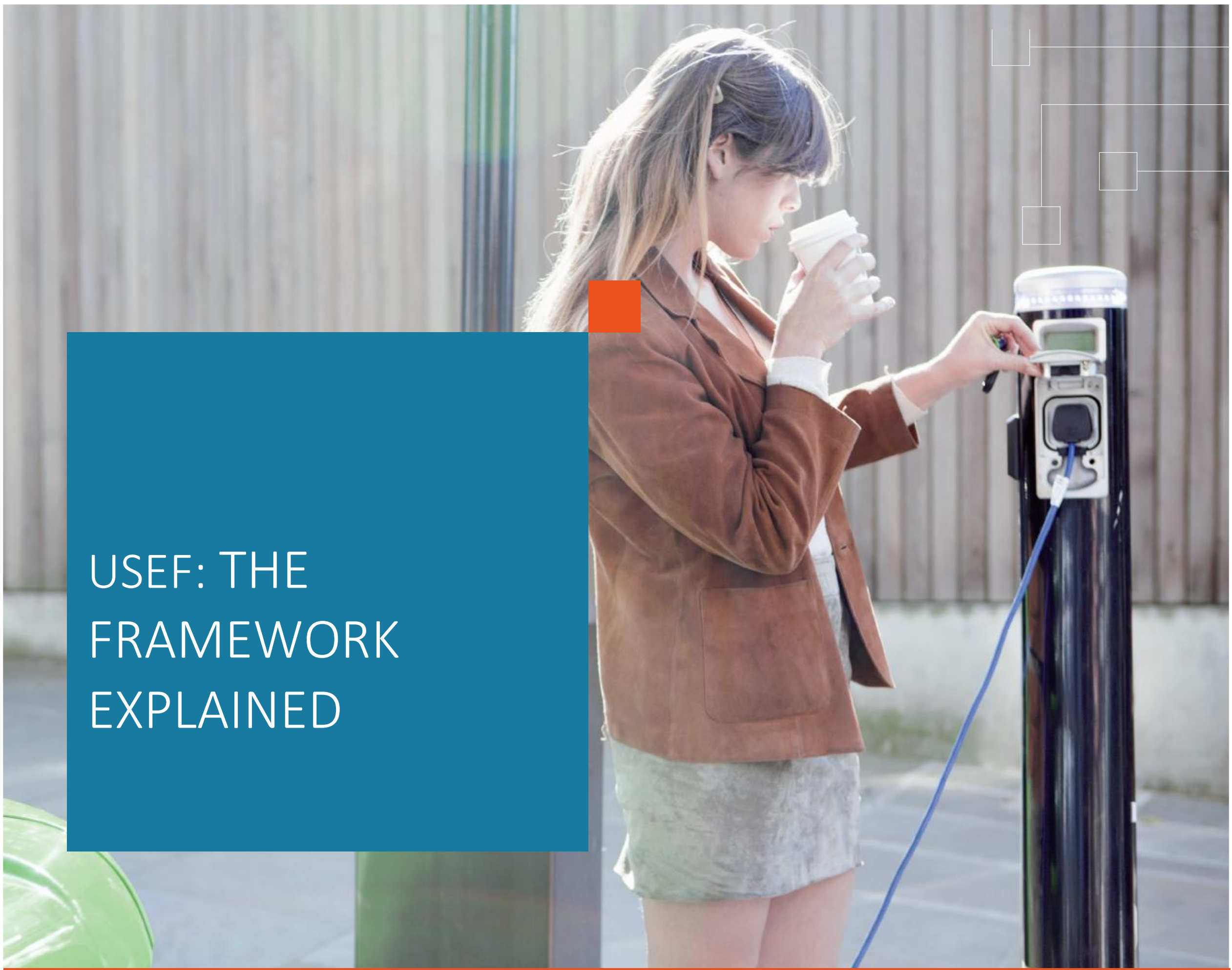

USEF: THE FRAMEWORK EXPLAINED

Update 25 May 2021

A solid foundation for smart energy futures

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With major contribution from (former) USEF design team members. A warm word of gratitude goes to the USEF Review Board and the USEF user community, who have supported us with valuable comments, sharpening issues and reviewing draft versions.

USEF a short summary

An integral market design for the trading of flexible energy use

USEF has been established to drive the fastest, most cost-effective route to an integrated smart energy future. It delivers one common standard on which to build all smart energy products and services. It unlocks the value of flexible energy use by making it a tradeable commodity and by delivering the market structure and associated rules and tools required to make it work effectively. USEF fits on top of most energy market models, extending existing processes, to offer the integration of both new and existing energy markets. It is designed to offer fair market access and benefits to all stakeholders. As well as delivering a common standard, USEF intends to set guidelines for the harmonization and development of distributed flexibility mechanisms.

USEF is developed by the USEF Foundation and maintained and audited by the USEF User Community. USEF was founded by seven key players, all active across the smart energy chain: ABB, Alliander, DNV, Essent, IBM, ICT Group and Stedin.

USEF key characteristics

Implements the European Commission's electricity market directive

Existing roles will be adapted and new roles will be created, some of which will be appealing to all kinds of organizations, from traditional suppliers to new market players. By defining the individual roles, how they interact and the resulting value, USEF helps to both understand, harmonize and realize the implementation of EC's directive on electricity market design with respect to demand-side participation.

Accelerates smart energy transition

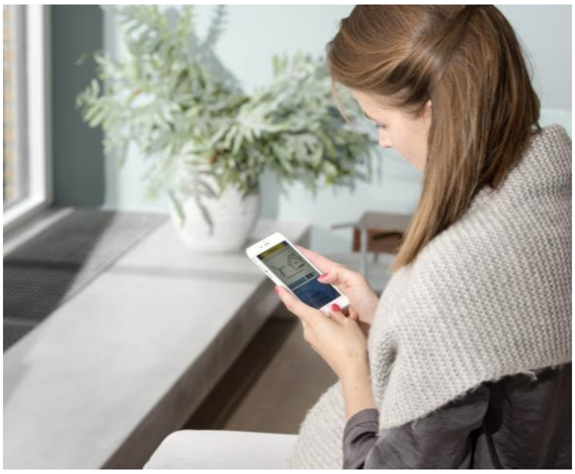
By adopting USEF and building on a common standard, projects are more rapidly connectable. Learning is shared, creating a faster route to best practice. USEF's work provides the groundwork to accelerate innovation, integration and scaling.

Reduces costs

By delivering a common standard to build on, USEF reduces the cost to connect different technologies and projects to the energy system. Its market-based coordination mechanism then defines the rules required to optimize that whole system, ensuring that energy is produced, delivered and managed at lowest cost. By harmonizing market processes and data exchange, both system operators and market parties can operate more efficiently throughout all markets and countries.

Connects smart energy products and projects

USEF's open IT architecture provides the freedom to create unique and commercially competitive smart energy products and services without vendor lock-in. It delivers a common standard on which to build, ensuring that all technologies and projects will be compatible and connectable to the future smart energy system.



Profitable for partners, project- and product developers

Smart energy projects adopting USEF will have increased relevance and impact. By building on one common standard and exchanging insights, implementations accelerate, future connectivity is assured and solutions are rapidly scalable. Smart energy product or service developers can apply USEF to gain early market share, developing unique products and services that will be connectable and cost-effective.

Sharing the outcome of our work

We believe that working together across roles and boundaries is the fastest route to a fair and integrated smart energy market. That is why the outcome of our work is free to download for all to use, learn, build on and benefit from. Visit our website for more background information and to view our key publications:

- USEF - The Framework Explained
- USEF - Flexibility Trading Protocol Specifications

Get involved in our USEF User Community

With detailed specifications and real-life (demonstration) projects, USEF is perhaps the most comprehensive and advanced initiative of its kind and we invite you to become part of the USEF User Community. By getting involved, you can help to shape the integrated smart energy future. Contact us if you are interested in becoming a member.

USEF - The Framework Explained

This publication describes the context and thinking behind USEF. In chapter 1, we address the need for a new market design and explain how flexibility can relieve stress in the energy system. Next, in chapter 2, we introduce the USEF Flexibility Value Chain, describing a generic way to access flexibility for multiple purposes and to serve a variety of stakeholders. Chapter 3 describes the USEF roles model and Aggregator Implementation models. These models categorize the relationship between the Aggregator and the Supplier (and its Balance Responsible Party). The USEF framework is unfolding via the USEF market coordination mechanism and USEF interaction model as described in chapter 4. The publication ends by discussing multiple related topics and complexities to further stimulate current and future flexibility deployment across all European markets and products (chapter 5).

Reading guideline and document overview

Reading guideline

This document provides a comprehensive overview of USEF and its work. While it addresses some topics in their entirety, others are only partly discussed. Where this is the case, the reader is referred to additional USEF publications for detailed understanding.

This comprehensive overview contains many aspects of flexibility and aggregation, which makes it appropriate and potentially beneficial to a range of stakeholders, including:

- EU- policy makers and regulatory bodies
- National policymakers and regulatory bodies
- Primary stakeholders of distributed flexibility, i.e. TSOs, DSOs, Suppliers, BRPs and, Aggregators
- (Industrial) bodies and associations
- Educational bodies

Regarding the structure, chapters are broadly organised as follows and readers should note that it is in the final, advanced sections that references to additional publications, e.g. workstream report and white papers, are typically made. All USEF publications are freely available and can be found on our website.

.1 **Each chapter starts with an introductory section explaining all the main concepts. Reading all of the introductory sections alone will provide a high-level overview of USEF and its work.**

.2 **The main concepts are discussed in more detail in the consequent sections.**

.n **The final sections include more advanced content and typically either provide an extra layer of detail to further explain main topic concepts or introduce important related topics.**

Content and document overview

Chapter 1. The need for a new market design

This chapter addresses the upcoming changes in the electricity landscape in a European context. It describes the need for a new market design and harmonization.

Chapter 2. The Flexibility Value Chain

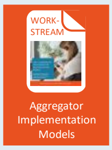
USEF's Flexibility Value Chain (FVC) provides a complete overview of customer needs for flexibility, and the associated markets and products in which Distributed Flexibility (DF) can potentially create value.

- Section 1: provides an introduction to the basics, USEF roles and a general introduction to the FVC with the Aggregator as a central role.
- Section 2: provides more in-depth insight into the FVC by presenting an overview of services that can be delivered by the Aggregator to a Flexibility Requesting Party (FRP) using DF.
- Section 3: introduces elements to distinguish flexibility delivery and remuneration types.

Chapter 3. USEF interaction model and Aggregator Implementation Models

The USEF interaction model and Aggregator Implementation Models (AIMs) are described. These models categorize the relationship between the Aggregator and the Supplier (and its Balance Responsible Party).

- Section 1: provides a description of the USEF interaction model – implicit and explicit flexibility
- Section 2: introduces different options and considerations for implementation of the Aggregator role
- Section 3: presents the 7 USEF Aggregator Implementation Models and their key aspects

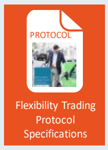


USEF's report on Aggregation Implementation Models contains more information about the different models. and discusses different recommendations and considerations for addressing complexities.

Chapter 4. USEF market coordination mechanism and interaction models

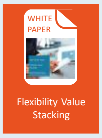
The USEF framework is unfolding via the USEF market coordination mechanism and the USEF interaction model.

- Section 1: provides a description of the USEF operating regimes and Market Coordination Mechanism.
- Section 2 & 3: introduces the information flow between market participants in the different MCM phase. Section 2 presents the general interaction and section 3 focuses on DSO constraint management.



USEF's Flexibility Trading Protocol Specifications contains more detailed information on the information exchange

Chapter 5. Complexities and other topics related to Distributed Flexibility



The final section of this publication discusses different complexities and related topics to further stimulate current and future flexibility deployment across all EU markets and products.

Sections 1, 2, 3 & 4: focus on complexities related to other aspects of DF, e.g. value stacking considerations, market restrictions, TSO/DSO coordination etc.

Sections 5, 6 & 7: present other USEF papers dealing with flexibility platforms, energy communities and practical European flexibility deployment.

Other white papers and workstream reports

There are additional USEF publications which are not introduced in this document. Find out more here.

Table of Contents

Abbreviations

aFRR	Automatic Frequency Restoration Reserve
AGR	Aggregator
AIM	Aggregator Implementation Model
BR	Balance Responsibility
BRP_{agr}	Aggregator's Balance Responsible Party
BRP_{sup}	Supplier's Balance Responsible Party
BRP_{frp}	FRP's Balance Responsible Party
BRP	Balance Responsible Party
BSP	Balancing Service Provider
CEC	Citizen Energy Community
CMSP	Constraint Management Service Provider
CSP	Capacity Service Provider
C&I	Commercial and Industrial
DA	Day-ahead
DF	Distributed flexibility
DSO	Distribution System Operator
EC	European Commission
ESCo	Energy Service Company
EV	Electric Vehicle
FCR	Frequency Containment Reserve
FRP	Flexibility Requesting Party
FVC	Flexibility Value Chain
HV	High Voltage
ID	Intraday
ISP	Imbalance Settlement Period
ISR	Imbalance Settlement Responsible
LV	Low Voltage
MCM	Market Coordination Mechanism
mFRR	Manual Frequency Restoration Reserve
MV	Medium Voltage
RR	Replacement Reserve
RTP	Real Time Pricing
ToE	Transfer of Energy
ToU	Time of Use
TSO	Transmission System Operator
SUP	Supplier
UFTP	USEF Flexibility Trading Protocol
USEF	Universal Smart Energy Framework

1 The need for a new market design

1.1 EU energy landscape context

The European Union is moving towards a more sustainable energy sector and has set ambitious emissions and renewable energy targets. The aim is to grow renewables generation in the energy mix from around 20% today to at least 27% by 2030.[1] At the same time, increased electrification and decentralisation mean that the way we use and produce energy are also changing. Distributed energy resources in the shape of generation and storage continue to increase, as does the growth in demand for electricity, e.g. for powering electric vehicles, heating / cooling systems and many other aspects of our daily lives. Inevitably, these changes alter overall patterns of demand and generation making them out of step and this creates imbalances and constraints in the grid. To manage all this change, we will need to make the power system more flexible.

Distributed Flexibility (DF) is essential for the European Union to meet its sustainable energy goals but as traditional, fossil fuel-burning flexibility resources are going offline, for environmental reasons, that flexibility will need to take new forms. At the same time, companies and individuals are increasingly installing their own renewable resources, shifting them from *customers* to *Active Customers* – who both use and provide power to the grid. Those Active Customers have the potential to deliver the new form of flexibility the power system needs. White the flexibility they offer individually may be small, when combined or 'aggregated' it could be enough to keep the power system balanced.

For Active Customers to gain access to this flexibility market and support the long term sustainability of the energy system, the role of the *Aggregator* is gaining increasing importance. The role bundles enough flexibility from multiple flexibility suppliers to provide useful volumes to flexibility users, e.g. transmission system operators (TSOs), distribution system operators (DSOs) and balance responsible parties (BRPs).

The European Union's Clean Energy Package (CEP) for all Europeans acknowledges the need for DR, aggregation and an aggregator role, to deliver more flexibility to the system, and provides a series of directives to support this. In particular, Article 17 of the Directive 2019/944 on electricity market design deals with Demand response through aggregation, compelling all Member States to develop the necessary regulatory framework for (independent) aggregators and DR to participate in all markets. In addition, Article 32 aims to incentivise the use of flexibility in distribution networks, encouraging Member States to develop the necessary regulatory framework to allow system operators to procure and deploy flexibility to alleviate congestion in their networks.

Both regulators and industry bodies agree that DF will be a vital part of future sustainable energy systems and that aggregators are necessary to make this possible - and the CEP sets the starting point for it. Quite how this will work in practice though is still not fully clear. Regulators, system operators and other parties in the energy landscape all have different perspectives on flexibility, and therefore approaches, but a truly transparent and integrated flexibility market requires more harmonisation of roles and processes.

1.2 Market solution rationale

A decade ago, European electricity markets were liberalized and unbundled. Power generation, trade and supply became fully market-based, whereas the transmission and distribution of electricity remained as regulated activities. The functioning of the market is dependent on the electricity network, as it may be hampered when there is insufficient grid capacity available at certain times and locations. Although the physical grid will always have capacity constraints, the electricity markets are governed by the 'copper plate principle' which is characterized by three elements:

[1] 27% is a binding EU target the EU countries agreed upon, although the key target of the European Commission is a 32% https://ec.europa.eu/commission/presscorner/detail/sl/MEMO_17_163; https://ec.europa.eu/clima/policies/strategies/2030_en

- Freedom to connect: Every customer has the right to be connected to the electricity grid, and has the right to upgrade its connection according to its need or preferences.
- Freedom to trade: Every market party has the right to trade energy with the counterparty of its choice within the same bidding zone.
- Freedom to dispatch: Every generator or customer has the right to produce or consume the amount of electricity that they choose, within the physical constraints of their connection and contractual limits of their connection agreement.

It is commonly acknowledged that energy transition and its associated developments, e.g. electrification, renewable generation and distributed generation, will subject the copper plate principle to pressure. Traditionally, the response to such developments would be grid reinforcement but, even if this were feasible, the associated costs would need to be borne by customers which would threaten, or at least slow down, energy transition as a whole. The alternative is to operate the grid more efficiently, which could imply operating it closer to its physical constraints, and flexibility can play an important role in this respect. The use of flexibility though, as stipulated by the European Commission, needs to be deployed through a market mechanism.

- USEF primary goal is to develop a mechanism that allows Distributed Flexibility (DF) to be deployed in all markets and products whist respecting the freedom to connect, trade and dispatch electricity.
- Special attention is given to the use of DF to delay or defer grid reinforcements to assist TSOs, and especially DSOs, as this is mostly uncharted territory and requires further development of regulatory, (market) process and information exchange levels.
- USEF recognizes that some of the freedoms may need to be restricted under exceptional circumstances, therefore a set of *operating regimes* are proposed, with the objective to create transparency about the conditions and impact of situations where restrictions to the three freedoms may be imposed.

The USEF framework is an extension to the current electricity market design of European markets and fully aligns with the current set-up of wholesale markets, balancing mechanisms and adequacy mechanisms, among others.

1.3 The need for harmonisation

The CEP states that Active Customers should be free to offer their flexibility to any party they choose but quite how the market should be organised to realise this, while also meeting the needs of other stakeholders, is not fully clear. Thanks to solid work by regulators and industry, good progress has been made in understanding the challenges of integrating demand-side response. These efforts have made it increasingly evident that no one solution for implementing flexibility aggregation will be suitable for all the different market situations likely to exist across Europe. In energy flexibility, one size does not fit all!

The implementation of the CEP into national laws involves further detailing of roles, flexibility services and market design. USEF believes that this process can benefit from a common language and lessons learned in different member states. Harmonization of markets and standardization of flexibility services, and protocols, will help aggregators to accelerate the delivery and usage of DF in the energy system.

To support this harmonisation, USEF delivers (through this report) the ingredients necessary for market-based DF and a comprehensive set of recommendations and considerations to help implement integration of demand-side flexibility in all relevant markets and products. To accelerate the use of flexibility in distribution networks, USEF introduces the Flexibility Trading Protocol (UFTP). Focused specifically on the exchange of flexibility between Aggregators (AGRs) and DSOs, it describes the corresponding market interactions between them, to resolve grid constraints by applying congestion management or grid-capacity management.

2 The Flexibility Value Chain

USEF considers that Distributed Flexibility (DF) can be deployed for multiple purposes and used to serve a variety of customers and markets. USEF's Flexibility Value Chain (FVC) provides a complete overview of customer needs for flexibility, and the associated markets and products in which DF can potentially create value.

The first section of this chapter provides the basics by providing a definition of DF, the different market roles, how they benefit from DF and how it can be delivered. Section 2 provides a more in-depth insight into the FVC by presenting an overview of services that can be delivered by the Aggregator to a Flexibility Requesting Party (FRP) using DF. Finally, section 3 introduces different flexibility delivery and remuneration types, to characterize the way services are delivered and how the FRP remunerates the Aggregator for providing them. The concept of flexibility value stacking is also introduced.

2.1 The basics

2.1.1 Distributed flexibility

Distributed Flexibility (DF) is defined as the ability of distribution-grid connected assets to shift or change their expected consumption or generation pattern in response to a signal. DF is provided to the distribution grid by Distributed Energy Resources (DERs) or flexible assets. These can be either load, generation or storage assets which offer flexibility regardless of their capacity. Leveraging the flexibility of lower capacity assets, to offer it in a diverse range of services, requires that it is aggregated. Aggregation can also help flexibility providers to lower risk since, if a specific asset is not available, they can still provide flexibility from other assets within their portfolio. This (aggregated) flexibility leveraged from flexible assets can then be used in a variety of services that will be introduced in section 2.2.

Although the scope of the USEF Framework is the integration of Distributed Flexibility, the focus is on flexibility on the demand-side, i.e. behind-the-meter. DF on the demand-side is where we find the highest complexity since this type of flexibility resides on the retail side of the market, often with no direct access to wholesale and balancing markets. Whereas the Supplier can provide some market access through implicit mechanisms, the relationship with the Supplier can complicate the situation in explicit mechanisms. USEF explains several concepts on implicit mechanisms, yet the major focus is on explicit DF mechanisms, since explicit mechanism are more complex to implement, whereas implicit mechanisms are already common in most markets. Also, the concept of energy efficiency is out of scope.

Generation, storage and load, when situated on the demand-side, need to be treated equally for the simple reason that a load reduction cannot be distinguished from a generation increase. These complexities will be explored throughout this document.

2.1.2 The USEF roles

The processes related to Distributed Flexibility involve the interaction of many actors in the energy landscape. USEF does not prescribe a single business model but rather a role model. This systematic approach results in a uniform description of roles and corresponding tasks and responsibilities which can be implemented in various ways, according to local market and business needs. Several different business models can be defined based on USEF's roles model. This approach leaves the interactions between market roles unchanged and provides a generally applicable model in which the definition of each business model is independent of other market participants.

To the extent possible, USEF has chosen to align the names of the roles used in its model with the existing business roles commonly accepted throughout Europe and defined by the Harmonised Electricity Market Role Model.[2] To aid clarity, we capitalize role names when referring to their USEF definitions and use lowercase when referring to the generic energy market concept.

Role	Definition
 Active Customer	The role of the Active Customer[3] is to consume, generate or to store electricity within its premises located within confined boundaries. USEF does not distinguish between residential end users, small and medium-sized enterprises, or industrial users; they are all referred to as Active Customers.
 Aggregator	The role of the Aggregator is to accumulate flexibility from Active Customers and their flexible assets and sell it to the BRP, the DSO, or to the TSO. The Aggregator's goal is to maximize the value of that flexibility by providing it to the service/FRP defined in the USEF flexibility value chain (section 2.2) that has the most urgent need for it. The Aggregator must cancel out the uncertainties of non-delivery from a single Active Customer so that the flexibility provided to the market can be guaranteed. This prevents Active Customers from being exposed to the risks involved in participating in flexibility markets. The Aggregator is also responsible for the invoicing / remuneration process associated with the delivery of flexibility towards the Active Customer. The Aggregator and its Active Customers agree on commercial terms and conditions for the procurement and control of flexibility.
 Supplier	The role of the Supplier is to source, supply, and invoice energy to its customers. The Supplier and its customers agree on commercial terms for the supply and procurement of energy.
 BRP	A Balance Responsible Party (BRP) corresponds to a market participant's, or its chosen representative's, responsibly for its imbalances in the electricity market. A BRP is contracted by the Supplier or Aggregator, and sometimes directly by large customers. As per article 5 of the EC directive 2019/943, all market participants shall be responsible for the imbalances they cause in the system, hence must ensure that at each ISP,[4] the exact amount of energy consumed is sourced in the system, or vice versa in case of energy production. The Active Customer's balance responsibility is generally transferred to the BRP, which is contracted by the Supplier. Hence the BRP holds the imbalance risk on each connection in its portfolio of Active Customers.
 DSO	The DSO is responsible for operating, maintaining 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.[5] In performing these tasks, the DSO shall procure the system operation services described in in section 2.2.
 TSO	The role of the Transmission System Operator (TSO) is to transport energy in a given region from centralized Producers to dispersed industrial Active Customers and Distribution System Operators over its high-voltage grid. The TSO safeguards the system's long-term and short-term ability to meet electricity transmission demands. The TSO is responsible for keeping the system in balance by deploying regulating capacity, reserve capacity, and incidental emergency capacity. The role of the TSO remains unchanged in USEF, but flexibility is identified as an input to the TSO for its

[2] THE HARMONISED ELECTRICITY MARKET ROLE MODEL, VERSION: 2020-01 Copyright © ebIX®, EFET and ENTSO-E. All Rights Reserved. https://www.ebix.org/artikel/role_model
[3] Note that the Active Customer role was denominated as Prosumer in USEF publications previous to this one.
[4] Commission Regulation (EU) 2019/943 of 5 June 2019 defines an imbalance settlement period (ISP) as the time unit for which the imbalance of the balance responsible parties is calculated (Article 2(15)).
[5] Currently, Distribution Network Operators (DNOs) are at different stages transitioning to DSO. Eventually, the DNO role will either disappear to leave room for DSOs, or will exist next to the DSO, comparable to TNO vs TSO.

Role	Definition
	system operation services as defined in the USEF flexibility value chain (section 2.2). The TSO can purchase flexibility via the BSP of the Aggregators active on its network. In some countries, the role of system operators and network operator are separate legal entities. In USEF we always refer to the system operator side, for example, Electricity System Operator (ESO) or Independent System Operator (ISO).
Producer	The role of the Producer is to feed energy into the energy grid. In doing so, the Producer plays an important role in the security of the energy supply. The Producer's primary objective is to operate its assets at maximum efficiency. Though its responsibility remains unchanged, the introduction of distributed flexibility and changes to the merit order can alter its operating conditions quite drastically, since renewable energy sources such as wind and solar power have a relatively low operating expense and compete with existing power generation units.
ESCo	The ESCo offers auxiliary energy-related services to Active Customers. These services include insight services, energy optimization services, and services such as the remote maintenance of flexible assets. If the Supplier or DSO is applying implicit distributed flexibility through (for example) time-of-use or kWmax tariffs, the ESCo can provide energy optimization services based on these tariffs. The ESCo has no formal responsibilities in the electricity system and as such, is not considered to be an active player in the electricity market (e.g. does not need to take balance responsibility).
Trader	A Trader 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 the energy exchange (day-ahead, intraday).
Exchange	An Exchange provides brokering between electricity Traders, Suppliers, BRPs and Aggregators.
CRO	The Common Reference Operator (CRO) is a USEF role responsible for operating the Common Reference, which contains information about connections and Congestion Points in the network.
MDR	The Metered Data Responsible (MDR)[6] is responsible for the establishment and validation of measured data. The MDR plays a role in USEF's flexibility settlement process and the wholesale settlement process.[7]
ISR	The Imbalance Settlement Responsible (ISR)[8] is responsible, for a certain scheduling area[9] (which often corresponds with a bidding zone[10]), for establishing and communicating the realized consumption and production volumes per ISP, either on the consumer level or on the aggregated level. The realized volumes are primarily based on actual measurements, but can also be based on estimates. The allocation volumes are input for the USEF flexibility settlement process and the wholesale settlement process.

[6] Note that the Meter Data Responsible (MDR) was denominated Meter Data Company (MDC) in USEF publications previous to this one.
[7] The ebIX role model considers additional roles on collection, aggregation and storing data. These roles are not described in this document because they are not relevant for the USEF processes.
[8] Note that the Imbalance Settlement Responsible (ISR) was denominated Allocation Responsible Party (ARP) in USEF publications previous to this one.
[9] As per Commission Regulation (EU) 2017/1485, 'scheduling area' means an area within which the TSOs' obligations regarding scheduling apply due to operational or organisational needs. This area consists of one or more Metering Grid Areas with common market rules for which the settlement responsible party carries out an imbalance settlement and which has the same price for imbalance.
[10] As per Commission Regulation (EU) 2017/1485 article 110: Where a bidding zone covers several control areas, TSOs within that bidding zone may jointly decide to operate a common scheduling process, otherwise, each control area within that bidding zone is considered a separate scheduling area.

Role	Definition
BSP	The Balancing Service Provider (BSP) is a market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs. The BSP is the trading counterparty through which the Aggregator provides Balancing Services to the TSO. BSPs are contracted by the TSO and is responsible for procuring balancing energy.
CMSP	The role of the Congestion Management Service Provider (CMSP) is to provide 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.
CSP	The role of the Capacity Service Provider (CSP) is to provide adequacy services to either the TSO or a BRP. This role is similar to the BSP and CMSP roles and is applicable for adequacy services only.

2.1.3 The value of flexibility

Flexible assets at Active Customer level - flexible loads, controllable local generation units and local storage units - can offer flexibility by allowing their load or generation profiles to be purposely changed from the planned, or normal, generation or consumption pattern. This DF can provide value to different parties:

- The *Active Customer* can use flexibility for in-home optimization, e.g. optimizing against variable energy and/or grid tariffs, or increasing self-consumption of self-generated electricity.
- The *Supplier* and its *Balance Responsible Party (BRP)* aim to reduce sourcing costs, maximize revenue from generation and avoid imbalance charges. Flexibility can help a Supplier/BRP to optimize its portfolio.
- The *Distribution System Operator (DSO)* is responsible for the installation and maintenance of distribution grids. To actively manage the available capacity, the DSO can use flexibility, e.g. to defer or avoid grid reinforcement costs.
- The *Transmission System Operator (TSO)* is responsible for the installation and maintenance of the transmission grid and for system stability. It may, depending on national regulation, also have responsibility for ensuring generation adequacy. TSOs can apply flexibility in multiple ways, from system operation services for balancing purposes, to constraint management (e.g. congestion management) at high-voltage level, and adequacy services.

Active Customers exposed to variable electricity and/or grid tariffs (e.g. Time-of-Use (ToU) tariffs) can profit from flexibility for in-home optimization, allowing them to shift their flexible assets to periods with relatively low electricity prices or grid tariffs. This valorisation of the Active Customer's flexibility is known as *implicit DF*. Typically, local optimization of flexible assets is performed autonomously by the Active Customer, or offered as a service to the Active Customer, by an ESCo (Energy Service Company). This is illustrated in Figure 2-1.

Another mechanism, *explicit DF,* sees flexibility directly exposed to energy markets and system operation products. Active Customers may receive (financial) rewards[11] for agreeing to respond to BRP, DSO or TSO requests to adjust their load or generation profile. Because explicit DF is dispatchable and can be tailored to exact market needs (size and timing), it may offer specific value for e.g. balancing and capacity management.

[11] The customer may or may not receive a part of the explicit remuneration. This should be specified in the aggregation contract.

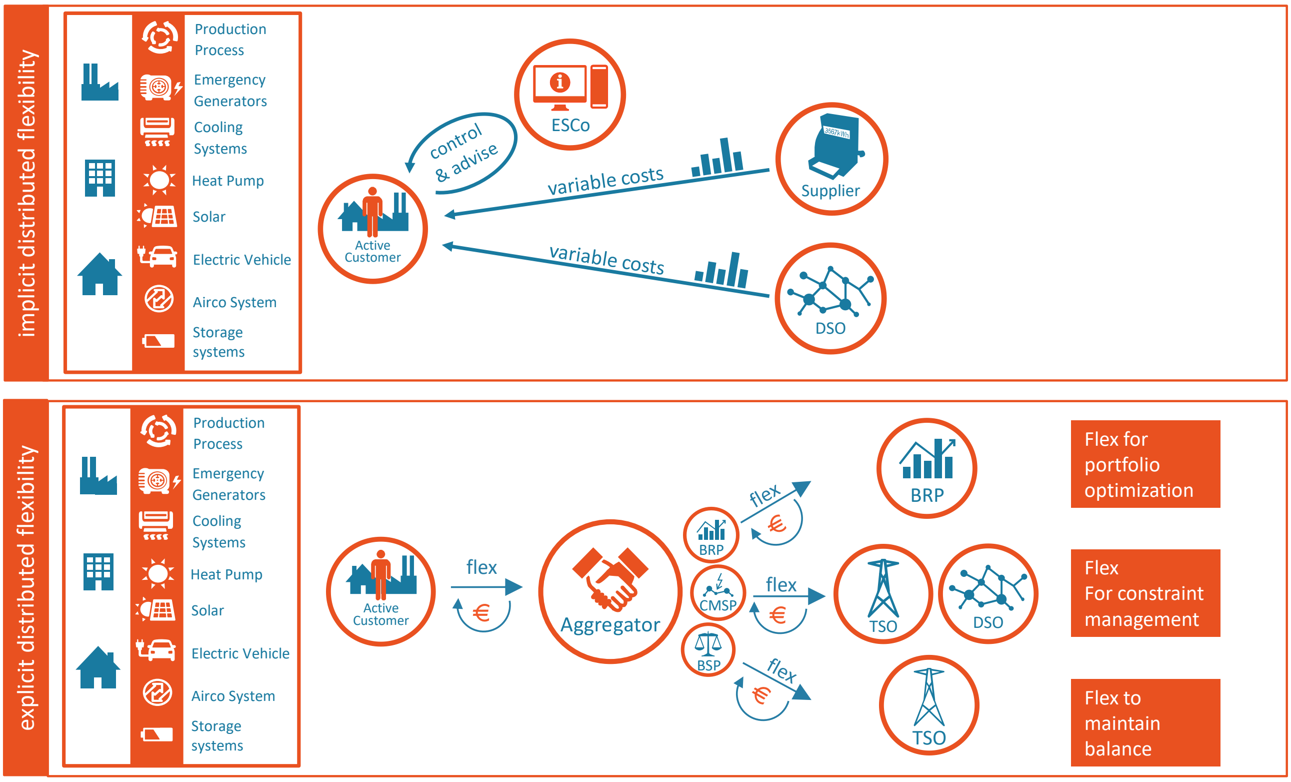


Figure 2-1: The USEF Flexibility Value Chain for implicit and explicit Distributed Flexibility (DF).

2.1.4 A central role for the Aggregator

In USEF's roles model, the Aggregator[12] (also known as Flexibility Service Provider) is a retailer of flexibility, sitting centrally in the FVC, between the Active Customer and the Flex Requesting Parties (FRP), i.e. the BRP, DSO and TSO. The Aggregator is responsible for acquiring flexibility from Active Customers, aggregating it into a portfolio, creating services that draw on it and offering these to different markets, through different roles such as BSP, CMSP, CSP and BRP, serving different market players. The value received by the Aggregator in return is shared with Active Customers as an incentive for them to shift, reduce or enhance their load or generation[13].

It is also possible to combine implicit and explicit DF, i.e. where the Aggregator (responsible for explicit DF) and the ESCo (responsible for implicit DF) can be either the same or different entities. See Figure 2-2 for an illustration of combined implicit and explicit DF. Note that certain restrictions apply to this combination, specifically when operated by different market parties - see [1] - the publication *Recommendations for DR market design* (2017) by USEF's Aggregator Workstream - for an overview of feasible combinations.

[12] The Aggregator is a market role that can be taken by either existing market parties (e.g. a Supplier or BRP) or new entrants.
[13] Aggregators can also provide non-financial value in return to the Active Customer, e.g. by providing insight into consumption patterns or providing home energy management tools that help the Active Customer to become more energy efficient.

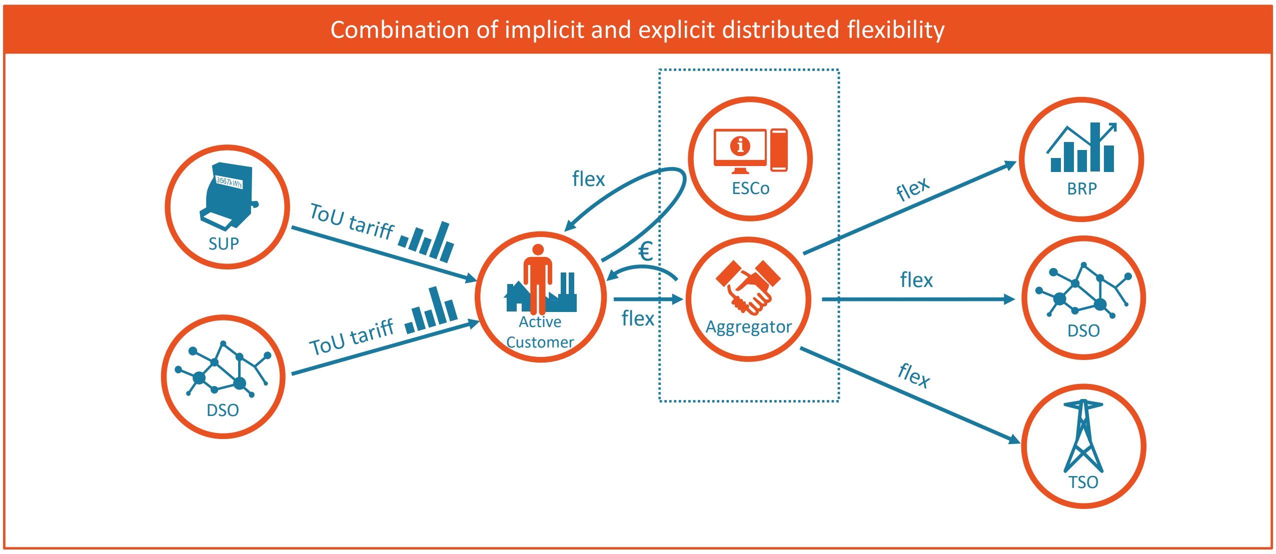


Figure 2-2: Combination of implicit and explicit Distributed Flexibility (DF).

2.2 Flexibility services

This section contains a more in-depth introduction to the FVC. It defines and categorizes flexibility services that an Aggregator can be delivered to the three distinguished Flexibility Requesting Parties (FRPs): DSO, TSO, BRP. For the sake of completeness, flexibility services aimed at the Active Customer are also included although these are provided by the ESCo role (implicit DF), rather than the Aggregator role. The categorization and definitions include examples of flexibility services already in use, or in development, in existing (European) markets. These should not be considered a recommendation of the type of flexibility services to be offered in every market.

2.2.1 Implicit distributed flexibility services

Figure 2-3 lists services for local (in-home, in-factory) optimization, provided by implicit DF, which can be offered by an ESCo to the Active Customer. These services include: Time-of-Use (ToU) optimization, control of the maximum load (kW_{max} control), self-balancing services or emergency power supply. These services are only financially viable if there is a (financial) incentive for each type of local optimization.

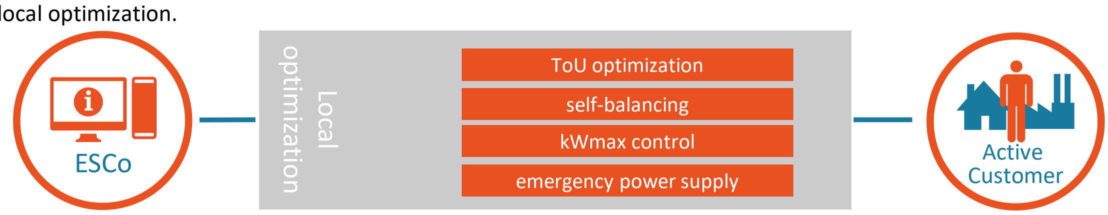


Figure 2-3: Implicit Distributed Flexibility (DF) services.

2.2.1.1 ToU Optimization

Time-of-use (ToU) optimization is optimization based on load shifting from high-price intervals to low-price intervals (or vice versa in case of generation shifting), or even complete load shedding during periods with high prices. The time discrimination of ToU tariffs can vary; for example, peak/off-peak tariffs generally apply for 2 periods of time whereas Real Time Pricing (RTP) can have higher granularity e.g. hourly prices. This optimization requires that price schedules are known in advance (e.g. day-ahead). Using DF for ToU optimization will lower the Active Customer’s energy bill. ToU optimization is an implicit form of wholesale trading, with the Supplier as the trading party.

2.2.1.2 In-home self-balancing

In-home self-balancing is typical for Active Customers who also generate electricity (e.g. through PV panels or CHP systems) and have flexible demand. Value is created through the difference in the prices for supply from the grid (buying) and feed-in to the grid (selling), including taxation. Note that self-balancing is not financially beneficial for Active Customers when national regulations allow for full administrative balancing (net-metering) of net load, and net generation, on an annual basis.

2.2.1.3 KW_{max} control

Control of the maximum load is based on reducing the maximum load (peak shaving) that the Active Customer consumes within a predefined period (e.g. month, year), either through load or generation shifting, or shedding, with the objection to minimize grid fees. Current grid tariff schemes, especially for Commercial and Industrial (C&I) customers, often include a tariff component that is based on the Active Customer's maximum load (kW_{max}) and/or the connection capacity. Using DF to reduce the maximum load can reduce the grid component of the electricity bill for the Active Customer. Helping them avoid the one-off costs associated with a grid connection upgrade is another potential benefit.

2.2.1.4 Emergency power supply

An additional service is emergency power supply during grid outages. Whether this is of sufficient value to the Active Customer depends mainly on the grid's reliability and the potential damage from a grid outage ('value of lost load'); this, in turn depends on the type of Active Customer (e.g. residential home, office building or hospital). Enabling the use of DF for islanding for emergency power supply may require additional investments, e.g. storage and synchronization systems.

2.2.2 Explicit distributed flexibility services

Figure 2-4 shows a list and classification of explicit DF services. These services can be classified as follows:

- *Constraint management services* help the grid operators (TSO and DSO) to optimize grid operation using physical constraints, and impact on markets[14].
- *Adequacy services* aim to increase security of supply by organizing sufficient long-term peak and non-peak generation capacity. Adequacy services can be provided to either the TSO or the BRP, depending on market design.
- *Wholesale services* help BRPs to decrease sourcing costs (purchase of electricity) – mainly on Day-Ahead (DA) and Intraday (ID) markets - but also costs for sourcing through balancing mechanisms. In the FVC the BRP is the FRP for wholesale services. In practice, the Aggregator can also provide flexibility to the Supplier. Since every market participant requires a BRP, wholesale services are considered by USEF to be (indirect) services to the BRP.[15]
- *Balancing services* include all services specified by the TSO for frequency regulation.

Note that the term *system operation services* can be used to refer to *balancing* and *constraint management services*.

[14] Especially in regions with flow-based market coupling.
[15] In general, wholesale markets are considered implicit markets, since there is no physical settlement for each individual trade. E.g. Suppliers (also those that combine their role with the Aggregator role) having their own retail portfolio, as well as trading-only market parties, operate in these implicit markets. However, an Aggregator without its own retail portfolio, when trading in wholesale markets, will need to source its energy through the Transfer of Energy (ToE). This makes wholesale trading explicit in this specific case. The ToE is further explained in section 3.3.

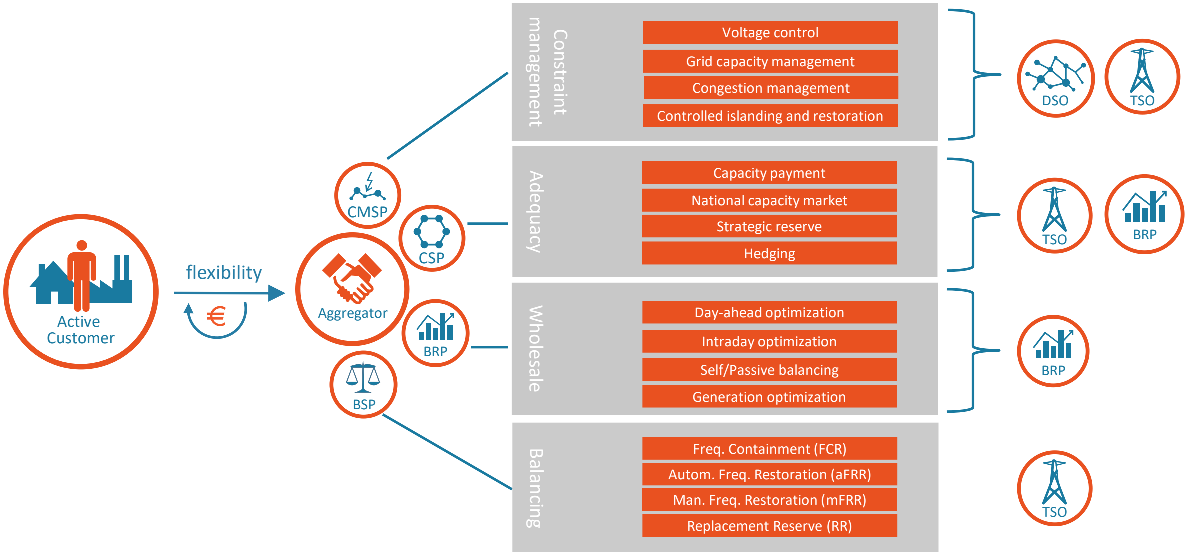


Figure 2-4: Explicit Distributed Flexibility (DF) services. The services are classified in four categories: Constraint Management, Adequacy, Wholesale and Balancing. The FRPs that can be served for each category are found on the right side of the figure[16]. The trading counter party through which the Aggregator brings the service to the FRP can be found on the left side[17].

In the Flexibility Value Chain, the Aggregator delivers the flexibility directly to the FRP. From the perspective of the FRP, however, the Aggregator may act as, or through, a role dedicated to the delivery of the flexibility service. Table 2-1 shows the associated roles for the four flexibility service groups.

Table 2-1: The role of the Aggregator per flexibility service group.

Flexibility service group	Flexibility Requesting Party	Trading Counter Party
Wholesale services	BRP[18]	Balance Responsible Party (BRP)
Constraint management services	DSO, TSO	Constraint Management Service Provider (CMSP)
Balancing services	TSO	Balancing Service Provider (BSP)
Adequacy services	TSO, BRP	Capacity Service Provider (CSP)

The specific services as shown in Figure 2-4 are described below.

2.2.2.1 Wholesale services

Day-ahead optimization

Day-ahead optimization aims to shift loads from a high to a low-price time interval on a day-ahead basis or longer. Using DF for day-ahead optimization enables the BRP to reduce overall electricity sourcing costs. DF can be traded via either a Day-Ahead (DA) exchange or by establishing a bilateral agreement.

Intraday optimization

Intraday optimization (via Intraday (ID) exchange or by bilateral agreements) closely resembles day-ahead optimization but the timeframe is constrained after closing of the day-ahead market[19] and, in general, intraday markets can trade products with finer granularity, closer to real-time. BRPs can use DF to repair day-ahead forecast errors for intermittent resources.

[16] The adequacy services capacity payments and strategic reserves can only be provided to the TSO. Flexibility services for hedging can only be provided to the BRP.

[17] Although the CSP is the trading counter party for adequacy services, for hedging typically the Aggregator delivers the flexibility services through the BRP.

[18] Typically, it's the Supplier, using a particular BRP. On the wholesale market, Suppliers (sourcing energy for their retail customers), Generators (selling their energy), Large customers (sourcing their energy) and energy trading market parties (and any combination) are active.

[19] Ex-post nominations are possible in some countries.

Self-balancing and passive balancing

Self-balancing is the reduction of portfolio imbalance by the BRP to avoid imbalance charges. The Aggregator can offer flexibility to the BRP to optimize the position of its portfolio to lower any (expected) imbalance cost. The trading of flexibility for this purpose is typically arranged via bilateral agreements.

In some countries (e.g. the Netherlands), the TSO remunerates a BRP that supports the reduction of system imbalance by deviating the balance position of its own portfolio in the right direction; this is called *passive balancing*. In such a system, real-time data is made available by the TSO so BRPs can predict imbalance prices. This mechanism basically creates a real-time market price for electricity, although it does contain certain risks related to the predictability of the total imbalance and thus the final imbalance prices per Imbalance Settlement Period (ISP). The Aggregator, in combination with a BRP role, can also participate in this mechanism by creating imbalance in its own portfolio.

Generation optimization

Generation optimization refers to optimizing the behaviour of central production units as they prepare for their next hourly planned production volume. Because the control speed of conventional power units is limited, they start ramping up or ramping down minutes before the hour. To avoid imbalance, some overshoot or undershoot in output is necessary which may reduce unit lifetime and increase their fuel consumption. This over- or undershoot can be avoided by using DF.

2.2.2.2 Constraint management

Constraint management services help grid operators (TSO and DSO) to optimize grid operation for physical and market constraints. Constraint management takes various forms; USEF distinguishes four flexibility services. Additional DSO services may be required in the future (e.g. reactive power for power quality[20] or restoration support). The focus for now is on real power services and a short description of each of these can be found below.

Voltage control

Voltage problems can occur e.g. when solar PV systems generate significant amounts of electricity, increasing the voltage level in the (local) grid. Using DF to increase the load or decrease generation can avoid exceeding any voltage limits. This means that DF can reduce the need for grid investment (such as automatic tap changers) or prevent generation curtailment. The grid operator (TSO and DSO) is the FRP for voltage control services.

Grid capacity management

Grid capacity management refers to the DSO or TSO using explicit DF to increase its operational efficiency, without any impact on the freedom of dispatch, trade and connect (copper plate principle). This implies that Aggregators (and Active Customers) are participating in the product on a voluntary basis (i.e. with proper financial incentives). The main purposes are explained in the below, non-exhaustive, list:

1. *To defer grid reinforcements*
   Traditionally, when future load projections exceed the (thermal) rating of a grid component, grid reinforcement is required. By influencing the peak load or generation, the need for reinforcement can be deferred. This is especially relevant for (but not limited to) grid areas where n-1 obligations apply.
2. *To optimize operational performance of assets*
   By reducing peak loads, the lifetime of components can be extended.
3. *To reduce grid losses*
   Since the energy lost during transportation is physically proportional to the square of the transported energy, the total losses can be reduced by reducing peak loads.
4. *During planned maintenance*
   When planned maintenance occurs, reliability can be further enhanced, (n-1) obligations can still be met, or the need to apply congestion management can be avoided, by reducing peak load (or generation) on a voluntary basis.

Grid capacity management should therefore be considered as (future) business as usual situation for the TSO/DSO, contrary to congestion management.

[20] Power quality support aims at voltage, frequency and waveform.

Congestion management

Congestion management refers to avoiding the overload of system components by reducing peak loads to avoid the causing failure situations. Contrary to grid capacity management, the possible overload (potentially leading to an outage) has not been anticipated during the long-term grid planning process, or the load/ generation increase happens at a higher pace then grid reinforcements can cope with. It is a temporary solution, where the long-term solution (in general) is grid reinforcement.

Congestion management is a highly-regulated mechanism, currently only available to TSOs in most European countries, but may, in the future, be made available to DSOs[21]. Depending on regulations, the TSO/DSO can have direct access to demand-side resources (e.g. load curtailment through smart meter infrastructure). Several congestion management mechanisms are more market-oriented, allowing Aggregators to participate. In general, congestion management mechanisms include limitations to the freedom of dispatch, trade and/or connect.

Controlled islanding and restoration

Controlled islanding aims to prevent supply interruption in a grid section resulting from faults in any sections that feed into it. DF can be used to better match demand with local supply. Following a loss of supply, the DSO can use DF to support increased and faster load restoration under depleted network conditions. For example, flexibility can be used to minimize the load to allow for restoration of other (non-flexible) loads.

Another relevant categorization for constraint management services is the distinction between pre-fault and post-fault products:

- For pre-fault products, the DNO procures a pre-agreed change in service provider output, based on (typically) day-ahead or intra-day network conditions, to avoid any expected physical constraint violations. As the conditions that could trigger such violations can occur frequently (e.g. cold days in winter with high electricity demand, or high renewable generation combined with low local demand), activations can occur frequently. These pre-agreed changes can be acquired through free bids, or may be governed by availability contracts.
- For post-fault products, the DSO procures the ability of a service provider to deliver an agreed change in output following a network fault. Done ahead of time, utilisation would be instructed when the fault occurs on the network through an automated system, close to- or in real time. Since faults occur rarely, activation of a post-fault product would also be rare. Although USEF allows for availability contracts which could also support post-fault products, it currently does not stimulate the use of 'free bids' in a post-fault product because, under current USEF arrangements, free bids which are not activated are not remunerated. However, they do provide value in a post-fault product and therefore USEF could accommodate post-fault products; this would require an *option payment*: paying for assets that are armed ahead of time, even when they are not activated. Although UFTP can facilitate this, it has not yet been fully elaborated in the USEF processes in section 4.

2.2.2.3 Balancing

USEF follows the definitions from the European Network code on Load-Frequency Control and Reserves [2] for the balancing services Frequency Containment Reserve (FCR), automatic or manual Frequency Restoration Reserve (aFRR/mFRR) and Replacement Reserve (RR). According to the European Network Code, balancing services aim to restore system frequency to its nominal frequency of 50 Hz. DF can be used to offer all four services to the TSO and these are described below.

Frequency Containment Reserve (FCR)

FCR aims to contain any system frequency deviation to within a pre-defined range after an incident. Typically, activation time in (milli)seconds is required. The FCR capacity is procured ahead (day-ahead is recommended). Remuneration between the TSO and the Aggregator[22] is based on availability and, optionally, on the activated energy.

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[21] For examples of market-based congestion management models for DSOs see [9], the USEF publication *An Introduction to EU market-based congestion management models* (2018).

[22] In the Network code, the role of Balancing Service Provider (BSP) is used.

Automatic Frequency Restoration Reserve (aFRR)
Automatic FRR aims to restore system frequency and is defined as a reserve which can be activated by an automatic control device. aFRR capacity can be bought ahead (contracted bids) but some TSOs additionally request offers that they can accept for the next ISP; these are called 'free bids'. Remuneration is by means of a combination of availability and energy. There is no availability remuneration for free bids. In addition, the TSO will check whether requirements are met and can charge penalties if required.

Manual Frequency Restoration Reserve (mFRR)
Although the objectives of mFRR and aFRR (restoring the system frequency) are the same, the requirements for the two services are different. mFRR generally has a longer duration and larger ramp rate, with fewer measurement and prediction updates required. Only energy remuneration, or a combination of energy and availability remuneration are common to both.

Replacement Reserve (RR)
According to the Network Code, RR replaces the activated reserves to restore the available reserves in the system or for economic optimization. In general, RR has longer duration and slower ramp rate compared to mFRR. Remuneration can be energy-based or a combination of energy and availability remuneration.

2.2.2.4 Adequacy

Adequacy services aim to increase security of supply by organizing sufficient long-term peak and non-peak generation capacity. DF is very suitable for these mechanisms offering either load shedding, or distributed generation, to reduce the need for generation capacity. Adequacy services are provided by the Aggregator through the role of CSP to either the TSO or a BRP. The latter can be obliged by regulation to take responsibility for security of supply or can decide to hedge its risk. In hedging, the trading counter party is typically a BRP. Four different Adequacy services are distinguished and are described below.

Capacity markets
A capacity market is an adequacy service, introduced by an authority to increase security of supply on a long-term basis to an area over a specific time period. In a capacity market, generation capacity is secured against long-term demand. Running a capacity market ensures that lowest cost assets are built, or remain in operation.

Capacity markets can be centralized or decentralized. In centralized capacity markets (e.g. the UK capacity market) the TSO procures the capacity. The TSO estimates the required capacity and contracts all generation assets that are accepted below the clearing price. In decentralized capacity markets (e.g. the French capacity market), the BRP/Supplier has a capacity obligation and is thus responsible for procuring the capacity. The clearing price is the point where demand for capacity and supply for capacity meet.

In decentralized capacity markets, flexibility can be on the demand side, to help a BRP to reduce its capacity obligation. The Aggregator can also choose to add DF as a 'supply' asset to the capacity market and, where this is the case, the Aggregator will receive the capacity-clearing price when its bid is accepted.

Capacity payments
Capacity payments (e.g. as provided to wholesale market participants in Ireland) are a centralized adequacy mechanism to help achieve enough liquidity in an energy market. For capacity to deliver to a market (long-term ahead) at a certain time period, the TSO pays the capacity provider. Capacity payments differ from capacity markets in that they strive for liquidity (on the supply side) and have less focus on clearing supply capacity towards expected demand.

Strategic reserves
Strategic reserves are capacity requests by an authority for specific periods. In the USEF roles model, running the strategic reserve is the responsibility of the TSO. The procured capacity can be activated by a (day-ahead) price trigger or a technical trigger. The difference between strategic reserves and capacity markets is that strategic reserves are dedicated for activation by the TSO (and are kept out of the market until the TSO provides the signal), while capacity markets ensure that procured assets are in operation (i.e. bid into wholesale markets). DF can be used as a strategic reserve.

Hedging

Hedging is a way for a BRP to mitigate price risks associated with volatile energy supply and demand. Since high prices typically occur in periods of scarce generation, hedging can be considered an adequacy mechanism. Hedging is typically done via over-the-counter contracts (e.g. contracts for difference, fixed price fixed volume, fixed price variable volume, options) or via futures exchanges[23]. DF can be used as an instrument in these hedging products or can be traded as a hedging product itself e.g. the Aggregator offers the FRP the opportunity to activate flexibility at a certain price level.

2.3 Characteristics of flexibility delivery and remuneration

The previous section shows that the Aggregator can provide various explicit DF services to serve the different needs of the FRPs. The market where flexibility is traded, or the bilateral agreement between the Aggregator and the FRP, defines the way flexibility is delivered and how it is remunerated. This section introduces a set of characteristics to distinguish flexibility delivery and remuneration types. This characterization supports comparison of flexibility services and provides insight into the settlement relationships between the Aggregator and FRP, and other parties.

2.3.1 Characteristics of flexibility delivery

Figure 2-5 shows the characteristics of flexibility delivery. The first component is the *availability* of flexibility, where the Aggregator ensures that enough flexibility is available to the FRP within the specified time period. The *activation* of flexibility refers to the actual control of assets to deliver flexibility. Activation is typically expressed in energy (kWh). Availability typically leads to activation, although the activation frequency strongly depends on the type of product. Therefore, in flexibility services focusing on availability, the activation delivery (characteristics and remuneration) is also specified, as are the terms and conditions for activating.

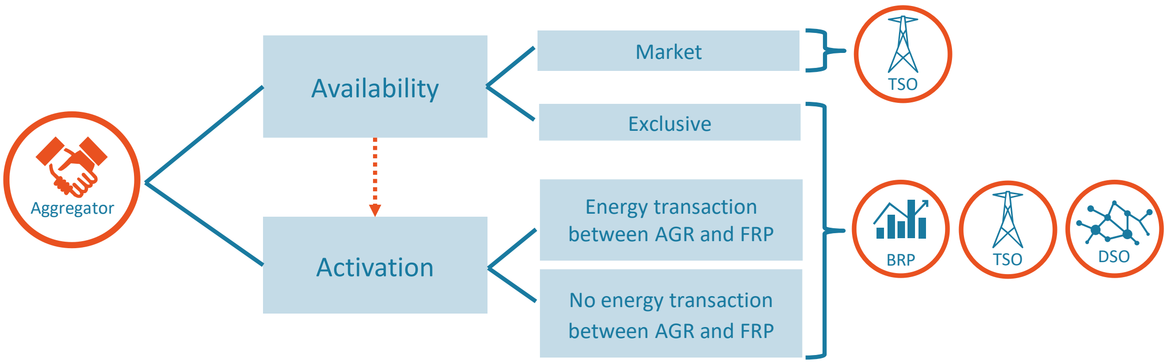

Figure 2-5: Characteristics of flexibility delivery.

2.3.1.1 Availability of flexibility

An FRP can require *availability* of DF in two different ways:

- **Market availability**: the Aggregator makes sure that the asset is available in one or more markets where the FRP is not a single buyer.
- **Exclusive availability**: the Aggregator reserves capacity for activation on request of the FRP.

Market availability shows up in adequacy services such as capacity markets and payments. This availability is non-exclusive since the FRP of the availability contract (the TSO) does not require the Aggregator to reserve the capacity for activation by the FRP.

[23] On a futures exchange, parties can settle a price to be paid later in time, e.g. six months.

Availability may be verified by validating the response after receiving a request for activation. FRPs may also use prequalification tests, audits of assets and control equipment, and (random) activation tests to verify the availability of flexibility offered by the Aggregator.

2.3.1.2 Activation of flexibility

The *activation* of DF can occur in two ways:

- **With energy transaction:** the Aggregator delivers *energy* which requires an *energy transaction* between Aggregator and FRP. The energy transaction volume can be based on the requested volume (this is the case in e.g. wholesale market trading) or the activated volume[24].
- **Without energy transaction:** the Aggregator only delivers a *service* to the FRP, not the energy. Typically, delivery without energy transaction between Aggregator and FRP is suitable for constraint management services because it offers load reduction or generation enhancement which are of interest to the DSO/TSO, e.g. to prevent congestion. For service delivery, the FRP allows the (BRP of the) Aggregator to organize the deviation in the energy profile in its preferred way. The Aggregator can either register another trade with an energy transaction to settle the energy, activate other assets in its portfolio as a countermeasure, or can accept the 'imbalance'. This becomes more complex if the Aggregator is controlling assets outside its own portfolio (see section 3.3).

2.3.1.3 Drop-by and drop-to services

The *availability* and/or *activation* of flexibility can be requested and validated by the FRP in different ways:

- **Drop-to services:** are defined as services where the FRP requests that the Aggregator ensures the availability and required activations are managed to keep the (aggregated) load or generation below or above a limit. This method is can found in adequacy or grid capacity management services. An example of a drop-to service can be found in the proposed/considered quota system for congestion management in Germany.
- **Drop-by services**: are defined as services for where the FRP requests that the Aggregator manages a decrease or increase in load/generation according to a baseline with the requested volume in MWh. The baseline would represent the load profile if flexibility activation had not been performed. Most of explicit flexibility services follow this structure.

Drop-to services offer an advantage because the FRP does not need to quantify the delivered energy volume and thus there is no need for a baseline. However, this advantage is limited, as a baseline can still be required for other purposes; for example, the FRP may still decide to remunerate based on activated flexibility volumes.

2.3.2 Characteristics of flexibility remuneration

This subsection introduces elements to describe how the FRP remunerates the Aggregator for providing DF services.
Note that *wholesale services* are not necessarily separately settled, as the delivered flexibility in this case is implicit in the BRPs' portfolio. Flexibility is only separately settled on wholesale markets which need a corresponding *Transfer of Energy (ToE)*. The Transfer of Energy and the different types of Aggregator Implementation Models (AIMs) that can be applied in practice will be discussed in the next chapter (chapter 3).

The remuneration of DF can be based on the performance of the Aggregator during the *availability* or *activation* period in various ways. Flexibility *availability* remuneration is typically paid per contract period and based on:

- **Availability remuneration:** the Aggregator receives a fixed price for the availability of capacity (kW/h or kW/ISP). The FRP can issue test activations to assess the quality of the availability service.
- **Assessment of delivery requirements compliance:** assessment of compliance with delivery requirements such as ramp rate, kW-max/min, response time, duration, partial delivery, overshoot, etc. If the Aggregator does not meet the requirements, it can result in penalties or disqualification of service delivery.

[24] The energy transaction is typically equal to the energy volume remunerated by the FRP. However, there are some exceptions: e.g. it is possible that the TSO settles the activated flexibility volume (and thus accepts overshoot) but remunerates only the requested volume. Where the energy transaction volume is defined as the requested volume, partial delivery or overshoot will lead to an imbalance position for the Aggregator's BRP. Where an energy transaction leaves DSOs or TSOs with a non-zero energy position this may need to be neutralized with a countertrade, a so-called redispatch.

Remuneration of flexibility *activation* is typically paid per activation, and based on:

- **Energy volume remuneration:** concerns any element in the remuneration that depends on the *requested volume* or the *activated volume* (baseline minus measurements) in kWh. To compare flexibility services on the remuneration of the activated volume, the baseline methodologies should also be compared as different products and generally use different baseline methodologies, which means that the same activation may result in different activated volumes for different products.
- **Power performance remuneration**: concerns any element in the remuneration that is dependent on the delivered power (kW) according to a baseline.

Note that a flexibility service may have multiple remuneration elements. The elements listed are commonly found in flexibility services but other remuneration elements may be adopted by flexibility service providers, i.e. Aggregators.

FRPs can also request tests or audits outside activation/availability periods:

- prequalification assessment of delivery requirements compliance and quality of baseline;
- assessment of the availability or quality of the baseline during non-activation within availability periods.

2.3.3 Value stacking

The business case for the Aggregator is not solely dependent on the above-mentioned remuneration elements. It also depends on the costs related to the delivery of flexibility e.g. the costs of availability reservation, flexibility activation and also opportunity costs i.e. benefits missed when choosing one specific service delivery over an alternative. Note that costs related to activation are borne by the Active Customer and are typically compensated by the Aggregator. The Aggregator could increase the value of flexibility using *value stacking*. Value stacking enables the Aggregator to provide multiple services to one or multiple FRPs from the same portfolio. For explicit DF services, different levels of value stacking are possible:

- *In time:* provision of different services during distinct time periods. For example, the provision of an aFRR balancing service to the TSO in the morning and a congestion management service to the DSO in the afternoon.
- *In pools:* use of pools to split-up a portfolio during a single time period and activating one asset, or pool, for one service and another asset, or pool, for another.
- *Double serving:* provision of multiple services during the same time period by stacking activations from one asset, pool or portfolio. This value stacking type can be differentiated into double serving with single or multiple energy transactions:
    - *Double serving with a single energy transaction*: combining services with and without energy transactions. For example, a congestion management service is provided to the DSO but there is no energy transaction between the Aggregator and the DSO. Subsequently, the reduction or increase in load or generation (resulting from the planned activation) is offered (and ordered) on the wholesale market (meaning there is an energy transaction with the market).
    - *Double serving with multiple energy transactions:* using the available flexibility to provide multiple services with energy transactions. For example, 40% of wind curtailment is sold on the wholesale market and the remaining 60% is activated as aFRR balancing service. The corresponding energy transactions take place on both the wholesale market (40% of flexibility) and with the TSO (60% of the flexibility).

Another important distinction, when performing value stacking, is whether flexibility is activated in the same direction for different services, or in opposite direction.

- Constraint management services typically support value stacking in the same direction but disallow value stacking in the opposite direction; e.g. because a balancing activation in the opposite direction could cancel out the effect of a congestion management activation.
- A day-ahead energy trade can be followed by an intraday-trade in the opposite direction. This type of asset-backed trading could even avoid the need for an activation, while still generating revenue (spread between DA and ID prices).

When applying value stacking, the Aggregator should ensure the following conditions are met:

- Exclusivity agreements should be respected. If the Aggregator has closed an exclusive availability contract with a FRP, he should ensure that agreed flexibility is exclusively available for this FRP within the agreed availability window.

- Energy can only be sold once. In cases of double serving, with multiple energy transactions, this should be taken into account.

For all three levels of value stacking, it is possible to allow for *dynamic pooling*: the ability to decide real-time what assets were activated to deliver each service. USEF allows for all types of value stacking, although the complex nature of the interactions between the Aggregator and different parties involved in *double serving with multiple energy transactions* can make it challenging to distinguish and quantify the individual stacked services. These interactions involve the trading and validation of product delivery and settlement. USEF provides a comprehensive method to distinguish and quantify individually stacked services (while avoiding *double selling of energy*). More information can be found in [3]: USEF's *Value Stacking* (2018) white paper.

The different aspects of value stacking and related implications are further explored in section 5.1.

3 USEF interaction model and Aggregator Implementation Models

3.1 The USEF interaction model

The previous chapter presented all implicit and explicit flexibility services and the main market roles involved. How do these roles interact though and how are implicit and explicit flexibility services related? This section describes the USEF-defined interactions between the main roles in the USEF roles model, as introduced in section 2.1.2.

The implicit and explicit flexibility supply chains are separated in the USEF interaction model. The physical transport of energy underlies both chains. Energy is transported and distributed from, and to, Active Customers using the High Voltage (HV) transmission network and Medium Voltage (MV) and Low Voltage (LV) distribution networks operated by the TSO and DSO respectively. In general, the DSO connects Active Customers to their networks, and a connection contract[25] describes the tariffs and terms and conditions for access to the grid.

The implicit flexibility chain remains unaffected in the USEF model. The Supplier establishes a contractual relationship with the Active Customer for the supply and sourcing of energy. That contract will establish the type of energy tariff; for example, ToU, Real Time Pricing (RTP) and peak/off-peak tariffs amongst others. The Supplier forecasts its customers' load profile and sources the energy through the BRP based on a pre-arranged BR agreement. The BRP might have a number of energy purchase contracts in place with power producers to source the energy demand of its Suppliers' Active Customers. Furthermore, the BRP has the option to arrange energy trading deals. There are multiple forms of trading: over-the-counter (OTC), spot markets, and intraday markets. These markets can be used to balance the BRP's portfolio. The ESCo can optionally provide implicit optimization services to the Active Customer and relevant services are described the in-home optimization services detailed in section 2.2.1.

The USEF explicit flexibility supply chain is designed to unlock and maximize the value of flexibility. To that end, the Aggregator establishes a contract with the Active Customer, describing the terms and conditions under which it can exploit the flexibility within the Active Customer-defined control space of the flexible asset.

The Aggregator optimizes the value of the flexibility in its portfolio by selling flexibility to parties who have the most urgent need for it and, hence, are willing to procure it at the highest price. As such, the Aggregator, associates with the different service provider roles (Balancing Service Provider, Capacity Service Provider and Constraint Service Provider) to establish a flexibility service contract with the flexibility requesting parties. The contract specifies the terms and conditions for trading flexibility, including the settlement of imbalance resulting from flexibility transactions.

The full USEF interaction model combines the implicit and explicit flexibility value chain interaction as depicted below.

[25] Note that Active Customers with a direct connection to the HV grid have a connection contract with the TSO. This contract is not depicted in the figure.

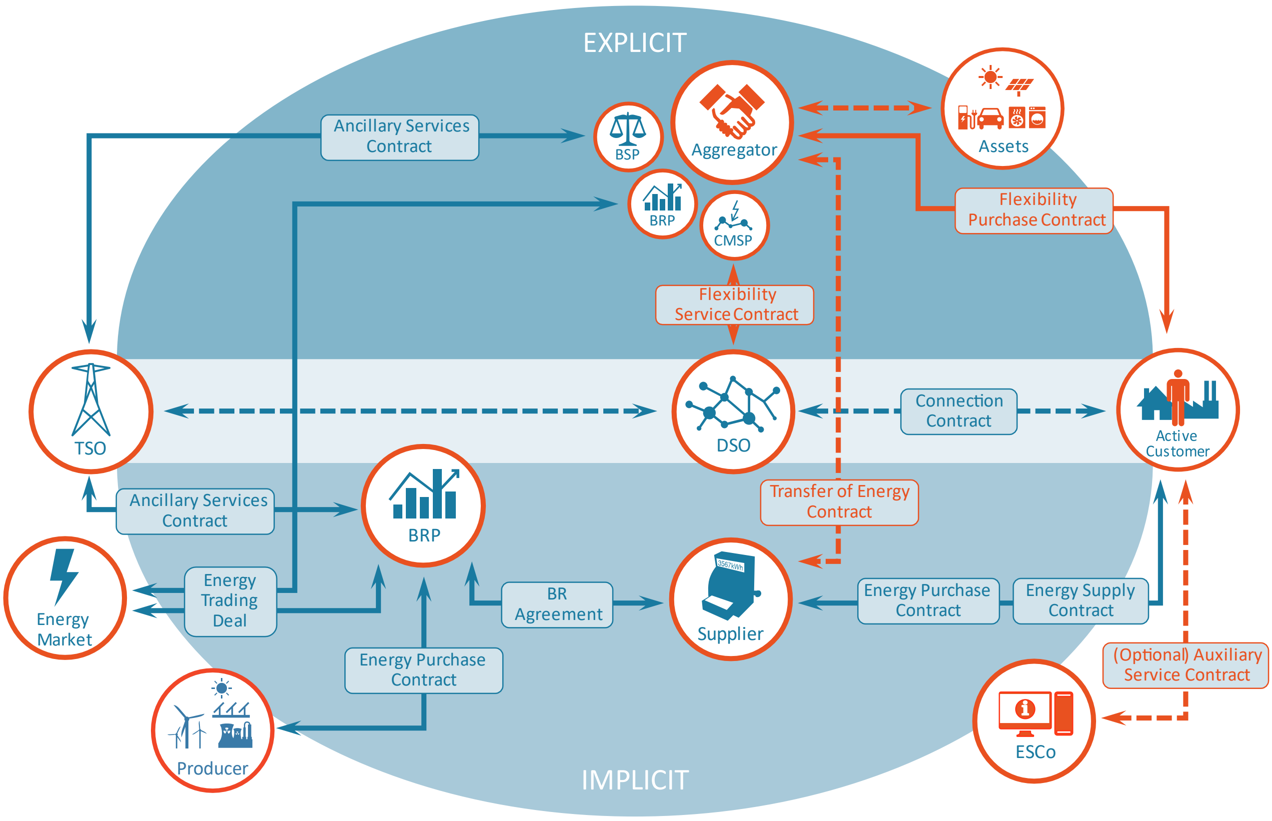

Figure 3-1: USEF implicit/explicit flexibility interaction model

Although the supply of the energy commodity can be separated from the supply of flexibility, ensuring that flexibility transactions do not disturb the balance position of the Supplier's BRP (BRP_{SUP}) is not straightforward. After all, flexibility only manifests itself once it is activated by the Aggregator and alters a part of the commodity supply. The following sections address the relevant considerations to be made when implementing the Aggregator role and describe its balance responsibility, and its relationship with the Supplier.

3.2 Considerations for the Aggregator role

There are many elements to the Aggregator implementation equation, e.g. technical considerations, regulatory aspects, information exchange requirements, and contractual relationships amongst others. However, before going into detail, we are going to focus on the most elemental aspects which are the flexibility product delivery and the split of flexibility and supply.

3.2.1 Split supply model

The most straightforward way to deliver flexibility, while separating the flexible asset from the rest of the load, is the implementation of a '*split supply model*'.

As shown in Figure 3-2:, this model splits the supply of the Active Customer load into controllable and non-controllable, so that one Supplier is responsible for the supply and balance responsibility (BR) for the controllable load and another Supplier is responsible for the supply and BR for the non-controllable load. To make use of the flexibility from the controllable asset, the controllable load Supplier can either partner with an Aggregator or perform the Aggregator role itself.

This model is typically implemented by adding additional meters, either parallel with the (original) main meter at the connection or behind the main meter, i.e. through sub-metering.[26] Synthetic profiles could also be used.

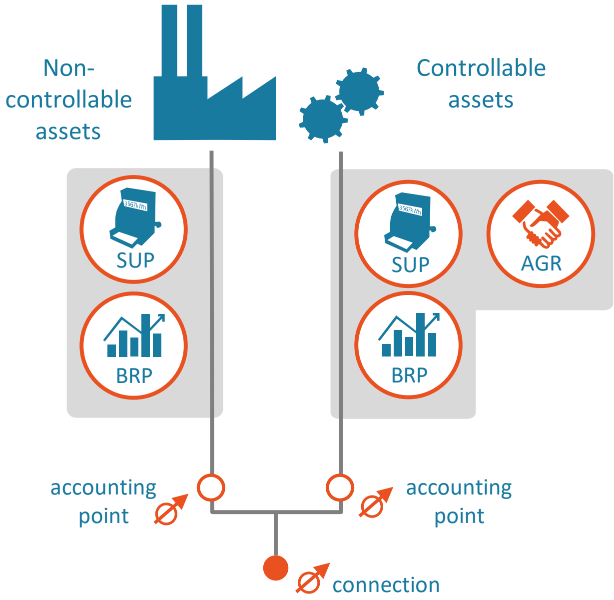

Figure 3-2: Split supply model. Left part is supply to the uncontrollable load; right part is supply to flexible asset.

The main drivers for implementing this model are:

- Relatively less impact on regulation compared to other Aggregator Implementation Models;
- The enabling regulatory framework for split supply might have been partly developed under Directive 2014/94 of the deployment of alternative fuels infrastructure, Article 4.12 Electricity supply for transport, which says that "Member States shall ensure that the legal framework permits the electricity supply for a recharging point to be the subject of a contract with a supplier other than the entity supplying electricity to the household or premises where such a recharging point is located."
- Implementation of the Directive 2019/944 article 59 clause (p) which states that "Monitoring the occurrence of restrictive contractual practices, including exclusivity clauses which may prevent customers from contracting simultaneously with more than one supplier or restrict their choice to do so, and, where appropriate, informing the national competition authorities of such practices";
- Feed-in of renewable energy, allowing Active Customers to choose different suppliers for energy consumption and energy production.

Where this model focuses on the split of supply, USEF also considers the full separation between supply and flexibility. Although it is more complex to implement, this separation may lower the market entry barriers for Aggregators since they would not be obliged to associate with a supplier. The split of flexibility and supply is addressed in the following section.

3.2.2 Separating explicit flexibility from supply

When separating supply and flexibility, the Aggregator takes responsibility for the activation of flexibility and the Supplier for the energy supply.
In this attempt to separate flexibility from supply, we apply three main principles:

1. The responsibilities of the Aggregator (and their BRP) are restricted to:
   (i) the activation periods. For the activation period the so-called rebound effect needs to be considered.

[26] Sub-metering applies when a meter is installed behind the main meter point. This could either be a dedicated meter, or a meter embedded in the controllable asset.

(ii) flexibility assets that are activated.
(iii) for each activated asset, the deviation from its baseline.

2. The Aggregator does not need to take responsibility for the Active Customer's supply of energy.

The effects of the flexibility activation for the Supplier and the related BRP should be identifiable such that Supplier could be compensated [4]. These principles entail the arrangement of certain key aspects that determine Aggregator, BRP and Supplier relationship, information exchange, effects on sourcing and balancing position. The next section further explains these key aspects.

In addition to the aggregator arrangements, one of the main challenges of deploying explicit flexibility is the flexibility delivery validation. While validating supply is straightforward through the main meter reading, validating flexibility delivery is more complex and so other methods are needed. The following complexities should be considered:

- Measurement and validation: Ensuring correct and trustworthy data. Since flexible assets are typically behind-the-meter, the Aggregator may apply sub-metering (see Figure 3-3:) to have a better visibility of the asset performance and quantify the delivered flexibility.
- Baseline methodology: The baseline determines the expected load/consumption pattern without flexibility activation. The baseline is used to validate the delivered flexibility by calculating the difference between the actual measurements and the baseline. Therefore, determining the baseline methodology and related responsibilities is key.
- Relationship between implicit and explicit flexibility: When an Active Customer is making use of both types of services, explicit and implicit flexibility, it is necessary to quantify both impacts unambiguously.
- Rebound effect: After a period in which flexibility has been activated, a rebound effect may occur. For instance, a reduction in energy consumption could lead to demand being shifted to a later time. The impact of this effect should be studied and taken into consideration.
- Portfolio conditions: The Aggregator might offer flexibility from within a portfolio, rather than a set of separate flexibility resources. The implications of these conditions should be determined.

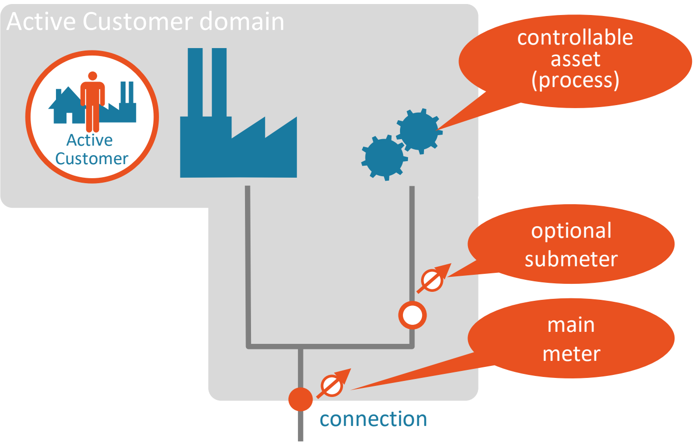

Figure 3-3: Sub-metering to isolate the flexible asset

USEF gives recommendations on how to tackle these complexities in the Workstream on Aggregator Implementation Models publication [1].

3.3 The USEF Aggregator Implementation Models

Based on the key aspects of the Aggregator-Supplier relationship, USEF identifies 7 different Aggregator Implementation Models, which are presented in the next sections. The final section briefly describes reference profile models as an alternative.

3.3.1 Key aspects of Aggregator-Supplier relationship

- **Contractual relationship:** Whether there should be a contractual relationship between Supplier and Aggregator. When the relationship is based on a contract, most (if not all) aspects can be arranged bilaterally. However, requiring a contract with the Supplier can affect the level playing field for Aggregators and so it is key to address this aspect when implementing the Aggregator role.

- **Balance position/Balance responsibility:** Whether the Aggregator needs to assume (or assign) balance responsibility. An Aggregator, as a market party trading flexibility, can cause imbalance in the energy system by over or under-delivering flexibility. As such, the Aggregator may need to assign a balance responsible party.[27] In addition, when an Aggregator is active in the same connection as a BRP_{sup}, the Aggregator's activity (if it is not known by the BRP_{sup}) can cause a deviation from the expected behaviour of the Active Customer, thus impacting the balance position of the BRP_{sup}. Both the Aggregator's balance responsibility and BRP_{sup}'s balance position need to be specified by the Aggregator Implementation Model.

- **Sourcing position:** The balance between the sourced and sold energy of an energy market role. For example, the Suppliers source (generate or buy) the energy to feed their portfolio of Active Customers. In the case of the Aggregators, when activating flexible assets, they sell flexibility (energy) in the form of load (generation) reduction or increase. Part of the energy previously sourced by the Supplier was never sold because of the Aggregator activity. On the other hand, in order to sell energy on the markets, the Aggregator needs to source this energy (which does not happen automatically when reducing the load of a customer that is part of another market player's perimeter). Therefore, there should be a mechanism that enables the Aggregator to source energy from the Supplier while keeping both the Aggregator and Supplier's sourcing positions balanced. Transfer of Energy (ToE) is the mechanism for an Aggregator to source activated flexibility from a Supplier. Both the transfer mechanism of the ToE, and the price formula associated with it, depend on the Aggregator Implementation Model.

- **Information exchange and Confidentiality:** The information needs of each relevant process for the different market roles, their required aggregation level, and the extent to which this information is deemed confidential. For confidentiality, it is key to identify what aggregation level is deemed commercially sensitive.

3.3.2 The 7 USEF aggregator implementation models

As became clear from the previous sections, the Aggregator, as a new market party, needs to be embedded into the existing energy market organization. This can be done in many ways, with different relationships to other stakeholders, and with varying responsibilities. Seven concrete Aggregator Implementation Models are presented below. USEF defines an Aggregator Implementation Model (AIM) as a market model for the Aggregator role, describing its contractual relationship to the Supplier and its BRP, and describing how balance responsibility, sourcing position and information exchange are organized.

[27] As per Regulation (EU) 2019/953, article 5: All market participants shall be responsible for the imbalances they cause in the system ('balance responsibility'). To that end, market participants shall either be balance responsible parties or shall contractually delegate their responsibility to a balance responsible party of their choice. Each balance responsible party shall be financially responsible for its imbalances and shall strive to be balanced or shall help the electricity system to be balanced.

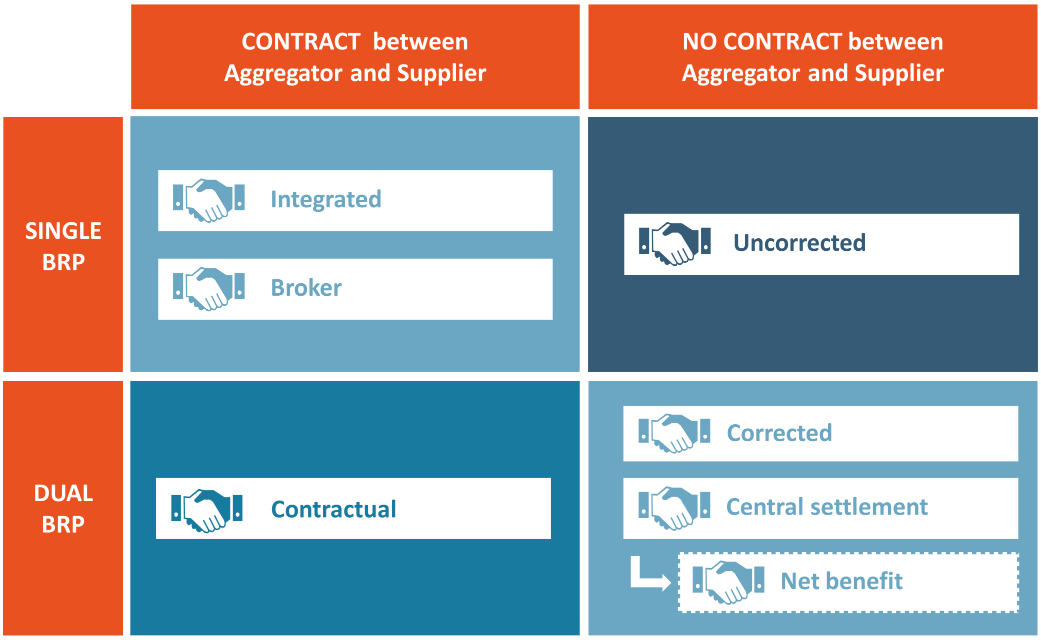

Figure 3-4: Aggregator model classification scheme

Table 3-1: Relevant characteristics for the Aggregator implementation models

AIM name	Contractual relationship	Balance position	Sourcing position	Information exchange and confidentiality
Integrated model	Aggregator and Supplier roles are combined in a single market party. No contract needed.	Balance responsibility is with the BRP_{sup}.	n.a.	n.a.
Broker model	Aggregator has a bilateral contract with Supplier or BRP_{sup}, potentially based on a framework contract.	Aggregator transfers the balance responsibility to the BRP_{sup} (multiple, in general). The ISR corrects the perimeter of the BRP_{sup} when offering balancing services.	Because the Aggregator is represented by $BRP_{sup.}$, there is no need for ToE. Any financial settlement occurs bilaterally (to be agreed in contract).	The BRP_{sup} should receive information regarding the activated flexibility in its portfolio on Active Customer level per ISP (to be agreed in contract).
Contractual model	Aggregator has a bilateral contract with Supplier about the Transfer of Energy (possibly based on a standardized contract).	Balance responsibility for the flexibility is with BRP_{agr}. BRP_{sup} holds full responsibility outside activation periods. During activation periods the allocation of the flexibility resource is set equal to the corresponding baseline.	Aggregator will source the energy ex-post from the Supplier. Sourcing volume equals the difference between measurement and baseline. A price formula to remunerate the energy needs to be agreed upon, preferably using a standardized method.	The BRP_{sup} should receive information regarding the activated flexibility in its portfolio on Active Customer level per ISP.
Uncorrected model	No contract between Aggregator and Supplier.	Balance responsibility for the connection is with BRP_{sup} at all times. The	There is no explicit compensation for the sourced energy, yet	n.a.

AIM name	Contractual relationship	Balance position	Sourcing position	Information exchange and confidentiality
		potential effect of flexibility activation in the BRP_{sup}'s balance position is not corrected.	implicitly energy is remunerated through imbalance mechanism.	
Corrected model	No contract between Aggregator and Supplier.	During activation periods, BRP_{agr} holds balance responsibility for the activated flexibility. The ISR corrects the balancing position of the BRP_{agr}. The BRP_{sup} perimeter can be corrected in two ways: **[type A]** The MDR corrects the Active Customer's consumption profile, based on the amount of flexibility that has been activated by the Aggregator. **[type B]** The ISR corrects the BRP_{sup} perimeter.	The Aggregator remunerates the sourced energy from the Supplier through the Active Customer. The Supplier bills the Active Customer the adjusted energy, i.e. not taking into consideration the activated flexibility. This can happen 2 ways:: **[type A]** The Supplier gets the corrected values from the MDR. **[type B]** The ISR communicate the Supplier the activated volumes and the Supplier makes the correction to bill their customers. Then the Aggregator compensates the Active Customer for the activated flexibility (for sourcing and for the service).	1) The Aggregator (or its BRP) does not need to inform the BRP_{sup} nor the Supplier of the Active Customer about the closed (new) flexibility contract. 2)For **[type B]** , the ISR should inform the Supplier the activated flexibility in its portfolio on Active Customer level per ISP.
Central settlement model	No contract between Aggregator and Supplier.	During activation periods, BRP_{agr} holds balance responsibility for the activated flexibility. The ISR corrects the perimeter of BRP_{agr} and BRP_{sup}.	The Supplier's sourcing position is compensated through ToE via the ISR.	1) The Aggregator (or its BRP) does not need to inform the BRP_{sup} nor the Supplier of the Active Customer about the closed (new) flexibility contract. 2) the BRP_{sup} should receive information on activated flexibility in its portfolio on aggregated level per ISP. (i.e. not revealing the Active Customer or Aggregator involved).
Net benefit model			The Supplier's sourcing position is compensated through ToE via the ISR. This ToE compensation, however, is partly or fully socialized, i.e. there is no remuneration by the Aggregator to the Supplier for the sourced energy.	

Member States are implementing the Electricity Balancing Guideline,[28] which includes the definition of the Balancing Service Provider role and the correction of the perimeter of the BRPs affected by the BSPs energy activations.
In addition to this guideline, art. 17.3(d) of the Directive 2019/944 states that all market participants engaged in aggregation are obliged to be financially responsible for imbalances that they cause in the electricity system.

Both developments have triggered several Member States to state that Aggregators acting as BSP do not need to assign a BRP. Instead, TSOs correct the imbalance position of the affected BRPs, where the AGR-BSP remains responsible for covering the imbalance cost when they fail to deliver, or over-deliver. However, some of these arrangements do not adequately address all other aspects and, therefore, depending on the specific implementation, they could be mapped differently into the USEF Aggregator Implementation Models. The USEF white paper on *Flexibility deployment in Europe* [5] looks at the particularities of each case.

The need to assign the BRP role is specifically relevant for Aggregators that are active at other markets at the same time, e.g. wholesale markets. The only caveat is that Aggregators that are *only* active in balancing products (in combination with the BSP role), may experience the need to perform or assign the BRP role as an administrative burden. In this case, the Aggregator could be exempted from this obligation. In practice, the Aggregator/BSP is still responsible for any imbalance that it causes, yet this will be organised differently than the implementation of the formal BRP role, as a way to improve the level playing field for BSPs.

3.3.3 Reference profile models

The Aggregator Implementation Models described in the previous section are based on the principle that the Aggregator takes responsibility during times of activation (the activation window). This might be difficult (or even impossible) when activation takes place on a day-to-day basis; for example, in the case of heat pumps in the residential setting. In these situations, it becomes difficult to hand-over balance responsibility to the Aggregator's BRP and defining a baseline that represents the (normal) behaviour becomes challenging, as flexibility activation becomes part of the 'normal behaviour'.

Another way of separating energy supply from flexibility activation, is to use a *reference profile*. The BRP_{sup} still holds full responsibility for the connection. The reference profile is known upfront and sourced/balanced by the BRP towards the corresponding timeframe (YA, MA, DA). Balancing risk after agreement on reference profile is transferred to Aggregator (or its BRP). These models are useful for flexibility in the residential setting where the activation takes place on a daily or hourly basis. For more details on this model refer to the *Work stream on aggregator implementation models* [1].

[28] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R2195

4 USEF market coordination mechanism and interaction models

4.1 The Operating Regimes and the Market Coordination Mechanism

4.1.1 Operating Regimes

USEF recognizes four different operating regimes. In the Green regime, the power grid is considered to be unconstrained (copper plate principle). USEF's Market Coordination Mechanism assures optimal use of DF for wholesale services, balancing services and adequacy services in any combination.

Classic Grid	Smart Grid	Regime	Description
Power Outage	Power Outage	Power Outage Grid Protection	Primary grid protection systems are activated (fuses, switches,..) to prevent damage to assets.
	Graceful Degration	Graceful Degradation Load Shedding	DSO makes autonomous decisions to lower loads & generation in the grid by limiting connections when market-based coordination mechanism cannot resolve congestion.
	Capacity Management (Free Market)	Capacity Management Peak Load Reduction & Power Balancing	DSO is active on the flexibility market. DSO reduces peak loads on congestion points in the grid by activating flexibility at both the demand and supply side.
Normal Operations (Free Market)	Normal Operations (Free Market)	Normal Operations Power Balancing	Operation without grid limitations. Optimization on commodity value. Active grid monitoring by DSO.

The introduction of distributed energy resources (DERs) and the electrification of energy use can significantly increase the peak load on the distribution grid. For certain parts of the grid, demand will, at peak times, exceed the available capacity. If the grid is constrained, USEF defines a Yellow regime where DSOs and TSOs can procure flexibility to reduce the peak load. In this regime constraint management services may be combined with the other types of services. The Market Coordination Mechanism will handle these combinations. USEF's UFTP protocol is targeted to DSO constraint management.

The Orange regime is introduced as a fall back, in case insufficient flexibility is available for the DSO to avoid an outage—the DSO can temporarily overrule the market to avoid an outage by limiting connections.

4.1.2 The market coordination mechanism

The USEF market coordination mechanism (MCM) facilitates all flexibility trading and has five phases:

- **Contract:** In the contracting phase, various contractual relationships need to be established. For example, bilateral contracts may be signed between Active Customers and Aggregators regarding the Active Customer's flexibility capacity and how it will be activated by the Aggregator.
- **Plan:** In the planning phase, the Aggregator examines its portfolio of clients, each with its individual needs and flexibility preferences. Energy demand and supply are forecasted for the upcoming period, usually a calendar day. Both the BRP and the Aggregator carry out an initial portfolio optimization. During this phase, the BRP may procure flexibility from its Aggregators.
- **Validate:** In the validation phase, the system operator determines whether the forecasted energy demand and supply can be safely distributed without limitations. If the prognosis predicts congestion, the system operator may procure flexibility from Aggregators to resolve it. It is important to note that there can be multiple iterations between the Plan and Validate phases: after validation, it is possible to go back to the Plan phase. These iterations continue until all the forecasted energy can be safely distributed without limitations.29
- **Operate:** In the operation phase, the actual assets and appliances are dispatched, and the Aggregator adheres to its prognoses. System operators monitor the grid in real-time. When needed, system operators can procure additional flexibility from Aggregators to resolve unexpected congestion or to solve imbalance issues.
- **Settle:** In the settlement phase, any flexibility the Aggregator has sold to the system operators is settled. This settlement comprises contracted and delivered flexibility as well as contracted flexibility that was not delivered.

The MCM aims 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 scale of the Contract Phase ranges all the way from years to days ahead. This is typically the time window for the forward markets and flexibility contracts. The USEF Plan and Validate phases may take place on both day-ahead and intraday time scales. The processes are similar; only the time frame differs. Day-ahead planning and validation involve the prognoses for an entire day (from 00:00 through 23:59), while their intraday counterparts only take the remainder of the current day into account.

4.2 Information flows between market roles (general)

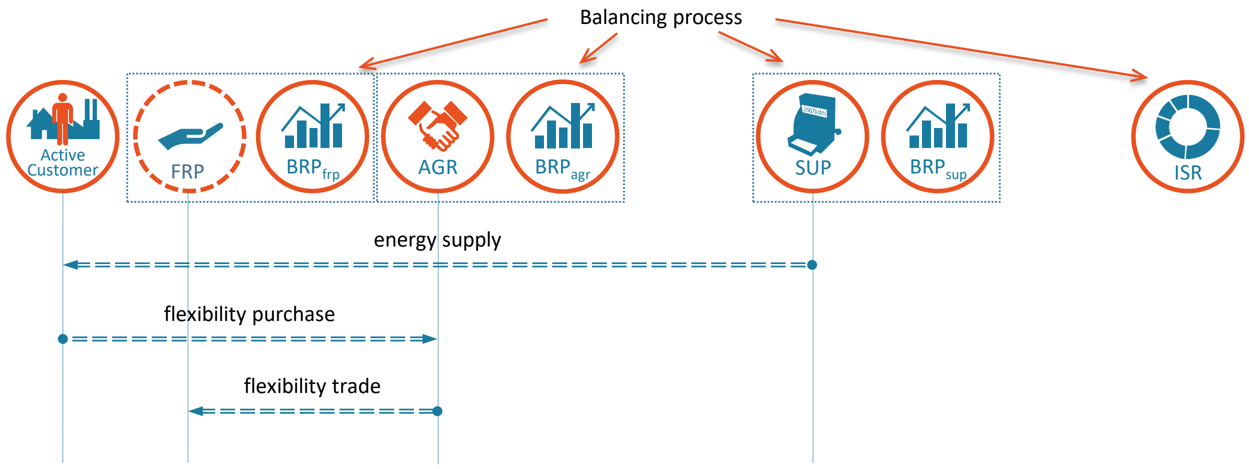

Figure 4-1: Introduction to the interactions

Figure 4-1 shows the market roles that interact in explicit flexibility trading. The active customer has a relationship with a Supplier for energy supply. It is assumed that the Active Customer owns flexible assets and wants to exploit the flexibility of these assets. To this end, he/she will contract an Aggregator (or multiple Aggregators) who purchases his/her flexibility and trades it on the flexibility markets. In this section we discuss the general interactions needed for flexibility trading and proper compensation for the Supplier[30]. For reasons of clarity we introduce the (generalized) role of "Flexibility Requesting Party", being either a BRP, a

[29] Note that it might not always be possible to resolve grid limitations with flexibility. In that case, USEF switches to the Orange regime.
[30] DIRECTIVE (EU) 2019/944 [4], article 17, clause 4.

DSO or a TSO. All market roles, including the Aggregator[31], bear balance responsibility and delegate this to a Balance Responsible Party (BRP). We distinguish BRP_{sup} i.e. the BRP related to the energy supply, BRP_{agr} i.e. the BRP related to the Aggregator, and BRP_{frp} i.e. the BRP related to the flex requesting party. BRP_{agr} is only relevant in the case of dual-BRP models (see 3.3.2). BRP_{frp} is typically needed for wholesale trades and redispatch[32]. The Imbalance Settlement Responsible (ISR) will take care of imbalance settlement.

4.2.1 Contract phase

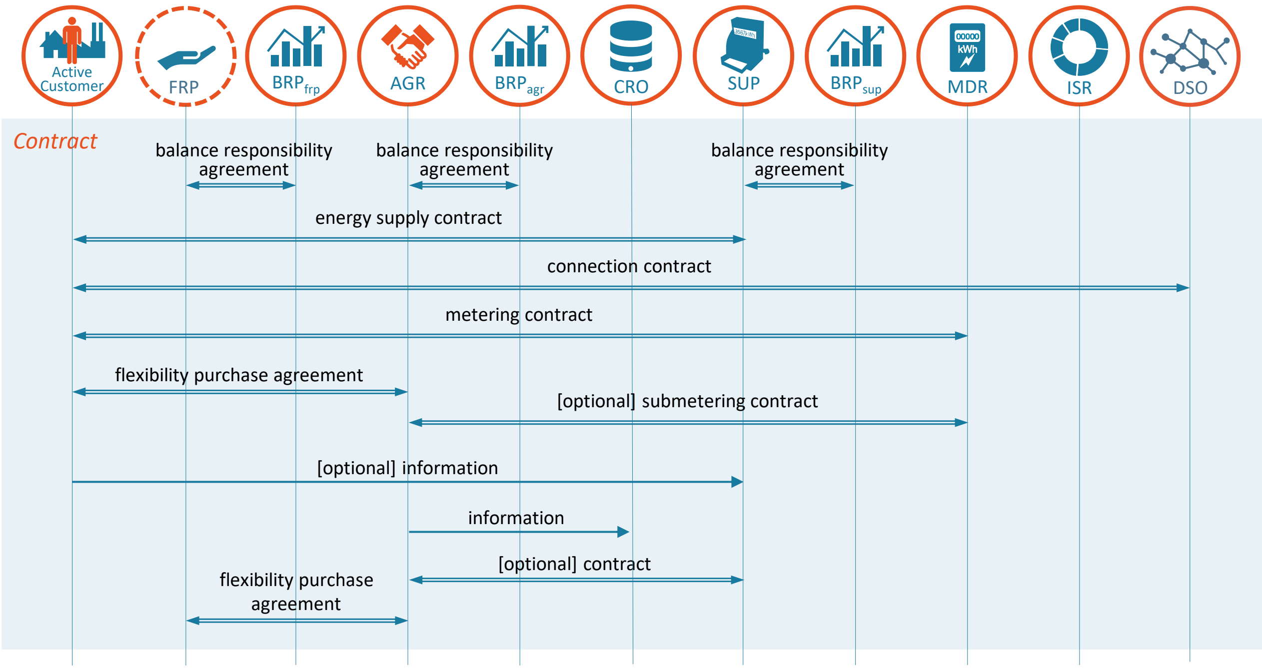

Figure 4-2: Information flow in Contract phase

Figure 4-2 shows the main information flow in the Contract phase. In order to assign the balance responsibility, each of the market roles agree upon a 'balance responsibility agreement' with their respective BRP[33]. Energy supply is arranged via a contract between Active customer and Supplier, which also involves a connection contract between Active Customer and DSO and a metering contract between Active customer and Metered Data Responsible (MDR). As the Active Customer wants to sell explicit distributed flexibility, he/she will choose an Aggregator to control his/her assets. This results in a flexibility purchase agreement. For submetering, the Aggregator contracts the MDR for submeter data. The Active Customer may need to inform its Supplier about the flexibility contract, and it might be that the Supplier prohibits entry into such a contract[34]. National legislation shall describe whether the Supplier is allowed to prohibit a flexibility contract between the Active Customer and Aggregator[35]. After signing a contract with an Active Customer, the Aggregator should deposit the technical characteristics of the flexibility contract to a central registry, allowing the TSO or DSO (depending whether the associated Active Customer is connected to the TSO or DSO grid) to determine the consequences to its grid operation. The common reference is used for this purpose and is depicted in the interaction diagram as information exchange between Aggregator and CRO[36].

Depending on the Aggregator Implementation Model used (see Section 3.3), there may be a contract between Aggregator and Supplier to arrange the Transfer of Energy. Last, but not least, the Aggregator and FRP will make arrangements for the delivery of flexibility. This could be a simple registration procedure but in most cases it involves a prequalification of the Aggregator and the

[31] DIRECTIVE (EU) 2019/944 [4], article 17, clause 3, sub (d).
[32] Redispatch is discussed in Section 5.4.1
[33] The need for Aggregator to associate with a BRP is dependent on the Aggregator Implementation Model
[34] See [10], recommendation 301
[35] See [10], consideration 302
[36] The current CRO structure, as described in UFTP v 1.01 [6], must be extended for this purpose

assets to be used. Arrangements can also be made about the availability of flexibility, service windows, volumes and prices. For wholesale trades via market platforms, the Aggregator needs to register as market participant.

4.2.2 Plan and Validate phases

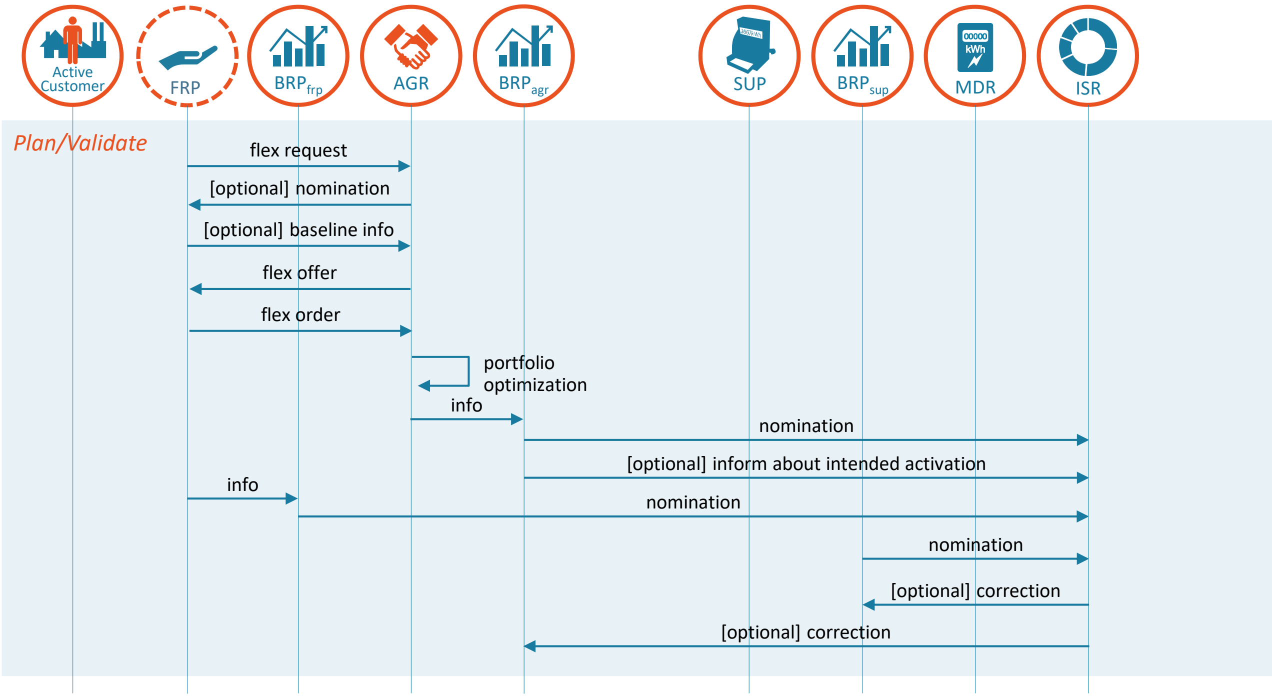

Figure 4-3: Information flow in Plan and Validate phase

Figure 4-3 shows the main information flow in the Plan and Validate phase. In this section, the phases are combined because the separation between them is only relevant for constraint management services (further detailed in section 4.3).

The flexibility trading process takes place via a sequence of requesting, offering and ordering flexibility. For flexibility trades via a platform, the request is often implicit because market players can also place offers on a platform without there having been prior requests. As flexibility is a deviation from the default profile (baseline), this baseline must be agreed upon. Sometimes the baseline is a forecast provided by the Aggregator, referred to as a nomination. This gives an interaction between Aggregator and FRP. Other baselines may lead to an information flow in the opposite direction, where the calculated baseline (e.g. based on historical data) is sent from the FRP to the Aggregator.

Offered flexibility is not necessarily ordered. Also, flexibility is not always ordered in advance as, in some products, the ordering takes place through activation in the Operate phase.

After the flexibility has been traded, the Aggregator prepares for the activation of flexibility, which might involve reservation of assets and preparing an activation schedule amongst other things. This is denoted as portfolio optimization and visualised as an internal process within the Aggregator role.

The BRP_{agr} and BRP_{frp} are informed about the trade so that it is accommodated in their respective nominations. As the Supplier (and BRP_{sup}) are not aware of the flexibility trade at this stage, BRP_{sup} will provide a nomination based on its own estimation. This means that the total set of nominations is not balanced and therefore, if not corrected, the BRP_{sup} would run into imbalance. The restoration of balance can take place in multiple ways and at multiple stages. Correction in Plan/Validate phase may take place by the ISR. Based on the information about the planned activation provided by the Aggregator, the ISR can either, and depending on the service requirements, 1) just prepare for later correction, 2) correct BRP_{agr} for the activated volume and all involved BRP_{sup}, based on their share in the Aggregator portfolio (pro-rata correction), or 3) correct BRP_{agr} for the activated volume and all involved $BRP_{sup,}$ based on the activated volume in their portfolio (full correction). In the case of 2), the Aggregator may inform the ISR at portfolio level. In the case of 3), the Aggregator needs to inform the ISR at Active Customer level.

4.2.3 Operate phase

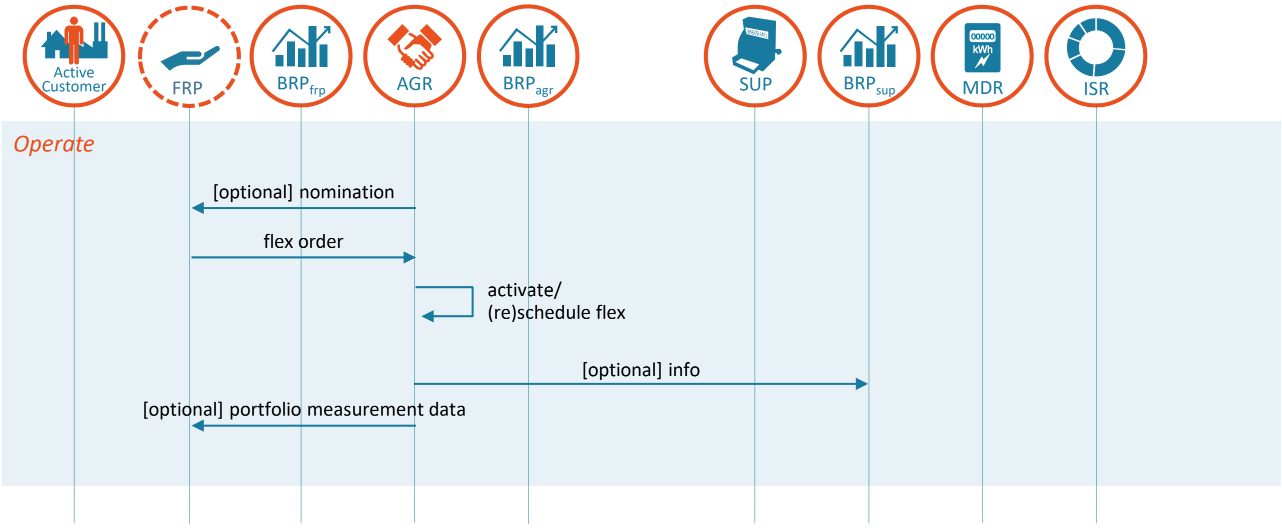

Figure 4-4: Information flow in Operate phase

The information flow in Operate phase is shown in Figure 4-4. As we know, flexibility is a deviation from the normal energy profile. Therefore, the FRP must be aware of the situation before activation (i.e. baseline). Some products, like aFRR and mFRR, require near-real time communication of a nomination[37], as this serves as a baseline once the flexibility has been activated. Flexibility that was already ordered in the Plan/Validate phase is now activated and the FRP may request activations by additional flex orders. Both require an activation and rescheduling of the underlying assets and this is an internal process for the Aggregator.

During the Operate phase, the Aggregator has the freedom to choose from all assets in its portfolio to meet the required volume. This implies that it is only after activation that the Aggregator knows the exact volumes at asset level. In general, this information is only needed during the Settle phase. For (very) large assets, equipped with on-line metering, there is a risk that the BRP_{sup} reacts to the activation and attempts to counterbalance it. To avoid this, the BRP_{sup} may need to receive information about a DR event at customer level[38].

In some products (and particularly common in balancing products) the FRP requires real-time measurement data, typically at portfolio level. This information is provided by the Aggregator.

4.2.4 Settle phase

The settlement phase comprises three parts:

- product settlement, i.e. quantification of delivered flexibility;
- settlement of the Transfer of Energy including perimeter corrections; and
- imbalance settlement process.

For product settlement (TSO and DSO products), the FRP must be able to verify whether the ordered flexibility has actually been delivered. This is accomplished by acquiring the actual measurements and subtracting the baseline. For this purpose, the FRP can quantify delivered flexibility based on meter data provided by the Aggregator[39]. Note that for several products, sub-ISP resolution

[37] See [10], recommendation 205 and 206
[38] See [10], consideration 305
[39] See [10], recommendation 110

is required for meter data, thus requiring a separate metering infrastructure. For ToE settlement, which is performed at ISP-resolution, there is a need for an independent party[40] to validate meter data. We assume the MDR takes this responsibility.

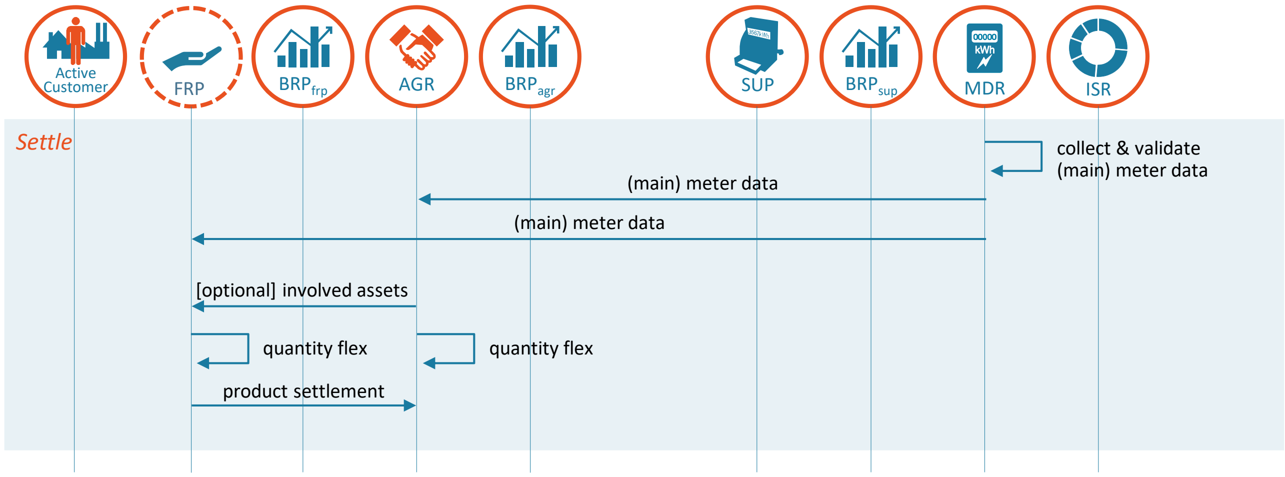

Figure 4-5: Information flow in Settle phase – product settlement based on main meter data

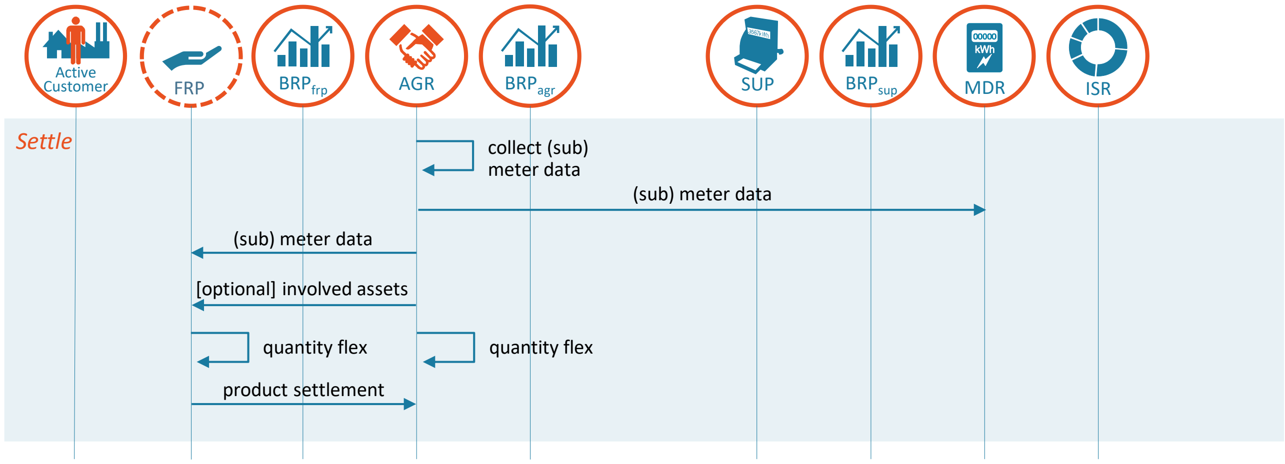

Figure 4-6: Information flow in Settle phase – product settlement based on submeter data collected by Aggregator

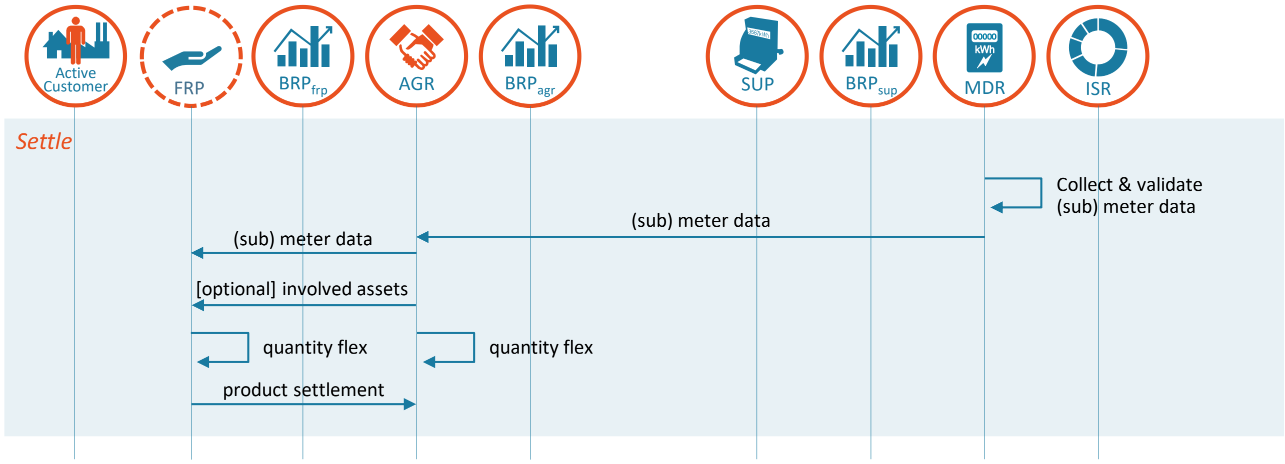

Figure 4-7: Information flow in Settle phase – product settlement based on submeter data collected by MDR

[40] See [10], recommendation 106

Figure 4-5 to Figure 4-7 show the information flow for product settlement. The process includes several options for acquiring measurements. First, it is relevant to know whether the Aggregator will be validated and settled based on main meter level or submeter level. If on main meter level, the MDR collects and validates meter data and distributes this to Aggregator and FRP (cf. Figure 4-5). If on submeter level, the submeter could either be installed by the Aggregator (Figure 4-6) or by the MDR (Figure 4-7)[41]. USEF recommends the MDR is responsible for validation because the quantified volume is also used for the Transfer of Energy[42]. In the first situation, the Aggregator sends meter data to the MDR for validation. In the latter situation, the MDR sends (validated) meter data to the Aggregator for product settlement. Based on the meter data, the FRP can quantify the flexibility and settle accordingly. The Aggregator is able to verify the calculation based on its own information.

For some products, the FRP may require information about the assets involved in the activation. This is depicted as an optional information flow. Note that product settlement by the FRP is not needed for wholesale trading as wholesale settlement is performed based on BRPs' portfolios rather than single trades. However, wholesale trading can involve a ToE which is shown in the next diagram.

Figure 4-8 to Figure 4-10 show the other stages of the settlement phase. The information flow related to the Transfer of Energy process depends on the Aggregator Implementation Model. For the description of the models see section 3.3.

Figure 4-8 show the other stages of the settlement phase for the contractual model. In the contractual model, the Aggregator and Supplier have agreed upon the ToE conditions beforehand. Once the volume is known, both parties send an ex-post nomination to the ISR reflecting the mutual energy trade. No additional perimeter corrections are needed.

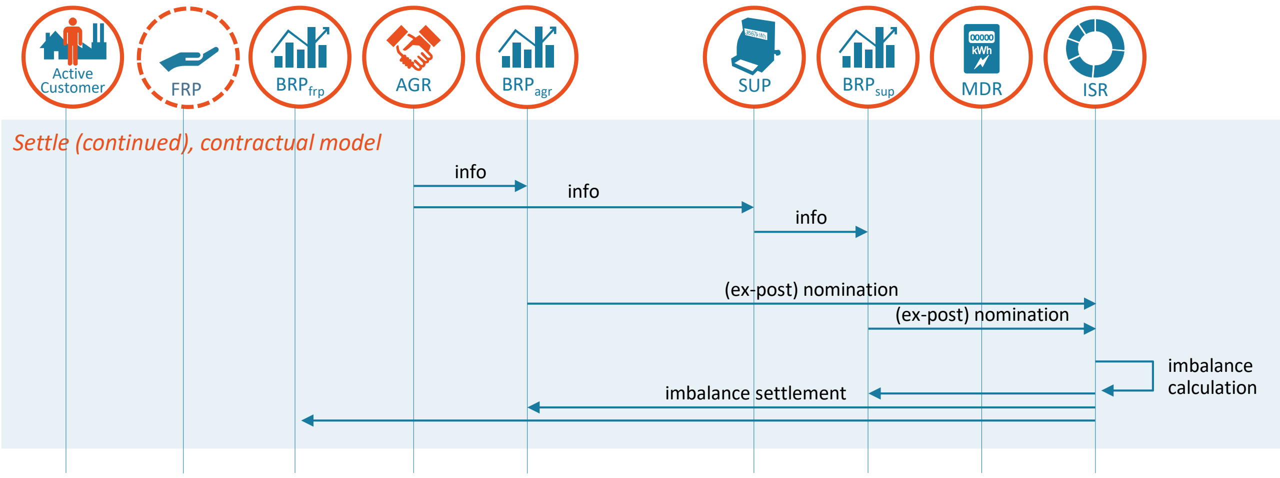

Figure 4-8: Information flow in Settle phase – Transfer of Energy and imbalance settlement (contractual model)

Figure 4-9 shows the other stages of the settlement phase for the central settlement model. In the central settlement model, the ISR is informed about quantified flexibility and activated assets. Based on this information, the ISR calculates activated volumes per BRP. The perimeters of the BRP_{agr} and BRP_{sup} are corrected for the activated volume. BRP_{sup} receives information about the (aggregated) imbalance volume (per ISP). As a last step, the ISR settles the transfer of Energy between the BRP_{agr} and BRP_{sup}.

[41] See [10], consideration 108
[42] See [10], recommendation 106

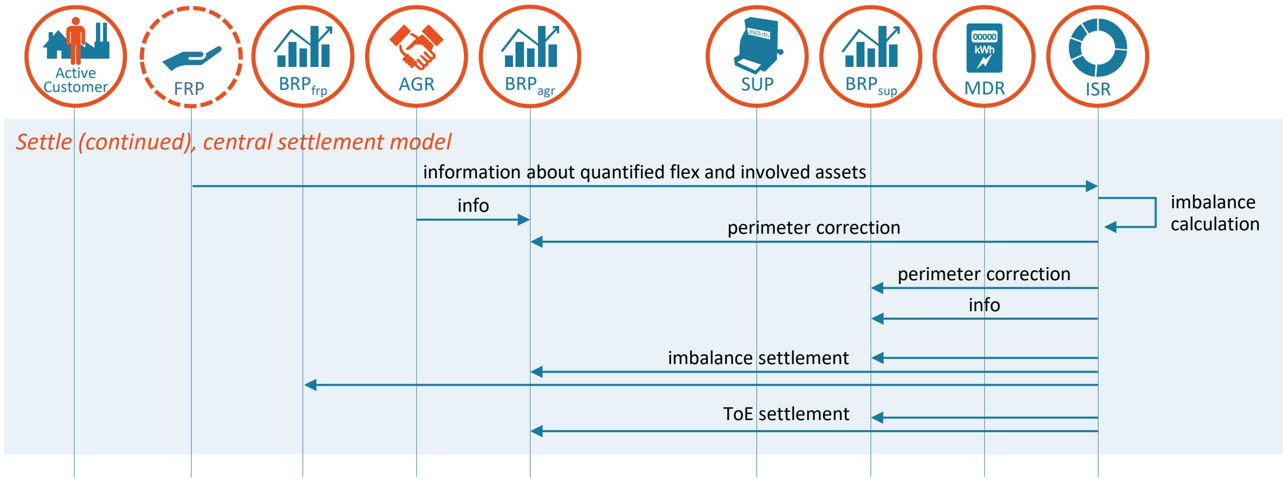

Figure 4-9: Information flow in Settle phase – Transfer of Energy and imbalance settlement (central settlement model)

Figure 4-10 shows the other stages of the settlement phase for the corrected model. In the corrected model, the perimeter of BRP_{agr} is corrected as in the central settlement model. For the supply side there are two variants. In [type A], true meter data correction happens, such that the effect of flexibility activation is not visible anymore and the supply side can invoice the original volumes. This assumes that the perimeter correction of BRP_{sup} takes place implicitly through the MDR correcting the meter data. In [type B], the meter data is not corrected. Instead, the Supplier is informed about the activated volume and the perimeter of BRP_{sup} is corrected by the ISR. In both types the Transfer of Energy is performed through the customer, hence there is no ToE settlement needed by the ISR.

For all models, after the Transfer of Energy, the standard allocation process takes place, to calculate and settle imbalance volumes.

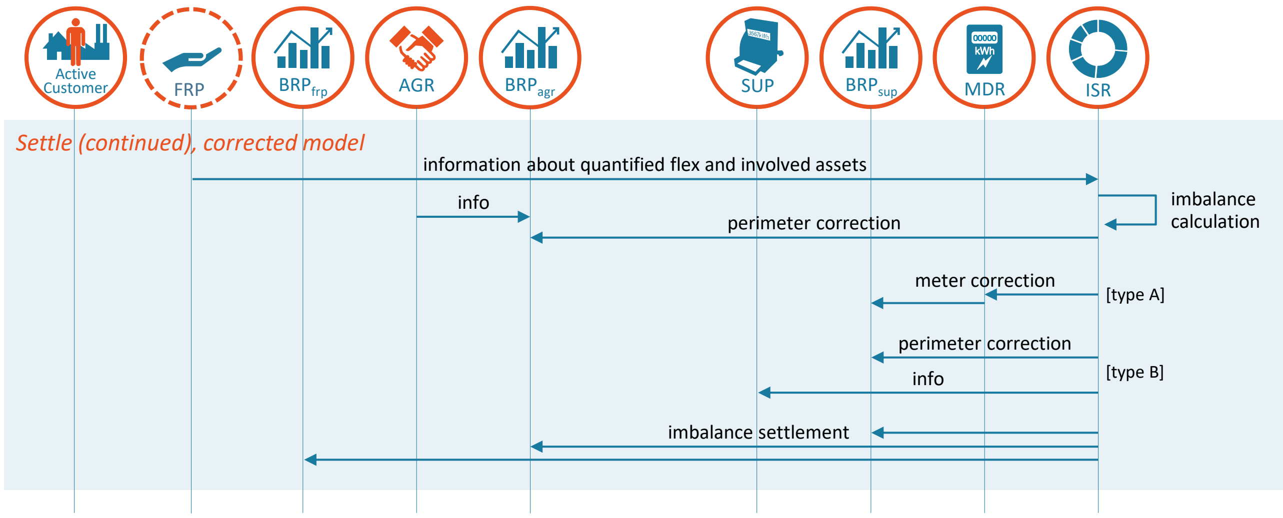

Figure 4-10: Information flow in Settle phase – Transfer of Energy and imbalance settlement (corrected model)

4.3 Information flows for DSO constraint management

The Flexibility Value Chain identified DSO constraint management services to help grid operators (TSOs and DSOs) to optimize grid operation against physical and market constraints. For most of these services, flexibility markets could be helpful. Grid capacity management and congestion management in particularly can benefit from market-based DF. The current deployment of those services is mainly in trial phase and harmonization and standardization are limited. To this end, USEF has developed the USEF

Flexibility Trading Protocol (UFTP) [6] as a practical tool for flexibility trading between the Aggregator and the DSO. In relation to the previous section, the DSO is the Flexibility Requesting Party (FRP). This section elaborates on the information exchange between Aggregator and DSO. Note that all interactions discussed in Section 4.2 also apply to this particular case. Also note that constraint management services are delivered via the CMSP role and this is not depicted in the drawings.

UFTP follows the concepts of Operating Regimes and Market Coordination Mechanism. The UFTP-based flexibility trading takes place in the Yellow regime and follows the 5 phases of MCM. In particular the following activities take place during the phases:

- **Contract**: Aggregator and DSO negotiate FlexOptions. This is flexibility that is reserved for DSO purposes and can be invoked by the DSO when needed. Typically, a contract includes availability remunerations and activation remunerations.
- **Plan**: information exchange between DSO and Aggregators related to congestion points. This information exchange through the 'Common Reference' involves communication with the Common Reference Operator (CRO). The Aggregator carries out an initial portfolio optimization.
- **Validate**: the DSO uses D-prognoses to validate whether the demand and supply of energy can be distributed safely without any limitations. If congestion occurs, the DSO can procure flexibility from Aggregators to resolve grid capacity issues.
- **Operate**: the actual assets and appliances are dispatched and the Aggregator adheres to its D-prognoses. When required, DSOs can invoke additional flexibility from Aggregators to resolve unexpected congestion.
- **Settle**: the flexibility that the Aggregator has sold to DSOs is settled. For this purpose, the actual consumed and produced volumes are allocated to the responsible parties first. Any unresolved or disputed volumes are reconciled shortly afterwards.

UFTP assumes that a flexibility market is set-up for a specific congestion point i.e. a set of connections which (directly) relate to a part of the grid where grid capacity might be exceeded because it may be insufficient to distribute the requested amount of energy; e.g. the secondary side of an LV transformer. A DSO identifies Congestion Points well in advance of actual overload situations occurring, based on its analysis of the trends in energy demand and knowledge of the grid topology. It then makes these known to relevant Aggregators i.e. those with Active customers in the concerned Congestion Point. Aggregators can then approach their customers in order to provide sufficient flexibility to offer the DSO in a situation where the Yellow regime is activated for specific Congestion Points. A Common Reference is set up for the exchange of information about Congestion Points, associated connections and associated Aggregators. It is operated by the Common Reference Operator. Please note that a congestion point is a part of the grid where congestion may possibly occur, rather than actually occurs. It is the DSOs responsibility to determine congestion points. More details are in [6].

UFTP supports both day-ahead and intraday flexibility trading and the unit of trade is a power-block with a duration equal to one ISP. More details are in [6].

UFTP was originally designed for a nominated baseline, the so-called D-prognosis. However, it also allows for alternative baseline methodologies via an external baseline reference. The information exchange in the following sections assumes a D-prognosis as baseline. In [6], the information exchange for alternative baseline methodologies is also discussed.

4.3.1 Contract phase

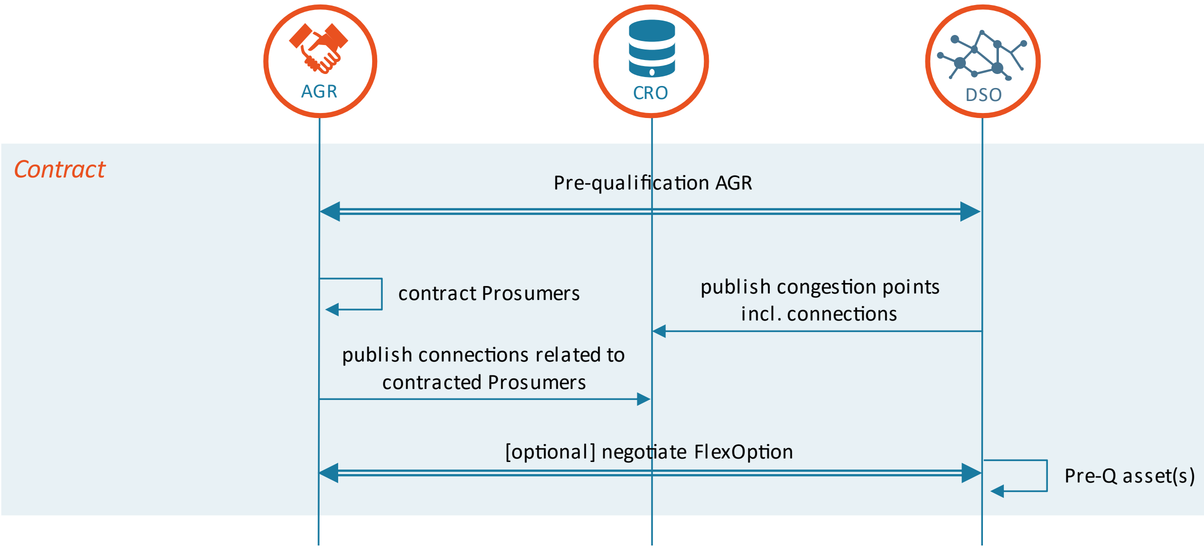

Figure 4-11: UFTP information flow in Contract phase

The contract phase is when DSOs and Aggregators begin interaction. Typically, this involves a pre-qualification process, where the Aggregators' capability to deliver flexibility, portfolio and IT systems are assessed. In addition, the contract phase includes the exchange of information related to congestion points and associated connections through the Common Reference.

As part of its internal grid planning process, a DSO determines where congestion may possibly[43] take place. Congestion points are declared whenever necessary, most likely several times a year, depending on the volume of trend analyses performed by a DSO and the condition of the grid. By publishing a particular congestion point, the DSO opens a flexibility market for it. Aggregators publish the Active Customers that they serve in the common reference, and may attract new customers to unlock their flexibility to this local (and other) market(s). As a result, a DSO can determine whether there is liquidity on the local market and Aggregators can determine which of their customers can participate in each DSO market.

USEF introduces two alternative options for the DSO to procure flexibility from Aggregators:

- Long-term flexibility options (*FlexOptions*): activation of flexibility options in prearranged bilateral contracts. Contracts of this nature oblige the Aggregator to offer a fixed amount of flexibility to the market via daily *FlexOffers*.
- Short-term flexibility options: procuring flexibility that Aggregators have offered for a specific day. In this situation, the Aggregator has no contractual obligation to offer the flexibility to the market but decides to do so on a day-to-day basis.

FlexOptions are negotiated during Contract Phase. This typically involves agreement on the following ingredients:

[43] The actual determination of congestion takes place in the day-ahead to real-time timeframe, cf. the validate and operate phases. This long-term assessment aims to identify and prepare the market.

Table 4-1: FlexOptions elements

Element	Description	Example(s)
Service Window and Duration	The service window in which the flexibility should be delivered and the duration of the contract.	▪ Every ISP between 17:00 and 19:00 on Fridays ▪ from December through March for the coming two years
Lead time	Time before the (recurring) flexibility option expires.	▪ One week before dispatch ▪ The day before dispatch at 16:00 ▪ Does not expire
Congestion Point	Congestion Point at which the flexibility should be realized.	▪ HV/MV transformer
Amount	Amount of flexibility being offered, specified as a delta to an agreed baseline.	▪ 10kW (average power per ISP)
Capacity remuneration	Price the Aggregator receives for offering the flexibility option	▪ €20/MW/day ▪ €40/MW/ISP
Volume remuneration	Maximum or predefined price for the flexibility, to be paid when the flexibility is ordered by the DSO.	▪ €20/MWh ▪ Less than €20/MWh ▪ €0
Maximum number of activations	The maximum number of activations at which the flexibility in the LT contract can be called upon.	▪ Once per contract ▪ Once per month ▪ Unlimited
Recovery Time	Minimum time between activations	
Penalties	Amount the Aggregator is penalized for not offering the option of flexibility and/or the flexibility itself.	n/a

The details of a FlexOption may be stored in the Common Reference which must be extended for this purpose.

4.3.2 Plan phase

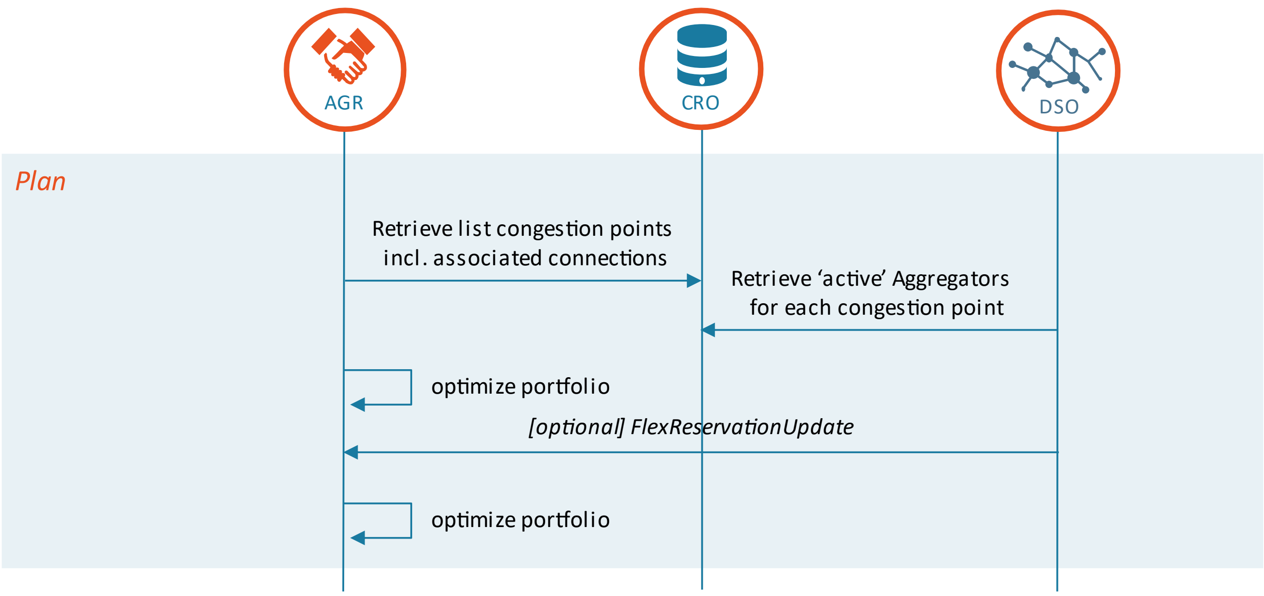

Figure 4-12: UFTP information flow in Plan phase

In general, USEF's Plan phase aims to find an economically optimized program to supply the energy demand of both Aggregator and BRP portfolios for a certain period. In this phase, the Aggregator optimizes its portfolio and typically arbitrages between different flexibility markets to maximize the value of the available flexibility. The result of this process is a balanced portfolio. The portfolio optimization process and exchange between Aggregator and BRPs, and corresponding trades on the energy markets, are out-of-scope for UFTP and depicted as the Aggregator's internal process.

Since the list of connections belonging to a congestion point, and the list of customers that are served by the Aggregator, may switch from day to day, USEF specifies that this information is requested on a day-to-day basis. This leads to a daily request by DSO and Aggregator. Note that CRO updates, being part of the Contract Phase, may arrive at any time and are valid the following day.

For bilateral contracts (FlexOptions), the DSO might provide a FlexReservationUpdate message e.g. signalling which part of the contracted volume is still reserved and which part is not needed and may be used by the Aggregator for other purposes. This will typically re-trigger the Aggregators portfolio optimization process. More information about the flex reservation mechanism is shown in [6].

4.3.3 Validate phase

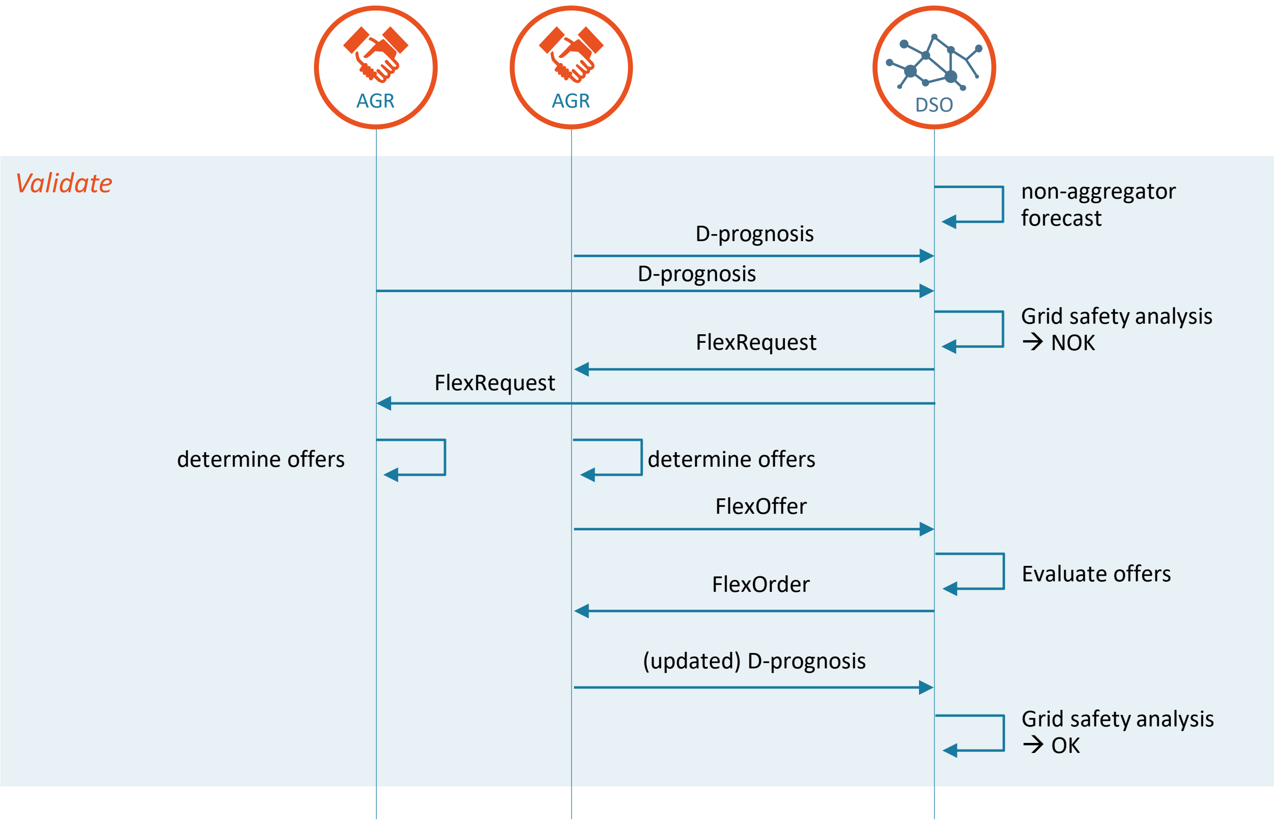

Figure 4-13: UFTP information flow in Validate phase

At the start of the Validate phase, each Aggregator creates a D-prognosis per declared congestion point and sends it to the DSO. This D-prognosis serves two purposes:

1. To communicate the planned production/consumption profile such that the DSO can include this in a grid safety analysis;
2. As baseline for flexibility trades between the Aggregator and DSO.

Traditionally, customer load was well predictable with (esp. in residential areas) low simultaneity. With customers increasingly being exposed to market prices, and more flexible load available, it is important to understand how this flexibility will be deployed, e.g. how this would increase simultaneous behaviour. For this reason, Aggregators need to inform the DSO how they intend the deploy the flexibility, by sending D-prognoses.

Even if a DSO chooses to use an alternative baseline (e.g. historical), there is still a need to communicate a D-prognosis. When all D-prognoses for a congestion point are received, the DSO combines these with forecasts from non-Aggregator connections to execute a final grid safety analysis. The analysis determines whether it is possible to distribute the planned energy or the limits of the distribution grid will be reached. In the latter situation, USEF moves to the yellow regime and the DSO procures flexibility in the market to resolve these congestion issues. The process of flexibility trading is as follows:

1. The DSO requests all Aggregators at the congestion point to provide flexibility. In this request, the DSO indicates the magnitude (amount of excess power) and timing (ISP) of the expected congestion, and how much capacity is available in the remaining ISPs. This is handled via a *FlexRequest.*
2. Aggregators who are able (and willing to) change their load/generation profile in line with the request create *FlexOffers*.
3. If the offers are a good fit; i.e. help to mitigate congestion, the DSO can procure flexibility by placing a *FlexOrder*.
4. Aggregators send an updated D-prognosis which incorporates the flexibility ordered.

If the flexibility offered is not sufficient to resolve the expected congestion, or no flexibility is offered, USEF moves to the orange regime. Here the DSO can take additional measures and these are outside the scope of UFTP.

Aggregators may respond with one or more FlexOffers. Where an Aggregator responds with multiple FlexOffers, the DSO can freely choose the most appropriate offer(s). Provided the flexibility has not been ordered via a FlexOrder, a FlexOffer may be revoked by the Aggregator (FlexOfferRevocation), see [6].

Flexibility trading may be repeated, including iterations between Plan phase and Validate phase. This goes on until the DSO ends the trading window, the so-called gate closure time. The last accepted D-prognosis before gate closure time serves as a basis for the Operate phase. Any open, unexpired FlexOffers may still be ordered after gate closure. More details about gate closure times for day-ahead and intraday trading are in [6].

UFTP allows for trading via a market platform. In this situation, Aggregators typically offer their flexibility without an underlying request (unsolicited flex offers) and the DSO selects appropriate offers.

More details of the flexibility trading process are in Section 5.4.1 and in [6].

4.3.4 Operate phase

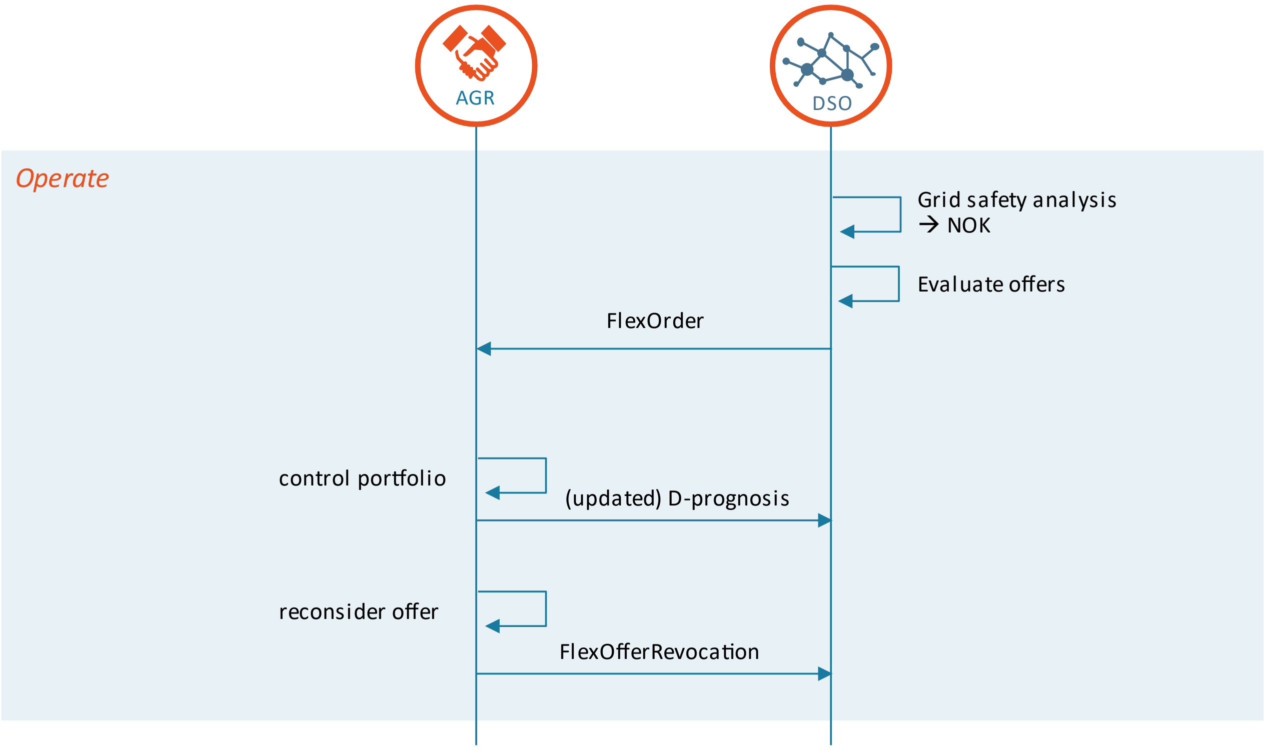

Figure 4-14: UFTP information flow in Operate phase

During the operate phase, the Aggregator's main goal is to adhere to its plan. In order to achieve this, it must first plan to ensure assets operate in accordance with its forecasted portfolio performance and that any flexibility sold is actually delivered.

Next, the Aggregator measures the net demand or supply of its portfolio, in order to detect deviations from its plan and D-prognoses. Where deviations occur, the Aggregator re-optimizes its portfolio. It is possible that deviations could be solved using the flexibility contained within the portfolio itself. If this is not the case, the Aggregator must change its plan (and probably limit its liabilities due to non-performance, to minimize fines) and control the assets to ensure that the new plans are realized and send an updated D-prognosis. During the Operate phase, the Aggregator may wish to revoke outstanding FlexOffers if it is no longer able or willing to deliver the flexibility.

Although the DSO will reduce congestion risks in the validate phase, the DSO can still request that Aggregators activate flexibility to resolve potential grid problems in the Operate phase. Again, due to time constraints, this will be done based on any open, unexpired flexibility offers from the Validate phase. When this flexibility is used, the corresponding BRP portfolio will no longer be in balance. Where the Aggregator is responsible for the balance, it will most likely charge the additional costs to the DSO.

4.3.5 Settle phase

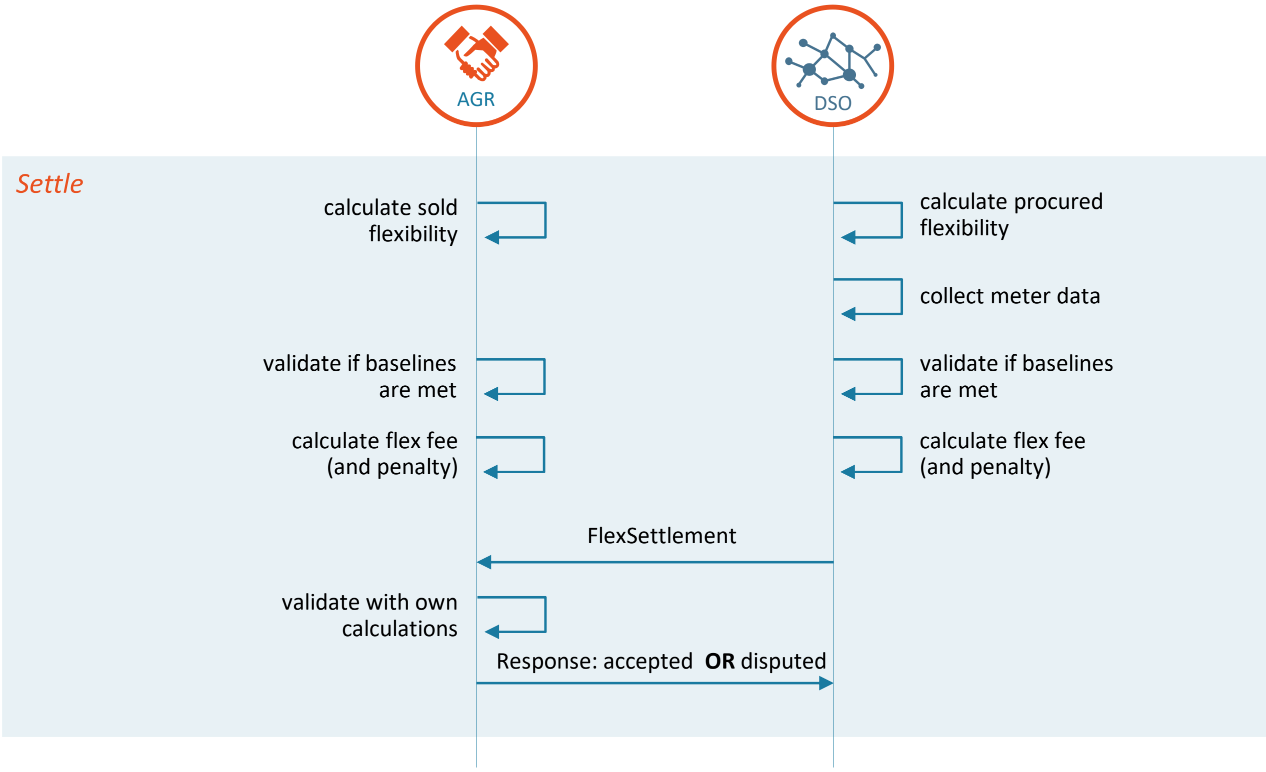

Figure 4-15: UFTP information flow in Settle phase

In the Settle phase, the Aggregator is remunerated for the delivered flexibility. There should be a check first, to ensure that the procured flexibility was actually delivered. A penalty may be applied when there is a mismatch between the agreed and delivered flexibility. USEF assumes that both Aggregator and DSO have all the information to make these calculations. Note that meter data is acquired via one of the alternatives given in Section 4.2.4.

Aggregators that have sold flexibility to the DSO need to limit their capacity to the value stated in the baseline, corrected for the sold flexibility. A penalty is raised for each ISP where the agreed capacity has (on average) been exceeded. The penalty is single sided, meaning that the AGR is allowed to deviate from its baseline as long as the deviation contributes to avoiding the grid constraint.

The DSO sends its calculation to the Aggregator for verification via a FlexSettlement message. If the verification result is within limits, the Aggregator sends an acknowledgement to the DSO. If the difference exceeds predefined limits, the DSO's calculation is disputed. The dispute process is not part of USEF.

Although the settlement process could be triggered on a day-to-day basis, it is more efficient to do this for a longer period. The USEF message allows for multiple 'settlement items'.

Note that in order to allow dynamic pooling (see 5.2) the Aggregator needs to specify which resources have been used, allowing the settlement process to take only those assets into account. This corresponds to the activation information, sent by the Aggregator to the ISR, as introduced in section 4.2. This information flow is not yet included in UFTP.

Further details on the settlement process and calculations are in [6].

5 Complexities and other topics related to Distributed Flexibility

5.1 Complexities of value stacking

The concept and different types of value stacking are introduced in section 2.3.3. There are different complexities associated with different types and the information flows between market participants may vary to enable stacking. This section will not explore all complexities in detail but it offers an overview of certain principles that are generally applicable:

1. Double serving with single energy transaction in opposite directions may be conflicting for some products. Providing two services in the same window of time that have opposite directions, i.e. upward and downward generation or demand, might cancel out the overall net effect. For services such as congestion management, the DSO is paying for a service to have a net effect in the local load/generation so if this effect is counteracted by another service, the desired effect will be neither visible or effective for the grid needs. To avoid this, there might be stacking restrictions for some products e.g. congestion management.
2. Value stacking has its limitations. When looking in more detail, some combinations of services do not seem feasible as demonstrated by the example above. Therefore, there should be a clear description which combination of services, under which conditions, should be supported and which not. Also, a distinction between same and opposite direction is needed.
3. Energy transfers can simplify the mechanism but will reduce the options. Assigning balance responsibility to the Aggregator, and associating energy trades to all services, might reduce stacking complexity. Based on the principle that energy can only be sold once, the complexity associated to double counting would be reduced. If an Aggregator has traded energy in the wholesale market, it will not be able to provide that energy to another service unless it has additional flexibility in its portfolio.
4. Product settlement needs to be coordinated
   Flexibility products are typically settled by the FRP (TSO, DSO) or by the ISR. If an asset is active for different products at the same time, consistency in settlement can only be achieved if settlement takes place in a coordinated manner. This can be complicated due to different baseline methodologies between the products and different timings for flexibility trading and (start of) flex activation. A central settlement entity or ISR may be the most efficient way forward.
5. Product design needs to be coordinated. Value stacking options depend to a large extent on product design. Some products require exclusivity, others may have the same effect when certain product characteristics are ill designed. The baseline methodology in particular has a strong impact on value stacking possibilities.

To conclude, value stacking is far from straightforward and its benefits and complexities must be balanced out. On one hand, value stacking is necessary and beneficial to the Aggregator's business case and optimisation of flexible resources. On the other hand, value stacking can be very complex and entail high administrative costs and other risks. Therefore, we recommend that both benefits and costs are thoroughly assessed in order to design a balanced system.

5.2 Unit vs. portfolio baseline and measurements (Dynamic pooling)

As described in section 3.2.2, one of the complexities associated with DR delivery verification is the *pooling conditions* of each particular service. In the Aggregator implementation workstream [1], USEF recommends that all flexibility providers should be allowed to offer their flexibility at portfolio, or pool, level instead of unit level so they are able to provide flexibility from a set of flexible assets without having to fix them in advance. Also, Aggregators should be able to choose the resources they are going to activate dynamically i.e. near real time, to apply dynamic pooling (described in section 2.3.3).

The rationale for this recommendation is that the Aggregator can decide which flexibility resources to activate after the activation request has been received from the FRP, or close to real-time for DA and ID products, so that it can optimise its resources.

Table 5-1: Balance responsibility for fixed and dynamic pools

Pool	Balance Responsibly
Fixed	The Aggregator is balance responsible for all flexible assets in their pool, regardless of whether they were all activated during flexibility delivery.
Dynamic	The Aggregator is balance responsible only for the flexible assets that were activated during the flexibility delivery.

Dynamic pooling, however, brings additional challenges:

- Difficulty verifying the flexibility activation due to the uncertainty of the resources that will be activated for a particular service.
- Difficulty correcting the perimeters of the affected Suppliers, especially ex-ante.
- Increased chances of gaming due to lack of transparency.

To overcome this challenge, USEF recommends that while the flexibility service is offered at a pool level, the baseline and measurements need to be provided at unit or resource level. By doing so, the service can be verified regardless of the combination of resources the Aggregator activates for a particular service. It should be noted that this alone does not eliminate the risk of gaming although it does make it more difficult.
A second implication of allowing dynamic pooling is that the Aggregator needs to specify (typically ex-post) which resources have been used to deliver a specific service at a specific time, allowing the settlement process to take only those assets into account. This corresponds to the activation information sent by the Aggregator to the ISR, as introduced in section 4.2.

Although this recommendation might pose a bigger administrative burden on the Aggregator, it will ensure a proper level of transparency in order to allow dynamic pooling which ultimately benefits the Aggregator.

5.3 Market restrictions for Congestion Management

USEF describes a mechanism where a TSO/DSO can purchase flexibility to alleviate potential congestion without affecting the three market freedoms. We label this mechanism *TSO/DSO capacity management* and it resides in the Yellow regime.
Several member states are developing regulatory frameworks where the TSO/DSO needs to apply a marked-based mechanism to procure flexibility, yet also has the right (to the extent needed) to:

- pose market restrictions upon customers located in the congested area (and thus upon the market parties that are serving these customers); and
- impose the obligation upon market parties (mainly producers) to participate in the congestion management product.

Although USEF focuses on fully market-based mechanisms, the USEF MCM and interaction model are also well suited to use in situations with certain market restrictions. USEF labels this mechanism *TSO/DSO congestion management*. This cannot be entirely mapped on the Yellow regime as this regime fully respects the three market freedoms. However, it does not impact the customer as heavily as other mechanisms under the Orange regime (load shedding and graceful degradation).
In fact, the concept of mandatory D-prognoses is a strong basis for enforcing market restrictions, as market parties can be held accountable for keeping the realization of their group of Active Customers to the day-ahead D-prognosis. However, this (and any associated penalty for not meeting the D-prognosis) is not further elaborated in the framework.

5.4 TSO/DSO interactions

The Market Coordination Mechanism within USEF describes the information exchange required to ensure an efficient and effective use of distributed flexibility in markets where it creates the highest value. Since in normal conditions (Green and Yellow regime), the flexibility is deployed by market parties (BRP, BSP, CSP and CMSP) or by the Active Customer itself (behind-the-meter

optimization) and activated by the Aggregator (explicit DF), Supplier (implicit DF) or ESCo/Active Customer (behind-the-meter), these market roles perform a central role in the information exchange, possibly facilitated by regulated entities.
With this market-based set-up, there is little need within the MCM for direct TSO-DSO interaction. In this section, we describe how the responsibilities and activities of TSOs and DSOs could impact each other, and additional direct TSO-DSO interaction which could be beneficial.

In this section we will focus on the following responsibilities and activities of the TSO and DSO:

1. The TSO is responsible for maintaining, in a continuous way, the system frequency within a predefined stability range for a certain scheduling area (which often corresponds with a bidding zone). Any imbalances are resolved by contracting and activating Balancing Service Providers in different time frames, in short *Balancing.*
2. The TSO is responsible for operating the transmission grid, safeguarding the system's short-term ability to meet electricity transmission demands. The TSO can apply TSO constraint management to ensure no thermal limits (or other technical constraints) are violated, by contracting and activating CMSPs. USEF distinguishes between capacity management, where no market restrictions are imposed, and capacity management, where some market restrictions are applied (see section 2.2.2.2).
3. The DSO is responsible for operating the distribution grid, safeguarding the system's short-term ability to meet electricity distribution demands. The DSO can apply DSO constraint management to ensure no thermal limits (or other technical constraints) are violated by contracting and activating CMSPs. USEF distinguishes between capacity management, where no market restrictions are imposed, and capacity management, where some market restrictions are applied (see section 2.2.2.2).

It is possible for these three activities to interact and even interfere e.g. activating flexibility to resolve a technical constraint could lead to system imbalance, and vice versa. Below we describe how interference is mitigated in USEF and the additional TSO-DSO interaction that may be required.

5.4.1 Potential impact of TSO / DSO constraint management on system balance

By defining and allocating the right responsibilities and mechanisms, no additional TSO-DSO interaction is needed to mitigate any impact on system balance. The general principle is that any activation of flexibility, as part of a constraint management service, needs to be counteracted to neutralize the effect on the system balance (the so-called *redispatch*). This is achieved in two steps, by the product specification and by assigning balancing responsibility.

Step 1: Constraint management product specification
The services that a TSO or DSO acquires from a CMSP for constraint management need to define where the redispatch responsibility lies. There are two options:

1. Redispatch responsibility is with the flexibility requesting party (TSO/DSO)
2. Redispatch responsibility is in the market.

In the former option, since regulated entities are, in general, not allowed to take a position on the energy market, the redispatch needs to be purchased in combination with, or at least at the exact same time as, the flexibility purchase.

There is another way to distinguish these two options; in option 1, the TSO/DSO buys energy from the CMSP and the same amount of energy is sold through the redispatch action. In option 2, the TSO/DSO buys a service from the CMSP. In this case the redispatch action will balance the CMSP's DR activation.

Step 2: Assign balancing responsibility
Where the redispatch responsibility is in the market, it is crucial to define where the balance responsibility associated with the flexibility activation resides. In addition, if the redispatch responsibility is with the FRP, the CMSP or Aggregator can still cause a system imbalance if they fail to deliver the service, or overshoot the delivery.

Balance responsibility is described through the Aggregator Implementation Models (AIMs), see section 3.3. The following options are possible:

- The CMSP/Aggregator takes balance responsibility (all dual-BRP models).
  This is in many cases the preferred option, also stipulated by EC's Clean Energy Package. If the action of the Aggregator, in this case in the role of CMSP, leads to an imbalance in its own portfolio, it has sufficient incentives (and also the opportunity) to balance its own portfolio, thus restoring the system balance.
- The Supplier of the affected Active Customer takes balance responsibility (all single-BRP models).
  When energy volumes are low, e.g. in a post-fault DSO congestion management product, the uncorrected model may be more suitable as the administrative burden is limited. Also, where the CM flex order is issued day-ahead or earlier, the Supplier should be able to balance its portfolio without additional costs. In both cases it is preferable that the Supplier / BRP is informed (by the Aggregator (broker model) or Active Customer).

In the Integrated model, the roles of CMSP/Aggregator and Supplier are combined in one market party and so can be seen as a combination of both options.

5.4.2 Potential impact of balancing services on TSO/DSO operations

Balancing services are typically activated after intra-day gate closure, or even in real time, whereas TSO / DSO congestion management services are typically activated before intra-day gate closure, and sometimes even day-ahead (except for specific cases such as post-fault products). The impact of this is most complex as it is difficult for TSO/DSO services to anticipate which assets will be activated, triggered by balancing services.
Another complexity is that balancing services are portfolio-bids[44] and do not reveal the locations of the assets that will be activated. There are several elements in USEF that mitigate this:

- The Common Reference[45] provides information about which market parties have which assets under their control at which location. This can help system operators in forecasting grid behaviour e.g. by developing worst-case scenarios.
- Market parties that operate flexibility need to submit D-prognoses. However, their applicability in this context is limited since balancing activities will only be included after they have been requested, which is close to real time.

Information exchange in case of TSO/DSO capacity management
Grid capacity management is applied by the TSO/DSO to increase its operational efficiency without impacting the freedom of dispatch, trade and connect (copper plate principle). This means that all assets within an area where capacity management is performed still need to be able to participate in balancing products. In situations where the TSO/DSO expects potential congestion, they need to purchase as much flexibility as necessary to facilitate the copper plate. They can use the Common Reference to inform the grid safety analysis. Since they have to facilitate all possible flexibility actions (also those triggered by other markets or the Active Customer itself), there is no additional information needed between TSO and DSO.

Information exchange in case of TSO/DSO congestion management
In this case, market restrictions apply. In general, this means that (a pool of) assets within a congested area should stick to their (its) D-prognosis, which will prevent participation in a balancing product (in the 'wrong' direction from the congestion point-of-view), or any other product. These market restrictions need to be communicated between the TSO/DSO and BSPs/BRPs but not between the TSO and DSO so, again, there is no direct need for TSO-DSO coordination.

Only where there is a pro-active TSO, capable of producing balancing requests longer in advance, is there is an opportunity to combine TSO congestion management and balancing. This is done by using the same merit order, ensuring no conflicts arise, and requires the balancing bids to be split up according to the congested areas – and this becomes further complicated when DSO congestion management is added to the equation. However, a coordinated approach for balancing TSO and DSO congestion management still does not remove the need for market restrictions, as the flexibility can still be applied for other purposes (e.g. behind-the-meter optimization). So, if market restrictions are required anyway, there is little reason for a fully coordinated

[44] A portfolio composed by assets located at different connections
[45] Cf. section 2.1.2

approach and this leaves the current mechanism for portfolio bids in balancing products (and also in constraint management products) intact.

5.4.3 Potential impact between TSO constraint management and DSO constraint management

There are two cases where these activities can be conflicting:

1. A congested area in the distribution grid could be situated in a congested area at TSO level. An asset that is activated in the distribution grid to resolve congestion at one level could worsen the situation at another level.
2. Every activation for constraint management is accompanied by a redispatch action (assuming the SO is responsible for the redispatch, see section 5.4.1). Without proper coordination, the redispatch action could take place in another congested area.

There is also an opportunity for further TSO-DSO coordination in this context:

3. If multiple TSO/DSO constraint management activations occur within the same ISP, multiple redispatch actions also need to be placed. If the System Operator is responsible for the redispatch, and if some of the activations have opposite directions (i.e. generation reduction / load enhancement vs. generation enhancement / load reduction), then the combined TSOs and DSOs could limit the redispatch to the net total of activations, reducing the over-all costs for the redispatch.

In case of TSO/DSO capacity management, similar to the situation described in section 5.4.2, no additional coordination is needed. An asset that is located in a congested DSO area, should still be able to participate in a TSO constraint management service, since the copper plate principle still needs to be respected. This applies to both cases 1 and 2. This means that the activation of a flexible asset in the distribution grid, as part of a redispatch service for the TSO, could trigger another DSO constraint management activation. This would place the redispatch costs at the right organisation.

In case of TSO congestion management situation described in case 1 (above), the DSO does not have any alternative but to activate flexibility in the congested area, even if this increases the congestion issue at TSO level. The TSO will have to counter this effect, but has a far larger area to acquire flexibility. In this case, the TSO would benefit from receiving this information from the DSO (also if the activation supports in solving the TSO congestion). For case 2, a redispatch is not likely to be offered from a TSO congested area since the local flexible assets are subject to market restriction.

It would be helpful for DSO congestion management if the TSO would refrain from activating assets in the DSO's constrained area. However, since TSO constraint management services are (in general) portfolio-based, the TSO does not know of the DSO constraint. As the assets/customers in the DSO congested area are likely to be subject to market restrictions, they will most likely be restricted from participating in the TSO market anyway. So, again, there is no direct need to coordinate the activations within the TSO/DSO constraint management products, and no need to make bids in TSO constraint management services asset-based. However, it is important that any market restrictions imposed by the DSO are known prior to the flex trading activity in the TSO constraint management mechanism and, therefore, important that the TSO/DSO constraint management products are designed in coordination, ensuring proper timing for both products.

To summarize, the following TSO-DSO coordination is recommended in addition to the market coordination mechanism, where TSOs and DSOs coordinate and interact with market parties:

- The DSO should inform the TSO about any DSO constraint management service activations in DSO areas that are part of a larger, congested TSO area, both if this increases or decreases the congestion issue on TSO level.
- TSO and DSO constraint management products should be aligned, especially with respect to the timing. Market restrictions on the DSO side should be known well in advance of the flex trading activity in the TSO constraint management mechanism.
- TSO and DSO redispatch activities can be coordinated, reducing the combined need for redispatching to net volumes.

5.5 Flexibility trading platforms

The USEF white paper on flexibility platforms further elaborates on the following concepts:

- Overview of different types of flexibility platforms
- Role of flexibility market platforms in the flexibility value chain
- TSO-DSO coordination
- Analysis of market initiatives for flexibility market platforms
- Reference architecture for flexibility platforms

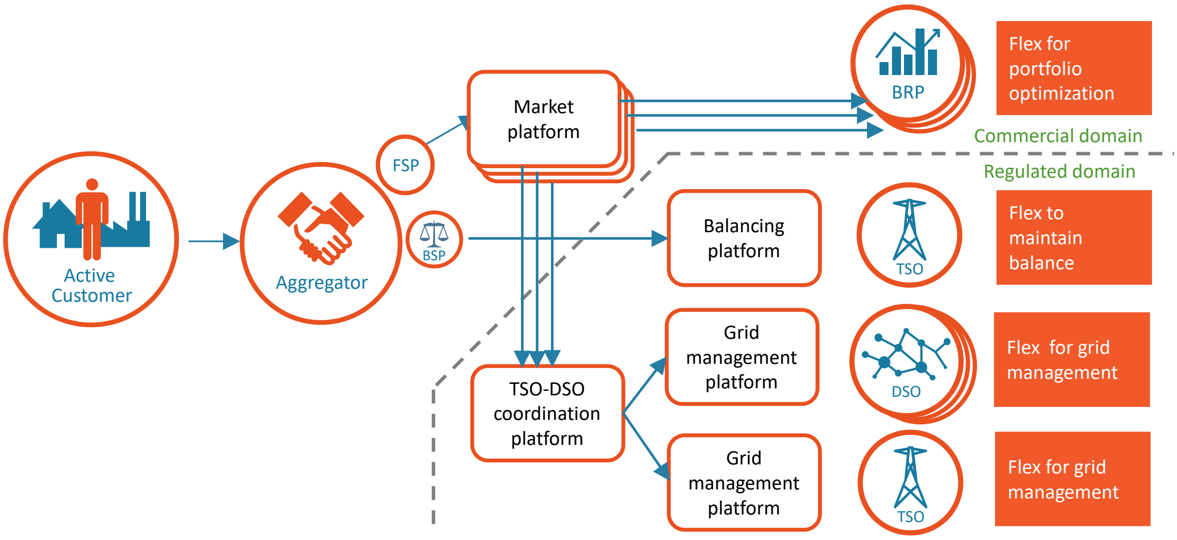

Figure 5-1: Gateway to coordinated ancillary services

Although the participation of a market operator doesn't fundamentally change the concept of the flexibility value chain (as a market operator is a BRP itself, and can be regarded as the requesting BRP, or a gateway to the requesting BRP), the paper does provide further explanation about how a flexibility market platform can/should be positioned in relation to other market players, as well as regulated entities. The overview also describes the potential cooperation between TSOs and DSOs, implemented in a TSO-DSO coordination platform, and highlights some of the challenges related to making these concepts work in practice. [7] The paper distinguishes DSOs that operate their own platform for grid management services (often referred to as local energy markets) from DSOs that use market platforms to interact with CMSPs within those local markets. Such a market platform, typically operated by a Nominated Electricity Market Operator (NEMO – not included in the USEF role model), can provide neutrality, higher transparency and can increase over-all market efficiency.

5.6 Energy communities

Citizens Energy Communities (CECs) are becoming increasingly popular. A CEC's primary purpose is provision of environmental, economic or social community benefits, rather than financial profits, to its members. CECs may offer a range of services; some related to generation, distribution and supply, storage or aggregation of energy (typically from renewable sources); others are energy-related services e.g. to increase energy awareness and efficiency.

CECs are becoming more professional and are exploring opportunities to extend their roles, both in the energy system and in terms of the type of activities they can offer to their members. Flexible loads, controllable local generation and storage units can all offer flexibility value by allowing their load or generation profiles to be purposely changed from the planned generation or consumption pattern. As a result, activities related to DF could be considered complementary for communities e.g. by extending and increasing the economic value of a community (renewable) energy generation project by incorporating demand-side flexibility.

In relation to implicit DF, members of a CEC can valorize their flexibility by optimizing their aggregated community load profile. This is equal to the implicit DF services listed in 2.2.1 but on community level. When it comes to valorizing flexibility through aggregation, CECs could collectively reach out to Aggregators and negotiate the participation of the whole pool. However, it could also be the community itself that takes on the role of Aggregator (instead of an already existing (profit-driven) market party) by assuming the role of the flexibility retailer between its members and Flex Requesting Parties (FRPs) i.e. the BRP, DSO and TSO.

Figure 5-2 illustrates all relevant energy and flexibility services for a CEC: ① Services that increase energy awareness, ② Services to facilitate the joint purchase and maintenance of (shared) assets, ③ Supply of (shared) energy, and ④ Peer-to-Peer supply, allowing Prosumers within the community to (administratively) exchange energy with each other. ⑤ and ⑥ are related to implicit DF from the individual customer's perspective and from the community perspective, respectively. ⑦ is the provision of explicit DF services via the Aggregator role.

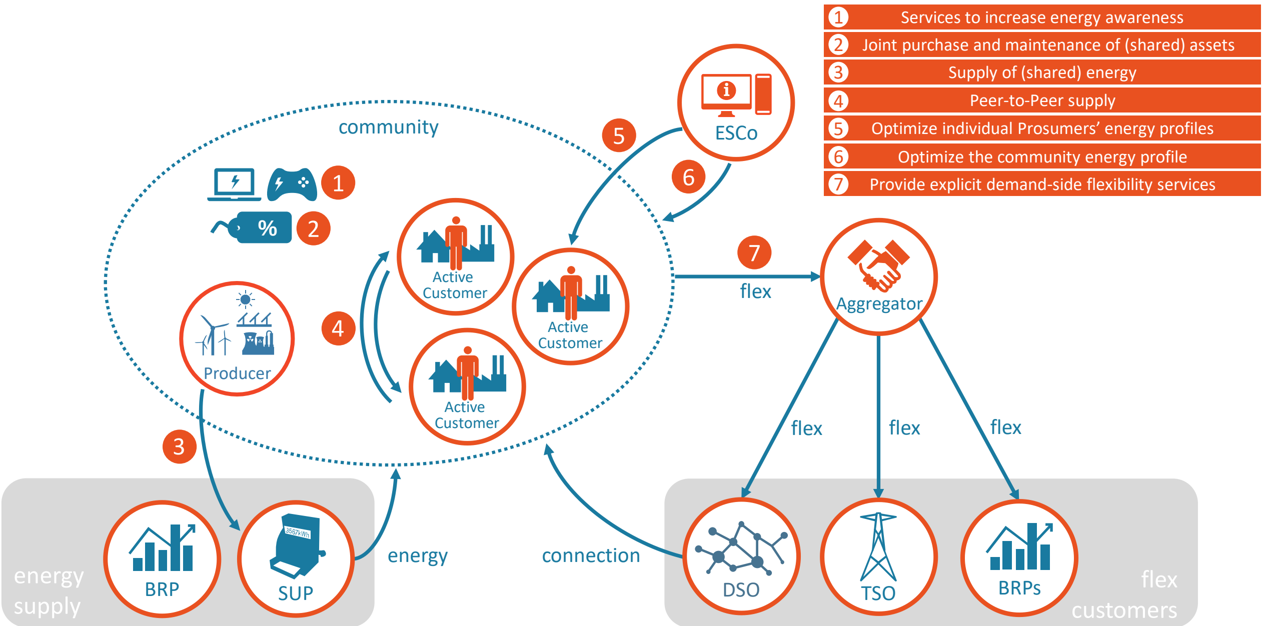

Figure 5-2: Energy and flexibility services for a CEC and its members

The USEF white paper 'Energy and Flexibility Services for Citizens Energy Communities' [8] provides a comprehensive overview of these services.

5.7 Country deployment

There are multiple products, markets and regulations for distributed flexibility across Europe. The USEF white paper 'Flexibility Deployment in Europe' [5] provides an overview of current deployments and maps them on to:

- USEF roles: Which USEF roles are implemented in each country? The paper focuses on the roles of Aggregator, Balancing Service Provider, Constraint Management Service Provider and Capacity Service Provider.
- USEF's Flexibility Value Chain:
  - Implicit services: looking at network and supply tariffs, what possibilities are there in the country to perform implicit flexibility services?
  - Explicit flexibility services: what services from the USEF flexibility value chain are open to DR and (independent) aggregation?
- USEF Aggregation Implementation Models: For services that allow for aggregation and DR, which Aggregator Implementation Model does each country apply?
- Value stacking: Do countries allow for stacking flexibility services? Is dynamic pooling allowed?

The paper gives an overview of the above topics for 9 different European countries: Belgium, Denmark, France, Finland, Germany, Great Britain, the Netherlands, Spain and Switzerland.

Appendix 1 Glossary

Adequacy	General meaning: the state or quality of being adequate; sufficiency for a particular purpose. Specific in energy markets: whether the generation capacity is sufficient to meet the demand. http://www.dictionary.com/browse/adequacy?s=t
Adequacy product	Product that is intended to increase the adequacy of the system. Is one of the possible flexibility products.
Allocation	Allocation of measured energy consumption in a certain control area to the different BRPs.
Ancillary and balancing services	Ancillary and balancing services refer to a range of functions which TSOs contract so that they can guarantee system security. These include black start capability (the ability to restart a grid following a blackout); frequency response (to maintain system frequency with automatic and very fast responses); fast reserve (which can provide additional energy when needed); the provision of reactive power and various other services. https://www.entsoe.eu/about-entso-e/market/balancing-and-ancillary-services-markets/Pages/default.aspx
Arbitrage	In economics and finance, *arbitrage* is the practice of taking advantage of a price difference between two or more markets: striking a combination of matching deals that capitalize upon the imbalance, the profit being the difference between the market prices. https://en.wikipedia.org/wiki/Arbitrage
Balancing	The act of reducing/increasing load/generation by a BRP in an attempt to restore its portfolio imbalance. Similarly, the act of reducing/increasing load/generation by a TSO in an attempt to restore the system imbalance. In the latter case, the TSO uses balancing services for this purpose. Balancing refers to the situation after markets have closed (gate closure) in which a TSO acts to ensure that demand is equal to supply, in and near real time. https://www.entsoe.eu/about-entso-e/market/balancing-and-ancillary-services-markets/Pages/default.aspx
Baseline	It is the best approximation of the energy consumption or production that would have occurred, if no DR event would have been triggered. Used to quantify the delivered flexibility.
Contracted bidding	The acts of placing bids on a market which was committed beforehand via a (contractual) obligation. This is a way for the contracting party to ensure certain market volume. Opposite of free bidding.
Dispatch	Turn on or off a power generation unit or adjust their power output according to an order. Dispatching of a generation unit is generally at the request of power grid operators or of the plant owner to meet the demand in the power system, and based on the merit-order. Opposite of intermittent energy sources. https://en.wikipedia.org/wiki/Dispatchable_generation
Ex-ante	The term ***ex-ante*** is a phrase meaning "before the event". *Ex-ante* is used most commonly in the commercial world, where results of a particular action, or series of actions, are forecast in advance (or intended). The opposite of *ex-ante* is *ex-post* (actual). https://en.wikipedia.org/wiki/Ex-ante
Explicit distributed flexibility	Form of flexibility where customers makes an explicit change in demand/generation in response to a signal, and is specifically rewarded (remunerated) for that change.
Ex-post	"Afterward", "after the event". Based on knowledge of the past. Measure of past performance. https://en.wikipedia.org/wiki/Ex-post
Ex-post nomination	The possibility for BRPs to include transactions after the Operation phase (i.e. after the associated ISP) by a change in their approved E-programs. This changed is processed by the TSO

	before the allocation. Via this mechanism BRPs can mutually settle imbalances and avoiding the imbalance penalties raised by the TSO.
Flexibility service quantification	Determination of the amount of load/generation reduction/increase in terms of instantaneous power [W] or energy during a certain time interval [Wh]. To determine whether the service was actually delivered with the right quantity. A *baseline* is needed for this purpose.
Free bidding	The act of placing bids on a market without a (contractual) obligation to do so. Opposite of contracted bidding.
Gaming	Using the rules and procedures meant to protect a system in order, instead, to manipulate the system for a desired outcome. Gaming is a form of abuse. See also *arbitrage*.
Grid	Network for the transport and distribution of energy.
Implicit distributed flexibility	Situation where customers are exposed to varying energy prices and/or grid tariffs and respond by adapting their energy demand profile. In general, consumers exposed to such tariffs might have an automated system or a 3rd-party (ESCO) service that helps them to consume their energy at optimal prices.
Merit-order	The merit order is a way of ranking available sources of energy, especially electrical generation, based on ascending order of price (which may reflect the order of their short-run marginal costs of production) together with amount of energy that will be generated. In a centralized management, the ranking is so that those with the lowest marginal costs are the first ones to be brought online to meet demand, and the plants with the highest marginal costs are the last to be brought on-line. Dispatching generation in this way minimizes the cost of production of electricity. Sometimes generating units must be started out of merit order, due to transmission congestion, system reliability or other reasons. https://en.wikipedia.org/wiki/Merit_order
Nomination	The act of informing the counterparty about the forecasted energy profile for the near future. For example, a day-ahead nomination for the full next day, an intra-day nomination for the remainder of the day or short-term nomination for one or more ISPs.
Passive balancing	A BRP helps reduce the imbalance for the whole control area by deviating from its own electricity program. If this contributes to reducing the total imbalance, the BRP may receive remuneration for its passive contribution, depending on market design.
Perimeter correction	Adjustment of the imbalance volume of the corresponding BRP. Normally performed by the ISR role to avoid that flexibility activation would result in an imbalance due to the changed energy volume.
Redispatch	The act to compensate a demand/generation increase/reduction of an asset by an opposite change at another asset within the same portfolio or region such that the remaining profile at portfolio level or region level remains constant. This mechanism is sometimes used to solve grid congestion issues.
Settlement	Determining the energy production and consumption and used flexibility as preparation for the billing process.
Sourcing (of energy)	Purchasing of energy.
Spot Market	A spot market or is a public financial market in which financial instruments or commodities are traded for immediate delivery. Day-ahead markets and intra-day markets are both spot markets. https://en.wikipedia.org/wiki/Spot_market
Transfer of Energy	Energy volumes transferred between the BRP of the Aggregator and the BRP of the Supplier. In this text the Transfer of Energy is used to compensate the BRP of the Supplier for the effects of flexibility activation by an Aggregator, and to source the energy associated with this activation.

References

[1]	USEF, „USEF - Workstream on Aggregator Implementation Models," Arnhem, 2017.
[2]	ENTSO-E, „Network code on Load-Frequency Control and Reserves," Brussels, 2013.
[3]	USEF, „USEF White Paper - Flexibility Value Stacking," USEF, Arnhem, 2018.
[4]	European Union, „DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast)," 5 6 2019. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944.
[5]	USEF, „Flexibility Deployment in Europe," 2021. [Online]. Available: https://www.usef.energy/app/uploads/2021/03/08032021-White-paper-Flexibility-Deployment-in-Europe-version-1.0-3.pdf.
[6]	USEF Foundation, „USEF Flexibility Trading Protocol Specifications," 28 01 2020. [Online]. Available: www.usef.energy.
[7]	USEF, „Flexbility Platforms," 2018. [Online]. Available: https://www.usef.energy/app/uploads/2018/11/USEF-White-Paper-Flexibility-Platforms-version-1.0_Nov2018.pdf.
[8]	USEF, „Energy and Flexibility Services for Citizens Energy Communities," 2019. [Online]. Available: https://www.usef.energy/app/uploads/2019/02/USEF-White-Paper-Energy-and-Flexibility-Services-for-Citizens-Energy-Communities-final-CM.pdf.
[9]	USEF, „USEF DSO Workstream - An introduction to EU market-based congestion management models," 2018.
[10]	USEF, „USEF: Workstream on Aggregator Implementation Models," Arnhem, 2017.
[11]	USEF, „Flexibility Trading Protocol Specifications," Arnhem, 2019.