduce barriers for aggregators and demand-side flexibility to enter these services. The ESO has committed to receiving 30% - 50% of competitive tenders from demand side flexibility by 2020.[40] It has also published roadmaps on frequency response and reserve, restoration, reactive power and wider access to the Balancing Mechanism, as discussed in section 2.2.1.

In the May 2018 Restoration Product Roadmap, NG ESO set an expectation to open restoration services to Distributed Energy Resources (DER) and work with DNOs and potential DER providers to design appropriate commercial services. Although DSR is excluded from restoration services, aggregation of DER could be relevant to them. [41]

Regarding the future of frequency response services, NG ESO is currently considering faster and close to real time frequency response services procurement. [42] It is launching a trial of weekly auctions for frequency response services, expected to launch in June 2019 and last for 24 months. The trial will facilitate participation of small generators and demand side technologies facing difficulties in forecasting their availability. In addition to the trial auction, NG ESO is redesigning the frequency response products. The ESO's February 2019 update proposes four new products: Dynamic Regulation, Dynamic Moderation, Dynamic Containment (High and Low) and Static Containment (High and Low). These products could replace the current frequency response products. [42]

Similarly, NG ESO has stated that it considers that roll-out of closer to real-time procurement of reserve services represents an opportunity for participation by new non-traditional providers such as wind, solar, DER and demand-side technologies. One of the key considerations is how the procurement of reserve services interacts with the procurement of new pan-European Standard Products for reserve, as well as the day-ahead energy markets.[43]

NG ESO and ELEXON have already taken action to facilitate wider access to BM for aggregators and flexibility providers that do not hold a supply licence and will be responsible for overall energy balance of the sites they administer. NG ESO's full plans for the wider access to the BM is scheduled to go live in December 2019 and include simpler data submission process at the Grid Supply Point (GSP) level to allow BM participants to submit

38 https://www.powervault.co.uk/about-us/

39 ENA ON, Workstream 1, Product 11, Flexible Resources Connections Guide, November 2018, Document Ref: ENA-ON-WS1-P11: http://www.energynetworks.org/assets/files/ON%20WS1%20P11%20Flexible%20Resources%20Connection%20Guide_v1.1.pdf

40 Power Responsive Annual Report 2018: http://powerresponsive.com/wp-content/uploads/2019/04/Power-Responsive-Annual-Report-2018_19-FINAL.pdf

41 Product Roadmap for Restoration, May 2018: https://www.nationalgrideso.com/sites/eso/files/documents/National%20Grid%20SO%20Product%20Roadmap%20for%20Restoration.pdf

42 Future of Frequency Response, February 2019: https://www.nationalgrideso.com/document/138861/download

43 Product Roadmap for Frequency Response and Reserve, December 2017: https://www.nationalgrideso.com/sites/eso/files/documents/Product%20Roadmap%20for%20Frequency%20Response%20and%20Reserve.pdf

data at an aggregated BM Unit level, more accurate settlement for behind the meter assets, improved ESO ability to optimise and dispatch aggregated BM Units and clearer and simpler metering requirements utilising new technologies to reduce the cost of submitting operational metering to the control room.[44]

2.2.3.2 European Balancing Services

The GB ESO and European TSOs are working together to develop new cross boarder balancing markets as required by the European Network Codes.

A new balancing platform being introduced in Europe is the Trans-European Replacement Reserve Exchange (TERRE), in which a new replacement reserve product will be procured through hourly auctions. GB Implementation of Project TERRE requires both Grid Code modification GC0097 and Balancing and Settlement Code modification P344.[45] [46] This change in the BSC allows consumers and independent aggregators to participate in the TERRE platform.

Project Manually Activated Reserves Initiative (MARI) is the European implementation project for the creation of a European platform to procure manual frequency restoration reserve (mFRR) through auctions every 15 minutes.

Both these European projects will be open for providers with a minimum of 1MW generation or demand, including aggregated units. Aggregators will be allowed to register as Virtual Lead Parties with "Secondary BM Units" and will have access to new international markets. New balancing products more aligned with the Replacement Reserves (RR) in the European market, such as FCR and FRR, are planned to be made available to DSR and aggregators.

2.2.3.3 DNO flexibility services

All GB DNOs have signed the Energy Networks Association' Flexibility Commitment to consider demand-side response or flexibility solutions over network reinforcement in all major projects.[47]

DNOs are currently looking to develop flexibility services, both in trials and on a commercial basis,[48] and at the time of writing several flexibility tenders have already taken place. DNOs are also considering low voltage DSR services, including, among others, smart EV charging and generation turn up/down.

In addition, the ENA Open Networks project has published details and requirements for four active power flexibility products, which are also considered by the DNOs: Scheduled Constraint Management, Pre-fault Constraint Management, Post-fault Constraint Management and Restoration Support. Section 5 provides further details on these services. Later in 2019, the ENA ON project seeks to set out design and requirements for DSO procurement of reactive power and ancillary services. [49]

All the above flexibility services are in principle open to aggregators.

2.2.4 RIIO-2 Price Control Framework

In July 2018 Ofgem published its framework decision for the next price control framework, RIIO-2.[50] [51] In the framework decision, Ofgem clearly states that they "intend to ensure that company business planning processes subject new investment to higher hurdles *(particularly testing network reinforcement options against alternative options such as demand-side measures and storage)*". Amongst others, Ofgem may consider different risk

44 Wider Access to Balancing Mechanism Roadmap: https://www.nationalgrideso.com/sites/eso/files/documents/Wider%20BM%20Access%20Roadmap_FINAL.pdf

45 https://www.nationalgrideso.com/codes/grid-code/modifications/gc0097-grid-code-processes-supporting-terre

46 https://www.ELEXON.co.uk/mod-proposal/p344/

47 http://www.energynetworks.org/assets/files/ENA%20Flex%20Committment.pdf

48 https://utilityweek.co.uk/ssen-to-begin-procuring-flexibility-across-entire-network/

49 Open Networks Project Phase 3 2019, Project Initiation Document: http://www.energynetworks.org/assets/files/electricity/futures/Open_Networks/ON-PRJ-Phase%203%20PID-v1.2%20Final%20(Published).pdf

50 Ofgem, RIIO-2 Framework Decision : https://www.ofgem.gov.uk/system/files/docs/2018/07/riio-2_july_decision_document_final_300718.pdf

51 RIIO2 denotes the second price control period under the RIIO framework. RIIO (Revenue=Incentives+Innovation+Outputs) is Ofgem's performance-based framework to set the price controls.

allocations for certain types of investment, although the specific arrangements to apply to DNOs will be confirmed once Ofgem publishes its sector-specific RIIO-2 methodology for electricity distribution.

Ofgem's statement reflects the direction set out previously in the 2017 Smart Systems and Flexibility Plan published jointly with the Department of Business, Energy & Industrial Strategy (BEIS).[52] This plan set out the joint aim to create a level playing field in price controls between demand and supply side solutions to network constraints. further development of flexibility services and new markets for DSR and aggregators, focusing particularly on flexibility services for DNOs.

2.2.5 Government Policy for the Future Energy Market

On 15 November 2018, Business Secretary Greg Clark delivered a speech on the future of the energy market, entitled "After the trilemma - 4 principles for the power sector,"[53] which set out government thinking and response to Dieter Helm's Cost of Energy Review.[54] The speech provided insight into the direction of the Government's energy strategy going forward, with potential implications for flexibility markets.

The Secretary outlined four key principles as the basis for Government energy policy:

- *the market principle*, endorsing the use of market mechanisms to take full advantage of innovation and competition;
- *the insurance principle*, meaning that the Government must be prepared to intervene to provide insurance and preserve optionality in the face of uncertainty;
- *the agility principle,* referring to the need for energy regulation to be agile and responsive to reap the great opportunities of the smart, digital economy; and
- *the "no free-riding" principle*, meaning that consumers of all types should pay a fair share of system costs.

The Secretary expressed his view on the future role of networks and the regulatory framework, underlining the public obligation from network companies to operate economically efficiently, as well as the importance for networks to effectively access the benefits from Energy Efficiency and Demand Side Response. The speech also highlighted the importance of fairness in the future systems, stressing that the Government aims for *"a fair distribution of costs, with good incentive properties, to ensure that we are actually minimising system costs and not just shifting them from one person to another."*

The Secretary's speech endorses the general direction indicated by the RIIO-2 review and confirms the government commitment to fairness and effective, competitive markets, which also reflects Government's ambition to facilitate the use of flexibility by networks in an economic, fair and efficient way.

2.3 Fit Analysis

This section compares the flexibility value chain as described in USEF with routes to market currently open to DSF in the GB energy system, as well as routes to market currently in development. The analysis shows that, although there is alignment on some key services, USEF describes a greater range of services than those that currently exist in the GB energy system. We consider this to be reflective of the nascent state of flexibility services in GB, and as such we see no barriers to the potential future realisation of the additional services that USEF proposes.

The fit analysis shows alignment in the following areas:

- Balancing Services are open to Demand Side Response (DSR) and aggregation in both GB and the USEF framework. GB Firm Frequency Response services and future frequency response products, which may replace the FFR, fall under the Frequency Containment Reserve services category in USEF. The Balancing Mechanism,

52 Ofgem and BEIS, *Upgrading Our Energy System – Smart Systems and Flexibility Plan*, July 2017.

53 https://www.gov.uk/government/speeches/after-the-trilemma-4-principles-for-the-power-sector

54 https://www.gov.uk/government/publications/cost-of-energy-independent-review

STOR and Demand Turn Up are classified as USEF's Replacement Reserve services, while Fast Reserve is considered a manual Frequency Restoration service.

- Adequacy services exist both GB and in USEF, and are open to participation by aggregators and DSR in both GB and USEF arrangements. The GB Capacity Market has been in place since 2014, but is currently under suspension and future requirements for aggregation and DSR are under discussion.
- GB distribution constraint management services are in early stages of development, but do allow participation of aggregators and DSR, which aligns with USEF DSO flexibility services. Recent policy and regulatory publications also endorse the market-based procurement of flexibility by DNOs. GB DNOs have started trials for flexibility services using the Piclo Flex platform or their own, bespoke platforms and focusing on standardising flexibility and DSR services for deferring or avoiding grid reinforcement. The ENA ON project is considering standardisation of active power flexibility services, such as pre/post-fault constraint management and restoration support, and will consider the development of reactive power services during 2019.
- Aggregators in GB are active in implicit demand-side flexibility services, such as Triad Avoidance, DUoS Charges Avoidance and consumption optimisation against Time-of-Use tariffs. USEF recognises the different value drivers for implicit flexibility, which already exist in GB, but the framework focuses on explicit flexibility services by aggregators.

The analysis has identified the following routes to market described in USEF but that do not (yet) exist in the GB energy system:

- Aggregators in GB can only access wholesale energy markets if they have a supply licence or a contractual agreement with a licensed supplier. USEF proposes ways of facilitating independent aggregation, setting out additional models for Aggregators to access wholesale energy markets, even if they do not have a supply licence or contractual requirements with a licensed supplier. USEF's models enable the wholesale energy settlement of flexibility transactions, as well as the settlement of imbalances imposed upon Suppliers due to activation of demand response by Aggregators. Section 6 describes these models in detail.
- GB constraint management services at transmission level are only open to generators with a capacity above over 50MW and are not open to aggregators. USEF proposes constraint management services where DSR can be used for active network management, providing another route to market for flexibility.

The analysis has also identified that GB DNOs are considering restoration support services at distribution level, which USEF has not yet considered concretely, and which could be incorporated in USEF to enhance the USEF flexibility value chain.

Figure 4 below summarises the fit analysis, mapping USEF and GB services based on purpose. Sections 5 and 6 below discuss the underlying processes and detailed requirements for these services in greater detail.

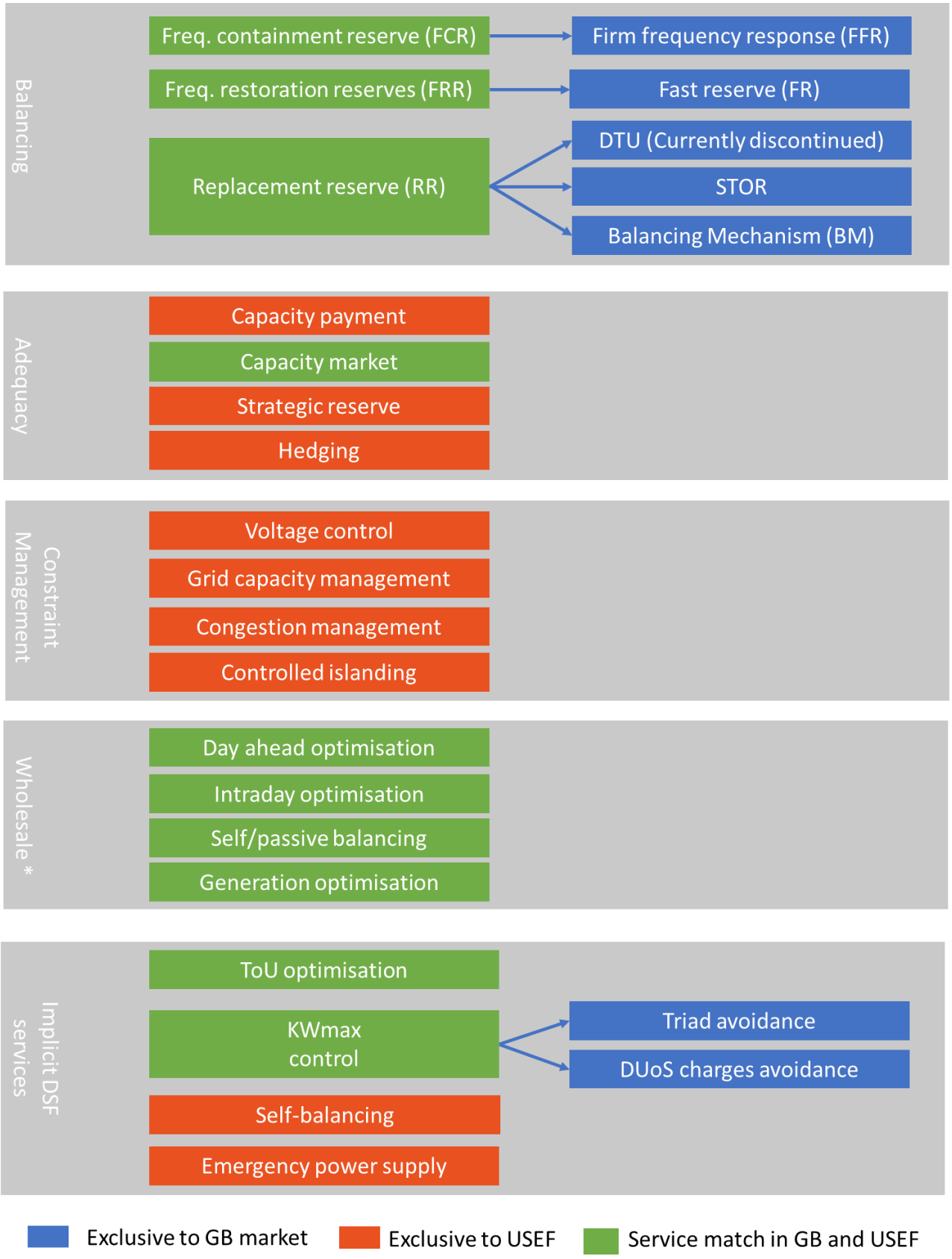

Figure 4: Mapping of GB and USEF DSR services

** Wholesale market services are not open for independent aggregation in GB.*

3 MARKET ORGANISATION

The transition to a smart and flexible energy system will inevitably create new services, new structures, and new roles that will operate alongside existing ones. Clear roles and responsibilities should be the basis for interactions among the Electricity System Operator (ESO), Distribution System Operators (DSOs), aggregators, and other players in energy and flexibility markets. The USEF framework provides a view on what these roles should be, their responsibilities and how they should interact, to maximise the potential benefits of flexibility for the energy system.

This section maps USEF roles and interactions against current and (potential) future roles and interactions in the GB energy system to draw out any key differences.

3.1 USEF Roles & Interaction Model

3.1.1 USEF Roles and Responsibilities

The USEF flexibility model is a roles model rather than a business model, an approach that allows multiple business models to be implemented based on the local market and business needs, creating more market opportunities. Where possible, USEF roles and names correspond to roles as defined by the European Network of Transmission Operators for Electricity (ENTSO-E).[55]

USEF defines the following roles and responsibilities:

- **Prosumer**: This role refers to end-users who only consume energy (e.g. demand-only sites), end-users who both consume and produce energy (e.g. households with PVs on their roof) as well as end-users that only generate (generators – only), including on-site storage (behind the meter). Residential, commercial and industrial consumers can all become Prosumers, when they have on-site generation, such as, for instance, solar photovoltaic (PV) panels or emergency diesel generators. To be noted, that USEF focuses on demand-side participation, which would mean that in principle a generation-only side would not fall into the category of Prosumer. However, since USEF proposes technology-agnostic mechanisms and does not differentiate flexibility provided by load, storage or generation resources, generation-only sites should be able to access the same mechanisms as demand-side.
- **Active Demand & Supply (ADS)**: Energy consuming or producing devices that can be actively controlled. Examples of ADS devices include electric vehicles, heat pumps and industrial cooling systems. ADS assets can be used to respond to price signals or other incentives to provide flexibility to the energy markets. ADS assets are owned by Prosumers, who retain final control of the assets and may decide to change asset usage or comfort levels to provide a flexibility service in exchange for a (financial) reward.
- **Aggregator:** A service provider that contracts, monitors, aggregates, dispatches and remunerates flexible assets at the customer side. Aggregators buy flexibility from Prosumers and sell it to market participants who are willing to pay for it, such as the Transmission System Operator (TSO) and DSO. They are called Aggregators because they combine (aggregate) multiple ADS assets or sites, which may by themselves be uneconomic or unable to meet minimum technical requirements, into a bigger portfolio to provide flexibility services. The role of the Aggregator in USEF is to facilitate flexibility markets and provide flexibility to the place where it is most needed, maximising the value of the flexibility.

  The Aggregator in USEF must ensure that flexibility services are commercially attractive to both sellers (Prosumers) and buyers, as well as reliable, minimising the risk of non-delivery. To achieve this, a USEF Aggregator takes on some responsibilities in the interaction and communication, as well as administration, around flexibility transactions. Sections 3.1.2 and 5 describe these in more detail.

55 The harmonised electricity market role model, ENTSO-E, EFET, ebIX (2018): https://docstore.entsoe.eu/Documents/EDI/Library/HRM/2015-September-Harmonised-role-model-2015-01.pdf

- **Supplier:** The role of the Supplier is to source and supply energy to end-users, to manage (hedge) delivery and imbalance risks, and to invoice its customers for energy. Where the Supplier role is combined with the Aggregator role, the Supplier also takes on the responsibilities for flexibility services.
- **Balance Responsible Party (BRP):** The role of the BRP is to actively balance demand and supply of its portfolio of Producers, Prosumers and Aggregators. The BRP is responsible for ensuring that during each settlement period electricity demand and supply within its portfolio (including wholesale buy/sell transactions) is balanced. The BRP is usually contracted by the Supplier and holds the imbalance risk for its portfolio of Prosumers. USEF defines three BRP roles:
  - the BRP_{agr} is a BRP associated with the Aggregator and is balance responsible for the activated flexibility;
  - the BRP_{sup} is a BRP associated with the Supplier and is balance responsible for the load and/or generation of the Prosumer; and
  - the BRP_{req} who is one of the Flexibility Requesting Parties and uses the Aggregator's flexibility to optimise its portfolio.
- **Distribution System Operator (DSO):** The role of the DSO is the active management of the distribution grid and network planning, so that the grid remains within its capacity limits. The DSO is also responsible for the cost-effective distribution of energy while maintaining grid stability in a given region. Therefore, within a flexibility market the DSO checks whether demand response activation can be safely executed without grid congestion problems and may purchase flexibility from the aggregators to execute grid operations. Furthermore, under certain circumstances, the DSO can curtail load without prior consent from the Aggregator, Supplier or Prosumer.
- **Transmission System Operator (TSO):** The TSO transports electricity from Producers to the DSO and large industrial Prosumers over its high-voltage grid. The TSO ensures the system's long-term ability to meet transmission demand requirements. The TSO is also responsible for balancing the system, by regulating capacity, reserve capacity and incidental emergency capacity.
- **Producer:** The Producer generates electricity and feeds it onto the transmission (or distribution) grid to meet electricity demand and to facilitate security of electricity supply. The introduction of flexibility in the system can affect the way Producers operate their assets, for example by facilitating capacity or congestion management by network operators to reduce the curtailment of intermittent, renewable energy sources.
- **Energy Service Companies (ESCo):** The role of ESCo is to offer auxiliary energy related services to Prosumers, such as assistance in energy management, energy insight services, energy optimisation and remote maintenance of ADS systems. In case of implicit demand response, ESCO can provide energy optimisation services to end-users based on implicit DR market and/or grid tariffs.
- **Common Reference Operator (CRO):** The CRO is responsible for operating the Common Reference. By Common Reference, USEF defines a repository that contains information about congestion points in the network and a list of connections for each congestion point. Appropriately registered market participants have access to the Common Reference to optimise their services and exchange information. For example, the common reference can be accessed by the Aggregators to assess whether they have sufficient flexibility from their customers in that congested area to provide to the DSO, and to explore new flexible resources to add to their portfolio, by contracting new customers within a congested area. Ultimately, the Common Reference can be used for matchmaking between DSOs seeking to procure flexibility in an area and aggregators offering flexibility in the same area.
- **Meter Data Company (MDC):** The MDC is responsible for the acquisition and validation of meter data. Its role is to facilitate the flexibility and balancing settlement processes by making accurate and valid data available to market agents.

- **Trader:** The Trader's role is to buy and (re)sell wholesale energy from market parties in bilateral transactions (over the counter) or via an energy exchange (day-ahead, intraday).
- **Flexibility Requesting Party (FRP**): A buyer of flexibility services from Aggregators in a bilateral transaction or through a flexibility exchange (market platform). A DSO, the TSO or a BRP can take the role of the Flexibility Requesting Party.
- **Allocation Responsible Party (ARP):** The ARP's role involves establishing and communicating the actual electricity volumes that are consumed and produced per Imbalance Settlement Period (ISP) within a certain metering area. The volumes can be based on actual measurements or estimations and are used as inputs for the flexibility settlement process and the wholesale settlement process.
- **Balancing Services Provider (BSP):** The BSP is the trading counterparty through which the Aggregator provides Balancing Services to the TSO. The BSP is contracted by the TSO and is responsible for procuring balancing energy, which is then assigned to one or more Balance Responsible Parties.
- **Constraint Management Services Provider (CMSP):** The role of the CMSP provides constraint management to a DSO or the TSO. In the provision of its services, the CMSP takes on specific responsibilities in communicating and coordinating flexibility transactions to effectively manage constraints between DSOs and/or the TSO, to ensure efficient dispatch of flexibility to maintain the safety and reliability of the networks.
- **Capacity Services Provider (CSP):** The role of the CSP is to provide adequacy services to either the TSO or a BRP. This role is similar to the BSP and CMSP and is applicable for the adequacy services only.

3.1.2 USEF Interaction model

The energy supply chain and the flexibility supply chain are separated in the USEF interaction model. Although the physical transport of energy underlies both chains, USEF separates the contractual arrangements and interactions between roles on the supply and flexibility side of the energy system. This allows for the energy supply chain to remain unaffected and to align with the European liberalized energy market model. The roles in the supply value chain are responsible for the supply of energy from the generation point to the end-user. The roles in the flexibility value chain are solely responsible for creating value through flexibility provision.

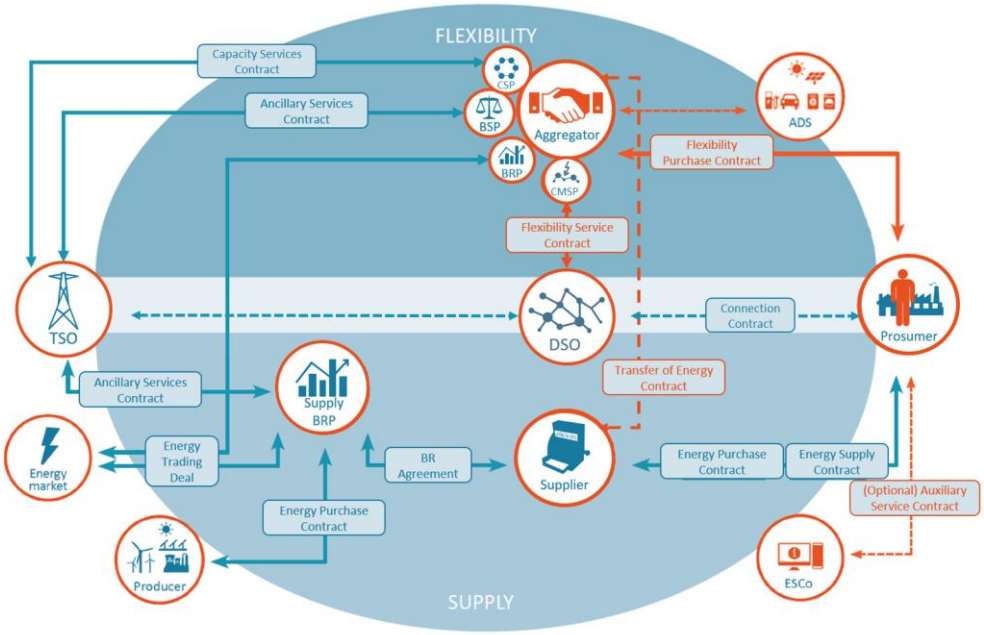

Figure 5: USEF flexibility side role interaction model

On the USEF energy supply side, as shown in Figure 5, the Supplier establishes a contractual relationship with the Prosumer to execute an energy supply transaction. Energy is transported and distributed to the Prosumer using the High Voltage (HV), Medium Voltage (MV) and Low Voltage (LV) networks, which are operated by the TSO and DSO, respectively. The DSO has a connection contract with the Prosumer that establishes the terms and conditions for grid access. The Supplier is responsible for forecasting its Prosumers' load and sourcing the requisite energy from the BRP based on a pre-arranged agreement. The BRP has an energy purchase contract with several Producers from which the BRP sources the energy demand previously agreed with the Supplier. The BRP may also enter into energy trading deals in various energy markets (bilateral, over-the-counter, spot, intraday). Additionally, the BRP may utilise TSO ancillary service contract to balance its portfolio and access additional value from the provision of services to the TSO. Finally, on the Prosumer side, the ESCo can offer energy-related auxiliary services, such as in-home optimisation.

In parallel to the supply chain, the flexibility chain operates to unlock and optimise the value of ADS flexibility. Several interactions between market participants are required and displayed in Figure 5. In the USEF Flexibility Value Chain, the first step for the Aggregator is to recruit Prosumers and establish a flexibility purchase contract with them, which will specify the terms and conditions for controlling a Prosumer's ADS assets to aggregate flexibility. The Aggregator sells the aggregated flexibility of its portfolio to Flexibility Requesting Parties (TSO, DSO and BRP) acting as (or via) flexibility trading counterparties and prioritising FRPs with the most urgent need for flexibility, who should offer the highest price.

The trading counterparties are the BRP, the CMSP, the CSP and the BSP. The interactions between the aggregator and the trading counterparties are specified in the flexibility service contract, which comprises the terms and conditions for trading flexibility, including imbalance settlement and the responsibilities of each party. Interactions between the BRP and the TSO are specified in the ancillary services contracts.

For DSO flexibility services, availability contracts between the DSO and the flexibility trading counter party might or might not be required, depending on the type of flexibility service that is contracted.

Although the supply and flexibility chain are separated, the flexibility transactions may indirectly affect the balance position of the Supplier's BRP, as well as the Supplier's energy position. USEF considers a number of feasible alternatives for the contractual relationship between Supplier, BRP and Aggregator, which are discussed in in detail section 6.

3.2 GB current and future Roles and Interactions

3.2.1 GB current and future roles

The GB energy system contains a group of roles with defined interactions and responsibilities. Some of these roles are defined also by ENTSO-E and exist in USEF, while there are also roles that are unique to the GB energy system or whose definition differs from USEF. In addition, some USEF roles are not defined in the current GB energy system.

GB roles and responsibilities are summarised below:

- The **generator** (Producer in USEF terms) is defined as "the person who generates electricity under licence or exemption under the Act acting in its capacity as a generator in Great Britain or Offshore. The term Generator includes an EU Generator and a GB Generator".[56]
- The balance responsibility in GB (i.e. the **Balance Responsible Party, BRP** role) typically lies with the energy suppliers, who are responsible for matching supply and demand in their portfolio. Although the BRP role is not defined in any licence or code in GB, it is a term widely used in GB and indicates a market party who is responsible for actively managing the balance demand and supply.[57]
- The **Non-Physical Trader** is a market participant who can enter contracts to buy and sell electricity without actually having any generation to sell or any customers' demand to satisfy and is therefore trading for profit. According to ELEXON "The Non-Physical Trader will buy electricity from a Generator at a negotiated price, and will sell it on to a Supplier, aiming for a higher price than it was paid for to make a profit. Most Non-Physical Traders try to sell exactly what they have bought; this is referred to as not taking a physical position." Traders have balancing responsibility for their activities to avoid imbalance charges.[58]
- The role of an entity who is responsible for allocating electricity volumes during the settlement processes (**Allocation Responsible Party or ARP** in USEF) is taken on by the Balancing and Settlement Code Company, ELEXON, for wholesale energy and the Balancing Mechanism. National Grid ESO is responsible for the settlement of non-BM balancing services and manages the payments of those. ELEXON collects metered data from large consumption sites which are connected to the Transmission Network and data from the supplier for sites connected at the Distribution Network. Some suppliers' sites have half-hourly (HH) meters, while the majority do not have HH meters. In that case, an estimated consumption is used based on profiling process which is carried out by ELEXON. The whole imbalance settlement process usually takes up to 14 months to be completed and is used by ELEXON to calculate energy imbalance charges. National Grid ESO provides ELEXON with information on the Bids and Offers that has accepted during the Balancing Mechanism and adjustment data for the balancing services.
- Similar to USEF and ENTSO-E definition, the **Distribution Network Operators (DNOs)** in GB are responsible for maintaining and monitoring distribution networks as defined by the Distribution Licence. Across GB there are 14 distribution network areas operated by six DNOs. The six DNOs are regulated monopolies by Ofgem in their respective geographical area.
- Currently, **Independent Distribution Network Operators (IDNOs)** also develop, operate and maintain local electricity distribution networks. IDNO networks are connected to the DNO network and are DNO network extensions primarily serving new housing and commercial developments. Thirteen IDNOs are currently licenced in GB and regulated in a similar way to DNOs, although the IDNO licence contains fewer conditions than the DNO licence. Ofgem regulates the level that IDNOs charge their customers for using their networks via a "Relative Price Control". In the future, many of the resources connected to an IDNO's network, including

56 Grid Code, Issue 5, Revision 30, December 2018

57 Ofgem's Decision Letter on P354: https://www.ELEXON.co.uk/wp-content/uploads/2017/01/P354-Decision-Letter-v1.0.pdf

58 https://www.ELEXON.co.uk/documents/training-guidance/bsc-guidance-notes/beginners-guide/

Distributed Energy Resources (DER), will play an increasingly significant role in the operation and development of networks, including emergency conditions. IDNOs will face a choice of utilising these flexibility resources to become IDSOs or remaining as network owners, possibly contracting SO capabilities (the IDSO role is explained separately).[59]

- The role of the **aggregator** exists in GB as a market participant that aggregates a range of energy resources to create a single flexibility asset and provides flexibility services in several markets and through a range products. Aggregators can be independent organisations or market actors combining roles such as prosumers, suppliers or generators. Currently there is an established and growing market for independent[60] aggregators for Industrial & Commercial (I&C) consumers; about 85% of I&C customers active in DSR are contracted by aggregators.[61] Recently, the GB market has seen several acquisitions of independent aggregators by energy suppliers, as well as independent aggregators seeking to become energy suppliers. Even when aggregators have joined with, or become, energy suppliers, they can perform "independent aggregation" if they contract a customer without the consent of that customer's energy supplier.

  Aggregation for residential customers is expected to develop as the roll out of smart meters, smart charging solutions, and smart appliances is progressing.[62] Initiatives like the ENA Open Networks (ON) project, as well as subsidised trials, are also implicitly and explicitly exploring the future role of aggregators – including the provision of services to residential customers.

  In a recent development, independent aggregators will be able to access the GB Balancing Mechanism **as Virtual Lead Parties (VLP)** which is a distinct new type of Balancing Settlement Code (BSC) party that only participates in settlement by offering balancing energy. The VLPs are aggregators of Supplier Volume Allocation (SVA) registered units for the sole purpose of participating in the provision of balancing services and are not subject to the same charges and obligations as existing BSC Parties. They can participate in both the Balancing Mechanism and Replacement Reserve market which is introduced by Project TERRE. [63] [64]

- In GB, the role of the **Electricity System Operator (ESO)** has been established and recently legally separated from the role of the transmission owner and is performed by National Grid Electricity System Operator (NG ESO), which is a new legally separated company. The ESO is a regulated monopoly by Ofgem, with its own licence and regulatory and price control framework. According to Ofgem's recent publication on ESO Roles and Principles, the ESO role is to manage system balance and operability second by second, to facilitate competitive markets, facilitate whole system outcomes and support competition in networks.[65] Future arrangement will require ESO working more closely with the DNOs to manage electricity flows across the grids. As the volume of potential flexibility service providers increases on distribution networks, the ESO will increasingly need these parties to procure efficient services required for regional transmission management, as well as national services such as balancing and frequency response. The ESO will need to work more closely with the emerging DSO entities to ensure a coordinated whole system approach to system operation that will maintain security of supply and deliver value for the end consumer.

- The role of the **Transmission Owner (TO)** in GB is performed by three separate companies, which are monopolies regulated by Ofgem and are responsible for investing, building and maintaining their electricity transmission network. National Grid Electricity Transmission (NGET) is the transmission owner for England and

59 ENA ON, Consultation Document, Future Worlds, July 2018: http://www.energynetworks.org/assets/files/14969_ENA_FutureWorlds_AW06_INT.pdf

60 Meaning not affiliated with a supplier or other market party.

61 Demand Side Response Report 2018, the Energyst: https://theenergyst.com/dsr/

62 BEIS & Ofgem, Smart Systems and Flexibility Plan: Progress Update https://www.ofgem.gov.uk/system/files/docs/2018/10/smart_systems_and_flexibility_plan_progress_update.pdf

63 Understanding your Market Role – ELEXON Guidance: https://www.ELEXON.co.uk/documents/training-guidance/bsc-guidance-notes/market-role-2/

64 https://www.ELEXON.co.uk/news/opening-europe-wide-market-electricity-balancing/?platform=hootsuite

65 Ofgem Guidance, ESO Roles and Principles, Match 2019: https://www.ofgem.gov.uk/system/files/docs/2019/03/eso_roles_and_principles_guidance_2019-20.pdf

Wales, Scottish Power Transmission operates in South Scotland and Scottish Hydro Electric Transmission operates in North Scotland and the Scottish islands groups. [66]

- In GB both the roles of the **prosumer** and the **consumer** are used. The consumer is an entity who receives energy from the grid and can be either residential, industrial or commercial customer. The prosumer is defined as a consumer who can dynamically vary its consumption and may also generate energy at the same site. In the future, both the capabilities and the number of prosumers are expected to rise as more people are expected to invest in domestic energy solutions like rooftop solar PV, electric vehicles, energy storage and low carbon heating assets.

  The Future Worlds of the ENA ON project use the term customer instead of prosumer. The project distinguishes between active and passive customers, stating that (in the future):

  "Passive Customers will be offered opportunities to better manage the cost of their consumption through smart metering, half-hourly energy tariffs and may even gain benefits from export back to the grid. As a result, passive Customers may increasingly move to become active Customers. Care needs to be taken to ensure that Customers that do remain passive are appropriately protected and have the opportunity through smart appliances to automatically optimise their consumption. Otherwise, in the future, passive Customers may bear a share of the costs of smart networks without receiving the benefits.

  Active Customers may choose to provide flexibility services through their energy Supplier or an Aggregator, or potentially even directly to a SO or Flexibility Coordinator." [67]

- In GB, the **Data & Communications Company (DCC)** operates as a monopoly regulated by Ofgem. The company was awarded the Smart Meter Communication Licence from BEIS in 2013, which allows DCC to establish and manage the smart metering data and communications infrastructure. DCC should also comply with the Smart Energy Code (SEC), which defines the rights and obligations of energy suppliers, network operators and other relevant parties involved in the end to end management of smart metering in Great Britain. Domestic energy suppliers and network operators are obliged to be DCC users through their licence. The ENA ON project envisages that in the future DCC will need to set up and maintain advanced data and communications networks and keep them updated with future technological developments. The DCC would need to set up communications with:[67]

  - Service providers and their commercial agents (e.g. Suppliers, Aggregators), including the need to facilitate automatic actions in response to price signals;
  - Platform developers and operators; and
  - SOs for both real-time operation and network design purposes.

  There are four further roles within the GB market with relevance to data and information exchange for balancing and settlements purposes:[68]

  - the **Energy Contract Volume Notification Agent (ECVNA)**: Parties connected to the transmission network are required to inform ELEXON of the volume of electricity that they are buying or selling in each settlement period. This is done by submitting an Energy Contract Volume Notification (ECVN), which is a contract between two BSC Parties stating who is buying/selling the electricity and the volume of electricity being traded. BSC Parties must appoint an ECVNA to submit the ECVN on behalf of them and their counterparties. An ECVNA is the only entity that can submit energy contracts but many Trading Parties are ECVNAs in their own right.

66 https://www.ofgem.gov.uk/electricity/transmission-networks/gb-electricity-transmission-network

67 ENA ON, Consultation Document, Future Worlds, July 2018: http://www.energynetworks.org/assets/files/14969_ENA_FutureWorlds_AW06_INT.pdf

68 ELEXON – Understanding Your Market Role: https://www.ELEXON.co.uk/wp-content/uploads/2013/11/market_role_v3.0_cgi.pdf

- the **HH & NNHH Data aggregator (HHDA & NHHDA)**: The Data Aggregator receives the metered data from the Data Collector and aggregates the data in accordance with the BSC rules.
- the **HH & NNHH Data Collector (HHDC & NHHDC)**: The Data Collector is responsible for collecting data from metering systems to determine the electricity consumption in accordance with the BSC rules.
- the **Data Transfer Service Administrator**: The DTS is a regulated centralised communications service where market participants exchange information about domestic customers. This information interchange uses a common set of industry requirements to facilitate business-critical processes, such as settlement, change of supplier and metering, which are implemented through the DTS. DTS is owned and maintained by the administrator, which is Elektralink.[69]

- In GB, aggregators, generators or suppliers that participate in the ESO balancing services, undertake the role of the **Balancing Services Provider (BSP)**, which is to provide balancing services to the ESO by decreasing or increasing generation or demand. BSPs are instructed by the ESO to deliver balancing services through the Balancing Mechanism (BM Balancing Service Providers) or deliver the services through bilateral agreements with the ESO. The role of the BSP will significantly change when the TERRE project is implemented, since GB BSPs through TERRE will be able to provide balancing services to other TSOs in addition to the GB ESO.[70]
- Generators and DSR providers, including aggregators, that participate in the Capacity Market perform the role of the **Capacity Services Provider (CSP).** The aim of this role is to provide adequacy services for the Capacity Market.
- The role of the **DSO** is likely to be a future role in the GB energy market, since DNOs are actively exploring ways to extend their role to system operators and have already begun the transition from DNO to DSO. Subject to regulatory approval, this transition will enable DNOs to actively manage their networks, implementing innovative solutions as alternatives to network reinforcement, such as DSR provision. DNOs have also committed that the role of DSO will coordinate with the ESO to ensure that there are no conflicts among different actors in the energy system. Ofgem and BEIS in their latest progress update on the Smart Systems and Flexibility Plan prioritised the creation of flexibility mechanisms at a local network level, which will be facilitated by the DSO role. [62]
- In align with the role of the DSO, the role of the **Independent Distribution System Operator (IDSO)** could emerge in the future. IDSOs may be more active in coordinating flexibility services within their network and making them available for other parties such as, for example, the ESO and DSOs. IDSOs will also continue to need to manage their own network.

The ENA project Open Networks (ON) has introduced some additional roles to the existing ones, which are referred to as "actors" and were developed under the Future Worlds Workstream. The actors that are exclusive to the Future Worlds of the project ON and associated with the purpose of the due diligence are described below: [71]

- **Settlement Agent:** "This actor is responsible for managing the settlement of payments to and from flexibility service providers. The Settlement Agent collects, validates, processes and aggregates metered data from service providers (generation and demand-based services); sets up and maintains the systems that collect, securely store, and securely transmit the data necessary for settlement process; manages the settlement of payments by flexibility service providers; calculates payments and charges; and invoices and collects payments due." Flexibility service providers include actors such as aggregators and suppliers.

69 https://www.electralink.co.uk/data-transfer-service/

70 Ofgem Decision Letter on P354 modification: https://www.ELEXON.co.uk/wp-content/uploads/2017/01/P354-Decision-Letter-v1.0.pdf

71 Open Networks, Future Worlds, July 2018: http://www.energynetworks.org/assets/files/14969_ENA_FutureWorlds_AW06_INT.pdf

- **Local Energy Systems:** Local Energy Systems (LES) utilise peer-to-peer trading/local energy market to the benefit of their participants (e.g. communities, companies, individuals). LES participants provide each other with energy and trade out the aggregate 'balance' in the wholesale electricity market. LES can provide flexibility services to Electricity System Operators (e.g. ESO, DSO) for electricity system balancing and transmission and distribution network constraint management. LES can include DER and active Customers.

- **Local Market Operator:** Local Market Operator (LMO) is a third-party actor responsible for building and operating flexibility platforms at the request of a System Operator or Flexibility Coordinator. The platforms could be for specific products or geographic areas. LMOs are neutral parties with responsibilities limited to the design and operation of the platforms requested.

In addition, the project Open Networks is exploring the development of a centrally co-ordinated **System Wide Resource Register** for Distributed Energy Resources (DER) and a Reinforcement Works Register. These registers would provide a single place where industry stakeholders could access comprehensive DER data. The registers would support stakeholders as they plan to connect to networks and provide services to network operators. They would also support network companies in their network investment planning and operational decision making." [72] The register will be offered by DNOs, IDNOs, TOs and the ESO to customers and other interested stakeholders and the role of the co-ordinator and the owner of the register has not been confirmed yet. The development of the register is work in progress for the ENA team who are at the initial stage of assessing the implementation options of the System Wide Resource Register and the information which will be provided through the register.

3.2.2 GB current and future interactions

The GB electricity market can be split into the generation, the transportation and the supply of electricity to consumers.

Traditionally large generation has been directly connected to the transmission network though a bilateral connections agreement and construction agreement with NG ESO. Embedded generators who need to connect to a local DNO should form bilateral connection agreement with the DNO. Depending on the generation capacity, some embedded generators might need to work with the ESO or establish contracts with both the DNO and the ESO.[73] The energy is then transported through the transmission and distribution networks and the system is balanced by the ESO.

New domestic and I&C demand customers connect to the DNO network through bilateral connections agreements. The suppliers buy energy from the wholesale market or directly from generators and arrange for it to be delivered to the end consumer through the transmission and distribution networks. The consumers establish contractual relationship with the suppliers who also set the prices that consumers pay for the electricity that they use. In April 2018, ELEXON published a white paper on enabling customers to buy power from multiple suppliers.[74] This proposal is in early stages of consideration and ELEXON is currently exploring these changes further with Ofgem, innovators and industry participants as part of wider BSC changes.

Suppliers buy electricity from the generators to meet the demand of their customers. In GB for settlement and trading purposes, electricity is considered to be generated, transported, delivered and used in half hour periods which are called Settlement Periods. For each Settlement Period, suppliers, acting as BRPs for their portfolio, assess in advance what the demand will be. They then contract with generators for that volume of electricity ahead of the corresponding Gate Closure. Within the HH period, generators are expected to generate and deliver

72 http://www.energynetworks.org/assets/files/2018%2029th%20Nov%20ON-PRJ-WS1%20Product%208%20Report%20V2.pdf

73 How to connect to the National Electricity Transmission System, National Grid, 2015: https://www.nationalgrideso.com/document/45796/download

74 ELEXON White Paper: Enabling customers to buy power from multiple providers: https://www.ELEXON.co.uk/wp-content/uploads/2018/04/ELEXON-White-Paper-Enabling-customers-to-buy-power-from-multiple-providers.pdf

their contracted volume of electricity and suppliers' BRPs are expected to use their contracted volume of electricity.[75]

However, in most cases the real-time requirements might change. In case BRPs fail to accurately predict the amount and timing of their customers' energy usage, energy imbalances occur. If resolving the issue requires action from the System Operator, then the BRP is responsible for that cost. Real-time management and balancing is required and provided by National Grid ESO through the Balancing Mechanism. In that case, National Grid ESO accepts bids and offers, by suppliers and generators respectively. This market is opening for aggregators with Limejump being the first aggregator to participate in the BM after derogation of the network code which allows BM participants to provide aggregated data.

In addition, as section 2 highlighted, National Grid ESO procures Balancing Services through contractual arrangements with BSPs. Aggregators participate in Balancing Services as BSPs and they set up contractual arrangements with the ESO. Similarly, to provide Capacity Market services as CSPs, successful aggregators get a capacity agreement from the ESO which clarifies their rights and obligations.

Aggregators need to sign a flexibility service contract with I&C customers to use their flexibility, which describes the terms and conditions for controlling customer's demand or generation. Under current arrangements, the Aggregator does not pay for any imbalances that may be caused because of managing demand and generation of its portfolio. Ofgem however considers that the penalties should be borne by the party that created the imbalance in the first place.[76] This topic is also being reviewed as part of BSC modification proposals to align with TERRE European Balancing Project.

Currently, BRPs are protected when volumes are delivered through the BM, since there is a system in place to adjust the energy accounts of the associated BRPs accordingly. This ensures that the relevant BRPs are not impacted by actions taken by the associated Balancing Services Providers during the BM.

Interactions among the key participants will change in the future once the DNOs become DSOs and need to procure their own flexibility services. These interactions will also being considered during the delivery of project FUSION and East Fife trials and are discussed in detail in section 5. Emerging interactions between DNOs/DSOs and DSF providers are already in place in certain areas. DNOs have already procured flexibility services in trials where they contract with flexibility providers for defined periods with high foreseen demand, so that flexibility can be delivered quickly when needed. In these cases, DSOs collaborate with aggregators, I&C customers and domestic customer through aggregation to get the flexibility capacity that they need.

3.3 Fit Analysis

Mapping roles and responsibilities in USEF against roles and responsibilities currently in place, as well as those being considered, in the GB energy system, shows that the transition to a smart, flexible system is still in its early stages. As a theoretical framework, USEF provides a detailed interpretation of future roles and responsibilities, which do not yet exist in the GB energy system. However, some of these USEF roles can be said to be in early development in GB, and there are no barriers to such roles being developed in full in the future.

At present, GB and USEF roles and interactions have the following in common:

- The role of the DSO in GB is emerging, but not yet formally established and regulated. However, since both GB and USEF DSO roles are based on the definition and interpretation given to that role by ENTSO-E, they can be expected to be aligned.

75 ELEXON Guidance on Electricity Trading Arrangements: https://www.ELEXON.co.uk/documents/training-guidance/bsc-guidance-notes/beginners-guide-2/

76 Ofgem's views on the design of arrangements to accommodate independent aggregators in energy markets: https://www.ofgem.gov.uk/system/files/docs/2017/07/ofgem_s_views_on_the_design_of_arrangements_to_accomodate_independent_aggregators_in_energy_markets.pdf

- USEF Aggregators interact with I&C customers, as well as SMEs and residential customers. In GB, the market for domestic aggregation is not established yet, although some aggregators are actively looking into the commercialisation of residential aggregation services. In addition, the development of residential aggregation is on the regulatory and policy agenda, as well as being targeted in public funding mechanisms. Hence, the waiting is for domestic aggregation to become commercially viable.

The analysis has identified the following areas where USEF provides a detailed view on future roles that do not yet exist in the same form in the GB energy system, although they are under consideration:

- USEF defines the role of the CRO, which operates a repository containing information about connections and congestion points in the electricity network. The CRO role facilitates informed decision making for flexibility sellers and buyers, as well as creating a level playing field for all market participants by ensuring the availability of transparent and consistent information. A CRO role does not currently exist in GB, but a similar functionality is being considered in the ENA ON project, which explores the creation of a System Wide Resource Register that will be offered by DNOs, IDNOs, TOs and the ESO to customers and other interested stakeholders.[77] However, the System Wide Resource Register as it is currently discussed does not account for information exchange to and from flexibility service providers.

- In USEF, the MDC role acquires and validates meter data required for flexibility and balancing settlement processes. The MDC role facilitates transparency and consistency in the flexibility settlement processes, providing accurate and valid data to market parties. In GB, there are several entities that are involved in data acquisition, sharing and management. For example, the DCC manages smart meter data and communication infrastructure, focusing on the domestic users of smart meters. The company provides the communication infrastructure for suppliers and DNOs to acquire the data, however it does not communicate and share data with the ESO, nor does it validate data. The ECVNA, Data aggregator, Data collector and DSR administrator all have a role to play in the data validation, information exchange and settlement processes, which are carried out by ELEXON.

  USEF, however, introduces a single entity that performs the meter data company role and interacts with all the market participants, which facilitates standardisation and transparency, and overall more efficient solution. This approach aligns with the Open Networks project's view on the future role of the Data and Communications Company.

- USEF identifies a specific role for providing constraint management services to networks, the CMSP. The CMSP in USEF takes on specific responsibilities (see sections 4 and 5) in communicating and coordinating flexibility to manage constraints with the TSO and DSOs, to ensure efficient dispatch and to maintain the safety and reliability of the networks. Although there are currently market participants that provide constraint management services to NG ESO, and DSO constraint management services are in their infancy, the GB energy system currently does not recognise this as a unique role with specific responsibilities. In addition to defining the CMSP responsibilities (e.g. towards prequalification, flexibility trading, dispatch, settlement), USEF's definition and inclusion of the CMSP role also clarifies the contractual relations of the CMSP with other roles (including, among others, the BRP and Aggregator).

- USEF offers a number of alternatives for the contractual relationship between the Supplier, the BRP and the aggregator in case flexibility transactions affect the balance position of the Supplier's BRP and the Supplier's energy position (in GB, the BRP is usually the supplier). In GB, these interactions are under consideration and have not yet been defined.

  Section 6.2 considers these interactions in detail. Whilst in USEF the Aggregator may act as, or via, a BSP, CSP, or CMSP to provide flexibility services, in GB these potential contractual relationships have not yet been

77 http://www.energynetworks.org/electricity/futures/open-networks-project/open-networks-project-workstream-products.html/workstream-1-t-d-process.htmlinf

explored, since the aggregator will be the BSP or the CSP itself. These additional USEF roles come with specific requirements and interactions with other market participants, enabling effective and economic flexibility transactions.

Mapping USEF's additional roles against new roles introduced by the ENA ON project shows the following:

- The "Future Worlds" role of the Settlement Agent is similar to the USEF Allocation Responsible Party role. The main difference is that USEF assigns part of the responsibilities of the Settlement Agent to the Meter Data Company, such as the collection of meter data as well as the setup and maintenance of systems that securely collect, store and transmit the data required for the settlement process. However, both USEF and the ENA ON project identify the need for a central entity to perform the settlement for flexibility transactions as well as the need for standardisation of communication, collection and validation of the meter data.
- The Future Worlds use the concept of Local Energy Systems (LES), which utilise peer-to-peer trading and local energy markets to the benefit of their participants (e.g. communities, companies, individuals). Although peer-to-peer trading is not in the scope of USEF, USEF recognises that energy communities are becoming increasingly popular and that the scope of Flexibility Value Chain, as defined by USEF, can be further extended to define the type of energy and flexibility services that LES can offer.[78]
- The role of the Local Market Operator is associated with the operation and the creation of flexibility platforms. USEF does not provide detailed guidance for operators of flexibility platforms, but only recommends a reference architecture model detailed in section 5.2 of this report. As such, the role of the Local Market Operator is not set out in USEF arrangements, but it could exist under the USEF framework design.

As a final observation, we have identified that the specific manifestation of the System Operator role in the GB energy system may warrant a tailored interpretation in USEF:

In the GB energy system, the role of the system operator is legally separated from the role of the transmission owner, while in USEF the responsibility for both electricity transportation at HV networks and system balance lies with a single entity. In addition, in GB there are three transmission network owners that interact with a single system operator. These properties constitute a variation on communications requirements and protocols set out in USEF. These communications however are not associated with the balancing services and therefore do not form a barrier to the potential implementation of USEF.

Table 1 below summarises the fit analysis, mapping USEF and GB roles.

78 https://www.usef.energy/app/uploads/2019/02/USEF-White-Paper-Energy-and-Flexibility-Services-for-Citizens-Energy-Communities-final-CM.pdf

Table 1: Mapping of GB, Future Worlds and USEF roles

USEF	GB	ENA Open Networks Future Worlds
Aggregator	Aggregator / Virtual Lead Parties	Aggregator/Virtual Lead Parties
Allocation Responsible Party (ARP)	ELEXON	Settlement Agent
Balance Responsible Party (BRP)	Balance Responsible Party (BRP)	Not explicitly defined
Balancing Services Provider (BSP)	Balancing Services Provider (BSP)	Not explicitly defined
Capacity Services Provider (CSP)	Capacity Services Provider (CSP)	Not explicitly defined
Common Reference Operator (CRO)		
Contraint Management Services Provider (CMSP)		
Distribution System Operator (DSO)	Distribution System Operator (DSO)	Distribution System Operator (DSO)
Energy Services Company (ESCo)	Energy Services Company (ESCo)	Not explicitly defined
Meter Data Company (MDC)	Data & Communications Company	Data Communications Company
Producer	Generator	Generator
Prosumer	Prosumer & Consumer	Prosumer & Consumer
Supplier	Supplier	Supplier
Trader	Trader	Not explicitly defined
Transmission System Operator	Electricity System Operator	Electricity System Operator
	Transmission Owner (TO)	Transmission Owner (TO)
Active Demand & Supply (ADS)		Flexibility Resources
		Local Energy Systems
		Local Market Operator

Legend:

Role exists in all the arrangements but with slightly different responsibilities or names
Exact match
Exclusive only to these arrangements

4 MARKET DESIGN

Effective flexibility mechanisms require transparency in stakeholders' requirements and preferences as well as in the alternatives that are available to stakeholders to meet their requirements. They also require guidelines to facilitate all the different agents involved in the energy system. All these requirements need to be reflected in the way that flexibility mechanisms are designed, operated and coordinated among the key market participants.

This section describes USEF operating regimes, the market-coordination mechanism, interactions and information exchange alongside existing and potential GB market arrangements.

4.1 USEF Market Design

The USEF market design aims to ensure well-functioning short-term electricity markets, where flexibility is dispatched based on market signals to where it is most essential and valuable. The flexibility market, as proposed by USEF, runs from the day before the delivery of the electricity to the moment of consumption, enabling full access to flexible technologies.

The USEF market–based coordination mechanism (MCM) allows optimisation of the value of flexibility across all roles in the system and provides all stakeholders with equal access to the system, whilst ensuring that all physical constraints (frequency and thermal limits of network components) are met. USEF aims to respect the freedom of connection, transaction and dispatch, to the extent possible.

The USEF market design provides USEF operating regimes, the MCM structure, MCM interactions and requirements for information exchange.

4.1.1 USEF operating regimes

USEF introduces four operating regimes to the energy market reflecting the status of constraints and congestion in the energy system. The use of four operating regimes aims to safeguard the reliability of the energy system, and to ensure that flexibility is used in an economically optimal, yet safe and reliable way. Figure 6 summarises all operating regimes and their characteristics.

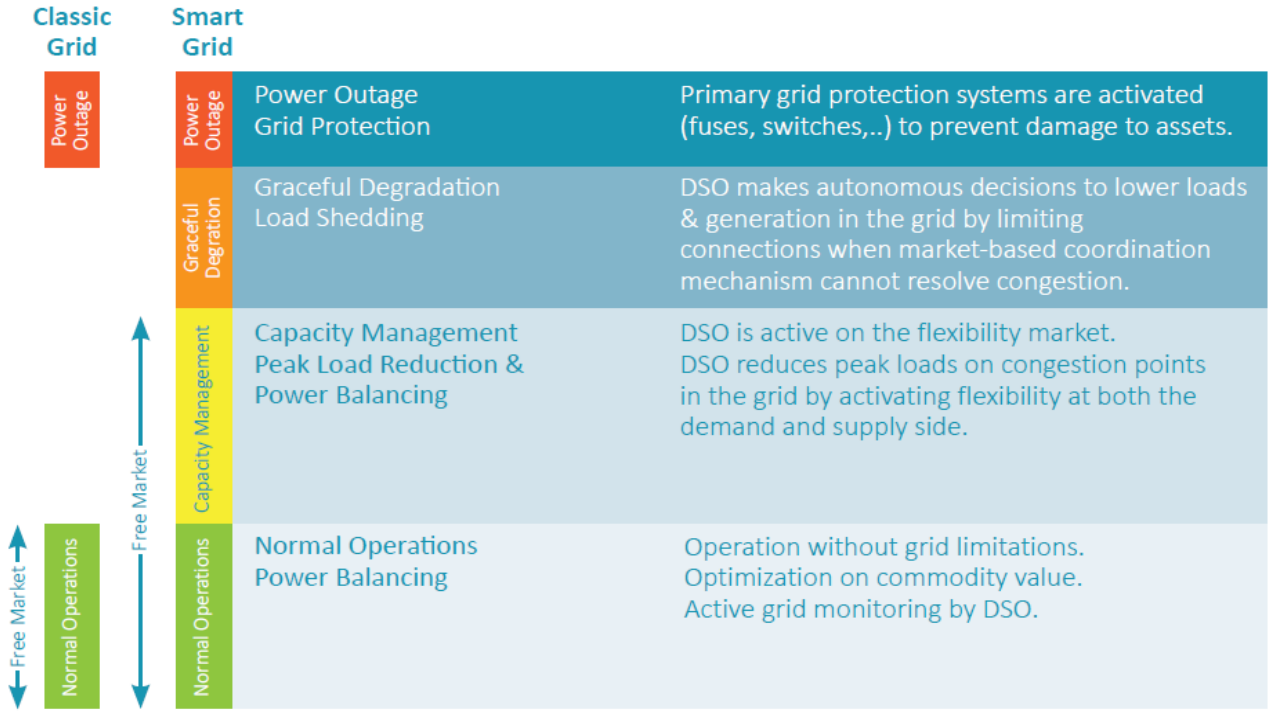

Figure 6: USEF Operating Regimes

The Green and Yellow regime ("Normal Operations" and "Capacity Management") assume a free market environment where timely and effective exchange of information between Aggregators, Distribution System Operators (DSOs) and the Electricity System Operator (ESO) will facilitate flexibility transactions on the distribution and transmission system. The MCM assures optimal use of flexibility available for Balance Responsible Parties (BRPs), Transmission System Operators (TSOs) and Distribution System Operators (DSOs) within the Green and Yellow regimes.

In the Green regime, there are no grid limitations in the operation and the commodity value of flexibility is optimised. In this regime flexibility is used for wholesale trading, adequacy mechanisms and balancing services for the TSO. In the Yellow regime, flexibility is required not only for energy balancing but also for grid capacity management, with the DSOs and TSOs activating flexibility to reduce peak loads on congestion points at both demand and supply side. In this regime, the three fundamental freedoms (connect, trade and dispatch) are fully respected and supported, and flexibility, including for grid management purposes, is active on fully market-based mechanisms.

The Orange regime ("Graceful Degradation) is introduced as a fall back in case insufficient flexibility is available for the DSO or TSO to avoid an outage. It enables the DSO or TSO to temporarily overrule the market to avoid an outage by limiting connections. In the Orange regime, the market mechanisms of the yellow regime can no longer resolve the congestion issue. Flexibility may still be activated through a market-based mechanism, yet certain freedoms are affected: flexibility bids may be compulsory, or dispatch restrictions may apply. Also, non-market-based mechanisms may be used (e.g. direct load control or generation curtailment). All mechanisms are strictly regulated and may therefore differ between member states. USEF does not prescribe which mechanisms should be applied, but it does set out how to switch between the different regimes.

The Red regime ("Power Outage") is activated when all the other solutions for managing constraints and congestions have failed. In this state of the system, grid protection is set as the top priority and the ESO and DSOs activate primary grid protection systems to prevent damage to assets.

4.1.2 USEF market coordination mechanism (MCM)

While the USEF operating regimes are required to understand when flexibility can be traded and dispatched for balancing and congestion management purposes, the market coordination mechanism in USEF includes all the steps of the flexibility trading process, from contractual arrangements to the settlement of flexibility.

The USEF MCM builds on top of existing European market arrangements and consists of five phases, as illustrated in Figure 7. These phases are iterative in nature and also occur concurrently for different time periods under consideration (i.e. while network operation is underway for the current time period, settlement is being undertaken for a past period, and planning is underway for the future). When examining the market process for a single time period, the five market phases can be categorised as occurring sequentially from years and months ahead of time, through real-time network operation, to post settlement.

Figure 7: USEF MCM Phases

Phase 1 – Contract: In the contracting phase, the necessary contractual relationships are established for the Aggregator to participate in explicit demand response. Contractual arrangements include bilateral contracts between Prosumers and Aggregators, the Aggregators and the Capacity Service Provider (CSP)/Constraint Management Service Provider (CMSP)/Balancing Service Provider (BSP), the CSP, CMSP, BSP and flexibility

customers such us the DSO, TSO or between Aggregators and one or more BRPs. The latter is subject to the implementation model. The contract phase occurs well in advance of real-time network operation.

Phase 2 – Plan: In this phase, the flexibility market develops an economically optimal programme of flexibility dispatch that meets the needs of the Aggregator and the BRP. The Aggregator and the BRP will internally optimise their portfolios to minimise their costs and maximise benefits to their customers, before collaborating to achieve added value through offering and ordering flexibility resources.

Phase 3 – Validate: The validating phase ensures that network operation can be achieved technically without exceeding distribution network and transmission network constraints. The DSO and the ESO perform a grid safety analysis to check whether the grid can safely distribute the forecasted energy demand and supply. Multiple iterations between the planning and validating phases may occur until the forecasted energy supply can be safely transported and distributed. It might not always be possible to resolve grid limitations with flexibility procurement and this is the stage where USEF moves to the Orange regime ("Graceful Degradation").

The aim of USEF's Plan and Validate phases is to make optimal use of grid capacity and to maximize all stakeholders' freedom of dispatch and transaction before the actual delivery of energy takes place. The time scales in these phases range from years and months down to just hours before the Operate phase starts. This broad window facilitates trading on different energy markets (such as the forward market, day-ahead spot market, and intraday spot market) and the ability to accommodate changes in required grid capacity.

Phase 4 – Operate: In the operating process, all plans are executed, resulting in the actual supply and demand of energy and flexibility. Flexibility services are activated in accordance with placed flexibility orders. However due to the inherent uncertainty within the energy system there will be deviations from forecasts and submitted plans and therefore Aggregators may need to activate additional flexibility to meet their customers' need.

Phase 5 – Settle: This is the last phase of the USEF MCM where any flexibility that has been delivered is verified and paid for. The settlement considers contracted and delivered flexibility as well as contracted flexibility that was not delivered. Settlement takes place between all parties that were part of the previous phases.

4.1.3 USEF MCM Interactions & Information Exchange

This section discusses the interactions and information exchange between market participants in each phase of the MCM, as visualised in Figure 8.

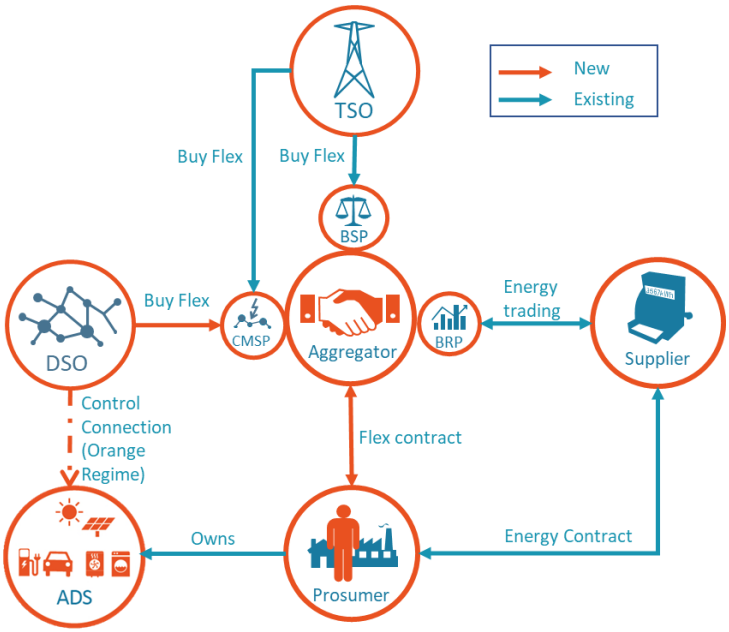

Figure 8: USEF interactions

4.1.3.1 Phase 1 – Contract

Interactions

The main interactions in this phase involve the contractual arrangements that are required for flexibility transactions according to USEF:

- A flexibility purchase contract between Aggregator and Prosumer. This contract includes the operating condition for the demand response service, the Prosumer's flexibility capacity and how it will be activated by the Aggregator. It also includes details on the settlement of the flexibility the Prosumer provides.
- A framework contract between the Supplier and the Aggregator for all Prosumers serviced by the Aggregator. This contract includes the information exchange and settlement of activated energy conditions for the demand response service, as defined in the contract between Aggregator and Prosumer.
- A flexibility service contract between Aggregator and BRPs. The contract between the Aggregator and the BRP_{req} (BRP of the Flexibility Requesting Party) sets out the conditions under which the Aggregator may offer its flexibility to the BRP. The contract between the Aggregator and the BRP_{sup} (BRP of supplier) describes how imbalances caused by demand response will be dealt with and how changes in the sourcing position of the suppliers caused by demand response will be settled. These conditions should also be reflected in the contract between the Supplier and the Aggregator if the Supplier does not have an associated BRP.
- The connection contract between the DSO and the connected customer has to reflect the possibility of load shedding in the Orange regime. This is however subject to regulatory arrangements in each country and it is possible that the connection conditions for the distribution of energy as described in the connection codes have to be altered. GB Connections contracts in GB include a clause for load shedding or disconnection in case of an emergency.[79]

In all the contractual arrangements, the procedures for handling personal data, particularly any exchange of personal data with other party, must be made explicit, to respect the Prosumer's privacy.

USEF also allows the introduction of 3 optional contracts:

- A long-term flexibility contract between the Flexibility Service Provider (BSP, CSP, CMSP) and DSO or the Flexibility Service Provider and the TSO. In this contract, the DSO or TSO may procure flexibility well in advance, in order to secure a certain supply of flexibility.
- A long-term flexibility contract between Aggregator and BRP. BRPs may procure flexibility well in advance to secure a certain supply of flexibility.
- A contractual relationship between an Energy Service Company (ESCo) and Prosumers.

Information Exchange

Information exchange at this phase includes information on the flexibility capacity from the Prosumer to the Aggregator, from the BSP to the TSO, from the CMSP to the DSO and TSO, from the CSP to the TSO and the BRP_{req} and from the BRP_{agr} (BRP of aggregator) to the BRP_{req}.

4.1.3.2 Phase 2 – Plan

Interactions

Phase 2 includes interactions between the Aggregator, Prosumers, BRP, TSO, and the DSO.

79 https://www.ukpowernetworks.co.uk/internet/asset/3210ad61-2228-4f93-8971-f304ab30e1cK/UK+Power+Networks+-+Marked+up+Metered+Connection+Agreement.pdf

The Plan phase starts when the Aggregator collects forecasts for the Prosumers it represents. The Aggregator then optimizes its own portfolio and plans how to maximize the value of the flexibility options in its portfolio, creating a plan which USEF refers to as an "A-plan". The Aggregator sends its initial A-plan to the BRP. If the forecasts change (e.g. because a new weather forecast is available), the Aggregator may create an updated optimised A – plan.

The BRP optimizes its portfolio of Aggregators, Producers, and Suppliers to attain an economically optimal program. During this process the BRP negotiates with the Aggregators to exploit the available flexibility in the market and optimize its value. These interactions between the BRP and the Aggregator occur daily.

After the Aggregators' A-plans have been aligned with the BRP portfolio (a process which might need several iterations), the BRP inform the TSO about their planned transactions and the networks that they will use for transporting the electricity. The sum of the transactions for each BRP is called an energy programme or "E-program." The E- program is the bases for imbalance settlement process between the BRP and the TSO.

Also in the Plan phase, the DSO determines potential congestions points and registers them in the Common Reference. This process takes place a few times a year. The Aggregators which are active at the Congestion Point can offer flexibility to the DSO to assist in the congestion management. In addition, the information in the Common Reference may invite further investment in local flexibility in the future.

Information exchange

This stage includes the following information exchange:

- The Aggregator collects forecasts from their Prosumers;
- The Aggregator creates the A-plan and shares it with the BRP;
- The BRP receives the A-plan from the Aggregator and communicates its flexibility needs to the Aggregator in the form of UFLEX;
- The BRP communicates its E-programme to the TSO;[80] and
- The DSO shares information on actual or potential congestion points, which are registered in the Common Reference.

4.1.3.3 Phase 3 – Validate

Interactions

In the validate phase, the DSOs and the TSO validate that the planned actions from the Aggregator and the BRPs can be performed in a safe way that does not create any constraints or stability issues in the grid. The DSO implements a process which is called the "Validate-D" process and the TSO implements a process called the "Validate-T" process.

Validate D - process

At the beginning of the phase 3 the Aggregators create a so-called "D-prognosis," which shows the amount of energy to be consumed or produced at a given congestion point. The D-prognosis is created once the A-plan is finalised (in phase 2) and is sent to the DSO. The DSO combines the D-prognosis with profiles of its customers that are not served by an Aggregator, validates the combined plan and accepts it or rejects it, after performing grid safety analysis. In case of constraints, USEF moves from the Green regime to the Yellow regime and the DSO or the ESO requests flexibility from the Aggregators. If the issue is not solved with flexibility procurement, USEF moves to the Orange regime, where the DSO temporarily overrules the market to prevent a power outage.

80 This process is not USEF specific and should align with each country's communication between the BRPs and the TSO.

Aggregators' A-plans might change due to DSO flexibility procurement and therefore further communication between the Aggregator and the BRP will be required.

Validate T – process

Once the DSO validates the D-prognosis, the DSO combines the aligned D-prognosis with forecasts for those connections that are not at a Congestion Point and creates a so-called "T-prognosis." The DSO sends the T-prognosis to the TSO for verification. The TSO then combines the T-prognoses of all the DSOs with profiles of its transmission-connected customers, validates the combined plan and accepts it or rejects it, following grid safety analysis.

Information exchange

This stage includes the following information exchange:

- The Aggregator send its D-prognosis to the DSO;
- The DSOs communicate their flexibility needs to the Aggregator in the form of UFLEX; and
- The DSOs share the T-prognosis with the TSO.

4.1.3.4 Phase 4 – Operate

Interactions

In Phase 4 the actual delivery of energy and flexibility takes place.

At this stage the Aggregator (via the counter trading party) delivers the flexibility that has been sold to the BRPs and DSOs for portfolio optimisation and grid capacity management and to the ESO for balancing and grid management. To deliver that, the Aggregator controls the Prosumers' Active Demand and Supply (ADS) assets as defined in their contractual agreement in phase 1. ADS settings can be adjusted before the Operate phase starts. During the Operate phase, the Aggregator measures the net demand of its cluster to detect deviations from its A-plan or D-prognoses. In case of deviations, the Aggregator reoptimizes its portfolio. Deviations can be solved through the market, or within the portfolio itself, in which case the Aggregator must change the operation set-points of the ADS assets.

The BRP's main interest is to minimize its imbalance costs. If circumstances change as a result of TSO maintenance of the system balance, or if the BRP detects that it is causing imbalance by deviating from its E-program, the BRP can procure additional flexibility from Aggregators.

In phase 4, the DSO can still ask Aggregators for additional flexibility to resolve congestion issues which will lead to imbalance of the Aggregator's BRP's portfolio. As result, the Aggregator will factor in any imbalance risk and charge the DSO an additional fee. If insufficient flexibility is available, the DSO switches to the Orange regime and starts limiting connections in order to avoid an outage.

The TSO is responsible for frequency stability. In case frequency stability is at risk, the TSO will use primary, secondary and tertiary control reserves to resolve the problem, and it may procure flexibility services to meet its requirements.

Information exchange

Information exchange in the Operate phase:

- Updates on Aggregator's A-plan and D-prognosis (from the Aggregator to the BRP and DSO, respectively);
- The DSO procures flexibility for congestion management if needed;
- The BRP procures flexibility for internal balancing and/or passive balancing if needed; and

- The TSO procures flexibility to maintain system balance if needed.

4.1.3.5 Phase 5 – Settle

Interactions

The last phase of the MCM settles all services that were delivered in previous stages. The following interactions take place in the settlement phase:

- Settlement of flexibility (Prosumer-Aggregator)

  Aggregators compensate their customers for offering flexibility. Aggregators may offer a fixed fee, or only pay for the flexibility actually activated. This choice is outside the scope of USEF.

- Settlement of flexibility for grid capacity management (DSO-Aggregator)

  The flexibility transactions (and associated deviations) between the DSO and Aggregators are settled in this phase. The basis for this settlement process is the latest set of validated D-prognoses prior to the flexibility activation request. D-prognosis changes are still possible, following activation request, but they are not used as baseline for the settlement processes.

- Settlement of flexibility for portfolio optimization (BRP – Aggregator)

  The BRP compensates the Aggregator for the flexibility offered for the purpose of portfolio optimization in the Plan and Operate phases. The aggregator may also need to compensate the BRP for any deviation caused to their balance position by the activation of flexibility resources (most likely as a result of flexibility orders placed during the operate phase), since changes initiated by the Aggregator affect the BRP's E-program.

- In the Orange regime, the DSO has the ability to shed load or curtail generation at a Prosumer directly, by reducing the maximum capacity at the connection level (all the way to zero, when needed). Although in USEF the financial compensation to the network customers from the DSO for the disruption is not prescribed, it is recommended in order to ensure that customer curtailment remains a last resort option and an unattractive solution for the DSO.

- The balancing settlement process for the ESO remains that same as the processes in each country.

Information exchange

All the above interactions require certain exchange of information among the participants:

- The meter data company (MDC) sends all the meter data requested by the BRPs and the DSOs, which will then be used for settlement validation;

- The Aggregator shares with the BRPs and the DSOs the calculated flexibility that has been sold to them, which will then be validated; and

- DSOs and BRPs calculate flexibility prices and penalties which they share with the Aggregator.

4.2 GB Market Design

The GB market has been designed to meet the needs of the traditional energy system. Markets that work for flexibility are in development and seek to enable flexibility services to compete alongside traditional investment options and other smart energy solutions, as well as to facilitate efficient investment decisions in the future.

4.2.1 Current arrangements in GB

The current arrangements for trading electricity in GB set out the rules under which generators may compete to supply electricity buyers using the transmission system that runs throughout England, Wales and Scotland.

Trading arrangements are applied in the forward bilateral market and the Balancing Mechanism. Market participants perform bilateral electricity trades in the forward markets a year or more in advance, until the market closes at the Gate Closure, when the ESO takes on the role of the residual balancer. Gate Closure is set at one hour before the relevant half hour settlement period.[81] In the forward market participants are free to trade across the entire GB market and no transmission limitations are explicitly considered at this stage. Demand Side Response (DSR) and aggregators, participate in these markets through implicit mechanisms.

The Balancing Mechanism operates from Gate Closure through to real time and ensures that supply and demand can be continuously matched or balanced in real time. Bid-Offer Acceptances are made for the relevant half hour settlement period. Bid-Offer Acceptances are instructed by NG ESO to a specific Balancing Mechanism Unit (BMU) to increase generation or reduce demand or vice versa. [81]

In addition to the Balancing Mechanism, the ESO has a range of balancing services to assist in balancing and constraint management under normal operations, as described in section 2. NG ESO also uses pre-gate balancing trades (PGBT), which are bilateral contracts with individual power plants before the Gate Closure to either increase or decrease their generation and system security services such as the intertrips. Both these services are only open to generators and therefore out of the scope of this due diligence report.[82] [83]

4.2.1.1 Interactions & Information Exchange

Participation in forward markets and the purchase of electricity to cover expected metered positions is optional and formal disclosure of price is not required. Competition in these markets is achieved through standardised but unrestricted bilateral contract trading. An amount of energy is agreed for delivery over a specified period at some point in the future, at a certain price per unit (MWh) delivered. Contracts can be established well ahead of delivery, sometimes years, right down to the time of delivery or Submission Deadline, when contracts are frozen. Contracts can be agreed between Parties and these are referred to as Over the Counter (OTC) contracts.

Electricity can also be traded on a power exchange anonymously. The exchange itself does not normally hold a physical position, i.e. it will always try and match sales to purchases.

As the market moves to the Gate Closure, the ESO assesses the physical position of all market participants. Therefore, all market participants are required to inform the ESO of the intended physical position. Initial Physical Notifications (IPNs) are submitted at 11.00 a.m. at the day ahead stage and are continually updated until Gate Closure when they become the Final Physical Notifications (FPNs) and when all Balancing and Settlement Code (BSC) Parties submit information regarding their planned production or consumption in the Settlement Period. The FPNs do not include potential activation during Balancing Mechanism transactions and deviation from them causes imbalances, which the ESO must resolve. BSC parties have no obligation to balance the FPN against expected demand or generation in any settlement period. However, they need to balance their contractual position to avoid exposure to imbalance prices and charges.[84]

4.2.1.2 Balancing Services processes and interactions[85]

As part of the normal operations of the electricity system, the ESO develops, procures and delivers the balancing services set out in section 2.2.1.1. The process is described in the following sequential steps:

1) The ESO identifies the need and high-level characteristics (development stage of the balancing service).

81 https://www.ELEXON.co.uk/documents/training-guidance/bsc-guidance-notes/beginners-guide-2/

82 Electricity Trades (GTMAs), National Grid: https://www.nationalgrideso.com/document/92431/download

83 https://www.nationalgrideso.com/balancing-services/system-security-services

84 How Imbalance Pricing works in the GB market, CEER: https://www.ceer.eu/documents/104400/-/-/66369fc0-516c-7b67-7106-0fa6e12c0511

85 ENA Open Networks Project Work stream 1: Product 1, Mapping current SO, TO & DNO processes: http://www.energynetworks.org/assets/files/electricity/futures/Open_Networks/WS1_%20Product%201_Mapping%20TO,%20SO%20and%20DNO%20processes%20v1.0.pdf

2) The ESO engages with potential providers and establishes interest in the service (development stage of the balancing service).

3) The ESO refines the service specification and carries out pre-qualification, where required.

4) The ESO runs the procurement process and assesses returns.

5) Contract requirements with service providers are established.

6) Service providers take the appropriate actions to provide and control the service, such as the installation of the right equipment.

7) The ESO sets up the systems to enable the service to be utilised together with any aggregation or optimisation of service providers.

8) The service is dispatched to meet system needs.

9) Metering and settlement for the services is provided.

4.2.1.3 Congestion Management Mechanism

The UK Department for Department for Business, Energy & Industrial Strategy (BEIS), alongside Ofgem, industry, sector bodies and other stakeholders have developed a National Emergency Plan (NEP) for both Electricity and Gas.[86] The NEP introduces crisis levels to ensure there is a consistent approach to the assessment of an emergency and to confirm that an appropriate level of response is implemented locally, nationally, and across the European Union, as required. Detailed emergency interface procedures and protocols are set out in the Grid Code and Distribution Code.[87] [88]

The Codes cover a range of potential emergency scenarios, such as load shedding, whether by voltage reduction or disconnection, and Black Start, specifying technical details, notification protocols and implementation requirements. The commercial treatment and associated market details are set out in the BSC.

In certain circumstances, the ESO may need to deviate from normal Balancing Mechanism operations and issues emergency instructions to BM Units and generators which are treated as a Bid-Offer acceptance. The ESO can also issue emergency instructions to the DNOs which may include a requirement for demand reduction and disconnection, an instruction to affect a load transfer between Grid Supply Points (GSPs) or an instruction to disconnect an item of plant or apparatus from the system. [89]

The DNOs themselves in case of emergency are also allowed to support defence and restoration plans, though emergency demand management which is initiated by them (different from getting instructions from the ESO). For instance, DNOs can perform a customer voltage reduction, a customer disconnection, automatic low frequency demand disconnection and emergency manual demand disconnection. [90] [91]

Another tool for constraint management that has been recently rolled-out by many DNOs is Active Network Management (ANM) across their networks. By limiting the output of Distributed Energy Resources (DER) at certain times, ANM allows increased connection beyond capacity levels which could connect using traditional planning assumptions.

---

86 BEIS: National Emergency Plan: Gas and Electricity 2016: https://www.gov.uk/government/publications/national-emergency-plan-downstream-gas-and-electricity-2016

87 The Distribution Code, Issue 27, 01 January 2016: http://www.dcode.org.uk/assets/files/dcode-pdfs/DCode%20v27%20121015v2%20DPC6.2%20and%20G12-4-1%20and%20guide%20stripped%20out%20161215.pdf

88 The Grid Code, Issue 5, 14 March 2019: https://www.nationalgrideso.com/document/33821/download (OC6,BC2.9)

89 Grid Code, BC 2.9: https://www.nationalgrideso.com/document/33821/download

90 This process is different from getting instructions from the ESO

91 Grid Code, OC6, Demand Control: https://www.nationalgrideso.com/document/33821/download

4.2.2 Future arrangements in GB

Future arrangements in GB are focusing on the development of local flexibility markets and the transition of DNOs to DSOs. BEIS and Ofgem have already set the deployment of markets that work for flexibility as one of their priorities in the "Smart Systems & Flexibility Plan." The 2018 report highlighted the ENA Open Networks (ON) project as the main initiative in GB that "explores a range of market models for the DSO transition, to inform the debate on how flexibility services can be procured and set out the links between the different actors under different models".[92] The project has considered five future market models for flexibility market development, called Future Worlds:[93]

- **World A- DSO Coordinates:** "A World where the DSO acts as the neutral market facilitator for all DER and provides services on a locational basis to National Grid in its role as the Electricity System Operator (ESO)."
- **World B –Coordinated DSO – ESO procurement and dispatch:** "A World where the DSO and ESO work together to efficiently manage networks through coordinated procurement and dispatch of flexibility resource."
- **World C – Price Driven Flexibility:** "A World where changes developed through Ofgem's reform of electricity network access and forward-looking charges have improved access arrangements and forward-looking signals for Customers."
- **World D – ESO coordinates:** "A World where the ESO is the counterparty for DER with DSO's informing the ESO of their requirements."
- **World E – Flexibility Coordinator:** "A World where a new national (or potentially regional) third-party acts as the neutral market facilitator for DER providing efficient services to the ESO and/or DSO as required."

As part of the ENA project, Baringa Partners carried out an impact assessment of the Future Worlds. The assessment found that all the Worlds are viable and a number of potential DSO transition paths with different triggers and outcomes can be followed.[94] All the identified transition paths, however, diverge from a starting point of World B, which will be implemented in the first stage of the transition period, until the early 2030s. According to Baringa's report, "World B seems to align most closely to today's arrangements and the results of the Impact Assessment have not presented an obvious reason to move away from Worlds B at this time."

Recent updates of the project also align with Baringa's starting points and suggest that World B is considered to be the option taken forward at this stage. As such, this DD report will only consider World B for the fit analysis. In World B, flexibility resources can provide services to multiple SOs and are able to stack revenues from these differing SOs. In case of conflict of interests, DSOs and the ESO will need to coordinate in a transparent manner. The flexibility market arrangements that are currently considered are shown in Figure 9.

92 Upgrading our Energy System, Smart Systems and Flexibility Plan: Progress Updated, October 2018: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/756051/ssfp-progress-update.pdf

93 http://www.energynetworks.org/electricity/futures/open-networks-project/future-worlds/future-worlds-consultation.html

94 Future World Impact Assessment, Baringa, 2019: http://www.energynetworks.org/assets/files/Future%20World%20Impact%20Assessment%20report%20v1.0_pdf.pdf

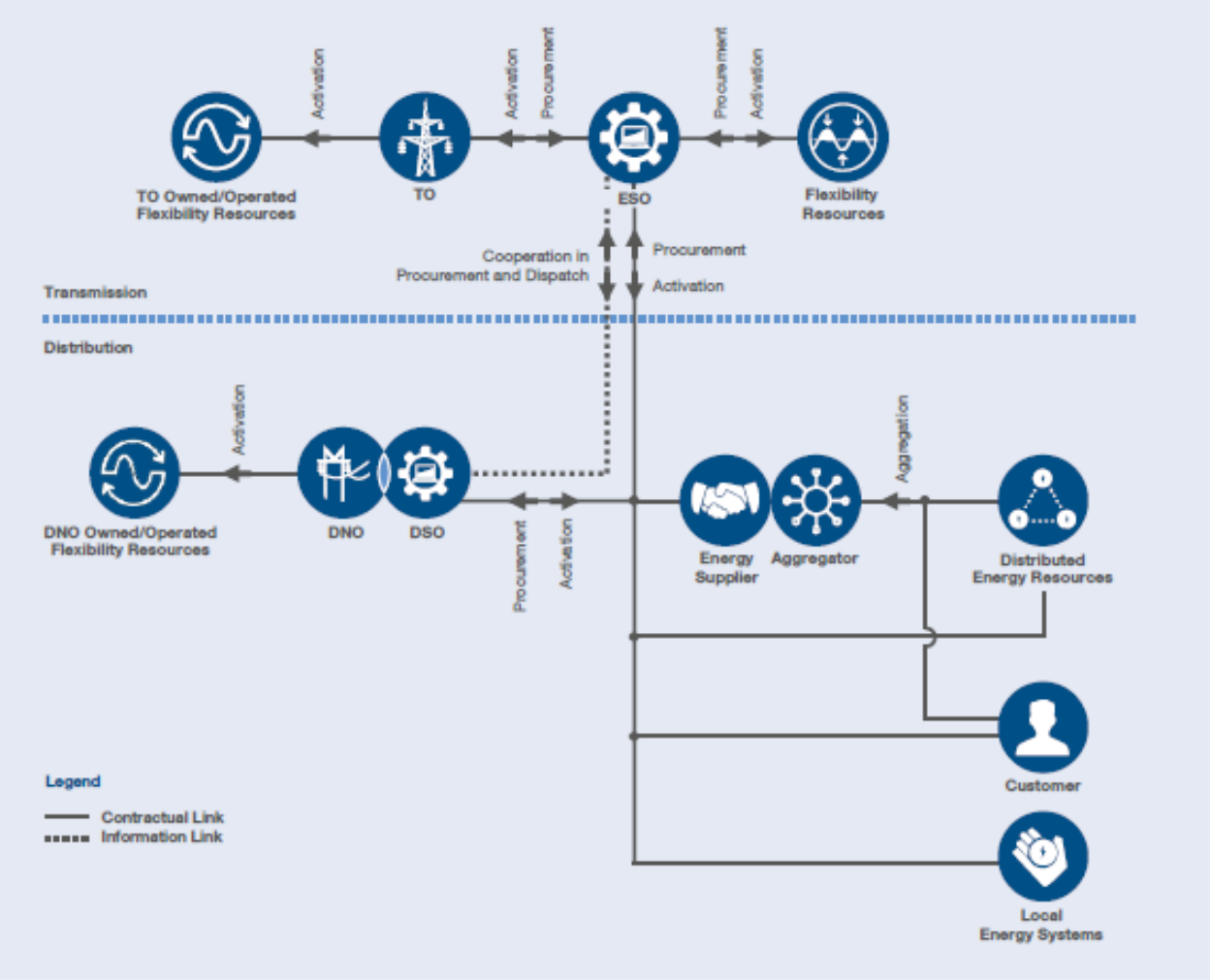

Figure 9: Flexibility Market Arrangements in World B of the ENA ON project[95]

4.2.2.1 Connection and Commercial arrangements

All Customers wishing to connect to distribution networks will discuss their development with their local DSO (or IDSO). The DSO will have clear boundary flow limits at each interface point with the transmission system and develop innovative connection offers around this limit to facilitate new parties wishing to connect. In case of potential issues across the transmission – distribution interface the DSO will discuss with the ESO and submit a 'Transmission Impact Assessment' (or similar) request to ensure coordinated development of networks. Developers wishing to connect to transmission networks would speak to the ESO who would develop a connection offer in collaboration with the host TO. Charging and access arrangements remain similar to the existing arrangements.[96]

4.2.2.2 Flexibility market arrangements

Future World B assumes a central ancillary services market for flexibility resources connected at the transmission and distribution networks which is organised and operated by the ESO and is similar to the current Balancing Services. There is also a regional market for flexibility sources connected to the distribution network which is facilitated by the DSO of the respective geographical region.[97]

95 ENA ON Consultation on Future Worlds, July 2018: http://www.energynetworks.org/assets/files/14969_ENA_FutureWorlds_AW06_INT.pdf

96 http://www.energynetworks.org/electricity/futures/open-networks-project/open-networks-project-workstream-products.html/ws2-customer-experience.html (WS2, Product 1)

97 EA Technology Report: Modelling the DSO transition using the Smart Grid Architecture Model: http://www.energynetworks.org/assets/files/Modelling-DSO-Transition-Using-SGAM_Issue2.1_PublicDomain.pdf

The ESO will procure services and activate flexibility resources connected to the transmission network for balancing the electricity transmission system. The ESO will also procure flexibility resources connected to the distribution network for transmission system management and for energy balancing in coordination with the DSO. The ESO can also offer flexibility services to the DSO from its portfolio of smart grid network solutions (i.e. network asset-based solutions).

The DSO is responsible for the development and operation of the electricity distribution network through an active network management approach. The DSO facilitates a regional flexibility services market for flexibility resources which are connected to the distribution network and directly procures these sources for distribution network management, in collaboration and coordination with the ESO via the regional market for flexibility services. DSOs can also offer flexibility services to the ESO from their portfolio of smart grid network solution.

In world B, the ESO and DSOs will work together to perform a coordinated dispatch of the distributed flexibility that have been procured by the ESO and DSO during their respective procurement activities. Therefore, information exchange of their flexibility requirements, procurement and activation is required to maximise synergies between transmission and distribution networks and minimise potential conflicts associated with the delivery of concurrent flexibility services.

In addition, the ESO and DSOs will need to exchange information with the aggregator, DERs or the end-customers. Information exchange on behalf of the ESO with the relevant parties will be similar to the current arrangements. Information exchange on behalf of the DSO is under consideration.

End consumers and DERs can establish a contractual arrangement for flexibility provision either with an Aggregator (or Supplier Aggregator) either directly with the DSO and/or the ESO. Local energy systems, which utilise peer-to-peer trading and/or local energy market, can directly contract with the DSO and the ESO.

In World B, Aggregators will be able to stack revenues freely from different flexibility services at both distribution and transmission level and it is likely that they will remain able to aggregate their portfolio across DNO networks.

4.2.2.3 System coordination and operation

System coordination and operation interfaces will remain similar to the current ones with DSO and ESO control rooms working together to ensure security of supply and asset safety. In the future, an increased number of active participants will connect to distribution networks. These connections will increase the requirement for coordination between DSOs and the ESO who will need to evolve their processes to manage increased uncertainty in system flows and demands.

According to the ENA ON Workstream 1 – Product 5 the commercial arrangements and procurement of services are completed ahead of real time, so that within the operation timeframe, only dispatch and conflict resolution is required.[98]

In the dispatch timescales, the route by which a system action has been procured is not relevant and the aim is to meet all DSO and TSO operational requirements in the most economic and efficient way. Hence, dispatch of DER resources and flexibility should not necessarily be linked to the party that has arranged to procure that resource. This implies that it may not be necessary to use the same model for procurement and dispatch, or even the same model between MW and MVAr services.

The information exchange from the DSO to the ESO includes:[99]

- headroom and footroom information at points of constraint;

98 Open Networks Workstream 1: Product 5, Co-ordination in an operational timeframe: http://www.energynetworks.org/assets/files/WS1%20Product%205%20-%20v2.5.pdf

99 Open Networks, Workstream 1: Product 5, Co-ordination in an operational timeframehttp://www.energynetworks.org/assets/files/WS1%20Product%205%20-%20v2.5.pdf?_sm_au_=iVV74vqHFrkfrJNt

- Active Network Management (ANM) operations;
- passive Distributed Generation (DG) and DER operation;
- volume of flexibility instructed;
- volume of flexibility contracted; and
- background data for network modelling (e.g. flows, topology, switch states, impedance, ratings).

The ESO should also send the following signals to the DSO:

- TSO boundary constraint information;
- volume of flexibility instructed within distribution network;
- volume of flexibility contracted within distribution network; and
- background data for network modelling (e.g. flows, topology, switch states, impedance, ratings).

4.2.2.4 Network design and development

Technical and commercial discussions between SOs will continue to be held similar to existing processes to ensure overall efficient network development. There will be an increased need for overall coordination of network and non-network solutions to meet future system needs. SOs would continue to have responsibility for the strategic design of their responsible networks. With regard to the ESO's strategic network design and development, this would require discussions with the TO on detailed development requirements. A transparent process would exist to look at solutions to transmission needs from non-network and distribution options.

4.2.2.5 System Defence and Restoration[100]

The "System Defence and Restoration" function has been introduced by the ENA ON and recognises that distribution networks and resources can play an increasing role in overall electricity system resilience and in the re-establishment of networks following a major system incident.

Activities included in "System Defence and Restoration" are contingency planning for High Impact Low Priority events (e.g. storms), the design and operation of resilience schemes to help manage extreme frequency deviations (e.g. Low Frequency Demand Disconnection), the design and operation of "islanding" arrangements and contributing to Black Start arrangements.

DSOs can also play a role to ensure DER resilience to system disturbances (e.g. Loss of Mains Protection, Fault Ride Through capability). The management of risks to networks with high volumes of connected DER is also part of the DSO role.

According to the DSO Roadmap, DSOs will be engaging with flexibility sources to ensure local network resilience and would have some capability to recover local areas post event. DSOs will set up contracts with the flexibility sources which will recognise DSO roles and the support these sources can provide to the DSOs. Underperformance on non – compliance of the service will be monitored and measured, through appropriate processes. DSOs would be dispatching services within their region using well defined protocols and systems. There would be some level of co-ordination with the ESO and with other DSOs that would support improved system defence and restoration capability.

ON work on whole system network resilience and defence mechanisms is in progress and has been de-prioritised as there are a number of initiatives in the industry such as National Grid's NIA Black Start project that are

[100] Open Networks Workstream 3: Product 2, Functional and System Requirements, DSO Functional Requirements: http://www.energynetworks.org/assets/files/ON-WS3-P2%20DSO%20Functional%20Requirements.pdf

progressing work in this area. The project will review the work delivered by other initiatives later in the year and decide on whether any further work needs to be commissioned to progress work on system resilience in 2019.

4.2.2.6 Next steps for the ENA ON Project[101]

The next and third phase for the ENA ON project will build on and add work to Phase 2 and explore several new areas. The focus in 2019 will be on:

- The project's deliverables for 2019 include the development of standards of performance between DSO and ESO for utilising flexibility on the distribution network, development of contracts and terms & conditions for ancillary services procurement, the creation of a visible measures of flexibility on the networks, consistent methodology for constraints management by DSOs, design of protocols for short-term contingency planning between ESO and DSO utilising ancillary services and last – resort mechanisms design.

  The ENA ON will also initiate new work to design changes that facilitate and encourage new markets and platforms for flexibility (e.g. peer-to-peer trading).

- Whole Electricity System Planning & T-D Data Exchange: The ENA ON project will take forward the work completed in 2018 on investment planning and forecasting to implement new processes as BAU, to further develop coordinated planning approaches in investment, operational and real time timescales and to standardise exchanging real-time T&D network operational data across networks.

- Customer Information Provision & Connections: The ENA ON project will roll-out good practices developed in 2018, bringing a level of convergence across networks in the connections process, progress queue management developments and will further improve visibility of information for customers and between network operators

- Workstream 3 of the ENA ON project will continue to support the assessment of the Future Worlds and the various pathway to the transition to DSO to continue to build an evidence based for any Ofgem and BEIS regulatory decision making.

- Whole Energy System work package will scope and progress cross vector thinking and developments.

4.2.3 Independent Comparison of USEF and ENA ON Future Worlds[102]

In 2018, SP Energy Networks contracted EA Technology to develop a representation of USEF in the Smart Grid Architecture Model (SGAM) representation of the USEF and to compare and contrast USEF against the market models that are suggested under the ON Future Worlds.

The EA Technology report has a different objective from the current DD and explores commonalities and differences between USEF and ENA Worlds in each of the DSO functions, as defined in the ENA ON project. The functions that are used as the basis for the comparison are: system coordination, investment planning, connections and connection rights, system defence and restoration, services and market facilitation, service optimisation and charging.

According to EA Technology, the SGAM analysis shows that the USEF model demonstrates a high level of functional commonality across all the five worlds, although the underlying market arrangements of four of the five ENA ON Future Worlds and USEF are by definition, largely mutually exclusive in implementation. According to EA technology, only World C ("Price Driven Flexibility") would not be mutually exclusive to USEF, as it was designed to be complementary to any world.

101 ENA ON, Consultation on Phase 3 2019 Work Programme: http://www.energynetworks.org/assets/files/electricity/futures/Open_Networks/ON-PRJ-Phase%203%202019%20Consultation%20Document-v3%20190115(published).pdf

102 EA Technology, Representing the Universal Smart Energy Framework on the Smart Grid Architecture Model.

4.2.4 Additional Industry Considerations on future arrangements

Energy UK has also published its view on roles and responsibilities in the provision of flexibility in GB.[103] Energy UK recommends a Whole Electricity System Coordination, where the ESO retains overall responsibility for national system security to ensure no operational conflicts. More specifically, the ESO holds responsibility for national balancing, frequency control and system restoration across the whole network. DSOs may take a more active role in congestions and voltage management across their operations areas. This model is a variation to World B of the ENA ON Future Worlds.[104]

4.3 Fit Analysis

The structure and mechanisms for a functioning flexibility market as defined in USEF are only partially supported by GB energy market arrangements at present. Except for balancing services procured by NG ESO, explicit flexibility in the GB energy market is in its infancy.

USEF defines operating regimes, functioning as a traffic light mechanism reflecting the status of constraints and congestion in the energy system to inform the (un)restricted trade and dispatch of flexibility. USEF also defines a flexibility market coordination mechanism (MCM) covering interactions between market participants to facilitate effective flexibility transactions. The equivalent of USEF's operating regimes and MCM do not (yet) exist in the GB market. These are areas where USEF could add specific elements and enhance the GB market design to commercialise flexibility and lower overall energy system costs.

The fit analysis has also identified that current arrangements for congestion management in the GB energy system are comparable to USEF's proposals for congestion management. GB congestion management mechanisms, as described in the National Emergency Plan (NEP), cover emergency situations where the ESO and the DNOs can temporarily overrule the market to avoid an outage by limiting connections, applying mandatory flexibility. This is similar to the orange operating regime proposed by USEF, where flexibility market mechanisms do not suffice, and network operators can intervene to protect the grid.

Given that USEF is a forward-looking framework that proposes a design of future flexibility market arrangements, perhaps the most relevant assessment is to look at the direction future market arrangements might take. For this reason, we have compared USEF with future flexibility market arrangements put forward by the ENA ON project, which can be considered the primary vehicle for industry discussion on this topic. The fit analysis has highlighted that USEF could add to future market design of the ENA ON Future Worlds in a number of places:

- Arrangements under the ENA ON Future World B focus on the procurement and deployment of flexibility from the perspective of network operators and do not fully explore the potential roles for other actors in future flexibility markets, such as Balance Responsible Parties (BRPs), generators, suppliers, aggregators and customers, which are considered in USEF. For example, the ENA ON does not capture interactions that will be required between the BRP and the aggregator or the supplier and the aggregator. Similarly, information exchange during the operational phase in the ENA ON describes information exchange among ESO, DSOs and customers, whilst USEF provides an approach to information exchange between the ESO, DSO, customer, aggregator, BRPs, Balancing Service Providers (BSPs), the Common Reference Operator (CRO) and the Meter Data Company. Hence, the USEF MCM provides a more comprehensive view on the processes and interactions that all flexibility market participants could follow in executing flexibility transactions.
- More detailed work on operation, settlement, measurement and validation will be undertaken under the ENA ON project in 2019. USEF already provides details and the standards of a market mechanism that will

103 Energy UK is the trade association for the GB energy industry.

104 Roles and Responsibilities in the Provision of Flexibility, Energy UK: https://www.energy-uk.org.uk/publication.html?task=file.download&id=6798

maximise the benefits of flexibility for all stakeholders in the GB energy system and can be used to inform flexibility market coordination in GB.[105]

- The ENA ON project to date has not developed a framework like USEF's operating regimes, which reflect the status of constraints and congestion in the energy system to inform the (un)restricted trade and dispatch of flexibility. USEF operating regimes aim to create transparency on network limitations that restrict the free trade of flexibility services by market participants. It should be noted that the ENA ON project has planned deliverables on last-resort mechanisms which will describe the shift from a market-led arrangement to a control-led one. USEF's operating regimes could inform this work, as they define and facilitate free market operations to maximise the economic potential of flexibility, as well as restricted states of network operation which safeguard the reliability and safety of the system.
- USEF considers that Aggregators have a central role in commercialising flexibility through explicit mechanisms with two distinct responsibilities. The first responsibility is to unlock flexibility at end-users and the second is to coordinate the use of flexibility, ensuring that all obligations between all relevant stakeholders are met. In the ENA ON, the first responsibility is partly recognized as a financial arrangement but does not involve possible alternative propositions to end-users other than purely financial. The second responsibility is performed by the cooperation between the DSO and ESO in World B, but this does not include coordination and settlement arrangements with other stakeholders, such as the BRPs. In addition, World B is mainly focused on existing flexibility providers (i.e. generation, batteries, I&C customers), while the interests of end-users (including residential prosumers) that want to use flexibility for other purposes (self-balancing, adjust demand to renewable generation, limit Carbon Dioxide (CO_2) emissions) is not considered.

In addition to these observations, the fit analysis has also identified areas of alignment between the ENA ON's World B and USEF. Both USEF and World B propose that the ESO and the DSOs procure flexibility independently from each other and that some level of information and exchange and coordination will be required. The commercial arrangements and procurement of services are completed ahead of real time, so that within the operational timeframe, only dispatch and conflict resolution is required. World B recognises the need for a coordination mechanism, but further details on how this coordination will work and how conflicts will be resolved have not yet been developed.

In summary, stakeholders in the GB energy system, including the ENA ON project, are currently still developing standards and processes to be applied in future flexibility markets. USEF provides a comprehensive framework, built on detailed principles and standards, and fully developed processes. In these areas, USEF could bring additional value to facilitate a fully open, transparent, competitive flexibility markets in which networks and other actors buy and sell flexibility on a level playing field.

[105] Open Networks Project, Phase 3 2019, Project Initiation Document: http://www.energynetworks.org/assets/files/electricity/futures/Open_Networks/ON-PRJ-Phase%203%20PID-v1.2%20Final%20(Published).pdf

5 DSO FLEXIBILITY TRANSACTIONS

Section 2 provided an overview of flexibility services and products that are available to Flexibility Requesting Parties (FRPs) in USEF and in the GB energy system. This section focuses on flexibility transactions for the DSO, discussing requirements to enable effective transactions as set out by USEF, and mapping these requirements against existing and potential future arrangements in the GB energy system. This section also considers existing and emerging flexibility platforms for Distribution System Operator (DSO) transactions and how they compare against USEF's view on such platforms.

5.1 Requirements to facilitate flexibility transactions – USEF vs GB:

Before stepping into the characteristics of DSO flexibility products, this section defines the characteristics of flexibility delivery and the type of flexibility products in USEF. The flexibility procurement and delivery consist of the following two components:

1. **The Availability of flexibility:** When availability of flexibility is procured and delivered, the Aggregator ensures that enough flexibility is available to the FRP for a given availability window. The Availability is expressed in power (MW). When availability is procured, testing and prequalification may occur.
2. **The Activation of flexibility:** This component refers to the actual control of assets to deliver flexibility and is expressed in energy (MWh). The Activation can either involve an actual energy transaction between the Aggregator and the FRP, or service delivery, where the Aggregator is remunerated for modifying load profiles in specific locations, without delivering the corresponding energy to the FRP.

The types of flexibility products classified by the type of flexibility they offer are as follows:

- **Capacity Products:** These products are based on the capacity to reduce or increase load. The associated energy component has typically a low volume due to infrequent activation, low volume per activation and/or symmetric activation so that energy component is equalled out.
- **Energy Products:** These products are based on actual energy reduction or increase for a certain duration, usually an imbalance settlement period or longer. These products are typically used for portfolio optimisation and energy market trading.
- **Hybrid Products:** These products are a combination of the capacity and energy products. Normally the capacity component remunerates the availability and the energy component remunerates the activation.

5.1.1 Flexibility products

5.1.1.1 USEF

In USEF, DSOs can solicit constraint management services to optimise grid operation against physical and market constraints. These constraint management services take various forms as set out in section 2. The most common products that are available for the DSO and some key characteristics of these products are summarised below:

- **Voltage Control** is typically needed when distributed generation sources generate significant amounts of electricity. Voltage control will "push up" the voltage level in the grid. Using load flexibility by increasing the load or decreasing the generation is an option to avoid exceeding the voltage limits. This mechanism can reduce the need for DSO grid investments (such as automatic tap changers) or mandatory generation curtailment. The notification of this product can be real-time or intra-day and the response from the Aggregator needs to be fast.
- **Congestion management**: In this product, the Aggregator offers flexibility to the DSO to avoid thermal overload of system components on day-ahead, intra-day market or real time, by reducing peak loads. Thermal overload may lead to grid failures and congestion management can be used as an alternative to defer or even

avoid the necessity of grid investments. Congestion management is not expected during long-term planning processes.

- **Grid Capacity Management:** In this product, the DSO uses explicit demand-side flexibility to increase its operational efficiency, without any impact on the freedom of dispatch, trade and connect. Aggregators can voluntarily participate in this product and facilitate grid reinforcement deferrals, optimisation of assets' operational performance, grid losses reduction and planned maintenance.

Grid Capacity Management and Congestion Management products are similar. The main difference is that Capacity Management is activated in the "yellow" operating regime, respecting the three USEF market freedoms of "connect", "trade" and "dispatch". Congestion Management is activated in the "orange" regime and implies certain market restrictions.

All the flexibility products can be either capacity or hybrid products. In case an Aggregator offers activation of flexibility (energy), the Aggregator does not need a contractual arrangement with the DSO and can participate in the flexibility market with "free bids" which are defined by the USEF Market Coordination Mechanism (MCM) as the act of placing bids on a market without a (contractual) obligation to do so. If availability is offered, then long-term availability contracts should be in place which will standardise elements such as duration, lead time, capacity remuneration, activation frequency and penalties. Capacity Management hybrid products are most likely to have short-term to medium-term procurement. Prequalification is required in case of availability of flexibility. USEF allows portfolio bidding for all these flexibility products.

5.1.1.2 Great Britain

GB DNOs can acquire implicit flexibility services through the Distribution Use of System (DUoS) charges, while explicit flexibility services for Distribution Network Operators (DNOs) are in development.

DUoS Charges Avoidance

DUoS charges can vary during the day and across different regions to encourage customers to spread their network usage throughout the day and avoid network usage at peak demand times in certain areas. Half-hourly metered customers are subject to a mechanism known as "traffic light system," or "time banding," which varies DUoS rates for specified time periods during the day. This is an implicit flexibility mechanism where consumers benefit from lower energy bills when they use the distribution network at off peak times. DNOs do not pay customers explicitly for this service, but customers that avoid higher rates incur lower overall network charges in their energy bill.

Flexible Connections[106]

DNOs offer flexible connections into their connecting options for both existing and potential customers and for both demand and generation. Flexible connections are made available in constrained areas so that reinforcement can be avoided or deferred. DNOs allow new customers to connect to the network, without reinforcing the network, even if customer's required capacity exceeds the peak network limits. Network companies allow these connections on the basis that the customer agrees to being constrained off when the network is reaching its capacity limits, usually through Active Network Management (ANM) or Timed Connections. This approach can reduce the cost and time of connecting to the network, as no extra works are required. Therefore, the customer pays lower connection costs than the costs that would have occurred in case of a conventional connection type, which would require network reinforcement to create additional capacity.

GB DSO flexibility products

Development of DSO flexibility products and services is still in its infancy, but all DNOs are actively involved. UKPN is the first DNO that has already launched a competitive tender for flexibility services.[107] WPD has announced its

106 http://www.energynetworks.org/electricity/futures/flexible-connections.html

plans for the first flexibility services procurement cycle during 2019.[108] ENW has asked potential flexibility providers to register their interest for flexibility provision in two areas of its network and NPg has launched its Expression for Interest publication to plan for a tendering process if appropriate.[109] [110] SP Energy Networks has also procured flexibility services trials for two areas of their network, while SSEN has recently decided to procure flexibility and demand-side response services across its entire network, not only in their constrained areas.

- **UKPN**'s invitation to tender provides some details on the flexibility services, although these are not product-specific. They do clarify that hybrid flexibility products will be procured and that standards developed in the ENA ON project (see below) will be followed as guidance. The products that are currently considered by UKPN are manual and automatic pre-fault constraint management and post-fault constraint management.[111]

  According to UKPN's invitation to tender, flexible resources can be aggregated together into a single controllable unit of flexibility (called a Flexible Unit) of at least 50kW. In addition, the point of connection with the distribution network must be in one of UKPN's flexibility zones which are currently published on the Piclo Flex platform.

- **WPD** is planning to procure flexibility services for 12 constraint management zones (CMZs) within 2019, using 3 flexibility products which align with ON outputs:[112]

  1. Secure product (pre-fault constraint management product): Hybrid product to be used to manage peak demand loading on the network and pre-emptively reduce network loading.
  2. Dynamic product (post-fault constraint management product): Hybrid product to support the network in the event of specific fault conditions, such as during maintenance work.
  3. Restore (Restoration Support): Energy only product to support power restoration following rare fault conditions.

- **ENW** uses 3 flexibility products to manage their constraint requirements:[113]

  1. Restore: This service is activated following a fault or unplanned event. Utilisation is uncertain and it has a low frequency of use. Actual energy reduction or decrease is required. ENW does not specify if they require availability of flexibility and whether availability of capacity will be compensated.
  2. Sustain: This service is required to increase or decrease demand or supply at peak times to help networks constraints management, before the fault occurs. Utilisation is uncertain, and it has a medium frequency of use. Actual energy reduction or decrease is required. ENW does not specify if there is also a required availability of flexibility and whether capacity availability will be paid.
  3. Continuous: This service requires a continuous capacity availability, with a high frequency of use and guaranteed utilisation.

  ENW recently published flexibility service requirements for the area of East Manchester and Cumbria. In Cumbria, they require a Restore response in the event of a network abnormality.

- **NPg** does not provide information on its specific technical requirements and flexibility products.

---

107 UKPN Flexibility Services Invitation to Tender: https://www.ukpowernetworks.co.uk/internet/en/have-your-say/documents/Invitation%20to%20Tender%20-%20PE1-0074-2018%20Flexibility%20Services_v1_1.pdf

108 https://www.flexiblepower.co.uk/tools-and-documents

109 https://www.enwl.co.uk/get-connected/network-information/flexible-services/

110 Northern Power Grid, Part 1: Launching DSO: https://www.northernpowergrid.com/asset/0/document/4686.pdf

111 UK Power Networks – Product Definitions: https://www.ukpowernetworks.co.uk/internet/en/have-your-say/documents/UK%20Power%20Networks%20-%20Product%20Definition.pdf

112 https://www.youtube.com/watch?v=EnGhYMMDzik&feature=youtu.be (WPD Webinar, Routes to participation)

113 https://www.enwl.co.uk/get-connected/network-information/flexible-services/

- **SP Energy Networks** has recently invited Flexibility Service Providers (FSPs) to tender for two areas within its network, seeking a post-fault constraint management product (a capacity product).[114]
- **SSEN** will procure flexibility through four initial services:
    1. CMZ Prevent: Required to manage peak demand on the network, usually weekday evenings.
    2. CMZ Prepare: Required to support the network during planned maintenance work.
    3. CMZ Respond: Required to support the network during fault conditions due to maintenance work
    4. CMZ Restore: Utilisation-only product, needed to support the network during networks faults that occur due to equipment failure.

Flexibility Products – ENA ON[115]

The ENA ON project has identified four active-power (MW) products to meet different distribution network congestion management needs:

1. **Scheduled Constraint Management** - The DSO procures, ahead of time, a pre-agreed change in input or output over a defined time period to prevent a network going beyond its firm capacity (thereby ensuring all load remains secure following the next fault). For example, a reduction in demand is procured over an evening peak period to mitigate risk of overload that might result should a fault occur on one of two in-feeds to a group.
2. **Pre-fault Constraint Management** – The DSO procures, ahead of time, the ability to access a pre-agreed change in Service Provider output based on network conditions close to real-time. Utilisation is then delivered by different mechanisms, depending on whether the DSO wishes to manage network risk manually, or automatically:
    a) Utilisation may be instructed manually, ahead of real-time, to prevent a network going beyond its firm capacity. This will generally be a manual call based on circuit loading forecasts. For example, a Service Provider is contracted to be available to the DNO over winter evening peaks. The DNO then calls the Service Provider on days forecast to have the worst predicted loadings; or
    b) Utilisation may be initiated through an automated DSO system. For example, a Service Provider is contracted to be available to the DSO over winter evening peaks. The DSO system then triggers the service when the loading reaches the firm capacity;
3. **Post-fault Constraint Management** - The DSO procures, ahead of time, the ability of a Service Provider to deliver an agreed change in output following a network fault. Utilisation is then instructed when the fault occurs on the network (but only if loading is beyond the post fault rating of the remaining assets). This will generally be instructed through an automated system and will utilise the short-term ratings of the assets, such that a sustainable post-fault flow can be achieved. For example, a Service Provider is contracted to be available to the DSO over winter evening peaks. The DSO system instructs the Service Provider to deliver the contracted change in output when the fault occurs; and
4. **Restoration Support** – Following a loss of supply, the DSO instructs a provider to either remain off supply, or to reconnect with lower demand, to support increased and faster load restoration under depleted network conditions. For example, a Service Provider may be restored at minimal load to allow for other (perhaps less flexible) customers to be restored.

114 https://picloflex.com/dashboard (areas Oswestry/Maes-y-Clawdd and Glenrothes)

115 ON Project DSO Service Requirements: Definitions: http://www.energynetworks.org/assets/files/ON-WS1-P2%20DSO%20Service%20Requirements%20-%20Definitions%20-%20PUBLISHED.pdf

Based on the current description of the ENA ON flexibility products, the scheduled constraint, pre-fault constraint and post-fault constraint management products can be classified as hybrid products where the flexibility provider gets paid for both the contracted availability and the delivered energy when this is required. The Restoration Support product is not yet defined in detail. WPD, however, includes restoration support as an energy only product in their procurement processes.[116]

Future products that will be considered by the ENA ON project are products for reactive power management.

5.1.2 Flexibility purchasing

Flexibility purchasing considerations include regulatory requirements, contractual arrangements, restrictions, interactions and responsibilities to trade flexibility.

5.1.2.1 USEF

Regulatory considerations

As discussed in section 4, Green and Yellow regimes have no restrictions for trading flexibility and it is the Orange regime that can be regulated based on the regulations that exist in each country or market.

Contractual arrangements

In USEF, contractual arrangements for DSOs depend on the way that they choose to procure flexibility from the Aggregator, which can be either through long-term flexibility contracts or through short-term flexibility procurement.

In long-term flexibility contracts between the Aggregator and the DSO, activation of flexibility is prearranged in bilateral contracts. Based on this contract the Aggregator has the obligation to offer a fixed amount of flexibility to the DSO. This option guarantees a certain availability of flexibility, where the availability price is arranged in advance. The activation price is determined by the merit order of the bids. In this case, the DSO may procure flexibility well in advance, to secure a certain supply of flexibility, through tender or auction processes. The Aggregator should always have sufficient flexibility available in the time frame and location specified by the long-term availability contract, which might prevent or limit trading this flexibility in other markets or products. The DSO, in return, will notify the Aggregator when the reserved flexibility will not be activated, so that the Aggregator sells the flexibility to other markets.

In short-term flexibility contracts, the Aggregator has no contractual obligation to offer the flexibility to the market and flexibility is provided on a day-to-day basis through "free bids" market on the specific day". Short-term contracts refer to the contracts that are signed between the Aggregator and the DSO closer to the real-time. Flexibility trading for congestion management, which typically occurs Day-Ahead, Intra-Day and sometimes Real-time, is classified as short-term. In this case the Aggregator is free to offer flexibility, reflecting also the marginal cost of this flexibility but the availability is not guaranteed for the DSO until the bid is made. There is, however, no guaranteed availability of free bids. USEF recommends that "free bids" can compete with contracted flexibility through the merit-order mechanism. As a result, the merit order itself ensures that the DSO can buy the economically optimal flexibility service while the availability contracts guarantee availability of flexibility (i.e. sufficient depth of the merit order). This mechanism provides the flexible resources that cannot be committed to a certain service window well in advance with the opportunity to participate in the congestion management product.

With regard to bilateral agreements with end-customers, within the free market (green and yellow regimes) all the flexibility is acquired through the Aggregators and therefore the DSOs do not need agreements with end-customers. Bilateral agreements, or direct control based on regulations, should be considered in the Orange regime where DSOs are allowed to directly decrease/increase demand or supply of their customers. Bilateral agreements should be in place for certain arrangements, such as the compensation that the DSO might provide to

116 https://www.flexiblepower.co.uk/tools-and-documents (Webinar – Routes to participation)

their customers in case of forced load shedding. USEF proposes that in "orange" and "red" regimes the DSO establishes bilateral agreements with all its customers, not only with customers contracted with an Aggregator.

Flexibility Trading

Once the associated contracts are in place the flexibility can be traded. The starting point for flexibility trading between the Aggregator and the DSO is the forecast (D-prognosis) from the Aggregator. To this end, USEF introduces the concept of **D-programs**, through which aggregators active in congested DSO areas are obliged to inform the DSO on planned activations of flexibility (day-ahead and intraday). Aggregators also need to inform DSOs about any contracted flexibility capacity. Note that this obligation applies to all aggregators, including aggregators that do not participate in DSO congestion management services. USEF also suggests extending this obligation to Suppliers for flexibility activated through implicit mechanisms. ESO and DSO congestion management processes in USEF are based on the same principles, meaning that the same information exchange will take place in case of congestion points at ESO level.

The combination of all D-prognoses and the DSO forecast for all other connections allow the DSO to perform a grid safety analysis for a specific Congestion Point. The safety analysis determines whether there is a potential congestion and hence a need for flexibility trading. In case of congestion, the DSO sends a flexibility request to the Aggregator (FlexRequest). In response, the Aggregator sends a flexibility offer (FlexOffer) including a price which is accepted/ordered by the DSO (FlexOrder). Following the FlexOrder, the Aggregator sends an updated D-prognosis, including the flexibility sold. Since the new D-prognosis gives rise to a changed profile, USEF MCM returns to the Plan phase where the Aggregator reoptimizes its portfolio and if needed renegotiates with the Balance Responsible Party (BRP).

When a DSO or the ESO requests a flexibility activation in the context of a congestion management product, that activation has a negative impact on the system balance. This impact can be neutralized by activating the same amount of flexibility, yet in another "direction" and outside the congested area (referred to as a "re-dispatch"). The need for a re-dispatch mechanism only emerges if the energy volumes are relatively large. In theory, five models are possible for re-dispatch responsibility in a DSO congestion management product:

- The DSO performs the re-dispatch and the re-dispatch should be simultaneously purchased with the flexibility activation ("congestion spread").
- The DSO performs the re-dispatch with no restrictions on when the re-dispatch should be purchased.
- The ESO performs the re-dispatch for the cumulative DSO/ESO flexibility activations.
- The aggregator or the Constraints Management Services Provider (CMSP) performs the re-dispatch, implying that the DSO purchases a service rather than energy. This option requires a Transfer of Energy to be facilitated. If the Aggregator is held responsible for the re-dispatch, the Aggregator needs to include the costs of re-dispatch in the bid. However, the re-dispatch takes place after the bid has been placed (re-dispatch is typically intraday or real time, where the bid is typically day ahead). Therefore, the costs of re-dispatch are unknown at time of bidding.
- The supplier performs the re-dispatch, implying that the DSO purchases a service rather than energy. This option does not require a Transfer of Energy (USEF uncorrected model). Typically, USEF's Uncorrected Aggregator Implementation Model can be applied, in which case the responsibility stays at the Supplier of the customer where the flexibility is activated.

Another specification for flexibility trading between the DSO and the Aggregator is that the flexibility offer is valid until a new flexibility offer is sent by the Aggregator, until it expires or is revoked. Also, the flexibility order is definite and binding, once it has been placed. The DSO chooses which flexibility offer to accept and it is not obligatory to start with the offer that has the lowest price. The DSO can therefore assess other characteristics such

as connectivity aspects, period to which the load is shifted, and reliability. The DSO must provide transparency about this selection process.

5.1.2.2 Great Britain

Flexible Connections[117]

Flexible Connections are connection arrangements whereby a customer's export or import is managed (often through real-time control) based upon contracted and agreed principles of availability of capacity. These arrangements can be applied to either Firm or Un-firm connection. The term Firm is used to describe a connection that remains available in a first fault scenario, since it has more than one circuits, ensuring continued availability in the event of a fault. Un-firm (or Non-firm) connections on the other hand are typically single circuit and therefore the connection becomes unavailable in the event of a fault or necessary maintenance. Un-firm connections typically incur lower connection charges because of the smaller investment required for the connection.

All DNO offers Flexible Connections which manage both system intact and outage conditions. DNOs' approaches to Flexible Connections show some consistency, but each DNO has also its own specifications for Flexible Connections management. Needs vary across the broad range of different applicants and one solution will not fit all. Four types of flexible connections are currently available: Timed Connections, Active Network Management, Operational Tripping Schemes, Export Limiting Devices.

Customers interested in a Flexible Connection have to apply for it. DNOs provide a range of information to assist in the decision making such as heat maps with the constraint areas, network overview information and regional development plans. The DNOs then inform the customer for the price of the flexible and non-flexible connection and the customer chooses how they want to proceed. Once the associated connection arrangements are in place, the DNO is eligible to manage the generation or the demand of the connection when this is required.

DUoS charges Avoidance[118]

As an implicit mechanism, DNOs do not "procure" flexibility through variable DUoS charges so much as provide an incentive for customers to vary their demand at certain times during the day. The effectiveness of the incentive depends on energy suppliers to pass through DUoS charges to customers, since suppliers collect charges on behalf of distribution networks.

DSO flexibility products

Table 2 summarises flexibility purchasing arrangements by GB DNOs as set out to date.

Table 2: Flexibility purchasing arrangements per DNO [108] [109] [110] [114]

DNO	Process	Contractual arrangements	Purchasing and Dispatch
UKPN	1. Expression of interest 2. Clarification 3. Pre-qualification 4. Competition 5. Post Competition	Bilateral contracts between the UK Power Networks and Flexible Providers (FPs) for defined seasonal and diurnal (24-hour) periods follow the tender process. The FP sets its own availability and utilisation fee via a competitive tender. The lowest cost combination of contracts which meets the requirement is accepted, subject to the cost of the contracts being below the benefit to the network. FPs can also offer optional services paid at a utilisation-only fee which is set by the FP from time to time. Pre - qualification is required to enter the tendering competition. Testing of the	UK Power Networks send instructions to notify the FP when to deliver and when to stop delivering its contracted flexibility from the FU. Utilisations instructions can be activated automatically or manually. Communication method: Text or mail or telephone or any other as agreed. Utilisation instruction will include Start time and optionally End time. UK Power Networks may request utilisation outside of the FP's contracted service period which is optional on the FP to accept. The request shall specify the start and end time and capacity required, which the FP may accept within certain limitations within 15

117 ENA ON, Flexible Resources Connections Guide: http://www.energynetworks.org/assets/files/ON%20WS1%20P11%20Flexible%20Resources%20Connection%20Guide_v1.1.pdf

118 WPD, DUoS Charging for LV and HV Metered Connections: https://www.westernpower.co.uk/downloads/7028

		flexibility availability and delivery takes place 1 month prior to the delivery date. The resources can be aggregated together into a single controllable unit of flexibility called a Flexible Unit (FU) of at least 50kW. The individual Facilities making up the FU can be changed during the service period. The aggregator can select which facilities within the FU deliver the service.	minutes of the request The FP can add, remove, or reallocate Facilities between aggregated Flexible Units (FUs) during the term of the contract, subject to approval by UK Power Networks. The FP can select which Facilities deliver the contracted service at any given time during operational timescales. This is notified to UK Power Networks post-event as part of the Performance Report.
WPD	1. Flexibility Providers Interest Register 2. Pre- qualification 3. Respond to tender 4. Contracts arrangements 5. Build & Operate	Bilateral contracts will be signed post-competition. The contracts will be awarded for the minimum of 1 year, with the option to extend into further years should the CMZs have ongoing requirements. WPD will update FPs at regular intervals. Key features of bilateral contracts: - No exclusivity clauses - No obligation to provide availability - No penalties for non-delivery, only loss of revenue through underperformance - Shared & Capped liabilities	Information exchange: WPD will provide a month ahead forecast of availability and utilisation needs in each zone. The month ahead forecast will provide participants with a forecast for every day of the upcoming month and will show the energy requirements forecast, the time and the price that WPD is willing to pay. During these first trials WPD will operate a pay-as-clear pricing structure --> no differentiation in price. Dispatch optimisation will take place in an order which aligns with the required flexibility. Service declaration for the 3 products is a week ahead. Acceptance or rejection for Secure and Dynamic products should occur a week ahead, while in case of Restore acceptance is automatic based on previous contractual arrangements. Dispatch notice is a week ahead for Secure and 15 minutes ahead for Dynamic and Restore products. Seasonal requirements for Secure and Restore are all year round, while Dynamic product services are required in summer.
ENW	1. Publish bulleting and bidder to register interest 2. Publish Request for Proposal 3. Clarification of questions from ENW 4. Responses submission from bidders 5. Evaluation and contract negotiations 6. Contract award 7. Delivery of flexibility services	Terms and Conditions are included in the Request for Proposal which are only available to bidders through online portal. Bilateral contracts will take place. The Flexible Resource must either be already connected to the network location which will require the service or the FPs must be able to locate (i.e. install, commission, and deliver) the Flexible Resource in the locality of the network asset that will need support. The minimum size for directly contracted resources should be at least 100kW. There are no restrictions on the size of sub-sites of aggregated portfolios, but the total portfolio size needs to be at least 250kW (flexibility capability and not capacity).	Information not available
NPG	1. Expression of interest (EOI) 2. EOI responses assessment 3. Invitation to tender launch 4. Notification of successful bidders 5. Utilisation of flexibility.	Information not available	Information not available

SPEN	1. Invitation to Tender 2. Pre- qualification 3. Tender window 5. Awards notification 6. Testing and commissioning 7. Service window	Bilateral contracts between SPEN and FSP will be established. Minimum aggregated entry size is 0.50MW.	Dispatch order by telephone during the trials. No automated dispatch is required.
SSEN	1. Procurement 2. Auction 3. Contract 4. Settlement	Open to a range of services from small-scale renewables, battery storage, electric vehicles, demand side response and energy efficiency measures.	Congestion areas will be published in Piclo Flex.

Flexibility Products – ENA ON

The ENA ON project provides "good practice" guidance for the development and procurement of flexibility services by DNOs, suggesting that DSOs need to engage with potential providers to raise awareness of the new opportunity and promote participation.[119] Figure 10 shows the process for DSO Service Procurement as set out by the ENA ON.

The guidance also describes four examples of active-power products for DNOs, including potential contractual and dispatch arrangements:

1. Scheduled Constraint Management

The DSO contracts with a Service Provider, which could be a dominant demand customer or smaller customers contracting via an aggregator, to limit their import each day during the stated period to avoid the peak demand in excess of the transformer rating (irrespective of whether the peak loading actually occurs).

2. Pre-fault Constraint Management

The DSO contracts with a Service Provider to limit their import either:

- only on days when the DSO forecasts that the peak demand will exceed the transformer rating and sends a request for the service to be delivered. Depending on circumstances, service call-off may be limited to the period 17:00hrs to 20:00hrs; October to March, or there might be optional utilisation outside these windows (typically this would be a manual process); or
- only on days when their monitored demand exceeds the transformer rating, following receipt of a signal from the DSO (typically this would be an automatic process).

3. Post-fault Constraint Management

The peak demand of a Bulk Supply Point load group is in excess of the operating rates during an outage of one of the transformers. The DSO contracts with a flexibility service provider to ramp-down (within prescribed timescales) their demand immediately after the fault loss of one of the transformers to maintain peak demand within the rating of the remaining transformer. This service makes use of the short-term ratings of assets – the magnitude of those ratings will determine whether the service could be instructed manually, or whether it would need to be triggered automatically.

4. Restoration Support

The peak demand on a High Voltage (HV) feeder is traditionally managed to ensure that following the fault loss of that feeder the demand can be fully restored via another feeder, by opening and closing appropriate network

[119] ENA ON, Good Practice for information provision on Flexibility Services, WS2, Product 4: http://www.energynetworks.org/assets/files/ON-WS2-P4%20Good%20Practice%20FLEXIBILITY%20SERVICES%20V1.1%20PUBLISHED%20(NEW%20TEMPLATE).pdf

circuit breakers. This means that there is "spare" capacity on the network that is only used under fault or maintenance conditions. Contracting for Restoration Support allows this 'spare' capacity to be used whilst the network is operating in its normal state on the basis that, following a fault, contracted Service Providers would remain off supply until the fault was rectified, thereby facilitating restoration of customers not contracted for Restoration Support.

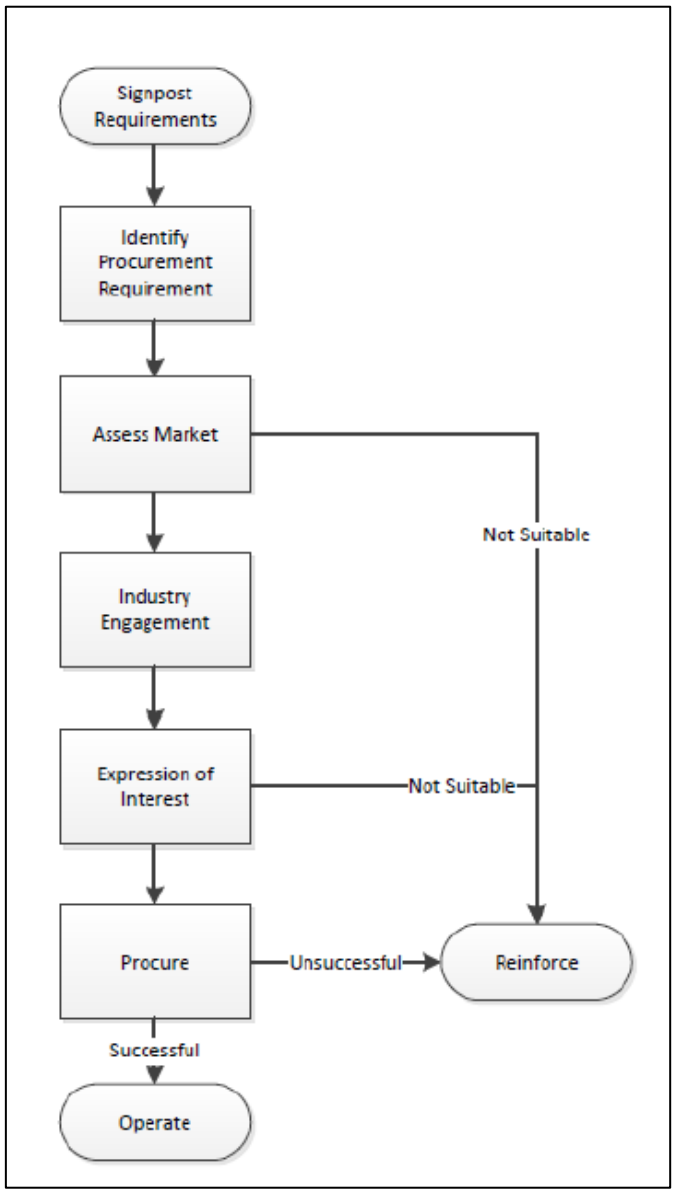

Figure 10: DSO Service Procurement Process

5.1.3 Pricing & Remuneration

Once the flexibility has been procured and delivered, the DSO compensates the Aggregator for the flexibility service provided.

5.1.3.1 USEF

In USEF, the DSO is responsible for the remuneration of the Aggregator based on the performance of the Aggregator during activation period. This may include compensation for availability within the service window, but outside the activation period. There are 2 different remuneration types:

- In case of activation of flexibility, the DSO pays the Aggregator for delivering the requested or activated volume and the payment occurs per transaction. Over-delivery of the flexibility service (i.e. the delivered

volume exceeds the contracted volume) is allowed but the extra flexibility is not compensated and only the contracted volume is paid to the Aggregator. Under–delivery, on the other hand, is penalised: the Aggregator gets paid for the delivered volume, but the deficiency incurs penalty charges. The amount of flexibility being offered is specified as a difference with a baseline value. The maximum or predefined price is paid when the flexibility is delivered as ordered.

- In case of availability of flexibility, the DSO pays the Aggregator a fixed price for the availability of capacity even if this capacity is never used. The DSO can issue test activations to assess the reliability of the availability service. The DSO can also monitor or audit to check whether the contracted flexibility is available during the service window. Failure by the Aggregator to deliver whole or part of the requested flexibility results in penalties or disqualification of service delivery.

An important aspect of remuneration is setting the baseline used by the DSO to determine the amount of flexibility that was delivered during the demand response activation. By definition, the baseline for an individual product describes what the load/generation profile would have been without the Demand Response (DR) activation specific to that service/product.

For DSO services, the baseline methodology is based on the D-prognoses that the Aggregator sends to the DSO for each Congestion point at the beginning of the Operating phase. Deviation from an Aggregator's D-prognosis for a particular Imbalance Settlement Period is only penalised if the DSO and Aggregator have traded flexibility for that Imbalance Settlement Period (ISP). Only deviations that lead to extra congestion are penalized; deviations that alleviate the congestion are accepted. USEF suggests that the flexibility quantification, including the baseline methodology, which is used within the product, is the same that will be used for the Transfer of Energy to settle imbalances. Therefore, the baselining methodology will also apply to the transactions between the Aggregator and the Supplier.

5.1.3.2 Great Britain

Flexible Connections

Pricing and remuneration processes vary by DNO and by type of flexible connection. The general approach is that customers are compensated for choosing a flexible connection with lower connection charges.

In case of timed connections, for example, a customer sets out its planned usage and shares it with the DNO. The DNO then designs an appropriate connection for that usage, taking into consideration that this connection has certain capacity requirements will export to or import from the grid during certain periods of the day or week. The DNO then provides a price to the potential customer based on customer's consumption/generation profile. Customers need to provide their anticipated usage pattern which would be reflected in the connection offer and later agreement. Similarly, when ANM is applied, DNOs offer a price for a "curtailed" and "non-curtailed" connection.

DUoS Charges Avoidance

DUoS charges reflect the cost of operating and maintaining the distribution network. DUoS charges are passed through to customers by energy suppliers, who collect charges on behalf of distribution networks. Customers are charged a variable rate in p/KWh for the volume of energy they have used during the relevant billing period. For half-hourly metered connections, which are subject to the time banding mechanism, the customer pays different variable DUoS rates depending on the time of day.

DSO Flexibility Products

The development of DSO flexibility services is in progress, and therefore elements such as pricing and remunerations have not yet been standardised. The ENA ON project will provide further guidance on these elements within 2019. Table 3 provides an overview of remuneration and settlement arrangements (see section 5.1.4) where these are available from DNOs specifications on flexibility services.

Table 3: Remuneration and settlement arrangements for DSO flexibility services. [108] [109] [110] [114]

	Remuneration / Pricing	**Settlement/ Verification**
UKPN	The flexibility provider (FP) receives a utilisation payment for the delivered energy and an availability payment for all period available. Over-delivery in one period will not compensate under-delivery in another period. The FP can set themselves unavailable for future service period, and no availability payments will be received for the affected periods.	Settlement take place following the utilisation period and "meter data is compared to the baseline to calculate the energy delivered during utilisation events". Minute by minute metering of sufficient accuracy is required. The metering data should be made available on request and at the end of every month. "The metering point shall be at the boundary between the site on which the Facility is located and the distribution network or on the terminals of the Facility if approved by UKPN." "The default baseline methodology calculates the baseline as the average generation or consumption of the Flexible Unit (FU) during representative historic peak periods at the time of the Competition." The FP nominates also the Flexible MW level from the calculated baseline. Both the baseline and the Flexible MW are fixed for the duration of the contracted services period. Baseline is not used for the availability payments and a performance factor is used instead. The performance factor compares the energy delivered to the energy contracted during the utilisation events and is then applied to the availability which was declared by the flexibility provider in the contract.
WPD	Pricing will be implemented in 3 phases: - Fixed: Where there is not sufficient flexibility to provide a competitive market, a fixed price at around £300/MWh will be set. - Pay as clear: Where there is sufficient competition, a clearing price will be derived from the procurement process. - Full Market: As distribution flexibility markets mature, they will progress to close to real-time operation, where the window for the contract price will be very short. Remuneration will be based on: "- arming and utilisation for Secure product. Arming is only paid for the duration of expected utilisation. - availability and utilisation for Dynamic product. Availability is paid in this case, instead of arming, due to reduced expectation of utilisation. Availability reflects a payment for readiness. - availability only for Restore."	Half Hourly metered data should be provided to WPD for settlements and verification. Each month, WPD will "use the first three full weeks of data to calculate the Average demand from the previous month", which is used as baseline. For generation, WPD will only assess the generation outputs data between 3pm-8pm weekdays. "This is gathered data at the point of generation and not at the settlement site. "The average generation from the 75hours being assessed is calculated and updated by the 1st of the following month. In a similar way the baseline for the demand is the average demand which is calculated by the consumption over the same 75hours that were used for generation calculations.
ENW	Depending on the product, availability and utilisation remuneration will take place. Pricing varies for flexibility services in different areas and it is part of the proposal, procurement and delivery process of each area. Subject to the delivery of flexible services, the provider will be entitled to invoice ENW and will receive payment by bulk electronic clearing (BACS) by the end of the following month (after the invoice is received).	Flexibility delivery performance will be verified via HH metering, using the variance in load between the receipt of ENW signal and the response, to determine whether requirements have been met.
NPG	Information not available	Information not available
SPEN	Information not available	Settlement is managed manually
SSEN	Depending on the product; availability and utilisation payments will be available	Information not available

Flexibility Products – ENA ON

The ENA ON project has not provided any detailed guidance regarding the remuneration and pricing of flexibility products. This is work in progress at the time of writing this report.

5.1.4 Transaction settlement & verification

5.1.4.1 USEF

The settlement phase is linked with the remuneration and pricing that were discussed in sections 5.1.3. Within the settlement, the DSO verifies whether the acquired flexibility has been delivered according to the agreements. If not, this can lead in certain circumstances to penalties, which are considered an integral part of the settlement process.

In case of flexibility activation, information is exchanged for verification of the delivered amount of flexibility. The Meter Data Company (MDC) collects smart meter data from the prosumer and sends the smart meter data to the DSO. The smart meter can be an industrial meter or also a sub-meter and the resolution of data is determined by the product. The DSO uses this data for verification of the actual delivery. In principle, the DSO, Aggregator and the TSO will evaluate performance based on metering data at the connection level. In practice, however, especially at industrial and commercial sites, the Aggregator will most likely install a sub-meter for the ADS assets to measure their actual performance. This enables both the Aggregator and the DSO to better predict and quantify the performance of the demand response service and the provided flexibility.

In case of flexibility value stacking where the Aggregator sells multiple products to different FRPs, verification is more complex. The difference between the baseline and the measurements may include the effect of multiple Demand Side Response (DSR) activations. To avoid double counting of the delivered flexibility in USEF the baseline for the wholesale services is set first, followed by the baseline for constraint management and then balancing services. This process implies that the DSOs need information from the Allocation Responsible Party (ARP) about the quantified DSR volume delivered by the TSO during the balancing services to calculate their baseline and, consequently, the volume of flexibility that was delivered based on measurements.

5.1.4.2 Great Britain

Flexible Connections

Settlement and verification are not applicable for flexible connections since the service is provided through the connection contract and activated by the DNO.

DUoS charges Avoidance

Energy suppliers are responsible for metering a customer’s demand for a given period. Based on this metered data, the energy supplier invoices the customers for both the supply service, as well as the distribution service, based on the applicable DUoS tariffs, reflecting DUoS time banding in case of half-hourly metered customers.

DSO Flexibility Products

Where available, settlement and verification processes of the DSO products are included in Table 3 above.

Flexibility Products – ENA ON[120]

Table 4 provides some high-level description of the requirements of flexibility products as identified by the ENA ON project, as well as reflecting information related to sections 5.1.1, 5.1.2 and 5.1.3.

Table 4: ENA ON flexibility product requirements

	Schedule Constraint Management	Pre-fault constraint management		Post-fault constraint management	Restoration support
		Manual	Automatic		
Minimum/Maximum bid size	100kW minimum (can be aggregated within area); no maximum				
Minimum/Maximum duration	0.5hr minimum, longer is more valuable				3hr minimum; longer is more valuable
Definition of congestion point (identification of the congested area)	Infrastructure - dependent, although will tend to be "below" the congested asset(s) in terms of voltage. More details in the procurement process				
Bidding period (time granted to the market partied to offer bids)	Months ahead				
Selection period (time required by the DSO to select the bids which will be activated)	Months ahead				
Activation period	Months ahead	Closer to real time (depends on driver) - e.g. day-ahead, week-ahead	Real time (pre-fault; time TBC)	Real time (post fault; time TBC)	Real time (post fault; time TBC)
Max ramping period	Scheduled, ramping period is not an issue		Of the order of minutes (i.e. "fast" with link to short-term ratings;)		N/A
Min full activation period	2hours	30 minutes (link with granularity of metering)			At least 3 hours
Mode of activation	Scheduled	Manual	Automatic (or manual depending on post-fault distribution asset capability)	Automatic (triggered by signal from DSO)	Manual
Availability windows	Defined at procurement according to requirement (e.g. could be winter weekday evening peaks)				N/A - "as required"
Max number of activations (per day/week/year)	Scheduled - likely on 1 call per day basis	Defined at procurement according to requirements			TBD
Recovery time	Scheduled - most likely on 1 call per day basis	Defined at procurement according to requirements			N/A
Baseline methodology	TBC (likely to vary both by product and by technology of provider)				
Measurements requirements	Minute by minute metering				
Aggregation allowed	Yes (within appropriate geographical area)				
Penalty for non-delivery (fixed or dependant on the bid size/or duration)	Loss of revenue; impact on future procurement/utilisation and potential for termination of contract. Consideration needs to be given to how to ensure the protection of the network - for example whether we need to establish a back-stop tripping capability				N/A

120 ENA ON, ON-WS1-P2 Product Definition: http://www.energynetworks.org/assets/files/ON-WS1-P2%20Product%20Definition_Final_7Sept2018%20-%20PUBLISHED.pdf

5.2 Platforms & Bilateral Markets

Various initiatives focused on demand-side flexibility design or create "flexibility platforms" or "flexibility markets" which can have different objectives such as market place creation, market facilitation, TSO-DSO coordination. Currently most markets and products within the flexibility value chain are operated on separate platforms. Although it is possible for the DSO to host grid management services on their own operational platforms, integrating markets and products in one platform and separating the role of the market operator from the product owner can provide a significant contribution to future flexibility trading. For example, TSOs and DSOs can have access to these platforms and thus access to a large and diverse pool of flexibility providers (BRPs, Aggregators, Prosumers).

This section describes USEF's view on the architecture of flexibility platforms as well as a number of new and existing GB flexibility market platforms, as a broad proxy for the GB direction of travel.

5.2.1 USEF Flexibility Platform reference architecture

USEF defines a Flexibility Platform as an IT platform capable of facilitating and coordinating the trade, dispatch and settlement of demand-side flexibility.

USEF introduces the concept of a reference architecture for explicit demand-side flexibility from the Prosumer to the Flexibility Requesting Party. The architecture consists of five platforms and hubs:

1. **the market platform**: The functionalities of the market platform include matching of flexibility offers and requests, publication of product characteristics and congestion points, financial settlements of energy transactions, integration with imbalance settlements, publication and matching of availability contracts.

2. **the TSO/DSO coordination platform**: The main functionality of this platform is the coordination on the dispatch and re-dispatch of demand-side flexibility between the TSO and the DSO.

3. **the market facilitation/central data hub**: As flexibility transactions and the number of involved parties in the flexibility services increase, a registry for flexibility transactions and a common settlement entity will be required. Therefore, USEF recommends the establishment of a regulated central data hub, where processes of flexibility transactions such as measurement and validation take place and are recorded. This data hub will provide a more transparent market, facilitating the standardisation of flexibility settlement processes as well as the participation of flexibility service providers in various flexibility services. The main functionalities of this hub are the measurement, validation, allocation of flexibility volumes to the right flexibility requesting party and transfer of energy in case of independent aggregation. Settlement can be processed within or outside the central data hub.

4. **the technology platform** (Virtual Power Plant (VPP)/ Microgrid controller): This platform dispatches the flexibility, undertakes forecasting, value optimisation and flexibility trade and risk management and congestion management coordination.

5. **the TSO/DSO operational platforms** (i.e. balancing, grid management): The operational platforms have several functionalities, which include forecasting and grid safety analysis, identifying flexibility needs, tendering of availability, settlement of availability contract, validation and physical settlement of product delivery and prequalification.[121]

[121] USEF White Paper, Flexibility Platforms: https://www.usef.energy/app/uploads/2018/11/USEF-White-Paper-Flexibility-Platforms-version-1.0_Nov2018.pdf

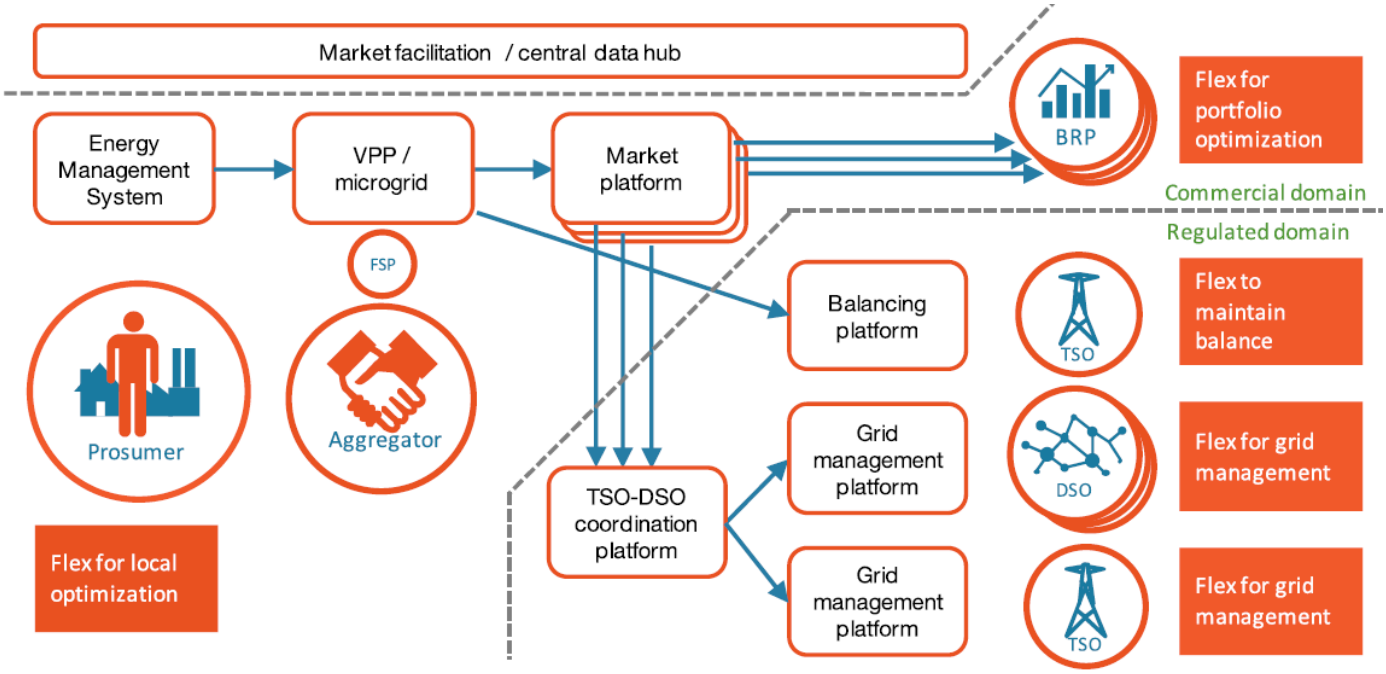

Figure 11: USEF Flexibility Platform reference architecture

USEF flexibility platforms aim to integrate markets and products and separate the market operator role from the product owner (ESO and DSO). USEF proposes standardisation of the interactions between the market platforms and grid management services, as both market operators and system operators will benefit from this activity:

- TSOs and DSOs should not limit their interaction to only one market operator (unless there is no competition). The TSO and DSO need to approach market operators in a non-discriminatory manner and cannot allow themselves to be locked-in to a (commercial) market operator. Also, liquidity can only improve if TSOs and DSOs can access several market platforms. An open, standardized interface will lower entry barriers for operators to participate in grid management services.
- Every TSO and DSO is a potential customer of market operators' platform. Since most market operators have a strong international focus, a significant number of system operators may interact with the market platform. A standardized interface would therefore strongly reduce the costs, while the competitive edge should be created using other elements such as the portfolio of flexibility providers active on the platform, or intelligent matching algorithms.

5.2.2 Flexibility platforms in Great Britain

The following platforms are currently active, or seeking to enter, the GB energy market:

Piclo Flex:[122] [123] The Piclo Flex platform is set up as a marketplace for DSO flexibility services. DNOs publish on Piclo Flex geographic locations where flexibility is needed, as well as specifications such as type of need, connection, and availability. DSOs can also launch new tenders by specifying their requirements and successful bid outcomes are published through Piclo Flex platform. Flexibility providers have access to this information and they can also register their assets, provide information on their assets and respond to bids. The Piclo Flex platform performs the automatic allocation of capacity by the marketplace algorithms. This platform is open to DSR and Aggregators and other flexibility sellers such as energy suppliers, EVs charging operators and batteries. They are not involved in financial settlement or imbalance settlement.

122 https://piclo.energy/flex

123 Piclo Flex Summary 2018: http://powerresponsive.com/wp-content/uploads/2018/05/OpenUtility-Piclo-Flex-Summary-May-2018.pdf

Cornwall Local Energy Market (LEM):[124] The Cornwall LEM flexibility platform, which was launched in June 2018, has been established to facilitate a more efficient market for local assets that provides them access to local and national flexibility markets. Centrica and WPD are project partners in the design, testing and trial of the platform. National Grid also takes part in the trial. The platform is used for the arming and dispatching of services and supporting the processes for validation of service delivery and settlement. The information on the platform can also be used for notifications between parties to avoid conflict of interests. Cornwall LEM enables access to both ESO and local opportunities for flexibility. Independent aggregators register local generation and flexibility assets in the LEM platform, have visibility of flexibility requirements in a given area and have access to more opportunities to utilise flexibility [125].

NODES flexibility platform:[126] NODES is a universal platform for local, flexible electricity markets with features allowing connecting to other markets.[127] The marketplace NODES was developed in early 2018 and is currently seeking to enter the GB energy market. Its main goal is to increase value for flexibility providers, and reduce costs for the DSO, also giving the opportunity to flexibility which is not used locally to be sold to the TSO and/or BRPs at the transmission grid to solve imbalance issues there. NODES aims to link the Flexibility Marketplace with the existing platforms that operate intraday and balancing markets. This will thereby create a fully integrated marketplace for flexibility. Figure 12 illustrates the NODES market design.

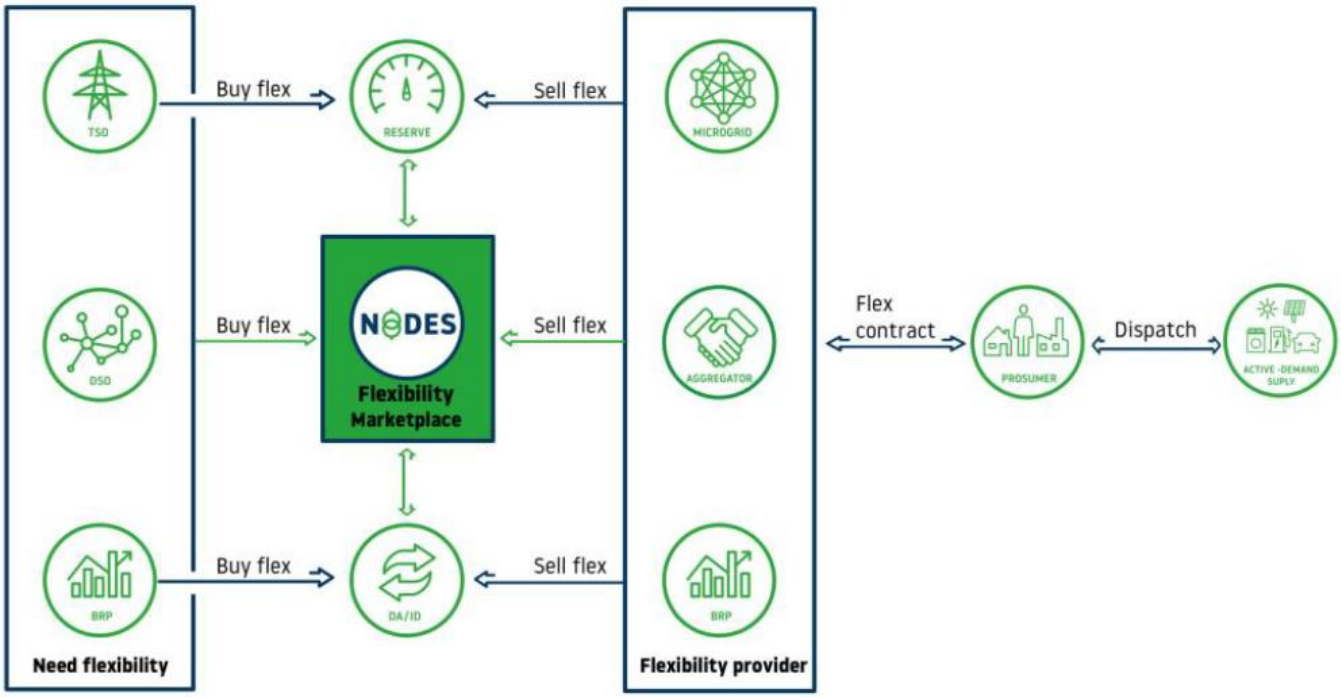

Figure 12: NODES market design

In providing a marketplace for local flexibility NODES' key objective is to ensure that identified flexibility can be used where it has the best value, whether this be in the DSO or TSO grid or for a Balance Responsible Party (BRP) that needs to rebalance its portfolio. By integrating the local flexibility market to existing intraday market and, in the future, reserve markets, NODES platform makes sure that the flexibility can be traded even if the local grid does not have an imminent need for the flexibility. In this way, the flexibility owner (Prosumer) and the

124 https://www.centrica.com/innovation/cornwall-local-energy-market

125 University of Exeter, Energy Policy Group, Barrier to Independent Aggregators in Europe: http://geography.exeter.ac.uk/media/universityofexeter/schoolofgeography/images/researchgroups/epg/Barriers_to_Independent_Aggregators_in_Europe.pdf

126 https://nodesmarket.com/

127 White paper, A fully integrated marketplace for flexibility, NODES: https://nodesmarket.com/2018/11/07/document-test/

Aggregator/BRP have a better chance of a good return-on-investment, thus incentivising flexibility providers to enable more flexibility in the system. Figure 13 illustrates the NODES market model.

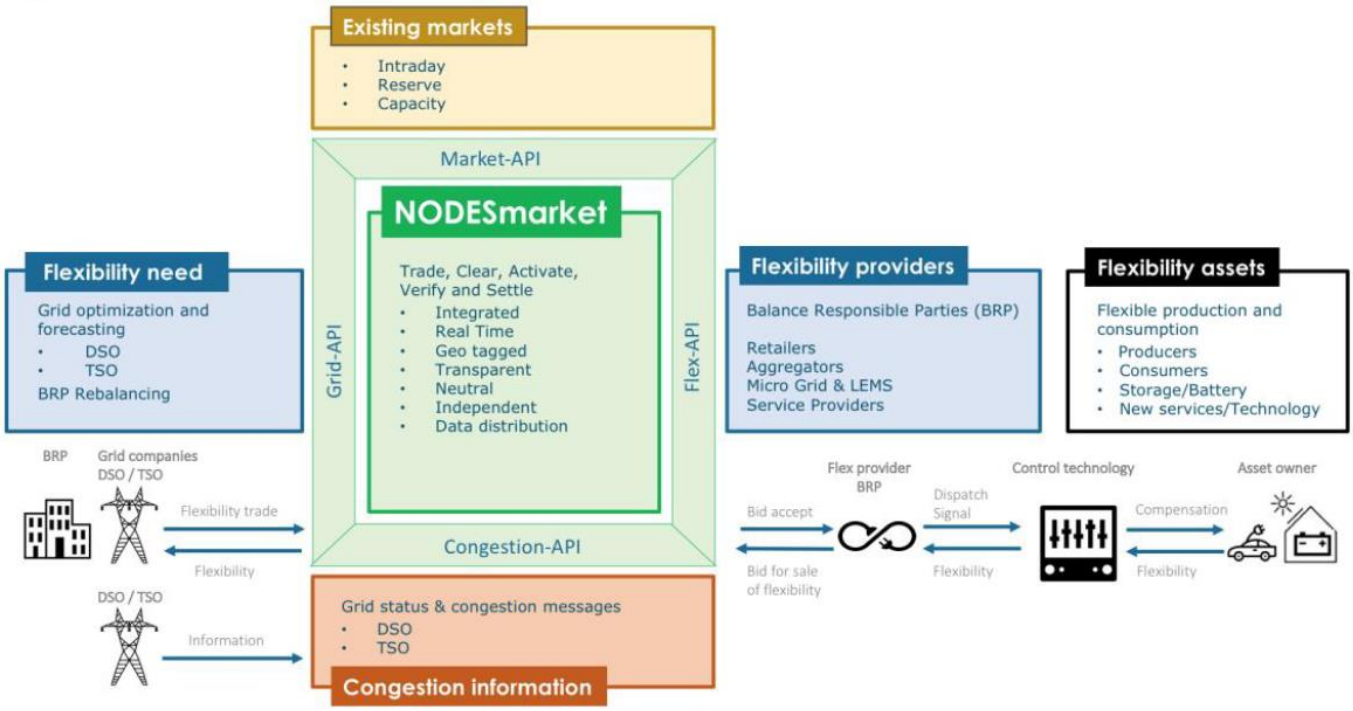

Figure 13: NODES market model

5.3 Fit analysis

5.3.1 DSO flexibility transactions

The fit analysis shows alignment between GB and USEF DSO flexibility transactions on the basic considerations for DSO flexibility products and processes:

- Both in GB and USEF, remuneration for flexibility services is based on capacity and/or energy payments. USEF products are hybrid, allowing a payment for the energy delivered through flexibility activation and a payment for the availability of flexible capacity. Most GB products are also hybrid, except for a few products that are energy-only or based on "arming" (i.e. keeping on standby) availability. Both these remuneration methods, however, can be supported by USEF arrangements.
- Both USEF and GB products require a high granularity of metered data for the validation and settlement processes. USEF assumes smart meter data communication in line with the metering resolution defined by the flexibility product requirements.

In a number of areas, the USEF framework provides more comprehensive arrangements to plan and manage the deployment of DSO flexibility services, above and beyond what current arrangements provide and what has been developed in the ENA ON project to date. USEF could add value in the following areas:

- USEF makes Aggregators an integral part of the planning process in providing flexibility to DSOs. It introduces the concept of D-programs, through which Aggregators active in congested DSO areas are obliged to inform the DSO on planned activations of flexibility (day-ahead and intra-day). Aggregators must also inform DSOs about any contracted flexibility capacity. USEF also proposes to extend this obligation to Suppliers for flexibility activated through implicit mechanisms. These interactions and information exchange are not currently included in GB DSO transactions, nor in ENA ON proposals. GB aggregators are only required to inform the DSOs about their availability and utilisation during the procurement and contractual arrangements.

D-plans are fundamental to USEF and facilitate better planning for DSOs to optimise the procurement and dispatch of flexibility.

- USEF introduces the concept of re-dispatch for congestion management to compensate for the effects on system balance of the local demand response activation. In USEF, the Aggregator, the Supplier and the DSO can perform re-dispatch. This concept has not yet been developed in GB DSO transaction arrangements and is essential for managing imbalances that are caused by the dispatch of flexibility.
- USEF allows "free bids" under short-term procurement, where there is no contractual obligation to offer the flexibility to the market and flexibility is provided on a day-to-day basis. Free bids allow flexibility providers a last-minute route to market, at a competitive price to DSOs, maximising the value to both flexibility providers and DSOs. In all GB products, as they have been designed to date, the DNO procures the flexibility service ahead of time and establishes bilateral contracts with the flexibility service providers. This is in line with USEF long-term availability contracts, where the activation of flexibility is prearranged in bilateral contracts awarded through tendering processes. Some DNOs (e.g. WPD) and the ENA ON project envisage the future flexibility market to progress towards near real-time operation and the window to set the contract price will be very short. This operation can be similar to the free bids market as proposed by USEF and provides a smooth transition to future, more liquid flexibility markets, where availability contracts may become obsolete.

The fit analysis has also identified that GB DNOs are considering restoration support services at distribution level, which USEF has not yet considered:

- USEF does not recognise restoration support services at DSO level, but only at TSO level. This is a service that could enhance the USEF flexibility value chain.
- USEF products do not distinguish between pre-fault and post-fault congestion management products. USEF was initially designed for low voltage networks where post-fault congestion management is not relevant due to the lack of n-1 resilience conditions. However, USEF allows for availability contracts which could also support post-fault products. USEF, though, does not currently support free bids in a post-fault product without additional requirements being put in place. For example, under current USEF arrangements free bids that are not activated are not remunerated. However, they do provide value in a post-fault product and therefore USEF could accommodate these GB products.

In addition, there are areas where GB and USEF have a defined, but conflicting view, which will need to be addressed, but do not prevent the implementation of USEF in GB:

- USEF proposes that penalties are applied in case of under-delivery. When the delivered energy is lower than the volume contracted, or when the test of availability of flexibility fails, then the Aggregator is penalised or disqualified. GB current flexibility services do not include any specific penalties other than loss of revenues and reputational impact in case of under-delivery. The ENA ON project only recently started considering the inclusion of penalties in the standardisation of flexibility products.[128]

  USEF proposes that penalties are necessary to ensure flexibility is as reliable as a grid reinforcement, at which point it becomes valuable to DSOs. Unreliable flexibility has no value to a DSO, or other flexibility buyers. Moreover, the aggregator is a market party and its main value driver is arbitrage. The aggregator will therefore always sell the energy to other market players where they provide a more economic alternative, even if the aggregator fails to deliver to the DSO. Therefore, the penalty should discourage any other arbitrage option, meaning that the penalty fee should exceed the balancing price.
- Baseline methodologies are different between USEF and GB DSO products. USEF's baseline for DSO transactions is the D-prognosis that is provided by the Aggregator, while in GB individual DNOs and the ENA

128 Stakeholder Workshop: Flexibility Market Principles (WS1A P1) & Commercial Arrangements (WS1A P4), 11/4/2019

ON have developed their own baseline methodologies. USEF's standardised baseline methodology ensures that settlement processes for flexibility services are implemented in a transparent and consistent way.

In addition, USEF proposes that the flexibility quantification (including the baseline methodology), used for product settlement, is the same that will be used in the Transfer of Energy to settle imbalances. Therefore, the baselining methodology will also apply to transactions between Aggregators and Suppliers. USEF's baselining methodology allows more types of demand-side resources to participate in the flexibility market and can provide a high accuracy, leading to more efficient and effective congestion management products.

5.3.2 Flexibility Platforms

USEF provides a reference architecture for explicit demand-side flexibility from the Prosumer to the Flexibility Requesting Party, which will facilitate the standardisation of interactions between the market platforms and grid management services. In GB, the majority of flexibility services and products are transacted on separate platforms with different functionalities, and there is currently no standard interaction between these platforms and system operators. For instance, NG ESO uses its own portal, whereas DNOs use commercial platforms such as Piclo Flex or their own, bespoke platforms.

A key feature in the USEF architecture is the regulated central data hub, where measurement and validation of flexibility transactions are performed and recorded. In GB, wholesale energy transactions are settled either bilaterally or through power exchanges. ELEXON is responsible for allocating electricity volumes for the imbalance settlement processes, including the validation and settlement of the Balancing Mechanism transactions. National Grid ESO is responsible for the settlement of non-BM balancing services and the payment of these services. DNOs are responsible for the validation and remuneration of flexibility associated with DNOs' flexibility transactions.

As a broad indicator of the status and direction of flexibility platforms in GB, the due diligence has mapped the functionality of three flexibility platforms that currently operate in GB against USEF's proposed reference architecture, showing that USEF's reference architecture is partly supported by existing flexibility market platforms.

Table 5: GB flexibility platforms mapping on USEF's reference architecture

	Piclo Flex	**Cornwall LEM**	**Nodes**
Market platform	Partially[129]	Yes	Yes
TSO – DSO coordination platform	No	Yes	Yes (subject to customer's request)
Market facilitation/central data hub	No	Yes	No
Technology platform	No	No	No
TSO/DSO operational platforms	No	Yes	No (TSO only)

[129] Only for matching of flexibility offers and requests, publication of product characteristics and publication of successful bids.

6 DETAILED MARKET ACCESS REQUIREMENTS

This section considers the requirements for aggregators or aggregated flexibility resources to access specific flexibility markets as well as on the commercial arrangements between aggregators and other market participants.

6.1 Requirements to access specific flexibility markets

6.1.1 Stacking of Flexibility Services

In USEF, the Aggregator can provide multiple services to one or multiple Flexible Request Parties (FRPs), from the same portfolio. This is an opportunity for value stacking under the following pathways:

- In time: Aggregators can participate in different services at different times of the day.
- Pooling: Aggregators can activate one asset for one service and another asset for another service. In this case, services can be delivered from a portfolio rather than a single unit.
- Dynamic pooling: This mechanism is similar to pooling but allows the Aggregator to decide which resources are used for a certain service up to real time.
- Double serving: The aggregator can use the same unit to provide multiple services to more than one FRPs during the same Imbalance Settlement Period.

Requirements and restrictions for value stacking include:

- Exclusivity agreements between the Aggregator and the FRP should be respected.
- Energy can only be sold once, which means that in case of double serving, the Aggregator cannot sell the same flexibility to more than one FRPs (without creating imbalance in its own perimeter).

In addition, the explicit demand response mechanism can still co-exist with implicit demand response schemes which operate under time-varying electricity prices or time-varying network grid tariffs.

In the **GB market**, stacking of services is possible, and depends on the service and the type of contract and/or procurement the provider is signed up to provide.

The Electricity System Operator (ESO) recently published a letter to trigger the review of exclusivity clauses within balancing services contracts, acknowledging the advantages of value stacking and the need of third parties, such as Distribution Network Operators (DNOs), to profit from these services. [130] Following the open letter, the ESO included some high-level principles of services and revenue stacking and initial options for flexibility value stacking in the ESO Balancing Services guide.[131]

The high-level principles according to the ESO are:

- "Security of Supply is maintained."
- "Providers can offer multiple services to multiple entities".
- "Assets can be contracted under two services in the same period if the requirements of each service are not conflicting".
- "Stacking is compatible with the Capacity Market Rules."

Initial options for service and revenue stacking as suggested by the ESO include:

- Flexibility providers with a single asset or portfolio of assets, operating across different Availability Windows can offer single or multiple services to single or multiple buyers, provided that they can deliver on their

[130] NG ESO Letter, Review of Exclusivity Clauses within Balancing Services Contracts: https://www.nationalgrideso.com/sites/eso/files/documents/Review%20of%20Exclusivity%20Clauses%20within%20Balancing%20Services%20Contracts%20Sep%202018.pdf

obligations under all contracts. It is the provider's responsibility to ensure that assets can perform as per the contract.

- A single asset or portfolio operating within one Availability Window can provide multiple services to multiple buyers if the requirements of these services are compatible and the provision of one service does not impede performance under an existing contract. For example, an asset or portfolio of assets provides active power services to the ESO and reactive power services to the DNO over the same time window.
- Multiple services can be provided to a single buyer by a single asset or portfolio of assets over an Availability Window, if the requirements of the services are compatible and if the provision of one service does not impede the ability to perform against an existing contract.
- A single active or reactive power service cannot be provided to multiple buyers over the same Availability Window, as this would result in the potential for double counting of MW or MVars. Also, once instructed by one Operator, the provider may become unavailable for the other.

Particularly, Table 6 and Table 7 show ESO balancing services that can be stacked across different Availability Windows and within the same Availability Window, respectively.[131] The tables show which services on the vertical axis can be stacked with the service on the horizontal axis, assuming that the flexibility provider has a contract for a service in the horizontal access.

Table 6: ESO balancing services that can be stacked across different Availability Windows

	Response products	Reserve products	Reactive power	Restauration - Black start	Balancing Mechanism	Capacity Market
Response products						
Reserve products						
Reactive power						
Restauration - Black start				N/A		
Balancing Mechanism					N/A	
Capacity Market			Service not listed as a Relevant Balancing Service under the CM rules	Service not listed as a Relevant Balancing Service under the CM rules		N/A

Stacking is possible

Not relevant service or further arrangements are required

Stacking is not possible

131 ESO: A guide to contractive, tendering and providing ESO balancing services, Dec 2018: https://www.nationalgrideso.com/sites/eso/files/documents/ESO%20Balancing%20Services%20Guidance%20Document%20V1.pdf

Table 7: ESO balancing services that can be stacked within an Availability Window

					Stacking is possible	
Response products	Electricity Forward Agreement (EFA) windows must align				Not relevant service or further arrangements are required	
Reserve products	Service not compatible				Stacking is not possible	
Reactive power						
Restoration - Black start				N/A		
Balancing Mechanism					N/A	
Capacity Market			Service not listed as a Relevant Balancing Service under the CM rules	Service not listed as a Relevant Balancing Service under the CM rules		N/A
	Response products	Reserve products	Reactive power	Restoration - Black start	Balancing Mechanism	Capacity Market

The ENA ON project also explores flexibility services stacking. In the ESO-DSO coordinated World B, flexibility sources can provide services to multiple SOs and are able to stack revenues. Aggregators will be able to stack revenues freely from different flexibility services at both distribution and transmission level and to aggregate their portfolio across DNO networks. Strong coordination between SOs will be required so that conflicts of services are resolved seamlessly for the Aggregator.

6.1.2 Combining implicit and explicit DSR

USEF considers that a flexible resource can be contracted simultaneously for some implicit and explicit Demand Side Response (DSR) services.

Table 8 provides feasible combinations according to USEF. The key requirement is that the resource's deployment under the implicit Demand Side Response (DSR) contract should be determined before activation of the explicit DSR contract, so that the relevant baseline(s) can be established accurately. If they coincide, it is impossible to determine whether the flexibility activation should be attributed to the Supplier (implicit DSR) or to the Aggregator (explicit DSR). If explicit DSR precedes implicit DSR, the impact of implicit DSR will be attributed to the Balance Responsible Party (BRP) of the Aggregator. In general, the combination is possible when implicit DSR precedes explicit DSR. However, even in that case, the Aggregator may decide to exclude resources with high load/generation volatility (because of the effects of implicit DSR) if the required baseline accuracy is not sufficient.

In the GB market, there are no formal restrictions for flexibility service providers to combine implicit and explicit flexibility services, although the service requirements for some products may preclude participation in others. In addition, even where it is technically feasible to combine services, the nature of some services might conflict and cause extra costs to the flexibility providers. For example, an electricity user providing Short Term Operating Reserve (STOR) by demand reduction may benefit from reduced Triad charges if the demand reduction due to a STOR call coincides with the Triad period. However, Triad charges may be increased if STOR load recovery coincides with a Triad period.

Table 8: USEF Possible combinations of implicit and explicit DSR[132]

Explicit DSR \ Implicit DSR	Single tariff Double tariff	Based (partly) on DA prices	Based (partly) on ID prices	Based (partly) on balancing prices
FCR				
aFRR				
mFRR				
National CM/ strategic reserves (through DA)				
National CM/ strategic reserves (dedicated)				
TSO Congestion management				
Day ahead trading				
Intraday trading				
Self-balancing / passive balancing				
Hedging/portfolio adequacy				
DSO Congestion management				
Voltage control				

Combination is possible
Combination is possible under certain conditions
Combination is not allowed/not possible

6.1.3 Measurement and validation

Flexibility services introduce new processes and therefore need specific requirements regarding measurement, validation, baseline methodology and the relationship between implicit and explicit Demand Side Flexibility.

6.1.3.1 USEF Requirements

USEF operational requirements for **measurement & validation** are defined as below:

- A flexible unit can only be operated by one Aggregator at a time. Contracts with different Aggregators should be sequential. If two or more Aggregators operate the same flexible resource at the same time, it is uncertain and complicated which operation control should take precedence. Also, it is not transparent how the activated flexibility should be allocated to the right Aggregator.

132 USEF Workstream on Aggregator Implementation Model: https://www.usef.energy/app/uploads/2017/09/Recommended-practices-for-DR-market-design-2.pdf

- A Prosumer can be managed by more than one Aggregator at the same time, provided the Aggregators operate a mutually exclusive set of resources. Sub-metering is required in this case to allocate the activated flexibility by each asset and to the right Aggregator.
- In case an Aggregator engages with a Prosumer at the main meter level, then the Prosumer should not be allowed to collaborate with another Aggregator during the contract period, which should also be defined in the contract.
- No regulation is required for the quantification of the flexibility that is delivered by the Prosumer to the Aggregator.
- If the baseline methodology of a flexibility service is provided by the Aggregator, the meter data which is used for calculating the baseline, can be collected by the Aggregator, provided the meter meets the technical requirements of the Transmission System Operator (TSO), Distribution System Operator (DSO) or Allocation Responsible Party (ARP).
- When a Prosumer enters into a flexibility contract with an Aggregator using a sub-meter, the need for the installation of an additional sub-meter should be avoided.
- The quantification of the delivered flexibility for TSO services is implemented by the TSO and for Balance Responsible Party (BRP) services (i.e. wholesale trading) by the ARP.
- As part of the separation of flexibility from supply there is a need to isolate the controllable asset that is used for demand response from the other assets at the Prosumer's site, thereby removing the responsibility from the Aggregator for the uncontrollable load. To this end, the Aggregator may apply sub-metering. Sub-metering also allows the Aggregator to operate different flexibility resources at the same Prosumer at the same time and serves additional purposes such as better quantification of Prosumer's performance towards the Aggregator, better quantification of Aggregator's performance towards the flexibility customer, better quantification of the activated flexibility as a basis for the transfer of energy.

USEF requirements for **baseline methodology**:

- The baseline methodology should be defined by the flexibility purchaser service for all the services except for the wholesale market services.
- In most cases of wholesale market services, the baseline methodology should be defined by the regulator. This baseline methodology is used for the Transfer of Energy, and only relates to the non-contractual, dual-BRP *Aggregator Implementation models (AIM)*, which are discussed in section 6.2
- Specific baseline methodology requirements for Frequency Containment Reserve (FCR) services include that the methodology should be a "Meter-Before/Meter-After" approach, where the baseline for each event is constant and equal to the most recent measurement. The measurement resolution is prescribed by the FCR product. The baseline should be determined at flexibility asset level.
- Baseline methodology for automatic Frequency Restauration Reserve (aFRR) should be based on rolling nomination by the aggregator for the settlement period. The nomination should be scaled to the most recent measured power level based on actual measurements. Resolution and time window of the nomination should be aligned with the product's characteristics. Nomination should be done at flexibility asset level.
- Manual Frequency Restauration Reserve (mFRR) baseline methodology is similar to the baseline for aFRR. The difference is that the baseline should be based on nomination by the Aggregator for the next Imbalance Settlement Periods (ISPs) and it should be frozen before or exactly after the notification signal.

6.1.3.2 GB Current Requirements

In the **GB market**, currently there are services in which the participation of aggregators and DSR is allowed and have been described in section 2. Detailed requirements for DSO flexibility services have been discussed in section

5. This section focuses on detailed requirements for TRIAD avoidance, the Balancing Mechanism (BM), the Capacity Market (CM) and the ESO Balancing Services (i.e. Firm Frequency Response, Demand Turn – Up, STOR, Fast Reserve).

TRIAD avoidance

TRIAD avoidance[133] [134]	
Category	**Description**
Service type	Implicit Mechanism for Transmission networks congestion management.
Delivery (availability of flexibility or activation of flexibility)	Activation of flexibility through price signals.
Remuneration type (energy or capacity based or both)	There is no payment for participation in TRIAD avoidance. The compensation for the transmission load reduction is reflected in the energy bill and particularly in the Transmission Network Use of System (TNUoS) charges of the energy bill for large or medium industrial and commercial customers. TNUoS charges are based on the average demand during the three TRIAD periods and multiplied by the tariff of the demand zone.
Measurement & Validation	HH metering (applicable to large or medium industrial and commercial customers). Domestic customers are not affected by Triads.
Baseline Methodology	N/A
Market Participation	Large or medium industrial and commercial customers can participate if their electricity supply contract allows the supplier to "pass-through" TNUoS costs.

Balancing Mechanism[135]

Balancing Mechanism (BM)	
Category	**Description**
Service type	Replacement Reserve
Delivery (availability of flexibility or activation of flexibility)	Activation of flexibility with energy transaction based on the activated volume.
Remuneration type (energy or capacity based or both)	Energy based, according to the contracted volumes during Bids and Offers processes.
Measurement & Validation	Operational metering data is sent to the ESO. The metering standards should be based to the BSC Codes of Practice (CoPs). BM participants with Balancing Mechanism Units (BM Units) send the data at Grid Supply Point (GSP) level. Aggregators are allowed to send aggregated data at Grid Supply Point Group level, following changes in the Balancing Settlement Code (BSC). The BSC currently only allows metering at the defined Boundary Point to be used for settlement purposes. However, with the future ability for consumers to participate in the BM and other alternative balancing products (following alignment of BSC with TERRE project), which will be

133 National Grid, Introduction to Triads: https://www.nationalgrid.com/sites/default/files/documents/44940-Triads%20Information.pdf

134 Ofgem Consultation, July 2018: https://www.ofgem.gov.uk/system/files/docs/2018/07/network_access_consultation_july_2018_-_final.pdf

135 National Grid, Wider access to the Balancing Mechanism Roadmap: https://www.nationalgrid.com/sites/default/files/documents/Wider%20BM%20Access%20Roadmap_FINAL.pdf

	settled under the BSC framework, there is a need to allow settlement from metering behind the Boundary Point at the asset which is delivering the Balancing Service. In that context, ELEXON is considering a BSC modification proposal P375.
Settlement	ELEXON
Portfolio conditions	To participate in the Balancing Mechanism, aggregators can register as Virtual Lead Parties with an aggregated Secondary Balancing Mechanism Unit (SBMU).[136] The service can be offered through a pool of assets. This modification (P344) will be active in December 2019.
Baseline Methodology	The Final Physical Notification, which is submitted at Gate closure is used as a baseline. For the settlement and validation process the metered data are compared against the FPNs. The FPNs are sent to the ESO. The ESO provides then the data to ELEXON which is used as a baseline for settling Bid Offers Acceptances. The Baseline methodology is currently under review (see section 6.1.3.2)
Market Participation	Participation is optional BM participants are required to have a contract with the ESO. Bids and Offers take place in half hourly settlement periods.
Minimum Entry Size	1MW

Capacity market[137] [138] [139] [140]

Capacity Market (CM)	
Category	**Description**
Service type	Adequacy Services
Delivery (availability of flexibility or activation of flexibility)	Availability of Flexibility
Remuneration type (energy or capacity based or both)	Capacity Based (capacity providers receive monthly payments for their agreed obligation at the auction clearing price.)
Measurement & Validation	Unproven DSR providers: DSR test one month prior to the delivery year at the latest, metering assessment 4 months prior to the delivery year at the latest, metering test (if required) 2 weeks before the delivery year. Proven DSR providers: DSR test certificate at prequalification stage, metering assessment, metering test. [141] Allowed metering and sub-metering arrangements include: 1. Metering arrangements used for Balancing Mechanism 2. Metering arrangements that are already used for Balancing Services

136 Introduction to Virtual Lead Parties, ELEXON: https://www.nationalgrideso.com/document/136281/download

137 NG EMR, Capacity Market Prequalification Guidance, September 2018: https://www.emrdeliverybody.com/Prequalification/CM%20Prequalification%20guidance%20v13.0%202018.pdf

138 EMRS Guidance, Capacity Market Metering, July 2018: https://www.emrsettlement.co.uk/documentstore/guidance/g1-capacity-market-metering.pdf

139 NG EMR, DSR Testing Process, June 2017: https://www.emrdeliverybody.com/Lists/Latest%20News/Attachments/107/DSR%20Test%20Guidance%20Document.pdf

140 https://gbcmn.nationalgrid.co.uk/faq/capacity-market-notices/what-is-a-capacity-market-notice-and-how-is-it-triggered

141 Capacity market metering, EMRS Guidance: https://www.emrsettlement.co.uk/documentstore/guidance/g1-capacity-market-metering.pdf

	3. Bespoke solutions where additional metering is required.
Settlement	EMR Settlement Ltd.
Portfolio conditions	Aggregators can participate with a portfolio of assets. Future changes in the capacity market will allow the components of a DSR Capacity Market Unit (CMU) to be altered/re-allocated during the delivery year. This would allow DSR aggregators to maintain the reliability of their portfolios. The proposals also intent to make mandatory metering tests only for the newly incorporated components instead of having to test the complete CMU.[142] The implementation of this proposal will provide more options to aggregators for flexibility stacking.
Baseline Methodology	The demand / generation during the test period is compared to the average demand / generation of the CMU over a DSR baseline period to reach the DSR test result. 16 data points are used in calculating the DSR baseline: The first 6 data points use data from the same settlement period on the same day of the week as the test date for the last 6 weeks. The remaining 10 data points depend on whether the DSR Test takes place on a working, or non-working day. If the DSR Test takes place on a working day, the relevant data points are from the last 10 working days. If the DSR Test takes place on a non-working day, the relevant data points are from the last 10 non-working days.
Market Participation	Participation is optional through auctions. The DSR provider must either be the DSR customer, or own the DSR customer or have a contractual control over the DSR Customer. Pre-qualification is required before entering the auction process.
Minimum Entry Size	2MW for DSR
Response Time	4 hours
Number of deployments	Providers are expected to be available to respond with their agreed generation volumes or load reductions when called on by National Grid at times of system stress.

ESO Balancing Services

Firm Frequency Response (FFR)* [143] [144] [145] [146]	
Category	**Description**
Service type	Frequency Containment Reservce (FCR)
Delivery (availability of flexibility or activation of flexibility)	Availability of flexibility
Remuneration type (energy or capacity based or both)	Capacity based and Energy based Availability Payments (£/h): Service providers are paid to make their unit/site available for the FRR service based on initial response and additional response.

142 Ofgem Letter on Capacity Market Rules, July 2018: https://www.ofgem.gov.uk/system/files/docs/2018/07/decision_on_amendments_to_the_capacity_market_rules_2014_004.pdf

143 NG Firm Frequency Response, FAQ: https://www.nationalgrideso.com/document/95581/download

144 NG FFR Agreement: https://www.nationalgrideso.com/document/93286/download

145 FFR Tender Rules and Standard Contract Terms, DEC 2018: https://www.nationalgrideso.com/document/93301/download

146 FFR Interactive guideline: https://www.nationalgrideso.com/document/103306/download

	Nomination fee (£/h): For being called upon to provide the service. Window initiation payment: For each nominated window in the tendered period Window revision payment: For any changes to the nominated window Response Energy Payment (£/MWh): Payment for energy delivered, for non-BM only.
Measurement & Validation	Telemetry on a second by second basis, or at National Grid's discretion, minute by minute. Aggregation of sub-units must take place so that a single demand meter feed is received for each contracted unit. Site meter level is used.
Settlement	NG ESO
Portfolio conditions	FFR can be offered as a single or aggregated unit, if there is a single dispatch point or a method in which the combined output can be monitored. Hence, aggregators can participate with a portfolio of asset provided that the sub-units have been tested before they can be part of a portfolio. This single or aggregated units are qualified as FFR units. At the same time, FFR units can be aggregated and allocated in different "Aggregated facilities". Following request to the ESO the re-allocation of FFR units can be done 25 times maximum in a 12-month period. In FFR tender rules and standard contract terms, it is specified that if the provider anticipates the unavailability of the contracted FFR unit, the provider can request – no later than two hours prior to Gate Closure of the relevant FFR services window - the substitution of the contracted FFR unit by another one in the same Grid Supply Point, specified in the Framework Agreement as substitute FFR unit. Following the request, National Grid shall either agree or decline the Once there is a contract in place for certain FFR unit, it is possible to stack extra volume to the FFR unit. The stacked volume can be tendered as normal if it complies with the initial contract window. The conditions under which assets can be combined in a FFR unit are not clear. Furthermore, pooling is hardly dynamic because National Grid needs to approve any substitution or re-allocation of FFR units.
Baseline Methodology	The performance is measured by the differences between demand/generation at the start of a sample period and its actual demand/generation. A new methodology, which is under trial, proposes using a forecast that captures the response of naturally variable baseline.
Market Participation	Monthly electronic tender. Framework agreement required. The unit/sub units must pass a pre-qualification assessment. Monthly tender process. Offer single or aggregated units/sites.
Minimum Entry Size	Minimum of 1 MW of generation or steady demand reduction. This can be aggregated from more than one site or smaller units.
Response time	Non-dynamic FFR: 30s or less Dynamic FFR - Primary: 2s or less Dynamic FFR - Secondary: 30s or less Dynamic FFR - High: 10s or less
Sustain time	Non-dynamic FFR: Max 30min Dynamic FFR - Primary: 20s Dynamic FFR - Secondary: 30min Dynamic FFR - High: Indefinitely unless otherwise agreed

Resource requirement	Metering equipment. Dispatch from aggregated units, must be done through a single point. No need to install systems to communicate with NG, however, metered data must be provided by e-mail on request.
Number of deployments	Non-dynamic: 10-30[147] per year (only activated for frequency deviation of 0.3Hz) Dynamic: Daily
Recovery period	No recovery period

** Note that NG ESO is currently considering new frequency response products that may replace FFR.* [148]

Demand Turn-Up (DTU)[149] [150] [151] - *currently discontinued by the NG ESO*	
Category	**Description**
Service type	Replacement Reserve (RR)
Delivery (availability of flexibility or activation of flexibility)	Activation of flexibility with energy transaction based on the requested volume
Remuneration type (energy or capacity based or both)	Energy and Capacity based Availability Payments (£/MW/h): service providers are paid to make their unit/site available for the DTU service within an Availability Window. These payments are only available for Fixed DTU providers. Utilisation Payments (£/MWh): service providers are paid for the energy delivered as instructed by National Grid. This payment is available to both Fixed and Optional DTU providers.
Measurement & Validation	Telemetry on a minute by minute basis or half hourly at site meter level.
Settlement	NG ESO
Portfolio conditions	DTU can be offered from a single unit or aggregated. Portfolio participation is allowed through pooling. DTU providers need to report their availability one week in advance, a requirement which excludes dynamic pooling participation.
Baseline Methodology	For settlement of utilisation payment, the aggregator can choose between "baseline methodology" or "forecast methodology" to the energy delivered.[152] - Baseline methodology: Baseline is determined by calculating the average of the generation/demand for the equivalent settlement periods in the relevant month not affected by plan outage. - Forecast methodology: It is derived from the forecast data for a relevant settlement period and adjusted by multiplying the relevant value by a fraction, the numerator of which is the actual metered demand/generation output and the denominator of which is the forecast demand / forecast generation in each case in respect of the two settlement periods immediately prior to the

147 Average number of times call on per year based on NGSO data: http://powerresponsive.com/wp-content/uploads/pdf/Power%20Responsive%20Guide%20-%20v8.pdf

148 https://www.nationalgrideso.com/document/138861/download

149 https://www.nationalgrideso.com/balancing-services/reserve-services/demand-turn?technical-requirements

150 DTU, Balancing Services Agreement: https://www.nationalgrideso.com/document/109956/download

151 DTU, Interactive Guidance document: https://www.nationalgrideso.com/document/88466/download

152 Optional DTU Balancing Service Agreement: https://www.nationalgrideso.com/document/109956/download

	first settlement period on the day subject to delivery.
Market Participation	Providers can participate in tenders as Fixed DTU or Optional DTU. Optional DTU offers the possibility of changing payments according to market conditions. No testing requirements before the tendering. Periodic tender process. Offer single or aggregated units/sites.
Minimum Entry Size	Minimum of 1 MW for a single unit or aggregated sites. Minimum of 0.1 MW for any site that is aggregated.
Response time	Linked to individual providers' capabilities. The average notice period for an instruction was 6 hours and 6 minutes in 2018.
Sustain time	Average in 2018 was 4h and 36min. However, it is linked to how capable the providers declare themselves in the contract.
Resource requirement	Metering equipment, mobile phone/landline and access to email.
Number of deployments	N/A

Short Term Operating Reserve (STOR) [153] [154] [155] [156]	
Category	**Description**
Service type	Replacement Reserve (RR)
Delivery (availability of flexibility or activation of flexibility)	Activation of flexibility with energy transaction based on the requested volume
Remuneration type (energy or capacity based or both)	Energy and Capacity based Availability Payments (£/MW/h): service providers are paid to make their unit/site available for the STOR service within an Availability Window. Utilisation Payments (£/MWh): service providers are paid for the energy delivered as instructed by National Grid. This includes the energy delivered in ramping up to and down from the contracted MW level. For BM service providers, this payment will be settled through the Balancing Mechanism. Optional Fee – Where STOR is utilised outside of the contracted windows, then the optional price is paid. The optional price does not need to be the same as the utilisation price. This will be entered as £/MWh in the tender.
Measurement & Validation	Telemetry on a minute by minute basis Aggregation of sub-units must take place so that a single demand meter feed is received for each contracted STOR unit. Site meter level is used of high accuracy standards that are equal or exceed the Codes of Practice guidance – although CoP standards are not required. [157]
Settlement	NG ESO

153 STOR, General Description of the Service, April 2017: https://www.nationalgrideso.com/document/85441/download

154 https://www.nationalgrideso.com/balancing-services/reserve-services/short-term-operating-reserve-stor?technical-requirements

155 National Grid, SRD Interface Technical Reference, User Manual: https://www.nationalgrideso.com/document/88456/download

156 National Grid, STOR, Interactive Guidance, Jan 2018: https://www.nationalgrideso.com/document/115786/download

157 https://www.ELEXON.co.uk/documents/change/modifications/p351-p400/p375-proposal-form/

Portfolio conditions	STOR can be provided in a single or an aggregated unit, allowing portfolio participation. [158] The aggregated assets composing the sub-unit can either be located at the same connection point or in more than one common connection point.[159] STOR can be offered as a flexible service, allowing the flexibility provider to choose whether to offer STOR a week in advance. Substituting a STOR unit needs approval from National Grid. It is unclear from the documentation whether there is flexibility in changing the assets/sites composing a STOR unit. Pooling is allowed, but dynamic pooling is limited.
Baseline Methodology	Baseline for the BM participants is the FPN (Final Physical Notification) for the specific settlement period. Baseline for non-BM participants is the base load that is estimated by the participant based on a specified ESO methodology: "Base load MW is typically calculated as the average metered MW for the 3 minutes before the instruction issue time and metered MW at instruction issue."[160]
Market Participation	No testing requirements before the tendering. Periodic tender process. Offer single or aggregated units/sites
Minimum Entry Size	Offer a minimum of 3 MW of generation or steady demand reduction. This can be aggregated from more than one site
Response time	240 minutes or less, although response time within 20 minutes are preferable
Sustain time	2-4 hours (Typically less than 20 min)
Stacking (this has probably been covered in the other section)	Stacking is not possible at the same time as STOR provision. It is possible outside of STOR contracted availability windows.
Ramp time	Specified in tendering process
Resource requirement	STOR dispatch PC connected equipment to a central server owned, operated and supplied by NG ESO & metering equipment
Number of deployments	Able to deliver 3 times per week
Recovery period	1200 minutes

Fast Reserve[161] [162]	
Category	**Description**
Service type	Manual Frequency Restoration Reserve (mFRR)
Delivery (availability of flexibility or activation of flexibility)	Activation of flexibility with energy transaction based on the requested volume

158 STOR interactive guideline: https://www.nationalgrideso.com/document/115786/download

159 STOR Standard Contract Terms: https://www.nationalgrideso.com/sites/eso/files/documents/STOR%20SCTs%20-%20Issue%2011.pdf

160 Ancillary Service Settlement Guide, Short Term Operating Reserve (STOR): https://www.nationalgrideso.com/document/85536/download

161 National Grid, Guide to Fast Reserve, https://www.nationalgrideso.com/document/92411/download

162 https://www.nationalgrideso.com/balancing-services/reserve-services/fast-reserve

Remuneration type (energy or capacity based or both)	Energy and Capacity based Availability Payments (£/h): service providers are paid to make their unit/site available for the service within the Tendered Service Period. Utilisation Payments (£/MWh): service providers are paid for the energy delivered as instructed by National Grid. Nomination or positional fee (£/h): Paid for being called upon to provide services within a FR nomination window.
Measurement & Validation	Telemetry on a minute by minute basis. Site meter level is used.
Settlement	NG ESO
Portfolio conditions	FR is similar to STOR, but with higher minimum volume, 50 MW, from a single or aggregated unit. There is no limit on the number of sub-units to facilitate aggregators to access the service.[163] Therefore, pooling is allowed limited dynamics.
Market Participation	Participation can be done in Firm or Optional service. With optional service, the framework agreement does not put obligations in monthly tender participation. Pre-qualification needed. Periodic tender process. Offer single or aggregated units/sites
Minimum Entry Size	Offer a minimum of 50 MW of generation or steady demand reduction. This can be aggregated from more than one site
Response time	2 minutes or less
Sustain time	15 minutes or more
Stacking (this has probably been covered in the other section)	Exclusive for the tendered availability windows
Ramp time	25MW/minute
Resource requirement	Metering equipment

Penalties in case of non-delivery or under delivery of the ESO balancing services are imposed by the ESO and are associated with repaying payments that have been made for service availability and/or utilisation. In addition, under-delivery or non-delivery may prohibit the future participation of the flexibility provider in the balancing service. According to the ESO, maximum penalties for non-delivery tend to equal the value of the contract entered into.

6.1.3.3 GB Future Requirements

Metering Requirements

Measurement level requirements are currently being reviewed by both NG ESO and ELEXON through the "Residential Response" project and the BSC P375 modification, respectively.

The ESO project "Residential Response" is developing new approaches for testing, monitoring and managing portfolios of residential-scale assets for participation in ESO Balancing Services. One of the project key

163 Fast reserve aggregators open letter: https://www.nationalgrideso.com/document/88781/download

deliverables is to "evaluate, develop, and test options for measuring power and frequency that meet NG ESO requirements for verifying service provision."[164]

The purpose of the BSC P375 modification is to *"settle Secondary Balancing Mechanism (BM) Units using metering equipment behind the defined Boundary Point for Balancing Services (known as 'behind the Meter'), rather than settling using Metering Equipment at the Boundary Point as per current BSC obligations."* This modification will separate balancing-related services on site from imbalance-related activities, such that energy volumes provided to balancing services will be accurately reflected in the metering data. The BSC P375 modification will facilitate the participation of Virtual Lead Parties (independent aggregators or consumers) to the Balancing Mechanism and TERRE. This modification is required as the BSC currently only allows metering at the boundary level of the site to be used for settlement purposes. However, *"with the future ability for consumers to participate in the BM and other alternative balancing products, which will be settled under the BSC framework, there is a need to allow Settlement from metering behind the Boundary Point at the asset which is delivering the Balancing Service."* As such, the Virtual Lead Parties will be allowed to install their own settlement metering located in close proximity to the flexibility asset, in order to measure the volume of balancing energy provided by the asset. If a site uses an existing sub-metering for other balancing services or the Capacity Market this can also be used for settlement purposes, only if the metering standards are equivalent or higher than the settlement standards.[165]

According to ELEXON, this modification will also facilitate the arrangements of balancing services provided by one consumer owning multiple assets through multiple aggregators. Potential sub-metering solutions are under consideration by ELEXON and further updates are expected to be available within 2019.

Baselining methodology

As the due diligence has indicated, the baseline used by the majority of ESO balancing services is set based on the behaviour of the flexibility assets prior to instruction for flexibility provision. However, the baselining methodology applied in the Balancing Mechanism and ESO balancing services is currently under review by NG ESO. NG ESO is planning to trial an alternative approach to baseline Firm Frequency Response (FFR) and envisages to develop a consistent methodology for all balancing services.

The "Wider BM Access Roadmap" sets out the NG ESO's commitment to support industry to develop a baselining mechanism that could replace current processes and facilitate participation of additional flexibility providers and independent aggregators to the Balancing Mechanism.[166] In this context, ELEXON's BSC P376 Modification proposes to "*allow the Final Physical Notification* (FPN)*, which feeds into the Settlement of Trading Charges, to be created via a Baselining Methodology. The new Physical Notification will be de-coupled from the Physical Notification used by National Electricity Transmission System Operator (NETSO) for dispatch. This change will allow Balancing Service Providers to be fully recompensed for their actual change from normal usage and the impact this change has on the system, thus enabling greater participation."* The BSC P376 modification was driven by the fact that FPN submission could become problematic for independent aggregators whose assets share network connections with other types of demand or generation. Inaccurate Physical Notifications may lead to incorrect payments to customers for flexibility provision. In practice, this modification proposes that the settlement and calculation of non-delivery volumes will utilise a baseline value that will be calculated based on historic metered data and using a transparent and objective methodology, rather than using the FPN submitted to National Grid ESO by the Virtual Lead Party for purposes of dispatch. As such, the FPNs for dispatch will be decoupled from the baseline value used for settlement so that the most suitable method can be used for each purpose.[167]

164 http://www.smarternetworks.org/project/nia_ngso0025

165 BSC Modification Proposal Form P375: https://www.ELEXON.co.uk/documents/change/modifications/p351-p400/p375-proposal-form/

166 Wider Access to the Balancing Mechanism Roadmap

167 BSC Modification Proposal Form P376: https://www.ELEXON.co.uk/documents/change/modifications/p351-p400/p376-proposal-form/

6.2 Facilitating access for commercial aggregators

As the GB energy system evolves, with traditional roles changing and new roles emerging, the role of commercial aggregators also evolves. This section describes USEF's possible market models for the Aggregator role, referred to as Aggregator Implementation Models (AIMs), and which set out the Aggregator's relation to the Supplier and the Balance Responsible Party (BRP) in organising balance responsibility, transfer of energy and information exchange. This section also describes existing and potential future arrangements in GB between the aggregator and other market participants, to the extent that they have been developed.

6.2.1 USEF

When implementing an aggregation model, several aspects must be considered:

- Firstly, USEF separates flexibility from supply. The Aggregator should take the responsibility for the flexibility, yet the energy supply remains the responsibility of the Supplier. Therefore, the responsibilities of the Aggregator are limited to the activation period, to assets that are activated by the Aggregator and to the deviation of these assets during the activation period from their baselines. Also, the Aggregator should compensate the Supplier and the BRP for DSR activation effects.
- In addition, the controllable asset that is used to provide flexibility should be isolated from other assets of the Prosumer, so that the Aggregator is only responsible for the controllable load (or generation). Sub-metering might be required or should at least be supported.
- A third point to be considered for Aggregators' access to the market is whether Prosumers can have contracts with more than one Supplier and whether the roles of the Aggregator, the Supplier and potentially the BRP are combined or can be performed in isolation.

USEF has developed the AIMs in an effort to answer the following questions:

1. Are the roles of the Supplier and Aggregator combined in a single market party?
2. Does the Aggregator need to assign its own Balance Responsible Party for its portfolio?
3. Does the Aggregator need a contract with the Supplier?
4. Do we need a Transfer of Energy to correct the open position of the Supplier? If so, how is energy transferred?

Figure 14 gives a two by two classification scheme on the second and third question and further differentiate by the forth question. The only model where the roles are combined in a single party is the integrated model. In all other models the roles are performed by different market parties. The integrated model is considered to be a contractual model because when the roles are combined, operational agreements between the roles are also required.

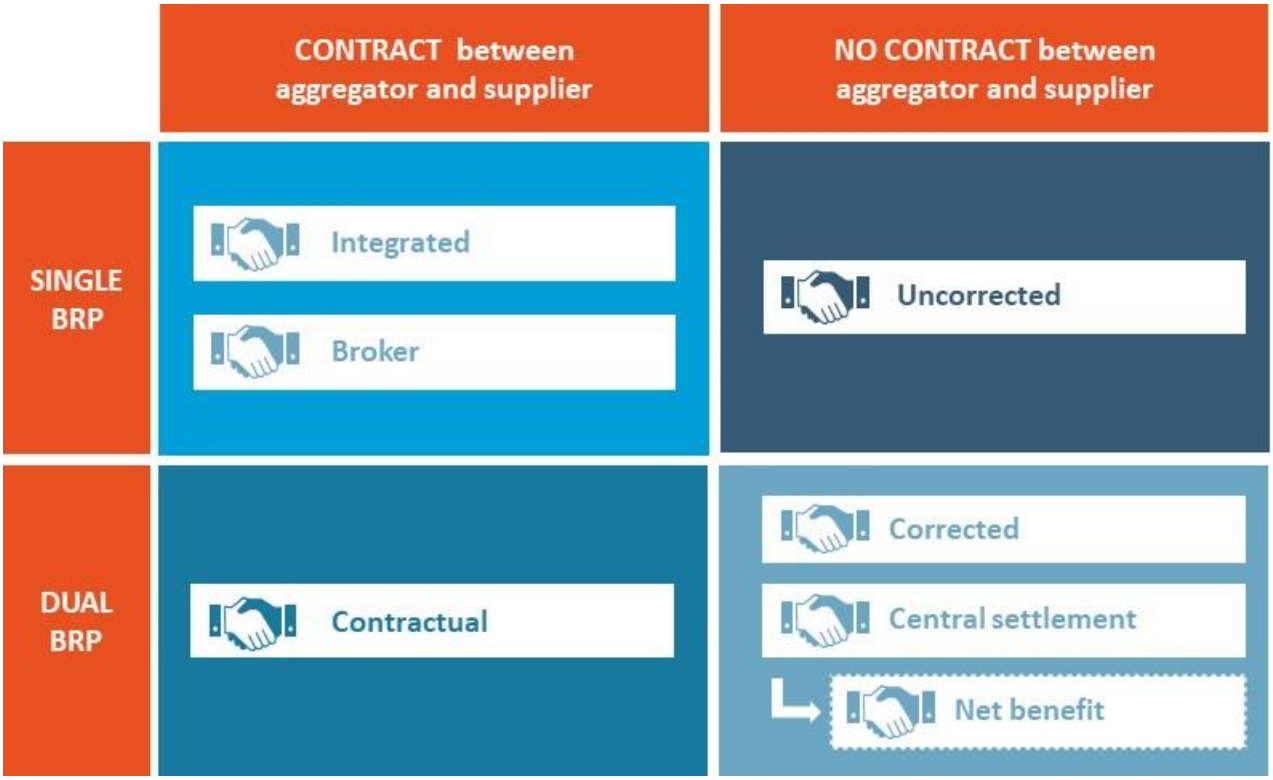

Figure 14: USEF Aggregator Model Classification scheme

In summary, USEF defines seven models to describe how prospective Aggregators can access the market:

1. **Integrated model:** The roles of Supplier and Aggregator are combined in one market party. Compensation for imbalances and the open supply position are not necessary. The Supplier/Aggregator has a contract with the Prosumer, selling energy and buying flexibility as per their contract. The Integrated Model is considered the "default" option.

2. **Broker model:** The Aggregator transfers the balance responsibility to the supplier's BRP. Compensations for open supply position and imbalances are settled based on contractual arrangements. The Aggregator has a bilateral contract with the Supplier or the BRP of the Supplier and transfers its balancing responsibility for the flexibility to the BRP of the Supplier.

3. **Contractual model**: The Aggregator associates with his own BRP. Balances are corrected through a hub-deal (ex-post) between the BRP of the Aggregator and the BRP of the Supplier and Transfer of Energy prices are based on contractual arrangements. The Aggregator has a contract with a BRP to enter energy markets and to cover imbalance and a contract with the Supplier for the Transfer of Energy. The BRPagr holds responsibility for the flexibility during activation period, as it needs to balance the sold energy with the energy sourced through the hub-deal. Aggregator will source the energy ex-post from BRPsup through a hub-deal. Sourcing volume equals the difference between measurement and baseline. A price formula needs to be agreed upon, preferably using a standardized method.

4. **Uncorrected model:** In this case, the activated volume is settled through the regular balancing mechanism. There are no energy transfers between the aggregator and the supplier, nor does the aggregator need to assign balance responsibility. BRPsup is remunerated through the regular balancing mechanism for energy that sourced but not used, if passively contributing to balance restoration is incentivised by the balancing mechanism. If the Aggregator is active on balancing or adequacy services, the remuneration takes place against (in general favourable) balancing prices.

5. **Corrected model:** In this model, the profile of the Prosumer is modified based on the amount of the flexibility that has been activated by the Aggregator. The remuneration takes place through the Prosumer based on retail prices. The Aggregator assigns its own BRP, the Allocation Responsible Party corrects the perimeter of the Aggregator's BRP based on the activated volumes.

6. **Central settlement model:** In this model, a central entity (the ARP) corrects the perimeters of both the BRP of the supplier and the BRP of the aggregator by transferring energy from one to each other. This results in no imbalance positions for the BRPs caused by the activation of flexibility and there is no direct Transfer of Energy between the Aggregator and the Supplier. In addition, the ARP settles financially the supplier for its open position based on a predefined price formula, applied to the energy that the Aggregator activated from the supplier's portfolio.

7. **Net benefit model**: Similar to the central settlement model, in the net benefit model the ARP corrects balancing perimeters and settles the compensation for the open supply model. The cost of this compensation is socialized if certain conditions are met. For example, in the US, a net-benefit test determines the price level from which the cost gets socialized. The Aggregator compensates alternatively the Supplier for price levels below price level which was determined by the net-benefit test.

It is worth noting that USEF does not endorse any of the seven models. USEF only defines and describes the models and the potential arrangements between the Aggregator, the BRP and the supplier. Ultimately, USEF's AIMs provide options to integrate demand-side flexibility in all relevant markets and products.[168]

6.2.2 Great Britain

Wider participation of Aggregators and DSR in GB energy markets is one of the priorities in Ofgem's and BEIS plans. However, there are still elements that need to be defined and designed such as balancing responsibility and delivery risk. Under current arrangements, suppliers can be exposed to delivery/imbalance risks due to the independent aggregator's activity. Ofgem has already raised these concerns in an Open Letter and in the Smart Systems and Flexibility Plan, and has suggested that the balancing' costs and delivery risks must be borne by the parties that created them, meaning in this case, the aggregator. [169]

Currently, there are 19 commercial aggregator companies in GB listed by National Grid, of which only 9 are registered as independent aggregators, whereas the others are registered as suppliers or in partnership with a supplier. [170] The recent change in the grid code and BSC, previously mentioned in Section 2.2.3, allows the participation of independent aggregators in the Balancing Mechanism (BM) without the supplier license by registering as a Virtual Lead Party (VLP). Under the Electricity Balancing Guideline (EB GL) definition, VLPs fall under the definition of BSPs and not under BRP, thus VLPs do not have balancing responsibility. VLPs are required to submit Half Hourly (HH) delivered volumes for each Metering System Identifier (MSID) pair notified to settlement.[171] In this way, ELEXON can calculate an adjustment and correct the supplier's perimeter. Thus, the supplier is not responsible for the activated volume by the aggregators working in their perimeter. Regarding non-delivery, ELEXON will artificially alter the balance position of the VLP to expose them to the imbalance costs. On the contrary, the imbalance caused by over-delivery is born by the supplier, or supplier's BRP. [172] [136]

Taking into account the above-mentioned considerations, several USEF AIMs are in place in GB. Uncorrected Model is applied for aggregators offering ancillary services; the ESO is responsible for the settlement of the ancillary services only but the aggregator does not have any balancing responsibility. ELEXON performs the imbalance

168 USEF Workstream on Aggregator Implementation Models

169 Ofgem's views on design for independent aggregators in energy markets, July 2017: https://www.ofgem.gov.uk/system/files/docs/2017/07/ofgem_s_views_on_the_design_of_arrangements_to_accomodate_independent_aggregators_in_energy_markets.pdf

170 https://www.nationalgrideso.com/balancing-services/demand-side-response-dsr

171 https://www.ELEXON.co.uk/group/p344-iwg4-virtual-lead-party-processes/

172 Virtual Lead Party Webinar Q&A: https://www.nationalgrideso.com/document/137181/download

settlement for the activated volume through the regular imbalance settlement mechanism. The Integrated Model is in place when a supplier and an aggregator are combined in a single market party. This would be the case of aggregators with supplier license participating in the BM and CM.

Following December 2019 and the introduction of the VLP in BM and TERRE, elements from the Central Settlement and the Broker Model will be found in GB arrangements. ELEXON corrects the perimeter of all involved Suppliers (pro rata to their share in the Aggregator's portfolio), thus avoiding imbalances caused by the volume activated by the VLP. Unlike the Central Settlement model, the foreseen arrangement does not charge the VLP for sourcing the energy from the supplier. The common element of these arrangements with the Broker Model is that the full balance responsibility of the connection lies in the BRP of the supplier, although GB VLPs do not necessarily have a bilateral agreement with their customer's supplier (BRP's supplier).

Ofgem is considering future changes in regulation so aggregators bear the imbalance cost. Particularly, Ofgem considers necessary that formation of independent aggregator bids and offers are supported by arrangements that allow for payments to cover the cost of energy sold by the independent aggregator, but initially sourced by the supplier.[169] This approach resembles USEF's Corrected model, in which the aggregator holds balance responsibility and compensates the prosumer for the activation of flexibility, keeping intact the balance position of the supplier. This model could be effective for non-domestic customers, but it is uncertain whether it would apply for the residential consumers.

6.3 Fit analysis

The fit analysis on market access requirements finds that both in the GB market and in USEF it is possible to combine explicit and implicit flexibility services. USEF imposes some restrictions on which combinations are possible, however the general concept of implicit and explicit services aligns in both frameworks.

The analysis has identified the following areas where USEF adds to GB market access requirements:

- Stacking of flexibility services is generally possible both in GB and USEF, as well as being considered by DNOs and the ENA ON project for DSO flexibility services. USEF allows all types of flexibility stacking, such as "in time", "double serving", "pooling" and "dynamic pooling." ESO balancing services allow "in time" and "double serving" stacking of flexibility services, so long as requirements for each service are not in conflict. In addition, the same assets can be used in different flexibility services; however, once an individual asset has been confirmed to provide a service, it cannot be freed up, or substituted, in real time in GB. Hence, "pooling" is possible while "dynamic pooling" is limited in GB because of complex processes to re-allocate assets/units.
- A USEF Prosumer can contract with, and be operated by, multiple Aggregators at the same time, although each Aggregator should operate a mutually exclusive set of resources. Sub-metering is therefore required to allocate flexibility from each asset and to each Aggregator. On the other hand, a flexible unit can only be operated by one Aggregator at a time and should be contracted accordingly. There are currently no GB arrangements to cover the coordination of multiple aggregators working with a single prosumer. Future arrangements will accommodate the option for a prosumer to contract with, and be operated by, multiple aggregators, with each aggregator operating a different asset of the prosumer.
- GB Balancing products require high-resolution measurements at site meter level or sub-metering (e.g. STOR requirements) and the Capacity Market allows sub-metering where required. Under current Balancing Mechanism and imbalance settlement arrangements, sub-metering is not permitted as ELEXON only considers valid measurements taken from the main meter at the boundary point. In the future, BSC modification P375 may allow aggregators/VLPs to install their own settlement sub-metering, located in close proximity to the flexibility asset, to measure the volume of balancing energy provided by the asset. USEF considers sub-metering essential for independent aggregation, and proposes that Aggregators should be allowed to apply sub-metering for all flexibility services to enable the settlement process.

- In USEF, the Flexibility Requesting Party (e.g. ESO, DSO) defines the baselining methodology for all flexibility services except for wholesale market services. For the wholesale market services, USEF proposes that the regulatory authority (Ofgem in GB) is responsible for defining or approving the baseline methodology for the Transfer of Energy (ToE). This baseline methodology only relates to the non-contractual, dual-BRP Aggregator Implementation models (AIM). In GB, the concept of ToE is not yet in place and therefore a baselining methodology has not yet been defined. Baselining methodologies for all other flexibility services are set by the flexibility requesting party which aligns with USEF.

The USEF Aggregator Implementation Models (AIMs) can also add value and innovative elements to the GB arrangements associated with the future role of aggregators, balance responsibility and the settlement of imbalances between the market participants. The fit analysis does not recommend AIMs that should be used in GB, but highlights which USEF models are already applied or could be applied in the future:

- Under current GB arrangements, the equivalent of the USEF Uncorrected Model is applied to aggregators offering ancillary services to the ESO. The USEF Integrated Model is in place where a supplier and an aggregator are combined in a single market party, i.e. aggregators with a supplier licence participating in the BM and CM.
- In the future, aggregators acting as Virtual Lead Parties (VLPs) will be able to participate in the Balancing Mechanism and TERRE products. ELEXON envisages that VLPs will not be responsible for their balance position. ELEXON will perform perimeter corrections to protect suppliers from the imbalance caused by aggregators/VLPs. The perimeter corrections will be adjusted to the supplier's share in the aggregator's portfolio. These arrangements are similar to USEF's Central Settlement Model, with the difference that in the Central Settlement Model the Aggregator is charged for sourcing the energy from the Supplier. In addition, the BM and TERRE settlement arrangements have a common element with the Broker Model: full balance responsibility of the connection lies in the Supplier (or the BRP of the supplier). In USEF, aggregators have a bilateral agreement with their customer's supplier (or its BRP), which is not the case for the VLPs.
- Ofgem is considering the Corrected Model to solve the energy sourcing issue. Under these arrangements, the formation of independent aggregators' bids and offers is supported by mechanisms that allow for payments to cover the cost of energy sold by independent aggregators, but initially sourced by the supplier. However, according to USEF this option could complicate arrangements for residential customers since the remuneration of the supplier would be done through residential customers (the Prosumers).

7 PRIVACY, CYBERSECURITY & COMMUNICATION REQUIREMENTS

USEF defines a message exchange protocol for flexibility coordination processes and provides guidelines for the management of data and communication, as well as for privacy and cybersecurity considerations. This section investigates whether relevant GB regulation and legislation and the USEF protocol and guidelines are compatible.

7.1 USEF Privacy, Cybersecurity & Communication Requirements

7.1.1 USEF Privacy & Cybersecurity Guidelines

This section describes the nine principles, which USEF proposes for privacy and cybersecurity. The USEF framework is based on security by design which is a default approach for Operators of Essential Services (OES).[173]

7.1.1.1 Privacy-value creation trade-offs

Individuals and business can both benefit from sharing certain privacy sensitive data, such as the benefits from providing tailor-made services to the end-user or more efficient management of the energy system. These legitimate interests and objectives have various management requirements, which are described in the following sections.

7.1.1.2 Data management

Data management in smart energy systems includes the collection, storing, retention, processing and sharing of data, information and knowledge through aggregation, anonymization and profiling techniques. The principles for data management broadly fall into two main categories; the first one consists of "Minimum Disclosure" principles, the second one of "Ethic of Knowledge" principles.

Minimum Disclosure Principles are data management principles related to the end-user performing the role of Data Subject.[174] The principles have a conservative basis that questions the trust between the Data Subject and the peer, meaning that the Data Subject only accepts to disclose data if:

- Data is required for fulfilling the service; and
- Disclosure provides value for the data subject.

The Ethic of Knowledge principles refer to the usage of data by the Data Collector, who follows specific ethics on retrieving and using data. These principles apply to the operator(s) of the IT infrastructure.

The data management principles described in this section are based on consent between the Data Collector and the Data subject, data minimization and protection against unwanted profiling. These principles provide a solid framework for creating trust between the involved parties.

The USEF guidelines specify the following principles for data management:

1. A data policy governs all data in a smart energy system;
2. All personal data in a smart energy system is subject to a data protection impact assessment;
3. Data management is designed in a technology and implementation agnostic way, using open standards wherever possible;
4. Disclosure of data is agreed upon in a transparent way by an explicit agreement between the actors;
5. Data are processed as much as possible on the Data Subject side;
6. The collected data is fit for purpose;

173 https://www.itgovernance.co.uk/nis-regulations-oes-operators-essential-services

174 A data subject is any person whose personal data is being collected, held or processed.

7. The Data Controller is responsible for the protection of collected data;
8. The Data Controller allows the Data Subject control over its personal data;
9. Anonymous data is not de-anonymized;
10. Data retention time is specified and motivated;
11. Information and Knowledge computed from a single Data Subject is considered to be Personal Data; and
12. Knowledge created from aggregated heterogeneous data is owned by its creator.

7.1.1.3 Data communication

Data communication refers to the data exchange between two entities: the sender and the receiver. The sender and receiver require a channel to communicate, which is created by means of a medium connecting sender and receiver. Effective communication requires the sender and receiver to agree on how to set up a connection over the channel, how to transport data in a secure way over the connection and how to interpret that data.

Smart energy systems, as defined in USEF, critically depend on trusted and reliable data communication. The communication should not have a negative impact on the quality of the data, not third parties should be able to intercept the data. To achieve this, both the communication channel and the data itself must be secured. During the data exchange the sending and receiving parties should be able to verify each other's identity and the receiver of the data must be assured of the integrity of the data. To increase robustness of smart energy systems, data communication between roles must be resilient.

The principles described in this section focus on the privacy & security requirements for data communication between the various roles in smart energy systems.

USEF applies the following principles for data communication:

1. The communication channel between source and destination does not contain intermediary nodes where the data needs to be disclosed;
2. Data secures itself;
3. Message encryption is based on a proven, independently validated cryptographic scheme;
4. Data communication between roles is controlled;
5. Parties that exchange data are able to identify each other;
6. The receiver is able to verify the integrity of data;
7. Security aspects of the individual data streams are subject to the security aspects of the system; and
8. Data communication between roles is resilient.

7.1.1.4 Confidentiality

Confidentiality refers to limiting information access and disclosure to authorized resources, and preventing access by or disclosure to unauthorized resources. Confidentiality is the cornerstone of information security and aims to keep important information secret and secure such as market information or information about persons and their behaviour, which violates their privacy.

Confidentiality can be achieved by restricting information flow and access, such as providing access to information only on a need-to-know basis. In addition, information must be accessible only for entities (persons or systems) that have the right to access the data. This implies that confidentiality requires a mechanism to determine the identity of each entity and proposes that more guarantees are needed to assure the identity of the entity in case of high confidentiality of information.

Releasing confidential information to other parties than the Data Subject, requires the verification of identities and that the Data Subject trusts that the other parties will respect the confidentiality level determined by the Data Subject. In other words, information that is rated as 'confidential' by the Data Subject must not be made publicly available by the receiving party.

Information that is considered confidential in a smart energy system and during flexibility transactions includes among other things, customer information, meter readings, the status of the grid and pricing information. The consequences of a breach of confidentiality are different for each participant of the flexibility market. For example, the Prosumer will experience loss of privacy while the Supplier will experience loss of goodwill and competitive disadvantage. To facilitate analysis of the confidentiality requirements, USEF proposes that this information should be classified in levels and a data policy should detail the requirements for managing information at each level of confidentiality.

USEF's principles on confidential of information are summarised below:

1. Information is shared on a need to know basis;
2. Information is classified into degrees of confidentiality needed;
3. Protect the data, not only the medium;
4. Separate information of different confidentiality classifications;
5. Confidentiality is ensured end-to-end; and
6. Protection is proportional to potential damage.

7.1.1.5 Integrity

The term "integrity" refers to the trustworthiness of data and its information over its entire lifecycle and implies that data cannot be modified undetectably. Flexibility markets and smart energy systems require integrity of data and information which will facilitate decision making on flexibility trading, grid controlling and energy management. This data is stored in IT systems and involved parties, such as the Prosumers, the Aggregators and the DSOs/TSOs much have the reassurance and the guarantee that the IT data falls into the defined reliability interval. In addition, smart grids and flexibility markets require integrity of data that will facilitate grid's operations.

USEF proposes the following integrity principles which apply to all IT systems which are required to operate a smart energy system and the flexibility services, as well as the analogue systems feeding into those IT systems:

1. Integrity is upheld for actionable information; and
2. The protection level is proportional to the potential damage.

7.1.1.6 Availability

The term "availability" in this section refers to the availability of information resources including systems, processes, information and data elements. The section focuses on systems and processes which are required for flexibility trading such as the USEF Market Coordination Mechanism (MCM) and the information exchange between the different roles of the flexibility market. Although the principles apply to other interactions and process used in a smart energy system, primary systems are not part of the scope of this section.

In a smart energy system, the availability of energy depends not only on the physical components, but also on the availability of IT systems which control the energy system. Unavailability of the IT system might occur due to planned downtime or unplanned downtime. Planned downtime is the time a system is down for maintenance and is predictable to a high extent. By planning maintenance outside the service window, planned downtime has no impact on the availability from a business perspective. Unplanned downtime is caused when the IT system suddenly fails and is therefore unpredictable. To avoid power and market outages due to unplanned of the IT

system, several measures must be taken. As is the case with confidentiality and integrity, a balance must be made to invest in high(er) availability and the financial damage in case of a failure.

USEF specifies 5 principles to ensure data availability:

1. Asses the vulnerability of assets;
2. Protection is proportional to potential damage;
3. Introduce redundancy for systems that need to be highly available;
4. Monitor high-availability systems; and
5. Unavailability is mitigated by failsafe operation.

7.1.1.7 Disaster recovery

Disaster recovery is a subset of business continuity and is the area of security planning that deals with protecting an organization's business functions from the effects of significant negative events related to its technology infrastructure. These negative events are classified as natural disasters, such as earthquakes and tornadoes, and as man-made disasters such as theft and terrorism. Additionally, the term "disaster" is linked to events related with the breach of data and information confidentiality, integrity and availability. The control measures against disasters of any type are classified as below:

- Preventive measures;
- Detective measures; and
- Corrective measures.

Disaster recovery processes consider both technical and organizational aspects. The technical aspects relate to architectural design and implementation choices. Organizational aspects deal with creating and testing recovery plans, assigning responsibilities and defining criteria for declaring a disaster and claiming successful recovery. Organizational aspects of disaster recovery are considered out of scope of USEF as USEF assumes that smart energy systems will be part of larger networked enterprise systems and fall under existing business continuity planning.

Efficient and effective recovery is required to limit the impact of a disastrous events on a smart energy system and the flexibility markets. Due to unplanned downtime, for example, Prosumer will lose trust in the smart energy systems and the involved roles (i.e. DSOs, Aggregators, Suppliers). Particularly at the beginning of the smart energy system deployment, a negative Prosumer experience could result in Prosumers' unwillingness to participate in a flexibility markets, which, in turn, affects the business case for companies involved in the smart energy system.

USEF applies the following principles for disaster recovery:

1. Investments in Disaster Recovery are based on a risk assessment;
2. The system architecture supports an implementation that matches industry-standard Recovery Time, Objective and Recovery Point Objective;
3. Smart energy systems are prioritized for recovery;
4. Smart energy systems are designed as highly-cohesive, loosely coupled; and
5. Back up only what is needed for restoring.

7.1.1.8 Identification, Authentication, Authorization

In the context of flexibility markets and flexibility transactions, the concepts of identification, authentication and authorization mean that an actor is able to identify itself to another actor, where necessary can prove its identity to the other party, and that it can be verified that an actor is actually authorized to participate in the information exchange or transaction. In some situations, this is a reciprocal action, where both actors identify, authenticate and sometimes also determine each other's authorization.

Although the principles of identification, authentication and authorization are applicable in a broader scope, the USEF principles consider only the parties that are involved in a flexibility market and exchange data with other parties.

Within USEF, the following principles underpin the identification, authentication and authorisation process:

1. Entities in smart energy systems have unique identifiers within their scope;
2. Authorization is based on either an (authenticated) identity of an entity or (certified)properties of an entity;
3. Identities have a life cycle;
4. The use of identity providers is supported;
5. Authentication mechanisms are fit for use;
6. Authentication mechanisms are risk based;
7. Authorizations have a life cycle;
8. Authorizations are classified into authorizations types;
9. Detected unauthorized transactions (or attempts to) are managed according to a predefined policy; and
10. An actor's actual behaviour feeds back into the identification/authentication system, setting "trust levels."

By using trust levels based on actual behaviour, the expected outcome of future actions can be predicted with a higher certainty, making the system more reliable.

7.1.1.9 Risk assessment

During the design and build phases of smart energy systems, potential privacy and security issues are likely to be raised. In order to efficiently and cost-effectively implement measures and controls to mitigate these issues, risk assessment is required to determine the associated risks in a common and unbiased way. Using an agreed-upon framework for risk assessment, risks can be identified, classified and, depending on the method chosen, quantified, allowing for a rational approach to reducing risks arising from privacy & security issues.

USEF uses a risk assessment method to:

- Identify, quantify and classify risks to improve the privacy and security aspects of USEF: This process requires that risk assessments are an integral part of the design process, safeguarding Privacy and Security by Design. It is worth mentioning that Privacy & Security by Design requirements are derived from Legal Protection by Design requirements.
- Guide the implementation and operation of USEF: This means that risk assessment provides the boundaries for the implementation of smart energy systems and inputs for the risk management process of organizations implementing, or interacting with, smart energy systems such as USEF.

USEF recommends using the Factor Analysis of Information Risk (FAIR) approach to risk assessments, which is a good fit with USEF for the design and implementation phase. FAIR is a taxonomy of factors that contribute to risk

and how they affect each other. [175] The ISO/IEC 27031 standard for cybersecurity, which deals with information security, network security and internet security, is not part of USEF principles.

Within USEF, risk assessment is based on the following principles:

1. Risks are categorized or quantified;
2. Risk assessment is integrated into the smart energy system life cycle; and
3. Risk assessment is based on an auditable method.

7.1.2 USEF data interchange

The United Nations rules for Electronic Data Interchange for Administration, Commerce and Transport (UN/EDIFACT) comprise a set of internationally agreed standards, directories, and guidelines for the electronic interchange of structured data, between independent computerized information systems.

EDIFACT is widely used across Europe between utilities, mainly because of the fact that many companies adopted it very early on. EDIFACT has seen some adoption in the European region, however, there are currently more XML-based standards being used nowadays. This was the main reason for USEF to choose XML or JSON[176] as an alternative, but other protocols are also suitable.

Although USEF does not specify how a message is sent over the wire, it is assumed in this section that JSON/XML over HTTPS is used. Both JSON/XML and HTTPS are well-known protocols, but other formats or protocols are also suitable for USEF as long as all parties participating in a USEF implementation agree on this and the privacy & security guidelines can be met by the selected protocol(s).

The HTTPS protocol ensures that data is exchanged unmodified between sender and receiver, and that both sender and receiver can authorize each other requiring client and server certificates. HTTPS is not in itself sufficient to fulfil all privacy & security guidelines and additional measures should be taken to ensure compliancy.

Although USEF data interchange has not been standardised, it provides an open protocol, meaning that each user can choose how to apply the protocol. Interfacing is based on a JAVA implementation. Java is a general-purpose computer-programming language that is concurrent, class-based, object-oriented and specifically designed to have as few implementation dependencies as possible. It is intended to let application developers "write once, run anywhere" (WORA), meaning that compiled Java code can run on all platforms that support Java without the need for recompilation. Java applications are typically compiled to bytecode that can run on any Java virtual machine (JVM) regardless of computer architecture. As of 2016, Java is one of the most popular programming languages in use, particularly for client-server web applications, with a reported 9 million developers.

7.2 GB Privacy, Cybersecurity & Communication Requirements

7.2.1 GB Privacy & Cybersecurity Regulations

7.2.1.1 Privacy

The UK data protection regime is set out in the Data Protection Act (DPA) 2018, along with the GDPR (which also forms part of UK law). It takes a flexible, risk-based approach which encourages organisations to consider and justify the use of data. Data protection is about ensuring people can trust organisations to use their data fairly and responsibly.

175 https://en.wikipedia.org/wiki/Factor_analysis_of_information_risk
176 https://nl.wikipedia.org/wiki/JSON

If an Operator of Essential Services experiences an incident that has the potential to compromise the security of personal data, they may also be required to report the incident to the Information Commissioner's Office (ICO), under the GDPR even if the incident does not warrant reporting under the NIS Directive. [177]

The GDPR Security Outcomes guidance from the National Cybersecurity Centre (NCSC) is closely aligned to NIS Cybersecurity principles. [178] [179] The approach has been developed in accordance with the following four key principles:[180]

A) Manage security risk;

B) Protect personal data against cyberattack;

C) Detect security events; and

D) Minimise the impact.

The following section describes these principles in detail.

7.2.1.2 Cybersecurity

GB cybersecurity regulations follow relevant EU directives. The EU recognised that any cybersecurity incident could affect a number of Member States and in 2013 put forward a proposal to improve the EU's preparedness for a cyberattack. This proposal became the directive on the security of Networks and Information Systems (the NIS Directive) in August 2016, giving Member States, including GB, 21 months to embed the Directive into their respective national laws.

The NIS Directive has been implemented at the same time as the new General Data Protection Regulations (GDPR), which require holders of personal data to provide security assurances around that data, and to report on any incidents that might affect them.

The GB NIS Cybersecurity principles define a set of top-level outcomes that, collectively, describes good Cybersecurity for operators of essential services (OES) like the USEF framework. Each principle is accompanied by a narrative which provides more detail, including why the principle is important. Additionally, each principle is supported by a collection of relevant guidance, which highlights and recommends factors to consider addressing Cybersecurity challenges.

The principles are part of the four NIS Directive Objectives as follows:

- **Objective A. Managing security risk**

Appropriate organisational structures, policies, and processes are in place to understand, assess and systematically manage security risks to the network and information systems supporting essential services. Objective A follows four key principles:

1. Governance;
2. Risk management;
3. Asset management; and
4. Supply chain.

- **Objective B: Protecting against cyber attack**

177 https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/

178 https://www.ncsc.gov.uk/guidance/gdpr-security-outcomes

179 https://www.ncsc.gov.uk/collection/nis-directive?curPage=/collection/nis-directive/nis-objective-a/a1-governance

180 A detailed description is available here: https://www.ncsc.gov.uk/guidance/gdpr-security-outcomes

Objective B aims to ensure that proportionate security measures are in place to protect essential services and systems from cyberattacks, based on the following principles:

1. Service Protection Policies and Processes;
2. Identity and Access Control;
3. Data security;
4. System security;
5. Resilient networks and systems; and
6. Staff awareness and training.

- **Objective C: Detecting cybersecurity events**

Objective C is to put in place capabilities to ensure security defences remain effective and to detect Cybersecurity events (potentially) affecting essential services. Objective C calls for

1. Security Monitoring; and
2. Proactive Security Event Discovery

- **Objective D: Minimising the impact of cybersecurity incidents**

Objective D involves capabilities to minimise the impact of a Cybersecurity incident on the delivery of essential services including the restoration of those services where necessary. Objective D is realised through

1. Response and Recovery Planning; and
2. Lessons learned.

Figure 15 provides an overview of NIS Directive Objectives A-D and their key principles, which inform the fit analysis between GB legislation and the USEF guidelines in section 7.3.

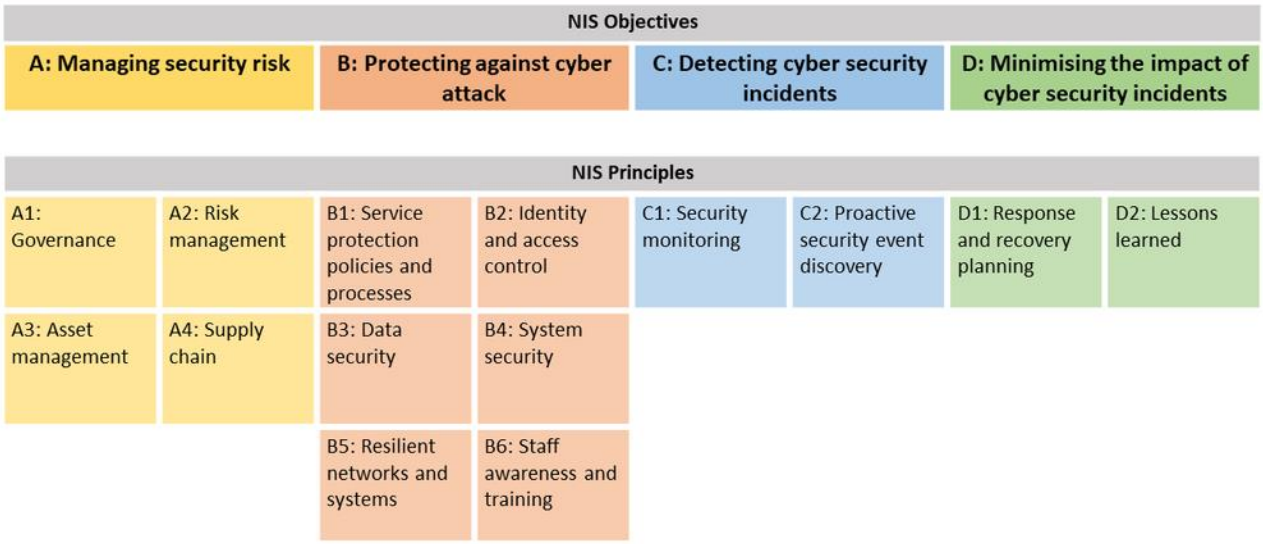

Figure 15: NIS cybersecurity objectives and principles.

The NIS directive also aims to raise the level of information security. Organisations within vital sectors, like utilities, are identified as "operators of essential services" (OES). OES are required to take appropriate and proportionate security measures to manage risks to their network and information systems, as well as to notify

serious incidents to the relevant national authority. The Information Security Management System ISO/IEC 27001 plays a key role to achieve this goal, and is adopted as a voluntary standard by key stakeholders in the GB energy industry. The NIS principles A-D have been developed to take account of the requirements in the ISO/IEC 27001 standard.[181]

7.2.2 GB data interchange

This section considers the current EDI on the level of DSO[182] and TSO.[183] The approach to define the interface process is a layered top down structure, similar to USEF. The highest layer is the business need for the interface to exist. This business transaction is supported by successive lower layers working down via the logical and physical design to the communications protocol and the physical format and media for the data transfer. For the data transfer protocol (S)FTP over TCP/IP and web services are used at the level of DSO and TSO. At the business process level, electronic data file transfer XML is used.

Figure 16 below provides a block diagram of the EDI between market participants, National Grid and ELEXON. The interaction is based on the National Grid's Market Operation Data Interface System (MODIS). The Market Participants can provide the required data using one of the methods below:

- File Upload;
- sFTP file transfer using XML File format; or
- Web Service.

Market participants use XML for messaging, which is similar to the USEF, although the messages are different.

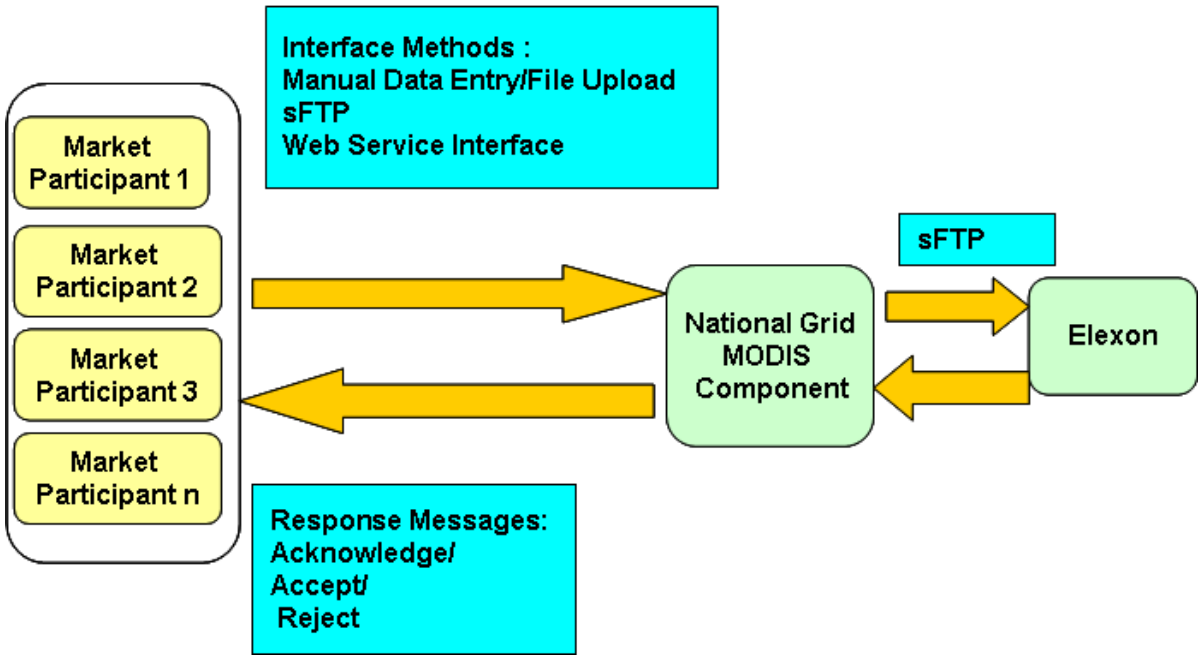

Figure 16: Example Interaction between market participants and National Grid.

181 https://www.ncsc.gov.uk/guidance/table-view-principles-and-related-guidance

182 https://www.ELEXON.co.uk/bsc-and-codes/

183 https://www.nationalgrideso.com/codes/grid-code/electrical-standards-documents-including-specifications-electronic-data

7.3 Fit analysis

7.3.1 Privacy and cybersecurity

The analysis takes as a basis that the USEF framework has been developed on the principle of "security by design," which can be seen as the basis for implementing USEF in GB. Table 9 below provides the comparison of USEF and GB NIS cybersecurity and privacy principles, which have been developed taking account of the ISO/IEC 27001 standard. The comparison is marked as follows:

- The USEF framework supports the GB NIS principle (√), partly supports the GB NIS Principle (P), or does not support the GB NIS principle (Ø); or
- The GB NIS principle is out of scope (X) or is not applicable (NA).

Table 9: USEF Cybersecurity and Privacy Mapping against GB NIS Principles

No.	Objective A: Managing Security Risk	USEF Cybersecurity	Notes	USEF Privacy	Notes
A1	**Governance**	P	By nature, USEF does not describe governance. It contains elements that support governance, like risks assessment.	P	By nature, USEF does not describe governance. It contains elements that support governance like the DPA 2018. USEF is anticipating GDPR.
A2	**Risk management**	√	NA	√	NA
A3	**Asset management**	X	Asset management is a matter for individual stakeholders, who may use Information Security Management System (ISO 27001)	X	Assets and privacy should be managed by each stakeholder based on the DPA 2018.
A4	**Supply chain**	P	Based on the USEF framework, separate contracts like SLA for Cybersecurity with external service providers can be agreed upon.	P	Based on the USEF framework separate contracts like Data Processing Agreements with external service providers can be agreed upon.

No.	Objective B: Protecting against cyberattack	USEF Cybersecurity	Notes	USEF Privacy	Notes
B1	**Service Protection Policies and Processes**	√	NA	√	NA
B2	**Identity and Access Control**	√	NA	√	NA
B3	**Data security**	√	NA	√	NA
B4	**System security**	√	NA	√	NA
B5	**Resilient networks and systems**	√	NA	√	NA
B6	**Staff awareness and training**	X	Should be part of Stakeholder management principles	X	Should be part of Stakeholder management principles

No.	Objective C: Detecting Cybersecurity events	USEF Cybersecurity	Notes	USEF Privacy	Notes
C1	**Security Monitoring**	P	USEF expects monitoring to be used for security.	NA	NA
C2	**Proactive Security Event Discovery**	X	USEF does not support proactive security event discovery, but individual stakeholders could choose to support it.	NA	NA

No.	Objective D: Minimising the impact of Cybersecurity events	USEF Cybersecurity	Notes	USEF Privacy	Notes
D1	**Response and Recovery Planning**	√	NA	√	NA
D2	**Lessons learned**	X	Should be part of Stakeholder management principles	X	Should be part of Stakeholder management principles

Both for cybersecurity and for privacy requirements, most of the principles proposed by USEF fully or partially align with applicable GB rules. However, there are also some principles that are not in the scope of USEF's guidelines or (for privacy) that do not apply altogether, but these could be implemented by individual stakeholders. These findings indicate that USEF implementation in GB would not encounter fundamental barriers with regard to privacy and cybersecurity considerations.

Given the fact that smart energy is a relatively new field, both in terms of technology, governance and regulation, smart energy systems should provide flexibility in addressing privacy issues that may surface with the advent of new smart energy systems and/or regulations. For example, Aggregators provide a forecast of the amount of energy to be consumed or produced at a given congestion point ("D-prognosis"), meaning that profiles from customers are available to market parties such as the DSO. In cases where privacy preferences fail, contractual agreements can be an alternative approach. In the case of a D-prognosis, embedding privacy rights in the service level agreements for smart energy services is a mitigative measure worth exploring during implementation.

7.3.2 Electronic Data Interchange

The approach to message exchange in the GB market differs from the approach proposed by the USEF framework. The main difference is the lack of standardisation in USEF, which provides an open protocol, free to use and interpret by individual stakeholders. USEF does not prescribe any specific technologies like HTTPS, web services, or SFTP for the lower layers of the communication. For messaging in the upper layers of the communication, both USEF and GB arrangements use XML, although USEF also allows alternatives like JSON. The implementation of the USEF network and data communication requirements can therefore be considered 'business as usual' for IT providers.

8 CONCLUSIONS & NEXT STEPS

8.1 Conclusions

This due diligence has tested the fit of the USEF framework with legal, regulatory and market arrangements governing the GB energy sector. Its key findings can be classified in the following three categories:

1) Areas where USEF adds to GB arrangements;

2) Areas of conflict where USEF and GB arrangements both have a defined but different view; and

3) Areas where GB arrangements add to USEF.

The USEF framework proposes arrangements for a future smart, flexible energy system in which the trade of flexibility and energy is integrated and coordinated. The GB energy system, like energy systems in general, is in transition to such a system, and so it is to be expected that the USEF framework proposes arrangements that have not yet been considered in GB. For this reason, most findings from this due diligence fall into category 1 above. However, the due diligence has also uncovered conflicts, which may require changes in either USEF or GB arrangements, as well as areas where GB arrangements could add to USEF. Most importantly, the due diligence has not indicated areas that could prevent USEF from being implemented in GB. Few modifications will be needed on USEF's side, and a limited set of recommendations to adjust current or (proposed) future arrangements in the GB energy system.

It is important to observe that the fit analysis confirms alignment between GB and USEF arrangements for the fundamentals of energy and flexibility markets, such as existing roles and interactions as well as flexibility services and routes to market. The analysis also finds that USEF's guidelines on privacy and cybersecurity mostly align with applicable GB rules, indicating that a USEF implementation in GB would not encounter fundamental barriers in this area. Finally, there are also key elements of alignment in future flexibility market design and the ENA ON project, for instance in that both USEF and the ENA ON World B propose that the ESO and the DSOs procure flexibility independently from each other and a level of information exchange and coordination will be required. This level of alignment is an expected key finding since both USEF and GB aim to align with ENTSO-E principles as the basis for future flexibility services and market organisation.

8.1.1 Areas where USEF adds to GB arrangements

USEF could add value to GB flexibility market arrangements in the following areas:

- Although there is alignment on key routes in the **flexibility value chain**, USEF describes a greater range of services than those that currently exist in the GB energy system. We consider this to be reflective of the current, nascent state of play in GB, and there are no barriers to the potential future realisation of the additional services USEF proposes.

  Aggregators in GB can only access wholesale energy markets if they have a supply licence or a contractual agreement with a licensed supplier. USEF proposes ways of facilitating independent aggregation, setting out additional models for Aggregators to access wholesale energy markets, even if they do not have a supply licence or contractual requirements with a licensed supplier. USEF's models enable the wholesale energy settlement of flexibility transactions, as well as the settlement of imbalances imposed upon Suppliers due to activation of demand response by Aggregators.

- As a theoretical framework, USEF proposes a **market organisation** based on clear roles and responsibilities, some of which do not yet exist in the GB energy system. Some of these USEF roles can be said to be in early development in GB, and there are no barriers to such roles being developed in full in the future.

    - USEF defines the role of the Common Reference Operator (CRO), which operates a repository containing information about connections and congestion points in the electricity network, facilitating

informed decision making for flexibility sellers and buyers. A CRO role does not currently exist in GB, but a similar functionality is being considered in the ENA ON project, which explores the creation of a System Wide Resource Register, although as currently discussed this does not account for information exchange to and from Flexibility Service Providers (FSP).

- In USEF, the Meter Data Company (MDC) acquires and validates meter data required for flexibility and balancing settlement processes. The MDC role facilitates transparency and consistency in the flexibility settlement processes, providing accurate and valid data to market parties. In GB, there are several entities that are involved in data acquisition, sharing and management. For example, the Data and Communications Company (DCC) manages smart meter data and communication infrastructure, providing the communication infrastructure for suppliers and DNOs to acquire the data, but does not otherwise share or validate data. Various other parties have a role to play in the data validation, information exchange and settlement processes, which are carried out by ELEXON.

  USEF, however, introduces a single entity that performs the meter data company role and interacts with all the market participants, which facilitates standardisation and transparency, and overall more efficient solution. This approach aligns with the Open Networks project's view on the future role of the Data and Communications Company.

- The GB energy system does not currently recognise USEF's Constraint Management Services Provider (CMSP) as a unique role with specific responsibilities (e.g. towards prequalification, flexibility trading, dispatch, settlement), although there are currently market participants that provide constraint management services to NG ESO and even to DSOs.

The absence of clearly defined roles and interactions cause uncertainty and lack of clarity on the future responsibilities of individual parties as well as the interactions between market participants. USEF could facilitate the development and design of these roles and interactions.

- In terms of **market design**, current GB arrangements do not cover the structure and the mechanisms for a functioning flexibility market as defined in USEF. USEF defines operating regimes, functioning as a traffic light mechanism reflecting the status of constraints and congestion in the energy system to inform the (un)restricted trade and dispatch of flexibility. USEF also defines a flexibility market coordination mechanism (MCM) covering interactions between market participants to facilitate effective flexibility transactions. These are areas where USEF could add specific elements and enhance the GB market design to commercialise flexibility and lower overall energy system costs.

  Given that USEF is a forward-looking framework that proposes a design for future flexibility market arrangements, the most relevant assessment is to look at the direction future market arrangements might take. For this reason, we have compared USEF with future flexibility market arrangements put forward by the ENA ON project, which can be considered the primary vehicle for industry discussion on this topic.

  - For instance, the ENA ON project is working on last-resort mechanisms which will describe the shift from a market-led to a control-led state. Also, the ENA ON has planned to undertake detailed work on operation, settlement, measurement and validation. USEF's Operating Regimes and MCM can be used to inform and enhance these deliverables.

  - More generally, USEF provides a fully-developed market mechanism, with all the appropriate standards, principles, interactions, and requirements for information exchange in place, where the ENA ON so far covers only certain aspects of a potential flexibility market design. Further this is done primarily from the perspective of network businesses. For instance, the ENA ON project considers the deployment and coordination of flexibility in the system to be chiefly a responsibility for system operators. As such, the ENA ON does not explicitly consider the (economic) perspective and potential

roles for other actors, such as Balance Responsible Parties (BRPs), Generators, Suppliers, Aggregators and Customers in unlocking flexibility.

  - USEF considers that Aggregators have a central role in commercialising flexibility through explicit mechanisms with two distinct responsibilities: to unlock flexibility at end-users and to coordinate the use of flexibility between market participants. In the ENA ON, the first responsibility is recognised only as a financial arrangement. The second responsibility is performed by the cooperation between the DSO and ESO in World B, but this does not include coordination and settlement arrangements with other stakeholders, such as the BRPs. In addition, World B is mainly focused on existing flexibility providers (i.e. generation, batteries, I&C customers), while the interests of end-users (including residential prosumers) that want to use flexibility for other purposes (self-balancing, adjust demand to renewable generation, limit Carbon Dioxide (CO2) emissions) are not considered.

- USEF defines requirements for **DSO flexibility transactions** such as contractual & regulatory arrangements, pricing, remuneration, settlement and validation processes. All these processes are under development in GB and therefore USEF's proposals could enable effective DSO flexibility transactions.

  - USEF makes Aggregators an integral part of the planning process in providing flexibility to DSOs. It introduces the concept of D-programs, through which Aggregators active in congested DSO areas are obliged to inform the DSO on planned activations of flexibility (day-ahead and intra-day), as well as on any contracted flexibility capacity. USEF also proposes to extend this obligation to Suppliers for flexibility activated through implicit mechanisms. This information flow facilitates better planning for DSOs and optimal procurement and dispatch of flexibility.

  - USEF also allows "free bids" under short-term procurement where there is no contractual obligation to offer flexibility to the market and flexibility is provided on a day-to-day basis. Free bids allow flexibility providers a last-minute route to market, at a competitive price to DSOs, maximising the value to both flexibility providers and DSOs.

  - USEF has also introduced the concept of re-dispatch to compensate the effect of the local demand response activation on system level. In USEF the Aggregator, the Supplier and the DSO can all perform re-dispatch. This is an area that has not yet been specified in the GB DSO transaction arrangements and is essential for managing imbalances that are caused due to flexibility dispatch.

  - USEF provides a reference architecture for explicit demand-side flexibility from the Prosumer to the Flexibility Requesting Party, which will facilitate the standardisation of interactions between the market platforms and grid management services. A key feature in the USEF architecture is the regulated central data hub, where measurement and validation of flexibility transactions are performed and recorded. In GB, the majority of flexibility services and products are transacted on separate platforms with different functionalities. Settlement and validation in GB are split between ELEXON, NG ESO and individual DNOs for different types of transactions.

- The analysis on **market access requirements** shows areas in which USEF proposals facilitate Aggregators' ability to maximise the services they can provide:

  - Stacking of flexibility services is generally possible both in GB and USEF and is being considered by DSOs and the ENA ON project for DSO flexibility services. However, the dynamic pooling of assets, which is proposed by USEF, is limited in GB because of complex processes to re-allocate assets/units.

  - A USEF Prosumer can contract with, and be operated by, multiple Aggregators at the same time, although each Aggregator should operate a mutually exclusive set of resources. Sub-metering is required to allocate flexibility from each asset and to each Aggregator, but flexible assets can only be operated by one Aggregator at a time. There are currently no GB arrangements to cover the

coordination of multiple aggregators working with a single prosumer, although such arrangements are in development, and could be informed by USEF.

- In GB, sub-metering is in place for balancing products and in the Capacity Market, but not in the Balancing Mechanism and imbalance settlement arrangements. However, BSC modification P375 may allow aggregators/VLPs to install their own settlement sub-metering for flexible assets in the future. USEF considers sub-metering essential for independent aggregation and proposes that Aggregators should be allowed to apply sub-metering for all flexibility services to enable the settlement process.
- In USEF the Flexibility Requesting Party (e.g. ESO, DSO) defines the baselining methodology for all flexibility services except for wholesale market services. For the wholesale market services, the regulatory authority (Ofgem in GB) is responsible for defining/approving the baseline methodology for the Transfer of Energy (ToE). This baseline methodology only relates to the non-contractual, dual-BRP Aggregator Implementation models (AIM). In GB, the concept of ToE is not yet in place and therefore a baselining methodology has not yet been defined.

USEF's Aggregator Implementation Models can also add to GB arrangements for the aggregator role, balance responsibility and settlement of imbalances between market participants. The fit analysis does not recommend AIMs that should be used in GB, but highlights which USEF models are already applied or could be applied in the future:

- Under current GB arrangements, the equivalent of the USEF Uncorrected Model is applied for aggregators offering ancillary services to the ESO and the USEF Integrated Model is in place where a supplier and an aggregator are combined in a single market party, for instance for aggregators with a supplier license participating in the Balancing Mechanism and Capacity Market.
- In the future, aggregators acting as Virtual Lead Parties (VLPs) will be able to participate in the Balancing Mechanism and TERRE products. ELEXON envisages that VLPs will not be responsible for their balance position. ELEXON will perform perimeter corrections to protect suppliers from the imbalance caused by aggregators/VLPs. The perimeter corrections will be adjusted to the supplier's share in the aggregator's portfolio. These arrangements are similar to USEF's Central Settlement Model, with the difference that in the Central Settlement Model the Aggregator is charged for sourcing the energy from the Supplier. In addition, the BM and TERRE settlement arrangements have a common element with the Broker Model: full balance responsibility of the connection lies in the Supplier (or the BRP of the supplier). In USEF, aggregators have a bilateral agreement with their customer's supplier (or its BRP), which is not the case for the VLPs.
- Ofgem is considering the equivalent of the Corrected Model to solve the energy sourcing issue. This option however, according to USEF, could complicate arrangements in case of residential customers since the remuneration of the supplier would be done through residential customers (the Prosumers).

8.1.2 Areas where USEF and GB arrangements have a different view

The due diligence shows that on some aspects of **DSO flexibility transactions** USEF and GB have a defined, but conflicting view, which will need to be addressed, but do not prevent the implementation of USEF in GB:

- USEF proposes that penalties are applied in case of under or non-delivery. When delivered energy is lower than the volume contracted, or when the test of availability of flexibility fails, then the Aggregator is penalised or disqualified. Current GB flexibility services do not include any specific penalties and the ENA ON project has only recently started considering the inclusion of penalties in the standardisation of flexibility products. USEF proposes that penalties are necessary to ensure flexibility is as reliable as a grid reinforcement, at which point it becomes valuable to DSOs. USEF proposes that penalties should discourage arbitrage by Aggregators, meaning that the penalty fee should exceed the balancing price.

- Baseline methodologies are different between USEF and GB DSO products. USEF's baseline is the D-prognosis that is provided by the Aggregator, while in GB individual DNOs and the ENA ON have each developed their one baseline methodology. USEF's standardised baseline methodology enables a level playing field in the flexibility market and ensures that settlement processes are implemented in a transparent and consistent way. In addition, USEF proposes that the flexibility quantification (including the baseline methodology), which is used for product settlement, is the same that will be used in the Transfer of Energy to settle imbalances. USEF's baselining methodology allows more types of demand-side resources to participate in the flexibility market and can provide high accuracy, leading to more efficient and effective Congestion Management products.

8.1.3 Areas where GB arrangements add to USEF

The due diligence has also identified some areas where USEF may need to adapt to fit to the GB energy system.

- In the area of **market organisation**, the specific manifestation of the System Operator role in the GB energy system may warrant a tailored interpretation in USEF. In the GB energy system, the role of the system operator is legally separated from the role of the transmission network operator, while in USEF the responsibility for both electricity transportation at HV networks and system balance lies with a single entity. In addition, in GB there are three transmission network owners that interact with a single system operator. These factors constitute a variation on communications requirements and protocols set out in USEF. These communications however are not associated with balancing services and therefore do not form a barrier to the potential implementation of USEF.

  The ENA ON Future Worlds also use the concepts of Local Energy Systems (LES) and Local Market Operators, which are not included in the USEF framework design, but could be reflected in USEF in the future.

- In **DSO flexibility transactions**, USEF does not allow for restoration support services at DSO level, but only at TSO level. This is a service that could enhance USEF flexibility value chain.

  In addition, USEF products do not distinguish between pre-fault and post-fault congestion management products. Although USEF allows for availability contracts which could also support post-fault products, it currently does not support "free bids" in a post-fault product, unless additional requirements are applied. For example, under current USEF arrangements free bids that are not activated are not remunerated. However, they do provide value in a post-fault product and therefore USEF could accommodate post-fault products.

8.2 Next Steps

The findings from this due diligence are the basis for the next phase in Project FUSION, which involves a public consultation on the USEF framework that will seek GB energy market stakeholders' opinion on a set of proposals to overcome gaps and conflicts between GB arrangements and the USEF framework, as well as to consider innovative elements of the USEF framework to inform future GB market design.

We will analyse the results and recommendations from the public consultation to inform a reference implementation plan for USEF in the GB energy market, particularly highlighting innovative elements of USEF that could advise future GB market design. This plan will both inform the trial within FUSION as well as the future design of the GB energy industry, to be refined over the course of the project and informed by the trial outcomes.

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our professionals are dedicated to helping our customers make the world safer, smarter and greener.