

Flexibility Value Stacking

Recommended processes, rules and interactions to enable value stacking for portfolios of flexible demand-side resources.



A solid foundation for smart energy futures

USEF White paper: Flexibility Value Stacking

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Abbreviations

AGR	Aggregator
ARP	Allocation Responsible Party
BRP	Balance Responsible Party
BSP	Balance Service Provider
CMSP	Constraint Management Service Provider
CSP	Capacity Service Provider
DA	Day-ahead
DR	Demand Response
FRP	Flexibility Requesting Party
FVC	Flexibility Value Chain
ISP	Imbalance Settlement Period
ТоЕ	Transfer of Energy
USEF	Universal Smart Energy Framework

1 Introduction

1.1 Background

The rise of renewables and general shift towards electrification are dictating the need for *demand-side flexibility*. By offering demand-side flexibility, Prosumers could be rewarded for deciding that part of their energy use is either not critical or not time dependent. The Universal Smart Energy Framework (USEF) describes a standard for unlocking the value of energy flexibility by making it a tradeable commodity and delivering the market structure, associated processes and rules required to make the trading of flexibility effective.

USEF is designed to enable *explicit demand response i.e.* demand-side flexibility directly exposed to *Flexibility Requesting Parties* through bilateral trading or electricity (balancing) markets, thereby offering fair market access and benefits to all stakeholders. In general, explicit demand response can co-exist with *implicit demand response* resulting from time-varying electricity supply and/or network tariffs.

USEF's Aggregator role unlocks and maximizes the value of demand-side flexibility by establishing a contract with the end-user (Prosumer) which describes terms and conditions related to use of his flexibility. By aggregating flexibility and offering flexibility services to different markets and market players, the Aggregator creates value from flexibility; this value can be shared with the Prosumer as an incentive to shift, reduce or enhance his load or generation. The range of services an Aggregator can offer are described in the USEF *Flexibility Value Chain* shown in Figure 1-1. Further information on the type of services that can be offered to the DSO, TSO and flex requesting Balance Responsible Parties (BRPs) can be found in [1].

To increase the value of demand-side flexibility, Aggregators must be able to undertake *value stacking* i.e. provide multiple services to one or multiple FRPs from the same portfolio. Different value stacking types can be distinguished as follows:

- 1 *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.
- 2 *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.
- 3 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:
 - a. 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).
 - b. 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. The corresponding energy transactions take place on both the wholesale market (40% of flexibility) and with the TSO (60% of the flexibility).

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. Additional information exchange is also required between the stakeholders involved to ensure that flexibility is not double counted.

In European countries, double serving is not yet allowed in most flexibility service combinations. However, enabling the Aggregator to provide multiple services during the same time period using one asset, pool or portfolio will bring economic benefits to all involved stakeholders (Prosumers, Aggregators and FRPs) and maximize the deployment of flexible assets – likely bringing down the costs of flexibility.

Double serving with multiple energy transactions will require regulatory and implementation rules. The concept is included in this paper because we believe it has potential to accelerate the development of effective demand-side flexibility use. A comprehensive method for the correct allocation of the activated volumes to the right market/product is therefore provided; this should help to answer questions about the right arrangement for this type of value stacking and which processes, rules and interactions are required. Examples provided address the delivery of multiple services, using the same unit (i.e. flexible asset), in the same time period; these demonstrate that it is possible to distinguish and quantify the individually stacked services used for value stacking.



Figure 1-1: USEF Flexibility Value Chain (FVC), showing the different explicit demand-side flexibility services types [1]. In the USEF role model the Aggregator delivers the flexibility directly to the Flex Requesting Parties (right side of the figure), however seen form the perspective of the FRP, the Aggregator may act as or through a role dedicated to the delivery of the flexibility service. For example, the role of BRP, Constraint Management Service Provider (CMSP), Capacity Service Provider (CSP) or Balance Service Provider (BSP).

1.2 Reading guideline

To address the concept of value stacking this paper is structured as follows:

- Chapter 2 introduces the design principles used to define the market model, stakeholders' responsibilities and key
 interactions for the trading of flexibility and stacking of services.
- Chapter 3 introduces examples of the delivery of three energy products to three distinct FPRs, using the same flexible unit in the same time period. The examples cover the delivery of: (1) a wholesale service, (2) a constraint management service, and (3) a balancing service.

This position paper builds upon the *Flexibility Value Chain* [1] USEF white paper as well as the USEF reports: *The Framework Explained* [2], and the *Workstream on Aggregator Implementation Models* [3]. The Flexibility Value Chain describes in detail the different services an Aggregator can offer. The Framework Explained covers the key components of USEF including the USEF role model, market coordination mechanism and operating regimes. The Workstream on Aggregator Implementation Models (AIMs) describes the different Aggregation Implementation Models classified by USEF; these include models for *independent aggregation* i.e. where a contractual relationship between the Aggregator and Supplier (of the Prosumer) is not required. To support stand-alone reading of this paper, the USEF roles model can also be found in Appendix 1.

2 Design principles for value stacking

This chapter describes the design principles used to define the USEF market model, stakeholders' responsibilities and key interactions for the delivery of (multiple) services with energy transactions through the use of (independent) aggregation.

The design principles related to the separation of energy and flexibility are introduced first. The (reasoning behind the) design principles that descend from the need to distinguish and quantify individual stacked services are then introduced. Finally, descriptions of the proposed order for flexibility quantification and information exchange for value stacking are provided. The reasoning behind the ordering of flexibility quantification processes is explained; this is based on the nature of products and baseline methodologies typically applied.

2.1 Separation of energy and flexibility

Within USEF there is a clear distinction between the energy supply chain and the flexibility supply chain. However, separating flexibility from energy is not straightforward because activation of flexibility leads to a deviation from the 'normal' energy consumption or generation pattern of the Prosumer and this, in turn, affects the amount of consumed/delivered energy. Consequently, the Supplier, supplying energy to the consumer, and the Balance Responsible Party (BRP), who holds balance responsibility for the supplied energy, are both affected. *Transfer of Energy* (ToE) can be used to allow the Aggregator (AGR) to source the energy that he intends to sell, and to neutralize the energy position of the Supplier and the balancing position of its BRP from the impact of Demand Response (DR) activation by the AGR.

There are three USEF design principles based on the separation of flexibility from underlying energy supply [3]:

- 1 The AGR responsibility is independent from the responsibility of supplying energy to the Prosumer.
- 2 The balance responsibility of the AGR (and his BRP) is restricted to:
 - a. the activation periods
 - b. assets (flexibility resources) that are activated¹
 - c. the deviation from the *baseline*, of each activated asset, with the baseline describing what would have been the load/generation profile without DR activation.
- 3 The effects of the DR activation for the Supplier and its BRP (BRPsup) should be properly compensated. Depending on the Aggregator Implementation Model, ToE from the (BRP of the) Supplier to the (BRP of the) AGR, might be required for this compensation to:
 - a. restore the balancing position of the BRPsup, and
 - b. ensure the Supplier is remunerated for the energy it has sourced but not sold (in case of load reduction/ generation enhancement). In case of load enhancement/generation reduction ToE is reversed.

As stated in *point 3* above, if and how ToE is arranged differs per Aggregator Implementation Model (AIM). The different AIMs classified by the USEF Aggregator Workstream [3] are shown in Figure 2-1. If ToE needs to be arranged for *independent aggregation* (no contract between the AGR and Supplier), the Allocation Responsible Party (ARP) is presumed to play a central role in the process. For example, in the *corrected model* the open supply and balancing position of the Supplier (and its BRP) are corrected via an administrative meter correction of the Prosumer's meter, while the balancing position of the BRP_{agr} is corrected by the ARP via a *perimeter correction*². In case of the *central settlement* and *net-benefit model*, ToE is arranged by the ARP via

¹ With the exception that an AGR may choose to take full responsibility for its pool, see also Rec. 704 in USEF Aggregator Workstream [1].

² A perimeter correction is an adjustment of the imbalance volume, typically performed by the ARP role.

perimeter corrections of both the balancing positions of both the BRP_{sup} and BRP_{agr}. Once the ToE is arranged, the ARP can perform the imbalance settlement process in the same way it would for situations without (independent) aggregation.

	CONTRACT between aggregator and supplier	NO CONTRACT between aggregator and supplier
SINGLE BRP	I Integrated	I Uncorrected
DUAL BRP	Contractual	I Orrected I I Central settlement

Figure 2-1: Seven Aggregation Implementation Models classified in the USEF Aggregator Workstream [3].

2.2 Stacking of services

To increase the value of demand-side flexibility, the following design principles are introduced to account for value stacking:

- Pooling is allowed: services can be delivered from a portfolio rather than a single unit.
- Dynamic pooling is allowed: the AGR can decide which resources are used for a certain service up to real-time.
- Double serving is allowed (if permitted by the specific service(s)/product(s)): the same portfolio or unit can be used to
 provide multiple service to one or more Flex Requesting Parties (FRPs) during the same Imbalance Settlement Period
 (ISP).
- It should be possible to distinct and quantify individually stacked services without *double counting* the activated flexibility.
- Activations of a single unit can be both the same as, or in opposite directions during the same one ISP.

As previously stated, the focus of this paper is the development of a comprehensive method for correct allocation of activated volumes to the right market/product where value stacking is based on *double serving with multiple energy transactions*, thereby enabling double serving of all flexibility service types (Figure 1-1). However, in practice the value stacking opportunities for the AGR can be limited. For example, FRPs can restrict the AGR in various ways³ e.g. based on agreements in bilateral contracts and/or service/product specifications. A typical example of such a restriction could be that the DSO could restrict the AGR from selling other products in opposite directions when buying a constraint management service or product; this would allow the DSO to prevent value stacking that would lead to (additional) congestion. In addition, it is highly likely that there will be close coordination between the TSOs and DSOs in future, to prevent any negative effects of (local) constraint management services on the systems, and vice versa.

TSO-DSO coordination mechanisms of this type remain outside the scope of this paper. More information on this topic can, amongst others, be found in [4]. Regardless of the coordination mechanism in place, the need to measure, calculate and allocate the activated flexibility to the relevant market parties remains. The latter is also stressed in [4].

The USEF Flexibility Value Chain paper [1] distinguishes between the *availability* and *activation* of flexibility. Availability refers to the amount of flexibility capacity (MW) available for activation by the FRP if required. Activation refers to the control of assets to deliver the flexibility to the FRP. The need to distinguish and quantify individually stacked services without double counting the activated flexibility is therefore limited to the activation of flexibility. As a result, the focus of this paper is on wholesale, constraint management and balancing services (as defined in [1]). Adequacy services are, by definition, services with availability delivery that can lead to an obligation for activation delivery on a wholesale market or of a balancing or constraint management

³ Note that introducing restrictions will typically result in a flexibility price increase.

service. More information on these and other characteristics of flexibility services (Figure 1-1) can be found in the USEF Flexibility Value Chain paper [1].

2.3 Flex quantification order to avoid double counting

Typically, the baseline for an individual product describes what the load/generation profile would have been without the DR activation specific to that service/product. However, when an AGR sells multiple energy products to different FRPs (during the same time period), the difference between baseline and measurements can include the effect of multiple (stacked) DR activations. Naturally, this depends on the baseline methodology and the baseline quality of each service/product. Baseline methodologies are typically defined by the FRPs⁴, except for wholesale markets where there is no requirement to quantify the delivered flexibility because it is implicit in the BRPs' portfolios. However, a baseline is required for products sold on the wholesale market which need a corresponding ToE. This baseline methodology for wholesale markets is presumed to be defined by the central authority⁵.

To avoid double counting in the flexibility quantification processes, additional information should be exchanged between the different stakeholders involved. The ARP is presumed to play a central role in the exchange of additional information required for value stacking because its central role in the imbalance settlement and ToE processes means that it already has (most of) the information available.

Based on the baseline methodologies for the different flexibility services types, it is assumed that typically the baseline for *wholesale services* will be set first, followed by the baseline for *constraint management services* and then *balancing services*. This order is based on the expected timing of selling the products: wholesale services are expected to be sold dayahead/intraday; constraint management services are expected to be sold after gate-closure time and publishing of the nominations; and balancing products are expected to be sold and activated (close-to) real-time. Selling (and consequently setting the baselines for) products in this order is also in-line with: (1) the recommendations and considerations for baseline methodologies for *wholesale services* in the USEF Aggregator Workstream [3]; (2) the baseline methodology for *constraint management services* based on D-prognosis (USEF The Framework Explained [2]); and (3) common practices and recommendations for baseline methodologies for *balancing services* in the USEF Aggregator Workstream [3].

Based on this order and baseline methodologies, the baseline for *balancing services* typically includes the (planned) activations for *constraint management services* and *wholesale trading*. In other words, the difference between the baseline and measurements for *balancing services* will only contain the DR volume activated for those services specifically. For *constraint management services*, the difference between the baseline and measurements will contain the DR volume activated for both *balancing services* and *constraint management services*. Finally, the difference between the baseline and measurements for *wholesale services* typically includes the effect of all three service types, as this baseline was set first, before the order and activation of all other products and services. Based on these conclusions, the proposed order of flexibility quantification and information exchange is as follows (see also Figure 2-2):

Where double serving with balancing products occurs, the TSO is first in line with flexibility quantification. Due to the nature of products and near real-time activations, the baseline for TSO services typically includes the effects of all other planned DR activations (e.g. constraint management services for the DSO and/or wholesale services to other BRPs). Subsequently, the TSO informs the ARP on the quantified DR volume. This information is needed for a variety of reasons:

• The ARP typically performs a perimeter correction for the delivery of balancing services based on either the requested or delivered DR volume.

⁴ See recommendation 202 in the USEF Aggregator Workstream [3].

⁵ See recommendation 203 in the USEF Aggregator Workstream [3], which amongst others states: *since there is not a single buyer in wholesale markets, the baseline methodology needs to be defined by a central authority. In wholesale markets there is no need to quantify the delivered flexibility, because this is implicit in the portfolio of the BRPs. The baseline methodology is therefore only used to quantify the ToE. This only needs to be regulated for the Corrected, Central Settlement and Net Benefit models.*

- Where independent aggregation requires ToE, the ARP needs the quantified volume for the ToE process.
- Additionally, the ARP can use this information to avoid double counting in a double serving scenario.
- Where double serving with constraint management products occurs, the DSO⁶ is second in line with flexibility quantification. Where value stacking of both balancing and constraint management services occurs, the DSO will be informed by the ARP about the quantified DR volume delivered to the TSO. The near real-time notifications for the activation of balancing services make it likely that the baseline retrieved by the DSO did not include the effect of balancing services delivery and so it needs to correct the quantified volume (baseline measurements) based on the amount of flexibility delivered to the TSO. The remaining deviation will be labeled as the DR volume activated for constraint management services⁷. Subsequently, the DSO will inform the ARP of the delivered DR volume; this information is needed for the following reasons:
 - Where independent aggregation requires ToE, the ARP needs the quantified volume for the ToE process.
 - Additionally, the ARP is presumed to use this information to avoid double counting in a double serving scenario.
- The delivery of wholesale services is quantified last by the ARP. Where wholesale services are sold via wholesale markets, flexibility quantification is required for the ToE. To validate the DR volume activated for the delivery of wholesale services, the ARP should request a baseline that excludes the effect of all other planned DR activations. As the ARP is informed by the TSO and DSO on the DR volumes activated for the services delivered to both parties, the ARP can correct the total quantified volume (baseline measurements) based on those volumes, thereby identifying the DR volume activated solely for the delivery of wholesale services.



Figure 2-2: illustration of the required information exchange between the different stakeholders involved to avoid double counting in case of value stacking of TSO, DSO and wholesale services (traded via wholesale markets).

⁶ Or TSO in case the resource is participating in a TSO constraint management service.

⁷ Typically, the AGR trades with the DSO after wholesale trades are made and so the baseline used includes the effects of wholesale trades. Where it is the other way around, the DSO could allow the AGR to make baseline modifications resulting from wholesale trading. Also see the USEF Framework [2] for the process of updating the D-prognosis. Allowing for baseline updates due to wholesale trading also favors the DSO, as the DSO wants its forecasts of congested areas to be as accurate as possible.

3 Value stacking examples

This chapter delivers and solves value stacking examples. It examines the main interactions required for trading, validation of product delivery and settlement, of each individual stacked service where double serving with multiple energy transactions occurs. Two examples are introduced followed by the key interactions; these are also illustrated. The examples are then solved, with concluding remarks provided in the chapter's final section.

3.1 Introduction to the value stacking examples

To explain how value stacking can be arranged, the following examples will be solved:

During a specific ISP, a single flexible unit is used by the AGR to deliver:

- 1 *a wholesale service* + *a balancing service*. The AGR will trade and activate flexibility on the day-ahead market (energy product delivery to BRP_{req}) and subsequently on the balancing market (aFRR product delivery to the TSO). This first example will cover two situations:
 - a. a situation where both products are delivered according to their offers, and
 - b. a situation where there was a partial product delivery (for the aFRR product).
- 2 a wholesale service + a constraint management service + a balancing service. The AGR will trade and activate flexibility on the day-ahead market (energy product delivery to BRP_{req}). Subsequently, the AGR also trades and delivers a congestion management product to the DSO (based on bilateral trading between the AGR and DSO). And, finally the AGR also trades and activates flexibility on the balancing market (aFRR product delivery to the TSO).

The examples will show that it is possible to distinguish and quantify individual stacked services to enable the AGR to perform value stacking, while avoiding double counting by the FRPs involved. Note that for the sake of simplicity, the examples are worked-out on unit-level. USEF does allow for flexibility to be delivered from a portfolio rather than a single unit/resource and assumes that markets and products allow pooling. In the final section of this chapter, the main difference in interactions between product delivery from a portfolio or pool and delivery from unit will be briefly discussed.

3.2 Key interactions for service/product delivery

To explain and illustrate the value stacking process, the focus is on the following interactions between the stakeholders: (1) (contract and) offer, (2) activation, (3) product settlement (based on flexibility quantification by the FRP), and (4) information exchange on product delivery for imbalance settlement and/or ToE (only relevant for dual-BRP models). Evidently, in practice more interactions are required between the stakeholders involved. However, to be able to zoom into the key interactions for value stacking, the current focus is on the above-mentioned interactions.

Figure 3-1 illustrates how the previously mentioned interactions (1)-(4) typically look in an aFRR product delivery where an (independent) AGR delivers the product. At the top and bottom, the figure distinguishes different FRPs. The bottom left and right show the system operators (i.e. the TSO and DSO, respectively) which, as shown in the Flexibility Value Chain in Figure 1-1, are the FRPs for *balancing* and *constraint management services*. The top shows suppliers, traders and BRPs which are FRPs for wholesale services. The latter parties can be served bilaterally or via an Exchange. In the middle of the figure (left to right), the roles of the Supplier and its BRP (connected to the Prosumer involved), the AGR (and its BRP), and the Prosumer involved, with its flexible assets (Active Demand & Supply - ADS) are shown. Next to the figure, the interactions between the different stakeholders required to effectively trade an aFRR product are specified. The color of the text corresponds to the color of the terms used in the next paragraph which explains these interactions in more detail.

The AGR (in the role of BSP⁸) delivers the aFRR product by controlling the flexible unit(s) at the Prosumer. Based on a contractual agreement (between the AGR and TSO), the AGR is allowed to make an (1) offer into the aFRR market⁹. In this example, this offer is then activated by the TSO. To be able to quantify product delivery, the TSO requires a (2) baseline as well as (3) measurements. Both the (input for) the baseline and the measurements are sent by the AGR to the TSO¹⁰. When the TSO concludes validation of the product delivery, it (4) settles with the AGR. Finally, the Allocation Responsible Party (ARP) is (5) informed about the amount of energy requested¹¹, so the ARP can perform a *perimeter correction*, meaning the ARP will adjust the imbalance volume of the BRP based on the volume communicated by the TSO. The imbalance settlement process is based on the (6) nominations¹² and (7) measurements of all BRP(s). The latter measurements are validated measurements sent by the TSO of the amount of energy activated by the AGR. How the ToE process is arranged differs per Aggregation Implementation Model (Figure 2-1).



Figure 3-1: Example of the key interactions required for the delivery of an aFRR product by an AGR. The AGR activates the flexible assets to provide the balancing energy it sold to the TSO and makes sure the required (input for the) baseline and measurements are sent. The TSO informs the ARP, which performs an (ex-post) perimeter correction based on the (balancing) energy requested. Imbalance due to partial delivery is handled as all other imbalance in the BRPs' portfolios.

The next section provides examples of value stacking (based on double serving with multiple energy transactions) and shows the interactions between AGR and the three FRPs (TSO, DSO and BRP_{req} via the Exchange), including the interactions required for trading, flexibility quantification (baselines and measurements) and settlement. Additional information must be exchanged amongst the different parties to enable individual product validation and avoid double counting. The information exchange is

⁸ In the USEF role model flexibility is delivered directly from the AGR, or other Flexibility Service Providers (FSPs), to the FRP. However, seen from the perspective of the FRP, the market party delivering the flexibility may need to combine its role with a role dedicated to the delivery of the flexibility service (or outsource this). For example, when an AGR delivers a balancing service to the TSO, it needs to combine its role with a Balancing Service Provider.

⁹ Typically, this offer will automatically appear as an option in the TSO's single buyer market, depending on the price of the offer and the required balancing volume, the offer may or may not be activated by the TSO.

¹⁰ Rec. 215 in the USEF Aggregator Workstream [3] elaborates on the baseline methodology for this type of product.

¹¹ Typically, the requested energy instead of the activated energy is used for the perimeter correction. This means that under- and overshooting will result in imbalance. See also Rec. 707 in the USEF Aggregator Workstream [3].

¹² The nomination, used for the imbalance settlement process, is typically on portfolio level and concerns the sum of all planned energy transactions. In the Netherlands this nomination is referred to as the *e-program*, which needs to be submitted day-ahead to the TSO (in the role of ARP).

handled via the ARP, in its role of facilitating the process of value stacking. Note that the interactions described account for all dual-BRP models. In single-BRP models, certain interactions or information exchanges that involve the BRP_{agr} are either covered by the BRP_{sup} or are redundant. The latter is also the case for all interactions related to the ToE process, as ToE is not required for single-BRP models.

3.3 Two examples of value stacking

3.3.1 First example: trading and activation of flexibility on the day-ahead market and balancing market



- The nomination should be on unit level
- Baseline must be frozen before market clearing

¹³ See also consideration 208 in USEF Aggregator Workstream [3], which amongst others states that the DA trading baseline should be based on:

⁻ Nomination by the AGR/BSP per ISP (limited to the ISPs that are included in the offer)

¹⁴ See also recommendation 203 in USEF Aggregator Workstream [3].





¹⁵ In addition, there can be a single-sided nomination for the ex-ante ToE between the BRP_{agr} and BRP_{sup}. This is based on notification by the BRP_{agr} that the offer concerns DR activations coming from specified assets in the BRP_{sup}'s portfolio.

¹⁶ In practice nominations are portfolio based.

¹⁷ See also rec. 205 in USEF Aggregator Workstream [3] for additional information on the baseline methodology for FRR products.

Step 3a: Flex quantification and (imbalance) settlement (full delivery of both services)



Next, all measurements required for product validation are sent to the involved stakeholders to enable flexibility quantification and settlement.

(1) The TSO receives the required measurements from the AGR, and quantifies and settles the delivered flexibility for the aFRR product based on: *EneravDelivered TSO = Baseline TSO – measurements*



(2) **f** The AGR is remunerated by the TSO according to the product contract. In this example, the *EnergyDelivered TSO* equals the *aFRR* offer, meaning that the flex is fully remunerated. Overshoot or partly delivered flex can result in a fine (as well as imbalance).

(3) ● The TSO communicates the requested energy (*aFRR offer*) as well as the quantified volume, i.e. *EnergyDelivered TSO*, to the ARP. The requested energy is typically used by the ARP to perform a perimeter correction on the imbalance volume of BRP_{agr}. Additionaly, the delivered energy will be used by the ARP for the ToE.

(4) Based on the measurements received from the MDC, the ARP quantifies the energy delivered to the DA market (*EnergyDelivered DA*). The *EnergyDelivered TSO* is taken into account during this quantification process: *EnergyDelivered DA* = *Baseline DA* + *EnergyDelivered TSO* – *measurements*



(5) **F** In dual-BRP models, the *EnergyDelivered DA* + *EnergyDelivered TSO* is used for the ToE. In this example there is no imbalance (0 MWh) as the *Nomination* = *EnergyDelivered DA*. The imbalance due to the delivery of *EnergyDelivered TSO* is corrected via a perimeter correction perfomed by the ARP. In this example, the aFRR product is delivered according to the offer, meaning there is no remaining imbalance for BRP_{agr}. The ARP settles the imbalances with all BRPs.



(5)	In dual-BRP models, the <i>EnergyDelivered DA</i> +
Ener	ergyDelivered TSO is used for the ToE. In this example there is no
imb	balance due to wholesale trading as the <i>Nomination</i> =
Ener	ergyDelivered DA. The imbalance due to the (partial) delivery of the
aFR	<i>RR product</i> is accounted for via the perimeter correction perfomed by
the	e ARP. The requested energy used for the perimeter correction does
not	t equal the energy sourced by the BRP _{agr} , and as a result the BRP _{agr} is
cont	nfronted with an imbalance.

3.3.2 Second example: trading and activation of flexibility on the day-ahead market, the delivery of congestion management service/product to the DSO, and trading and activation of flexibility on the balancing market.







Next, the DSO receives the D-prognosis (forecast) from the AGR stating what the load/generation profile will be in case there is no flexibility order (*FlexOrder*) by the DSO. The DSO uses this forecast to determine whether there is a potential congestion and hence a need for flex trading. Once a trade is made between the AGR and the DSO, the forecast (D-prognosis) is considered to be the baseline for flexibility quantification by the DSO (*Baseline DSO*). The baseline methodology for DSO services/products is defined by the DSO as the purchaser of the flexibility service¹⁸. The use of the D-prognosis as baseline is in line with the USEF 2015 Specifications.

Note that this example is based on an intraday trade between the AGR and DSO and therefore, the baseline includes the effect of the DA trade.

(1) Starting point for flexibility trading between the AGR and the DSO is a forecast (D-prognosis) from the AGR. Based on this forecast, the DSO sends a flexibility request to the AGR (*FlexRequest*). In response, the AGR sends a flexibility offer (*FlexOffer*) which is accepted/ordered by the DSO (*FlexOrder*). In this example, the D-prognosis is in-line with *Baseline DA* + *Nomination*, and the FlexOffer (which is ordered) concerns a load decrease of 5 MW (1.25MWh/15min.) during ISP 1-2.



¹⁸ Rec. 202 in the USEF Aggregator Workstream, amongst others, states: the baseline methodology should be defined by the purchaser of the flexibility service, e.g. the TSO for balancing services and the DSO for congestion management services. The regulator may need to approve this methodology depending on its exact role and responsibility.



¹⁹ Note that this is a design choice: the DSO can also allow for baseline modifications after the offer is accepted.

²⁰ Rec. 804 in USEF Aggregator Workstream, amongst others states: products that aim to solve local problems may require a redispatch mechanism to compensate the effect of the local DR activation on system level. Either the AGR or the DSO/TSO should be responsible for the redispatch.

²¹ If the (BRP of the) AGR is responsible for the redispatch, the ARP should still be informed about the procurement of the DSO service. This is required so the ARP knows it needs to send additional information to the DSO later for value stacking including balancing services. Additionally, the ARP wants to be informed by the DSO on the quantified volume for the DR service so it can arrange the ToE based on the quantified volume.



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Step 4: Flex quantification and (imbalance) settlement (full delivery of all services)



Next, all measurements required for product validation are sent to the involved stakeholders to enable flexibility quantification and settlement.

(1) The TSO receives the required measurements from the AGR and the TSO quantifies and settles the delivered energy for the aFRR product based on:

EnergyDelivered TSO = Baseline TSO – measurements



(2) fin this example, the *EnergyDelivered TSO* equals the *aFRR* offer, hence the flex is (fully) remunerated.

(3) The TSO communicates the requested energy (*aFRR offer*) as well as the *EnergyDelivered TSO* to the ARP. The requested energy is typically used by the ARP to perform a perimeter correction on the imbalance volume of BRP_{agr} . Additionaly, the delivered energy will be used by the ARP for the ToE.

(4) **1** The ARP informs the DSO about the *EnergyDelivered TSO* so the DSO can take this volume into account while peforming flexibility quantification for the validation of the delivery of the congestion management service/product.

(5) The DSO receives the measurements from the MDC and quantifies the the delivery of the DSO product (*ServiceDelivery DSO*), based on: *ServiceDelivery DSO* = *Baseline DSO* + *EnergyDelivered TSO* – *measurements*



Note that the term *ServiceDelivery DSO* is used instead of *EnergyDelivered DSO because* energy is sold, or not sold, to the DSO depending on who is resonsible for the redispatch. In this example an energy transaction between the AGR and DSO took place, hence the DSO is responsible for the redispatch.



3.4 Concluding remarks

The examples provided in the previous section of this chapter show that it is possible to distinguish and quantify individual stacked services where double serving with multiple energy transactions is used. This shows that it is well possible to measure and allocate the activated flexibility to the relevant market parties. Thereby enabling the AGR to perform value stacking, while avoiding double counting of flexibility by the FRPs involved.

The examples are worked-out on unit-level, however USEF does allow for pooling: meaning that services can be delivered from a pool or portfolio rather than a single unit. Where pooling is used, the interactions covered in the examples do not differ but the baselines and (sum of the) measurements required by the FRP can either be based on the portfolio or consist of several individual baselines and measurements from pools, or units, within the portfolio. USEF also allows for dynamic pooling, meaning that the AGR can decide at any point, up to real-time, which resources are used for a certain service. Interactions also don't differ where dynamic pooling is used, however, additional administration is likely required to keep track of the units used for each product. Dynamic pooling baselines will need to be provided on unit-level, amongst others, to prevent gaming.

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The value stacking examples are focused on the key interactions distinguished for the trading, validation and settlement of products. In Appendix 2 of this paper, generic sequence diagrams are provided which cover all the interactions required for effective trading. The diagrams include service delivery to either a single, or multiple, FRPs.

In conclusion, this paper provides a solution for the arrangement of value stacking. Its focus is on *double serving with multiple energy* transactions, as this value stacking type is considered the most complex. The key interactions required between the stakeholders involved are described and two examples calculated. These provide a comprehensive method for correct allocation of activated volumes to the relevant market parties. Enabling value stacking is important for increasing the value of demand-side flexibility and, thereby, facilitating the energy transition in the most efficient way. To allow value stacking in practice, the interactions between the different stakeholders involved should be standardized. The key interactions described in this paper, and the USEF Framework in general, can provide a solid basis for this standardization effort. USEF therefore invites all major stakeholders to participate in its work to help create this standard, in order to accelerate the development of effective use of demand-side flexibility.

Appendix 1 The USEF roles model

This appendix describes the different roles distinguished in the USEF roles model. Note that in practice roles can be combined by a single market party. For example, the DSO can also take the role as MDC and the TSO can also take the role as ARP.



A Prosumer can be regarded as an end-user that no longer only consumes energy, but also produces energy. USEF does not distinguish between residential end-users, small and medium-sized enterprises, or industrial users; they are all referred to as Prosumers. In this text we also use the term Prosumer for end-users that have controllable assets (Active Demand & Supply) and are thereby capable of offering flexibility.



In USEF, Active Demand & Supply (ADS) represents all types of systems that either demand or supply energy which can be actively controlled. This enables the ADS device to respond to price and other signals from the Aggregator and to provide flexibility to the energy markets via the Aggregator. The Prosumer owns the device and defers responsibility for controlling its flexibility to the Aggregator. The Prosumer has final control over its assets, which means the Aggregator's control space is limited by the Prosumer's comfort settings. Hence the Prosumer is always in control of its comfort level; if the associated remuneration is high enough however, the Prosumer might be willing to compromise on its comfort levels. In this context we also use the terms units, assets or resources when referring to ADS.



The role of the Aggregator is to accumulate flexibility from Prosumers and their Active Demand & Supply and sell it to the BRP or Supplier, the DSO, or (through the BSP) to the TSO. The Aggregator's goal is to maximize the value of that flexibility by providing it to the service defined in the USEF Flexibility Value Chain that has the most urgent need (or value) for it. The Aggregator must cancel out the uncertainties of non-delivery from a single Prosumer so that the flexibility provided to the market can be guaranteed. This prevents Prosumers from being exposed to the risks involved in participating in the flexibility markets. The Aggregator is also responsible for the invoicing process associated with the delivery of flexibility. The Aggregator and its Prosumers agree on commercial terms and conditions for the procurement and control of flexibility.

The role of the Supplier is to supply energy, to buy the energy, hedge its position on all timeframes, manage the energy and



the associated risks, and invoice energy to its customers. The Supplier and its customers agree on commercial terms for the supply and procurement of energy. A Supplier is a specialization of the Trader role as it exchanges energy with Prosumers as well.



A Balance Responsible Party (BRP) is responsible for actively balancing supply and demand for its portfolio of Producers, Suppliers, traders, Aggregators, and Prosumers, with the means granted by those actors. In principle, everyone connected to the grid is responsible for his individual balance position and hence must ensure that at each imbalance settlement period (ISP), the exact amount of energy consumed is somehow sourced in the system, or vice versa in case of energy production. The Prosumer's balance responsibility is generally transferred to the BRP and this is usually contracted by the Supplier. Hence, the BRP holds the imbalance risk for each connection in its portfolio of Prosumers.



The DSO is responsible for the active management of the distribution grid and introduces the system operation services defined in the USEF Flexibility Value Chain. The DSO is responsible for the cost-effective distribution of energy while maintaining grid stability in each region. To this end the DSO will 1) check whether DR activation within its network can be safely executed without grid congestion and 2) may purchase flexibility from the Aggregators to execute its system operations tasks.



The role of the Transmission System Operator (TSO) is to transport energy in each region from centralized Producers to dispersed industrial Prosumers and Distribution System Operators over its high-voltage grid. The TSO safeguards the system's long-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.



these tariffs. Unlike the (role of) Aggregator, the ESCo is not active (nor exposed) on wholesale or balancing markets.

Appendix 2 Sequence diagrams

This appendix includes sequence diagrams for the *Plan & Validate, Operate* and *Settle phase* to provide an overview of the (chronologic order) of all interactions defined by USEF that make trading of demand-side flexibility effective. The sequence diagrams are generic, and hence meant to serve all Aggregation Implementation Models [3]. A distinction between the different interactions required for each Transfer of Energy (ToE) method is made in the *Settle phase*. If ToE is not required (in case of single-BRP models), this means that all interactions that involve BRP_{agr} will need to be covered by BRP_{sup}. In addition, the quantification of the activated DR volume for *wholesale services* in the Settle phase is not required, as the flexibility is implicit in the BRP_{sup} portfolio. Finally, all interactions concerning the ToE are not required in single-BRP models.

Note that the sequence diagrams cover all interactions defined within USEF to make the trading of flexibility effective. These include bilateral trading with BRP_{sup} and BRP_{req}, the declaration Congestion Points (CPs) in the Common Reference operated by the Common Reference Operator (CRO), and the distribution of measurements by the Meter Data Company (MDC). Background information on these roles and interactions can be found in USEF: The Framework explained [2].

Plan & Validate



 $^{1}\,$ Bilateral trading in this way is only possible if the roles of ${\rm BRP}_{\rm req}$ and ${\rm BRP}_{\rm sup}$ are combined.

² In addition to the nomination of BRP_{agr}, which concerns the delivery of the wholesale product to the Exchange, there needs to be a single sided ex-ante nomination for the ToE between BRP_{agr} and BRP_{sup}, in order to bring the portfolio of BRP_{agr} in balance.

³ Once a FlexOffer is ordered, the D-prognosis (forecast) is updated to include the effect of the FlexOrder. By deducting the effect of the FlexOrder on the updated D-prognosis, the baseline can be constructed (i.e., load/generation profile without the effect of DR activation for the constraint management product).

⁴ *If the DSO is responsible for the redispatch*: the nomination from BRP_{ap}, concerns the delivery of the requested energy for the constraint management product to the DSO. In addition to this nomination, there needs to be a single sided ex-ante nomination for the ToE between BRP_{ap}, *If the DSO is not responsible for the redispatch*: the ARP needs to be notified by the BRP_{ap}, on the requested energy for the constraint management service for the DSO. In addition to this *notification*, there needs to be a single sided nomination ex-ante for the ToE between BRP_{ap}, and BRP_{sup}, as well as a nomination for the countertrade/redispatch of the constraint management service, to bring the portfolio of BRPagr in balance.

Operate



 1 Bilateral trading in this way is only possible if the roles of ${\rm BRP}_{\rm req}$ and ${\rm BRP}_{\rm sup}$ are combined.

² Once a FlexOffer is ordered, the D-prognosis (forecast) is updated to include the effect of the FlexOrder. By deducting the effect of the FlexOrder on the updated D-prognosis, the baseline can be constructed (i.e., load/generation profile without the effect of DR activation for the constraint management product).

³ If the DSO is responsible for the redispatch: the nomination from BRP_{agr} concerns the delivery of the requested energy for the constraint management product to the DSO. In addition to this nomination, there needs to be a single sided ex-ante nomination for the ToE between BRP_{agr} and BRP_{upp}. If the DSO is not responsible for the redispatch: the ARP needs to be notified by the BRP_{agr} on the requested energy for the constraint management service for the DSO. In addition to this notification, there needs to be a single sided nomination ex-ante for the ToE between BRP_{agr} and BRP_{sup}, as well as a nomination for the countertrade/redispatch of the constraint management service, to bring the portfolio of BRPagr in balance.

⁴ See also Rec. 305 in USEF Aggregator Workstream.

Settle **í**ľ BRP_{sup} **∕**₩ €` X Exchange BRP BRP, SUP AGR TSO ARP MD DSO requested meter data1 requested meter data Wholesale/ balancing products [bilateral²] quantify flex settle FlexOrders activated resources requested meter data quantify flex Balancing products settle product delivery inform on balancing product request and quartified flex perimeter correction³ (if required) inform on quantified flex for balancing products requested meter data Constraint management services quantify flex settle FlexOrders inform on CM product/service request and quantified flex activated resources Wholesale products [exchange] quantify flex⁴ inform on product request and quantified flex ToE - perimeter correction (Central Settlement) Transfer of Energy⁵ ToE – ex-post nomination (Contractual Model) ToE – administrative meter correction and perimeter correction (Corrected Model) inform⁶ imbalance settlement compensation

¹ The requested meter data, used as input for the ToE, can also come from the AGR instead of (sub-)meters at the Prosumer site, installed by the MDC. See Rec. 108 in the USEF Aggregator Workstream.

² Bilateral trading in this way is only possible if the roles of BRPreq and BRPsup are combined.

 3 Depending on the Aggregation Implementation Model, perimeter correction can be for BRPsup.

⁴ If required: take into account the delivered flex volume for balancing and constraint management products/services.

 $^{\rm 5}{\rm Transfer}$ of Energy method depends on the Aggregation Implementation Model.

⁶ See also Rec. 303, 304 & 309 in USEF Aggregator Workstream.

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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
 - o 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.