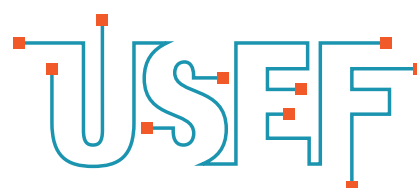




White Paper

Flexibility Value Chain

Update 2018



A solid foundation for smart energy futures

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Table of Contents

1 The Flexibility Value Chain	4
1.1 Introduction of the Flexibility Value Chain	4
1.2 Value stacking	6
2 Flexibility services	7
2.1 Explicit demand-side flexibility services	7
2.2 Implicit demand-side flexibility services	11
3 Remuneration of flexibility services	13
4 Characteristics of flexibility delivery	14
4.1 Drop-by and drop-to services	15
5 Concluding remarks	16

1 The Flexibility Value Chain

The combined increase in intermittent generation and electrification make the need for demand-side flexibility in the energy system more urgent and this provides opportunities. USEF considers that flexibility can be deployed for multiple purposes and used to serve a variety of customers and markets. USEF's flexibility value chain provides a complete overview of customer needs for flexibility, and the associated markets and products in which demand-side flexibility can potentially create value.

This chapter provides a general introduction to the Flexibility Value Chain (FVC) by explaining who can benefit from flexibility and how it can be delivered. Chapter 2 provides a more in-depth insight into the FVC by presenting an overview of services that can be delivered using demand-side flexibility.

1.1 Introduction of the Flexibility Value Chain

Active demand and supply at Prosumer 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 demand-side flexibility can provide value to different parties:

- The *Prosumer* can use it for in-home optimization, e.g. optimizing towards variable energy or grid tariffs or increasing their own consumption of self-generated energy.
- The *Balance Responsible Party (BRP)* aims to reduce its sourcing cost (purchase of electricity), maximize revenue of generation and avoid imbalance charges and the demand-side flexibility from Prosumers can help a BRP optimize its portfolio this way.
- The *Distribution System Operator (DSO)* is responsible for the installation and maintenance of distribution grids. A DSO can increase its performance and efficiency by using demand-side flexibility for congestion management which helps defer or avoid the costs of grid reinforcements.
- The *Transmission System Operator (TSO)* is responsible for installation and maintenance of the transmission grid and for system stability. Depending on national regulation, the TSO can also have responsibility for ensuring generation adequacy. This combined responsibility is reflected in the number of services an Aggregator can offer the TSO - from ancillary services for balancing purposes to constraint management (e.g. congestion management) and adequacy services.

Prosumers exposed to variable energy or grid tariffs (e.g. Time-of-Use (ToU) tariffs) can profit from flexibility for in-home optimization, allowing them to shift their load and/or generation to periods with low energy or grid prices. This valorization of the Prosumer's flexibility is known as implicit demand-side flexibility. In the USEF role model¹ the Prosumer can be served by an EScO to maximize the valorization of his flexibility. This is illustrated in Figure 1.

¹ The USEF role model is described in the publication *USEF: The Framework Explained* (2015).

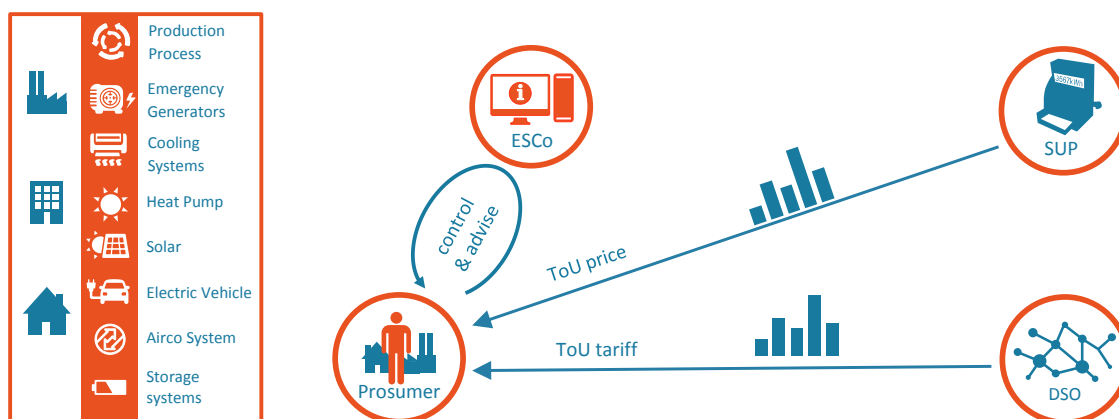


Figure 1 The USEF Flexibility Value Chain for implicit demand-side flexibility.

Another mechanism, *explicit demand-side flexibility*, sees flexibility directly exposed to energy markets and ancillary products. Prosumers receive (financial) rewards for agreeing to respond to BRP, DSO or TSO requests to adjust their load or generation profile. Because it is dispatchable and can be tailored to the markets' exact needs (size and timing), explicit demand-side flexibility may offer specific value for e.g. balancing and capacity management.

USEF's role model assigns the Aggregator² (also known as Flexibility Service Provider) a central position in the FVC for explicit demand-side flexibility, as a retailer of flexibility between the Prosumer and the Flex Requesting Parties (FRP), i.e. the BRP, DSO and TSO. This is illustrated in Figure 2. The Aggregator is responsible for acquiring flexibility from Prosumers, aggregating it into a portfolio, creating services that draw on the accumulated flexibility and offering these to different markets, serving different market players. The reward value that the Aggregator receives in return is shared with Prosumers as an incentive to shift, reduce or enhance their load or generation³.

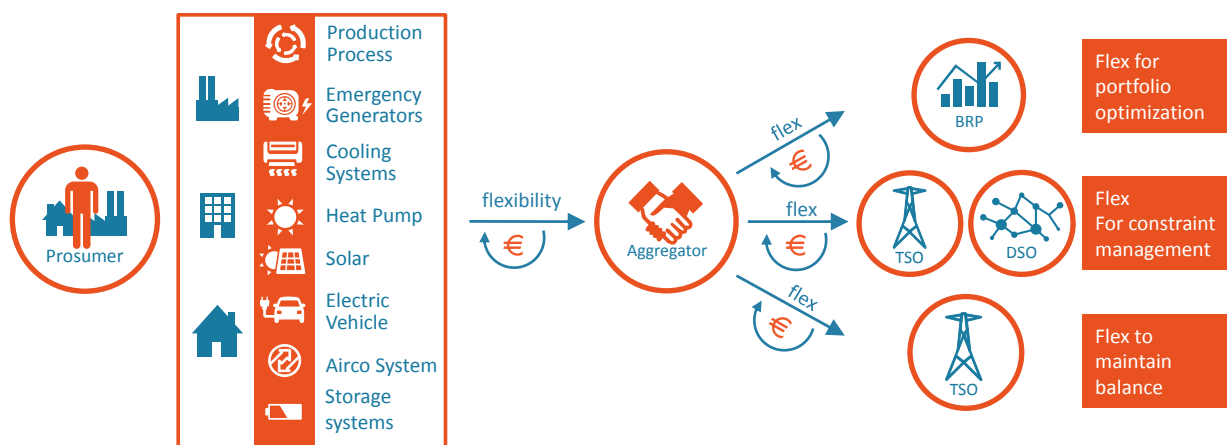


Figure 2 The Flexibility Value Chain for explicit demand-side flexibility.

It is also possible to combine implicit and explicit demand-side flexibility; where the Aggregator (responsible for explicit demand-side flexibility) and the ESCo (responsible for implicit demand-side flexibility) can be either the same or different entities. See Figure 3 illustration of combined explicit and implicit demand-side flexibility.

² The Aggregator is a market role that can be taken by either existing market parties (suppliers) or new entrants.

³ Aggregators can also provide non-financial value in return to the Prosumer, e.g. by providing insight into consumption patterns or providing home energy management tools that help the Prosumer to become more energy efficient.

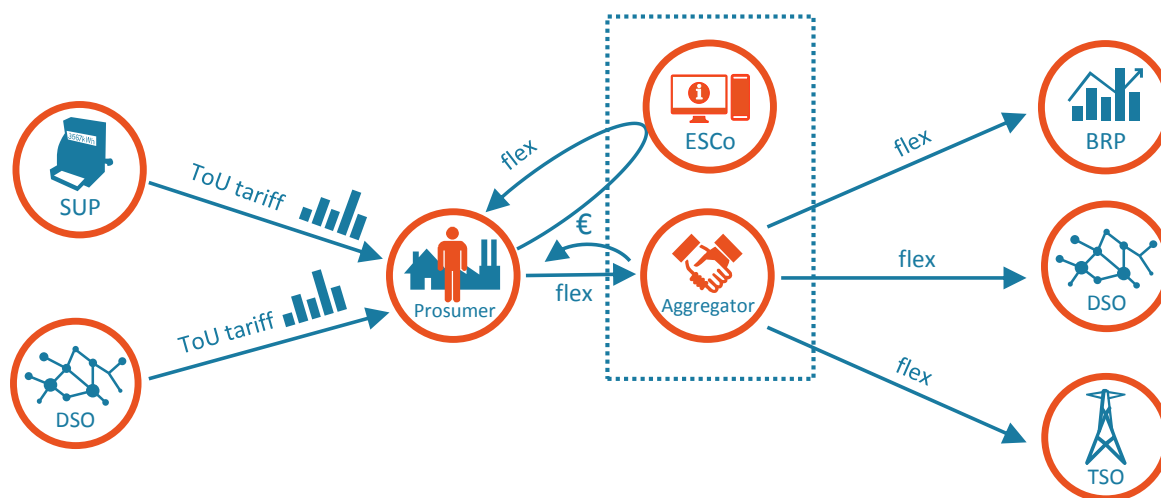


Figure 3 Combination of implicit and explicit demand-side flexibility.

The combination of implicit and explicit DR, specifically when operated by different market parties, has certain restrictions. See the publication *Recommendations for DR market design* (2017) by USEF's Aggregator Workstream for an overview of feasible combinations.

1.2 Value stacking

The FVC provides an opportunity for *value stacking*: enabling the Aggregator to provide multiple services to one or multiple FRPs from the same portfolio. Different levels of value stacking are possible:

- *In time*: e.g. participate in a FRR in the morning and in DSO capacity management in the afternoon.
- *In pools*: activate one asset for one service, another asset for another.
- *Double serving*: provide multiple services at the same time by stacking activation from one asset. There are two different approaches to doing this:
 - *With a single energy transaction*: e.g. sell energy in an intra-day market and provide a load reduction service to the DSO with the same activation. In this case, there is an energy transaction with the intra-day market but not with the DSO.
 - *With multiple energy transactions*: e.g. offer 40% of a wind curtailment to one product and 60% to another, or sell energy in DA and buy the energy in real time. In this case, there are energy transactions with multiple parties. A mechanism for this type of value stacking is introduced in USEF's *Value Stacking* (2018) white paper.

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.

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

- Exclusivity agreements should be respected. If the AGR 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.

Since there is currently a lack of regulation and implementation rules for value stacking, it is not allowed for most service combinations in European countries. To propel the implementation of value stacking, USEF provides a comprehensive method to distinguish and quantify individually stacked services (while avoiding *double selling of energy*). More information can be found in USEF's *Value Stacking* (2018) white paper.

2 Flexibility services

This chapter contains a more in-depth introduction to the Flexibility Value Chain by defining flexibility services that can be delivered to the four potential customer roles: DSO, TSO, BRP and Prosumer.

A categorization and definition of flexibility services that an Aggregator can offer to the DSO, TSO and BRP are provided in this chapter. For the sake of completeness, flexibility services aimed at the Prosumer are also included although these are provided by the EScO role, rather than the Aggregator role. The categorization and definitions include examples of flexibility services already in use or in development in existing (European) markets and should not be seen as a recommendation of the type of flexibility services to be offered in every market. For an up-to-date overview of current implementations of these services, see the most recent version of the publication *Flexibility services in Europe – a USEF mapping (2018)*.

2.1 Explicit demand-side flexibility services

Figure 4 shows a list and classification of explicit demand-side flexibility services. The flexibility services can be classified as follows:

- *Wholesale services* help BRPs to decrease sourcing costs (purchase of electricity) – mainly on DA and ID markets - but also costs for sourcing through balancing mechanisms. Examples include an Aggregator providing flexibility to both its associated BRP, and another BRP e.g. via an Exchange or bilateral trade. In the USEF role model 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.
- *Constraint management services* help the grid operators (TSO and DSO) to optimize grid operation using physical constraints and impact on markets⁴.
- *Balancing services* include all services specified by the TSO for frequency regulation.
- *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. The BRP can be obliged by regulation to take care of security of supply (e.g. the French capacity market) or can decide to hedge its risk.

The term *ancillary services* can be used to refer to balancing and constraint management services.

In USEF's role model, 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 1 shows the associated roles for the four flexibility service groups.

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

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

⁴ Especially in regions with flow-based market coupling.

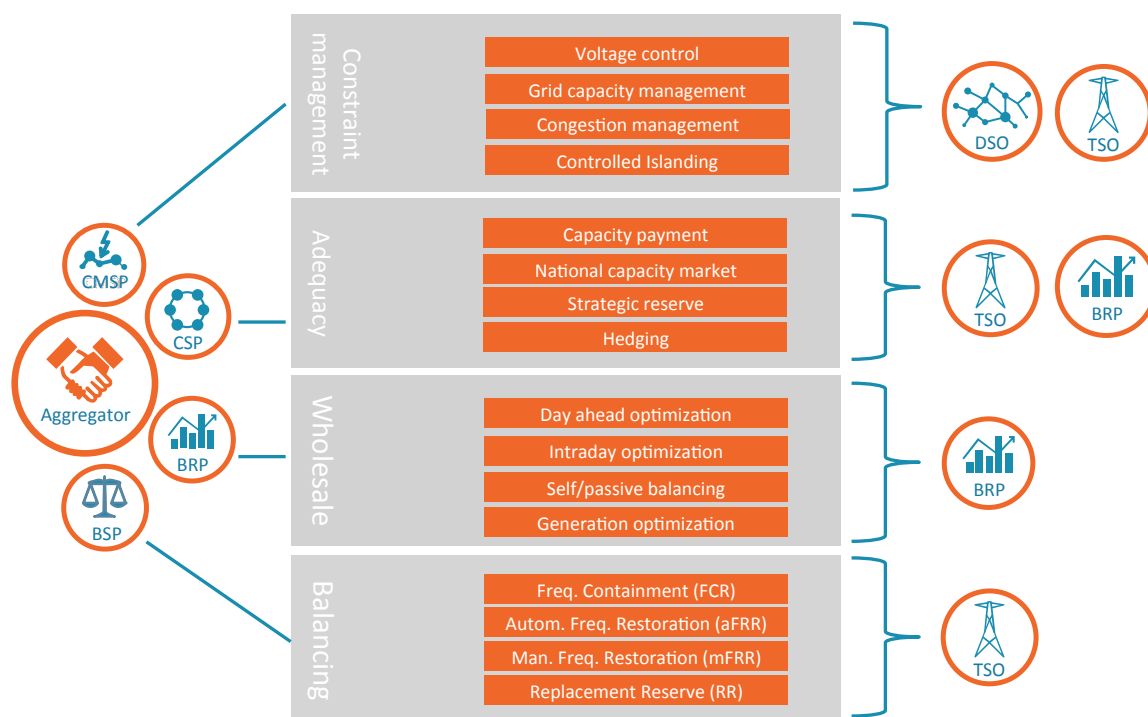


Figure 4 Explicit demand-side flexibility services. The services are classified in four categories: Constraint Management, Adequacy, Wholesale and Balancing. The FRPs that can be served for each category are found on the right side of the figure⁵. The trading Counter Party through which the Aggregator brings the service to the FRP can be found on the left side⁶.

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

2.1.1 Wholesale

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 demand-side flexibility for day-ahead optimization enables the BRP to reduce overall electricity purchase costs. Demand-side flexibility can be traded via either a day-ahead exchange or by establishing a bilateral agreement.

Intraday optimization

Intraday optimization (via intraday exchange or by bilateral agreements) closely resembles day-ahead optimization but the timeframe is constrained after closing of the day-ahead market⁷ and, in general, intraday markets can trade products with finer granularity, closer to real-time. BRPs can use demand-side flexibility available intraday to repair day-ahead forecast errors for intermittent resources.

Self-balancing and passive balancing

Self-balancing is the reduction of portfolio imbalance by the BRP to avoid imbalance charges. The BRP uses demand-side flexibility to optimize the position of its portfolio to lower any (expected) imbalance cost.

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-

⁵ 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.

⁶ Although the CSP is the Trading Counter Party for adequacy services, for hedging typically the Aggregator delivers the flexibility services through the BRP.

⁷ Ex-post nominations are possible in some countries

time data is made available by the TSO so BRPs can predict imbalance prices. This strategy carries risks related to the predictability of the total imbalance and thus the final imbalance prices.

Generation optimization

Generation optimization refers to optimizing the behavior 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 demand-side flexibility.

2.1.2 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. A short description of each of these can be found below.

Voltage control

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

Grid capacity management

Grid capacity management refers to the DSO or TSO using explicit demand-side flexibility to increase its operational efficiency, without any impact on the freedom of dispatch, trade and connect (copper plate principle). This implies that Aggregators (and Prosumers) 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 component 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.

Congestion management

Congestion management (CM) refers to avoiding the overload of system components by reducing peak loads to avoid failure situations caused by overload. 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 than 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 available to TSOs only in most European member states, but may, in the future, be made available to DSOs⁸. Where certain CM regulations allow, the TSO / DSO direct access to demand-side resources (e.g. load curtailment through smart meter infrastructure), several CM mechanisms are more market-oriented so Aggregators are able to participate. In general, CM mechanisms include limitations to the freedom of dispatch, trade and/or connect.

Controlled islanding

Controlled islanding aims to prevent supply interruption in a grid section, caused by faults occurring in any section that feeds into it. Demand-side flexibility can be used to better match demand with local supply.

2.1.3 Balancing

USEF follows the definitions from the Network code on Load-Frequency Control and Reserves⁹ (Entsoe, 2013) for the balancing services Frequency Containment Reserve (FCR), automatic or manual Frequency Restoration Reserve (aFRR / mFRR) and Replacement Reserve (RR). According to the Network Code, balancing services aim to restore system frequency to its nominal frequency of 50 Hz. Demand-side flexibility can be used to offer all four services to the TSO; these services 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 Aggregator¹⁰ is based on availability, and optionally on the activated energy.

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 if 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.

2.1.4 Adequacy

Adequacy services aim to increase security of supply by organizing sufficient long-term peak and non-peak generation capacity. Demand-side flexibility is very suitable for these mechanisms, offering either distributed generation, or sheddable loads, 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.

⁸ For examples of market-based congestion management models for DSOs see the USEF publication *An Introduction to EU market-based congestion management models*.

⁹ https://www.entsoe.eu/fileadmin/user_upload/_library/resources/LCFR/130628-NC_LFCR-Issue1.pdf

¹⁰ In the Network code, the role of Balancing Service Provider (BSP) is used.

Four different Adequacy services are distinguished in the USEF Flex Value Chain:

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 the 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 decentral 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 demand-side flexibility as a 'supply' asset to the capacity market; 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 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 role 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. Demand-side flexibility can be used as a strategic reserve. 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).

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 exchanges¹¹. Demand-side flexibility can be used as an instrument in these hedging products or can be traded as a hedging product itself e.g. a (the BRP of the) Aggregator offers the FRP the opportunity to activate flexibility at a certain price level.

2.2 Implicit demand-side flexibility services

Figure 5 lists services for local (in-home, in-factory) optimization provided by implicit demand-side flexibility which can be offered by an ESCo to the Prosumer. These services include: Time-of-Use (ToU) optimization, control of the maximum load (kW_{max} control), self-balancing services or controlled islanding. These services are only financially viable if there is an (financial) incentive for each type of local optimization.

¹¹ On a futures exchange, parties can settle a price to be paid later in time e.g. six months.

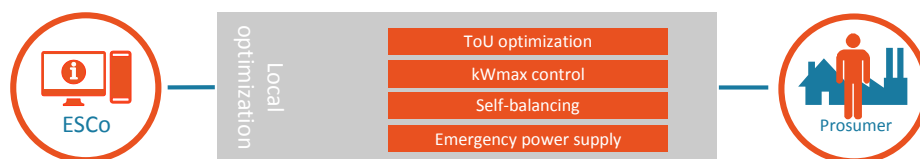


Figure 5 Implicit demand-side flexibility services.

2.2.1 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 the case of generation shifting) or even complete load shedding during periods with high prices. This optimization requires that price schedules are known in advance (e.g. day-ahead). Using demand-side flexibility for ToU optimization will lower the Prosumer's energy bill.

2.2.2 In-home self-balancing

In-home self-balancing is typical for Prosumers who also generate electricity (e.g. through PV panels or CHP systems) and/or have options to choose alternative energy carriers (e.g. heat or gas). Value is created through the difference in the prices of buying, generating and selling electricity, including taxation. Note that self-balancing is not meaningful when national regulations allow for administrative balancing of net load and net generation.

2.2.3 KW_{max} control

Control of the maximum load is based on reducing the maximum load (peak shaving) that the Prosumer consumes within a predefined period (e.g., month, year), either through load or generation shifting or shedding. Current grid tariff schemes, especially for Commercial and Industrial (C&I) customers, often include a tariff component that is based on the Prosumer's maximum load (kW_{max}) and/or the connection capacity. Using demand-side flexibility to reduce the maximum load can reduce the tariff costs for the Prosumer.

2.2.4 Emergency power supply

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

3 Remuneration of flexibility services

Section 2 shows that the Aggregator can provide various explicit demand-side flexibility services, which can serve the different needs of the Flexibility Requesting Parties (FRPs). This section introduces elements to describe how the FRP remunerates the Aggregator for providing these services.

The FRP can remunerate the Aggregator based on the performance of the Aggregator during the availability or activation period in various ways:

- **Energy volume remuneration.**
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 flexibility volume, the baseline methodologies should also be compared as different products generally use different baseline methodologies, meaning that the same activation may result in different activated volumes for different products.
- **Power performance remuneration.**
Power performance remuneration concerns any element in the remuneration that is dependent on the delivered power (kW) according to a baseline.
- **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.

Energy volume remuneration and power performance remuneration are paid per activation; availability remuneration and assessment of delivery requirements compliance are paid per contract period.

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 services providers, i.e. Aggregators, and FRPs.

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

Failure by the Aggregator to comply to delivery requirements, or sufficient quality of the baseline, can result in penalties or disqualification of service delivery.

The business case for the Aggregator depends not only on the abovementioned remuneration elements but also on the costs related to the delivery of flexibility e.g. the cost of reservation of availability, the cost of activating flexibility and opportunity costs i.e. missing benefits when choosing the specific service delivery over other alternative services. Costs related to activation are borne by the Prosumer and are typically remunerated by the Aggregator.

4 Characteristics of flexibility delivery

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 distinct to flexibility delivery type. The characterization of the flexibility delivery supports comparison of flexibility services and provides insight into the settlement relationships between Aggregator and FRP and between Aggregator and other parties.

Figure 6 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 service window. Availability is typically expressed in power (MW). The *activation* of flexibility refers to the actual control of assets to deliver flexibility. Activation is typically expressed in energy (MWh). Availability typically leads to activation. Therefore, in flexibility services focusing on availability, the activation delivery (characteristics and remuneration) is also specified, as are the terms and conditions for activating.

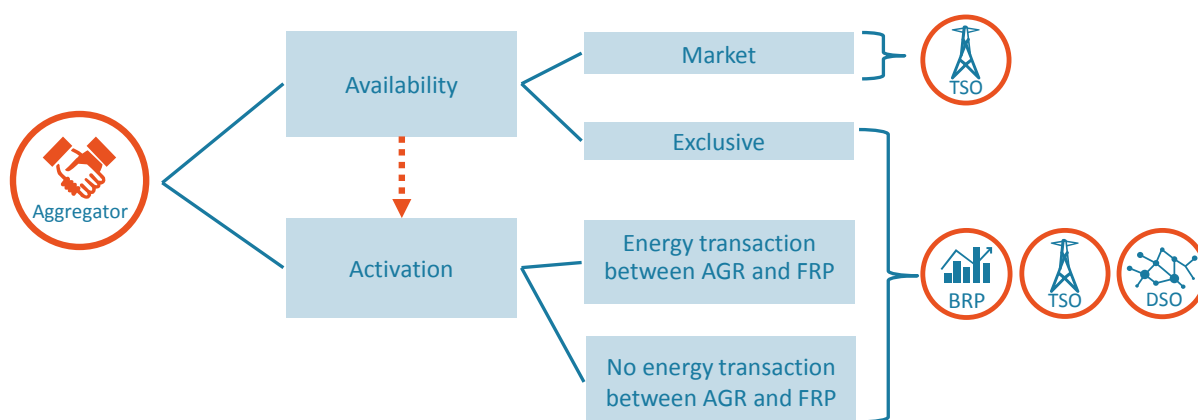


Figure 6 Characteristics of flexibility delivery.

An FRP can require availability in two different flavors:

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

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 that the Aggregator reserves the capacity for activation by the FRP.

Availability may be verified by correct 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. As described in section 3, availability can be remunerated separately from activation.

Also the activation can occur in two ways:

- 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 volume¹².
- 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 for 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 his preferred way. The Aggregator can either register another trade, with an energy transaction to settle the energy; activate other assets in his portfolio as a countermeasure; or can accept the 'imbalance'. In practice, the latter means that the Aggregator's BRP (dual BRP models) or Supplier (single BRP models) manages the effect of flexibility activation in his portfolio.

4.1 Drop-by and drop-to services

The concept of *drop-by* and *drop-to* services relate to the delivery type classification presented in this section and the remuneration elements presented in Section 3.

- *Drop-by services* are defined as services for which the Aggregator is remunerated by the FRP for a decrease or increase in load / generation according to a baseline with the requested volume in MWh.
- *Drop-to services* are defined as services for which the Aggregator is remunerated by the FRP for the availability and required activations to keep the (aggregated) load or generation below or above a limit. An example of such a drop-to service can be found in the proposed/considered quota system for congestion management in Germany.

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 proper remuneration the 'normal' power level may be determined, which is very similar to a baseline. This notion of the power level is important to compare the bids of different Aggregators.
- During activation, the FRP may still decide to remunerate based on activated flexibility volume and so will need a baseline to calculate this volume.
- In situations with a dual-BRP Aggregation Implementation Model (AIM)¹³, activations lead to a *Transfer of Energy*. Even when a baseline is not needed to determine the energy transaction volume, a baseline for the Transfer of Energy must still be defined.

¹² 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 redispatch.

¹³ See USEF publication *Recommended practices for DR market design* (2017).

5 Concluding remarks

In this white paper we showed that flexibility can be deployed for multiple purposes and used to serve a variety of customers and markets. USEF's flexibility value chain provides a complete overview of customer needs for flexibility, and the associated markets and products in which demand-side flexibility can potentially create value. We identified explicit flexibility services that an Aggregator can offer to the DSO, TSO and BRP, classified into 4 groups. We also identified services for local (in-home / in-factory) optimization provided by implicit demand-side flexibility which can be offered to the Prosumer by an EScO.

To support comparison of flexibility services, different remuneration and flexibility delivery types were discussed. How the Aggregator is remunerated by the FRP for the service delivery can differ per flexibility service type. In Section 3 different remuneration elements were discussed. It is important to distinguish between the *availability* of flexibility - where the Aggregator ensures that enough flexibility is available to the FRP within the specified service window - and the *activation* of flexibility - the actual control of assets to deliver flexibility. The remuneration elements introduced in Section 3 each correspond to either the availability or activation.

In section 4, we further dissected availability and activation. A key question during activation is whether there is an energy transaction between Aggregator and FRP. For wholesale services this is the case by nature; for other service classes this is not always necessary. However, whenever flexibility is activated, there is always an energy volume involved which can be handled by the aggregator in various ways.

Finally, we discussed the need for baselines and made special reference to *drop-by* and *drop-to services*. Drop-to services do not require a baseline to quantify the delivery, however a baseline might be needed for other reasons, e.g. for the transfer of energy.

We hope that the concepts introduced in this paper can act as a guideline for the development and harmonization of flexibility services in the EU.

About the USEF Foundation

To accelerate the transition to a commercially viable smart energy system, USEF Foundation has developed basics for a unified smart energy market, connecting projects and technologies at the lowest cost. With a value-to-all approach, USEF enables the commoditisation and trading of flexible energy use. The framework defines the market structure, stakeholder roles, how they interact and how they benefit by doing so.

Founded by key players active across the smart energy chain, USEF partners ABB, Alliander, DNV GL, IBM, ICT Group and Stedin work together to effectively address the challenges of one integrated system which benefits new and traditional energy companies as well as consumers. USEF's work has been incorporated in national and international policy proposals and the framework has been implemented in different smart energy projects across Europe.

More information can be obtained at www.usef.energy

About the USEF framework

USEF provides:

- Common terminology
- Framework for explicit demand side flexibility, with a main focus on
- Roles & responsibilities
- Market coordination of flexibility
- Standardized market processes and information exchange
- Measurement, validation and settlement
- Facilitation of different Aggregator Implementation Models, incl. Independent aggregation
- Product design, with a focus on DSO grid capacity management
- Exchanging Exchange of experiences and best practices through USEF's user community
- Exchange on product design, business cases, implementation aspects, etc.
- Capture of best practices in future releases of the framework.