USEF: THE FRAMEWORK SPECIFICATIONS 2015

A solid foundation for smart energy futures

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Revision History

Revision	Comments	Issue Date
2014:I	Release 2014:I for pre-review	25 May 2014
2014:I	Release 2014:I for review board	4 June 2014
2014:I.I	Release 2014:I.I for RI development team[1]	9 October 2014
2014:I.II	Release 2014:I.II for review board and developers	7 January 2015
2015	Initial Public Release	2 November 2015

1. A summary of the changes in the version of USEF is described in [2].

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RELEASE DATE:
2 NOVEMBER 2015
ISBN:
978-90-824625-1-7

The Universal Smart Energy Framework

One common market standard for a European smart energy future.

The Universal Smart Energy Framework (USEF) has been developed to drive a fast, fair and lowest cost route to an integrated smart energy future. By delivering one common standard, it enables cost-efficient connectivity of all smart energy projects and technologies. Its market structure, rules and tools for the commoditization and trading of flexible energy usage work with the different existing energy markets. Those markets become integrated and enabled for flexibility trading by adopting USEF and, in turn, are encouraged to achieve energy delivery and usage at the lowest cost and highest efficiency. Designed to offer fair market access and benefits to all stakeholders, USEF defines their individual roles and responsibilities, how they should interact, and how they can benefit by doing so. As well as reducing the congestion challenges faced by grid operators, it offers commercial opportunities to developers of innovative smart energy projects, products and services, and financial incentives to end-users who are willing to be flexible regarding when they consume energy.

USEF is developed, maintained and audited by the USEF Foundation, a partnership of key players in the smart energy domain consisting of energy suppliers, network operators, electrical equipment manufacturers, consultancies and ICT companies. It was founded by ABB, Alliander, DNV GL, Essent, IBM, ICT and Stedin. The shared experience within the smart energy industry has enabled us to understand both the scope of the opportunity provided by flexibility and the need to join forces across roles and boundaries to realize it. We believe that this is the optimum way to achieve a unified smart energy future that offers benefits to everyone involved.

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1 About the USEF Specifications

USEF provides a modular design for smart energy systems that can be customized to the needs of (future) smart energy projects. It guarantees the interoperability of products and services and it ensures that solutions become repeatable and future proof, thus safeguarding investments in the smart energy future.

USEF provides a minimal set of specifications to secure the essential interoperability between all the components in a smart energy system. At the same time it leaves room for competition between products, services and solutions from different vendors and market parties, stimulating innovation of their products, providing additional value and functionality to the customers.

The USEF foundation acts as the steward of the framework and will continuously update and improve these specifications[2]. Future releases of USEF will be distributed through the USEF website www.usef.energy) and will be accompanied by implementation guidelines that accelerate development of smart energy related business.

1.1. Reading Guideline

The USEF specifications are accompanied by 'USEF: The Framework explained' [1] providing insight into the background, scope and concepts behind USEF. Reading that document is a prerequisite for understanding this USEF specification document.

In "USEF: The Framework explained" the key components of USEF are described:

- The USEF flexibility value chain, describing a generic way to access flexibility for multiple purposes and to serve a variety of stakeholders.
- The USEF roles model, a uniform description of roles and corresponding tasks and responsibilities, which can be implemented in various ways according to the local market and/or business needs.
- The USEF interaction model, describing the interaction between the different roles.
- The USEF market coordination mechanism (MCM), providing all stakeholders with equal access to a single integrated flexibility market, and smoothly aligned with existing processes in the energy market.
- Implementation options for the Aggregator role: the standard aggregator model, the virtual transfer point model and the Flex-only Balance Responsibility model.

USEF follows the principle of privacy & security by design and therefore the specifications are accompanied by a privacy & security guideline [3] that is applicable to the entire design, implementation and operation of USEF and derived products, services and solutions.

"USEF: The Specifications" (this document) builds on top of these key components and the privacy & security guideline. It elaborates on the Market Coordination Mechanism, Wholesale Processes, which serve as prerequisite for USEF, and Grid Operations.

The specifications consist of two main parts:

I) Informative description. The informative section describes the entire framework in a more detailed level, compared to [1]:

- Process model - Coherent and consistent process models are provided for USEF its Market-based Coordination Mechanism (Chapter 2) and Grid Operations (Chapter 4).
- A process description, including the specifications and rules that apply to each of these processes, is provided. A motivation for the design is included, wherever assumed desirable.

[2] USEF 2015 is an incremental release of the energy framework and at this point inconsistencies cannot be excluded completely. Please report inconsistencies found to the USEF foundation such that these can be corrected in future releases of USEF.

- Interface descriptions - Interface descriptions (Sections 2.4 and 4.4) are provided for the interactions between roles in the process model. These include a motivation for the specifications and rules that apply to these interfaces.
- Wholesale processes (Chapter 3) – describing preconditions for implementing USEF in the current energy markets. USEF does not include these preconditions in the normative part of the specification, since they affect existing market processes that must be adjusted to include flexibility trading and most likely will differ from country to country depending on the market design, rules and regulations.

II) Normative description. This part provides the norm for implementation of USEF in a correct and unambiguous way. This part contains:

- Use case descriptions – The use case descriptions (Chapter 5) provide detailed descriptions of each process step of the process model, incl. Scope & Level, Goal in Context, Preconditions, Primary and Secondary actors, the Main scenario, etc. The privacy & security guideline [3] has been applied to the use case descriptions.
- Message descriptions – The Message transport and descriptions (Chapter 6) describes the syntax of all the messages needed for the interfaces described in the framework, as well as detailed requirements for exchanging those messages.

1.2. Scope of USEF 2015

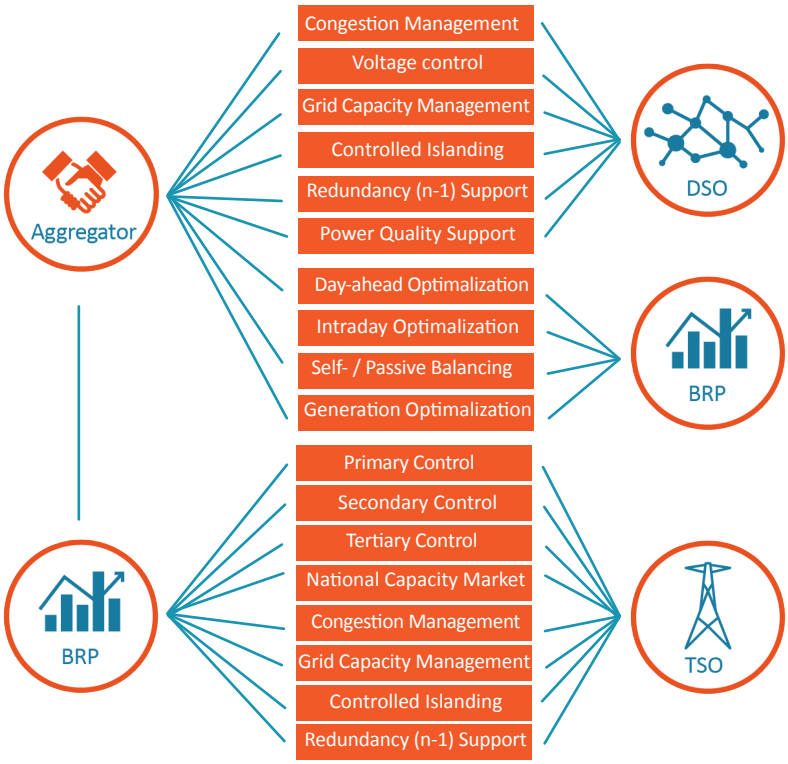


Figure 1-1 USEF Flexibility Value Chain

USEF has defined the Flexibility Value Chain, a set of 18 different flexibility services [1]. USEF 2015 includes a subset of the Flexibility Services. Table 1-1 shows all services which are in scope of USEF and the subset which is covered in the USEF 2015 specification. Future versions of the specification will cover additional services.

Customer	Ref	Service	USEF Scope	Relevant phases	USEF 2015 coverage
DSO	D1	Congestion Management	Y	C-P-V-O-S	Y
DSO	D2	Voltage Control	Y	C-P-V-O-S	N
DSO	D3	Grid Capacity Management	Y	C-P-V-O-S	N
DSO	D4	Controlled Islanding	Y	C-S	N
DSO	D5	Redundancy (n-1) Support	Y	C-S	N
DSO	D6	Power Quality Support	N	-	-
BRP	B1	Day–Ahead Optimization	Y	C-P-V-O-S	Y
BRP	B2	Intraday Optimization	Y	C-P-V-O-S	Y
BRP	B3	Self / Passive Balancing	Y	C-P-V-O-S	Y
BRP	B4	Generation Optimization	Y	C-P-V-O-S	Y
TSO	T1	Primary Control	Y	C-S	N
TSO	T2	Secondary Control	Y	C-P-V-O-S	N
TSO	T3	Tertiary Control	Y	C-P-V-O-S	N
TSO	T4	National Capacity Market	Y	C-P-V-O-S	N
TSO	T5	Congestion Management	Y	C-P-V-O-S	N
TSO	T6	Grid Capacity Mgmt	Y	C-P-V-O-S	N
TSO	T7	Controlled Islanding	Y	C-S	N
TSO	T8	Redundancy (n-1) Support	Y	C-S	N
Prosumer	P1	ToU Optimization	N	-	-
Prosumer	P2	KWmax Control	N	-	-
Prosumer	P3	Self-Balancing	N	-	-
Prosumer	P4	Controlled Islanding	N	-	-

Table 1-1: Scope of USEF specifications 2015.

Coverage of the three Aggregator implementation models that were introduced in [1] is as follows. The standard aggregator model is fully covered in the USEF 2015 specifications. Also the VTP-model is covered, when the understanding of the “connection” as defined in Section 6.4.6 is slightly altered. Connection now serves both as entry point for aggregators and entry point for DSO to implement USEF’s orange regime. The VTP-model is fully applicable when reading VTP for connection. A minor extension to the Common Reference structure will be needed, which is not yet described. Finally, the Flex-BR model is still under discussion in Europe and therefore not included in the USEF 2015 specifications.

To facilitate interoperability between different Active Demand & Supply devices and the Aggregator’s control mechanisms, and thus to prevent vendor lock-in, a standardized device interface is needed. USEF introduces a device interface (the UDI) for standardized ADS control. USEF has no intention to define this UDI in detail, but specifies a minimal set of functional specifications and minimal information exchange for such an interface. USEF assumes that external standards can be applied on UDI level. USEF will monitor those standardization activities which may lead to one or more recommended practices. The USEF 2015 specification and the USEF reference implementation includes an example UDI, to demonstrate the USEF concepts up through the level of ADS control (Section 6.5).

1.3. Levels of compliancy

The smart energy market is an emerging market, which will gradually grow based on where viable business cases arise. USEF provides a coherent framework which facilitates companies to access this new market. USEF foresees multiple pathways for the implementation of fully USEF compliant products, services and solutions.

USEF identifies three levels of compliancy: protocol, process, and service compliancy. Protocol compliancy deals with the syntax and semantics of messages sent in a USEF implementation. Process compliancy considers the processes in and interactions amongst the roles defined by the USEF market model. Finally, service compliancy deals with the validation whether a service provider is capable of providing the flexibility service according to the contractual arrangements.

The USEF foundation continues to work on providing detailed compliancy guidelines for the verification of USEF implementations at the levels described above.

1.4. USEF: The Framework Implemented

'USEF: The Framework Implemented' is the name for the reference implementation accompanying the USEF2015 Specifications. This reference implementation is fully in line with the normative part of this document.

The reference implementation shows the viability of the design by providing a fully functional implementation. It provides a starting point for third parties aiming to commercially exploit all or part of the USEF framework, or aiming to develop products and services built on top of the USEF framework. The reference implementation also serves as a test bed for testing extensions of, or improvements to, the framework's design that are brought forward by the USEF community. The reference implementation has passed conformance testing and is publicly available in the form of downloadable source code. Being source code, it can easily be transferred, read, modified, and extended to suit the needs of individual customers adopting USEF.

Recommended Practice:
In order to make the universal descriptions of the framework applicable in practice and more comprehensible the specifications are accompanied by recommended practices. These paragraphs are clearly indicated, in blue, throughout the specifications.

2 Market-based Coordination Mechanism

The USEF Market-based Coordination Mechanism (MCM) facilitates the delivery of value propositions (i.e. marketable services) to various market parties without imposing limitations on the diversity and customization of the propositions. The USEF MCM is designed for all energy commodities[3] and enables the market to optimize in time, capacity and power. MCM provides access, under equal conditions, for all stakeholders to a single integrated market. This unique approach aims for a future-proof design of the energy market.

2.1 Scope

USEF MCM is meant as an addition to the current liberalized market model, therefore most market processes remain unchanged and will therefore not be described by USEF. This chapter focuses on the new market processes and describes where existing processes need to be altered. Since undisturbed market operation is only possible in the Green and Yellow regimes, this chapter only describes the processes during for normal operations (Green regime) and for grid capacity management (Yellow regime). The processes involving grid operations in the Orange and Red regimes are covered in Chapter 4 The wholesale processes are covered in Chapter 3.

A general description of the MCM is provided in Section 5.5.12. Section 2.3 describes the processes that take place in the four phases of the MCM. The information flows, which allow the roles to communicate with each other in the MCM, are described in Section 2.4 (Interface descriptions). In Section 2.5, some guidelines concerning the implementation of the MCM are described.

The specifications in this chapter do not describe how to act when exceptions take place in a process step.

2.2 General Description

The USEF MCM operations scheme distinguishes four phases and the corresponding processes can be summarized as depicted in Figure 2-1:

- **Plan:** In the Plan phase the demand and supply of energy are planned for the upcoming period, usually a calendar day. Both the BRP and Aggregator carry out an initial portfolio optimization. During this phase, the BRP can procure flexibility from its Aggregators. The Plan phase results in an agreed-upon Aggregator plan (A-plan) between the Aggregator and the BRP.
- **Validate:** In the Validate phase, the DSO validates whether the demand and supply of energy can be distributed safely without any limitations, with the use of D-prognoses. If congestion occurs, the DSO can procure flexibility from Aggregators to resolve the grid capacity issues. It is important to note that iterations exist between the Plan and Validate phases. This means that after validation, it is possible to go back to the Plan phase. These iterations take place until the foreseen energy flows can be distributed safely in an economically optimized way.
- **Operate:** In the Operate phase, the actual assets and appliances are dispatched and the Aggregator adheres to its D-prognoses and A-plan. When needed, DSOs and BRPs can invoke additional flexibility from the Aggregators to resolve unexpected congestions (for the DSO) or to provide balancing services or re-optimize their portfolio (for the BRP).
- **Settle:** in the Settle phase the flexibility that the Aggregator has sold to the BRPs or DSOs is settled. For this purpose the actual consumed and produced volumes are first allocated to the responsible parties; unresolved or disputed volumes are reconciled shortly thereafter.

[3] USEF 2015 is designed only for electricity. However, conceptually, MCM may be applied to all energy commodities.

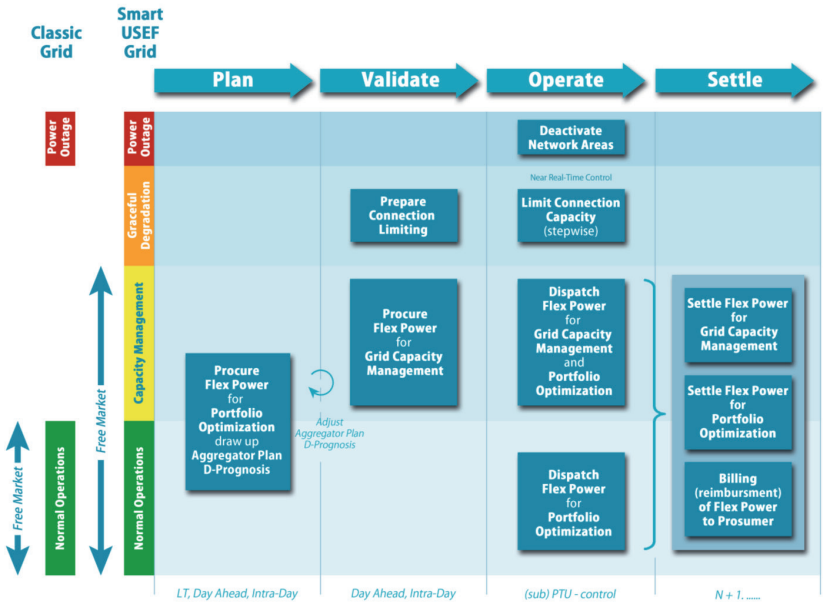


Figure 2-1: USEF Operations scheme.

The aim of the Plan and Validate phases is to make optimal use of the flexibility and maximize the freedom of dispatch and transaction of all stakeholders before the actual delivery of energy takes place. The time scale of these phases is ranging from already years and months ahead towards one day ahead and ultimately a certain amount of hours before the actual delivery of energy (i.e. the Operate phase) starts. This broad time window supports trading on various energy markets (i.e. forward market, day-ahead spot market and intraday spot-market) and the monitoring of changes of the required grid capacity. USEF proposes that the national regulator determines the details of the gate closure times. A common practice in energy markets is currently two hours before delivery in the intraday process.

USEF specifies that iterations between the Plan and Validate phases take place at least twice: first during the day ahead, and secondly during intraday. Hence, two points in time are determined when the markets are closed and the Aggregator plans (A-plans) and D-prognoses are aligned: 1) end of day-ahead 2) end of intraday. This specification allows for the iterative process of creating and aligning A-plans and D-prognoses to converge more easily and fits well with many current national processes applied in the day ahead and intraday trading market. Please find more details in Section 2.3.2.5 (Iterations between the Plan and Validate phases).

The Validate phase exists of two different steps, executed in parallel: Validate-E and Validate-D. The D-prognosis and the validation thereof (i.e. Validate-D) is the added value of MCM, as it allows for the use of flexibility and demand response within the distribution grid. Validate-E is already in place on a national level, and will not be altered because of USEF. Therefore, it is only mentioned here for the sake of completeness, but it will not be described by USEF.

2.3 Process Model

This section describes the processes that take place in the four phases of the MCM in detail, including the specifications and rules that apply to each of these processes. Wherever assumed desirable, a motivation for the design is included.

2.3.1 Plan

The aim of the Plan phase is to find an economically optimized program to supply the demand of energy of both the portfolio of Aggregators and BRPs for a certain period. The result of the Aggregator is reflected in its A-plan, similar to the current E-programs of the BRPs. The processes that take place during the Plan phase are schematically depicted in figure 2-2.

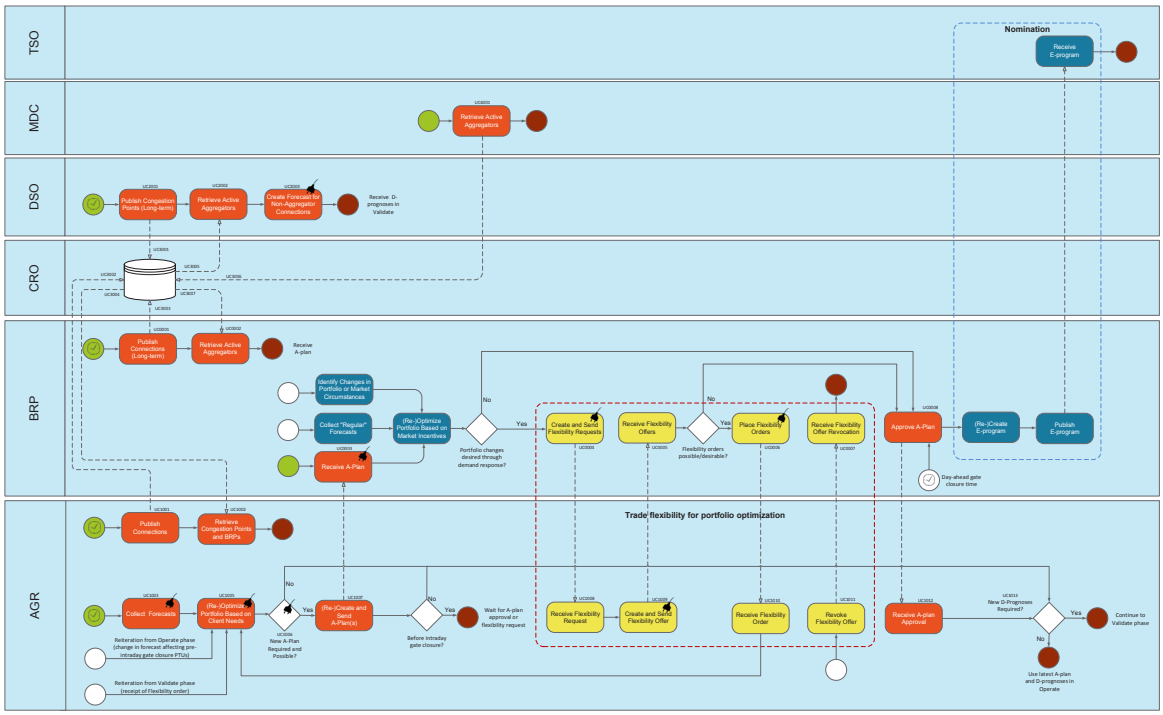


Figure 2-2: Process flows of the Plan phase. New processes are depicted in red, existing processes are depicted in blue. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

2.3.2.1 Overall Description

The Plan phase starts when the Aggregator collects forecasting information of those Prosumers that it serves. USEF does not specify which information is used for this forecast, but this may include information from the Active & Demand & Supply. In the Plan phase the DSO also determines where congestion may possibly take place (so-called: congestion points; refer to Section 4.2.1. for more details). Please note that contrary to forecasts that are created on a daily basis, congestion points are declared less frequently, probably in the order of several times a year, depending on the amount of trend analyses performed by the DSO and the condition of the grid.

Having collected the forecasts, the Aggregator plans how to maximize the value of the flexibility options in its portfolio (optionally taking into account congestion point information), resulting in an A-plan. The Aggregator optimizes its portfolio based on its client's needs, optionally taking into account its long-term contractual obligations. For example, in-home optimization or optimization for maximum sharing of sustainable energy amongst clients may be applied. In this A-plan, for each timeslot the aggregated amount of energy consumed/produced is stored. If changes to the forecasts take place (e.g. because a new weather forecast is available), the Aggregator may re-optimize its portfolio, resulting in an updated A-plan.

After this optimization, the Aggregator sends the A-plan to the BRP for validation (see Section 2.4.2.2 for more details). The BRP uses the validated A-plans for optimizing its portfolio, in order to attain an economically optimized program. During this optimization, it will negotiate with its Aggregators to exploit the available flexibility in the market and optimize its value. For example, based on a spread in energy prices on the day-ahead market, a BRP may request Aggregators to provide flexibility, resulting in a new A-plan to be exchanged between Aggregator and BRP. If the BRP identifies market changes that may have an impact on its portfolio, it may re-optimize its portfolio.

The BRP uses the information in the A-plan to determine its E-program. The E-program is sent to the TSO for validation, which forms the basis for imbalance settlement between BRP and the TSO.

2.3.2.2 Exchange of A-plan between Aggregator and BRP

The Aggregator is responsible for the creation of an A-plan for each BRP, since the Aggregator has the best information on the use of the flexibility from the Prosumers in its portfolio. The A-plan only includes the forecasted load of those Prosumers served by the Aggregator and that have a connection related to the BRP. The structure of the A-plan is described in Section 2.4.2

At the start of the Plan phase an Aggregator sends its A-plan to the BRP. The BRP assesses each received A-plan on validity (see Section 2.4.2) and informs the Aggregator whether or not the A-plan is accepted. As long as the gate closure time has not passed, the Aggregator can update its A-plan, either due to changed circumstances or flexibility sold. During these iterations, an accepted A-plan is assumed actual as long as no updated A-plan is accepted by the BRP.

For the exchange of A-plans USEF specifies the following:

- The A-plan contains one full calendar day for the day ahead process. In the intraday process, all remaining PTUs of the calendar day must be included
- The energy is given per Program Time Unit (PTU) as a minimum time granularity
- The A-plan does not include details about the available flexibility or prices

USEF recommends applying the following timing details:

- The PTU is used as the time granularity
- The A–plan is sent day-ahead to the BRP, at the latest two hours before the gate closure of the national balancing regime (day-ahead gate closure).
- The volumes in the A-plan can be updated until one hour before the start of the respective PTU (intraday gate closure).

2.3.2.3 Flexibility trading between Aggregator and BRP

The BRP can procure flexibility from its Aggregators either by using long-term flexibility options, or by performing a flexibility request to find out how much flexibility Aggregators offer on a specific day (i.e. the short-term flexibility options). In the latter case, the following steps take place:

1. The BRP makes a request to its Aggregators to provide flexibility;
2. The Aggregators receive the flexibility request and;
3. Create an offer for the flexibility;
4. The BRP receives the flexibility offers;
5. For those offers, which the BRP would like to pursue, the BRP places a flexibility order;
6. The Aggregators receive the flexibility orders, resulting in the actual procurement of flexibility by the BRP from Aggregators.

When these steps of selling and procuring flexibility have been taken, or when long-term flexibility contracts have been invoked, the Aggregator re-optimizes its portfolio after which the A-plan is re-created and sent to the BRP. Subsequently, the possible procurement of new flexibility by the BRP takes place again. This iterative process allows for the maximum use of flexibility in the market.

For the procurement of flexibility by the BRPs, USEF specifies to apply the following:

- The BRP does not have to wait for all Aggregators to have sent their A-plans in order to start procuring flexibility, since the process is iterative and can be restarted when either the Aggregator or a BRP re-optimizes its portfolio. Please note that this is in contrast to the DSO, who only places a flexibility request when all D-prognoses have been received.
- An Aggregator can cancel or update flexibility offers until they have been accepted by the BRP. It is up to the Aggregator to determine the acceptance deadline.
- A flexibility order is definite and binding once it has been placed. It can only be made un-binding if both the Aggregator and BRP agree to this.
- For settlement purposes, it is advised that both the Aggregator and BRP store the agreed upon flexibility orders.
- USEF proposes to initially implement the procurement of flexibility between Aggregators and BRPs using bilateral contracts (i.e. decentralized market). Most logically, this will develop in a centralized marketplace in the long-term.

- The flexibility bidding messages can use the same format as the one flexibility bidding messages used by the Aggregator and DSO. These are described in Section 2.3.2.4
- The acceptance of flexibility orders triggers an update of the A-plan.
- The aggregation level of the bidding takes place at the level of the national balancing market (i.e. national imbalance market).
- A flexibility order is linked to a flexibility offer and an A-plan for settlement purposes.

The formats for the A-plans, flexibility requests and the flexibility offers are described in Section 2.3.2.4.1

2.3.2 Validate

The Validate phase consists of two intricately linked processes, executed in parallel by different market roles: the 'Validate-D' and 'Validate-E' processes. In these processes, the draft D-prognosis and draft E-program that result from the Plan phase are validated by the DSO and TSO respectively[4]. Please note that the 'Validate-E' process, performed by the TSO, is an existing process, which is already in practice in many countries. USEF is designed in such a way that the 'Validate-E' process is not altered. Therefore, only the 'Validate-D' process is described in this section.

Traditionally, the only measure that a DSO can take to ensure the safe distribution of energy is grid reinforcement. USEF introduces a new measure: a market for flexibility services. In this market, the DSO has the possibility to procure flexibility from Aggregators, which allows the DSO to perform active grid capacity management and thus to solve potential congestion. This new market will open up opportunities for Prosumers to reduce their energy bills and for market parties to develop new services and business models. In the next sections, the validation of the D-prognosis is explained in detail. The processes during the Validate phase are depicted in the following figure.

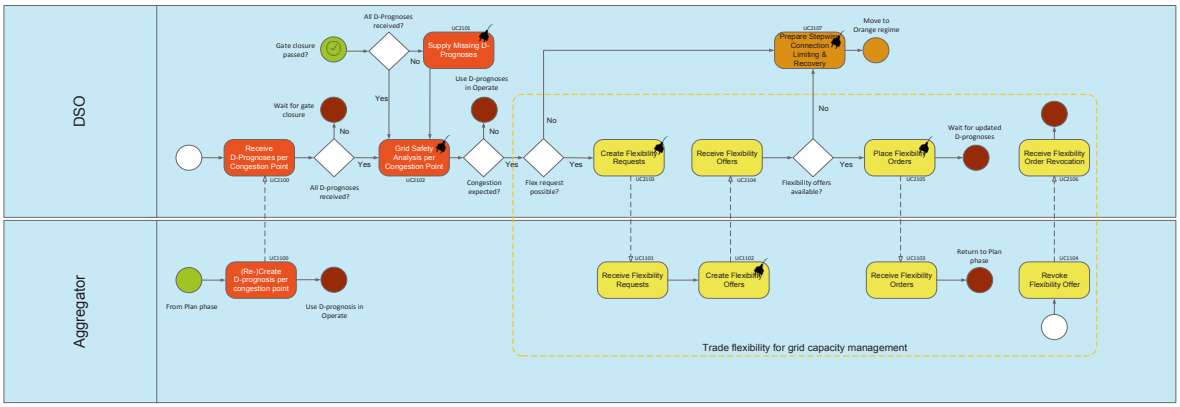


Figure 2-3: Process flows of the Validate phase. New processes are depicted in red. Processes depicted in yellow refer to the grid capacity management regime. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

2.3.2.1 Overall description

At the start of the 'Validate' process, each Aggregator creates a D-prognosis per declared Congestion Point (see Section 2.4.1) and sends it to the DSO. The DSO assesses the received D-prognoses and informs the Aggregators whether or not a D-prognosis is accepted (see Section 4.3.2.1 acceptance criteria). The Aggregator acts upon the acceptance/rejection - prepare the operate phase or next iteration or recreating a new D-prognosis according to the reason for rejection. As soon as all D-prognoses for a Congestion Point are received, the DSO combines these D-prognoses together with the forecasts of non-aggregator connections in order to execute a final grid safety analysis (leaving open the option to perform a preliminary analysis based on partial D-prognoses at an earlier stage).
This analysis determines whether it is possible to distribute the planned energy, or that the limits of the distribution grid are reached. In the latter case, USEF moves to the Yellow regime and the DSO procures flexibility in the market to resolve these congestion issues, either by invoking long-term flexibility contracts[5] with Aggregators, and/or by placing flexibility orders with the Aggregators that offer flexibility for that specific day (i.e. the short-term market). The process of ordering flexibility is described in detail in Section 2.3.2.4.

4 The difference between 'Validate-E' and 'Validate-D' lies with the fact that in 'Validate-E', the TSO only validates consistency, whereas in 'Validate-D' the DSO performs a grid safety analyses

5 This distinction is specifically mentioned here, in order to emphasize that USEF also allows for long-term flexibility contracts in the Yellow regime.

If the offered flexibility is not sufficient to resolve the expected congestion or no flexibility is offered, USEF moves to the Orange regime. Please note that in this case, USEF specifies that the DSO does procure all offered flexibility from the market (i.e. from the Yellow regime) to solve parts of the congestion. This is because any flexibility offered will still help to reduce the impact of the Orange regime (e.g. the amount of connections to be impacted by the graceful degradation). Please refer to Chapter 4 for more details.

The procurement of flexibility by the DSO may impact the A-plan[6]. Therefore, the Validate phase is iterative with the Plan phase, i.e. the Aggregator can make adjustments to its A-plan as far as time and/or the (bilateral) agreement between Aggregator and BRP allows it. When the gate closure time is reached, all issues need to be resolved and the A-plan and the D-prognoses need to be aligned. This is the responsibility of the Aggregator. Please refer to Section 2.3.2.4 for more details.

Finally, the DSO combines the aligned D-prognoses with forecasts of those connections, which are not on a congestion point or not served by an Aggregator to create T-prognoses, which are sent to the TSO for verification.

2.3.2.2 Exchange of D-prognosis between Aggregator and DSO

The Aggregator is responsible for the creation of a D-prognosis for each Congestion Point, since the Aggregator is in contact with and acts on behalf of the Prosumer. Moreover, an Aggregator is obliged to create a D-prognosis as soon as a DSO has declared a Congestion Point (see Sectio 2.4.3.2 for rationale). The D-prognosis only includes the forecasted load of those Prosumers served by the Aggregator and that have a connection related to a congestion point. The structure of the D-prognosis is described in Section 2.4.3**.**

At the start of the Validate phase an Aggregator sends its D-prognosis per Congestion Point to the DSO. These D-prognoses are subsets of the A-plan of the Aggregator. The DSO assesses each received D-prognosis on validity (see Section 4.3.2.1) and informs the Aggregator whether or not a D-prognosis is accepted. As long as the gate closure time has not passed, the Aggregator can update its A-plan, either due to changed circumstances or flexibility sold, which might result in updated D-prognoses. If this is the case, these updated D-prognoses must be sent to the DSO as well. During these iterations, an accepted D-prognosis[7] is assumed actual as long as no updated D-prognosis is accepted by the DSO.

For the exchange of D-Prognosis, USEF specifies the following:

- The D-Prognosis contains one full calendar day for the day ahead process. In the intraday process, all remaining PTUs of the calendar day must be included
- The average power is given per PTU as a minimum time granularity
- The D-Prognosis does not include additional information like details about the available flexibility or prices

USEF provide the following recommended practices for timing details[8]:

- The PTU is used as the time granularity
- The D-Prognosis is sent day-ahead to the DSO, at the latest two hours before the gate closure of the national balancing regime (day-ahead gate closure)
- The volumes in the D-Prognosis can be updated until one hour before the start of the respective PTU (intraday gate closure)

For more details on gate closure timing and the convergence of the A-plan and the D-prognosis see Section 2.3.2.3**.**

2.3.2.2.1 Flexibility market gaming

USEF acknowledges that, by design of the MCM, the possibility exists that an Aggregator may willingly manipulate the flexibility market in the Yellow regime, by providing inaccurate information in a D-prognosis in order to create a congestion problem for the DSO. The DSO would then have to order more flexibility from the market than needed, thus paying for resolving a non-existing problem.

6 This is not the case when the Aggregator can manage the deviation himself, e.g. one Prosumer uses more energy, another Prosumer uses less energy and these two level each other out.

7 The accepted D-prognosis is the D-prognosis that used as a basis for the next period (Intraday) or phase (Operate).

8 For the difference between day-ahead and intraday, please refer to Section 2.3.2.5

USEF believes that gaming can be discouraged sufficiently because of the following reasons:

1. The DSO has multiple options to solve congestion problems. Naturally, not all options are equally applicable for certain situations:
    c. Grid reinforcements (e.g. cables, transformers);
    d. Flexibility investments (e.g. batteries, backup generation);
    e. Long-term flexibility contracts through Aggregators (e.g. through tendering);
    f. Spot flexibility market through Aggregators (i.e. using daily flexibility offers);
    g. Temporarily allowing load above maximum, resulting in increased depreciation of assets.
2. Gaming causes the risk of reputation damage. As a result, Aggregators may miss out on further tenders;
3. Gaming causes the risk of killing the local flexibility market by driving the DSO towards grid reinforcements;
4. Additional regulatory measures are possible, for example by enforcing a license for Aggregators.

Recommended Practice:
A monthly evaluation of the accuracy and potential manipulation of D-prognoses. This ensures that proper D-prognoses are supplied.

Please note that even if the settlement risk is managed by the initiator, the incentive to Prosumers still has to be paid for.

Another option would be to completely freeze the D-prognoses for all Aggregators after the first flexibility has been sold for a PTU. However, this would limit further trading opportunities in the intraday process. Since the unpredictability of intermittent sources is a primary driver of the need for demand response, this option is not desirable. The settlement rules are described further in Section 2.3.4.8.

2.3.2.3 Processing D-prognoses

After all D-prognoses relating to a particular congestion point are accepted, the DSO combines them to make an accumulated D-prognosis. When accumulating the D-prognoses, it is necessary for the DSO to estimate and add the distribution requirements needed for those connections that are not served by an Aggregator and hence are not included in the D-prognoses. Using the accumulated D-prognosis, the DSO can determine whether it is possible to distribute the planned energy, or whether the limits of the distribution grids are reached.

USEF specifies that the DSO has to wait for all Aggregators to have sent their D-prognoses before identifying grid constraints, and thus before issuing flexibility requests. This is not only because it ensures that the DSO can determine possible congestion more precise, but also because it ensures a fair process of offering and procuring flexibility. In case a DSO issues a flexibility request for a certain Congestion Point, other Aggregators receiving this request have market information available, giving them a competitive advantage when offering flexibility to the DSO.

2.3.2.3.1 Identify Grid Constraints

In this step, the DSO performs a grid safety analysis per Congestion Point, based on its accumulated D-prognosis. This analysis can lead to one of the following results:

- Grid safety analysis leads to the conclusion that no congestion will arise. All power flows are within calculated safety margins.
- Grid safety analysis leads to the conclusion that congestion will arise, as the energy flows exceed calculated safety margins. The DSO starts the process of acquiring flexibility from the market.

In the (unlikely) case that no Aggregators are active in the Congestion Point there is no market to supply the DSO with flexibility to reduce the energy flows to levels below the safety margins. In this case, the system moves to the Orange regime. The resulting DSO processes are described in Chapter 4.
Please note that during the Validate phase, the system cannot move to the Red regime. The Red regime can only take place in the Operate phase, since it deals with an actual physical power outage.

It must also be noted that the DSO cannot refuse a D-prognosis because of possible congestion problems. The rationale behind this is induced by the freedom of dispatch - the D-prognosis is determined by the demand for distribution capacity, not by the available distribution capacity.

2.3.2.4 Flexibility trading between Aggregator and DSO

2.3.2.4.1 Process of flexibility trading

If the outcome of the grid safety analysis is that congestion will arise, the system is moved to the Yellow regime and the DSO will have to take action. In order to solve the expected congestion, the following steps are taken:

1. The DSO requests all Aggregators at the congestion point to provide flexibility. In this request, the DSO indicates the magnitude (amount of excess power) and timing (PTU) of the expected congestion, and how much capacity is available in the remaining PTUs
2. The Aggregators receive the flexibility request for adjusting[9] distribution requirements
3. Aggregators create offers for the flexibility;
4. The DSO receives the flexibility offers
5. The DSO procures flexibility to resolve the congestion issues, either by placing an order for the flexibility the Aggregators have offered for that specific day (short-term flexibility options), or by activating flexibility options in prearranged bilateral contracts (long-term flexibility options) with an Aggregator
6. The DSO determines whether the expected congestion is solved using the ordered flexibility. If this is not the case, the system moves to the Orange regime (see Chapter 4 for more details)
7. The Aggregators receive the flexibility orders, resulting in the actual procurement of flexibility by the DSO from Aggregators.

After the required flexibility has been procured by the DSO, the Aggregators providing flexibility go back to the Plan phase to update their A-plan (if applicable) and send their new D-prognoses to the DSO.

2.3.2.4.1.1 Two flexibility products

In Step 5, two flexibility products are introduced for the DSO to procure flexibility from the Aggregator:

- Long-term flexibility options: activation of flexibility options in prearranged bilateral contracts. Based on this contract the Aggregator has the obligation to offer a fixed amount of flexibility to the market in the form of daily FlexOffers. This product guarantees a certain availability of flexibility, but the price (model) has to be arranged in advance. As a result, the DSO can select the contract(s) with the lowest costs that provide the required flexibility, but such contracts most likely will not reflect all flexibility available in the market nor will the price level reflect the actual marginal costs for the flexibility provided. This operation is comparable to the way in which national TSOs contract primary, secondary and tertiary control reserve power. A tender or auction procedure can be implemented for this purpose and perhaps procedures can be based on those for contracting secondary control reserves. Furthermore, long-term flexibility options, subject to prearranged specific conditions that might include a maximum or fixed price for the activation of the flexibility.

- Short-term flexibility options: procuring flexibility that Aggregators have offered for a specific day. In this case the Aggregator has no contractual obligation to offer the flexibility to the market but decides to do so on a day-to-day basis. This product inherently deals with short-term flexibility that is only valid for a specific day. The price level of the flexibility provided by the Aggregators will reflect the marginal costs much better, however the availability of the flexibility in this product is not guaranteed. This is comparable to the way market parties are free to offer capacity to the TSO on the secondary and tertiary markets (regulating and reserve power) on a daily basis.

The first product seems attractive for the DSO to reduce the availability risks in the Validate phase, as a minimum supply of flexibility is secured. This will however come at a price. It is up to the DSO to find a balance between the costs and certainty to ensure that the reliability of the grid can be maintained at all times. USEF does not set any specifications regarding the use of these products. They are mentioned here for informative purposes. It is important to note that both products are part of the same flexibility market. This also provides options for a natural growth path in the evolution of flexibility trading. At first, availability of flexibility supply and demand might be a primary concern for both buyers and sellers leading to a focus on long term contracts. When the flexibility market matures and availability becomes less of an issue, both buyers and sellers will be willing to rely more on the short term flexibility options leading to a more liquid market.

[9] Either by decreasing energy use, increasing local generation, or time-shifting load. Also, in the case of EVs, location shifting may be possible.

2.3.2.4.2 Rules for flexibility trading

For the procurement of flexibility by the DSOs, USEF specifies the following rules:

- A flexibility offer is valid until a new flexibility offer is sent by the Aggregator, until it expires or is revoked. It is up to the Aggregator to determine the acceptance deadline.
- A flexibility order is definite and binding once it has been placed.
- The DSO chooses which flexibility offers it accepts to solve the congestion. In this regard, it is not obligatory for the DSO to start with the offer that has the lowest price. The DSO has the freedom to assess the balance between that price and quality[10] of the flexibility offered in both long term contracts and short term offers.
- Bidding takes place at congestion point level, making every congestion point a local flexibility market.
- The DSO only sends a flexibility request when the result of the grid safety analysis leads to congestion based upon the (updated) D-prognoses. This ensures that biddings are only made if the DSO has need for them.
- A flexibility order is linked to a flexibility offer and a D-prognosis for settlement purposes.

2.3.2.4.3 Recommendations for flexibility trading

Recommended Practice for flexibility trading:

For the procurement of flexibility by the DSOs, USEF recommends the following. The rationales behind these recommendations are described in the next paragraphs.

- Biddings are open and take place anonymously.
  - bids are published openly real-time by the DSO.
  - bids are published openly the next day by the DSO.
- Pay-as-bid is used for pay-out.
- Timing of the flexibility orders is between 24 and 4 hours before delivery.

More details concerning the structure of the biddings are described in Section 2.4.4.2.

The DSO sets the minimum size of one energy 'block', which is effectively the minimum offering for an Aggregator to participate in the local market. This minimum size is not specified nor recommended by USEF, as it may change for one congestion point to another.

2.3.2.4.3.1 Rationale behind open bids and anonymous bidding

The DSO may choose either to publish bids (open bids), or not to publish them (closed bids):

- Open bids are published so that all other market players (and other stakeholders) know both the prices and quantities offered on a real-time basis. This kind of bids offer the possibility for other market players to beat the lowest offer with the smallest possible difference. For example, if an Aggregator bids 60 then a second Aggregator could offer 59.
- Closed bids are used when open bids would lead to possible market manipulation by market players. For example, if both ask - and bid curves are known, it is possible for large market players to push up the price. However, this is not the case within the USEF flexibility market as there is only a bid curve.

[10] For example, it is desirable for the DSO to procure flexibility that moves energy use from a moment in time of high load to a moment in time of very low load, rather than procuring flexibility that moves energy use from a moment in of high load to a moment in time at which the maximum of the distribution capacity is almost reached.

Recommended Practice:
USEF recommends implementing open bidding, as it will maximize transparency, which allows new Aggregators to enter the market more easily. It will also create trust in the functioning of the flexibility market for all stakeholders.

Within open bidding, USEF also recommends to apply anonymous bidding, which means that the identity of the party that has made an open bid is unknown to other market participants. This prevents them from being able to analyse the bidding strategy of market players. Anonymous bidding is common practice on most relevant energy markets with open bidding.

2.3.2.4.3.2 Rationale behind pay-as-bid pricing

There are two options for the pay-out mechanism: pay-as-bid and marginal pricing.

- In a **pay-as-bid** [3] pricing model, all suppliers of flexibility receive the price included in their individual bids when called to supply flexibility to the DSO. This is also known as discriminatory pricing.
- With marginal pricing, also known as single clearing bid, all Aggregators would receive the same price for their flexibility. Because it is not possible to pay Aggregators less than their individual bids, the uniform price would have to be the most expensive offer accepted by the DSO.

Recommended Practice:
For the clearing price, USEF recommends to apply a pay-as-bid model, as this will lead to the lowest costs for the DSO and ultimately for society.

2.3.2.4.3.3 Rationale behind timing of bid acceptance

There are two conflicting interests for the buyer of flexibility (i.e. the DSO):

1. Procuring flexibility as soon as it is available gives certainty on the availability of flex;
2. Procuring flexibility as late as possible gives certainty on the need for flexibility.

As both interests refer to the buyer of flexibility, the best solution is to let the DSO decide for himself how to weigh these conflicting interests. The Aggregators state the validity in their offers using the 'Accept before' field, so this information is known to the buyer. However there is also the option to change or withdraw a bid thus creating uncertainty for the buyer.

Because the acceptance of a bid triggers a (partial) freeze of the D-prognosis of the Aggregator offering the flexibility, the uncertainty for the DSO is reduced as these D-prognoses cannot be updated any more for the PTU's in which flexibility is ordered. This could lead to situations of all flexibility being bought as soon as the first congestion is detected (day-ahead), preventing an intraday market to arise. This is especially the case when the DSO buys some flexibility from all Aggregators.

Recommended Practice:
To strike a balance between a good forecast, especially for wind power, and the possibility to still shift loads backwards in time USEF recommends buying most of the flexibility day-ahead (e.g. 80%) and buying the remaining flexibility (e.g. 20%) four hours before delivery in the Operate phase.

2.3.2.5 Iterations between the Plan and Validate phases

2.3.2.5.1 Gate closure times

As a result of the market operations in the Yellow regime, it may be the case that the A-plan is adjusted. The A-plan is not adjusted if the Aggregator can resolve the changes in its own portfolio. For example, an Aggregator may sell flexibility to a DSO by shifting energy use from 6PM to 4PM in a certain congestion point. If the Aggregator shifts the same amount of energy from 4PM to 6PM in a location outside the congestion point, these two time shifts cancel each other in the portfolio of the Aggregator and the A-plan does not change. However, when the Aggregator cannot or chooses not to resolve the changes in its own portfolio, the Aggregator may wish to re-

optimize its portfolio and create a new A-plan. By doing so, the MCM is back in the Plan phase (see Section 2.3.1), the only difference being that the Aggregator now takes the already sold flexibility into account. Moreover, in the Plan phase itself, the Aggregator has the freedom to continuously re-optimize its portfolio, whenever deemed necessary (e.g. when new and improved forecasts are available). The same applies for the BRP, who can perform additional flexibility requests when its portfolio changes due to market circumstances. The rationale behind this high degree of freedom for the Aggregator and the BRP is to ensure that the flexibility that Aggregators offer is applied in the most optimal and cost-effective way (i.e. flexibility is used there where it creates most value).

However, these iterative processes also lead to the issue that the A-plans and the D-prognoses change continuously, and continuous alignment between Aggregator/BRP and Aggregator/DSO is needed. As a result, there is a risk that the iterative process between the Plan and Validate phases does not converge (i.e. the A-plans and D-prognoses are not agreed upon at the moment of gate closure).

In conclusion, there is a balance between on the one hand making sure that the iterative processes converge, and on the other hand offering a high degree of freedom to ensure that the available flexibility is used in the most optimal and cost-effective way.

For reason mentioned above, USEF specifies that there need to be at least two moments in time when the MCM has converged, meaning that both the A-plans and the D-prognoses need to be aligned between Aggregator/BRP and Aggregator/DSO respectively. This moment is called the gate closure time.
In alignment with the current practices in the liberalized energy markets, the two gate closure times are:

1. Day-ahead closure time: the moment at which the day-ahead market closes. During the day-ahead period, the Plan and Validate phases can be iterated as often as needed, as long as the system converges before the gate closure time. After the day-ahead closure time, the processes in the Plan phase can only be restarted during the intraday period. The aligned A-plans and D-prognoses are used as a starting point for the intraday period.
2. Intraday closure time: the moment at which the intraday market closes. Also during intraday, the Plan and Validate phases can be iterated as often as needed, as long as the system converges before the gate closure time. After the intraday closure time, the processes in the Plan phase cannot be restarted at all, as the MCM moves to the Operate phase. Again, the aligned A-plans and D-prognoses serve as a starting point for the Operate phase.

Please note that, in contrasts to the day-ahead closure time, of which there exists only one for a specific day, there will be multiple intraday gate closures. The exact amount of intraday gate closures depends on choices regarding PTUs and timing before the start of the PTU (i.e. start of the Operate phase). This is illustrated in the following figure.

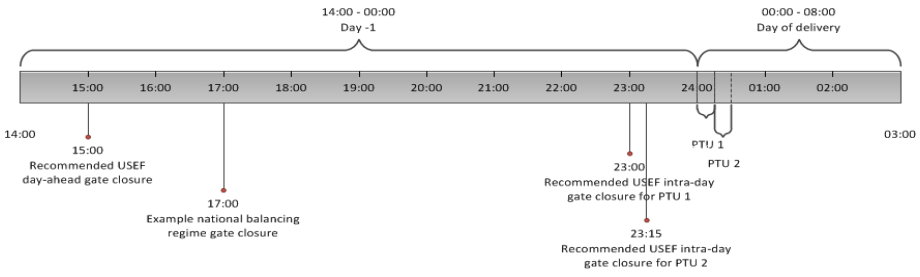


Figure 2-4: Example of USEF gate closure times.

Recommended Practice:
The national regulator determines the specific timing details of the gate closures. As stated in the sections dealing with sending the A-plan (4.4.1.2) and D-prognosis (4.4.2.2) USEF recommends:

- A day-ahead gate closure time of 2 hours before the gate closure of the national balancing market
- An intra-day gate closure time of one hour before the start of the PTU

It is the responsibility of the Aggregator to ensure that the A-plan and the D-prognoses are aligned between Aggregator/BRP and Aggregator/DSO respectively before gate closure. Furthermore, it is also the responsibility of the Aggregator to ensure that the A-plan and D-prognoses are consistent with each other (each D-prognosis is a subset of the A-plan). If the Aggregator does not manage to get all plans aligned before a gate closure time, USEF specifies that the latest accepted D-prognosis between Aggregator and DSO is used to serve as a basis for the next period or phase. Any costs that come from necessary changes to the A-plan (which is then not aligned with the BRP) is at the expense of the Aggregator.

In this regard, it is also important to note that, during the Aggregator re-optimizing its portfolio, the DSO regards the accepted D-prognoses as the only valid D-prognoses.

Taking the above into account, the Aggregator is recommended to take the risk into account of having to change the A-plan when determining how much flexibility it offers for what price.

2.3.2.5.2 Updates of the D-prognosis

Ordering flexibility or a change in forecast before the gate closure time can trigger the need to update a previous A-plan and as a result a previously sent D-prognosis. An example of this may be wind arriving one hour later than expected.

2.3.2.5.2.1 Updates after flex has been ordered

USEF specifies that as soon as PTUs are altered as the result of a flexibility deal the resulting load for these PTU's will be used for settlement. This means that as soon as the DSO has ordered a reduction in the grid load from the Aggregator, the D-prognosis for these PTUs can still be increased in an updated D-prognosis. However, following from the settlement rules a penalty will apply. A further reduction of the load for these PTUs is still possible without a penalty.

The load resulting from a flex deal will be stored independently from any subsequent updates of the D-prognosis because it allows the DSO to verify the actual delivery of the flexibility for settlement purposes. The involved Aggregator is thus allowed to supply more flexibility than agreed, but not less. Please note that this specification only applies to the involved Aggregator and for the PTU's that are affected by flex deals. Other Aggregators can still change their D-prognoses for all PTUs without incurring a penalty. More details about the penalty calculation can be found in the settlement Section 2.3.4.8.

2.3.3 Operate

Similar to the current liberalized energy market, the total energy system remains in balance without any congestion issues as long as no deviations from the validated A-plans, D-prognoses and E-programs occur. It is however quite unlikely that all D-prognoses and E-programs are executed exactly. Deviations can arise from all sorts of sources ranging from changing weather expectations to an extension of a football match. Deviations can lead to imbalances in supply and demand of energy on total system level (affecting the BRP), to changes in the agreed upon A-plan (affecting the Aggregator), as well as to local congestions in the distribution system (affecting the DSO). USEF MCM is designed such that during the Operate phase, additional flexibility can be applied in order to compensate for these deviations. The processes for invoking this flexibility are depicted in Figure 2-5**.**

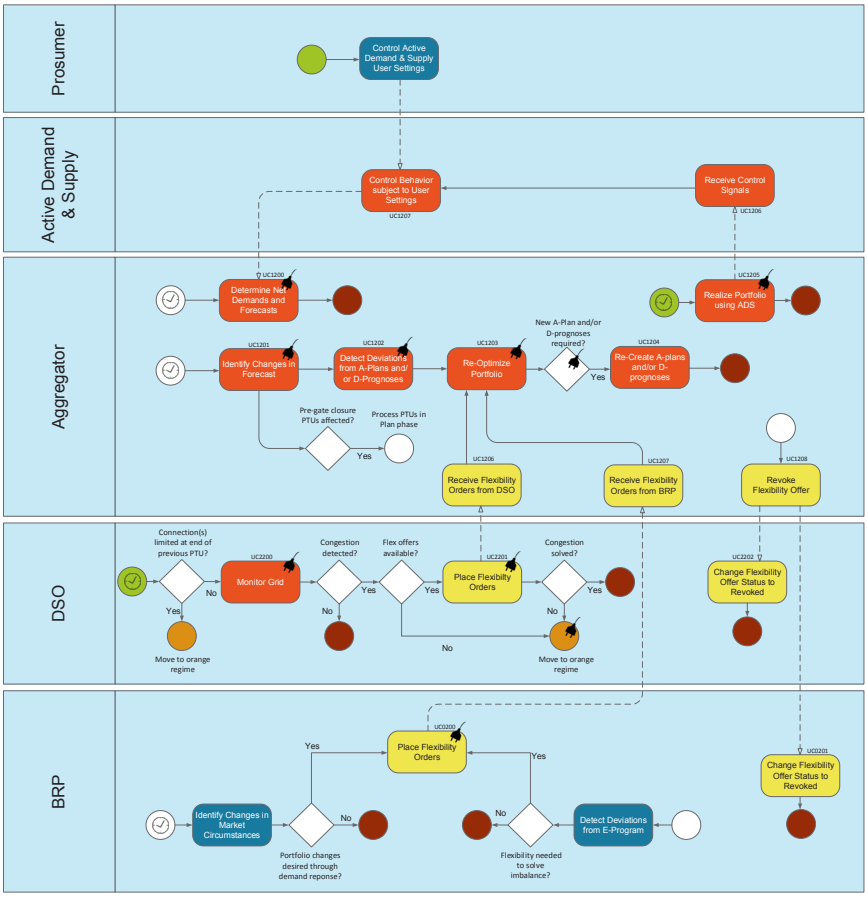


Figure 2-5: Process flows of the Operate phase. New processes are depicted in red, existing processes are depicted in blue. Process depicted in yellow relate to the grid capacity management regime. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

2.3.3.1 Active Demand & Supply and Prosumers

Active Demand & Supply (ADS) devices are appliances and assets that provide flexibility to the system. If flexibility is needed, the Aggregator sends a control signal to a device, after which the device changes its settings to consume or produce less energy, consume or produce more energy or shift its energy use. The Prosumer controls the ***user settings*** of a device (e.g. adjusting thermostat settings in the living room), which results in changes in the device settings. These user settings usually reflect the comfort level that the Prosumer wants to achieve with its ADS.

2.3.3.2 Aggregator

During the Operate phase, the main goal of the Aggregator is to adhere to its agreed-upon A-plans and D-prognoses. In order to achieve this, the Aggregator must first plan the Active Demand & Supply to operate in such a way that the aggregator portfolio performs as forecast and that any flexibility sold during the Plan and Validate phases is actually delivered.
Next, the Aggregator measures the net demand or supply of its portfolio in order to detect deviations from its A-plans and D-prognoses. In the likely event that deviations occur, the Aggregator re-optimizes its portfolio: possibly, deviations can be solved within the portfolio itself, using the flexibility therein.

If this is not the case, the Aggregator must change its A-plans and/or D-prognoses (likely in such a way that its liabilities due to non-performance fines are minimized) and control the ADS in such a way that the new plans are realized. As a courtesy to BRP and DSO, updated A-plans and D-prognoses may be re-sent, but these updates should not be taken into account for settlement purposes.
In order to control Active Demand & Supplies during operate, the Aggregator will benefit from timely feedback such as (near) real-time measurements on connection level or on individual device level. In the absence of such data, the Aggregator can still apply a best-effort control and check the result at the start of the next PTU.

Recommended practice:
USEF recommends measurements of the actual profiles with a sub-PTU granularity of 1-5 minutes and latency < 1 minute. The USEF ADS control data structures include the Device Time Unit (DTU) for this purpose (see Section). The PTU duration should be evenly divisible by the DTU duration.

2.3.3.3 BRP

During the Operate phase, it is in the interest of the BRP to minimize its imbalance costs[11]. Either when market circumstances are favorable, or when the BRP detects that it causes imbalance by deviating from its E-program, the BRP can procure additional flexibility with Aggregators. Because of time constraints, there is not a detailed process of requesting and offering flexibility (as is the case in the Plan phase). Instead, the BRP can simply place a flexibility order, based on either a pre-arranged contract or flexibility offers from the Plan phase which are still valid. This implies that the Aggregator will need to 'reserve' flexibility in case this contract is invoked. USEF realizes that this strict process does not lead to optimal use of flexibility, but the practical aspect of limited time during the Operate phase does not allow for this.

When setting up a contract between Aggregator and a BRP, the Aggregator has to realize that when the BRP places a flexibility order during the Operate phase, this will most probably lead to a deviation in the D-prognosis. Furthermore, the Aggregator must make sure this flexibility order does not conflict with the Prosumer's interest, which the Aggregator must serve as well. This is a typical business risk that the Aggregator should take into account when contracting flexibility.

2.3.3.4 DSO

Although the DSO will reduce congestion risks in the Validate phase, the DSO can still request Aggregators to dispatch flex power options to resolve potential grid problems in the Operate phase. Again, due to time constraints, this will be done on the basis of pre-arranged contracts between the DSO and the Aggregator, or flexibility offers from the Validate phase which are still valid. The Aggregator has to 'reserve' flexibility for this. When this flexibility is used, the portfolio of the corresponding BRP no longer will be in balance. As a result, the Aggregator will most likely charge additional cost to cover the caused imbalances to the DSO, and may notify the BRP if changes are significant.

2.3.4 Settle

The settlement between the Aggregator and the DSO on one hand, and the BRP on the other hand, should be based on the value of the flexibility offered by the Aggregator. Therefore it is necessary to understand how the flexibility is monetized and to understand the possible flexibility services towards DSO and BRP. This is the Flexibility Value Chain as described in [1].

2.3.4.1 Settlement between BRP and Aggregator

Any increase or reduction of demand or production behind the meter of a Prosumer, initiated by an Aggregator, will have impact on the program of the associated BRP. Therefore USEF requires that an Aggregator has a contractual relationship with every BRP associated with the load under its control. Since this relationship is based on a bilateral, commercial contract, USEF does not prescribe the corresponding contractual arrangements. However, a default settlement process is described below, to support future USEF implementations.

This section describes how the supply of flexibility from the Aggregator to the BRP is settled. Several methods are possible, depending on how the flexibility is deployed by the BRP, more precisely how the delivered flexibility of the BRP is reimbursed by its customers (TSO or energy traders). A distinction is made between an energy flex product, where the Aggregator is responsible for matching its A-plan, and a power flex product where the Aggregator is not. Both products are described in this informative part, however, only the settlement of the energy flex product is included in the normative part.

2.3.4.2 Responsibility of Aggregator to meet its forecast

Pivotal in the discussion about the settlement is the question: To what extent does the BRP need to hold the Aggregator accountable for matching its forecast (i.e. the A-plan)? If so, apart from reimbursements also penalties need to be included if the Aggregator is not able to meet its A-plan. This question strongly relates to the topic of baseline performance. Is the performance of the Aggregator measured relative to its A-plan, or should another baseline method be applied?

[11] Additionally, the BRP may also be an active player on balancing markets or (other) capacity markets.

As previously stated, the answer to this question is depending on the way the flexibility is deployed. Therefore USEF Flexibility Services for the BRP and the TSO (cf. Table 1-1) are examined (the B- and T-numbers below refer to the services in the table).

Starting from the current situation where the BRP is responsible for the imbalance, and thus responsible for forecasting its entire portfolio, the question is: When an Aggregator includes part of the BRP portfolio into the Aggregator portfolio, offering flexibility to the BRP, to what extent does the Aggregator need to be held accountable for the imbalance in its (smaller) portfolio? In general, the BRP will be better able to bear this responsibility, as the BRP has a bigger portfolio where forecasting errors can be better evened out.

Also a distinction between retail Prosumers and Commercial & Industrial (C&I) Prosumers should be made. Some C&I Prosumers are already accountable for their own imbalance. If the portfolio of an Aggregator consists of C&I Prosumers, it is more likely that the Aggregator will be accountable for the imbalance as this will be passed on to the Prosumer. This Section first focusses on the retail Prosumer (although the earning models B5 and B6 will be more applicable to C&I Prosumers).

Flexibility objective	**Aggregator accountable for meeting its forecast? Arguments in favor (Yes) / against (No)**	
	Yes	No
B1,B2 Portfolio optimization (energy)	Sourcing will only be optimal if forecast is met. Incentive is needed for Aggregator to optimize the quality of its forecast	· Some evening out effects in the portfolio of the BRP · Forecasting may be difficult, especially for smaller portfolios, endangering the business case for the Aggregator.
B3 Passive balancing (energy)	· Important to counter the market position, own position is less relevant. However, the deviation from the forecast will be the measure for the contribution of the Aggregator to the passive balancing, which corresponds to making the Aggregator responsible for its forecast. · No evening out possibilities as this will harm the Aggregators that have been contributing positively.	Forecasting may be difficult, especially for smaller portfolios, endangering the business case for the Aggregator.
T1-T4 All power related services		No direct relation to portfolio balancing, as the BRP's nomination is modified accordingly.

Table 2-1: Arguments to hold the Aggregator accountable for its forecast

2.3.4.3 Recommended Aggregator service models towards BRP

Based on the arguments in the table above, USEF recommends two different service models:

1. Service providing energy flexibility – This service can be used by the BRP for either portfolio optimization or passive balancing. The BRP will hold the Aggregator responsible for its forecast (A-plan), differences between the A-plan and realization will be settled / penalized.
2. Service providing power flexibility –This service can be used by the BRP for either primary, secondary and/or tertiary control, or national generation capacity markets. The Aggregator will not be held responsible for its forecast, although it may be required to generate a forecast (indicative).

2.3.4.4 Settlement of energy flexibility service

This is sometimes referred to as an implicit form of Demand Side Management. This kind of DR has been historically developed by suppliers through price-based signals such as CPP to optimize the sourcing costs of their portfolio, especially during peak periods in winter.
The Aggregator supplies an A-plan in the Plan phase (see Section 2.3.1). This A-plan will be fixed at a certain point in time (in general before the fixation of the E program by the BRP).

- Portfolio optimization (commodity optimization) (B1, B2)
  When the billing of the commodity is based on day-ahead market prices (i.e. based on spot market prices, raised with handling costs and a margin by the supplier), this will automatically include the settlement of the portfolio optimization. The value of the service provided by the Aggregator can therefore not be based on the realization, but should be based on a performance contract (fixed fee per Prosumer per year per device). The value of portfolio optimization is depending on a proper forecast, so penalties may be raised when the forecast is not met.
  When appliances are measured individually, the forecast may be limited to the controllable load (rather than on connection level).
  Commodity optimization is also possible with a traditional tariff structure (e.g. fixed fee), in this case the Supplier sourcing is optimized and the Prosumer is rewarded differently.

- Passive balancing (B3)
  Deviation from the A-plan will be settled against the difference between Spot and imbalance prices[12] (minus BRP margin %). This implies that if the deviation is aligned with the market position, the Aggregator is penalized.

In this case the Aggregator has a very close relationship to the BRP; often the BRP takes on the role of Aggregator. Also the flex transaction cannot be separated from the volume transaction, esp. in case of ToU contracts the flex is implicitly rewarded through the volume effect.

When the Aggregator is offering services to the DSO as well, its activities (load shifting) may affect the BRP's program. Even when the Aggregator is only offering power flexibility to the BRP, the BRP may add an energy settlement component, in order to settle the consequences of the Aggregator's activities (especially after nomination gate closure) for the DSO.

2.3.4.5 Settlement of power flexibility service

This is sometimes referred to as an explicit form of Demand Side Management. It generally implies a control process and specific rules to organize an energy transfer from the seller of the flexibility to the buyer of the flexibility. USEF organizes this transfer by placing the BRP between the Aggregator and the buyer of the flexibility (e.g. the TSO).

The Aggregator may supply an indicative forecast in the Plan phase, this will not be used for settlement purposes.

- Primary control (T1)
  Fixed fee based on minimum or average capacity available
- Secondary control (active balancing) (T2)
  This can consist of two components:
  a. Fixed fee for minimum or average capacity available
  b. Price per unit/hour for flexibility offered to the BRP. Price is based on difference between imbalance prices for ramping up (decrease load) and ramping down (increase load) in case of load shifting, or difference in day-ahead commodity market and imbalance price for ramping up, in case of load reduction.
     As an alternative, the BRP could calculate the average value of active balancing flexibility (per unit per hour), especially since active balancing involves risks that need to be borne by the BRP.
     It should be clear when the flexibility has been applied for active balancing. This cannot be accomplished by comparing with the forecast, but should be established by observing a load discontinuity at the time the flexibility is called.
- Tertiary control (T3)
  Same as (T2), although this could be limited to the fixed fee as the fixed fee will be substantially larger than the volume component.
- National generation capacity markets (T4)
  Similar to (T3). There will be a volume effect that will be beneficial (as energy prices will be high anyhow).

[12] Dependent on the national imbalance pricing regulations

2.3.4.6 Summary of settlement calculations

The process diagram (cf. Figure 2-6) and the corresponding use cases (cf. Section 5.10) are limited to the settlement of the energy flexibility services.

Consequently, two out of five possible settlement components will be elaborated in detail:

a. Portfolio services = P * Q (per PTU) (possibly B1, B2, B3)
   P = Flex market price
   Q = Acquired flexibility (energy) ("Delivered Flex Quantity")
   The Aggregator is rewarded for shifting energy to periods with lower energy prices.
   The price is determined through the flex market, a measure for this price is the price spread between imbalance market prices and spot market prices.
b. Imbalance costs = P * Q (per PTU) (B1, B2, B3)
   P = imbalance price – day-ahead commodity market price
   Q = realization – forecast (energy) ("Imbalance Quantity")
   The Aggregator is penalized for not meeting its A-plan (in other words: for shifting energy to periods with higher energy prices).
   The price is equal to, or derived from the price spread between imbalance market prices and spot market prices.

The other three possible settlement components relate to either a power flexibility service, or to a long term flexibility contract. Therefore these will not be elaborated in detail:

c. Fixed fee for commodity optimization (B1, B2)
   E.g. if the effect of commodity optimization is shared by the supplier/BRP with the prosumer directly through ToU tariffs, a fixed fee may be agreed upon to reward the Aggregator's activities.
d. Fixed fee per power flexibility available (T1, T2, T3, T4)
   E.g. an Aggregator may offer 10 kW flexibility throughout the year. This means that if the BRP requests flexibility offers any day during this year the Aggregator is obliged to place a flexibility bid for (minimum) 10 kW, thus should be able to reduce its load during this period when requested. This way the BRP can ensure that he can meet its contractual obligations towards the market, whilst still using the market mechanism to acquire the economically most advantageous flexibility, as Aggregators without a long-term contract are also allowed to offer flexibility bids.
e. Ancillary services: P * Q (per PTU) (T2, possibly T3, possibly T4)
   P = Flex market price
   Q = power discontinuity * time duration
   For ancillary services, the A-plan is not a strong baseline method, as ancillary services need adjustment of current, real time loads, not adjustments from forecasting schemes. Therefore a different baseline method is needed, showing discontinuity in the load pattern at the time when the DR signal was triggered.
   The price is determined through the flex market, a measure for this price is the price spread between imbalance market prices and spot market prices.

2.3.4.7 Process flow of the flex settlement phase (energy flexibility service)

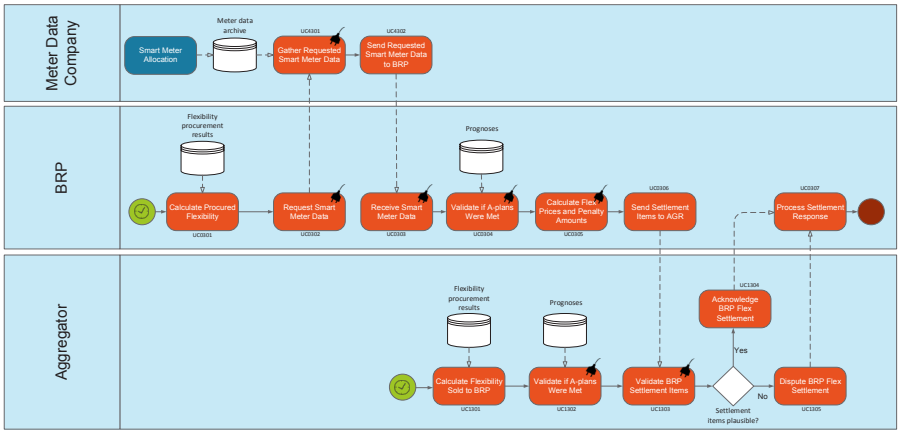


Figure 2-6: Process flow flex settlement between BRP and Aggregator. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

Each month, the BRP will calculate the flex settlement volumes and prices for each Aggregator according to the following steps.

The Aggregator will validate the output applying the same calculations.

1. Calculate procured flexibility
    a. For each PTU , both the volumes and prices of the acquired flexibility are collected
2. Validate if A-plans are met
   This step is performed irrespective of whether flex has been acquired for that specific PTU.
    a. Since A-plans are not modified when the flexibility is acquired in the operate phase, in this step the A-plan is modified with the results of the flexibility acquisition during the operate phase.
    b. By comparing these Agreed A-plans with the allocation data (based on smart meter interval measurements), the BRP determines if the A-plan is met per PTU by determining the differences for each PTU.
3. Consolidate flex settlement volumes and calculate prices
    a. The settlement volumes and prices are calculated, according to the example in Appendix 2.
    b. The results of this calculation are sent to the Aggregator. It shows per month the accumulated delivered flex volume, the accumulated deviation from the agreed A-plan, the accumulated financial settlement amount.
4. Calculate sold flexibility (equivalent to 1)
5. Validate if A plans are met (equivalent to 2)
6. Plausibility check
    a. The settlement volume and price are calculated, equivalent to 3
    b. The results are compared to the settlement message received from the BRP
7. Data plausible?
    a. If the difference in the previous plausibility check is within limits, the Aggregator sends an Acknowledge to the BRP
    b. If the difference exceeds predefined limits, an audit trail is requested from the BRP
8. Generate audit trail
    a. The BRP will supply the detailed calculations of step 3a, by providing
        i. Per flexibility bid accepted the total volume and price per MW per PTU agreed (a flex offer can cover more than one PTU)
        ii. Per PTU the deviation from the A-plan and the penalty raised.
9. Verification of audit trail
    a. The Aggregator will compare the results of its own calculations with the audit trail.
    b. If the audit trail provides sufficient justification for the differences observed in step 6, the Aggregator will send an Acknowledge to the BRP.
    c. If the difference is not justified, the audit trail has shown for which flex acquisition(s) and for which PTU(s) the difference(s) has(have) occurred. The Aggregator can raise a dispute.
    d. This dispute process is not part of USEF, but part of the bilateral arrangement between BRP and Aggregator.

An example calculation of the flex settlement between BRP and Aggregator is included in Appendix 2.

2.3.4.8 Settlement between DSO and Aggregator

The DSO is responsible for settling the flexibility that is has acquired from the Aggregator. Within this settlement, the DSO needs to check whether the acquired flexibility has been delivered according to the agreements. If not, this can lead in certain circumstances to penalties, which is considered an integral part of the settlement process.
This section describes how the supply of flexibility from the Aggregator to the DSO is settled. Several methods are possible, depending on how the flexibility is offered to the DSO, more precisely if the DSO uses the mechanism of long term and short term flex options, and whether these flex options are rewarded, even if they are not exercised. The flex options are described in this informative part, however only the settlement of the acquired (short term) flexibility is included in the normative part. Also passive contribution to constraint management is not included in the normative part.
Calculations are (in general) performed on PTU level, where the settlement is calculated over a one month period.

The settlement consists of five components:

- Settlement of long-term flexibility options
  The DSO may acquire long-term flexibility options to ensure that congestion can be avoided at all times. This may be necessary to justify a decision to delay or defer grid investments, although grid constraints are expected in the (near) future.
  The DSO will determine (e.g. through audits) that the Aggregator is always capable of providing the contracted flexibility (at contracted times).
- Settlement of short-term flexibility options
  When grid constraints are expected during the Validate phase by the DSO, all Aggregators are asked to place flexibility offers. Aggregators whose flex bids are accepted by the DSO, are expected to meet their (adjusted) D-prognosis. It is, however, as important for the DSO that the other Aggregators are also bound to their D-prognoses. To enforce and reward this, the DSO may also accept an option on the flexibility of the Aggregator, even if the bid is not accepted, to ensure the Aggregator will not jeopardize grid constraints by invoking its flexibility for other purposes. The DSO will pay the Aggregator for the option, as this will put a constraint on the total capacity of the Aggregator's portfolio.
- Settlement of acquired flexibility
  The DSO will acquire flexibility through the market mechanism if congestion is expected, either ahead of time (Validate phase) or real-time (Operate phase). The market price is determined by the equilibrium of demanded and offered flexibility.
- Settlement of deviations from D-prognoses
  Aggregators that have sold flexibility to the DSO need to limit their capacity to the value stated in the D-prognosis, reduced with the sold flexibility. A penalty is raised for each PTU where the agreed capacity has (on average) been exceeded. The penalty is single sided, meaning that the Aggregator is allowed to deviate from its D-prognosis as long as the deviation contributes in avoiding the grid constraint.
- (Optional) settlement of passive contribution to constraint management
  Aggregators that passively support the management of grid constraints, either by staying below the agreed value expressed in the flexibility option, or by reducing more power than agreed in the exercised flexibility bid. This is specifically relevant if constraints have been resolved by passive contributions, whereas other Aggregators have exceeded the agreed capacities.
  In this case the passive contribution can be rewarded by the raised penalties (zero sum calculations).

The settlement method implicitly assumes that each Aggregator has the motivation and capacity to produce D-prognoses with a high quality.

2.3.4.8.1 Settlement calculations

The process diagram (cf. Figure 2-7) and the corresponding use cases (cf. Section 5.10) are limited to the settlement of the acquired flexibility and the settlement of the deviations from the D-prognosis.

Consequently, two out of five possible settlement components will be elaborated in detail:

a. Fee for acquired flexibility (exercised flexibility options) = P * Q
   P = flexibility fee
   Q = power called ("Delivered Flex Quantity")
   The flexibility fee is determined by the equilibrium of demanded and offered flexibility (flexibility market).
b. Excess penalty = P * Q
   P = excess penalty (asymmetrical, only applied when deviation has contributed to congestion)
   Q = allocation – D-prognosis – power flexibility called in Operate phase ("Power Deficiency Quantity")
   where ***allocation*** is the average realized power during the PTU.
   This penalty only applies to Aggregators that have sold flexibility (for this PTU), and corresponds with not meeting the agreements of the flexibility bid.

The other three possible settlement components relate to either the settlement of flexibility options, or the settlement of passive contribution. Therefore these will not be elaborated in detail:

c. Fixed fee per power flexibility available (long-term contract)
   E.g. an Aggregator may offer 10kW flexibility during 5:00 and 7:00 PM throughout the year. This means that if the DSO requests flexibility offers any day during this year during a PTU within this time frame, the Aggregator is obliged to place a flexibility bid for (minimum) 10kW, thus should be able to reduce its load during this period when requested. This way the DSO can ensure that constraints can be solved, whilst still using the market mechanism to acquire the economically most advantageous flexibility, as Aggregators without a long-term contract are also allowed to offer flexibility bids.
   The DSO will pay compensation for the long-term flexibility contract in proportion to the agreed power, the duration of the time slot, the nomination lead-time and the duration of the contract.
   Fixed fee is derived from:
   - The costs for allowing thermal limitations to be violated;
   - The avoided costs for grid reinforcements;
   - The value of flexibility for alternative uses;
   - The costs of alternative flexibility options.

d. Fee for flexibility options = P * Q
   P = flexibility option fee
   Q = power option
   In this settlement component an Aggregator can be rewarded for participating on the flexibility market through short term products. Rationale for relating the flexibility option settlement to the capacity offered is that an option to cap the capacity of an Aggregator twice the size of another Aggregator, has twice the value to the DSO.
e. Passive contribution = P * Q
   P = contribution fee (asymmetrical, only applied when deviation has relieved congestion). Derived from excess penalties raised.
   Q = allocation – D-prognosis – power flexibility called during Operate phase where ***allocation*** is the average realized power during the PTU.

2.3.4.8.2 Process flow of the flex settlement phase

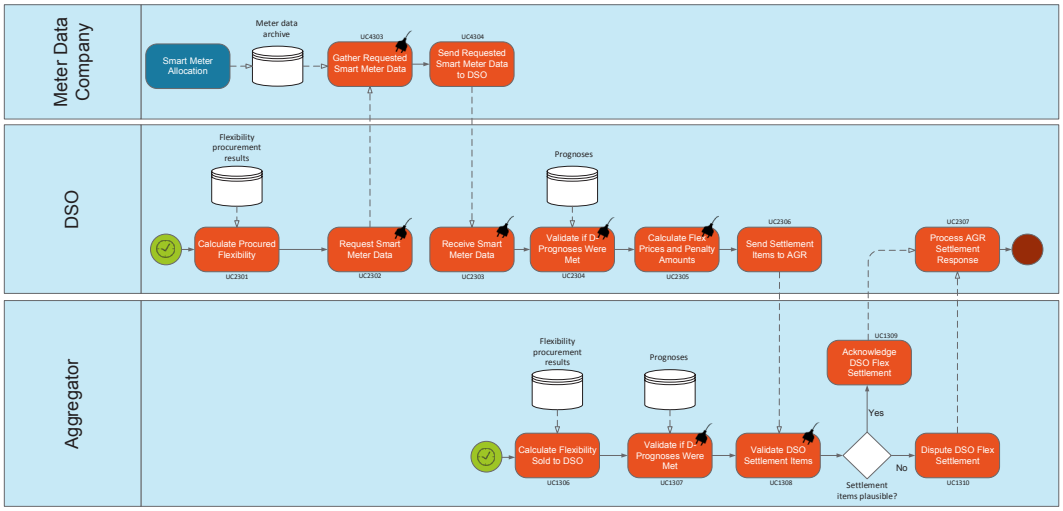


Figure 2-7: Process flow flex settlement between DSO and Aggregator. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

Each month, the DSO will calculate the flex settlement volumes and prices for each Aggregator according to the steps below. The Aggregator will validate the output applying the same calculations.

1. Calculate procured flexibility
   a. For each congestion point and for each PTU, both the volumes and prices of the acquired flexibility are collected
2. Validate if D-prognoses are met
   This step is only performed if flexibility has been acquired for that specific Aggregator, congestion point and PTU.
   a. Since D-prognoses are not modified when the flexibility is acquired in the Operate phase, in this step the D-prognosis is modified with the results of the flexibility acquisition during the Operate phase.
   b. By comparing these final D-prognoses with the allocation data (based on smart meter interval measurements), the DSO determines if the D-prognosis is met per PTU per congestion point by determining the differences for each PTU.
   c. When more than one flex offer has been accepted for the same PTU, the validation of the D-prognosis for this PTU is only applied to the most recent flex offer.
3. Consolidate flex settlement volumes and calculate prices
   a. The settlement volumes and prices are calculated, according to the example in Appendix 2.
   b. The results of this calculation are sent to the Aggregator. It shows per month the accumulated settlement volume, the accumulated deviation from the agreed D-prognosis, the accumulated settlement price (accumulated over the PTUs and the congestion points).
4. Calculate sold flexibility (equivalent to 1)
5. Validate if D-prognoses are met (equivalent to 2)
6. Plausibility check
   a. The settlement volume and price are calculated, equivalent to 3
   b. The results are compared to the settlement message received from the DSO
7. Data plausible?
   a. If the difference in the previous plausibility check is within limits, the Aggregator sends an Acknowledge to the DSO
   b. If the difference exceeds predefined limits, an audit trail is requested from the DSO
8. Generate audit trail
   a. The DSO will supply the detailed calculations of step 3a, by providing
      i. Per congestion point per flexibility bid accepted the total volume and price per PTU agreed (a flex offer can cover more than one PTU)
      ii. Per congestion point per PTU the deviation from the D-prognoses and the penalty raised.

9. Verification of audit trail
    a. The Aggregator will compare the results of its own calculations with the audit trail.
    b. If the audit trail provides sufficient justification for the differences observed in step 6, the Aggregator will send an Acknowledge to the DSO.
    c If the difference is not justified, the audit trail has shown for which congestion point, for which flex acquisition(s) and for which PTU(s) the difference(s) has (have) occurred. The Aggregator can raise a dispute.
    d. This dispute process is not part of USEF.

An example calculation of the flex settlement between BRP and Aggregator is included in Appendix 2.

2.4 Interface descriptions

The MCM process model introduces several information flows between actors in USEF, necessary for the processes and interactions in USEF to function properly. Specifically, USEF describes the structure of the Congestion Point (Section 2.4.1), the A-plan (Section 2.4.2), and the D-prognosis (Section 2.4.3). Also, the interfaces used for the flexibility trading processes are described (Section 2.4.4). Providing these specifications allow the information exchange between Aggregator, DSO and BRP to take place in a standardized way. Please note that the A-plan and the D-prognosis use the same data structure (Section 6.4.14) as a basis for implementation. The actual implementation specifications (i.e. how to make an A-plan or D-prognosis from this data structure) are described in the relevant use cases. This section does describe the rationale for the applications of the various data structures.

2.4.1 Congestion Points

A Congestion Point is a set of connections, which are (directly) related to that part in the grid where the grid capacity might exceed – for instance the secondary side of an LV transformer. In other words, on a Congestion Point the grid capacity is not always sufficient to distribute the requested amount of energy. Please note that a Congestion Point is ***not*** a part in the grid where congestion actually takes place, it is a part in the grids where congestion ***may possibly*** occur. It is up to the DSO to determine Congestion Points.

Recommended practice:
How to determine which grid points are congestion points is up to the DSO and therefore out of scope of USEF. However, USEF recommends declaring congestion points at the lowest possible level in the grid as this allows for detailed insight of local congestion while simultaneously, through aggregation, safeguarding the reliability of the grid safety analysis[13].

2.4.1.1 Structure of the Common Reference

As shown in the process flows, a DSO declares its Congestion Points in the Plan phase. An Aggregator must be able to retrieve information about these points, in particular a list of those Congestion Points it represents customers on, so it can take this information into account when optimizing its portfolio. Moreover, an Aggregator needs this information in order to fulfil its obligation to provide D-prognoses to the DSOs operating the Congestion Points where it represents customers.

Since a Prosumer can switch to another Aggregator, and since the existence of Congestion Points in the grid changes over time, USEF introduces a Common Reference. The Common Reference contains a list of connection identifiers (for example EANs) for each Congestion Point, as registered by the participating DSOs. Each Aggregator also registers on which connections it represents Prosumers. This Common Reference is shared between all parties involved, in a way that the Privacy and Security principles [4] are respected. This implies, among other things, that only the information that needs to be shared is included in the Common Reference. The Common Reference is operated by the Common Reference Operator role. Conceptually, it contains the entities and relationships shown in Figure 2-8: Logical structure of the Common Reference**.**

[13] According to Van Oirsouw [50], reliability of the forecast is proportional to the amount of connections taken into account. In other words: the more connections are in a congestion point, the better the DSO can determine whether congestion will occur at that congestion point

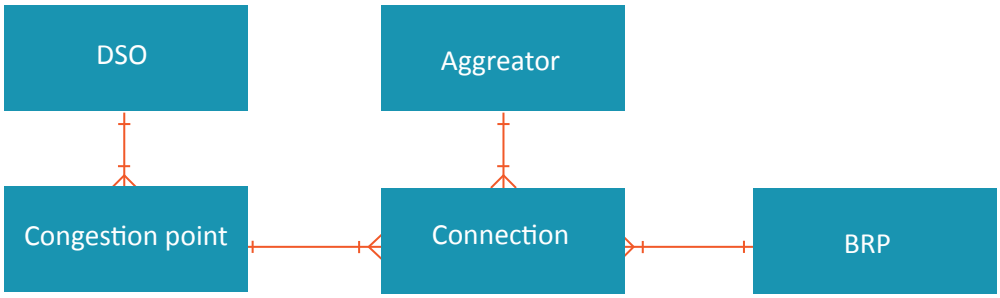


Figure 2-8: Logical structure of the Common Reference

A Common Reference must include at least all connections related to a single Congestion Point, which would lead to multiple Common References per DSO. From a practical point of view it is logical to include all Congestion Points of a DSO in a single Common Reference, or even extend the scope to national or European grid level.

Recommended practices for the use of a Common Reference:

- USEF recommends to broaden the scope as much as possible (on national or even European level), in order to enlarge the possibilities for the development of market forces.
- USEF also recommends using time-slices to keep track of changes in the Common Reference, taking into account retention times as stated in [4]. This serves to keep the history of the Common Reference available in case of disputes, but also to be able to register future changes. For example a DSO might announce that starting next week a new Congestion Point will form.

The Common Reference is updated and queried using the CommonReferenceUpdate and CommonReferenceQuery messages described in the message catalog (Section 6.4). More details on the update process are included in the use case Declare Congestion points in Section 5.5.1.

2.4.1.2 Accessibility of the data in the Common Reference

Access to the Common Reference data is limited by legal or contractual requirements of the various parties consulting it[14]. This implies that a DSO can only see the data for the connections it is responsible for. Consequently, it can see which Aggregators are serving the connections in order to assure that the D-prognoses of a congestion point are submitted by all Aggregators serving connections related to that specific congestion point.
The Common Reference is not a marketing instrument and safeguards both Prosumer privacy and DSO security requirements. Aggregators can only see the information on all Congestions Points for which they serve connections. In addition, they can retrieve the number of connections per Congestion Point. Implementing the Common Reference this way ensures that the DSO does not need to share details of its grid topology, since the DSO only shares details about Congestion Points.
Similarly, the BRP and the Supplier can only see which Aggregator is active on their connections. This implies that the Common Reference Operator needs access to the already existing connection register in order to determine which connections are served by the BRP / Supplier.

[14] Another option is to treat the Common Reference as open data, implying that everyone can access the data in the Common Reference. Although the open data model can ease the implementation of the Common Reference, the acceptance of such a model by the Prosumers is highly dependent on the culture in the geographical area the model is used.

2.4.2 A-plan

2.4.2.1 Structure of the A-plan

In the Plan phase, the Aggregator exchanges information with the BRP about the energy that the Prosumers served by the Aggregator are expected to consume or produce. This information is exchanged using the Aggregator plan or ***A-Plan***.
The A-plan is implemented using the Prognosis data structure, described in Section 6.4.14. See also the (Re-)Create A-Plan use case in Section 5.5.12.

2.4.2.2 Rationale behind structure of the A-plan

The structure of the A-plan has been designed taking into account the following considerations.

2.4.2.2.1 Level of detail of the A-plan

In the A-plan, at least the amount of energy consumed/produced per PTU must be recorded, comprising of an aggregation of both controllable load (i.e Active Demand & Supply) and non-controllable load per connection.
Although including additional information in the A-plan is beneficial for the convergence in the Plan phase, it might have a downside as well. To create a healthy market around the flexibility to be traded, both parties involved – Aggregator and BRP – should have an acceptable share of the gains. Taking into account that from the Aggregator perspective, the BRP active at the connection is needed for commodity optimization, providing the available flexibility including the price to be paid for it in advance makes it easier for the BRP to optimize its profit at the expense of the Aggregator. Moreover, selling flexibility is the core business of an Aggregator. Therefore, the Aggregator is recommended to provide as little information as possible about its business details.
To summarize:

- It is sufficient for the Plan phase to only provide the energy consumption and production per PTU in the A-plan;
- The A-plan comprises both controllable and non-controllable load per connection;
- The identifier of both Aggregator and BRP are included, as well as the date and iteration number;
- The Aggregator does not include details about flexibility or prices.

2.4.2.2.2 Acceptance of the A-plan by the BRP

The BRP checks the validity of the A-plan based on three rules:

- Syntax: does the format of the A-plan adhere to the USEF specification
- Semantics: does the content of the A-plan comply with the business rules
- Timing: is the A-plan received before the gate closure

This process can have two possible outcomes; 'accepted' and 'rejected'. In case the A-plan adheres to all three rules, the BRP sends an acceptance message to the Aggregator. A rejection message is sent when one or more of the rules are not passed (syntax, semantics or timing). The BRP will let the Aggregator know on which grounds the A-plan has been rejected. The BRP cannot reject an A-plan on other grounds than these three rules. In case the A-plan is rejected the latest accepted A-plan remains valid until the Aggregator sends a new and correct A-plan.
One of the reasons for sending a new A-plan is that the BRP has ordered flexibility. It is however possible that the new A-plan does not reflect the ordered flexibility for whatever reason. In that case the A-plan is still accepted, assuming the A-plan conforms to the rules described above. The BRP may add information in the acceptance message whether or not the agreed flexibility is included in the A-plan. This is an optional step that aids detecting discrepancies in the administration of FlexOrders on both sides. There is however no direct consequence for not correctly incorporating a FlexOrder in an A-plan.

2.4.3 D-prognosis

2.4.3.1 Structure of the D-prognosis

In the Validate phase, the Aggregator creates a D-prognosis per pre-defined congestion point, in which the energy per timeslot that needs to be distributed is recorded. The DSO uses the D-prognoses, and where applicable the estimated capacity needed for the connections without an Aggregator, to check whether or not congestion will occur in the defined congestion points. In case the energy to be distributed during one or more timeslots exceeds the capacity of a grid component, the DSO requests flexibility in order to reduce the peak load.

The D-prognosis is expressed using the Prognosis message, described in Section 6.4.14. See also the (Re-)Create D-prognoses use case in Section 5.6.1.

2.4.3.2 Rationale behind structure of the D-prognosis

The structure of the D-prognosis was designed taking into account the following considerations:

- The timeframe of a D-prognosis is 24 hours (i.e. one day), divided into equal timeslots.
- The distribution grid has a hierarchical structure. Therefore, it is possible that a single connection is related to multiple congestion points – on feeder level, distribution transformer level, and substation level. In that case a D-prognosis is only needed at the lowest hierarchical congestion point.
- During the processes in the Plan and Validate phases, the D-prognoses can change. Therefore, it must be possible to exchange D-prognoses iteratively, both in the day ahead and the intraday process. It must be possible to track these iterations, including the status of the iteration (initial, in progress, validated).
- Aggregators operating in parts of the grid with congestion points have an obligation to provide their D-prognoses to the DSOs. This to obtain the most accurate prognosis for the grid capacity at the congestion point, which is the basis for the DSO's decision whether to request flexibility.
- Congestion can occur due to either too much consumption or too much production. Therefore, the D-prognosis comprises both local consumption and local production of energy;
- The D-prognosis comprises both controllable load (i.e. Active Demand & Supply) and non-controllable load per connection.
- An Aggregator can have customers in different parts of the grid. Therefore, one Aggregator may have to send multiple D-prognoses to one DSO;
- The connections related to a congestion point can be served by different Aggregators. Therefore, the DSO may receive multiple D-prognoses per congestion point.

Recommended Practice:
Concerning the granularity of the timeslot in the D-prognosis, USEF recommends using PTUs. This recommendation follows from two main considerations.

First, the reliability of the forecasted power (e.g. kW) and energy use (e.g. kWh) depends on the granularity of the timeslot. On the one hand, the timeslot in the D-prognosis must be small enough to get a reliable insight in the capacity needed – the longer the time, the higher the risk that the actual peak load is averaged out. On the other hand, a bigger timeslot provides a more reliable forecast of the energy consumption. In other words, the reliability of the forecast of the power is negatively correlated to the length of the timeslot, the reliability of the forecast of the energy is positively correlated to the length of the timeslot.

Secondly, since the D-prognosis has a relation with the A-plan, the T-prognosis and the E-program, the granularity of these information structures should fit. The A-plan is recommended to use the PTU as the unit of time, while the T-prognosis use a time basis of *n* times the PTU. In order to realize a fit, it is therefore required to apply a time basis T = PTU/n for the D-prognosis, with *n* a positive integer.

2.4.4 Interfaces for flexibility trading

Flexibility is offered by the Aggregators to the DSO and the BRP. This Section describes the exchange of information that is needed when flexibility is requested, offered and accepted between the Aggregator, DSO and BRP. These processes are described in the Plan and Validate phases of the MCM.

Before the market process between Aggregator and DSO is described, a distinction must be made between congestion points and expected congestion. A congestion point is a defined point where the DSO expects to have grid capacity issues in the (near) future. Expected congestion is the congestion at that congestion point that might occur in case no measures are taken during certain PTUs.

For an Aggregator, the congestion points provide information whether or not it is interesting to approach customers; only in areas where congestion points exists an Aggregator can generate revenue from selling its Prosumers' flexibility to the DSO. The information about expected congestion is needed for the Aggregator to offer the flexibility it can provide to a DSO during the Validate phase.

2.4.4.1 Flexibility request

The flexibility request can be used by both the DSO and the BRP to request flexibility offers. If a DSO expects congestion at a specific congestion point, as a result of a grid safety analysis, USEF introduces the possibility for the DSO to procure flexibility with Aggregators to solve the expected congestion. The procurement of flexibility starts when a flexibility request is sent. This section describes the specification of the flexibility request by the DSO and BRP.
USEF specifies that when sending a flexibility request, the DSO provides the following information about expected congestion:

1. **Information about expected congestion is provided to all registered Aggregators:** The reduction needed must be available at least for all Aggregators operating in the specific congestion area, due to the legal obligation of the DSOs to treat all market parties in a non-discriminatory way. The grid topology however is considered to be confidential information. **Therefore, USEF recommends that information about expected congestion is not provided freely to the entire market on a national level.**
2. **Information about expected congestion includes the reason for overload (production/consumption):** A grid overload on a congestion point can occur by either too much production or too much consumption. To reduce overload in case of too much production, either the production must be reduced, or the consumption must be increased. For overload in case of too much consumption, this is just the other way around (increase production or decrease consumption). This implies that from the congestion information provided it must be clear what is the cause of the overload.
3. **Information about expected congestion includes the amount of reduction needed.** Taking into account the need to know principle, there is no need for the DSO to provide information about how much reduction is needed; it is sufficient to only provide information that a reduction is needed for a certain PTU. However, considering the public task of the DSO, the information about the amount of reduction needed may be considered as public information. Providing more information is likely to result in a more optimal use of flexibility and therefore better usage of the grid.
4. **Information about expected congestion includes available grid capacity for other PTUs.** Giving insight in the available grid capacity for the PTUs without congestion provides the Aggregators with additional information that can be used in providing their flex offers. In addition, it reduces the likelihood the load shift provided by the Aggregators creates a new peak that overloads the grid, and thus is likely to converge quicker, making the time needed to align a D-prognosis shorter. Whether or not this time needed is mainly depends on the number of congestion points a DSO has defined. On the downside, the more information is provided by the DSO, the easier it is to get insight in the entire grid topology, especially for crucial points in the grid.

USEF specifies that when sending a flexibility request, the BRP provides the following information:

1. **Information about the expected increase or decrease in load per PTU.** Similar to the DSO, the BRP can use the flexibility request to inform the Aggregators within its portfolio about the amount of flexibility required. Please note that not all PTUs are filled in mandatory, nor is it required to inform the Aggregators about the available room in other PTUs.
2. **If no information about available room in other PTUs is provided by the BRP, it is up to the Aggregator to offer where the load can be shifted to**. It is also possible to offer an increase or decrease in load only; in this case the load is not shifted to another PTU.

Detailed specifications of flexibility request message can be found in Section 6.4.17.
The need for flexibility may vary over time and for a DSO also over location, and components in the grid are connected hierarchically.

This implies that, whenever new information is available to the DSO and BRP (e.g. an Aggregator sends a new Aggregator plan or D-prognosis), the BRP and DSO can send a new flexibility request.

2.4.4.2 Structure of the biddings

A structure for the biddings is chosen that allows the Aggregator to offer flexibility to the BRP and DSO. Within this message structure the Aggregator can offer two types of flexibility:

1. A reduction or increase in load for one or multiple PTU's (eg load shedding or increase of production)
2. A reduction or increase in load for one or multiple PTU's combined with the inverse effect on other PTU's (e.g. load shifting)

The following messages are used:

- FlexOffer;
- FlexOrder,
- FlexOfferRevocation.

First the FlexOffer message is send from the Aggregator to the DSO or BRP to offer flexibility for sale. It contains the flexibility (essentially a positive or negative volume per PTU) and the price for the flexibility. Further details on the message are presented in Chapter 6.
The FlexOrder message is used by USEF for buying the flexibility from to the Aggregator. It has a close relation with the original FlexOffer message. The FlexOrder is used to signal the acceptance of the offer. If the Aggragator wants to withdraw a FlexOffer before it has been accepted the FlexOfferRevocation message is used.

For the exchange of information in relation to the bidding process, USEF specifies the following rules:

- When using the FlexOffer and FlexOrder messages, the interval duration step should be set to one PTU. This ensures that the time intervals of all flexibility offers match with each other and with the national balancing regime.

For the exchange of information in relation to the bidding process, USEF proposes to apply the following recommended practices:

- If the Aggregator wishes to make multiple offers to the BRP or DSO he risks that both offers are accepted. Additional rules on how to deal with this situation can be part of the bilateral contract between those parties.
- The exact timing restrains for the complete day-ahead and intraday bidding processes need to be determined upfront but should not be dictated by USEF. USEF recommends allowing at least 1 hour for offers to be made, and 30 minutes for the DSO or BRP to call on these offers in both the intraday and day-ahead processes.

2.5 Implementation Guidelines

This section described some guidelines for the implementation of USEF, as well as options for the further development of the flexibility market. Please note that these guidelines are not part of the USEF specifications, they are merely a suggestion or recommended practice for parties that intend to implement USEF. In a future version of USEF, the guidelines might become part of the specifications.

2.5.1 Aggregator portfolio

An Aggregator needs an in-depth insight on a day-to-day basis about the flexibility it has available for offering to the BRP and the DSO. For this insight detailed information about the flexibility each Prosumer that the Aggregator serves can provide is required. This information is stored in the Aggregator portfolio, which is used for creating the A-plan and the D-prognosis on one hand and for the realization of the flexibility on the other hand.
Also, the Aggregator portfolio is used as a basis for optimization purposes. First portfolio optimization of the Aggregator is based on the Aggregator portfolio. Secondly, in-home optimization and aggregator performed by the BEMS is based on the Aggregator Portfolio. Please refer to Section 6.5.1 for more details.

2.5.1.1 Granularity of the information

With regard to the granularity of the information (time dimension and aggregation dimension) in the Aggregator portfolio, USEF recommends the following:

- **PTU is used as unit for the time dimension.** Using a more granular unit results in less reliable values for the expected energy consumption, while using a less granular unit omits the information needed to exchange information with the other USEF roles, especially the BRP which is using the PTU as timeslot in trading energy on the national energy market.
- **Information is stored per individual smart device**. For the aggregation level dimension, information can be stored per individual smart device, per household or even a higher aggregation level. In case information is stored for individual devices, an Aggregator knows exactly what flexibility it has available for offering to the BRP and or DSO. In addition, it can use the information to actually realize the flexibility it has offered. The downside of storing these granular data is related to privacy – the detailed information can be misused for profiling the individual customers. In case an Aggregator wants to store the granular information, it must have at least consent, better to this included in the contract between Supplier and Prosumer.

2.5.1.2 Information stored in the Aggregator Portfolio

USEF recommends that the following type of information is stored in the Aggregator Portfolio:

- The energy consumption and/or production per device
- The flexibility available per device
- The energy consumption and/or production per device is needed for creating the A-plan and the D-prognoses. Since the A-plan and the D-prognosis contain information about the energy volumes per connection, also storing information about the consumption/production of connection (i.e. including non-smart devices) is recommended.
- With regard to the flexibility per device, at least the amount of energy that can be shifted and/or reduced is needed to determine the amount of flexibility available. Besides that, additional information might be needed. In this, a distinction must be made between information needed to forecast the flexibility – like weather conditions or customer behavior – and the information about the actual flexibility. Only the latter is within the scope of USEF and therefore discussed here.
- Flexibility related to a single entity (smart device, household, etc.) can be seen as a deviation from an initial plan (i.e. forecast). This implies that the information related to the flexibility must contain both the initial plan and the possible deviations. USEF does not provide any recommendations how to determine the initial plan and the possible deviations.

2.5.2 Congestion information provided after the market process

After the flexibility bids are provided by the Aggregators, a DSO calls for the best fitting bid(s) for the accumulated D-prognosis. The actual flexibility that the DSO has purchased can be published including the average price paid for the flexibility[15], in order to provide transparency to the market.

Recommended Practice:
This information can be published per DSO after the day-ahead/intraday process has finished. USEF recommends that the accepted flex bids are published by the DSO in an anonymized way.

[15] This is provided for informational use only – the settlement is based on the actual price agreed upon, which is confidential information.

2.5.3 Further development of the flexibility market

USEF sees several options for further development of the flexibility market as described in the previous sections. The options that will be explored for future versions of USEF include:

- Introduction of a Market Operator to facilitate trading between Aggregators, BRPs and DSOs;
- Buy-back options for flexibility deals;
- The possibility of the TSO to procure flexibility in order to solve congestion on in the transmission grids.
- The possibility to work with reference load curves instead of prognosis.
- The further integration of existing TSO flexibility products into the flex market.

3 Wholesale Processes

A key element of USEF is to disclose demand side flexibility, and to create value either in energy markets or in grid operations. USEF introduces the Market-based Coordination Mechanism to allow both value creation models, however the current wholesale market design in most European countries is obstructing the flexibility with small consumers / prosumers to access wholesale markets. In this section, modifications to the wholesale processes are described, which are a prerequisite for USEF. They are therefore not part of the Settlement phase of USEF.

This chapter also describes the (positive) impact of these modifications to the energy balance and financial balance of the key stakeholders.

3.1 Scope

This chapter describes the modifications to the wholesale processes, which are a prerequisite for the implementation of USEF. The main modifications are needed within the allocation and reconciliation / settlement processes, to allow small Prosumers to be allocated based on actual consumption, rather than synthetic profiles. The accompanied changes to the energy balance and financial balance of the key stakeholders are also provided in this chapter.

3.2 Process modifications

The wholesale processes allocation and reconciliation need to provide retail (non-telemetric) customers access to wholesale markets by allocating their connections based on the actual (measured) consumption. For this purpose daily interval meter reads (15 minutes) are required, which can be supplied by a smart meter infrastructure (the smart meter is therefore a prerequisite for USEF). The allocation of retail customers based on smart meter interval data is denoted by the term ***smart meter allocation***. The settlement is referred to as ***wholesale settlement,*** which renders the reconciliation process redundant for this segment.
The basic premise of the design is to keep the modifications to current wholesale market processes as limited as possible. As wholesale market processes differ between European countries, the main focus is on the process flow, where small deviations may occur due to regulatory conditions with respect to roles and responsibilities.
Allocation of retail customers can be very similar to the allocation of large commercial and industrial (C&I) customers (i.e. based on actual measured consumption/production per PTU); however some differences should be taken into account:

- The service levels of smart metering are different from the service levels for C&I measurements, therefore the process design should take a possible lower data quality (esp. incompleteness of smart meter data) into account.
- The volume risks due to incomplete or incorrect measurements are significantly lower, which allows for a lower data quality (costs of data quality should be balanced).
- The number of retail Prosumers has a far higher order of magnitude than the number of C&I Prosumers. To prevent large amounts of data to be transferred repeatedly between market parties, aggregation of data is required early in the process chain.
- Privacy issues may emerge when individual consumption data is distributed between and stored at different market parties. Again aggregation of data early in the process chain may resolve this issue.

The current process for retail customers, where allocation is based on static, synthetic profiles, will not become obsolete, but will coexist with smart meter allocation to allow customers a choice between the current single or double tariff structures, and dynamic tariffs based on smart meter allocation. This also allows for a gradual implementation.

3.2.1 Nomination

As the nomination process occurs on an aggregated level (the portfolio of the BRP), this market process is not affected by the inclusion of smart meter data. However, the forecast or plan process that provides input to the nomination can be highly affected. This is described in the **Plan** process (cf. Figure 5-2: process flows of Plan phase).

3.2.2 Allocation

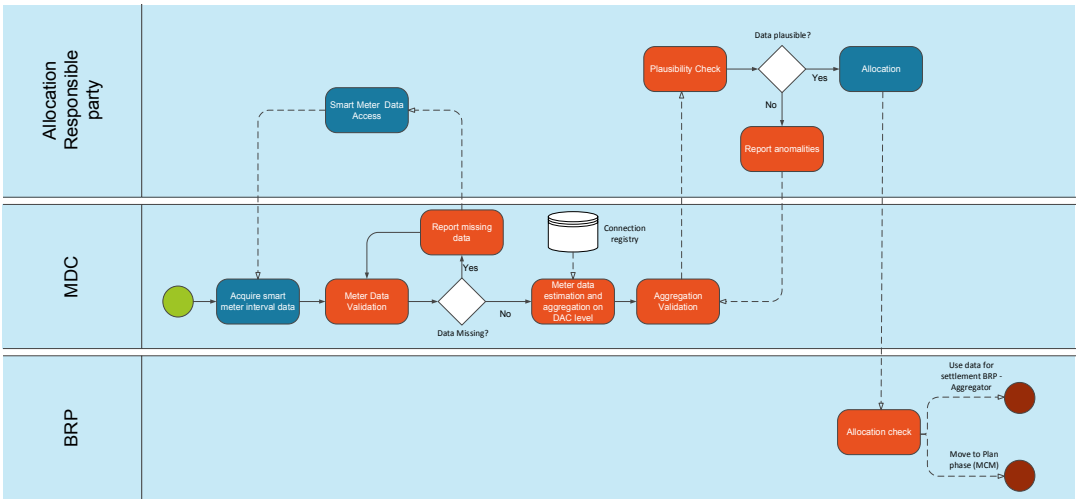


Figure 3-1 : Allocation process diagram. New processes are depicted in red, existing processes are depicted in blue.

1. The daily allocation process starts on D+1 with the collection of smart meter data by the Meter Data Company (MDC). Data is acquired through the smart meter infrastructure, which is (in general) operated by the DSO.
2. The MDC performs several predefined validations.
3. Missing data is re-queried by the MDC.
4. The MDC aggregates the interval data (PTU) per BRP, per supplier, per Aggregator, per grid area[16] for the connections that need to be allocated on the actual (measured) consumption per PTU. This aggregation is called a Dynamically Allocated Cluster (DAC), it represents the summed load (on connection level) of all Prosumers participating in this cluster and can be considered as one virtual (C&I) connection.
5. If the re-queried data is still unavailable, it will be extrapolated within the DAC, proportional to the Standard Annual Usage (SAU) of the missing connection(s) relative to the total SAU of the DAC. This is done at the aggregated (DAC) level as the individual level is not needed in the allocation process.
6. After validating, the MDC will send the aggregation interval data to the Allocation responsible Party (ARP) as input for the allocation process.
7. The ARP performs a plausibility check on this profile prior to including it in the allocation calculations.
8. The remaining allocation process needs little modification. The ARP excludes the connections that are part of a DAC from the synthetic allocation process, which implies that the connection register should administer if a connection is part of a DAC and if so, to which DAC. The DAC profile will be treated as a regular C&I connection profile in the allocation process.
9. The ARP sends the final allocation of each DAC to the responsible BRP. The BRP performs a validation of the allocation, which it may outsource to the MDC as the MDC has detailed metering data at its disposal.
10. The allocation data provides input both for the settlement process with the Aggregator and for the ***Plan*** process where it can be used for forecasting. The allocation process provides input to the TSO for the imbalance settlement. As this process is not affected it is not shown in the diagram, nor described.

3.2.2.1 Relation to flex settlement

The aggregated allocation data is input for the flex settlement processes.

[16] The ***grid area*** aggregation is included to comply with current practices in many EU countries. If allocation is performed on national level, this aggregation can be removed as there is no relation to grid constraints (areas).

3.2.2.1.1 Flex settlement between BRP and Aggregator

- Since the Aggregator is one of the aggregation levels in the allocation process, the BRP can perform its settlement calculations based on the allocation data per BRP per Aggregator, accumulated over the grid areas and suppliers.
- Since not every customer / connection will be part of an Aggregator's portfolio, the BRP will serve as the default Aggregator of every connection within its portfolio, ensuring that the segmentation of all connections in BRP, Supplier, Aggregator and grid area is complete and disjunct.

3.2.2.1.2 Flex settlement between DSO and Aggregator

- Since the collection of connections associated with congestion points, is only a small subset of all connections, and given the dynamic character of congestion points, USEF proposes not to add the congestion point as a fifth aggregation level to the allocation process.
- USEF recommends considering the allocation process related to congestion points as a special service of the MDC to the DSO (responsible for the flex settlement process).
- Parallel to the allocation process described below, the allocation per congestion point will be determined as follows
  - Based on the Common Reference, the smart meter interval data of all connections associated with the congestion point will be collected
  - Incomplete and invalid data will be handled, consistent with the main allocation process.
  - The aggregated volumes (per BRP, per Aggregator, per Congestion Point, per Supplier) will be sent (on request) by the MDC to the DSO
  - The DSO needs to finish the allocation process before the MDC can compose the allocation aggregation related to the congestion points.
  - In this way, the DSO in its role as flex settlement operator, does not require interval data on Prosumer level.

3.2.2.1.3 Flex settlement between Aggregator, Supplier and Prosumer

Different options exist for the flex settlement towards the Prosumer. The specifications are dependent on the bilateral agreements between the Aggregator, the Supplier and the Prosumer. Smart meter allocation as described above could be the basis for the settlement towards the Prosumer. USEF does not prescribe settlement options, this is left as choice for the Aggregator, allowing him to build attractive propositions.

It should be noted, however, that additional data exchange is needed if the Prosumer settlement is based on imbalance prices combined with a capacity based flex remuneration. In the current energy system a portfolio-based correction is made to exclude capacity based flexibility calls from the commodity based settlement process. This is done to ensure that flex is remunerated in the commodity settlement or in the capacity settlement, but not both at the same time. If Prosumers settlement is directly based on a combination of capacity and commodity elements a similar correction of the settlement data is needed at Prosumer (EAN) level. This data then needs to be provided by the Aggregator, adding significantly to the complexity. To ensure a uniform processing of this correction an independent party would need to facilitate this process for the whole market.

3.2.2 Wholesale Settlement between BRPs

Replacing the reconciliation process for profiled customers, the monthly wholesale settlement process is performed by the ARP in the role of market facilitator. The TSO is responsible for the financial settlement, however as no modifications are foreseen in the financial administration, the role of the TSO is not included in the diagram. Focus in this description is the calculation of the settlement volumes for Prosumers participating in smart meter allocation.
There are two reasons for defining a wholesale settlement process for Prosumers participating in smart meter allocation:

1. In the design incompleteness of smart meter data is not considered an exception, but part of the regular process. Therefore an estimation (in fact extrapolation) process is defined to manage this incompleteness. Volume differences between estimations and measurements will be settled in this monthly process.
2. Depending on the market organization, energy volumes that cannot be allocated directly (i.e. based on actual measurements) may be allocated (socialized) to retail customers through a Measurement Correction Factor (MCF). The allocation process, as described in the previous section, does not apply the MCF to the DACs but only to the remaining profiled connections, since

the DACs rely on actual measurements. However if the MCF needs to be applied due to regulations, a settlement is needed for this reason as well.

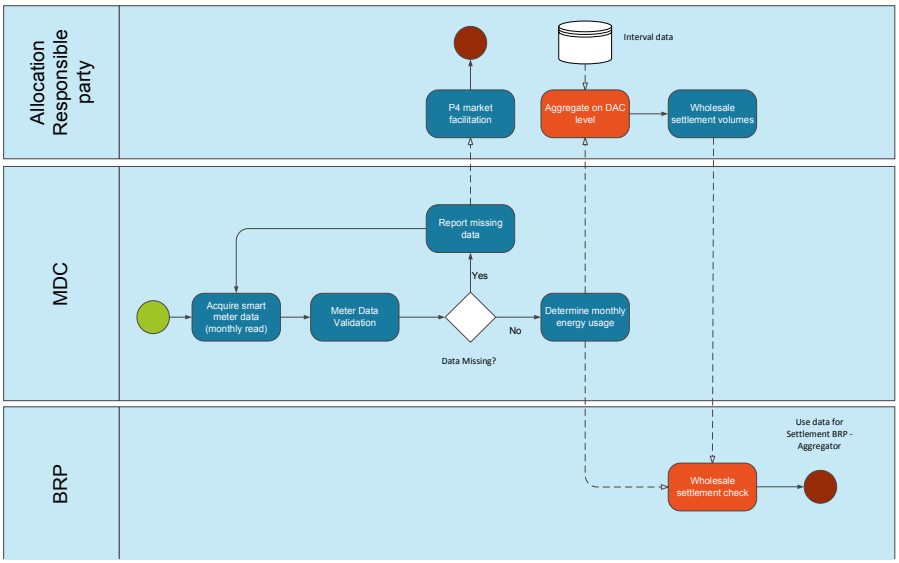


Figure 3-2: wholesale settlement diagram. New processes are depicted in red, existing processes are depicted in blue.

1. Each month the MDC determines the monthly energy volumes per Prosumers, based on smart meter data. This is an existing process, with the exception that the frequency may differ from country to country (e.g. once every two months or annually). The monthly volumes for all Prosumers that participate in a DAC are sent to the ARP. Missing data is reported to the DSO through the (P4) portal for market facilitation.
2. For each DAC, the ARP calculates the sum of the monthly volumes of all connections belonging to this DAC[17]. The total volume is compared with the sum of the volumes of the daily allocation profiles for this DAC. The settlement volume equals the difference between these two calculations; this is either one monthly volume or two monthly volumes (when differentiating peak – off peak tariffs).
3. The resulting volume(s) will be settled by the TSO against neutral month prices.
4. The BRP checks the wholesale settlement volumes, which it may outsource to the MDC as the MDC has detailed metering data at its disposal. These volumes are input to the settlement process of the BRP with the Aggregator.

For a proper settlement process, completeness of the monthly volumes is required. As the completeness of the smart meter data is not guaranteed, the MDC needs to determine the monthly volume even in the case when no smart meter data is available. These estimations should be performed according to a predefined, transparent methodology. Deviations in the estimation of the monthly volume will be automatically settled as soon as smart meter data becomes available for the connection involved in the consecutive month(s).

3.2.3 Standard Annual Usage Determination

Contrary to the normalized synthetic load profiles, the Standard Annual Usage (SAU) volume(s) are still relevant for the Prosumers participating in smart meter allocation, for three reasons:

1. The SAU is used to estimate the daily load profile through extrapolation in case smart meter data is incomplete or invalid.
2. The SAU can be used for billing when Prosumers prefer a fixed monthly invoice, rather than an invoice fluctuating with seasonal patterns.
3. The SAU may be used by the BRP or Aggregator for forecasting purposes.

[17] For this purpose the ARP needs to keep track of changes in the DAC over time, for example due to supplier switches.

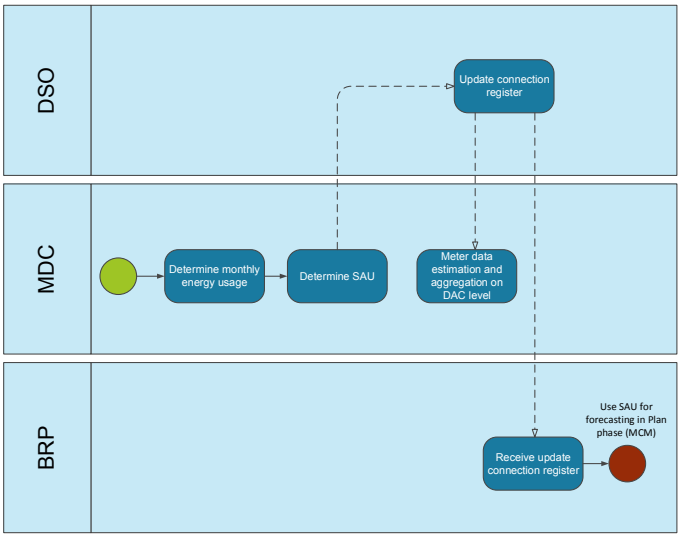


Figure 3-3: Standard Annual Usage determination diagram.

1. Each month the MDC determines the SAU. The SAU determination process is equivalent to the current market process with the exception that the frequency may differ (e.g. once every two months or annually).
2. On the basis of the most recent monthly volume, the SAU is modified to reflect this measurement; this process will be confined to the case where actual measurements are available. If no actual measurements are available no new SAU can be determined. The SAU is sent to the DSO to update the connection register.
3. The SAU is used by the MDC in the allocation process, and by the BRP in the Plan process.

More straightforward, and therefore not specified in the process diagrams, are (other) modification to the administration of master data. Most noticeably, DAC switches will occur when Prosumers switch from synthetic profile allocation to smart meter allocation (or vice versa), or when Prosumers switch from one DAC to another DAC (often associated with either a supplier switch or moving). This should be administered in the connection register, where the historical information should also be kept.

3.3 Energy Balance and Financial Balance

The above described settlement process is a regulated monthly process with a sliding time window of n settlement months, consisting of an y-month process for yearly meter readings plus a z-month process for meter data disputes. This section first describes the current situation, followed by the changes to the energy balance and financial balance.

Where the regulated settlement process stops after n months, the bilateral settlement between market participants (customers, suppliers, BRPs, DSOs) might continue for years. Reasons for prolonged bilateral settlement include both metered data corrections as well as repairs in the settlement process.

DSOs and TSO are responsible for executing the regulated part of the process, which is prescribed in detail in legislation. The DSOs are executing the volumetric part, where the TSO is executing the financial side of the process. Although the TSO is performing some basic validation of the volumetric results (completeness, plausibility) they do not have the means to fully control the DSOs results.

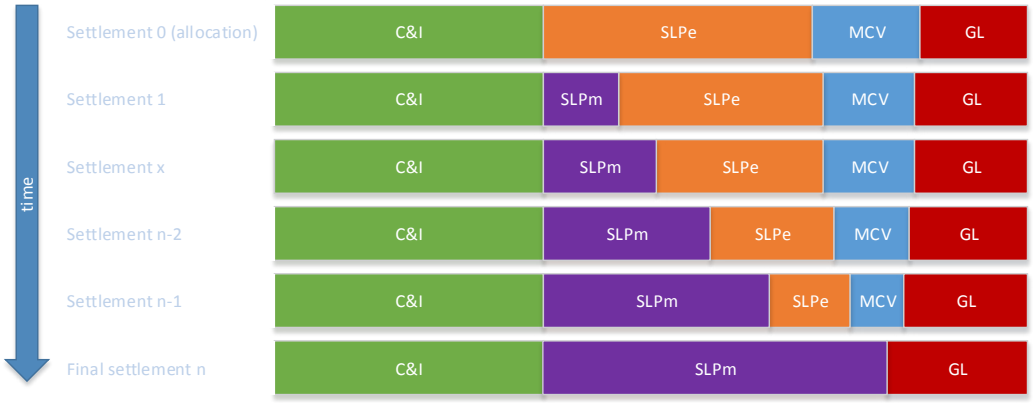


Figure 3-4: Traditional settlement (SLPe=estimated SLP; SLPm=metered SLP; MCV=Metering Correction Volume; GL=Grid Losses).

Note: Figure 3-4 and Figure 3-5 do not show any required repair volumes for C&I, DAC or total feed-in.

Each month the DSOs replace estimated generation or consumption of individual connections by collected meter data and aggregate the results at the level of DSO/ grid area/ BRP/ supplier/ segment/ tariff. Segment includes segments like large (telemetered) customers (C&I), profiled customers (SLP), DAC customers, grid losses (GL), etc. Tariffs can differ among segments. The Measurement Correction Factor (MCF) plays an important role in this process.

The TSO will receive the aggregated results from the DSOs and, after validation, will perform financial settlement with the BRPs. The financial settlement will be based on the volumes reported by the DSOs multiplied by monthly weighted average spot prices.

Next to the TSO-invoice, the BRP also receives specifications from the DSOs about the settled energy volumes. The specifications include both aggregated data as well as customer level data. The specification can be used for financial settlement with each individual supplier.

3.3.1 Supplier Energy Balance

Although the settlement process is quite straight forward, suppliers have no direct control over it, while their revenues can be largely impacted by the outcome of this process. Therefore most suppliers will execute an in-depth settlement validation process, which is often called the Energy Balance Process.
Basically the ***supplier energy balance*** compares the settled wholesale volumes against the customer invoiced volumes enabling suppliers in monitoring both the quality of the wholesale settlement process, as well as the quality of their internal billing process.

Some common elements of the energy balance are:

- Billed energy;
- Settled energy;
- Completeness of settlement (based on connection level receipts);
- Meter data corrections;
- Historical results for trend analysis;
- Forecasted results for making financial reservations.

Each of the above elements will specify:

- To which DSO/ grid area/ BRP/ segment/ tariff the element belongs;
- In which process (Bilateral versus regulated) the element was corrected.

3.3.2 DSO Energy Balance

DSOs use an energy balance to monitor the quality of the settlement process as well as the grid losses volume which they need to procure.

Basically the ***DSO energy balance*** compares, for each grid area, the produced volumes against the consumed volumes.

Depending on the sophistication of the energy balance it can contain elements like:

- Allocated energy;
- Reconciled energy;
- Completeness of settlement;
- Grid losses;
- Energy theft;
- Historical results for trend analysis;
- Forecasted results for making financial reservations.

Each of the above elements will specify to which grid area/BRP/Supplier/segment/tariff it belongs.

3.3.3 Impact of smart meter allocation on the Energy Balance

The introduction of smart meter allocation will improve overall allocation accuracy, but will not fundamentally change the energy balance processes: all of the existing customer segments (large customers, profiled customers, unmetered customers, etc.) will remain, and a DAC segment will be added.

Figure 3-5: smart meter enhanced settlement (DACe=estimated DAC)

As the traditional settlement process contains many uncertainties, it is difficult to distinguish process and data errors from normal energy variations, e.g. profiled customers with off-profile behavior. The introduction of smart meter allocation is expected to lower uncertainties, making it easier to detect process and data errors.
On the financial side smart meter allocation will lead to faster wholesale settlement and to faster customer settlement, relieving suppliers and DSOs of making lengthy financial reservations for SLP final payments, as shown in 5.5.12.

DAC customers can be invoiced monthly or even more frequently, based on metered volumes. There is no need for advance payments from the metering perspective.

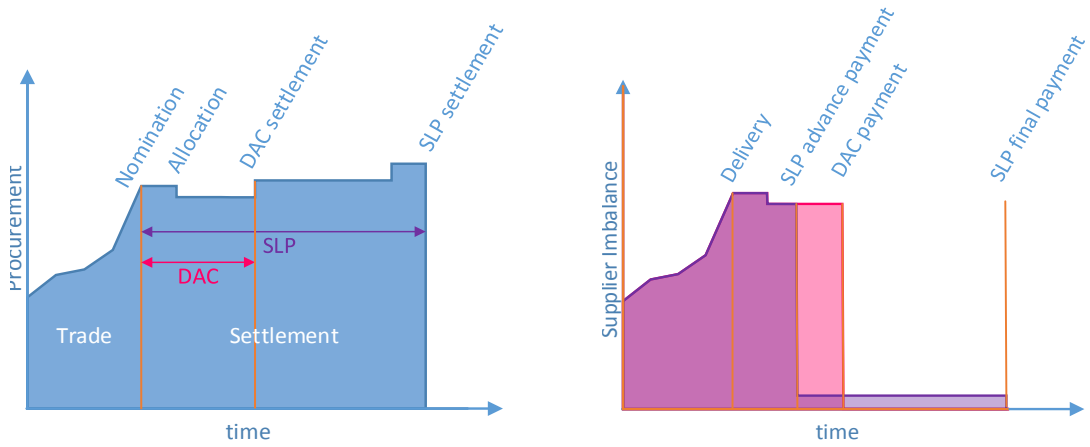


Figure 3-6: Faster procurement and shorter imbalance reservations of the DAC segment

Further advantages of smart meter allocation are:

- Higher allocation accuracy, although (by design) a substantial part of DAC will get an estimated allocation.
- The development and maintenance of synthetic load profiles can be terminated, except for the unmetered segment.
- Improved detection of grid areas with high grid losses.

Requirements for successful introduction of the DAC segment are:

- Customers will be in need of a dispute process for smart meter allocated data. It is not likely that disputes can be resolved before final allocation and therefore there is a need to include a dispute process in the wholesale settlement process.
- C&I- and DAC-corrections, after final allocation, need to be included in the monthly settlement process. This will reduce the operational complexity and risk of bilateral settlement.
- The segment of profiled customers will need to be serviced, including lengthy settlement, as long as it has a substantial market share.

4 Grid Operations

An important aspect of the introduction of smart energy systems is the operation of the energy infrastructure to ensure an affordable, reliable and sustainable energy supply. USEF describes how to achieve this using a newly introduced grid capacity management regime, hence providing an alternative to grid reinforcements. In addition, USEF also describes how to gracefully degrade certain parts of the grid in case of capacity market failure, to avoid a total power outage.

4.1 Scope

Grid operations consist of two activities: capacity management (Yellow) and graceful degradation (Orange). Four main elements can be identified that describe the capacity management process of USEF:

1. Using D-prognoses to anticipate congestion;
2. Procurement of Prosumer flexibility through Aggregators to avoid congestion;
3. Active monitoring of the grid;
4. Graceful degradation, to handle extraordinary grid conditions.

The first two elements are an essential part of the Market-based Coordination Mechanism (MCM) described in Chapter 2. This chapter described the specific elements related to Grid Operation activities for these first two elements. Elements three and four are completely the domain of Grid Operations and are described in detail in this chapter.

4.2 Introduction

The aim of the USEF Grid Operations is to ensure energy supply in a cost-effective way taking the three basic market freedoms (freedom of connection, freedom of transaction and freedom of dispatch) into account. In order to achieve this, USEF introduces different operating regimes. Starting point for these regimes is the declaration of congestion points. In this section, these regimes and the concept 'Congestion Points' are explained.

4.2.1 Congestion Points

It is expected that the load on the grid will significantly increase as a result of the increasing demand for electricity. Also the increasing share of distributed generation will have a large impact on certain parts of the grid. For certain parts in the distribution grid either the demand or the distributed generation will, at peak times, exceed the available grid capacity[18]. In USEF, the DSO will publish these parts of the grid where overload might occur by declaring so-called Congestion Points. A Congestion Point is a set of connections which are (directly) related to that part in the grid where the grid capacity might be exceeded – for instance the secondary side of an LV transformer.

A DSO determines Congestion Points well in advance of actual congestion occurring, based on analysis of the trends in energy flows in its grids. Aggregators can look up the declared Congestion Points in the Common Reference (see Section 2.4.1.1).

When a Congestion Point is declared, all Aggregators are obliged to provide an overview of the amount of energy per PTU that they want to have distributed over that congestion point by the DSO on a daily basis – this is called a D-prognosis. This allows the DSO to make a reliable forecast for the energy to be distributed and to take necessary steps (procuring flexibility) required to optimally use the grid.

[18] It is recognized that distributed generation might introduce other issues, like voltage control issues as well. Future versions of the USEF specification will follow up on these issues.

4.2.2 Normal operations (Green regime)

The DSO receives the D-prognoses (see Section 2.3.2.2) from the Aggregators at the end of the Plan phase. In the Validate phase the DSO performs a grid safety analysis. In case this analysis shows that the energy flows are expected to remain within the safety margins there is no need for the DSO to procure flexibility – the grid will be operated in the Green regime.
During the Operate phase in the Green regime, the actual energy flows need to be monitored to continuously check the grid condition. The measurements at Congestion Points are used to verify that the actual load indeed stays within the limits of the grid capacity. Additional measurements in the grid are used to predict future congestion points. Keep in mind that how to measure the energy flows is an internal process of the DSO and therefore out of scope of USEF.

4.2.3 Grid capacity management (Yellow regime)

In areas where the Validate phase shows a possible grid overload for certain PTUs, the DSO will procure flex power options to keep the power flows and voltage levels within acceptable limits. To do so the DSO basically has two options that can be applied in parallel:

- Long-term flexibility options – DSOs have the possibility to arrange flexibility contracts with one or more Aggregators in advance. See Section 2.3.2.4 for more details.
- Short-term flexibility options – DSOs can procure the required local flexibility from the Aggregator during the Validate phase of the MCM. See Section 2.3.2.4 for more details.

4.2.4 Graceful degradation (Orange regime)

In exceptional situations where the market is no longer able to maintain the network load within acceptable limits due to insufficient available flexibility, within USEF compliant networks the process of graceful degradation can be started - they are operated in the Orange regime. In this regime the DSO temporary overrules the market by limiting connections in the overloaded part of the grid.

Implementation of this operating regime acts as a backstop for the Yellow regime and leads to a higher overall availability of the grid, but the service level will be limited for certain Prosumers in this regime. Therefore clear public criteria are essential to legitimize this way of operation and maintain its public acceptance.
The DSO can invoke the Orange regime in two ways:

- When the DSO concludes in the Validate phase that, even when all flexibility offers of the market are exhausted, the grid will be overloaded;
- When unexpected situations arise in the Operate phase, such as unexpected loads or failure of grid components.

The DSO can offer different service levels and connections to various types of Prosumers by differentiating in the connection code. Clients who critically depend on electricity, but without back up, (i.e. nursing homes) can therefore have a higher service level than clients where a service interruption has a lesser impact. If and how these priorities are set and whether or not price differentiation may occur, is up to the local implementation of the Orange regime. What the appropriate rules are for connection limiting in the connection code depends strongly on the local situation, therefore USEF does not specify what these rules should be.

When deciding on the rules for connection limiting it is important to keep in mind that connection limiting (Orange) may not compete with flexibility (Yellow). As described in chapter **2**, USEF is a market based solution. Therefore the non-market option of Orange should only be considered to be a last resort in case the market did not function. The rules regarding connection limiting in the connection code should guarantee that using the Orange regime is (financially, regulatory) not attractive enough to the DSO to use it regularly and therefore would start to compete with Yellow.

4.3 Process Description

4.3.1 Plan

4.3.1.1 Process flow in the Plan phase

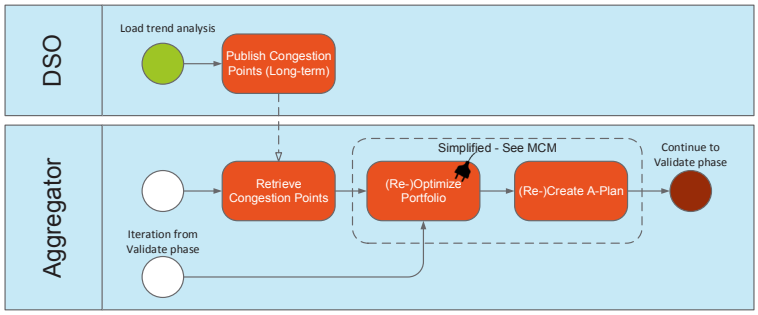


Figure 4-1: Process diagram of the Plan phase.

Declare Congestion Points
Grid operation within USEF revolves around declared Congestion Points in the grid. Based on periodic trend analyses, the DSO determines in which parts (i.e. transformer, feeder) of the grid the demand or generation may exceed the available capacity in the foreseeable future. The DSO declares these parts of the grid to be a Congestion Point. The connections related to a Congestion Point are centrally administrated in the Common Reference (see Section 2.4.1.1).

USEF specifies:

- That the DSO has to specify Congestion Points when trend analysis show congestion possibly arises in the next year;
- Trend analysis should be performed on a regular basis;
- Congestion Points and their related connections are administrated in the Common Reference;
- Aggregators have access to the (Congestion Point information in the) Common Reference.

Recommended practice:
Taking the possibility of excessive growth of PV and EV into account: USEF recommends increasing the frequency of trend analysis to twice a year, at least in those areas where high volumes of PV and EV are expected to occur.

The process of declaring Congestion Points is described as a use case (UC2001) in Chapter 5.

Retrieve Congestion Points
Aggregators can retrieve Congestion Point information from the Common Reference. This process is described in detail by MCM in Chapter 2 and as a use case (UC1002) in Chapter 5.

4.3.2 Validate

4.3.2.1 Process flow in Validate

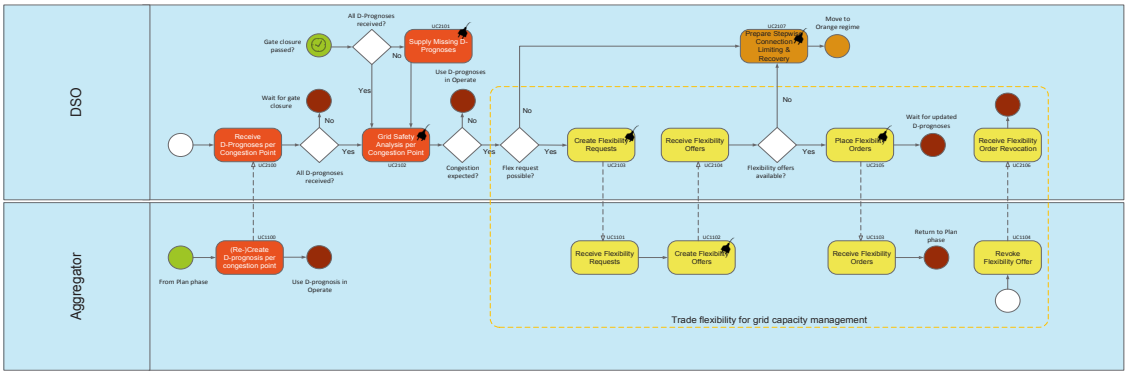


Figure 4-2: Process diagram of the Validate phase.

Assess D-prognoses per Congestion Point

The validate phase starts with Aggregators having created their D-prognoses and having sent them to the DSO. Aggregators have to supply a D-prognosis for every Congestion Point for which they serve one or more customers. The initial D-prognosis should be sent to the DSO before a defined deadline at the start of the Validate phase. Aggregators are free to update their prognoses in case of changes during Plan phase or to reflect the trading of flexibility with the DSO in the Validate phase itself. A defined deadline for sending updates shortly before the end of the Validate phase guarantees that the DSO can process the updates correctly.

When the DSO receives a prognosis, the DSO will assess the correctness based on three rules:

- Syntax: does the format of the D-prognosis adhere to the USEF specification
- Semantics: does the content of the D-prognosis comply with the business rules
- Timing: is the D-prognosis received before the gate closure

The assessment process can have two possible outcomes; ‘accepted’ or ‘rejected’. In case the D-prognosis complies with all three rules, the DSO sends an acceptance message to the Aggregator. A rejection message is sent when one or more of the three rules are not met (syntax, semantics or timing). The DSO will inform the Aggregator on which grounds the D-prognosis has been rejected. The DSO cannot reject a D-prognosis on other grounds than these three rules, even if the updated D-prognosis causes congestion – based on the freedom to dispatch. In case the D-prognosis is rejected the latest accepted D-prognosis remains valid until the Aggregator sends a new and correct D-prognosis.

In USEF the DSO and Aggregator will trade flexibility to solve congestion through the process of FlexRequests, FlexOffers and finally a FlexOrder by the DSO to the Aggregator. When an updated D-prognosis is received for a Congestion Point where a FlexOrder was placed, the DSO can add information in the acceptance message whether or not the agreed flexibility of the FlexOrder is included in the D-prognosis. This is an optional step that supports detecting discrepancies in the administration of FlexOrders on both sides. There is, however, no direct consequence for not correctly incorporating a FlexOrder in a D-prognosis. Besides administrative issues an Aggregator can have other reasons for not incorporating a FlexOrder in the D-prognosis. For instance an equipment failure, forecasting errors or a FlexOrder with the BRP that more than compensates for the penalties of the original FlexOrder with the DSO.

USEF specifies:

- Aggregators supply a D-prognosis for each Congestion Point in which they serve one or more connections. A D-prognosis is an aggregation of multiple connections into a single forecast.
- A DSO must accept all D-prognoses that have the right USEF message syntax, semantics and are received at the right time.
- When a D-prognosis is rejected the latest approved D-prognosis for that specific Aggregator-Congestion Point combination remains valid.
- A deadline is defined for sending the initial D-prognoses at the start of the Validate phase, as well as a deadline for sending updated D-prognoses just before the end of the Validate phase.

Recommended practice:
It is recommended that a set of rules is defined with negative (financial) consequences for Aggregators that fail to deliver a D-Prognosis on time.

This process is described as use case (UC2002) in Chapter **5**.

Check for completeness or passed deadline

As soon as all Aggregators have submitted a D-prognosis for a certain Congestion Point – the DSO can verify this by consulting the Common Reference - the DSO can continue the process in the Validate phase. Continuing the process as soon as possible is beneficial for both DSO and Aggregator – the first having sufficient time to resolve possible congestion by requesting flexibility, the latter having early insight in the need for flexibility by the DSO and with that the possibility to determine an optimal price for flexibility.
It might be the case that on gate closure not all Aggregators have provided a D-prognosis. The DSO then continues the process using an estimate of the D-prognoses for the Aggregators in default. These estimates should be based on historical information rather than based on standard synthetic profiles, since it is likely that the customers of an Aggregator have a profile that substantially differs from such a synthetic profile.

USEF specifies:

- The DSO queries the Common Reference to check if all Aggregators active at the Congestion Point have submitted a D-prognosis.

Create forecast for non-Aggregator connections

Not all connections related to a Congestion Point are served by an Aggregator. These connections do, however, contribute to the use of the available grid capacity. Therefore, the DSO has to create a forecast for all connections within the Congestion Point not served by an Aggregator. This forecast will be input for the grid safety analysis together with the D-prognoses from Aggregators, which are active at the Congestion Point. In the situation that all connections have a registered aggregator this step can be skipped. The generation of this forecast is an internal process of the DSO and is therefore not further specified within USEF.

USEF specifies:

- In case the Common Reference indicates that some connections, belonging to a Congestion Point, have no registered Aggregator the DSO creates a load forecast for these connections.

This process is described as use case (UC2002) in Chapter **5**.

Recommended practice:
In case an Aggregator failed to deliver a D-prognosis in time, it is advisable the DSO uses a D-prognosis based on the most recent D-prognosis of the same Aggregator for a comparable day (i.e. weekday, weekend day, holiday, etc.) to perform a grid safety analysis instead of treating the connections as non-Aggregator ones.

Grid safety analysis per Congestion Point

The combination of all D-prognoses and the DSO forecast for all other connections allow the DSO to perform a grid safety analysis for a specific Congestion Point. How this grid safety analysis is done by the DSO is not specified, this is an implementation choice of the DSO. The outcome of the analysis should be sufficient for the DSO to determine when (in which PTUs) and how much flexibility is required at a Congestion Point[19].

USEF specifies:

- In the Validate phase, the DSO performs a Grid Safety Analysis for every Congestion Point for all PTUs in a day indicating that congestion is expected. It should specify the reduction needed to solve the congestion in every congested PTU as well as the available capacity in non-congested PTUs.

This process is described as a use case (UC2015) in Chapter **5**.

Is congestion expected?

When the D-prognoses in combination with the forecasts of non-Aggregator connections show that the energy can be distributed safely within the capacity limits of the grid on a particular Congestion Point no additional action from the DSO is required besides creating the T-prognosis (see chapter 2). The DSO is then ready to move to the Operating phase. However updated D-prognoses or changes in the forecast for non-Aggregator connections might still be sent which would trigger DSO-Validate process again.

In case the grid safety analysis does indicate that it will not be possible to distribute the energy according to the D-prognoses and forecasts of non-aggregator connections (the limits of the distribution grid[20] for a particular Congestion Point are expected to be reached), USEF MCM will switch to the Yellow regime. This will start the process of acquiring flexibility from the market by the DSO to try to resolve the overload.

USEF specifies:

- If the Grid Safety Analysis on a Congestion Point shows no congestion for any PTU, the Validate phase results in the Green regime for that particular Congestion Point.
- If the Grid Safety Analysis on a Congestion Point shows one or more congested PTUs, the Validate phase results in the Yellow regime for that particular Congestion Point.

Flex request possible?

In case of a possible overload situation the DSO will consult the market for flexibility that can resolve (part) of the congestion. There are however situations where such a market consultation, in the form of a FlexRequest, is not feasible or useful:

- There are no Aggregators active at the Congestion Point
- There is not enough time left in the Validation phase to completely process a FlexOrder
- The DSO can reasonably expect that a new FlexRequest will not result in new FlexOrders. For instance when a recent similar FlexRequest has not resulted in any FlexOrders.

In the cases mentioned above there is the flexibility market does not offer a solution for the congestion. Therefore, a transition to the Orange regime – resulting in graceful degradation - is the only remaining possibility for a safe but limited distribution of energy.

USEF specifies:

- The DSO consults the flexibility market as a way to resolve the congestion before switching to the Orange regime
- If congestion is expected but no D-prognoses are submitted the USEF MCM will switch to the Orange regime

19 In this version of the specification, the need for flexibility for a DSO is based on the grid capacity (power). It is however recognized that there might be other reasons for a DSO to request flexibility, for instance due to voltage issues. This will be worked out in a future version of the specification.

20 It is up to the DSO to determine these limits in relation to the actual grid capacity.

Procure flexibility from the market

The process of procuring flexibility using the Market-based Coordination Mechanism (MCM) is described in detail in Section 2.3.2.4. The procurement of flexibility from the market in the Validate phase starts with the creation of FlexRequests by the DSO. Providing the available grid capacity (in other PTUs) as well – instead of only providing the PTUs where an overload is to be expected, which is the bare minimum for a FlexRequest - is likely to result in a more optimal use of flexibility and therefore better usage of the grid. For that reason information about the congestion reason, too much production or consumption, the amount reduction required and the remaining capacity in other PTUs is shared. Taking into account that in most – if not all - situations each PTU has a different amount of energy to be distributed than the adjacent PTUs, a FlexRequest will effectively include all (remaining) individual PTUs for the (part of the) day that is processed.

Because the DSO has the legal obligation to treat all market parties in a non-discriminatory way, all Aggregators should have access to the same congestion information. Therefore a FlexRequest is available to all Aggregators, whether an Aggregator has connections related to the associated Congestion Point or not. The actual retrieving of the FlexRequests of a DSO is the responsibility of the Aggregator to avoid that a DSO is unnecessarily sending FlexRequests to Aggregators that are not interested in providing flexibility.

For the MCM to function correctly, USEF specifies that the DSO shares the following information in the FlexRequest (see Sectio 6.4.17 for the formal message description):

- The PTUs for which congestion is expected at a certain Congestion Point;
- The reason for the congestion for each PTU, either an generation surplus or a consumption surplus;
- The amount of generation/consumption reduction that is required to solve the congestion;
- The amount of available capacity in other PTUs that can be used to solve the congestion.

Prepare stepwise connection limiting and recovery

USEF requires DSOs to have decision rules for the graceful degradation in the Orange regime. These decision rules are needed to make proper contractual arrangements with the Prosumer and to provide the transparency needed for the acceptance of USEF by all stakeholders. In order to develop these decision rules the DSO needs to know the capacity of each connection point and the installed base of local generation for a clear insight of the potential local energy flows. The decision rules include information about the categorization of the connections and how to prioritize these connections as described upfront in the Plan phase.

Limiting a connection can be either the reduction of the capacity of a connection or entirely disconnect the connection, partly depending on the capabilities of the physical specifications of the connection. For instance, a charge spot might have the ability to switch between fast charging (with a high capacity need) and slow charging (with a low capacity need). In the Orange regime, the first step is to make a charge spot to switch from fast to slow charging – if that is not sufficient to solve the overload, the charge spot will be entirely disconnected.

Based on the decision rules, USEF specifies that in the Orange regime the DSO has to create two plans for graceful degradation, based on the best information available in the Validate phase:

- Degradation plan for connection capacity limiting: The degradation plan will define connection points to be limited based on the priority. This will be an iterative process until the amount of power reduction needed is achieved.
- Restoration plan for recovery: It is also important to develop a restoration plan to indicate when and how each limited connection point will be restored to its normal capacity. Restoring all limited connection points at the same time to their normal capacity could have a large impact on the distribution grid due to high inrush current and/or significant voltage drop, e.g. reconnecting a large number of CHPs.

USEF Specifies:

- The DSO must have decision rules that describe the process of graceful degradation.
- Based on the decision rules a degradation plan for stepwise connection capacity limiting is created that indicates the order in which connections are limited.
- Based on the decision rules a restoration plan is created that indicates the order in which connection capacity is restored.
- The DSO does not communicate about the transition to Orange in Validate because it does not facilitate a better use of grid or market functioning, but could induce flexibility gaming.

Recommended practice:

- The decision rules are publically available for better end-user acceptance
- The decision rules should be approved by the regulator.
- The Connection Code includes information about the type of load (PV, EV fast chargers) as well as priority (critical electrical applications). This way better decision rules can be defined to make decisions which connection to limit first depending on the type of congestion and time of day. For instance limiting the capacity of connections with PV during production congestion in the early afternoon and limiting fast charging EV connection in the early evening during consumption congestion. This way graceful degradation can be implemented in a more effective way where, in general, a higher level of service is provided.

4.3.2.2 Operating regimes in Validate

In the Validate phase operating regimes are declared for a Congestion Point for all PTUs in the whole nomination period (typically 24 hours). The following transitions are possible:

- Green to Yellow
- Green to Orange
- Yellow to Orange

Starting operating regime
The Validate phase starts by default in Green and when no congestion is expected based on the grid safety analysis it will also finish in Green.

Transitions to Yellow
In case the grid safety analysis shows that for certain PTUs congestion is expected on the Congestion Point, based on the provided D-prognoses, a transition from the Green regime to the Yellow regime will take place, on the condition that at least one Aggregator is serving connections related to that specific Congestion Point. The transition to Yellow applies to the entire period (typically a day) that was subject to the grid safety analysis (in case of day-ahead nominations), in order to make it possible to shift the load to an earlier PTU as well. The scope of the Yellow regime is limited to the Congestion Point for which the grid safety analysis indicated an expected overload. As soon as the system is in the Yellow regime, the DSO will try to procure flexibility from the market or invoke its long-term flexibility contracts.

Transitions to Orange
In exceptional situations where the market is no longer able to maintain the network load within acceptable limits, the DSO starts the process of graceful degradation. This occurs when there is no registered Aggregator for the area of the Congestion Point or when the offered flexibility is not sufficient to handle the grid overload.

The DSO temporary overrules the market and grid connections are reduced (stepwise) in their connection capacity until the network load is within acceptable limits again. The Orange regime is limited to the Congestion Point for which the congestion is expected. While Aggregators will be informed about the Yellow regime because a flexibility request is send, market parties will not be informed about the transition to the Orange regime in the Validate phase to avoid gaming.

It is important to realize that in the Validate phase the connection capacities are not yet actually limited – it is only a preparation for the transition. Only in case that in the Operate phase an overload situation is reached, the actual limiting will take place. The restoration of the connection capacity will bring the system back into the Yellow regime. This transition is however only relevant in the Operate phase.

4.3.3 Operate

Section 2.3.3 described the Operate phase of USEF in the Green and Yellow regimes. This section focuses on describing the Operate phase where the USEF compliant grid moves to the Yellow or Orange regime.

4.3.3.1 Process flow in Operate

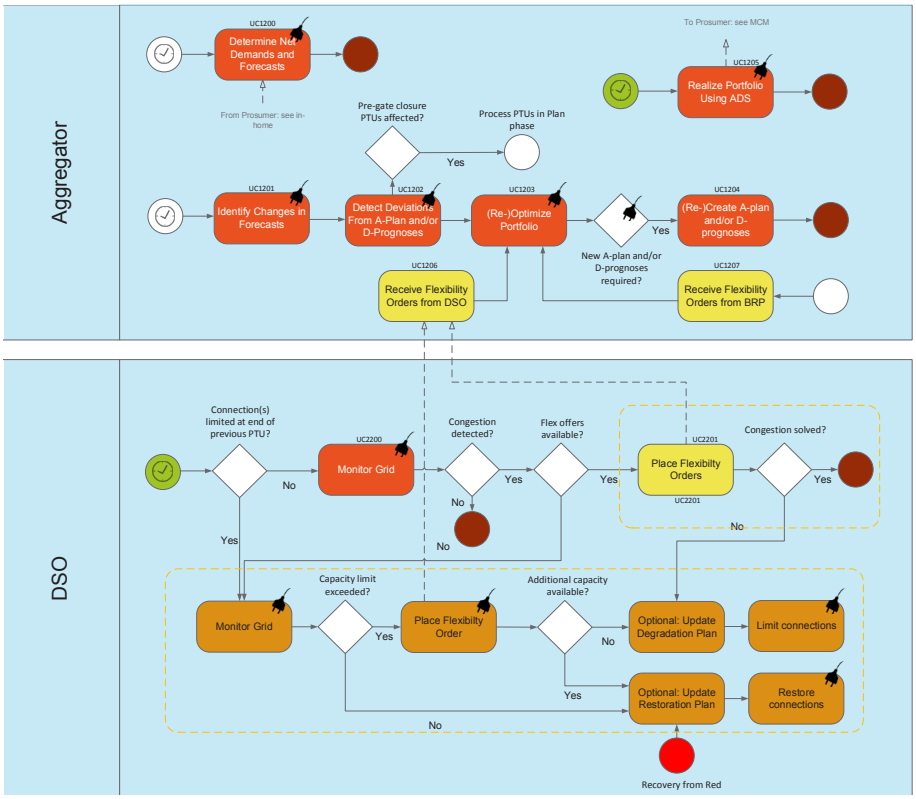


Figure 4-3: Process diagram of the Operate phase.

In the operate phase the first responsibility of the DSO is to monitor the grid. Based on insight gained from monitoring, the DSO can detect a capacity constraint in the grid and invoke available FlexOffers to resolve the load constraint. In case insufficient flexibility is available, the DSO will activate the process of graceful degradation. The response of the Connection should be almost instantaneous (USEF currently estimates reaction times of seconds) and invoking the capacity limitations should be fully automated without intervention of any other stakeholder in the system. It is essential that the DSO can operate the right actuators, so the location of the congestion area and the location of and type of Prosumers in the grid have to be known by the Distribution Management System[21]. The degradation (and restoration plan) will be executed according to the pre-determined business rules.

The following paragraphs describe each process in the Operate phase in more detail.

Connection(s) capacity limited at end of the previous PTU

If at the end of the Operate phase of the previous PTU one or more connections capacities have been limited, the Operate phase of the current PTU starts in Orange. If no connection capacities are limited the process starts in Green.

Monitor grid

Grid Monitoring is the main process in the Operate phase for the DSO. The process is repeated until congestion is detected or the Operate phase of the PTU ends. In case of congestion, the Grid Monitoring process is repeated after the appropriate processes have been executed to solve the congestion, both in Yellow and in Orange. This feedback process is not included in the process flow diagram for clarity of the diagram.

The main factor limiting the capacity of most distribution grids are not the cables but the transformers. As a consequence, the transformers are the most likely positions in the grid to measure power and to detect congestion. However, the current monitoring capability of DSOs is still limited and real-time measurement is normally not available at the MV/LV substations.

21 USEF expects the DSOs to have a Distribution Management System (or Energy Management System) in place for their daily operations

Currently pseudo-measurement information is therefore often used to estimate network state variables at the LV grid. Implementing the Monitor Grid functionality within USEF by means of pseudo-measurements can be cost-effective but will most likely not provide the same information quality as actual measurements. It is up to the DSO to decide how the process is implemented. USEF does specify that near real-time load information is required; whether this is based on pseudo-measurements or actual measurements is not specified.

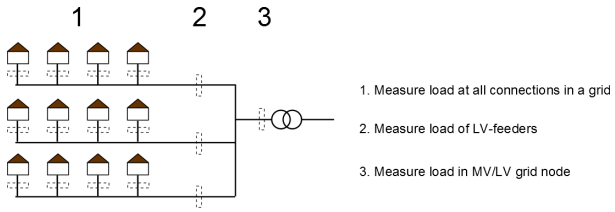


Figure 4-4: Locations in the grid where the load can be measured.

New A-Plan Required and Possible? gives an overview of the locations where the load in the LV grid can be measured. The level at which the DSO should have load information available in near real-time depends on how the Congestion Point is defined. Near real-time information should at least be available at the same level of granularity as the level at which the Congestion Point is defined. This means that if, for example, the Congestion Point is defined on the LV-feeder level, then load information should be available at least at this level. Optionally the information can have a higher granularity, in this example that would mean information on the individual connection level.

USEF specifies:

- The DSO has to continuously monitor the grid status in the Operate phase.
- When a DSO has declared a Congestion Point it needs to have near real-time load information with the same granularity as the definition of the Congestion Point.

This process is described as a use case (UC2009) in Chapter 5.

Congestion detected?
If congestion is detected during the operate phase the DSO will try to order flexibility to solve it, otherwise the Orange regime must enacted.

Flexibility offers available?
If congestion is detected the DSO has one final opportunity to order flexibility. Given the time limitations no new flexibility orders can be created and accepted in the Operate phase. This implies that only outstanding flexibility offers can be ordered and/or long-term flexibility contract dispatched.

USEF specifies:

- No flexibility requests can be made in the Operate phase
- Outstanding flexibility offers can be ordered and long-term flexibility contracts can be dispatched in the Operate phase to solve congestion.

Congestion can be solved
This step is to check if the congestion can be solved by placing a flexibility order or not. This process is described in detail by MCM in Chapter 2.

Place flexibility order
As described earlier the DSO can order flexibility under certain conditions in the Operate phase. Just as in the Validate phase the DSO is obliged to order all available flexibility just as in the Validate phase before the Orange regime can be activated. For more information about this requirement see the Validate phase Section 4.3.2 in this chapter.

USEF specifies:

- The DSO must order all available flexibility in the Operate phase before enacting the Orange regime.

This process is described in detail by MCM in Chapter 2.

(Optional) Update degradation or restoration plan

In the Operate phase, the degradation and restoration plan can be updated to reflect the actual conditions of the Congestion Point that has been captured in near real-time by monitoring the grid. This is optional as limiting connections is an iterative process until the congestion is resolved or the system moves to the next PTU.

Recommended Practice:

- USEF recommends updating the degradation and restoration plans with the most up-to-date information in the Operate phase to speed up this iterative process and lower the impact of graceful degradation.

Limit connections

As the graceful degradation depends on the actual load situation of each connection point, it is an iterative process within several PTUs to resolve a certain Congestion Point. The DSO opts for limiting connections on the basis of the maximum allowable capacity that is reflected by the degradation plan. The DSO sends a threshold signal to the relevant connection point concerning the maximum capacity limit.

Limiting connections is an iterative process. The number of limited connections, the order in which connections are limited and the maximum capacity is determined in real-time based on the near real-time load information. Every time the load information, coming from the Monitor Grid process, is updated, the connection limiting (or restoration) is updated as well.

The DSO has the option to implement both granular capacity limiting as well as a more direct form of switching off a connection entirely. In the first case a basic service level can still be provided, for instance limiting the functionality of an EV charging point to only allow slow charging. In the latter case the connection will be limited to 0 kW by temporarily disconnecting the connection from the grid.

USEF specifies:

- If the DSO decides to use the graceful degradation option of USEF, the DSO requires the functionality to limit the connection capacity at the connection level.
- The number, the order and to which capacity the connections are limited is determined in real-time based on near real-time load information and the degradation plan.
- Every time new load information is available and indicates that the capacity limit of the Congestion Point is exceeded the limit connection process is repeated.

Restore connections

When the load no longer exceeds the connection capacity limit the DSO can start the process of restoring the connections in accordance with the Restoration Plan. The control signal from the DSO with the new increased capacity is sent to inform the connection point.

USEF specifies:

- The number, the order and to which capacity the connections are restored is determined by the DSO in real-time based on near real-time load information and the restoration plan.
- Every time new load information is available and indicates that the capacity limit of the Congestion Point is not reached, the limit connection process is repeated.

Regulate connection capacity

The functionality to limit a connection is directly controlled and operated by the DSO to guarantee the availability of the graceful degradation option. The limiting is therefore also done at the connection level, explicitly not at the device level. Although Aggregators can offer direct switching off loads from certain devices or even a complete connection, this is regarded to be a market-driven form of flexibility and therefore part of the Yellow regime. The required processes and hardware for graceful degradation are fully under the control and responsibility of the DSO.

Graceful degradation in USEF is performed at the connection level, for instance at the smart meter in a house, although other physical points for connection limiting can also be defined. At the Prosumer site, the connection could communicate with other (in-home) devices to improve service when the connection is limited. For instance by switching off certain non-essential loads at site, or supporting the electricity supply using storage. This additional functionality is not part of grid operation and is described in [1].

USEF specifies:

- The equipment and processes for graceful degradation are under control and the responsibility of the DSO.
- The signal for connection limiting is send to the Connection which is operated by the DSO.

Recommend practice:

- USEF recommends using the smart meters or flexible fuses to limit the capacity at the connection points.

4.3.3.2 Operating regimes in Operate

In the Operate phase operating regimes are declared for a Congestion Point for a PTU basis. The following transitions are possible in USEF:

- Green to Yellow
- Green to Orange
- Yellow to Orange
- Red to Orange

Transitions to Red are possible from all other regimes but is are not included in USEF because these are uncontrolled events.

Starting operating regime

The Operate phase can start in either the Green or Orange regime. When no connections are limited at the end of the Operate phase of the previous PTU, the process starts in Green. Even when flexibility was ordered in the Validate phase for the PTU at hand, the process will start in Green when no connections were previously limited. In case one or more connections were limited the process starts in Orange. In the exceptional situation of a black-out (Red regime) the functionality of stepwise restoration in the Orange regime is used to recover more efficiently.

Transitions to Yellow

Preferably all congestion is anticipated through the use of D-prognoses and solved in the Validate phase. In the case that one or more D-prognoses or the forecast for non-aggregator connections are significantly off and congestion does occur; the DSO can move to Yellow in the Operate phase. However, there must be valid open flexibility offers available or the DSO must have pre-arranged long-term contracts available. These can then be ordered in the Operate phase in the Yellow regime. In other cases of congestion the only available solution is going to the Orange regime. This is due to the fact that timing constraints do not allow for ordering flexibility for the current PTU.

Transitions to Orange

If serious congestion occurs in the Operate phase then the Orange regime is available to maintain a limited service level and guarantee safe operation of the grid. In case market-based solutions in the form of flexibility offers or long-term contracts are available these should be used first. After this condition is met, the process of graceful degradation can start.
The red regime is beyond the scope of USEF as USEF does not take into account self-healing grids or improvements of reliability by re-routing energy flows in the grid. However, USEF supports grid restoration from the red regime using the connection limiting functionality. When an USEF compliant grid recovers from a black-out it starts in the Orange regime. The degradation and restoration plans will be updated all connections will be limited. After grid switches are reclosed, connections are restored according to the recovery plan until all connections are fully operational.

4.3.4 Settle

In addition to the USEF settlement processes within MCM, additional settlement processes are required in case of connection limiting in the Orange regime. This section describes these additional processes.

4.3.4.1 Settlement DSO – Prosumer in Orange Regime

The DSO has the ability to shed load or curtail generation at a Prosumer directly, by reducing the maximum capacity on connection level (to zero, when needed), in the Orange regime. The impact of load shedding or curtailment is settled afterwards between the DSO and the Prosumer directly. USEF does not prescribe that this connection limiting should (financially) be settled. This is however recommended.

USEF specifies:

- The smart meter will register the duration of the outage and the capacity limitation; the compensation (unit price) will be determined by the regulator.

Recommended practice:

- USEF recommends that regulators determine the settlement of load shedding and curtailment based on the following elements:
  - The time the customer service was interrupted, analogously to current practices in some countries. This includes this situation where the maximum (reduced) capacity has been exceeded, and the connection has been disabled completely as a consequence. This compensation also covers situations where local generation was disconnected due to the capacity limitation or outage. In this case the lost revenues will be compensated based on the duration.
  - When the capacity has been limited, but no outage has occurred, compensation is paid based on the duration and the capacity reduction.
- USEF proposes to compensate every minute lost (no threshold value) however the granularity will also be determined by the regulator. Each month, the DSO calculates the remuneration for the Prosumers that have been affected by the actions within the Orange regime. For each congestion point where the Orange regime was applied:
- The DSO collects the connections that are associated with the congestion point from the common reference
- The DSO acquires the smart meter data to determine:
  - Whether the capacity of the connection was reduced within the Orange regime
  - The size and duration of the capacity reduction
- For each connection where an outage has occurred as a consequence of the capacity reduction, the DSO acquires:
- The duration of the outage
- The DSO calculates the compensation for the Prosumers that were affected by the capacity reductions:
  - The capacity reduction compensation is calculated according to compensation = capacity reduced (kW) * duration (m) * reduction unit price (€ / kW / m)
  - The outage compensation is calculated according to compensation = duration (m) * outage unit price (€ / m)
  - The DSO sends the compensation details to the Prosumer
- The Prosumer receives the compensation details.

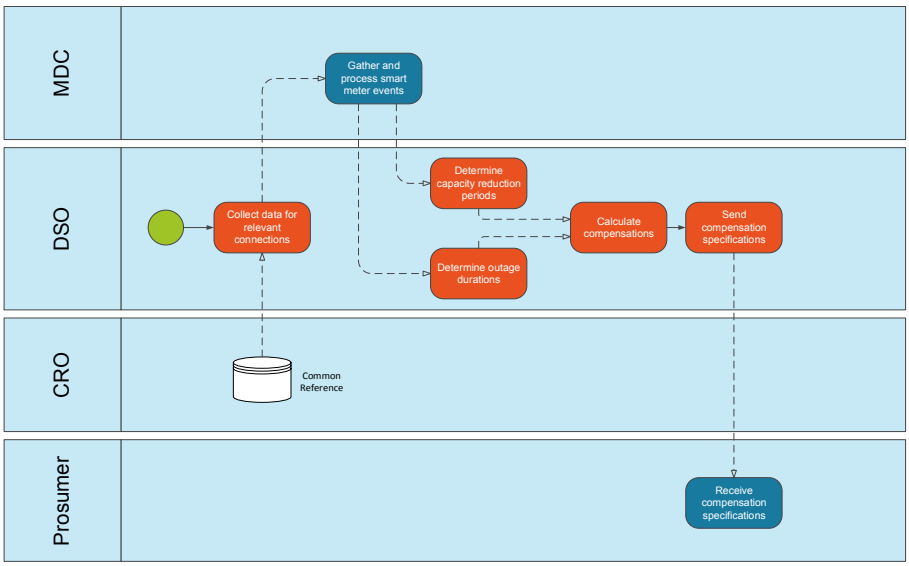


Figure 4-5: Flex settlement between DSO and Prosumer in the Orange regime

4.3.4.2 Settlement DSO - BRP in the Orange regime

When the DSO sheds load or curtails generation in the Orange regime, this will also affect the program of a BRP. This is similar to the (current) situation in the Red regime, where the program of BRPs will also be affected by power outages. USEF proposes to settle the imbalance consequences of activities in the Orange regimes with the BRP, rather than the Aggregator, as load and generation may also be affected that is not part of an Aggregator's portfolio.

Recommended practice:

- USEF recommends that the rules for settling the imbalance cost resulting from load shedding and curtailment are in line with current (national) regulations for outages in the Red regime.

4.4 Interface descriptions

A number of information flows between market parties is required for the correct functioning of Grid Operation in USEF. This involves information about the declaration of Congestion Points, requesting flexibility by the DSO and connection limiting for graceful degradation. The first two are described in the interface description of MCM, see Chapter 2.4. The connection control interface between the DSO and the connection is described in this section and implements the connection limiting functionality for graceful degradation.

4.4.1 Connection Control

In order to guarantee a quick response in the graceful degradation process, the functionality to limit connections is fully owned and operated by the DSO. This includes the required hardware at the Prosumer site. Therefore the argument could be made that connection limiting is an internal process and therefore the connection control interface is an internal interface as well. However, the hardware is placed in the domain of the end-user and a large-scale infrastructure is required. Therefore standardization of the interface will reduce risk and lower costs by improving interoperability between hardware solutions. For this reason USEF specifies the minimal set of requirements for the interface.

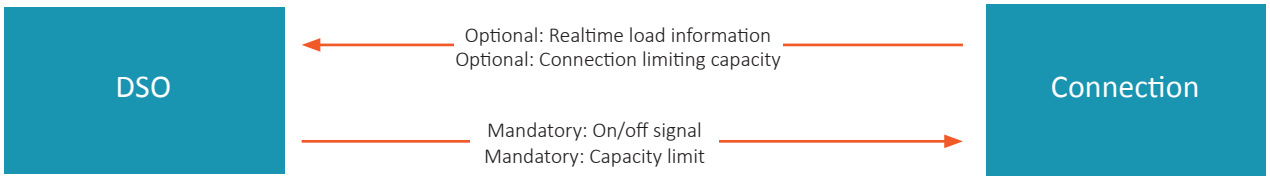


Figure 4-6: Information exchange between DSO and Connection.

The minimal requirement for the connection control interface in USEF specifies one way communication from the DSO to the connection over which the following information is send:

- **On/off signal**
  This signal is used to disconnect a connection all together from the grid. Although USEF recommends that connection limiting is implemented by lowering the capacity limit of connections a hard control signal to switch a connection entirely is also supported. Given the hardware cost for capacity regulating hardware, it might not be cost-effective to equip all connections with this functionality. A remote on/off switch is a lower cost solution for connection limiting.
- **Capacity limit**
  A signal that is used to regulate the maximum allowable capacity over the connection. This signal should indicate the 'direction' of the capacity limit, if it is an import (consumption) limitation or an export (production) limitation.

Optionally the communication can be two-way, adding an information flow from the connection to the DSO. The following information is optionally communicated in this way:

- **Real-time load information**
  If the DSO wants to implement real-time load measurement in the Monitor Grid process for the Operate phase the connection can supply this information using this interface.
- **Connection limiting capability**
  Given that the fact that USEF allows for both hard on/off switching as well as capacity regulation, the DSO might choose to implement the functionality to request which capability is available at each connection. This information can be used to improve the quality of the degradation and restoration plan in the Validate and Operate phases. Alternatively this information can be administrated in a different way by the DSO. Therefore this functionality is optional.

At the Prosumer site, the connection could communicate with other devices to improve service when the connection is limited. For instance by switching off certain non-essential services, or supporting the electricity supply using storage. This additional functionality is not part of grid operation and is described in [1].

In a future release of USEF the connection control interface will be further defined. Part of this future release will be the integration between the connection control interface and existing standards and protocol for energy infrastructure communication such as DLMS/COSEM [4].

5 Use case descriptions

5.1 Scope

This chapter provides the details of the functions that each of the stakeholders need to have available in order to be active in the USEF MCM. In order to be USEF compliant, these functions must be implemented according to the use case descriptions in this chapter.

The use cases have been derived from the MCM process diagrams detailed in Chapter 2). Each of the process steps in the process diagrams has been listed as one use case. The decision points (i.e. gateways) in the process diagrams are included in the relevant neighboring use case.
The use cases make uses of messages that are described in Chapters **6**

5.1.1 Introduction

The core of the USEF specification is the Market-based Coordination Mechanism and the processes governing it. They define how the different stakeholders active in the MCM should behave and interact. All use cases related to these functions are described to the extent relevant for the USEF specifications. All aspects not specified by USEF are explicitly mentioned. An example of this is that USEF does not specify how an aggregator (AGR) optimizes its portfolio and determines how much flexibility is available where and when. The result of this portfolio optimization is however a prerequisite for participating in the flexibility bidding process, which consists of core use cases. This particular sample use case can be found in Section 5.5.11**.**

Given the open nature of the USEF specifications, any implementation can choose to adopt all or only part of the specifications. In any case, all participants within a single USEF market will have to adopt a common specification of the market processes and information exchange.

5.2 Privacy and Security by design

USEF – like most complex information systems – deals with sensitive data and therefore requires security and privacy preservation measures. Privacy & security are system-wide issues, protection of individual subsystems/components is not enough; the system is as strong as the weakest link. USEF therefore follows the principle of privacy & security by design.

USEF provides a separate privacy and security guideline [4] that lists approximately 50 design principles that together present a complete view of the privacy and security aspects associated with smart energy systems. It takes into account the current legal and social views on privacy & security and links these to the future directions into which they will likely evolve.

The guideline forms the basis for the logical security architecture that is reflected in USEF's process flows and use cases.

5.3 Common concepts

The USEF specification is technology and implementation agnostic. It standardizes the logical interfaces and defines the minimum functionality of the components in the form of use cases (this chapter) and message transport specifications and message descriptions (Chapter **6**). This leaves room for innovation and possibilities to develop specific implementation architectures based on e.g. size of the market, specific local circumstances or commercial exploitation of USEF platforms. Stakeholders involved in a USEF market can and must develop business functions and capabilities independently, and focus on their core business and competitive advantage.

While the USEF specification is technology and implementation agnostic, there are some basic principles to which any USEF implementation architecture must adhere. Some of these are listed as high-level requirements. When an ICT implementation architecture is defined, the actual implementation requirements must be defined and included in the design.

- A USEF market implementation will typically consist of multiple information systems interacting together according to the USEF interaction standard in order to run the market processes. The USEF foundation does not want to narrow down the open nature of the USEF specifications by defining exactly how the information system architecture must be implemented.
- The USEF specifications do currently not define exceptions and how to handle them. Therefore, the use cases also prescribe only the default main scenario without error handling, and only the successful outcome. The single exception to this rule is described in the next bullet. USEF does provide some recommended practices for handling some of the failure handling.
- Any USEF IT architecture must adhere to the USEF privacy & security guideline (see [4]). In the USEF use cases the most relevant privacy & security considerations are provided.

5.4 Reading guidelines

This chapter contains separate sections per USEF phase: Plan, Validate, Validate Orange, Operate, Operate Orange, Settle and Settle Orange. In each section the use cases are specified in a standard table format:

ID	Identification of the use case
Triggered by	Reference to other use case(s) that invoke this use case
Triggers	Reference to other use case(s) that is (are) invoked by this use case
Goal in context	High-level description of the activity.
Preconditions	The state of the system that must be present prior to a use case being performed.
Successful outcome	The state the system will be in immediately after a use case has finished without failure.
Failure outcome	The state the system will be in immediately after a use case has finished after failure, plus identification of the failure.
Primary actor	Main actor that is executing this use case
Secondary actors	Other actors that are involved in this use case
Main scenario	The main flow of actions/events, described using pseudo-code.
Alternatives	Potential alternative flow of actions/events.
Related information	General remarks
Message type	Only defined for use cases that send a message. The details of the message types are defined in Chapter 6.
Privacy & Security considerations	Specifies the data product, the data controller and/or processor, as well as specific responsibilities regarding the privacy & security requirements from [4].

Table 5.1: Standard table format for USEF use cases.

The use case identification numbers are linked to the role executing that particular use case:

- UC0nnnn: BRP use cases
  UC1nnnn: AGR use cases
  UC2nnnn: DSO use cases
  UC3nnnn: CRO use cases
  UC4nnnn: MDC use cases

Functions in use cases that are required to be supported, but not specified by USEF how to be supported, are listed in ***italics.***
The chapter concludes will a complete inventory of the use cases, grouped by USEF role.

5.5 Use Cases – Plan phase

In section 2.3.1 the informative description of the plan phase processes has been given. In this section the use cases will be described as derived from the plan phase process diagrams. Each activity (rounded rectangle) in the process diagrams is listed as a use case.

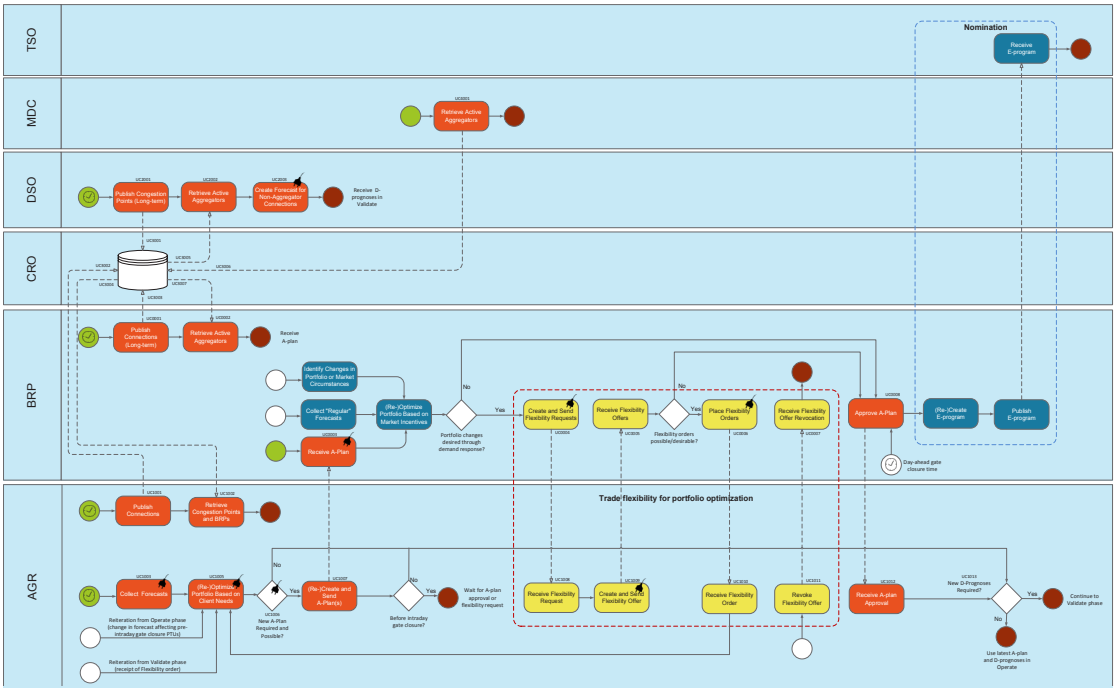


Figure 5-1: Process flows of the Plan phase. New processes are depicted in red, existing processes are depicted in blue. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

The USEF MCM plan phase specifies the following use cases:

ID	Name	Role	Message/Data structure
UC2001	Publish Congestion Points (Long-term)	DSO	CommonReferenceUpdate
UC3001	Receive DSO Congestion Point Update	CRO	CommonReferenceUpdate
UC1001	Publish Connections	AGR	CommonReferenceUpdate
UC3002	Receive AGR Connection Update	CRO	CommonReferenceUpdate
UC1002	Retrieve Congestion Points and BRPs	AGR	CommonReferenceQuery
UC3004	Send Congestion Points and BRPs to AGR	CRO	CommonReferenceQueryResponse
UC2002	DSO: Retrieve Active Aggregators	DSO	CommonReferenceQuery
UC3005	Send Active Aggregators to DSO	CRO	CommonReferenceQueryResponse
UC2003	Create Forecast for Non-Aggregator Connections	DSO	
UC1003	Collect Forecasts	AGR	
UC1005	(Re-)Optimize Portfolio Based on Client Needs	AGR	UDI ConnectionPortfolio
UC1006	New A-Plan Required and Possible?	AGR	
UC1007	(Re-)Create and Send A-plan(s)	AGR	Prognosis
UC0001	Publish Connections (Long-term)	BRP	CommonReferenceUpdate
UC3003	Receive BRP Connection Update	CRO	CommonReferenceUpdate
UC0002	Retrieve Active Aggregators	BRP	CommonReferenceQuery
UC3007	Send Active Aggregators to BRP	CRO	CommonReferenceQueryResponse
UC0003	Receive A-plan	BRP	Prognosis
UC0004	Create Flexibility Requests	BRP	FlexRequest

UC1008	Receive Flexibility Request	AGR	FlexRequest
UC1009	Create and Send Flexibility Offer	AGR	FlexOffer
UC0005	Receive Flexibility Offers	BRP	FlexOffer
UC1011	Revoke Flexibility Offer	AGRP	FlexOfferRevocation
UC0007	Receive Flexibility Offer Revocation	BRP	FlexOfferRevocation
UC0006	Place Flexibility Orders	BRP	FlexOrder
UC1010	Receive Flexibility Order	AGR	FlexOrder
UC0008	Approve A-Plan	BRP	PrognosisResponse
UC1012	Receive A-Plan Approval	AGR	PrognosisResponse
UC1013	New D-Prognoses Required?	AGR	
UC4001	MDC: Retrieve Active Aggregators	MDC	CommonReferenceQuery
UC3006	Send Active Aggregators to MDC	CRO	CommonReferenceQueryResponse

Table 5.2: Use cases for the Plan phase.

The following existing BRP processes do not change, and are thus not specified in this document:

- Collect “regular” forecasts,
- Identify changes in portfolio or market circumstances,
- Re-optimize portfolio based on market incentives,
- Re-create/publish E-program, and
- Receive E-program

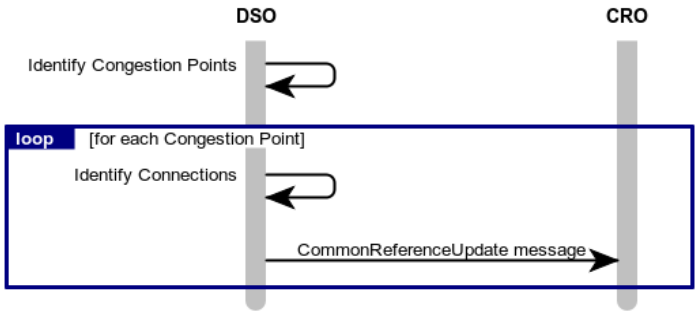
5.5.1 Publish Congestion Points (Long-term)

ID	**UC2001**		
Triggered by	DSO		
Triggers	UC3001 (Receive DSO Connection update)		
Goal in context	Use all available information to predict Congestion Points within the Grid. Publish these Congestion Points, including their associated Connections, to the Common Reference, in order to make them available to the AGRs.		
Preconditions	Common Reference is available to DSO and AGRs		
Successful outcome	The Common Reference is updated with the latest Congestion points and associated Connections (i.e. all connected Prosumers)		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Common Reference not updated	CRO is operating in closed mode and the DSO is not pre-registered as an authorized participant
Primary actor	DSO		
Secondary actors	CRO		

<table>
<tr><td>Main scenario</td><td>Once a Flex market is functional for an area, the DSO has to update and publish a register of possible Congestion Points, including the Connection identifiers of connected Prosumers. This register is maintained by the Common Reference Operator.

To determine which of its grid points qualify as Congestion Points, the DSO uses data from measurements, assets and knowledge databases. Algorithms are used to calculate the expected demand and supply on the Grid. Asset use for the Yellow regime is calculated and, based on these constraints, some areas in the grid are be labeled as (potential) Congestion points.
Which Connections belong to each Congestion point is determined based on GIS data and knowledge of the topology of the Grid.

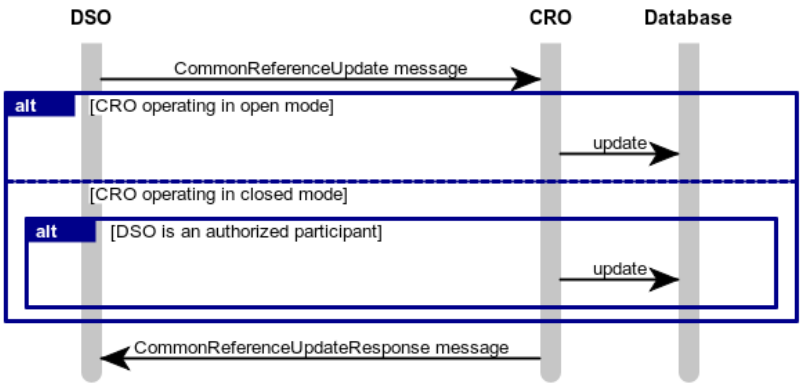
Once populated, the Common Reference will allow AGRs to determine if there are Prosumers in their portfolio that can offer Flex via their Connections to on one or more Congestion Points. The AGR is required to submit D-Prognoses to the DSO(s) operating each of the Congestion Points on which they represent Connections.

 
</td></tr>
<tr><td>Related information</td><td>USEF does not specify how the DSO determines the Congestion Points. Populating the Common Reference with Congestion Points is a pre-condition for the Flex Market.

Knowledge about which Grid points are considered Congestion Points by DSOs is valuable to Aggregators, as it would give them good targets for their marketing efforts. Similarly, it would be interesting for DSOs to know which particular Connections are represented by an Aggregator, as those Prosumers may require other services as well.

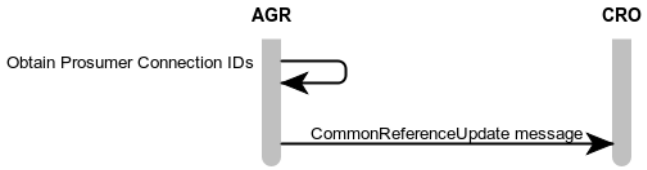
However, the Common Reference is not a marketing tool, and its query interface is limited on purpose: DSOs may only obtain Aggregator identities and combined Connection counts, only for those Congestion Points they have registered themselves. Similarly, Aggregators may only obtain DSO identities, Congestion Point identifiers and Connection identifiers for those Connections they have registered themselves.</td></tr>
<tr><td>Message type</td><td>CommonReferenceUpdate</td></tr>
<tr><td>Privacy & Security considerations</td><td>
<table>
<tr><th>Data Product</th><th>Role</th><th>Responsibilities</th></tr>
<tr><td>Congestion Point</td><td>CRO (Data processor)</td><td>The CRO should only disclose the existence of the congestion point on a need-to-know basis, i.e. only to those AGRs which provide an associated Connection identifier in their queries.</td></tr>
<tr><td>Connections associated with Congestion Point</td><td>DSO (Data controller)</td><td>Connection identifiers should be treated as personally identifiable information</td></tr>
</table>
</td></tr>
</table>

5.5.2 Receive DSO Congestion Point Update

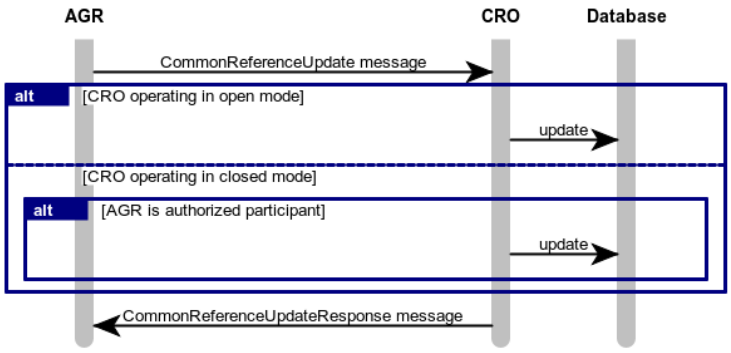
ID	UC3001		
Triggered by	UC2001 (Publish Congestion Points)		
Triggers	n/a		
Goal in context	Receive Congestion Points with associated Connections from the DSO. Store this information in the database underlying the Common Reference.		
Preconditions	Common Reference available to DSO and AGRs		
Successful outcome	The Common Reference register is updated with the latest information about Congestion Points and Connections operated by the DSO sending the update.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Database is not updated	CRO is operating in closed mode and the DSO is not pre-registered as an authorized participant
Primary actor	CRO		
Secondary actors	DSO		
Main scenario	The Common Reference consists of a database with a logical structure as shown in Figure 2-8, for which the Common Reference Operator accepts updates from DSOs. If operating in open mode, the CRO will accept updates from any USEF-compliant participants implementing the DSO role. In closed mode, participants will need to be pre-configured in order for updates to be accepted.  		
Related information	A functioning Common Reference is a pre-condition for the Flex Market. It's the responsibility of the Common Reference operator to have policies regarding access, data retention, data security and conflict resolution compliant with the USEF Privacy & Security guidelines.		
Message type	CommonReferenceUpdate		

Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Congestion Point	CRO (Data processor)	The CRO should only disclose the existence of the congestion point on a need-to-know basis, i.e. only to those AGRs which provide an associated Connection identifier in their queries.
	Connections associated with Congestion Point	CRO (Data processor)	Connection identifiers should be treated as personally identifiable information.

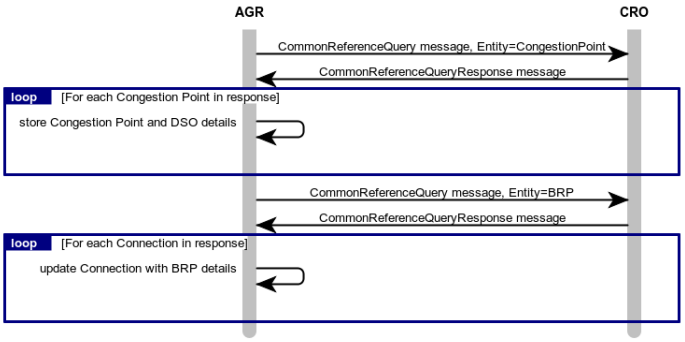
5.5.3 Publish Connections

ID	**UC1001**		
Triggered by	AGR		
Triggers	UC3002 (Receive AGR Connection Updates)		
Goal in context	Publish all contracted Prosumer Connections in the Common Reference, in order to later discover Congestion Points and associated DSOs.		
Preconditions	Common Reference is available to DSO and AGRs		
Successful outcome	The Common Reference is updated with the all Prosumers (listed by their Connection identifiers) represented by the Aggregator.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Rejected	Update not accepted	Common Reference is operating in closed mode and the AGR is not pre-registered as an authorized participant
Primary actor	AGR		
Secondary actors	CRO		
Main scenario	Once a Flex market is functional for an area, the AGR has to publish a list of the Connection identifiers of the Prosumers it has contracted. This list is stored and, subject to access controls, made available to other market participants by the Common Reference Operator.  		
Related information	Populating the Common Reference with all Aggregator-represented Connections is a pre-condition for the Flex Market. All Aggregators need to have equal access to the Common Reference.		
Message type	CommonReferenceUpdate		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections represented by AGR	AGR (Data controller)	Connection identifiers should be treated as personally identifiable information.

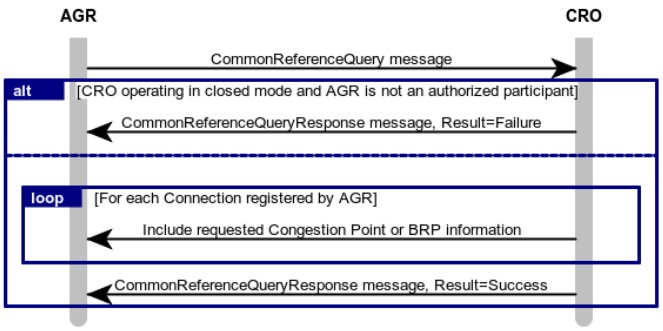
5.5.4 Receive AGR Connection Update

ID	UC3002		
Triggered by	UC1001 (Publish Connections)		
Triggers	n/a		
Goal in context	Receive a list of the Connections on which the Aggregator has contracted Prosumers. Store this information in the Common Reference database.		
Preconditions	Common Reference is available to DSO and AGRs		
Successful outcome	The Common Reference is updated with the latest information about the Connections on which Prosumers are represented by the Aggregator sending the update.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Database is not updated	CRO is operating in closed mode and the AGR is not pre-registered as an authorized participant
Primary actor	CRO		
Secondary actors	AGR		
Main scenario	The Common Reference consists of a database with a logical structure as shown in Figure 2-8, for which the Common Reference Operator accepts updates from AGRs. If operating in open mode, the CRO will accept updates from any USEF-compliant participants implementing the AGR role. In closed mode, participants will need to be pre-configured in order for updates to be accepted.  		
Related information	A functioning Common Reference is a pre-condition for the Flex Market. It's the responsibility of the Common Reference operator to have policies regarding access, data retention, data security and conflict resolution compliant with the USEF Privacy & Security guidelines. All AGRs need to have equal access to the Common Reference.		
Message Type	CommonReferenceUpdate		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections represented by AGR	CRO (Data processor)	Connection identifiers should be treated as personally identifiable information, AGR linked to each Connection as commercially sensitive information.

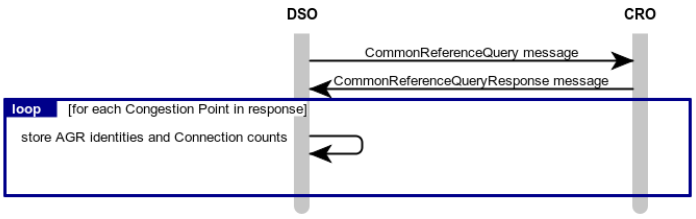
5.5.5 Retrieve Congestion Points and BRPs

ID	UC1002		
Triggered by	AGR (as part of day-ahead initialization)		
Triggers	n/a		
Goal in context	Retrieve a list of all registered Connections represented by this AGR, grouped by Congestion Point, in order to send prognoses to the responsible DSO, as well as the BRP for each registered Connection, in order to send prognoses to these BRPs.		
Preconditions	The DSO has determined its Congestion Points and published this information, including the associated Connection identifiers in the Common Reference (see UC2001). The BRP has published which Connections it represents in the Common Reference (see UC0001). The AGR has registered the Connection identifiers for which it represents Prosumers in the Common Reference (see UC1001)		
Successful outcome	The AGR receives a list of Connections, grouped by Connection Point and responsible DSO, as well as a list of Connections, grouped by BRP.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Rejected	Query not performed	CRO is operating in closed mode and the AGR is not pre-registered as an authorized participant
Primary actor	AGR		
Secondary actors	CRO		
Main scenario	The Common Reference allows an Aggregator to determine if there are any Congestion Points where Prosumers in its portfolio can offer Flex. If so, the Aggregator is from then on required to supply D-Prognoses to the DSO associated with each Congestion Point.  		
Related information	Aggregators will only obtain DSO identities, BRP identities, Congestion Point identifiers and Connection identifiers for those Connections they have registered in the Common Reference themselves.		
Message type	CommonReferenceQuery		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections represented by AGR	AGR (Data controller)	Connection identifiers should be treated as personally identifiable information.
	Congestion Point	AGR (Data processor)	Existence of congestion points is commercially sensitive information.
	BRP	AGR (Data processor)	Which BRPs represent which Connections is commercially sensitive information.

5.5.6 Send Congestion Points and BRPs to AGR

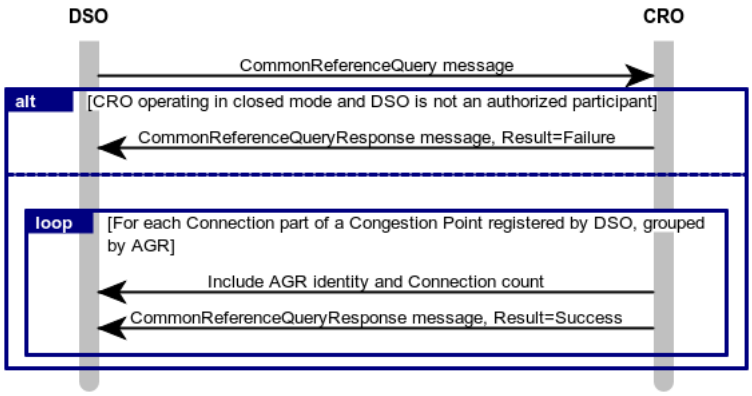
ID	UC3004		
Triggered by	UC1002 (Retrieve Congestion Points and BRPs)		
Triggers	n/a		
Goal in context	Respond to Congestion Point and BRP queries from the AGR: validate need-to-know, retrieve data from the database underlying the Common Reference.		
Preconditions	Common Reference available to DSOs, BRPs and AGRs; AGR has registered which Connections it represents (UC1001)		
Successful outcome	The AGR receives Congestion Point and BRP information for the Connections it represents		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Query failed	No data is received	CRO is operating in closed mode and the AGR is not registered as an authorized participant
Primary actor	CRO		
Secondary actors	AGR		
Main scenario	The Common Reference consists of a database with a logical structure as shown in Figure 2-8, which the Common Reference Operator uses to supply data to AGRs. If operating in open mode, the CRO will accept queries from any USEF-compliant participants implementing the AGR role. In closed mode, participants will need to be pre-configured in order for updates to be accepted. 		
Related information	A functioning Common Reference is a pre-condition for the Flex Market. It's the responsibility of the Common Reference operator to have policies regarding access, data retention, data security and conflict resolution compliant with the USEF Privacy & Security guidelines.		
Message type	CommonReferenceQueryResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections represented by AGR	CRO (Data processor)	Connection identifiers should be treated as personally identifiable information.
	Congestion Point	CRO (Data processor)	Congestion Points represent commercially sensitive information, and the CRO should only disclose their existence and scope to AGRs including at least one Connection identifier which belongs to that Congestion Point in their queries.
	BRP	CRO (Data processor)	Which BRPs represent which Connections is commercially sensitive information.

5.5.7 DSO: Retrieve Active Aggregators

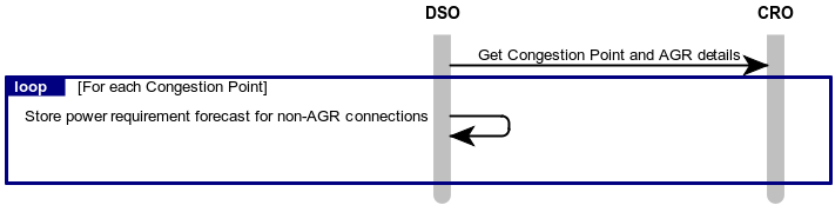
ID	UC2002		
Triggered by	DSO (as part of day-ahead initialization)		
Triggers	N/A (this process is a prerequisite for UC2015)		
Goal in context	Retrieve a list of all DSO-registered Congestion Points with, for each such point, a list of Aggregators representing Prosumers there, including the number of Connections each Aggregator represents. The DSO then knows from which Aggregators D-prognoses can be expected, and which percentage of the total Connections on each Congestion Point is affected by those prognoses.		
Preconditions	The DSO has determined its Congestion Points and published this information, including the associated Connection identifiers in the Common Reference (see UC2001). The AGR has registered the Connection identifiers for which it represents Prosumers in the Common Reference (see UC1027)		
Successful outcome	AGRs which represent Prosumers at any of the Congestion Points registered by the DSO are available to the DSO		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Rejected	Query not performed	CRO is operating in closed mode and the DSO is not pre-registered as an authorized participant
Primary actor	DSO		
Secondary actors	CRO		
Main scenario			
Related information	DSOs may only obtain Aggregator identities and combined Connection counts for those Congestion Points they have registered in the Common Reference themselves.		
Message type	CommonReferenceQuery		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	AGR share per Congestion Point	DSO (Data processor)	The number of connections represented by the various AGRs on the DSO's Congestion Points is commercially sensitive information
	Congestion Points	DSO (Data controller)	Existence of Congestion Points is commercially sensitive information

5.5.8 Send Active Aggregators to DSO

ID	UC3005
Triggered by	UC2002 (Retrieve active aggregators)

Triggers	n/a		
Goal in context	Respond to AGR queries from the DSO: validate need-to-know, retrieve data from the database underlying the Common Reference.		
Preconditions	Common Reference available to DSOs, BRPs and AGRs; DSO has registered its Congestion Points (UC2001).		
Successful outcome	The DSO receives AGR information: for each Congestion Point it has registered, it receives the identity of each AGR (if any) plus the number of Connections that AGR represents.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Query failed	No data is received	CRO is operating in closed mode and the DSO is not registered as an authorized participant
Primary actor	CRO		
Secondary actors	DSO		
Main scenario	The Common Reference consists of a database with a logical structure as shown in Figure 2-8, which the Common Reference Operator uses to supply aggregated aggregator data to DSOs. If operating in open mode, the CRO will accept queries from any USEF-compliant participants implementing the AGR role. In closed mode, participants will need to be pre-configured in order for updates to be accepted.  		
Related information	A functioning Common Reference is a pre-condition for the Flex Market. It's the responsibility of the Common Reference operator to have policies regarding access, data retention, data security and conflict resolution compliant with the USEF Privacy & Security guidelines.		
Message type	CommonReferenceQueryResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	AGR per Connection	CRO (Data processor)	The exact identity of the AGR for each Connection should not be disclosed to the DSO. Instead, only aggregate connection counts should be provided (which represent commercially sensitive information)
	Congestion Points	CRO (Data processor)	Existence of Congestion Points is commercially sensitive information

5.5.9 Create Forecast for Non-Aggregator Connections

ID	UC2003		
Triggered By	DSO (as part of day-ahead initialization)		
Triggers	n/a		
Goal in context	Create forecast for connections which are not served by an AGR		
Preconditions	Common Reference is populated with congestion point and connection information by DSO and AGRs, and DSO has retrieved the active AGRs for the period being forecast		
Successful outcome	Internal forecast created for the load caused by non-AGR connections on each congestion point		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors			
Main scenario			
Alternatives	The DSO may also perform this function in the Validate phase.		
Related information	USEF does not specify how the DSO performs the forecast. DSOs need to support this function, in any manner.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Congestion Points	DSO (Data controller)	Existence of Congestion Points, as well as details on associated AGRs and forecasts represent commercially sensitive information

5.5.10 Collect Forecasts

ID	UC1003		
Triggered by	User-configurable timer in Aggregator Plan phase		
Triggers	UC1005 (Re-optimize Portfolio)		
Goal in context	Collect forecasts from Active Demand & Supply equipment of connected/contracted Prosumers, or calculate forecasts on behalf of those customers as needed		
Preconditions	AGR has contracted at least one customer		
Successful outcome	Initial day-ahead forecast for A-plan		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors	Active demand & supply (ADS; optional)		

Main scenario	During day-ahead plan phase, the AGR needs to collect the forecasts from the Prosumers it represents in order to create its A-plan. Depending on the proposition and the technology available, the AGR can for instance choose to have each ADS generate a forecast which is collected by the AGR (main), or choose to generate/calculate those individual forecasts for each Prosumer or ADS (see alternative). AGR requests day-ahead forecasts from all connected ADS. AGR receives individual forecasts from each ADS, validates forecasts and stores correct forecasts in an initial A-plan forecast. AGR acknowledges reception of the each forecast to the ADS. AGR rejects incorrect forecasts to the corresponding ADS. AGR checks for missing individual forecasts (generate for missing forecasts, see Alternatives below) AGR releases initial forecast for portfolio optimization.		
Alternatives	AGR uses historical/statistical/environment data to generate/calculate individual forecasts AGR releases initial forecast for portfolio optimization.		
Related information	USEF does not specify how the AGR determines the forecast. AGRs need to support this function, in any manner. This function is a prerequisite for creating a meaningful A-plan.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections	AGR (Data controller)	The list of Connections represented by the AGR is commercially sensitive information
	Connection Forecasts	AGR (Data controller)	Detailed forecast data should be considered personally identifiable information, and should not be retained longer than strictly required. The retention period should be specified and be communicated to the data subject.
	ADS Details	AGR (Data controller)	Details associated with individual ADS (such as IP addresses, serial numbers, configuration metadata, etc.) should be considered personally identifiable information and treated as such.

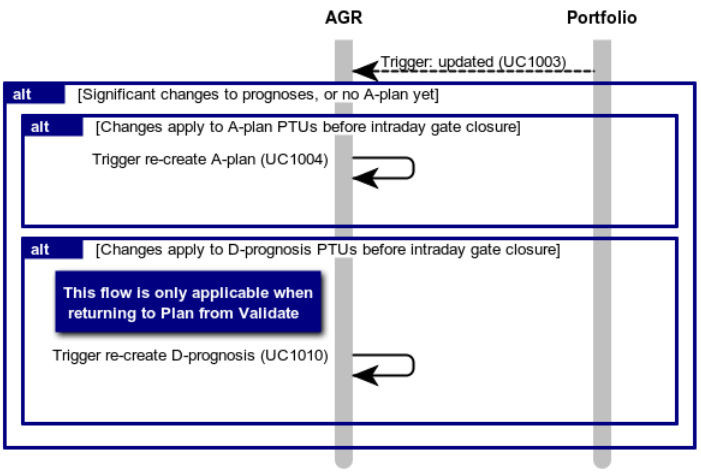
5.5.11 (Re-)Optimize Portfolio Based on Client Needs

ID	**UC1005**		
Triggered by	UC1003, return from Operate phase (in case changes in forecast affect PTUs which are still pre-intraday gate closure), return from Validate phase (in case flexibility trading takes place)		
Triggers	UC1006 (new A-plans), UC1100 (new D-prognoses)		
Goal in context	(Re-)Optimize portfolio based on client needs		
Preconditions	AGR has created initial day-ahead forecast for A-plan and/or has created an updated forecast for A-plan		
Successful outcome	Optimized portfolio which comprises of an A-plan and an internal flexibility portfolio. Portfolio released for further processing.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR portfolio manager		

Secondary actors			
Main scenario	AGR generates optimized portfolio comprising of A-plan and internal flexibility forecast. AGR releases portfolio for further processing.		
Alternatives			
Related information	USEF does not specify how the AGR optimizes its portfolio nor how it determines availability of flexibility. AGRs need to support this function, in any manner. This function is a prerequisite for issuing A-plans to BRPs and D-prognoses to DSOs (if applicable) and for subsequent flexibility trading.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Portfolio	AGR (Data controller)	The portfolio represents commercially sensitive information. Depending on the AGR's implementation, it may also include personally identifiable information, for which the responsibilities listed in the USEF P&S Guideline may apply.

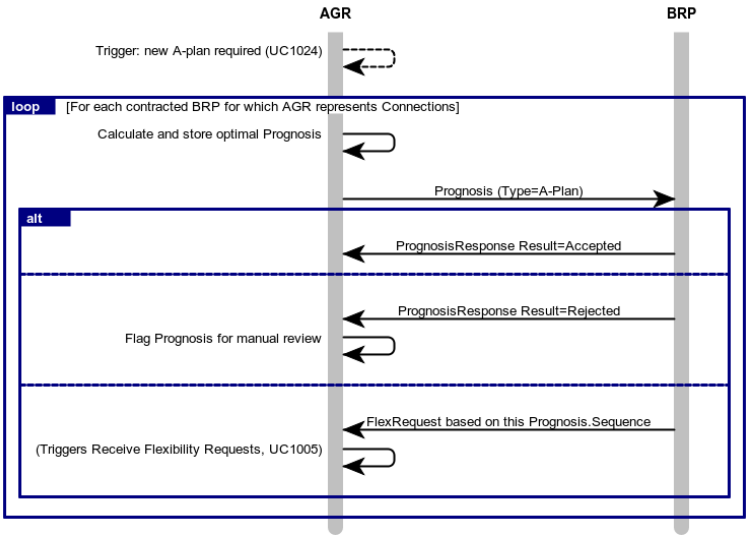
5.5.12 New A-Plan Required and Possible?

ID	**UC1006**		
Triggered by	UC1005 (Re-optimize Portfolio)		
Triggers	UC1007 (Send A-Plans) or UC1013 (New D-Prognoses Required?)		
Goal in context	Decide if new A-Plan(s) will be created that will have to be approved by the corresponding BRP. This decision is based on the timing of gate closure of the Plan phase and the changes in the portfolio compared to previous A-plan. If the Plan phase is being re-entered from the Validate phase, also decide if one or more new D-prognoses should be sent to the corresponding DSO.		
Preconditions	AGR has created initial day-ahead optimized portfolio or has updated the portfolio		
Successful outcome	Decision made whether new A-plan(s) and/or one or more D-prognoses should be created		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a
Primary actor	AGR portfolio manager		
Secondary actors	n/a		

Main scenario			
Alternatives			
Related information	USEF does not specify how the AGR administrates its portfolio and what is considered as a significant portfolio change.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Portfolio	AGR (Data controller)	The portfolio represents commercially sensitive information. Depending on the AGR's implementation, it may also include personally identifiable information, for which the responsibilities listed in the USEF P&S Guideline may apply.

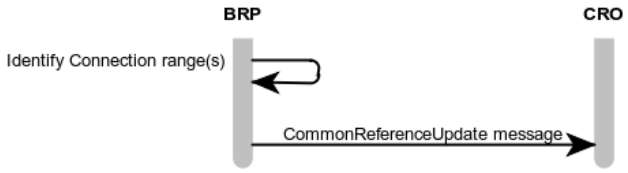
5.5.13 (Re-)Create and Send A-Plan(s)

ID	**UC1007**		
Triggered by	UC1006 (New A-Plan Required), A-plan rejection (likely after manual intervention)		
Triggers	UC0003 (Receive A-Plan)		
Goal in context	(Re-)Create A-plan for BRP. A-plans are specified by the Prognosis message.		
Preconditions	AGR has created initial day-ahead optimized portfolio or has updated the portfolio		
Successful outcome	Prognosis created and sent to BRP(s) for which AGR-BRP contract present in the market		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Prognosis rejected by BRP	Error in Prognosis procedure
Primary actor	AGR		
Secondary actors	BRP		

Main scenario			
Alternatives			
Related information			
Message type	Prognosis (with Type=A-Plan and containing a PTU list) and PrognosisResponse.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Portfolio	AGR (Data controller)	The portfolio represents commercially sensitive information. Depending on the AGR's implementation, it may also include personally identifiable information, for which the responsibilities listed in the USEF P&S Guideline may apply.
	A-plan	AGR (Data controller)	The A-plan represents commercially sensitive information

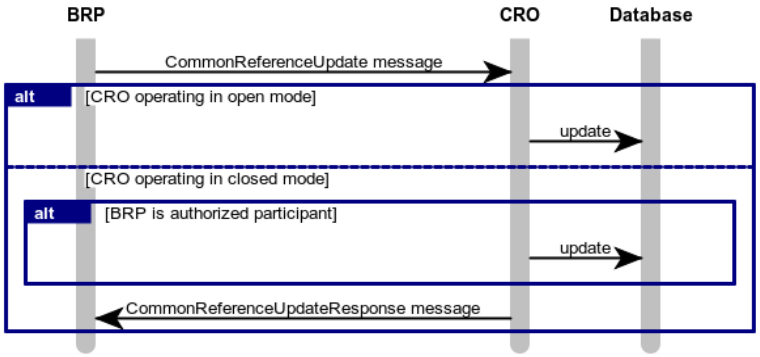
5.5.14 Publish Connections (Long-term)

ID	**UC0001**		
Triggered by	BRP (as part of day-ahead initialization or other long-term process)		
Triggers	UC3003 (Receive BRP Connection Updates)		
Goal in context	Publish the identifiers of all Connections in the BRP's coverage area in the Common Reference, in order to match them to Connections with an active AGR.		
Preconditions	Common Reference is available to BRP and AGRs		
Successful outcome	The Common Reference is updated with the BRP's Connections		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Common Reference not updated	CRO is operating in closed mode and the BRP is not pre-registered as an authorized participant
Primary actor	BRP		

Secondary actors	CRO		
Main scenario			
Alternatives	Absent a Common Reference, each BRP can manually configure the AGRs active in its coverage area (and vice versa).		
Related information	The Common Reference has strict Privacy & Security requirements, and its interface is limited on purpose: BRPs may only obtain Aggregator identities for those Connections they have registered themselves. Similarly, Aggregators may only obtain BRP identities and Connection identifiers for those Connections they have registered themselves.		
Message Type	CommonReferenceUpdate		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections	BRP (Data controller)	Connection identifiers should be treated as personally identifiable information. Which connections are represented by a BRP is commercially sensitive information.

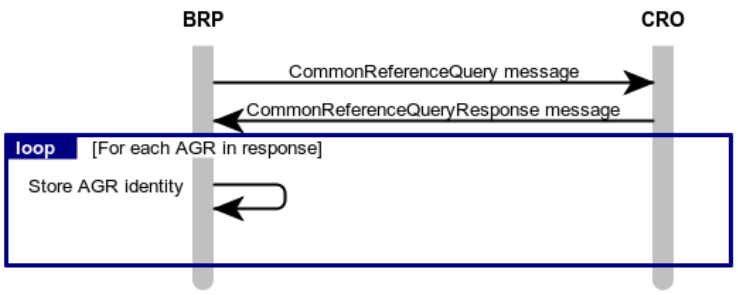
5.5.15 Receive BRP Connection Update

ID	**UC3003**		
Triggered by	UC0001 (Publish Connections)		
Triggers	n/a		
Goal in context	Receive Connection identifiers from the BRP. Store this information in the database underlying the Common Reference.		
Preconditions	Common Reference available to BRP and AGRs		
Successful outcome	The Common Reference register is updated with the latest information about Connections in the coverage area of the BRP sending the update.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Database is not updated	CRO is operating in closed mode and the BRP is not pre-registered as an authorized participant
Primary actor	CRO		
Secondary actors	BRP		

Main scenario	The Common Reference consists of a database with a logical structure as shown in Figure 2-8, for which the Common Reference Operator accepts updates from BRPs. If operating in open mode, the CRO will accept updates from any USEF-compliant participants implementing the BRP role. In closed mode, participants will need to be pre-configured in order for updates to be accepted.  		
Related information	A functioning Common Reference is a pre-condition for the Flex Market. It's the responsibility of the Common Reference operator to have policies regarding access, data retention, data security and conflict resolution compliant with the USEF Privacy & Security guidelines.		
Message type	CommonReferenceUpdate		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections	CRO (Data processor)	Connection identifiers should be treated as personally identifiable information. Which connections are represented by a BRP is commercially sensitive information.

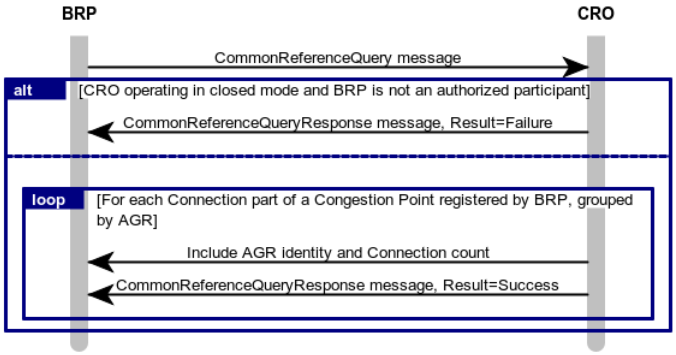
5.5.16 Retrieve Active Aggregators

ID	**UC0002**		
Triggered by	BRP (as part of day-ahead initialization)		
Triggers	n/a (this process is a prerequisite for UC0003)		
Goal in context	Retrieve a list of all registered AGRs representing Connections represented by the BRP. The BRP then knows from which Aggregators A-plans can be expected.		
Preconditions	The BRP has determined its Connections and published this information in the Common Reference (see UC0001). The AGR has registered the Connection identifiers for which it represents Prosumers in the Common Reference (see UC1027)		
Successful outcome	AGRs which represent Prosumers also represented by the BRP are available to the BRP		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Rejected	Query not performed	CRO is operating in closed mode and the BRP is not pre-registered as an authorized participant
Primary actor	DSO		
Secondary actors	BRP		

Main scenario			
Related information	BRPs may only obtain Aggregator identities for those Congestion Points they have registered in the Common Reference themselves.		
Message type	CommonReferenceQuery		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections	BRP (Data controller)	Connection identifiers should be treated as personally identifiable information. Which connections are represented by which AGR is commercially sensitive information.

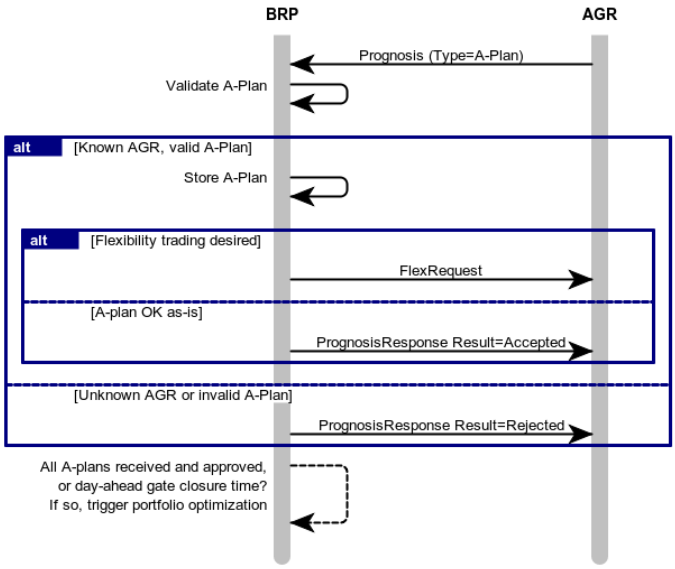
5.5.17 Send Active Aggregators to BRP

ID	**UC3007**		
Triggered by	UC0002 (Retrieve Active Aggregators)		
Triggers	n/a		
Goal in context	Respond to AGR queries from the BRP: validate need-to-know, retrieve data from the database underlying the Common Reference.		
Preconditions	Common Reference available to BRPs and AGRs; BRP has registered its Connection (UC0001).		
Successful outcome	The BRP receives AGR information: for all Connections it has registered, it receives the identity of each AGR (if any) plus the number of Connections that AGR represents.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Query failed	No data is received	CRO is operating in closed mode and the BRP is not registered as an authorized participant
Primary actor	CRO		
Secondary actors	BRP		

Main scenario	The Common Reference consists of a database with a logical structure as shown in Figure 2-8, which the Common Reference Operator uses to supply aggregated aggregator data to BRPs. If operating in open mode, the CRO will accept queries from any USEF-compliant participants implementing the BRP role. In closed mode, participants will need to be pre-configured in order for updates to be accepted.  		
Related information	A functioning Common Reference is a pre-condition for the Flex Market. It's the responsibility of the Common Reference operator to have policies regarding access, data retention, data security and conflict resolution compliant with the USEF Privacy & Security guidelines.		
Message type	CommonReferenceQueryResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connections	CRO (Data processor)	Connection identifiers should be treated as personally identifiable information. Which connections are represented by which AGR is commercially sensitive information.

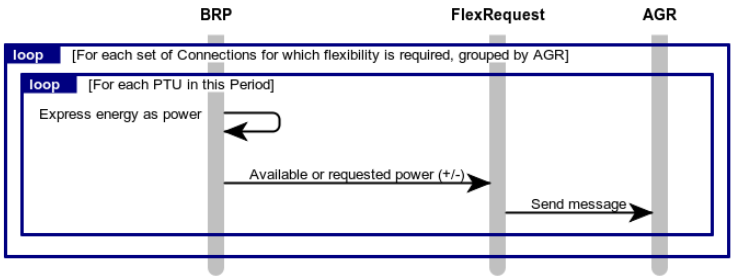
5.5.18 Receive A-Plan

ID	**UC0003**		
Triggered by	UC1007 (Re-Create and Send A-Plan)		
Triggers	Portfolio optimization		
Goal in context	Collect A-plans from AGRs and assess them on validity (syntax, semantics and timing). A-plans are specified by the Prognosis message.		
Preconditions	AGR-BRP market contract in place		
Successful outcome	All plans received and stored and portfolio optimization triggered		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Reject sent to Aggregator	Aggregator plan failed to pass validation
Primary actor	BRP		
Secondary actors	AGR		

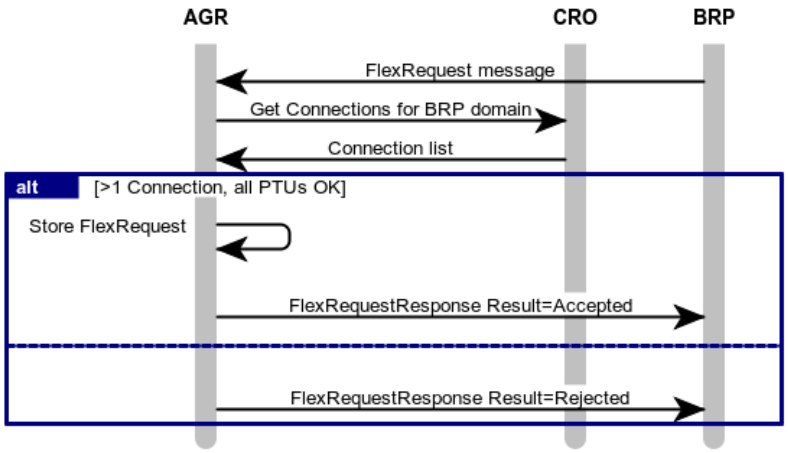
Main scenario	A-plans are received early in the BRP "day-ahead" process which starts at a configurable fixed time and ends when prognoses have been received from all active AGRs OR when the E-program needs to be created (BRP day-ahead plan closure time, configurable). 
Alternatives	
Related information	Active AGRs in the BRP coverage area are available from the Common Reference, and should have been retrieved prior to executing this use case. Alternatively, a list of known AGRs should be configured manually. Semantic validation failures that lead to rejection are: ■ The AGR specifies a PTU duration that is not the agreed-upon common value for my market; ■ The AGR specifies a time zone that has a different UTC offset than is the agreed-upon common value for my market; ■ The message sequence is lower than a previously received A-plan; ■ The originating AGR is not known (previously retrieved CRO data does not include this AG with at least one Connection); ■ The prognosis is sent too late (i.e. none of the PTUs in it is still before the day-ahead gate closure time for the specified Period: note that in the Operate phase, such prognoses may still be accepted for informational purposes); ■ The prognosis does not include all PTUs in the Period it applies to; ■ One or more Power values in the prognosis are absurd. USEF does not specify the BRP portfolio optimization or change detection processes, nor any processes related to the E-program. Note that, in case the BRP would like the AGR to modify its Prognosis and thus engage in flex trading, flexibility requests may be sent by the BRP based on a non-approved A-plan instance, which will become superseded by that action (whether actual flex trading takes place or not, a new instance of the A-plan will need to be sent and subsequently approved). Also note that the BRP will generally want to conclude receiving A-Plans a number of PTUs ***prior*** to the USEF day-ahead gate closure time, in order to allow market participants to engage in flex trading in the Validate phase. For this purpose, an implementation-specific Plan phase wrap-up time could be set.
Message types	Prognosis (with Type=A-Plan and a PTU list) and PrognosisResponse

Privacy & Security considerations	Data Product	Role	Responsibilities
	A-plan	BRP (Data controller)	The content of the A-plan represents commercially sensitive information. A-plans from an AGR representing only a single Connection should be considered personally identifiable information

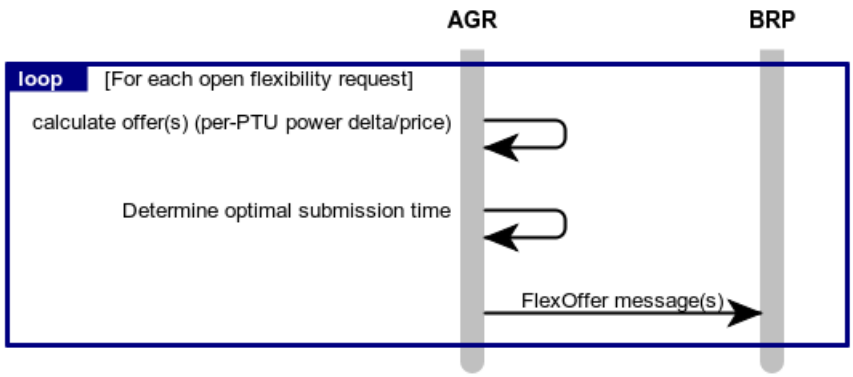
5.5.19 Create Flexibility Requests

ID	UC0004		
Triggered by	BRP portfolio optimization process		
Triggers	UC1008 (Receive Flexibility Request)		
Goal in context	If flexibility is desired, create and send requests to Aggregators potentially capable of delivering such.		
Preconditions	AGR-BRP market contract in place		
Successful outcome	Flexibility requests submitted to AGR(s)		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a
Primary actor	BRP		
Secondary actors	AGR		
Main scenario			
Alternatives			
Related information	Each flex request should include both the PTUs for which flexibility is desired, as well as the PTUs for which a certain margin is still available, allowing aggregators to time-shift load. For each period during which flexibility is desired, the BRP may create any number of flexibility requests (including no requests at all). If multiple requests are created, their content must not be identical. Which variations (more/less requested flexibility per PTU, time-shift of load) are created is a BRP-internal business decision.		
Message type	FlexRequest		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexRequest message	BRP (Data controller)	The content and timing of a flexibility request represent commercially sensitive information.

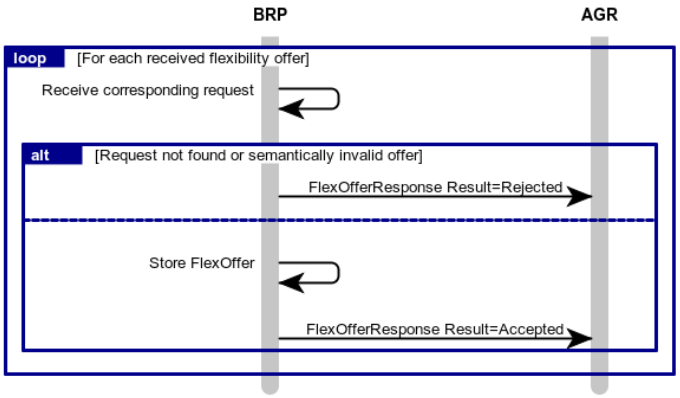
5.5.20 Receive Flexibility Request

ID	UC1008		
Triggered by	UC0004 (Create Flexibility Requests)		
Triggers	UC1010 (Create Flexibility Offer)		
Goal in context	Receive and store flexibility requests from a BRP with a coverage area with Aggregator-represented Connections. These requests serve as the basis for subsequent flexibility offers.		
Preconditions	AGR-BRP market contract in place		
Successful outcome	Flexibility request received and acknowledged by Aggregator		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Reject sent to BRP	FlexRequest is semantically invalid (i.e. does not contain all PTUs or no PTUs where flexibility is desired) or is not sent by a BRP listed in the Common Reference for at least one Connection represented by the receiving AGR.
Primary actor	AGR		
Secondary actors	BRP		
Main scenario			
Alternatives			
Related information	A flexibility request is usually based on an earlier prognosis. If not, this is slightly unusual, but not a reason not to accept the request: after all, the flexibility offer that is created and sent later does not need to match the initial request (or prognosis) perfectly.		
Message types	FlexRequest and FlexRequestResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexRequest message	AGR (Data controller)	The content and timing of a flexibility request represent commercially sensitive information.

5.5.21 Create and Send Flexibility Offer

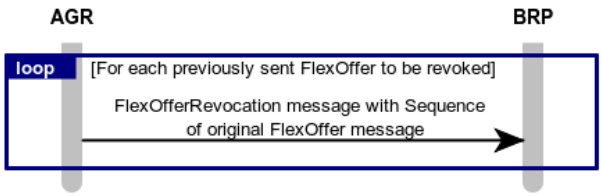
ID	UC1009		
Triggered by	UC1008 (Receive Flexibility Request)		
Triggers	UC0005 (Receive Flexibility Offer)		
Goal in context	Create flexibility offers based on previous BRP flexibility requests and send these to the originating BRPs. Each offer indicates to which extent we can provide requested flexibility and the desired compensation for doing so.		
Preconditions	Previous flexibility requests have been accepted and stored		
Successful outcome	Flexibility offers sent to the BRP		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a
Primary actor	AGR		
Secondary actors	BRP		
Main scenario	 This is a continuous function calculating flex offers and the optimal timing to send them to the BRP. Flex offers can completely or partially cover a flex request. Additional flex offers can be generated and sent to the BRP, either with additional or alternative offers.		
Alternatives	ADS are informed when flexibility has been offered, so reservations can be made at an early stage. Flex offers can be based on long-term contracts between BRP and AGR (always a certain amount of flexibility available) or on current planning conditions (flex depending on forecast).		
Related information	USEF does not specify how the AGR determines the optimal flexibility offers, the offer price and the optimal timing to send the offer to the BRP. AGRs need to support this function, in any manner. AGRs may elect to send multiple FlexOffer messages in response to a single FlexRequest: this includes sending a FlexOffer that better meets the BRP request at a much later time when circumstances have changed. Unsolicited FlexOffers are not allowed.		
Message type	FlexOffer		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOffer message	AGR (Data controller)	The content (especially pricing) of a flexibility offer represents commercially sensitive information.

5.5.22 Receive Flexibility Offers

ID	UC0005		
Triggered by	UC1009 (Create Flexibility Offer)		
Triggers	UC0006 (Receive Flexibility Offer, conditional on availability/desirability)		
Goal in context	Receive and store flexibility offers for later evaluation.		
Preconditions	One or more flexibility requests sent		
Successful outcome	Received one or more flexibility offers		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Invalid flex offer	Flex offer(s) rejected by BRP
Primary actor	DSO		
Secondary actors	AGR		
Main scenario			
Alternatives	Flex offers can be based on long-term contracts between BRP and AGR (always a certain amount of flexibility available) or on current planning conditions (flex depending on forecast). The BRP could implement a function to check whether AGR(s) comply with the long term contract rules, e.g. whether AGR(s) have sent the mandatory fixed flexibility offers if agreed in the contract.		
Related information	Any flexibility offer that is in response to a previous request and is semantically valid (i.e. consists of a list of power delta and price information for each PTU) should be accepted. Whether the offer is helpful in resolving congestion will be evaluated later.		
Message types	FlexOffer and FlexOfferResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOffer message	BRP (Data controller)	The content (especially pricing) of a flexibility offer represents commercially sensitive information.

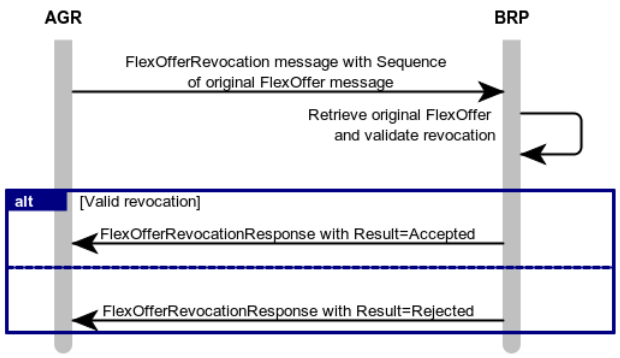
5.5.23 Revoke Flexibility Offer

ID	UC1011
Triggered by	AGR-internal process
Triggers	UC0007 (Receive Flexibility Offer Revocation)
Goal in context	Inform the BRP that a previously sent flexibility offer is no longer valid, despite the validity period of the offer not having expired yet.

Preconditions	A flexibility offer has been sent to and acknowledged by the BRP		
Successful outcome	Flexibility offer revocation notification submitted to the BRP		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a
Primary actor	AGR		
Secondary actors	BRP		
Main scenario			
Alternatives			
Related information	Only flexibility offers communicated using a FlexOffer message which has already been acknowledged by the BRP can be revoked. If the acknowledgement is still pending, the AGR should delay sending its FlexOfferRevocation message until it has been received.		
Message types	FlexOfferRevocation and FlexOfferRevocationResponse		

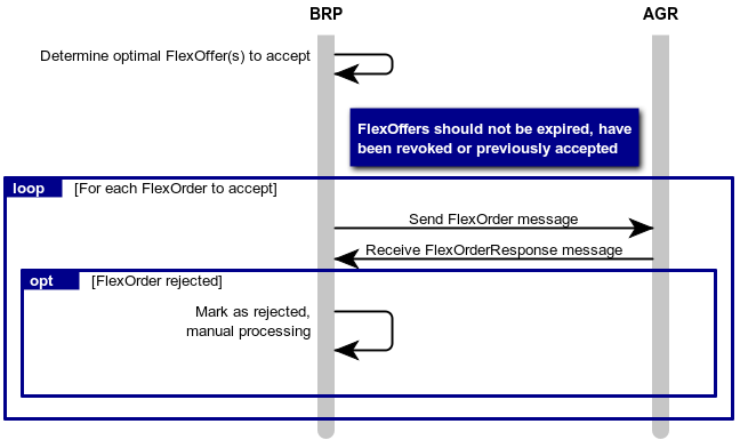
5.5.24 Receive Flexibility Offer Revocation

ID	**UC0007**		
Triggered by	UC1011 (Revoke Flexibility Offer)		
Triggers			
Goal in context	Receive and validate a flexibility offer revocation notice from the AGR. If the revocation applies to a previously received offer, mark that offer as revoked.		
Preconditions	A flexibility offer has been received from and acknowledged to the AGR		
Successful outcome	Flexibility offer marked as revoked		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Reject sent to AGR	FlexOfferRevocation message does not refer to a previously received and acknowledged FlexOffer message, or the revocation is received too late (see Related Information)
Primary actor	BRP		
Secondary actors	AGR		

Main scenario			
Alternatives			
Related information	Flex offers may be revoked at any time in the plan and validate phases (i.e. as long as none of the PTUs in the Period the offer applies to is already in Operate phase), even if there is already an active flex order based on the offer. Only if the offer did not exist in the first place or any of its PTU(s) are already in Operate or Pending Settlement, may the revocation be rejected.		
Message types	FlexOfferRevocation and FlexOfferRevocationResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOfferRevocation message	BRP (Data controller)	The existence and timing of a flexibility offer revocation represent commercially sensitive information.

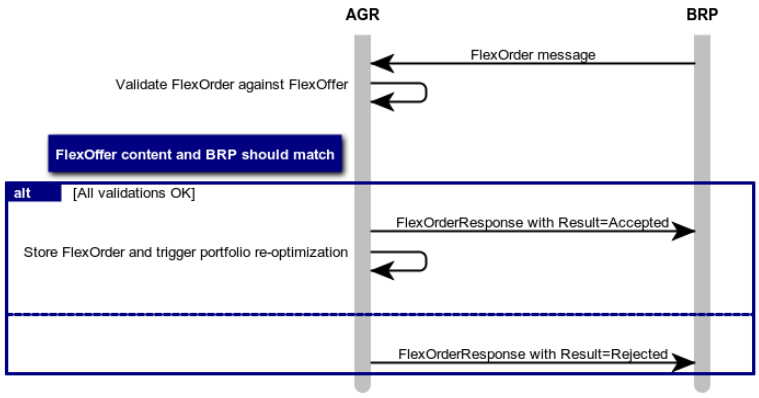
5.5.25 Place Flexibility Orders

ID	**UC0006**		
Triggered by	UC0005 (Receive Flexibility Offers, conditional on possibility/desirability)		
Triggers	UC1010 (Receive Flexibility Order)		
Goal in context	Accept (some) flexibility offers to order flexibility based on the Prognosis. Flexibility orders are specified by the **FlexOrder** message.		
Preconditions	**FlexOffer**(s) received by BRP		
Successful outcome	Flexibility procured		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Rejected by AGR	**FlexOrder** failed to pass validation by the AGR
Primary actor	BRP		
Secondary actors	AGR		

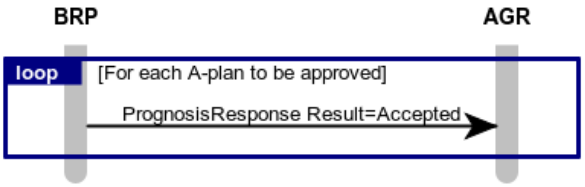
Main scenario	 This is a continuous function processing flex offers and determining the optimal offer to accept and the timing to accept them by sending flex orders to the AGR. Flex offers can completely or partially cover a flex request. As long as the flex request is not completely covered, additional flex offers can be accepted.		
Alternatives			
Related information	USEF does not specify how the BRP determines which flexibility offers to accept and when to except them. BRPs need to support this function, in any manner.		
Message type	FlexOrder		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOrder message	BRP (Data controller)	The content (especially pricing) and existence/ timing of a flexibility order represent commercially sensitive information.

5.5.26 Receive Flexibility Order

ID	**UC1010**		
Triggered by	UC0006 (Place Flexibility Orders)		
Triggers	UC1005 (Re-optimize Portfolio)		
Goal in context	Receive flexibility orders from BRP. Flexibility orders are specified by the **FlexOrder** message and acknowledged using a **FlexOrderResponse**.		
Preconditions	**FlexOffer**(s) sent to DSO(s)		
Successful outcome	**FlexOrder** acknowledged to BRP Valid flexibility order created Portfolio re-optimization triggered		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Reject sent to DSO	**FlexOrder** failed to pass validation
Primary actor	AGR		
Secondary actors	DSO		

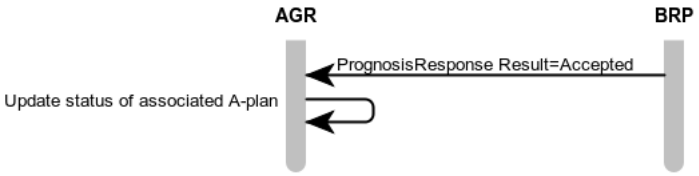
Main scenario			
Alternatives	It is up to the AGR to decide whether ADS are informed when flexibility has been procured, so ADS can reserve it.		
Related information			
Message type	FlexOrder		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOrder message	AGR (Data controller)	The content (especially pricing) and existence/ timing of a flexibility order represent commercially sensitive information.

5.5.27 Approve A-Plan

ID	**UC0008**		
Triggered by	UC0003 (Receive A-Plan), UC0005 (Receive Flexibility Offers) or day-ahead gate closure		
Triggers	UC1012		
Goal in context	Approve a previously received A-plan using a **PrognosisResponse** message, since no (further) flex trading with the originating aggregator is possible or desired.		
Preconditions	**Prognosis** message received from AGR		
Successful outcome	**PrognosisResponse** message sent to AGR		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a		
Primary actor	BRP		
Secondary actors	AGR		
Main scenario			
Alternatives			
Message type	5.5.27.1.1.1.1 PrognosisResponse		

Related information	Even if flex trading is still in progress at the USEF day-ahead gate closure time, the BRP should approve the latest receive A-plan at this time. The AGR will consider the plan final at that time anyway.

5.5.28 Receive A-Plan Approval

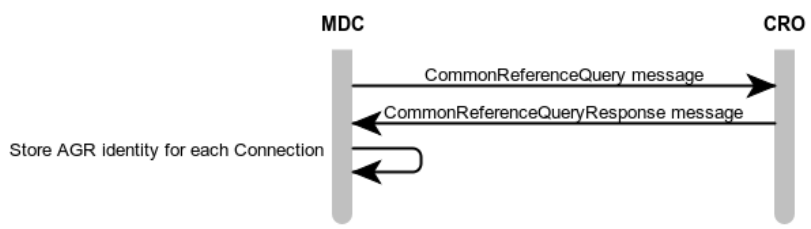
ID	**UC1012**		
Triggered by	UC0008 (Approve A-Plan)		
Triggers	UC1013 (New D-Prognoses Required?)		
Goal in context	Update the status of an A-plan previously sent to the BRP to Approved		
Preconditions	**Prognosis** message sent to BRP		
Successful outcome	**PrognosisResponse** message received from BRP		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a		
Primary actor	AGR		
Secondary actors	BRP		
Main scenario			
Alternatives			
Message type	PrognosisResponse		
Related information	If no explicit approval has been received for an A-plan, and the USEF day-ahead gate closure time* is reached, the AGR can unilaterally consider the A-plan to be final. (*Note that the AGR will generally want to conclude A-Plan approvals a number of PTUs *prior* to the USEF day-ahead gate closure time, in order to engage in flex trading in the Validate phase. For this purpose, an implementation-specific Plan phase wrap-up time could be set.)		

5.5.29 New D-Prognoses Required?

ID	**UC1013**
Triggered by	UC1012 (Receive A-Plan Approval)
Triggers	Continuation to Validate phase (conditionally: if reiterating, only when new D-prognoses are actually required)
Goal in context	Decide whether to continue to the Validate or Operate phase
Preconditions	Plan phase has been iterated at least once
Successful outcome	Continuation to Validate or Operate phase

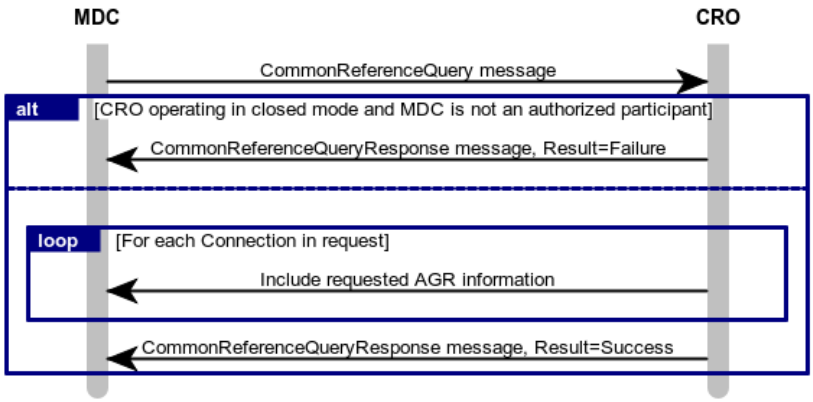
Failure outcome	Failure	Outcome	Condition leading to outcome
	n/a		
Primary actor	AGR		
Secondary actors			
Main scenario	At the end of the Operate phase, the aggregator should check whether new D-prognoses are required. This will always be the case after the first iteration of Operate, since no D-prognosis will exist yet. If D-prognoses should be created or updated, the Validate phase should be iterated. Otherwise, the latest A-plan and D-prognoses should be used in Operate.		
Alternatives			
Related information			

5.5.30 MDC: Retrieve Active Aggregators

ID	UC4001		
Triggered by	MDC (as part of day-ahead initialization)		
Triggers	N/A		
Goal in context	Retrieve a list of all Aggregators registered for the Connections represented by the Meter Data Company. The MDC uses this information to provide per-aggregator meter reading aggregations in the settlement phase.		
Preconditions	Common Reference available to AGRs and MDCs; The MDC has created a list of the Connections it represents.		
Successful outcome	The MDC stores a snapshot of the active aggregator for each represented Connection during the active Period.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Rejected	Query not performed	CRO is operating in closed mode and the MDC is not pre-registered as an authorized participant
Primary actor	MDC		
Secondary actors	CRO		
Main scenario			
Related information			
Message types	CommonReferenceQuery and CommonReferenceQueryResponse		

Privacy & Security considerations	Data Product	Role	Responsibilities
	Aggregator representing each Connection	MDC (Data processor)	Connection identifiers should be treated as personally identifiable information; AGR linked to each Connection as commercially sensitive information.

5.5.31 Send Active Aggregators to MDC

ID	UC3006		
Triggered by	UC4001 (Retrieve Active Aggregators)		
Triggers	n/a		
Goal in context	Respond to AGR queries from the MDC: validate need-to-know, retrieve data from the database underlying the Common Reference.		
Preconditions	Common Reference available to AGRs and MDCs; AGRs have registered which Connections they represent (UC1001)		
Successful outcome	The MDC receives AGR information for the Connections it includes in its query message		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Query failed	No data is received	CRO is operating in closed mode and the MDC is not registered as an authorized participant
Primary actor	CRO		
Secondary actors	MDC		
Main scenario	*The Common Reference consists of a database with a logical structure as shown in Figure 2-8, which the Common Reference Operator uses to supply data to MDCs. If operating in open mode, the CRO will accept queries from any USEF-compliant participants implementing the MDC role. In closed mode, participants will need to be pre-configured in order for updates to be accepted.*  		
Related information	A functioning Common Reference is a pre-condition for the Flex Market. It's the responsibility of the Common Reference operator to have policies regarding access, data retention, data security and conflict resolution compliant with the USEF Privacy & Security guidelines.		
Message type	CommonReferenceQueryResponse		

Privacy & Security considerations	Data Product	Role	Responsibilities
	Aggregator representing each Connection	CRO (Data processor)	Connection identifiers should be treated as personally identifiable information, AGR linked to each Connection as commercially sensitive information.

5.6 Use cases – Validate phase

In Section 2.3.2 informative description of the validate phase processes has been given. In this chapter the use cases will be described as derived from the validate phase process diagrams. Each activity (rounded rectangle) in the process diagrams is listed as a use case.

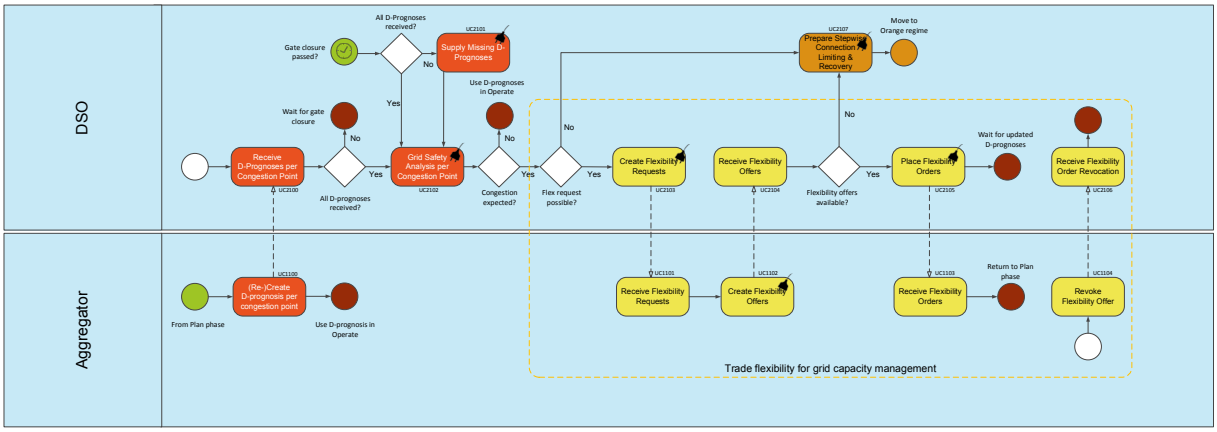


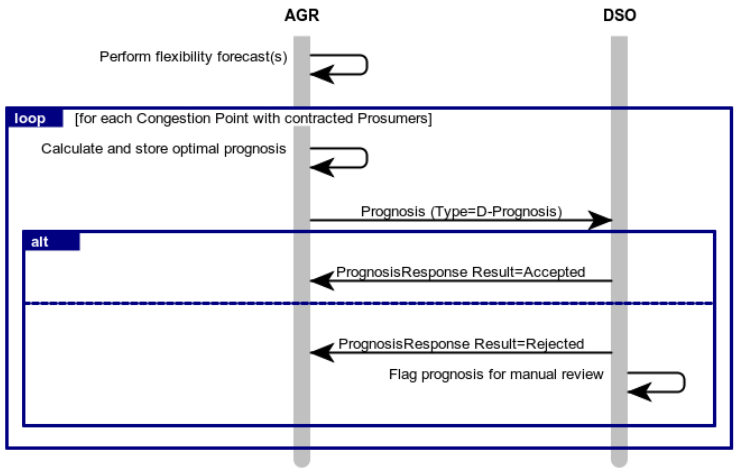
Figure 5-2: Process flows of the Validate phase. New processes are depicted in red. Processes depicted in yellow refer to the grid capacity management regime. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

The USEF MCM validate phase specifies the following use cases:

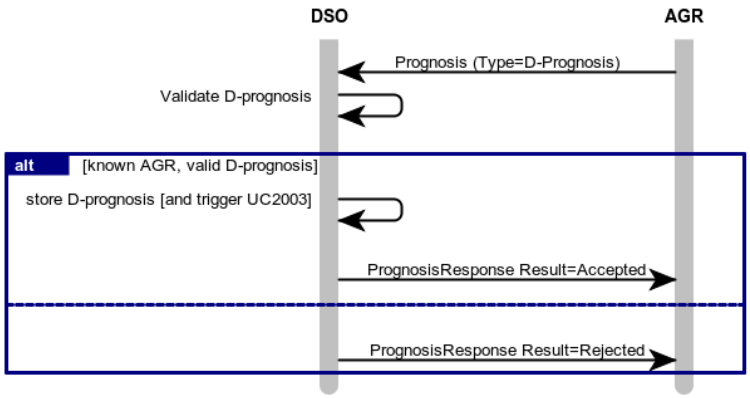
Table 5.3: Use cases for the Validate phase.

ID	Name	Role	Message
UC1100	(Re-)Create D-Prognoses per Congestion Point	AGR	Prognosis / PrognosisResponse
UC2100	Receive D-Prognoses per Congestion Point	DSO	Prognosis / PrognosisResponse
UC2101	Supply Missing D-Prognoses	DSO	Prognosis
UC2102	Grid Safety Analysis per Congestion Point	DSO	
UC2103	Create Flexibility Requests	DSO	FlexRequest
UC1101	Receive Flexibility Requests	AGR	FlexRequest / FlexRequestResponse
UC1102	Create Flexibility Offers	AGR	FlexOffer
UC2104	Receive Flexibility Offers	DSO	FlexOfferResponse
UC1104	Revoke Flexibility Offers	AGR	FlexOfferRevocation
UC2106	Receive Flexibility Offer Revocations	DSO	FlexOfferRevocationResponse
UC2105	Place Flexibility Orders	DSO	FlexOrder
UC1103	Receive Flexibility Orders	AGR	FlexOrderResponse

5.6.1 (Re-)Create D-Prognoses per Congestion Point

ID	UC1100		
Triggered by	UC1013 (Plan phase decision that new D-prognoses are required)		
Triggers	UC2100 (DSO: Receive D-Prognoses)		
Goal in context	(Re-)Create D-prognoses per congestion point based on the AGR portfolio. These D-prognoses will be submitted to the DSO.		
Preconditions	Congestion point(s) defined and retrieved from the CRO, AGR-DSO contracts in place and A-plan defined		
Successful outcome	D-prognosis message created and accepted by the DSO for each congestion point on which the AGR has active Connections		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Prognosis rejected by DSO	Rejected response from DSO
Primary actor	AGR		
Secondary actor	DSO		
Main scenario			
Alternatives			
Related information	Congestion Points (with associated DSOs) at which the AGR has contracted Prosumers are available from the Common Reference, and should have been retrieved prior to executing this use case.		
Message types	Prognosis (with Type=D-Prognosis and containing a PTU list) and PrognosisResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Prognosis	DSO (Data controller)	Content of D-prognoses represents commercially sensitive information

5.6.2 Receive D-Prognoses Per Congestion Point

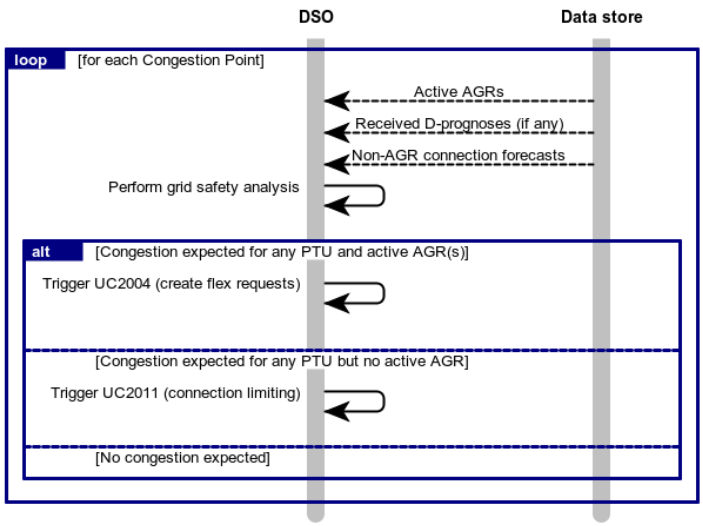
ID	UC2100		
Triggered by	UC1100 (D-prognosis message sent by an AGR)		
Triggers	UC2102 (Grid Safety Analysis, conditional on availability of all D-prognoses)		
Goal in context	Receive D-prognosis for a congestion point from an AGR. The received prognosis is checked, after which it is either accepted or rejected.		
Preconditions	Retrieve AGRs per Congestion Point from CRO (UC2002) AGRs have created D-prognoses (UC1010)		
Successful outcome	Prognosis accepted		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Prognosis rejected by DSO	Reject response to AGR
Primary actor	DSO		
Secondary actor	AGR		
Main scenario			
Alternatives			
Related information	Active AGRs at Congestion Point are available from the Common Reference, and should have been retrieved prior to executing this use case. Semantic validation failures that lead to rejection are: ■ The AGR specifies a PTU duration that is not the agreed-upon common value for my market; ■ The AGR specifies a time zone that has a different UTC offset than is the agreed-upon common value for my market; ■ The message sequence is lower than a previously received D-prognosis; ■ The prognosis specifies a Congestion Point that is unknown to me; ■ The Congestion Point is known, but the originating AGR is not known (previously retrieved CRO data does not include this AGR with at least one Connection); ■ The Period specified is in the past (i.e. all PTUs in it are already pending settlement); ■ The prognosis does not include all PTUs in the Period it applies to; ■ One or more Power values in the prognosis are absurd.		
Message types	Prognosis (with Type=D-Prognosis and a PTU list) and PrognosisResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Prognosis	DSO (Data controller)	Content of D-prognoses represents commercially sensitive information

5.6.3 Supply Missing D-Prognoses

ID	UC2101		
Triggered by	Time-based trigger (day-ahead gate closure while not all D-prognoses have been received)		
Triggers	UC2102 (Grid Safety Analysis)		
Goal in context	If not all AGRs have submitted their D-prognosis by gate closure time, generate substitute prognoses on behalf of those aggregators in order to be able to perform a grid safety analysis.		
Preconditions	Retrieve AGRs per Congestion Point from CRO (UC2002) A system for per-Congestion Point prognoses for a given number of Connections is in place.		
Successful outcome	Substitute Prognosis messages generated and stored on behalf of AGRs which did not send those messages themselves.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
		n/a	
Primary actor	DSO		
Secondary actor			
Main scenario			
Alternatives			
Related information	USEF does not specify how this function should be implemented: the DSO must perform it using any existing or new system or combination thereof.		
Message types	Prognosis (with Type=D-Prognosis and a PTU list).		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Prognosis	DSO (Data controller)	Content of D-prognoses and the fact that a given AGR did not submit one in a timely fashion represent commercially sensitive information.

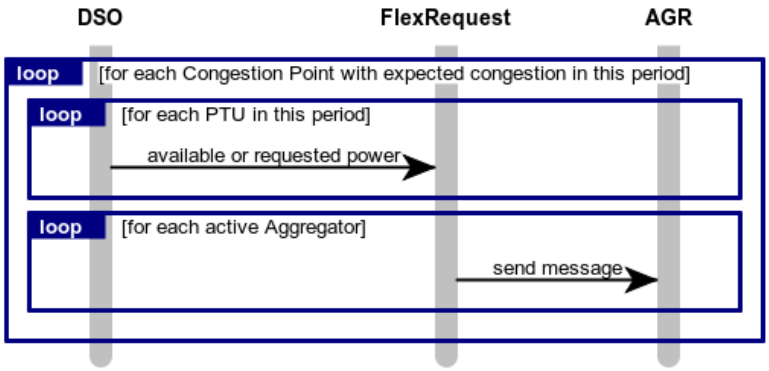
5.6.4 Grid Safety Analysis per Congestion Point

ID	UC2102		
Triggered by	UC2100 or UC2101 (Receive or supply missing D-prognoses)		
Triggers	UC2103 (create flex requests), conditional on congestion being expected		
Goal in context	Check for (possible) congestion per congestion point, based on D-prognoses received and non-AGR connection forecasts		
Preconditions	D-prognoses received (see UC2100); forecast for non-AGR connections created (see UC2003)		
Successful outcome	Planning room calculated, capable of deciding whether flexibility requests are required or not		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a
Primary actor	DSO		
Secondary actors			

Main scenario			
Alternatives			
Related information	The combination of all received D-prognoses and the (synthetic profile) forecasts performed for prosumers not represented by an aggregator (or for which no D-prognosis has been submitted) allows the DSO to perform a grid safety analysis. How exactly the grid safety analysis is implemented by the DSO is not specified: this is left up to the particular organization. The outcome of the analysis should be sufficient for the DSO to determine when (i.e. during which PTUs, if any) congestion is expected, and how much flexibility is required to resolve congestion. This outcome must include the flexibility required in certain PTUs and the available room in other PTUs.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Grid safety analysis	DSO (Data controller)	The input parameters for and processing involved in the grid safety analysis are proprietary DSO information; the outcome of the analysis is commercially sensitive information.

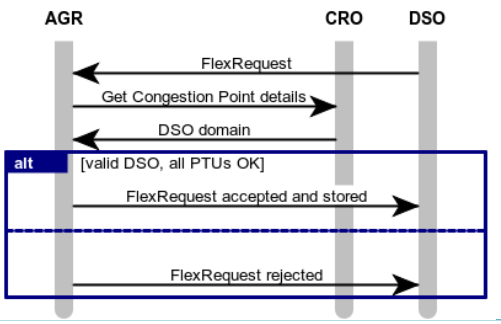
5.6.5 Create Flexibility Requests

ID	**UC2103**		
Triggered by	UC2102 (Grid Safety Analysis, conditional on congestion being expected)		
Triggers	UC1101 (AGR receive flex requests)		
Goal in context	If grid congestion is expected, create and send requests for flexibility to Aggregators potentially capable of helping to lessen that congestion.		
Preconditions	AGR-DSO market contract in place One or more Congestion Points registered in the Common Reference, with at least one Aggregator with contracted Connections on that point DSO grid safety analysis performed		
Successful outcome	Flexibility requests submitted to AGR(s)		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a

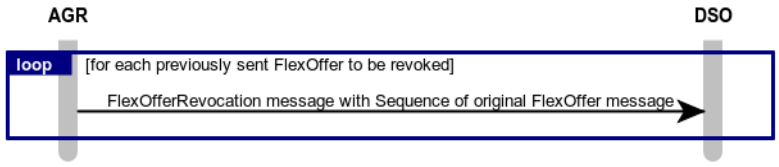
Primary actor	DSO		
Secondary actors	AGR		
Main scenario			
Alternatives			
Related information	Each flex request should include both the PTUs for which congestion is expected, as well as the PTUs for which capacity is still available, allowing aggregators to time-shift load. For each period during which congestion is expected, the DSO may create any number of flexibility requests (including no requests at all). If multiple requests are created, their content must not be identical. Which variations (more/less requested power per PTU, time-shift of load) are created is a DSO-internal business decision.		
Message type	FlexRequest		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexRequest message	DSO (Data controller)	The existence and content of a flexibility request represent commercially sensitive information.

5.6.6 Receive Flexibility Requests

ID	**UC1101**		
Triggered by	UC2103 (DSO send flex requests)		
Triggers	UC1102 (Create flex offers)		
Goal in context	Receive and store flexibility requests from a DSO operating on a Congestion Point with Aggregator-represented Prosumers. These requests serve as the basis for subsequent flexibility offers.		
Preconditions	AGR-DSO market contract in place One or more Congestion Points registered in the Common Reference, with at least one Aggregator with contracted Connections on that point		
Successful outcome	Flexibility request received and acknowledged by Aggregator		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Reject sent to DSO	FlexRequest is semantically invalid (i.e. does not contain all PTUs or no PTUs where congestion is expected) or is not sent by a DSO listed in the Common Reference as active on the Congestion Point it applies to.
Primary actor	AGR		
Secondary actors	DSO		

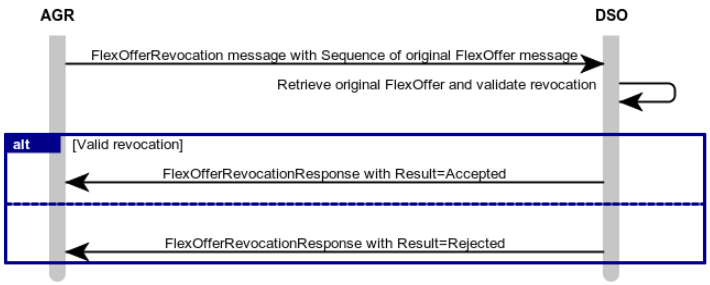
Main scenario			
Alternatives			
Related information	A flexibility request is usually based on an earlier prognosis. If not, this is slightly unusual, but not a reason not to accept the request: after all, the flexibility offer that is created and sent later does not need to match the initial request (or prognosis) perfectly.		
Message types	FlexRequest and FlexRequestResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexRequest message	AGR (Data controller)	The existence and content of a flexibility request represent commercially sensitive information.

5.6.7 Revoke Flexibility Offer

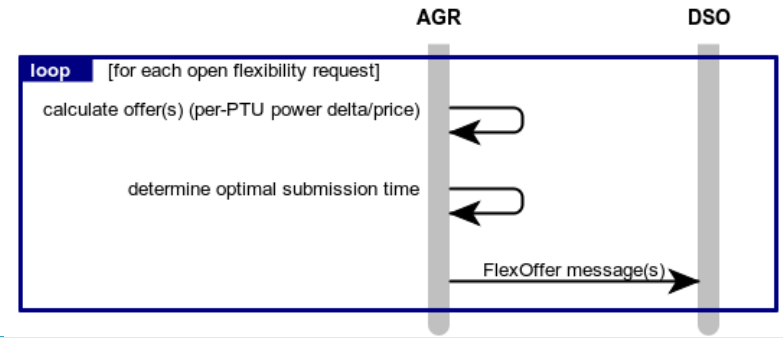
ID	**UC1104**		
Triggered by	AGR-internal process		
Triggers	UC2106 (DSO receive flex offer revocation)		
Goal in context	Inform the DSO that a previously sent flexibility offer is no longer valid, despite the validity period of the offer not having expired yet.		
Preconditions	A flexibility offer has been sent to and acknowledged by the DSO		
Successful outcome	Flexibility offer revocation notification submitted to the DSO		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a
Primary actor	AGR		
Secondary actors	DSO		
Main scenario			
Alternatives			
Related information	Only flexibility offers communicated using a FlexOffer message which has already been acknowledged by the DSO can be revoked. If the acknowledgement is still pending, the AGR should delay sending its FlexOfferRevocation message until it has been received.		
Message types	FlexOfferRevocation and FlexOfferRevocationResponse		

Privacy & Security considerations	Data Product	Role	Responsibilities
	FlexOfferRevocation message	AGR (Data controller)	The existence and timing of a flexibility offer revocation represent commercially sensitive information.

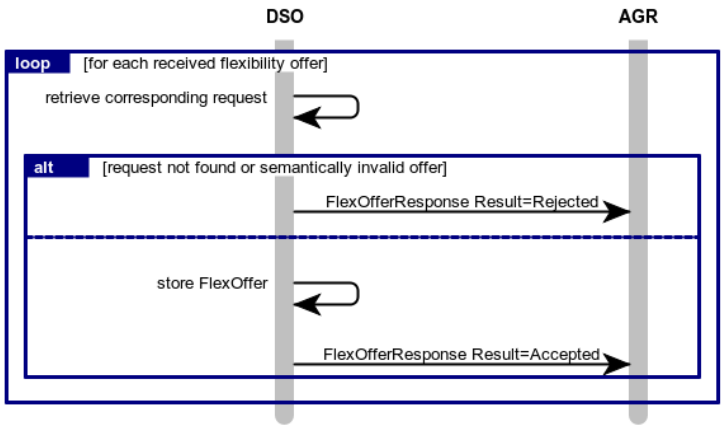
5.6.8 Receive Flexibility Offer Revocation

ID	UC2106		
Triggered by	UC1104 (AGR revoke flex offer)		
Triggers			
Goal in context	Receive and validate a flexibility offer revocation notice from the AGR. If the revocation applies to a previously received offer, mark that offer as revoked.		
Preconditions	A flexibility offer has been received from and acknowledged to the AGR		
Successful outcome	Flexibility offer marked as revoked		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Reject sent to AGR	FlexOfferRevocation message does not refer to a previously received and acknowledged FlexOffer message, or the revocation is received too late (see Related Information).
Primary actor	DSO		
Secondary actors	AGR		
Main scenario			
Alternatives			
Related information	Flex offers may be revoked at any time in the plan and validate phases (i.e. as long as none of the PTUs in the Period the offer applies to is already in Operate phase), even if there is already an active flex order based on the offer. Only if the offer did not exist in the first place or any of its PTU(s) are already in Operate or Pending Settlement, may the revocation be rejected.		
Message types	FlexOfferRevocation and FlexOfferRevocationResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOfferRevocation message	DSO (Data controller)	The existence and timing of a flexibility offer revocation represent commercially sensitive information.

5.6.9 Create Flexibility Offers

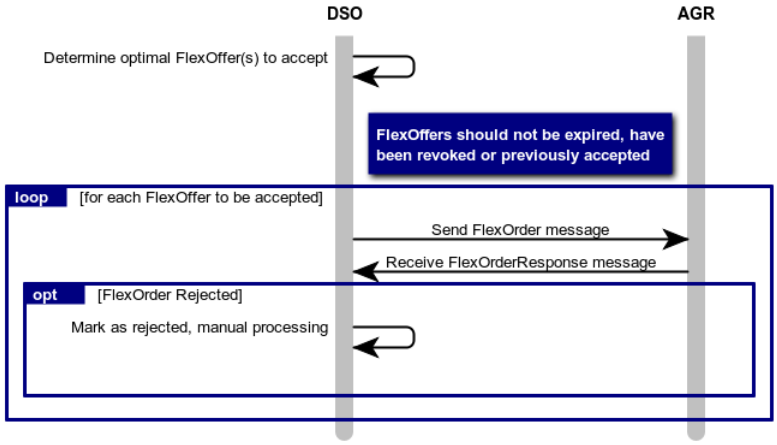
ID	UC1102		
Triggered by	UC1101 (Receive flex requests)		
Triggers	UC2104 (DSO receive flex offers)		
Goal in context	Create flexibility offers based on previous DSO flexibility requests and send these to the originating DSOs. Each offer indicates to which extent we can provide requested flexibility and the desired compensation for doing so.		
Preconditions	Previous flexibility requests have been accepted and stored		
Successful outcome	Flexibility offers sent to the DSO		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a
Primary actor	AGR		
Secondary actors	DSO		
Main scenario			
Alternatives	ADS are informed when flexibility has been offered, so reservations can be made at an early stage. Flex offers can be based on long-term contracts between DSO and AGR (always a certain amount of flexibility available) or on current planning conditions (flex depending on forecast).		
Related information	USEF does not specify how the AGR determines the optimal flexibility offers, the offer price and the optimal timing to send the offer to the DSO. AGRs need to support this function, in any manner. AGRs may elect to send multiple FlexOffer messages in response to a single FlexRequest: this includes sending a FlexOffer that better meets the DSO request at a much later time when circumstances have changed. Unsollicited FlexOffers are not allowed. In case no flexibility is available, the AGR sends a FlexOffer message without a PTU list.		
Message type	FlexOffer		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexRequest message	AGR (Data controller)	The existence and content of a flexibility request represent commercially sensitive information.
	FlexOffer message	AGR (Data controller)	The content of a flexibility offer represents commercially sensitive information.

5.6.10 Receive Flexibility Offers

ID	UC2104		
Triggered by	UC1102 (AGR send flex offers)		
Triggers	UC2105 (Place flex orders, conditional in offers being available and desirable)		
Goal in context	Receive and store flexibility offers for later evaluation.		
Preconditions	One or more flexibility requests sent		
Successful outcome	Received one or more flexibility offers		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Invalid flex offer	Flex offer(s) rejected by DSO
Primary actor	DSO		
Secondary actors	AGR		
Main scenario			
Alternatives	Flex offers can be based on long-term contracts between DSO and AGR (always a certain amount of flexibility available) or on current planning conditions (flex depending on forecast). The DSO could implement a function to check whether AGR(s) comply with the long term contract rules, e.g. whether AGR(s) have sent the mandatory fixed flexibility offers if agreed in the contract.		
Related information	Any flexibility offer that is in response to a previous request and is semantically valid (i.e. consists of a list of power delta and price information for each PTU) should be accepted. Whether the offer is helpful in resolving congestion will be evaluated later.		
Message types	FlexOffer and FlexOfferResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOffer message	DSO (Data controller)	The existence and content of a flexibility offer represent commercially sensitive information.

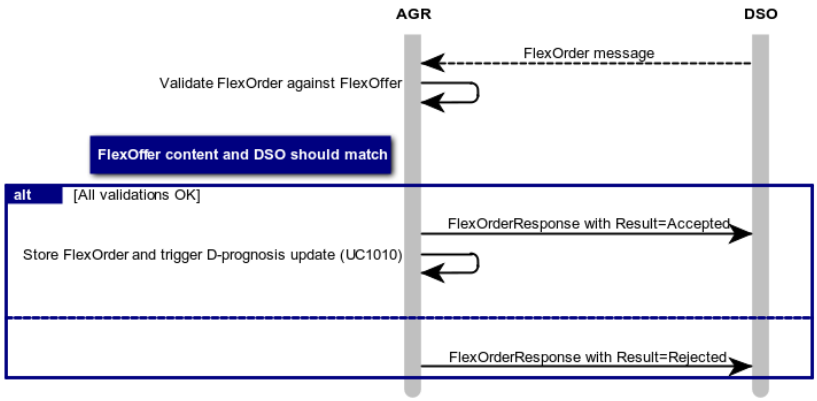
5.6.11 Place Flexibility Orders

ID	UC2105
Triggered by	UC2104 (receive flex offers)
Triggers	UC1103 (AGR receive flex orders)

Goal in context	Accept (some) flexibility offers to solve Congestion based on the Prognosis. Flexibility orders are specified by the **FlexOrder** message.		
Preconditions	**FlexOffer**(s) received by DSO		
Successful outcome	Flexibility procured		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Rejected by AGR	**FlexOrder** failed to pass validation by the AGR
Primary actor	DSO		
Secondary actors	AGR		
Main scenario	 This is a continuous function processing flex offers and determining the optimal offer to accept and the timing to accept them by sending flex orders to the AGR. Flex offers can completely or partially cover a flex request. As long as the flex request is not completely covered, additional flex offers can be accepted.		
Alternatives			
Related information	USEF does not specify how the DSO determines which flexibility offers to accept and when to except them. DSOs need to support this function, in any manner.		
Message types	FlexOrder and FlexOrderResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOffer message	DSO (Data controller)	The existence and content of a flexibility offer represent commercially sensitive information.
	FlexOrder message	DSO (Data controller)	The content of a flexibility order represents commercially sensitive information.

5.6.12 Receive Flexibility Orders

ID	UC1103
Triggered by	UC2105 (DSO send flex orders)
Triggers	UC1005 (re-optimize portfolio, via return to Plan phase)
Goal in context	Receive flexibility orders from DSO. Flexibility orders are specified by the **FlexOrder** message and acknowledged using a **FlexOrderResponse**.
Preconditions	**FlexOffer**(s) sent to DSO(s)

Successful outcome	**FlexOrder** acknowledged to DSO Valid flexibility order created Re-optimize Portfolio triggered		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Reject sent to DSO	**FlexOrder** failed to pass validation
Primary actor	AGR		
Secondary actors	DSO		
Main scenario			
Alternatives	It is up to the AGR to decide whether ADS are informed when flexibility has been procured, so ADS can reserve it.		
Related information			
Message types	FlexOrder and FlexOrderResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOrder message	AGR (Data controller)	The content of a flexibility order represents commercially sensitive information.

5.7 Use cases - Validate phase – orange regime

In Section 4.3.2 the informative description of the validate phase processes during yellow/orange regimes has been given. In this chapter the use cases will be described as derived from the operate phase during orange regime process diagrams. The orange activity (rounded rectangle) in the process diagram is listed as a use case.

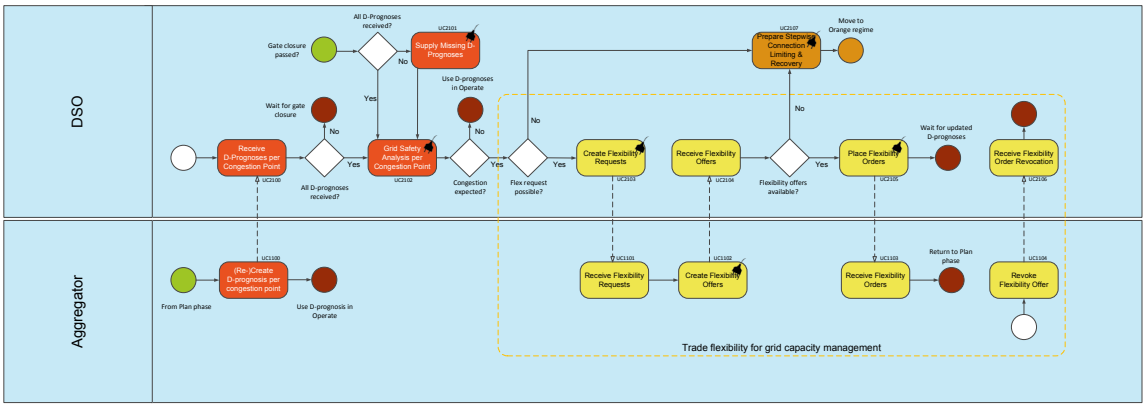


Figure 5-3: Process diagram of the Validate phase.

ID	Name	Role	Phase	Message
UC2107	Prepare Stepwise Connection Limiting & Recovery	DSO	Validate	

5.7.1 Prepare Stepwise Connection Limiting & Recovery

ID	UC2107		
Triggered by	UC2102 (grid safety analysis) or UC2104 (receive flex offers) conditional on congestion being expected and no flex being available		
Triggers	Move to Orange regime for the affected PTU(s)		
Goal in context	Prepare connection limitation & recovery for orange regime		
Preconditions	Congestion points defined		
Successful outcome	Plan available for connection limitation & recovery for orange regime		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors			
Main scenario	DSOs must support a function to decide on the graceful degradation under the orange regime. DSOs need to be able to prioritize and categorization connections in order to decide which connections they limit and which they restore during the operate phase in the orange regime. USEF does not specify how DSOs implement this function.		
Alternatives			
Related information			

5.8 Use cases - Operate phase

In Section 2.3.3 the informative description of the operate phase processes has been given. In this chapter the use cases will be described as derived from the operate phase process diagrams. Each activity (rounded rectangle) in the process diagrams is listed as a use case.

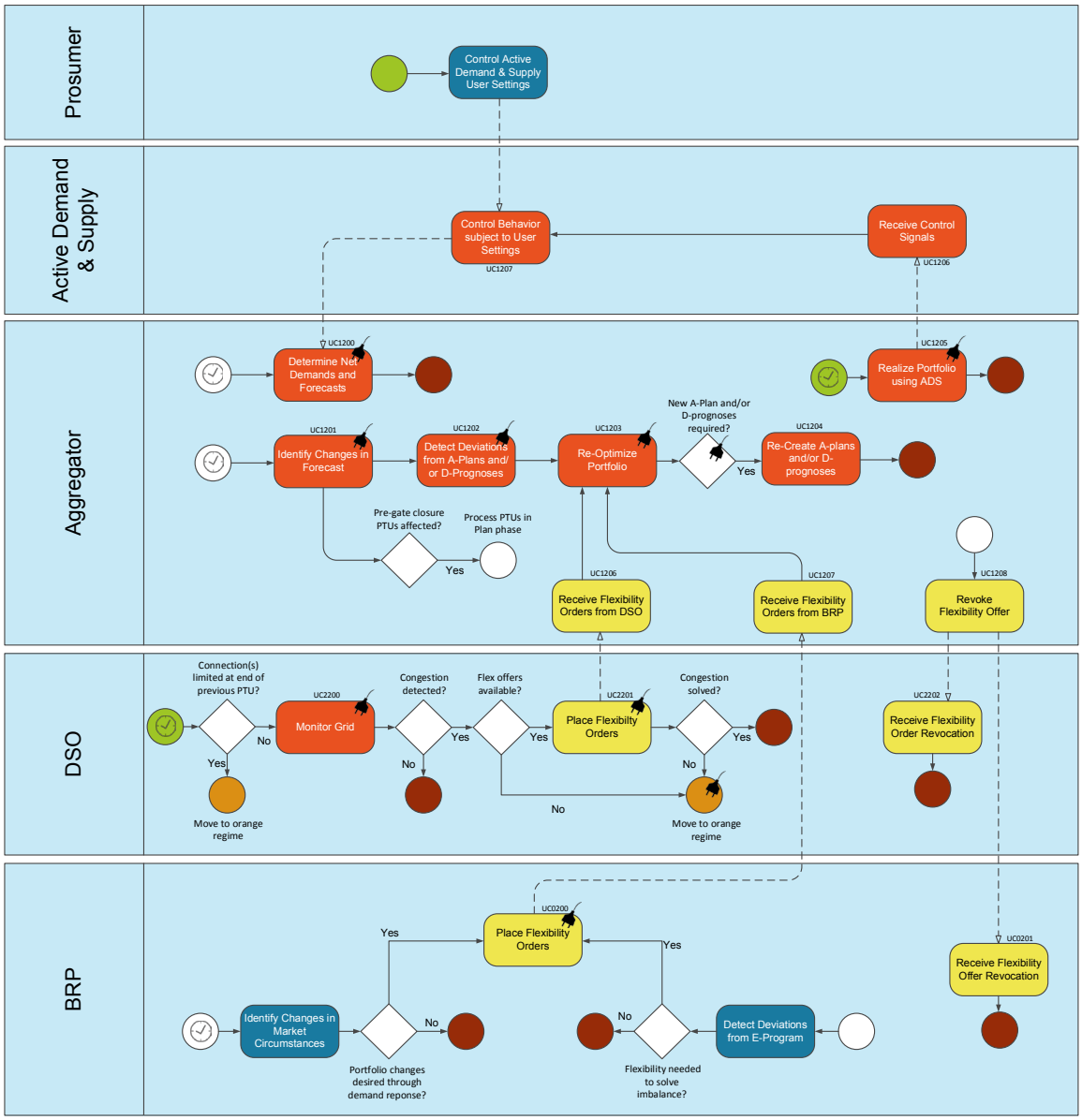


Figure 5-4: Process flows of the Operate phase. New processes are depicted in red, existing processes are depicted in blue. Process depicted in yellow relate to the grid capacity management regime. Plug icons indicate Pluggable Business Components in the USEF reference implementation Note that the process flows in the Operate phase run continuously.

The USEF MCM Operate phase specifies the following use cases:

Table 5.4: Use cases for the Operate phase.

ID	Name	Role	Message
UC1200	Determine Net Demands and Forecasts	AGR	
UC1201	Identify Changes in Forecast	AGR	
UC1202	Detect deviations from A-plans and/or D-prognoses	AGR	
UC1203	Re-optimize portfolio	AGR	
UC1204	Re-Create A-Plans and/or D-Prognoses	AGR	Prognosis
UC1205	Realize Portfolio using ADS	AGR	
UC1206	ADS: Receive Control Signals	AGR	(UDI)

UC1207	ADS: Control Behavior Subject to User Settings	AGR	
UC2200	Monitor grid	DSO	
UC2201	DSO: Place Flexibility Orders	DSO	FlexOrder
UC1208	Receive Flexibility Orders from DSO	AGR	FlexOrder
UC0200	BRP: Place Flexibility Orders	BRP	FlexOrder
UC1209	Receive Flexibility Orders from BRP	AGR	FlexOrder
UC1210	Revoke Flexibility Offer	AGR	FlexOrderRevocation
UC2202 UC0201	Receive Flexibility Offer Revocation	DSO BRP	FlexOrderRevocation

5.8.1 Determine Net Demands and Forecasts

ID	**UC1200**		
Triggered by	Always on (user-configurable repeating timer)		
Triggers	n/a (note that forecast changes will be picked up by UC1201)		
Goal in context	Determine net demands and forecasts		
Preconditions	Net demand measurement in place at each prosumer contracted by the AGR; local or centralized forecast ability for prosumer behavior		
Successful outcome	Continuous near real-time net demand measurement output and forecast updates		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors	Smart Meter (user port)/ ADS via UDI		
Main scenario	This is a continuous process to collect near real-time measurements and forecasts of the net demand of all prosumers contracted by the AGR. Measurements can be collected from the user port on smart meters or from additional AGR measurements in ADS. Measurements should be available at least at the PTU granularity as used in the USEF MCM (and with that in A-plan and D-prognosis). Forecasts can be provided by ADS, centralized systems, or a combination thereof.		
Alternatives			
Related information	USEF does not specify exactly how the AGR determines net demands and forecasts, since this depends entirely on the infrastructure deployed by the AGR, but expects measurement data to be collected using the USEF Device Interface.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	AGR (Data controller)	Smart meter readings should be considered personally identifiable information, and should not be retained longer than strictly required. The retention period should be specified and be communicated to the data subject.
	Connection Forecasts	AGR (Data controller)	Detailed forecast data should be considered personally identifiable information, and should not be retained longer than strictly required

	ADS Details	AGR (Data controller)	Details associated with individual ADS (such as IP addresses, serial numbers, configuration metadata, etc.) should be considered personally identifiable information.

5.8.2 Identify Changes in Forecast

ID	UC1201		
Triggered by	Always on (user-configurable repeating timer)		
Triggers	UC1202		
Goal in context	Identify changes in forecast		
Preconditions	AGR has created initial day-ahead forecast (individual and aggregated)		
Successful outcome	Updated forecast. A-plan/D-prognosis deviation analysis triggered. If applicable: Plan phase triggered for eligible PTUs.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors			
Main scenario	*The AGR must continuously identify (significant) changes in the forecast(s) it created earlier. Such changes may not only trigger actions in the Operate phase, but also prompt a return to the start of the Plan/Validate phase for PTUs for which the intraday gate closure time has not yet passed, since the assumptions on which the A-plans and D-prognoses were previously sent in those phases have changed.*		
Alternatives			
Related information	USEF does not specify how the AGR determines the forecast. AGRs need to support this function, in any manner. This function is a prerequisite for creating meaningful A-plans and D-prognoses. Although shown in the Operate phase to emphasize the fact that this is a continuously running process, most (if not all) forecast changes will apply to future PTUs, some of which will be outside the current period. For the latter PTUs, the Plan phase will need to be re-iterated in order to re-evaluate the prognoses for the applicable future period(s).		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Connection forecast	AGR (Data controller)	Aggregate forecasts represent commercially sensitive information; the underlying estimation and risk models are proprietary to the aggregator.
	A-plans and D-prognoses	AGR (Data controller)	A-plans and D-prognoses represent commercially sensitive information.

5.8.3 Detect deviations from A-Plans and/or D-Prognoses

ID	UC1202
Triggered by	UC1200, UC1201
Triggers	UC1203, return to Plan phase for PTUs affected by a forecast change and for which the intraday gate closure time has not yet passed

Goal in context	Detect deviations from A-plan and/or D-prognoses		
Preconditions	Continuous near real-time net demand measurement input available		
Successful outcome	Deviations from A-plan and/or D-prognoses detected		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors			
Main scenario	This is a continuous process to compare actual net demand with both the A-plans and the D-prognoses per congestion point.		
Alternatives			
Related information	USEF does not specify exactly how the AGR detects plan deviations, since risk assessment is subject to business-specific requirements.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	AGR (Data controller)	Smart meter readings should be considered personally identifiable information, and should not be retained longer than strictly required. The retention period should be specified and be communicated to the data subject.
	A-plans and D-prognoses	AGR (Data controller)	A-plans and D-prognoses represent commercially sensitive information.

5.8.4 Re-Optimize Portfolio

ID	**UC1203**		
Triggered by	UC1202, UC1206 or UC1207		
Triggers	n/a		
Goal in context	Re-optimize the aggregator portfolio: considering the available of flexibility, determine which steering (if any) is desired in order to meet agreed-upon A-plans and/or D-prognoses and/or other aggregator goals.		
Preconditions	Deviations from A-plans or D-prognosis detected, or flexibility orders received from DSO or BRP		
Successful outcome	Optimized portfolio for AGR Operate process (which does not exclude changes to PTUs not yet in that phase)		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR portfolio manager		
Secondary actors			
Main scenario	When the AGR receives flexibility orders during operate, these must be included directly in the optimized portfolio comprising of A-plans, D-prognoses and internal flexibility forecasts. The updated portfolio is used to control active demand and supply.		
Alternatives			

Related information	It is not relevant for USEF how the AGR optimizes its portfolio or how it determines availability of flexibility. The portfolio is a pre-condition for managing AGR operate processes, and is expected in a data structure as described in the USEF Device Interface (UDI) section of this document.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Portfolio	AGR (Data controller)	The content of the portfolio, as well as the underlying estimation, risk and optimization models are proprietary to the aggregator.

5.8.5 Re-Create A-Plans and/or D-Prognoses

ID	**UC1204**		
Goal in context	(Re-)Create A-plan and/or D-prognoses to be realized.		
Preconditions	AGR has created initial A-plans and D-prognoses in the Plan/Validate phases, and has subsequently detected deviations in Operate that resulted in a portfolio state that requires those prognoses to be re-created.		
Successful outcome	Prognoses created that reflect all relevant changes		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors			
Main scenario	See UC1007 (Re-Create and Send A-Plans), UC1100 (Re-Create D-and Send Prognoses per Congestion Point)		
Alternatives			
Related information	The basic process for re-creating A-plans and D-prognoses is the same as used to create them in the first place in the Plan/Validate phases. When re-creating prognoses in Operate, values for PTUs that are already in the past should remain unchanged, since these will be ignored by BRPs and DSOs anyway. Care should be taken not to repeatedly re-create prognoses: if, for example, both UC1201 (Identify Changes in Forecast) and this use case indicate a need for updates prognoses for a given period, the re-create process should only run once.		
Message type	Prognosis		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	A-plans and D-prognoses	AGR (Data controller)	A-plans and D-prognoses represent commercially sensitive information.

5.8.6 Realize Portfolio using ADS

ID	**UC1205**
Triggered by	PTU entering Operate phase (effectively a continuous process)
Triggers	UC1206 (ADS: Receive Control Signals)
Goal in context	Realize the flexibility contained in the aggregator portfolio using steering signals determined by the portfolio optimization process

Preconditions	ADS in place and controlled by the AGR		
Successful outcome	Behavior of the active demand & supply is changed according to the strategy determined through portfolio optimization		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors	ADS		
Main scenario	USEF does not define how AGRs manage and control ADS in order to manage consumption and/or production. AGRs must be able to support this function in order realize the agreed A-plan and D-prognoses, in any possible manner.		
Alternatives			
Related information	USEF expects ADS control to be implemented using the USEF Device Interface: exact mechanisms are not prescribed, since these depend entirely on the infrastructure deployed by the AGR.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Portfolio	AGR (Data controller)	The content of the portfolio, as well as the underlying estimation, risk and optimization models are proprietary to the aggregator.
	ADS Details	AGR (Data controller)	Details associated with individual ADS (such as IP addresses, serial numbers, configuration metadata, etc.) should be considered personally identifiable information.

5.8.7 ADS: Receive Control Signals

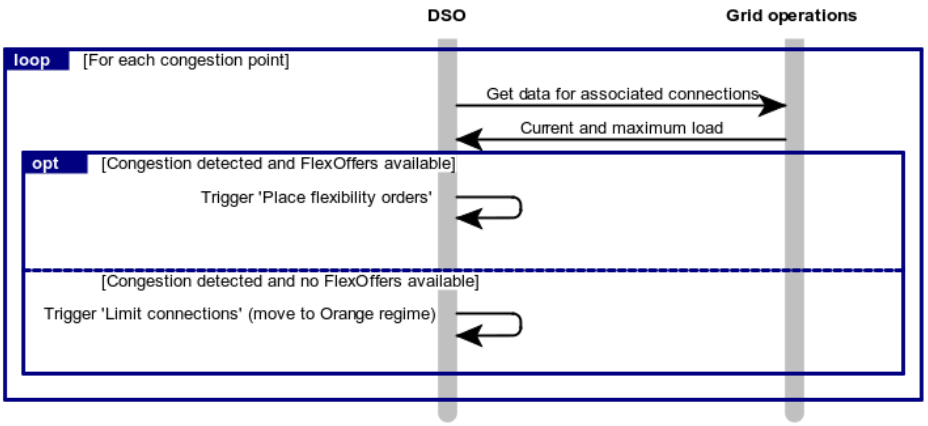
ID	**UC1206**		
Triggered by	UC1205 (Realize Portfolio using ADS)		
Triggers	UC1207 (ADS: Control Behavior subject to User Settings)		
Goal in context	Receive control signals from the aggregator, which indicate which device behavior is desired at which time		
Preconditions	Persistent connection between ADS and AGR in place		
Successful outcome	Successful receipt of control signals sent by AGR		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	ADS		
Secondary actors	AGR		
Main scenario	USEF does not define how AGRs must communicate with their ADS devices, nor what the content of those communications is. AGRs must support this function, in any manner.		
Alternatives			
Related information	USEF expects ADS control to be implemented using the USEF Device Interface: exact mechanisms are not prescribed, since these depend entirely on the infrastructure deployed by the AGR.		

5.8.8 ADS: Control Behavior Subject to User Settings

ID	UC1207		
Triggered by	UC1206 (ADS: Receive Control Signals)		
Triggers	Communication between ADS controller and actuators		
Goal in context	Process previously received control signals from the aggregator, as well as user settings, both of which indicate which device behavior is desired at which time, in such a way that the behavior can be realized		
Preconditions	User settings supplied by Prosumer; control signals received from AGR; communication with device actuators in place		
Successful outcome	Successful realization of device behavior subject to supplied constraints		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	ADS		
Secondary actors	AGR and Prosumer		
Main scenario	USEF does not define how ADS controls device actuators, nor how it translates user settings and control signals to useful behavior. AGRs must support this function, in any manner.		
Alternatives			
Related information	USEF expects ADS control to be implemented using the USEF Device Interface: exact mechanisms are not prescribed, since these depend entirely on the infrastructure deployed by the AGR.		

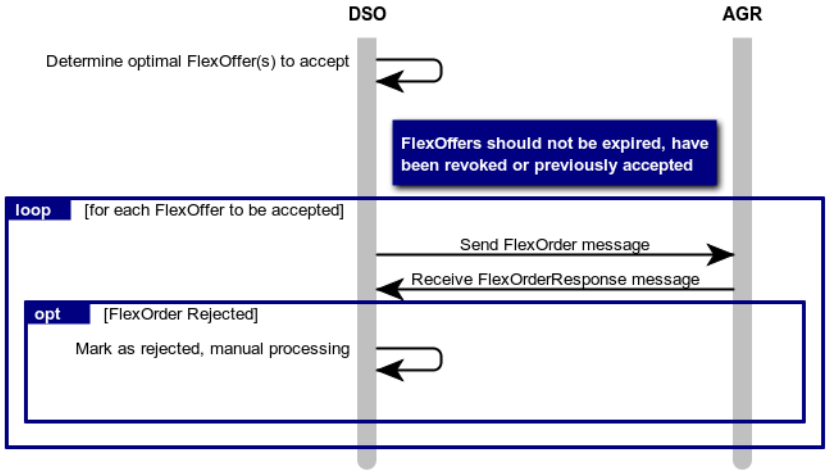
5.8.9 Monitor Grid

ID	UC2200		
Triggered by	PTU entering Operate phase (effectively a continuous process)		
Triggers	Nothing, UC2010 or UC2012		
Goal in context	Detect actual problems with grid constraints		
Preconditions	Continuous near-real-time net demand measurement input available		
Successful outcome	Congestion (or absence thereof) detected		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors			

Main scenario	During the Operate phase the DSO continuously monitors the actual production and consumption at each congestion point and identifies whether grid constraints are violated. If so, the DSO will make a last-effort attempt to procure flexibility (failing which the congestion point transitions to the orange regime). 
Alternatives	
Related information	

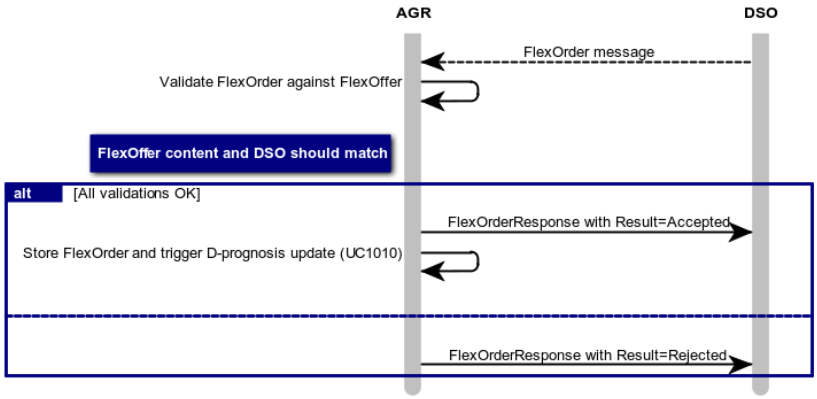
5.8.10 DSO: Place Flexibility Orders

ID	**UC2201**		
Triggered by	UC2200		
Triggers	On failure to procure sufficient flexibility: move to Orange regime		
Goal in context	Accept (some) flexibility offers to solve congestion during Operate phase. Flexibility orders are specified by the **FlexOrder** message.		
Preconditions	Congestion detected while monitoring the grid		
Successful outcome	Flexibility procured		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Procured flex < Required flex	Move to orange regime	FlexOrders are insufficient to resolve congestion (for any reason, including inability to send orders, order rejection or lack of AGR response)
Primary actor	DSO		
Secondary actors	AGR		

Main scenario	This function is triggered when flexibility is required to resolve congestion detected during the operate phase. Because of this, the DSO will want to be less selective when determining the optimal FlexOffer(s) to accept: in fact, any FlexOffer steering load in the right direction should be accepted at this point.  Note that in case a FlexOrder is rejected, manual processing is unlikely to result in timely resolution. Still, the underlying failure reason should be investigated.		
Alternatives			
Related information			
Message type	FlexOrder		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOffer message	DSO (Data controller)	The existence and content of a flexibility offer represent commercially sensitive information.
	FlexOrder message	DSO (Data controller)	The content of a flexibility order represents commercially sensitive information

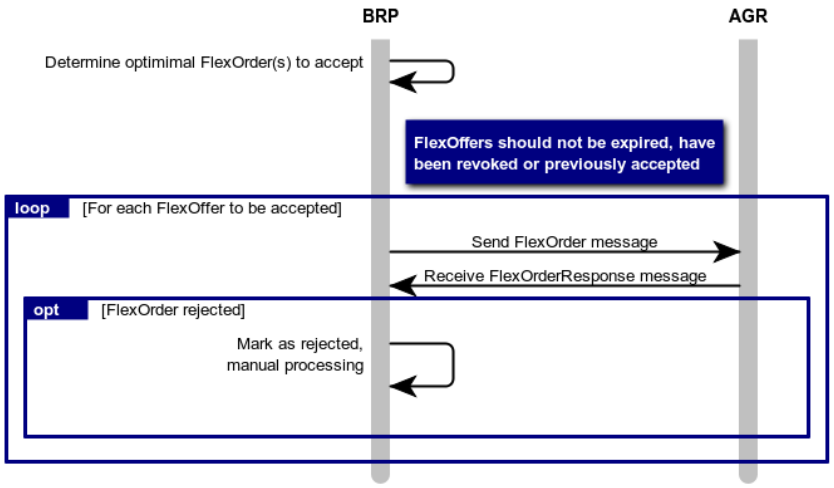
5.8.11 Receive Flexibility Orders from DSO

ID	**UC1208**		
Triggered by	UC2201 (DSO: Place Flexibility Orders)		
Triggers	UC1203 (Re-optimize Portfolio)		
Goal in context	Receive flexibility orders from DSO. Flexibility orders are specified by the **FlexOrder** message and acknowledged using a **FlexOrderResponse**.		
Preconditions	**FlexOffer**(s) sent to DSO(s)		
Successful outcome	**FlexOrder** acknowledged to DSO Valid flexibility order created Re-optimize Portfolio is triggered		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**

	Reject	Reject sent to DSO	**FlexOrder** failed to pass validation
Primary actor	AGR		
Secondary actors	DSO		
Main scenario	 Note that although the updated D-prognosis is unlikely to be of immediate use to the DSO, it's definitely required for settlement.		
Alternatives			
Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOrder message	AGR (Data controller)	The content of a flexibility order represents commercially sensitive information.

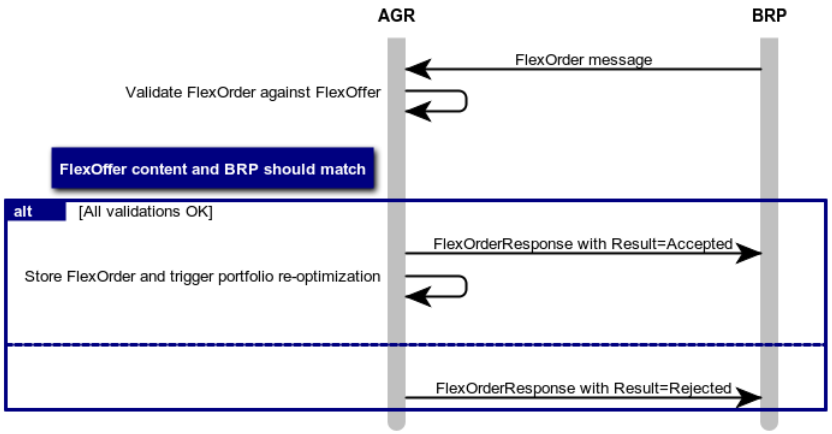
5.8.12 BRP: Place Flexibility Orders

ID	**UC0200**		
Triggered by	Existing BRP-internal *Identify changes in market circumstances* or *Detect deviations from E-program* processes indicate need for flex		
Triggers	UC1207 (Receive Flex Orders from BRP)		
Goal in context	Place flexibility orders during the Operate phase. Flexibility orders are specified by the **FlexOrder** message.		
Preconditions	Open flexibility offers available		
Successful outcome	Aggregator is notified that FlexOffer is accepted		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	**FlexOrder** rejected by Aggregator	**FlexOrder** failed to pass validation by the AGR
Primary actor	BRP		
Secondary actors	AGR		

Main scenario	This function can be automatically triggered when flexibility is required to react on portfolio re-optimization or imbalance correction during the operate phase.  		
Alternatives			
Related information	USEF does not specify how the BRP determines which flexibility offers to accept and when to except them. BRPs need to support this function, in any manner.		
Message type	FlexOrder		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOffer message	BRP (Data controller)	The existence and content of a flexibility offer represent commercially sensitive information.
	FlexOrder message	BRP (Data controller)	The content of a flexibility order represents commercially sensitive information.

5.8.13 Receive Flexibility Orders from BRP

ID	**UC1209**		
Triggered by	UC0200 (BRP: Place Flexibility Orders)		
Triggers	UC1203 (Re-Optimize Portfolio)		
Goal in context	Collect flexibility orders from BRP. Flexibility orders are specified by the **FlexOrder** message.		
Preconditions	**FlexOffer**(s) sent to BRP		
Successful outcome	**FlexOrder** acknowledged to BRP Reoptimize portfolio triggered		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**

	Reject	Reject sent to BRP	**FlexOrder** failed to pass validation
Primary actor	AGR		
Secondary actors	BRP		
Main scenario			
Alternatives			
Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOrder message	AGR (Data controller)	The content of a flexibility order represents commercially sensitive information

5.8.14 Revoke Flexibility Offer

ID	**UC1210**		
Triggered by	AGR-internal process		
Triggers	UC2202, UC0201 (BRP/DSO receive flex offer revocation)		
Goal in context	Inform the BRP or DSO that a previously sent flexibility offer is no longer valid, despite the validity period of the offer not having expired yet.		
Preconditions	A flexibility offer has been sent to and acknowledged by the BRP or DSO		
Successful outcome	Flexibility offer revocation notification submitted to the BRP or DSO		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	n/a	n/a	n/a
Primary actor	AGR		
Secondary actors	BRP/DSO		
Main scenario	See UC1011		
Alternatives			
Related information	Only flexibility offers communicated using a FlexOffer message which has already been acknowledged by the BRP/DSO can be revoked. If the acknowledgement is still pending, the AGR should delay sending its FlexOfferRevocation message until it has been received.		
Message types	FlexOfferRevocation and FlexOfferRevocationResponse		

Privacy & Security considerations	Data Product	Role	Responsibilities
	FlexOfferRevocation message	AGR (Data controller)	The existence and timing of a flexibility offer revocation represent commercially sensitive information.

5.8.15 Receive Flexibility Offer Revocation

ID	UC2202 (DSO), UC0201 (BRP)		
Triggered by	UC1210 (AGR: Revoke Flex Offer)		
Triggers			
Goal in context	Receive and validate a flexibility offer revocation notice from the AGR. If the revocation applies to a previously received offer, mark that offer as revoked.		
Preconditions	A flexibility offer has been received from and acknowledged to the AGR		
Successful outcome	Flexibility offer marked as revoked		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Reject	Reject sent to AGR	FlexOfferRevocation message does not refer to a previously received and acknowledged FlexOffer message, or the revocation is received too late (see Related Information)
Primary actor	DSO		
Secondary actors	BRP/AGR		
Main scenario	See UC0007 (BRP), UC2106 (DSO)		
Alternatives			
Related information	Flex offers may be revoked in the operate phase, provided that none of the PTUs in the Period the offer applies to are already in or past the Operate phase, even if there is already an active flex order based on the offer. Only if the offer did not exist in the first place or any of its PTU(s) are already in Operate or Pending Settlement, may the revocation be rejected.		
Message types	FlexOfferRevocation and FlexOfferRevocationResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOfferRevocation message	DSO (Data controller)	The existence and timing of a flexibility offer revocation represent commercially sensitive information.

5.9 Use cases - Operate phase – Orange regime

In Section 4.3.3 the informative description of the Operate phase processes during yellow/orange regimes has been given. In this chapter the use cases will be described as derived from the Operate phase during Orange regime process diagrams. Each (Orange) activity (rounded rectangle) in the process diagrams is listed as a use case, unless listed as optional.

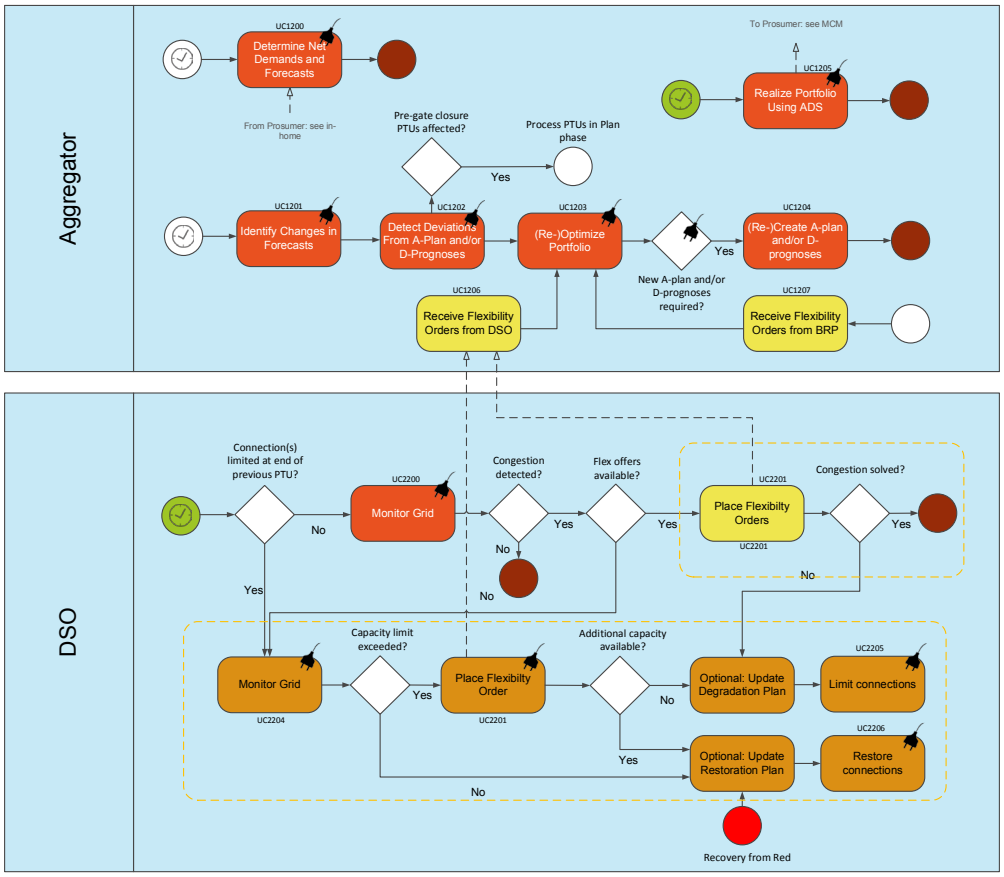


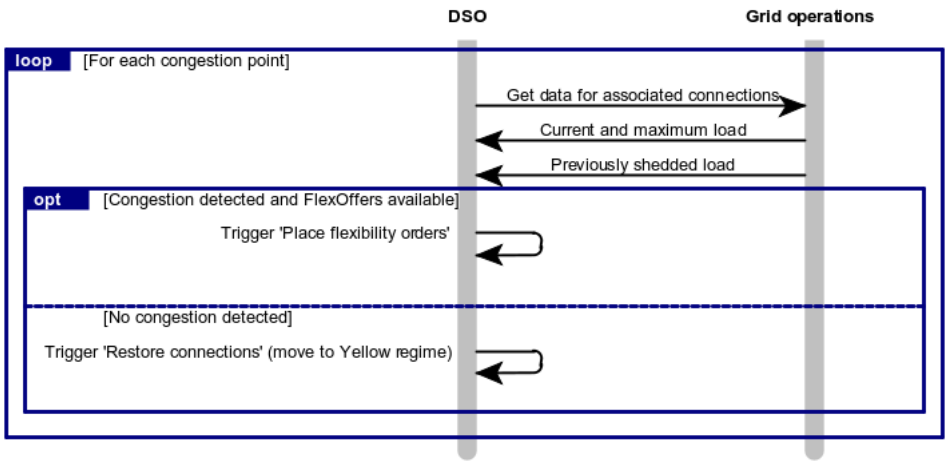
Figure 5-5: Process diagram of the Operate phase

This section describes the use cases specifically for the orange regime. It contains a regime-specific version of the regular **Monitor Grid** (UC2009) use case, since the decision logic is significantly different. The Connection is out of scope for the USEF specification.

Table 5.5: Use cases for the Operate phase in the Orange regime.

ID	Name	Role	Phase	Message
UC2203	Monitor grid	DSO	Operate	
UC2204	Limit connections	DSO	Operate	
UC2205	Restore connections	DSO	Operate	

5.9.1 Monitor grid

ID	UC2203		
Triggered by	PTU entering Operate phase (continuous process) for a congestion point operating in Orange regime		
Triggers	UC2201 (Place flex orders, same process as in yellow regime), UC2206 (restore connections, indirectly)		
Goal in context	Detect actual problems with grid constraints, considering both actual load and previously shedded load		
Preconditions	Continuous near-real-time net demand measurement input available; load of previously limited connections available		
Successful outcome	Congestion (or absence thereof) detected		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors			
Main scenario	During the Operate phase under Orange regime the DSO continuously monitors the actual production and consumption at each congestion point and identifies whether, if previously shedded load is added to actual load, grid constraints are still being violated. If so, an attempt is made to resolve this congestion by placing flex orders. If not, a return to Yellow regime is initiated. 		
Alternatives			
Related information			

5.9.2 Limit connections

ID	UC2204		
Triggered by	UC2201, in case insufficient flexibility procured		
Triggers	N/A		
Goal in context	Limit grid connections		
Preconditions	Connections selected for limitation		
Successful outcome	Connections limited		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors			
Main scenario	DSOs must support a function to limit selected grid connections. USEF does not specify how DSOs implement this function: however, the load reduction achieved by limiting the connections should be stored, in order to be able to perform future congestion detection.		
Alternatives			
Related information			

5.9.3 Restore connections

ID	UC2205		
Triggered by	Return to Yellow regime		
Triggers	N/A		
Goal in context	Restore selected limited grid connections to normal state		
Preconditions	Connections selected for restoration		
Successful outcome	Connections restored		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors			
Main scenario	DSOs must support a function to restore previously limited selected grid connections to their normal state. USEF does not specify how DSOs implement this function.		
Alternatives			
Related information			

5.10 Use cases - Settle phase

In Section 2.3.4 the informative description of the settle phase processes has been given. In the Green and Yellow regimes, two flex settlement processes have been identified: the settlement of flex between BRP and AGR, and between DSO and AGR. In this chapter the use cases will be described as derived from the corresponding process diagrams. Each activity (rounded rectangle) in the process diagram is listed as a use case, unless listed as out of scope.

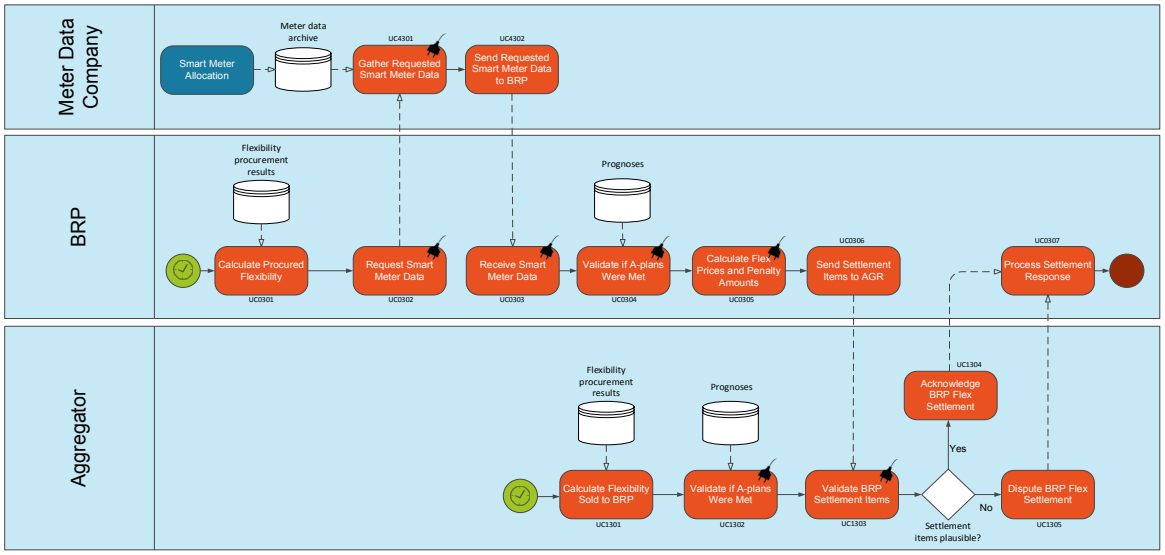


Figure 5-6: Process diagram of the Settle phase – BRP-AGR settlement. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

The USEF MCM settle phase specifies the following use cases for the settlement between BRP and Aggregator:

Table 5.6: Use cases for the settle phase (BRP-AGR).

ID	Name	Role	Message
UC0301	Calculate Procured Flexibility	BRP	
UC0302	Request Smart Meter Data	BRP	MeterDataQuery
UC4301	Gather Requested Smart Meter Data	MDC	MeterDataQuery
UC4302	Send Requested Smart Meter Data to BRP	MDC	MeterDataQueryResponse
UC0303	Receive Smart Meter Data	BRP	MeterDataQueryResponse
UC0304	Validate if A-plans Were met	BRP	
UC0305	Calculate Flex Prices and Penalty Amounts	BRP	
UC0306	Send Settlement Items to AGR	BRP	SettlementMessage
UC1301	Calculate Flexibility Sold to BRP	AGR	
UC1302	Validate if A-Plans Were Met	AGR	
UC1303	Validate BRP Settlement Items	AGR	
UC1304	Acknowledge BRP Flex Settlement	AGR	SettlementMessageResponse
UC1305	Dispute BRP Flex Settlement	AGR	SettlementMessageResponse
UC0307	Process AGR Settlement Response	BRP	SettlementMessageResponse

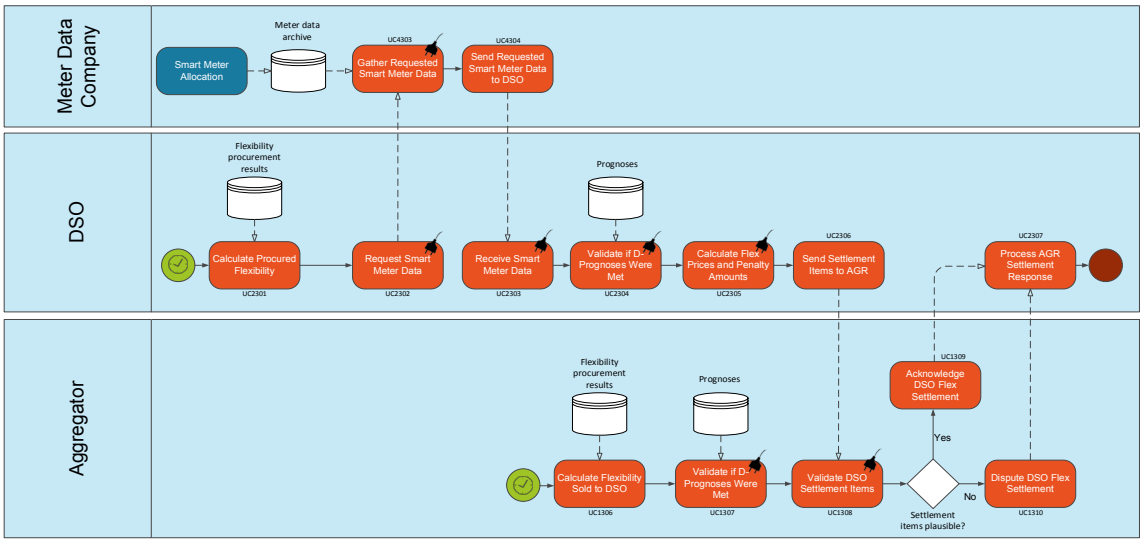


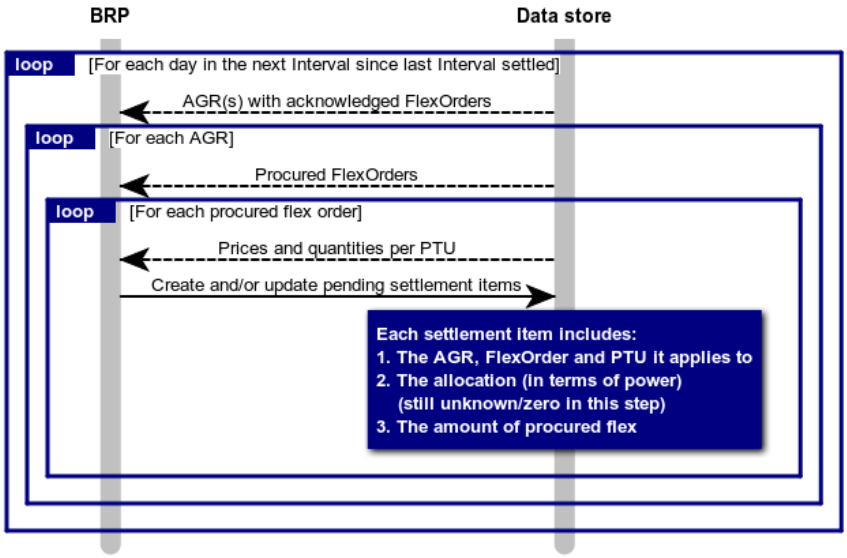
Figure 5-7: Process diagram of the Settle phase – DSO-AGR settlement. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

The USEF MCM settle phase specifies the following use cases for the settlement between DSO and Aggregator:

Table 5.7: Use cases for the settle phase (DSO-AGR).

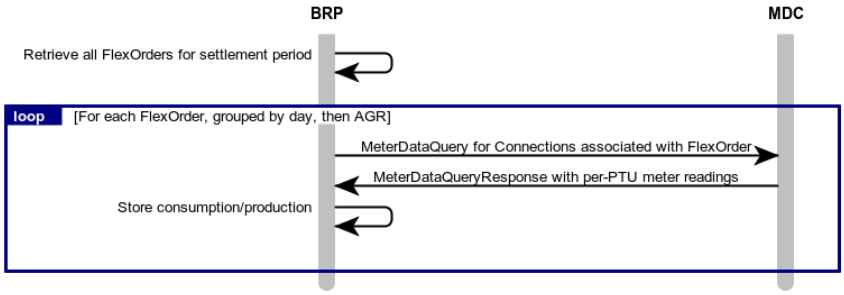
ID	Name	Role	Message
UC2301	Calculate Procured Flexibility	DSO	
UC2302	Request Smart Meter Data	DSO	MeterDataQuery
UC4303	Gather Requested Smart Meter Data	MDC	MeterDataQuery
UC4304	Send Requested Smart Meter Data to DSO	MDC	MeterDataQueryResponse
UC2303	Receive Smart Meter Data	DSO	5.10.1.1.1.1.1 MeterDataQueryResponse
UC2304	Validate if D-Prognoses Were Met	DSO	
UC2305	Calculate Flex Prices and Penalty Amounts	DSO	
UC2306	Send Settlement Items to AGR	DSO	SettlementMessage
UC1306	Calculate Flexibility Sold to DSO	AGR	
UC1307	Validate if D-prognoses Were Met	AGR	
UC1308	Validate DSO Settlement Items	AGR	SettlementMessage
UC1309	Acknowledge DSO Flex Settlement	AGR	SettlementMessageResponse
UC1310	Dispute DSO Flex Settlement	AGR	SettlementMessageResponse
UC2307	Process AGR Settlement Response	DSO	SettlementMessageResponse

5.10.1 Calculate Procured Flexibility

ID	UC0301		
Triggered by	Periodic trigger (typically once per month; note that all market participants have to agree on a single settlement period)		
Triggers	UC0302 (Request Smart Meter Data)		
Goal in context	Periodic (configurable, default monthly) settlement between BRP and AGR, based on ordered and delivered flexibility during the settlement period		
Preconditions	List of all FlexOrders placed during the settlement period available		
Successful outcome	Initial settlement items (invoice lines) created		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	BRP		
Secondary actors			
Main scenario	Interval is the settlement period, e.g. a calendar month. All participants in a given market should use the same interval.  		
Alternatives			
Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Flex order messages	BRP (Data controller)	The content of flexibility orders represents commercially sensitive information.

5.10.2 Request Smart Meter Data

ID	UC0302
Triggered by	UC0301 (Calculate procured flexibility)
Triggers	UC4301 (MDC: Gather requested smart meter data)

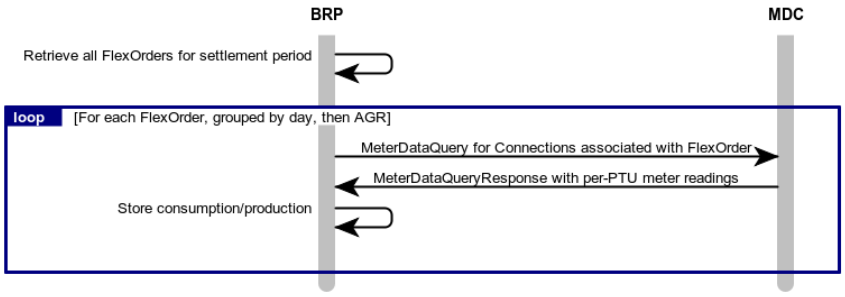
Goal in context	Obtain per-PTU smart meter readings for all Connections represented by the BRP as well as an AGR for the days on which flexibility has been procured during the settlement period (i.e. for which settlement items exist)		
Preconditions	Settlement items have been created		
Successful outcome	Actual consumption/production determined for each Connection for which flex has been procured from an AGR for one or more PTUs.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Missing data	Unable to continue settlement	Missing or incomplete MDC response
Primary actor	BRP		
Secondary actors	MDC		
Main scenario			
Alternatives			
Related information			
Message types	MeterDataQuery, MeterDataQueryResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	BRP (Data controller)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary.

5.10.3 Gather Requested Smart Meter Data

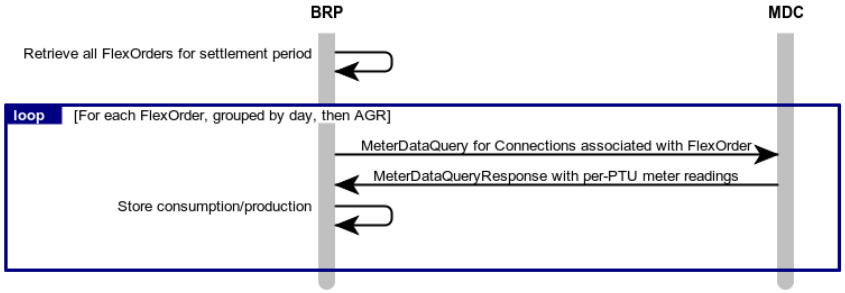
ID	**UC4301**		
Triggered by	UC0302 (BRP: Retrieve smart meter data)		
Triggers	UC4302 (Send requested smart meter data to BRP)		
Goal in context	Based on the request from the BRP, query the meter data archive and transform the results to per-PTU, per-Connection consumption/production values		
Preconditions	Smart meter data has been gathered during the settlement period		
Successful outcome	Requested data available for transmission to the BRP		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	MDC		
Secondary actors			

Main scenario	The MDC should be able to supply the data requested using the MeterDataQuery message, using any mechanism suitable for the MDC's internal operations. USEF does not specify how data queries and transformations should take place.		
Alternatives			
Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	MDC (Data processor)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.10.4 Send Requested Smart Meter Data to BRP

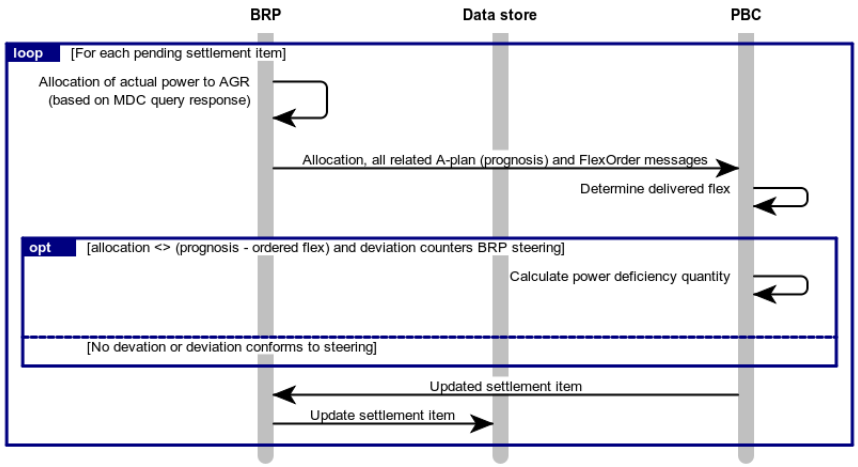
ID	**UC4302**		
Triggered by	UC4301 (Gather requested smart meter data)		
Triggers	UC0303 (BRP: Receive smart meter data)		
Goal in context	Send the requested, gathered and transformed smart meter data to the BRP		
Preconditions	The meter data archive has been queried and the results transformed		
Successful outcome	Requested data delivered to the BRP		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	MDC		
Secondary actors	BRP		
Main scenario			
Alternatives			
Related information			
Message types	MeterDataQuery and MeterDataQueryResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	MDC (Data processor)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.10.5 Receive Smart Meter Data

ID	UC0303		
Triggered by	UC4302 (MDC: Send requested smart meter data to BRP)		
Triggers	UC0304 (Validate if A-plans were met)		
Goal in context	Receive requested smart meter data from the MDC		
Preconditions	Smart meter data has been requested from the MDC		
Successful outcome	Requested data received from the MDC		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	BRP		
Secondary actors	MDC		
Main scenario			
Alternatives			
Related information			
Message type	MeterDataQueryResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	BRP (Data controller)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

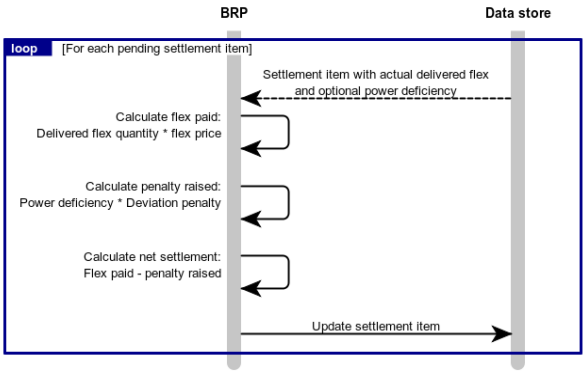
5.10.6 Validate if A-Plans Were Met

ID	UC0304		
Triggered by	UC0303 (Receive smart meter data)		
Triggers	UC0305 (Calculate flex prices and penalty amounts)		
Goal in context	Assessment if the procured FlexOrders have been delivered and if the realization deviates from the approved A-plans.		
Preconditions	PTU level aggregated energy consumption/production allocation data available for this AGR (based on smart meter data) Initial settlement items have been created.		
Successful outcome	Delivered flex quantity for each FlexOrder and imbalance quantity for each PTU determined as basis for delivered flex remuneration and penalty calculation.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**

	Allocation data incomplete	Flex is assumed to be fully delivered	
Primary actor	BRP		
Secondary actors			
Main scenario			
Alternatives	If a FlexOrder is procured from a specific AGR for a specific PTU, after another FlexOrder has been procured from the same AGR and for the same PTU, and if the AGR has sent an updated A-plan in between the two FlexOrders, indicating that the previous FlexOrder will not be (fully) delivered, the volume that is the basis for the penalty calculation will be increased as follows: imbalance quantity += updated A-plan – (A-plan – flex quantity) where the A-plan and flex quantity are associated with the FlexOrder preceding the updated A-plan, and expressed in terms of power.		
Related information	Due to gate closure times, not all PTUs that should be considered the latest are necessarily contained in the same Prognosis message. To allow for proper settlement, both BRP and AGR need to create a comprehensive Prognosis, selecting the latest valid PTUs from actual Prognosis messages as required. The example Pluggable Business Component included with the USEF reference implementation contains functionality for this, as well as a simple method to calculate the delivered flex.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	A-plans	BRP (Data controller)	The content of A-plans represents commercially sensitive information.
	Load allocation	BRP (Data controller)	The allocation of consumption/production to individual aggregators represents commercially sensitive information.

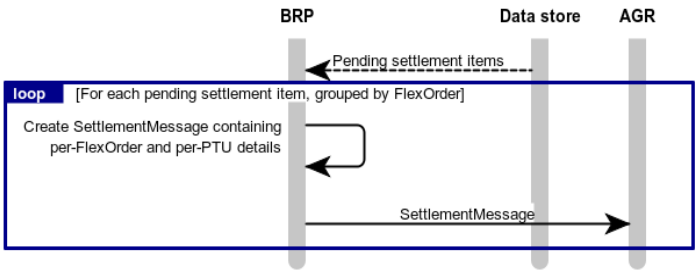
5.10.7 Calculate Flex Prices and Penalty Amounts

ID	UC0305
Triggered by	UC0304 (Validate if A-plans were met)
Triggers	UC0306 (Send settlement items to AGR)
Goal in context	Send consolidated settlement volumes and prices to the AGR(s) for a specific period.
Preconditions	All quantities from UC0301 and UC0304 available

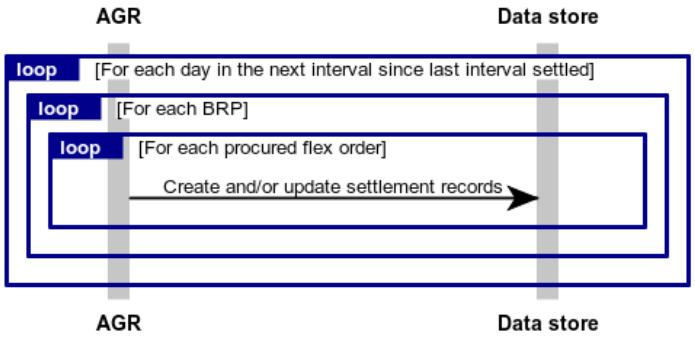
Successful outcome	Periodic settlement invoice data available to be sent to AGR(s)		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	BRP		
Secondary actors			
Main scenario			
Alternatives			
Related information			
Message type			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Pricing and penalties	BRP (Data controller)	Price and penalty levels, as well as the allocation to individual aggregators represent commercially sensitive information.

5.10.8 Send Settlement Items to AGR

ID	**UC0306**		
Triggered by	UC0305 (Calculate flex prices and penalty amounts)		
Triggers	UC1303 (AGR: Validate BRP Settlement Items)		
Goal in context	Send consolidated settlement volumes and prices to the AGR(s) for a specific period.		
Preconditions	All settlement items available and complete		
Successful outcome	Periodic settlement invoice(s) sent to AGR(s)		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	BRP		
Secondary actors	AGR		

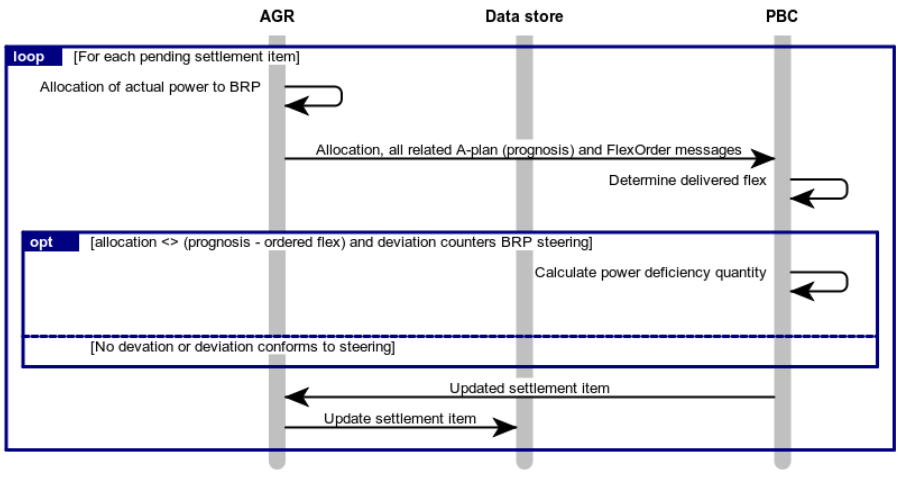
Main scenario			
Alternatives			
Related information			
Message type	SettlementMessage		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	BRP (Data controller)	Settlement items represent commercially sensitive information.

5.10.9 Calculate Flexibility Sold to BRP

ID	**UC1301**		
Triggered by	Either periodic or initiated by the receipt of the message generated in UC0306 (BRP: Send settlement items to AGR).		
Triggers	UC1302 (Validate if A-plans were met)		
Goal in context	Periodic (configurable, default monthly) settlement between BRP and AGR, based on FlexOrders sold to BRP		
Preconditions	List of all sold FlexOrders available		
Successful outcome	Price and quantity for each FlexOrder determined		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors			
Main scenario			
Alternatives			

Related information	Sold flexibility is calculated based on a list of all FlexOrders placed (and acknowledged) by BRPs during the settlement period, grouped by day, then by BRP. For each entry in this list, the consumption/production per PTU needs to be retrieved, if available, from the data stored by the Determine Net Demands process. Note that some AGRs may not implement this process, and the data may be incomplete even if they do, so not having actual load information for a PTU should not cause issues. Data that should be available for each PTU is the load forecast for that PTU in the latest A-plan sent to the BRP and period, plus the details (amount and price of the flexibility sold) of the FlexOrders associated with it.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Flex order messages	AGR (Data controller)	The content of flexibility orders represents commercially sensitive information.

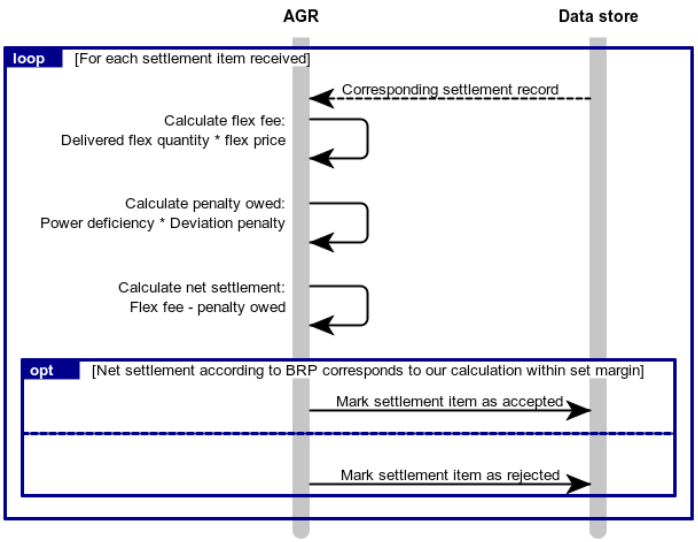
5.10.10 Validate if A-plans Were Met

ID	**UC1302**		
Triggered by	UC1301 (Calculate flexibility sold to BRP)		
Triggers	UC1303 (Validate BRP settlement items, after settlement message has been received as well)		
Goal in context	Assessment if the sold FlexOrders have been delivered, based on deviation in the realization of (explicitly or implicitly) approved A-plans		
Preconditions	PTU level aggregated energy consumption/production allocation data available Sold flexibility calculated (UC1301)		
Successful outcome	Delivered flex quantity for each FlexOrder and imbalance quantity for each PTU determined as basis for flex remuneration and penalty calculation		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Allocation data incomplete	Flex is assumed to be fully delivered	
Primary actor	AGR		
Secondary actors			
Main scenario			

Alternatives	If a FlexOrder is sold for a specific PTU, after another FlexOrder has been sold for the same PTU, and if the AGR has sent an updated A-plan in between the two FlexOrders, indicating that the previous FlexOrder will not be (fully) delivered, the volume that is the basis for the penalty calculation will be increased as follows: imbalance quantity += updated A-plan – (A-plan – flex quantity) where the A-plan and flex quantity are associated with the FlexOrder preceding the updated A-plan, and expressed in terms of energy.		
Related information	Due to gate closure times, not all PTUs that should be considered the latest are necessarily contained in the same Prognosis message. To allow for proper settlement, both BRP and AGR need to create a comprehensive Prognosis, selecting the latest valid PTUs from actual Prognosis messages as required. The example Pluggable Business Component included with the USEF reference implementation contains functionality for this, as well as a simple method to calculate the delivered flex.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	A-plans	AGR (Data controller)	The content of A-plans represents commercially sensitive information.

5.10.11 Validate BRP Settlement Items

ID	**UC1303**		
Triggered by	UC0306 (Settlement items received from BRP)		
Triggers	UC1305 (Dispute BRP settlement, if validation fails), otherwise UC1304 (Acknowledge BRP settlement)		
Goal in context	Verification of settlement calculations performed by BRP, and expressed in settlement invoice message		
Preconditions	All quantities from UC1301 and UC1302 available Invoice received from BRP (UC0306)		
Successful outcome	Settlement invoice from BRP verified		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors			

Main scenario			
Alternatives	Plausibility check can be skipped, or performed incidentally: unchecked items should be marked as accepted		
Related information			
Message type			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	AGR (Data controller)	Settlement items represent commercially sensitive information.

5.10.12 Acknowledge BRP Flex Settlement

ID	**UC1304**		
Triggered by	UC1303 (conditionally)		
Triggers	UC0307 (BRP: Process settlement response)		
Goal in context	Acknowledge that the settlement items received from the BRP are plausible according to the AGR		
Preconditions	Validation within UC1303 successfully performed		
Successful outcome	Settlement items for the given period acknowledged		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors	BRP		
Main scenario	Send a message to the BRP to acknowledge all (listed) previously received settlement items are accepted.		
Alternatives			
Related information			
Message type	SettlementMessageResponse		

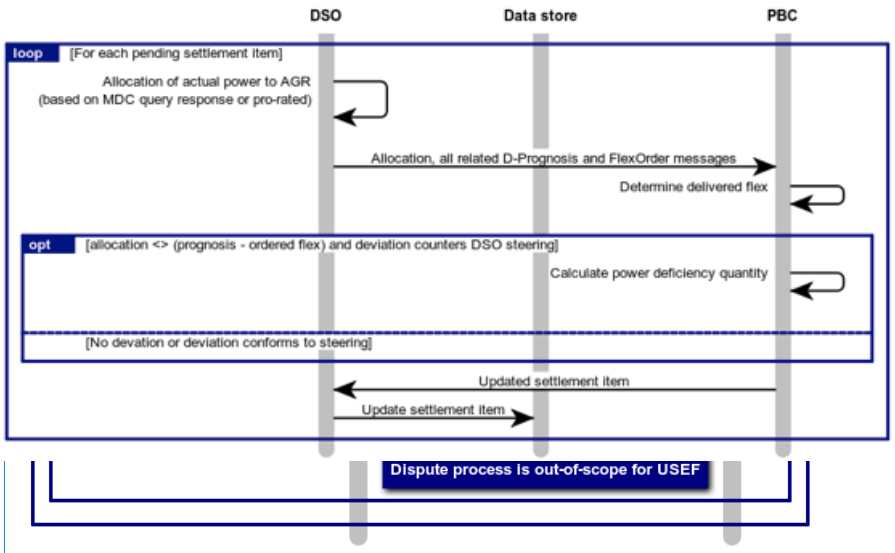
Privacy & Security considerations	Data Product	Role	Responsibilities
	Settlement items	AGR (Data controller)	Settlement items, including the acknowledgement of their correctness, represent commercially sensitive information.

5.10.13 Dispute BRP Flex Settlement

ID	UC1305		
Triggered by	UC1303 (conditionally)		
Triggers	UC0307 (BRP: Process settlement response)		
Goal in context	Start a dispute process if the detailed settlement calculations of the AGR and BRP show different results		
Preconditions	Validation within UC1105 failed for a specific Interval (Interval and details of differences known).		
Successful outcome	Dispute process started		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors	BRP		
Main scenario	Send a message to the BRP in order to raise a dispute, specifying which previously received settlement items are disputed.		
Alternatives			
Related information			
Message type	SettlementMessageResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	AGR (Data controller)	Settlement items, including the fact that their correctness is disputed, represent commercially sensitive information.

5.10.14 Process AGR Settlement Response

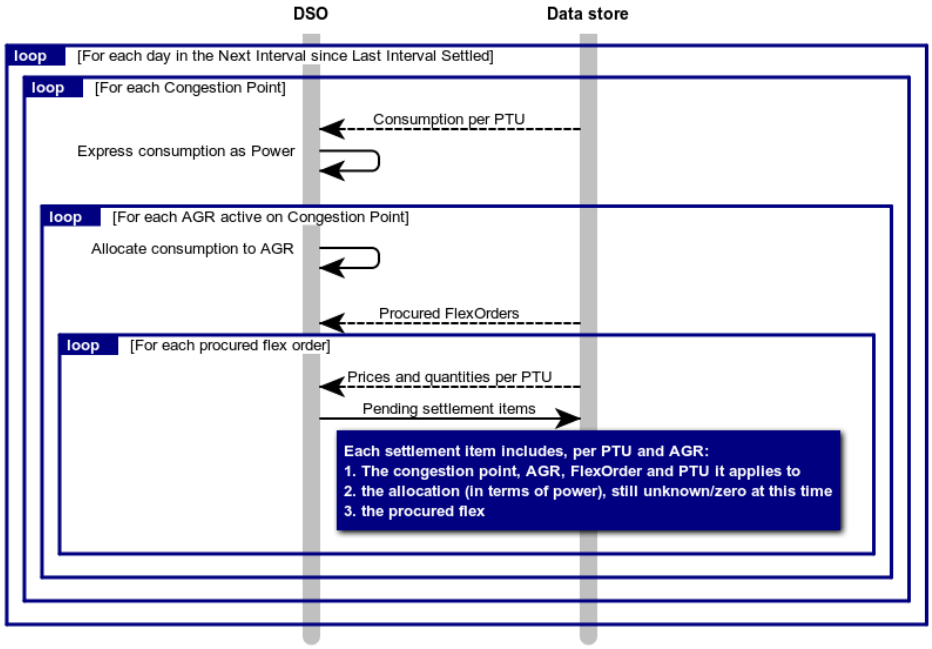
ID	UC0307		
Triggered by	UC1304 (AGR: Acknowledge BRP settlement) or UC1305 (AGR: Dispute BRP settlement		
Triggers			
Goal in context	Process response from AGR and update status accordingly.		
Preconditions	Message received from specific AGR concerning an invoice.		
Successful outcome	Status of invoice changed		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	BRP		

Secondary actors	
Main scenario	
Alternatives	
Related information	
Message	SettlementMessageResponse

Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	BRP (Data controller)	Settlement items, including the fact that their correctness is acknowledged or disputed, represent commercially sensitive information.

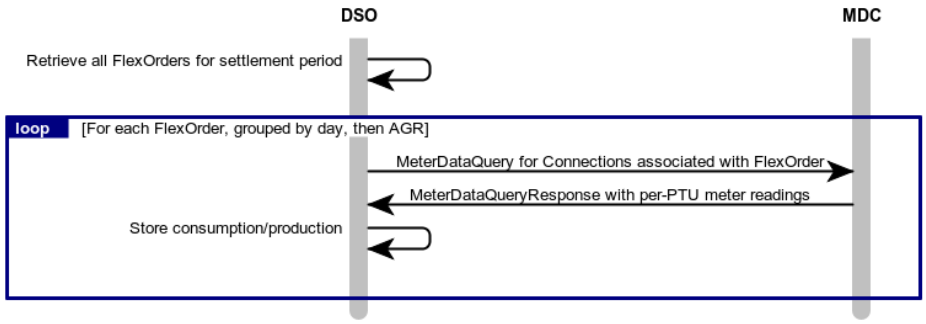
5.10.15 Calculate Procured Flexibility

ID	**UC2301**		
Triggered by	Periodic trigger (note that all market participants should use the same settlement periods)		
Triggers	UC2302 (Request smart meter data)		
Goal in context	Periodic (configurable, default monthly) settlement between DSO and AGR of procured FlexOrders.		
Preconditions	List of all procured FlexOrders available for this DSO		
Successful outcome	Initial settlement items (invoice lines) created		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors			

Main scenario	Interval is the billing period, e.g. a calendar month. 		
Alternatives	Depending on the data store implementation, this use case may be combined with UC2304.		
Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	FlexOrder messages	DSO (Data controller)	The content of flexibility orders represents commercially sensitive information.

5.10.16 Request Smart Meter Data

ID	**UC2302**		
Triggered by	UC2301 (Calculate procured flexibility)		
Triggers	UC4303 (MDC: Gather requested smart meter data)		
Goal in context	Obtain per-PTU smart meter readings for all DSO Connections represented by an AGR for the days on which flexibility has been procured during the settlement period (i.e. for which settlement items exist)		
Preconditions	Settlement items have been created		
Successful outcome	Actual consumption/production determined for each Connection for which flex has been procured from an AGR for one or more PTUs.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Missing data	Unable to continue settlement	Missing or incomplete MDC response
Primary actor	DSO		
Secondary actors	MDC		

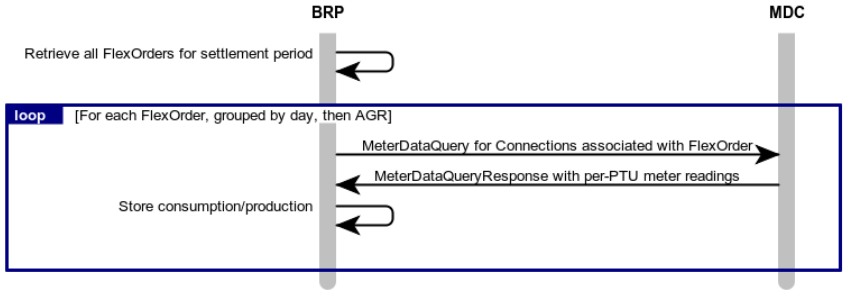
Main scenario			
Alternatives			
Related information			
Message types	MeterDataQuery, MeterDataQueryResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	DSO (Data controller)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.10.17 Gather Requested Smart Meter Data

ID	**UC4303**		
Triggered by	UC2302 (DSO: Retrieve smart meter data)		
Triggers	UC4304 (Send requested smart meter data to DSO)		
Goal in context	Based on the request from the DSO, query the meter data archive and transform the results to per-PTU, per-Connection consumption/production values		
Preconditions	Smart meter data has been gathered during the settlement period		
Successful outcome	Requested data available for transmission to the DSO		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	MDC		
Secondary actors			
Main scenario	The MDC should be able to supply the data requested using the MeterDataQuery message, using any mechanism suitable for the MDC's internal operations. USEF does not specify how data queries and transformations should take place.		
Alternatives			
Related information			

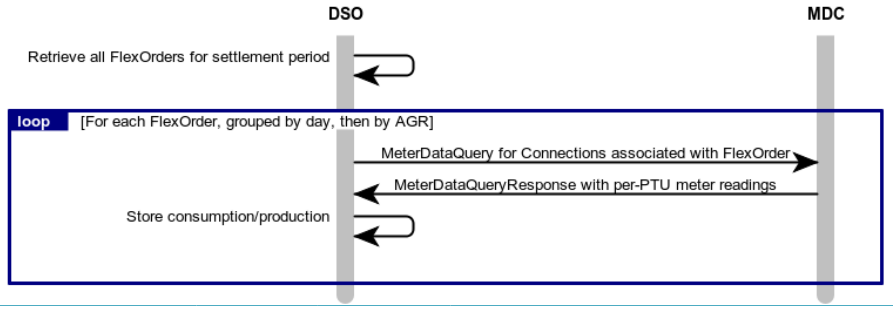
Privacy & Security considerations	Data Product	Role	Responsibilities
	Smart meter data	MDC (Data processor)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.10.18 Send Requested Smart Meter Data to DSO

ID	UC4304		
Triggered by	UC4302 (Gather requested smart meter data)		
Triggers	UC2303 (DSO: Receive smart meter data)		
Goal in context	Send the requested, gathered and transformed smart meter data to the DSO		
Preconditions	The meter data archive has been queried and the results transformed		
Successful outcome	Requested data delivered to the DSO		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	MDC		
Secondary actors	DSO		
Main scenario			
Alternatives			
Related information			
Message type	MeterDataQueryResponse		

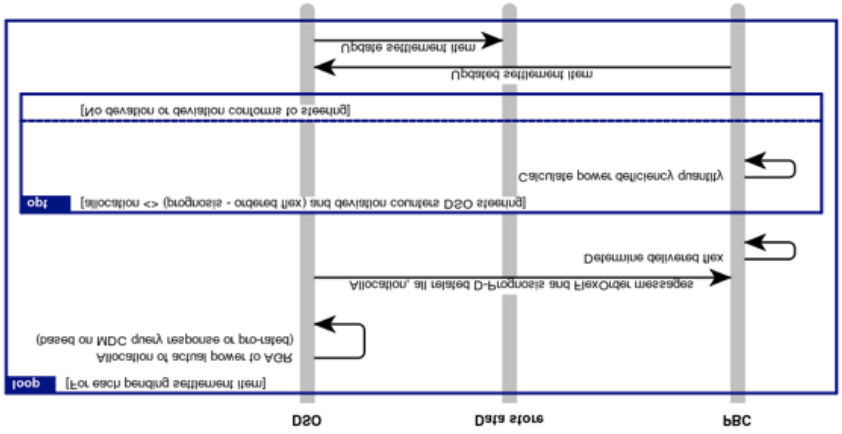
Privacy & Security considerations	Data Product	Role	Responsibilities
	Smart meter data	MDC (Data processor)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.10.19 Receive Smart Meter Data

ID	UC2303		
Triggered by	UC4304 (MDC: Send requested smart meter data to DSO)		
Triggers	UC2304 (Validate if D-prognoses were met)		
Goal in context	Receive requested smart meter data from the MDC		
Preconditions	Smart meter data has been requested from the MDC		
Successful outcome	Requested data received from the MDC		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors	MDC		
Main scenario			
Alternatives			
Related information			
Message type	MeterDataQueryResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	DSO (Data controller)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

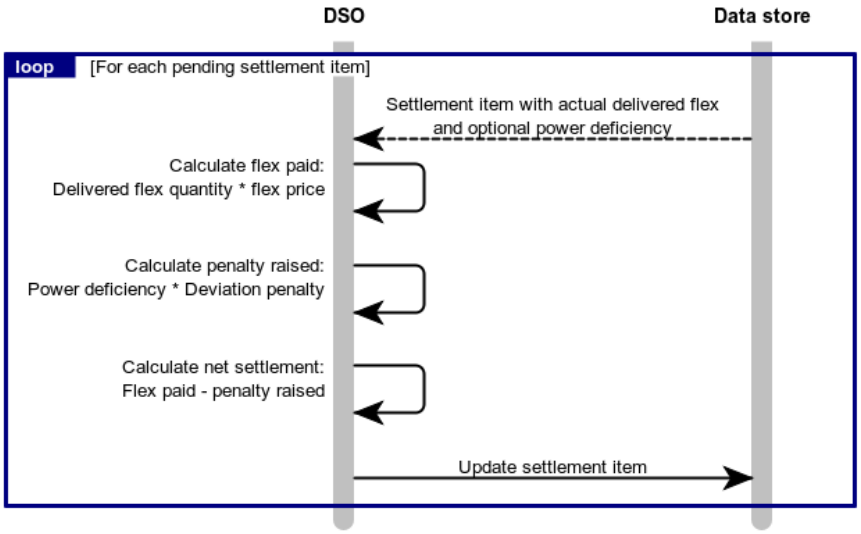
5.10.20 Validate if D-prognoses Were Met

ID	UC2304
Triggered by	UC2303 (Receive smart meter data)
Triggers	UC2305 (Calculate flex prices and penalty amounts)
Goal in context	Assessment if the procured FlexOrders have been delivered, based on deviation of the realization from approved D-prognoses.
Preconditions	Procured flexibility collected (UC2301): settlement items available (PTU level aggregated energy consumption/production allocation data available for all connections related to every Congestion Point)
Successful outcome	Delivered flex quantity for each FlexOrder and power deficiency quantity for each PTU determined as basis for flex remuneration and penalty calculation

Failure outcome	Failure	Outcome	Condition leading to outcome
	Allocation data incomplete	Flex is assumed to be fully delivered	
Primary actor	DSO		
Secondary actors			
Main scenario			
Alternatives	If a FlexOrder is procured from a specific AGR for a specific Congestion Point and a specific PTU, after another FlexOrder has been procured from the same AGR and for the same Congestion Point and the same PTU, and if the AGR has sent an updated D-prognosis in between the two FlexOrders, indicating that the previous FlexOrder will not be (fully) delivered, the volume that is the basis for the penalty calculation will be increased as follows: power deficiency quantity += updated D-prognosis – (D-prognosis – flex quantity) where the D prognosis and flex quantity are associated with the FlexOrder preceding the updated D-prognosis.		
Related information	Due to gate closure times, not all PTUs that should be considered the latest are necessarily contained in the same Prognosis message. To allow for proper settlement, both DSO and AGR need to create a comprehensive Prognosis, selecting the latest valid PTUs from actual Prognosis messages as required.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	D-prognoses	DSO (Data controller)	The content of D-prognoses represents commercially sensitive information.
	Load allocation	DSO (Data controller)	The allocation of consumption/ production to individual aggregators represents commercially sensitive information.

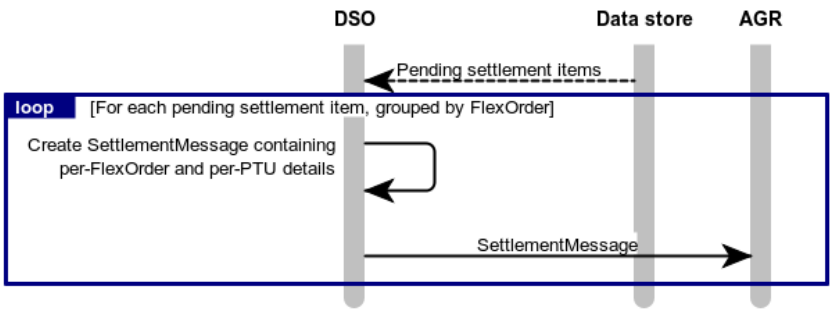
5.10.21 Calculate Flex Prices and Penalty Amounts

ID	UC2305
Triggered by	UC2304 (Validate if D-prognoses were met)
Triggers	UC2306 (Send settlement items to AGR)
Goal in context	Send consolidated settlement volumes and prices to the AGR(s) for a specific period.
Preconditions	All quantities from UC2301 and UC2304 available
Successful outcome	Periodic settlement invoice data available to be sent to AGR(s)

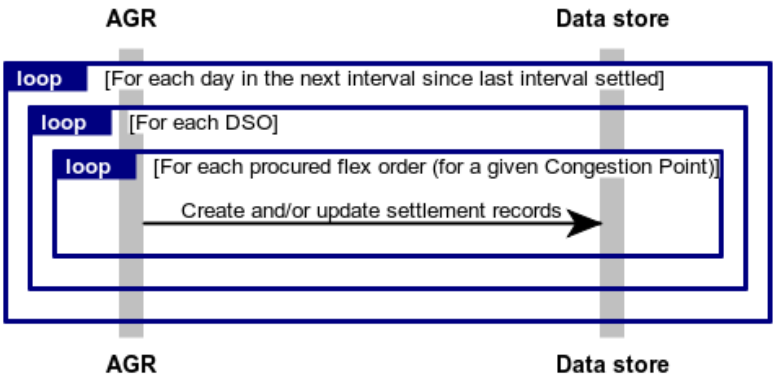
Failure outcome	Failure	Outcome	Condition leading to outcome
Primary actor	DSO		
Secondary actors			
Main scenario			
Alternatives			
Related information			
Message			

5.10.22 Send Settlement Items to AGR

ID	UC2306		
Triggered by	UC2305 (Calculate flex prices and penalty amounts)		
Triggers	UC1308 (AGR: Validate DSO settlement items)		
Goal in context	Send consolidated settlement volumes and prices to the AGR(s) for a specific period.		
Preconditions	All settlement items available and complete		
Successful outcome	Periodic settlement invoice(s) sent to AGR(s)		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors	AGR		

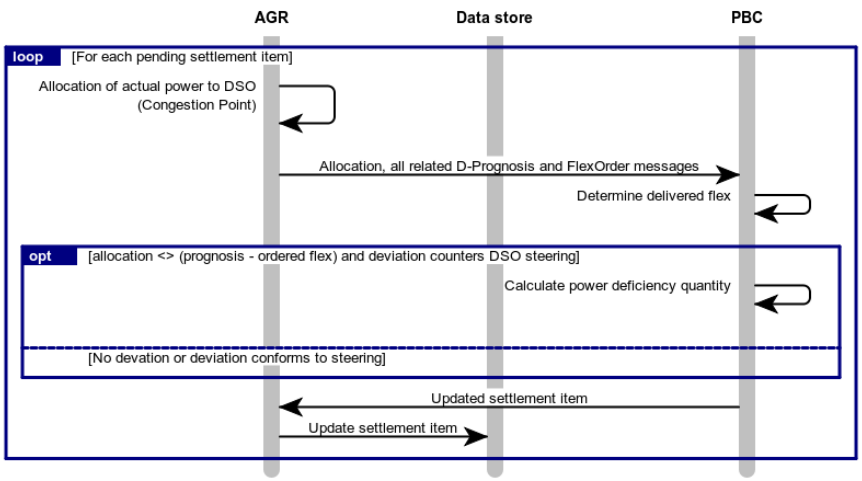
Main scenario			
Alternatives			
Related information			
Message type	SettlementMessage		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	DSO (Data controller)	Settlement items represent commercially sensitive information.

5.10.23 Calculate Flexibility Sold to DSO

ID	**UC1306**		
Triggered by	Either periodic or initiated by the receipt of the message generated in UC2103.		
Triggers	UC1108 (Validate if D-prognoses were met)		
Goal in context	Periodic (configurable, default monthly) settlement between DSO and AGR, based on FlexOrders sold to DSOs.		
Preconditions	List of all sold FlexOrders available		
Successful outcome	Price and quantity for each FlexOrder determined		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors			
Main scenario			

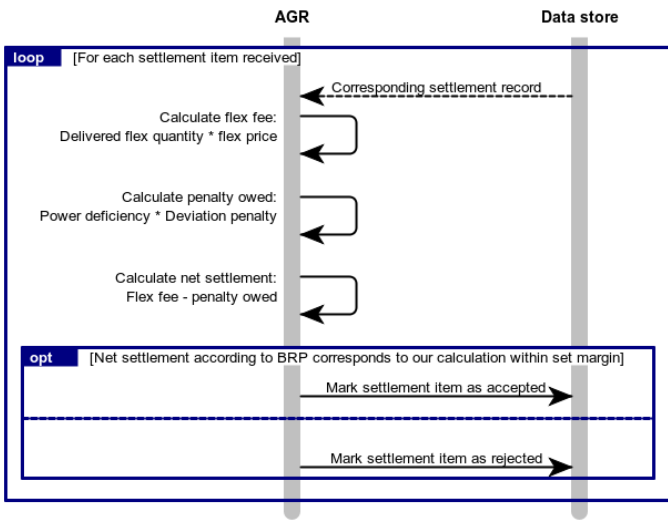
Alternatives			
Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Flex order messages	AGR (Data controller)	The content of flexibility orders represents commercially sensitive information.

5.10.24 Validate if D-prognoses were met

ID	**UC1307**		
Triggered by	UC1306 (Calculate flexibility sold to DSO)		
Triggers	UC1308 (Validate settlement items, once settlement message received)		
Goal in context	Assessment if the sold FlexOrders have been delivered, based on deviation of the realization from approved D-prognoses.		
Preconditions	PTU level aggregated energy consumption/production allocation data available for all connections related to every DSO and Congestion Point Sold flexibility collected (UC2101)		
Successful outcome	Delivered flex quantity for each FlexOrder and power deficiency quantity for each PTU determined as basis for flex remuneration and penalty calculation		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Allocation data incomplete	Flex is assumed to be fully delivered	
Primary actor	AGR		
Secondary actors	DSO		
Main scenario			

Alternatives	If a FlexOrder is sold for a specific Congestion Point for a specific PTU, after another FlexOrder has been sold for the same Congestion Point and the same PTU, and if the AGR has sent an updated D-prognosis in between the two FlexOrders, indicating that the previous FlexOrder will not be (fully) delivered, the volume that is the basis for the penalty calculation will be increased as follows: power deficiency quantity += updated D-prognosis – (D-prognosis – flex quantity) where the D-prognosis and flex quantity are associated with the FlexOrder preceding the updated D-prognosis.		
Related information	Due to gate closure times, not all PTUs that should be considered the latest are necessarily contained in the same Prognosis message. To allow for proper settlement, both DSO and AGR need to create a comprehensive Prognosis, selecting the latest valid PTUs from actual Prognosis messages as required.		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	D-prognoses	AGR (Data controller)	The content of D-prognoses represents commercially sensitive information.

5.10.25 Validate DSO Settlement Items

ID	**UC1308**		
Triggered by	Receipt of settlement message and completion of UC1307 (Validate if D-prognoses were met)		
Triggers	UC1309 or UC1310 (depending on whether settlement message from DSO is accepted as-is or disputed)		
Goal in context	Verification of settlement calculations performed by DSO, and expressed in settlement invoice message.		
Preconditions	All quantities from UC1306 and UC1307 available. Invoice(s) received from DSO(s)		
Successful outcome	Settlement invoice(s) from DSO(s) verified.		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors			
Main scenario			

Alternatives	Plausibility check can be skipped, or performed incidentally.		
Related information			
Message type			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	AGR (Data controller)	Settlement items represent commercially sensitive information.

5.10.26 Acknowledge DSO Flex Settlement

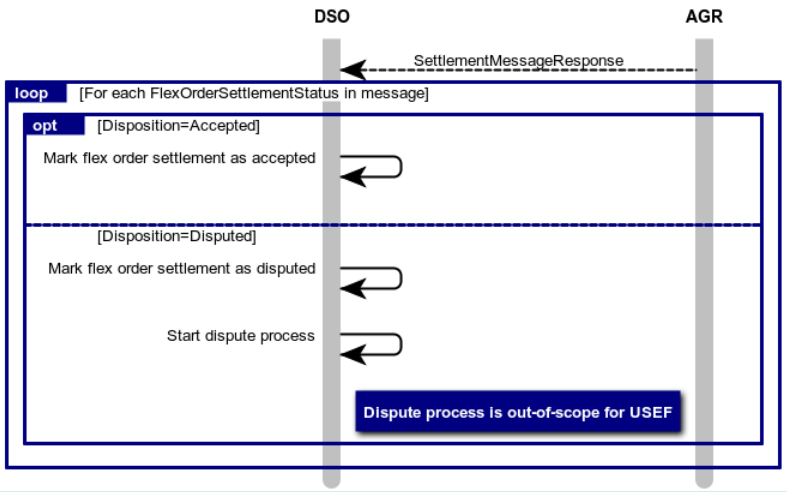
ID	**UC1309**		
Triggered by	UC1308 (conditionally)		
Triggers	UC2307 (DSO: Process settlement response)		
Goal in context	Acknowledge that the settlement items received from the DSO are plausible according to the AGR		
Preconditions	Validation within UC1309 successfully performed		
Successful outcome	Settlement items for the given period acknowledged		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors	DSO		
Main scenario	Send a message to the DSO to acknowledge all (listed) previously received settlement items are accepted.		
Alternatives			
Related information			
Message type	SettlementMessageResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	AGR (Data controller)	Settlement items, including the acknowledgement of their correctness, represent commercially sensitive information.

5.10.27 Dispute DSO Flex Settlement

ID	**UC1310**
Triggered by	UC1308 (conditionally)
Triggers	UC2307 (DSO: Process settlement response)
Goal in context	Start a dispute process if the detailed settlement calculations of the AGR and DSO show different results
Preconditions	Validation within UC1309 failed for a specific DSO and a specific Interval (DSO, Interval and details of differences known).
Successful outcome	Dispute process started

Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	AGR		
Secondary actors	DSO		
Main scenario	Send a message to the DSO in order to raise a dispute, specifying which previously received settlement items are disputed, as well as which items are accepted.		
Alternatives			
Related information			
Message type	SettlementMessageResponse		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	AGR (Data controller)	Settlement items, including the fact that their correctness is disputed, represent commercially sensitive information.

5.10.28 Process AGR Settlement Response

ID	**UC2307**		
Triggered by	UC1309 or UC1310 (AGR accepts or disputes settlement items)		
Triggers			
Goal in context	Process response from AGR and update status accordingly.		
Preconditions	Message received from specific AGR concerning an invoice		
Successful outcome	Status of invoice changed		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors	AGR		
Main scenario			
Alternatives			

Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Settlement items	DSO (Data controller)	Settlement items, including the fact that their correctness is acknowledged or disputed, represent commercially sensitive information.

5.11 Use cases - Settle phase – Orange regime

In Section 4.3.4 and 4.3.4.1 the informative description of the Settle phase processes during Orange regimes has been given. In this chapter the use cases will be described as derived from the corresponding process diagram. Each (Orange) activity (rounded rectangle) in the process diagram is listed as a use case, unless listed as out of scope.

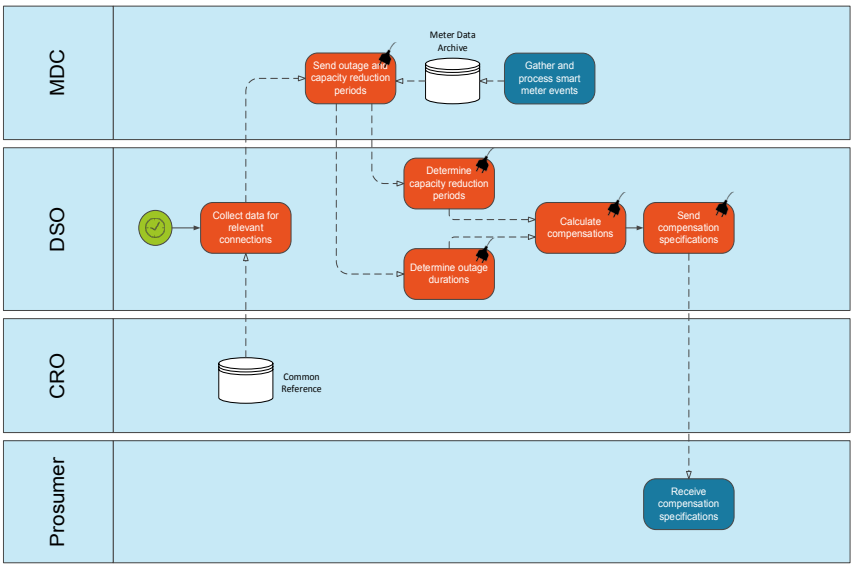


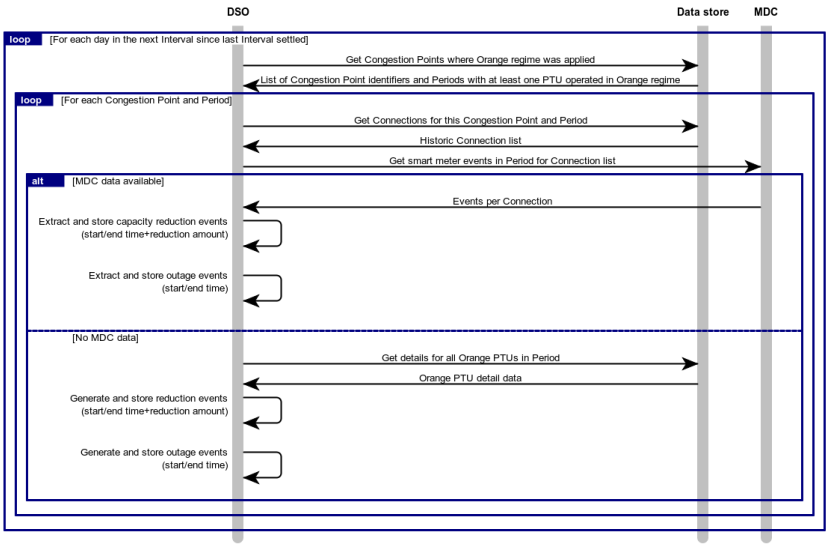
Figure 5-8: Process diagram of the Settle phase – Orange regime. Plug icons indicate Pluggable Business Components in the USEF reference implementation.

This section describes the use cases specifically for the Orange regime. The processes “gather and process smart meter events” and “receive compensation specifications” are out of scope for the USEF specifications.

ID	Name	Role	Phase	Message
UC2310	Collect Data for Relevant Connections	DSO	Settle	MeterDataQuery
UC4310	Send Outage and Capacity Reduction Periods	MDC	Settle	MeterDataQueryResponse
UC2311	Determine Capacity Reduction Periods	DSO	Settle	
UC2312	Determine Outage Durations	DSO	Settle	
UC2313	Calculate Compensations	DSO	Settle	

Table 5-8: Use cases for the Operate phase in the Orange regime.

5.11.1 Collect Data for Relevant Connections

ID	UC2310		
Triggered by	Periodic trigger		
Triggers	UC2311 (Determine capacity reduction periods), UC2312 (Determine outage durations) (both upon receipt of MDC response)		
Goal in context	Periodic (configurable, default monthly) settlement between DSO and Prosumer for capacity limitations applied to Connections		
Preconditions	List of all "orange regime" measures applied by the DSO (internal information)		
Successful outcome	Smart meter data requested		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Smart meter data not available	Use own data for settlement	
Primary actor	DSO		
Secondary actors	MDC		
Main scenario	This function is automatically triggered by a timer with a configurable interval (default is monthly), or manually by the DSO Operator.  		
Message type	MeterDataQuery		
Alternatives	Alternatives depend on smart meter possibilities		
Related information	Smart meter capabilities differ per region. This use case will not be feasible to implement in all regions		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	DSO (Data controller)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.11.2 Send Outage and Capacity Reduction Periods

ID	UC4310		
Triggered by	UC2310 (DSO: Collect data for relevant connections)		
Triggers	UC2311 (DSO: Determine capacity reduction periods), UC2312 (DSO: Determine outage durations)		
Goal in context	Based on the request from the DSO, query the meter data archive and transform the results to outage and capacity reduction intervals		
Preconditions	Smart meter data has been gathered during the settlement period		
Successful outcome	Requested data available for transmission to the DSO		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	MDC		
Secondary actors	DSO		
Main scenario	The MDC should be able to supply the data requested using the MeterDataQuery message, using any mechanism suitable for the MDC's internal operations. USEF does not specify how data queries and transformations should take place.		
Alternatives			
Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	MDC (Data processor)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.11.3 Determine Capacity Reduction Periods

ID	UC2311		
Triggered by	UC4310 (Receipt of MDC reply with capacity reduction periods)		
Triggers	UC2313 (Calculate compensations)		
Goal in context	Periodic (configurable, default monthly) settlement between DSO and Prosumer for capacity limitations applied to Connections		
Preconditions	Smart meter data retrieved		
Successful outcome	All capacity reductions at Connection level known		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
	Smart meter data differs from own data	Smart meter data prevails	
Primary actor	DSO		
Secondary actors			
Main scenario	See UC2310: Any business rules with regard to capacity reduction should be applied in this use case.		
Alternatives			
Related information			

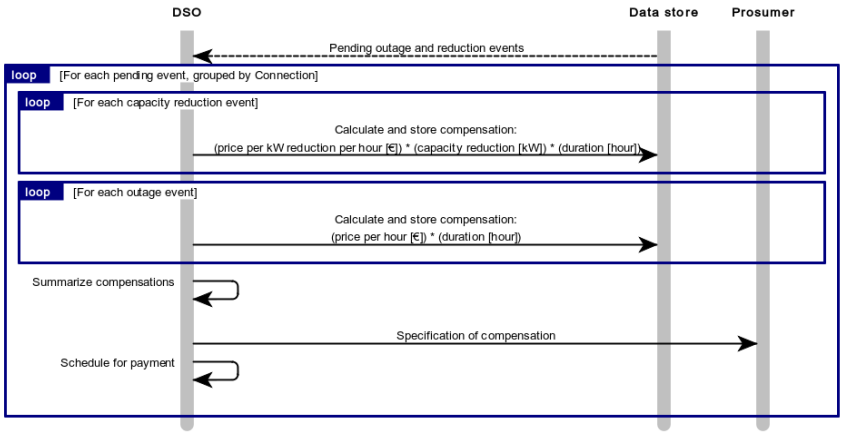
Privacy & Security considerations	Data Product	Role	Responsibilities
	Smart meter data	DSO (Data controller)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.11.4 Determine Outage Durations

ID	UC2312		
Triggered by	UC4310 (Receipt of MDC reply with outage periods)		
Triggers	UC2313 (Calculate compensations)		
Goal in context	Periodic (configurable, default monthly) settlement between DSO and Prosumer for capacity limitations applied to Connections		
Preconditions	Smart meter data retrieved		
Successful outcome	All outages at Connection level known		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors			
Main scenario	See UC2310: Any business rules with regard to outages should be applied in this use case.		
Alternatives			
Related information	Note that the smart meter data may include other outages which are not a result of capacity limitations. These outages should be discarded		
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Smart meter data	DSO (Data controller)	Smart meter data represents personally identifiable information, and should not be retained for a longer period than strictly necessary. The retention period should be specified and be communicated to the data subject.

5.11.5 Calculate Compensations

ID	UC2313
Triggered by	UC2311 (Determine capacity reduction periods), UC2312 (determine outage durations)
Triggers	
Goal in context	Periodic (configurable, default monthly) settlement between DSO and Prosumer for capacity limitations applied to Connections
Preconditions	Impact of capacity limitations is known

Successful outcome	Prosumers have received compensations		
Failure outcome	**Failure**	**Outcome**	**Condition leading to outcome**
Primary actor	DSO		
Secondary actors	Prosumer		
Main scenario			
Alternatives	Various alternative compensation schemes are possible		
Related information			
Privacy & Security considerations	**Data Product**	**Role**	**Responsibilities**
	Compensation details	DSO (Data controller)	Details of outage periods and compensations represent commercially sensitive information.

5.12 Use case inventory per USEF role

This section provides a complete use case inventory, grouped per USEF role.

Table 5.9: Use case inventory per USEF role.

ID	Name	Role	Phase
UC0001	Publish Connections (Long-term)	BRP	Plan
UC0002	Retrieve Active Aggregators	BRP	Plan
UC0003	Receive A-Plan	BRP	Plan
UC0004	Create Flexibility Requests	BRP	Plan
UC0005	Receive Flexibility Offers	BRP	Plan
UC0006	Place Flexibility Orders	BRP	Plan
UC0007	Receive Flexibility Offer Revocation	BRP	Plan
UC0008	Approve A-Plan	BRP	Plan
UC0200	Place Flexibility Orders	BRP	Operate
UC0201	Receive Flexibility Offer Revocation	BRP	Operate
UC0301	Calculate Procured Flexibility	BRP	Settle
UC0302	Request Smart Meter Data	BRP	Settle
UC0303	Receive Smart Meter Data	BRP	Settle

UC0304	Validate if A-plans Were Met	BRP	Settle
UC0305	Calculate Flex Prices and Penalty Amounts	BRP	Settle
UC0306	Send Settlement Items to AGR	BRP	Settle
UC0307	Process Settlement Response	BRP	Settle
UC1001	Publish Connections	AGR	Plan
UC1002	Retrieve Congestion Points and BRPs	AGR	Plan
UC1003	Collect Forecasts	AGR	Plan
UC1005	(Re-)Optimize Portfolio Based on Client Needs	AGR	Plan
UC1006	New A-Plan Required and Possible?	AGR	Plan
UC1007	(Re-)Create and Send A-Plan(s)	AGR	Plan
UC1008	Receive Flexibility Request	AGR	Plan
UC1009	Create and Send Flexibility Offer	AGR	Plan
UC1011	Revoke Flexibility Offer	AGR	Plan
UC1010	Receive Flexibility Order	AGR	Plan
UC1012	Receive A-Plan Approval	AGR	Plan
UC1013	New D-Prognoses Required?	AGR	Plan (re-iteration)
UC1100	(Re-)Create D-prognoses per Congestion Point	AGR	Validate
UC1101	Receive Flexibility Requests	AGR	Validate
UC1104	Revoke Flexibility Offer	AGR	Validate
UC1102	Create Flexibility Offers	AGR	Validate
UC1103	Receive Flexibility Orders	AGR	Validate
UC1200	Determine Net Demands and Forecasts	AGR	Operate
UC1201	Identify Changes In Forecast	AGR	Operate
UC1202	Detect Deviations from A-Plan and/or D-Prognoses	AGR	Operate
UC1203	Re-Optimize Portfolio	AGR	Operate
UC1204	Re-Create D-Plans and/or D-Prognoses	AGR	Operate
UC1205	Realize Portfolio using ADS	AGR	Operate
UC1206	ADS: Receive Control Signals	AGR	Operate
UC1207	ADS: Control Behavior Subject to User Settings	AGR	Operate
UC1208	Receive Flexibility Order from DSO	AGR	Operate
UC1209	Receive Flexibility Order from BRP	AGR	Operate
UC1210	Revoke Flexibility Offer	AGR	Validate
UC1301	Calculate Flexibility Sold to BRP	AGR	Settle
UC1302	Validate if A-Plans Were Met	AGR	Settle
UC1303	Validate BRP Settlement Items	AGR	Settle
UC1304	Acknowledge BRP Settlement	AGR	Settle
UC1305	Dispute BRP Flex Settlement	AGR	Settle
UC1306	Calculate Flexibility Sold to DSO	AGR	Settle
UC1307	Validate if D-Prognoses Were Met	AGR	Settle
UC1308	Validate DSO Settlement Items	AGR	Settle
UC1309	Acknowledge DSO Settlement	AGR	Settle

UC1310	Dispute DSO Settlement	AGR	Settle
UC2001	Publish Congestion Points (Long term)	DSO	Plan
UC2002	DSO: Retrieve Active Aggregators	DSO	Plan
UC2100	DSO: Receive D-prognoses per congestion point	DSO	Validate
UC2101	Supply Missing D-Prognoses	DSO	Validate
UC2102	Grid Safety Analysis per Congestion Point	DSO	Validate
UC2103	Create Flexibility Requests	DSO	Validate
UC2104	Receive Flexibility Offers	DSO	Validate
UC2105	Place Flexibility Orders	DSO	Validate
UC2106	Receive Flexibility Order Revocation	DSO	Validate
UC2107	Prepare Stepwise Connection Limiting & Recovery	DSO	Validate (Orange)
UC2200	Monitor Grid	DSO	Operate
UC2201	DSO: Place Flexibility Orders	DSO	Operate
UC2202	Receive Flexibility Offer Revocation	DSO	Operate
UC2203	Monitor Grid	DSO	Operate (Orange)
UC2204	Limit Connections	DSO	Operate (Orange)
UC2205	Restore Connections	DSO	Operate (Orange)
UC2301	Calculate Procured Flexibility	DSO	Settle
UC2302	Request Smart Meter Data	DSO	Settle
UC2303	Receive Smart Meter Data	DSO	Settle
UC2304	Validate if D-Prognoses Were Met	DSO	Settle
UC2305	Calculate Flex Prices and Penalty Amounts	DSO	Settle
UC2306	Send Settlement Items to AGR	DSO	Settle
UC2307	Process AGR Settlement Response	DSO	Settle
UC2310	Collect Data for Relevant Connections	DSO	Settle (Orange)
UC2311	Determine Capacity Reduction Periods	DSO	Settle (Orange)
UC2312	Determine Outage Durations	DSO	Settle (Orange)
UC2313	Calculate Compensations	DSO	Settle (Orange)
UC3001	Receive DSO Common Reference Update	CRO	Plan
UC3002	Receive AGR Common Reference Update	CRO	Plan
UC3003	Receive BRP Connection Update	CRO	Plan
UC3004	Send Congestion Points and BRPs to AGR	CRO	Plan
UC3005	Send Active Aggregators to DSO	CRO	Plan
UC3006	Send Active Aggregators to MDC	CRO	Plan
UC3007	Send Active Aggregators to BRP	CRO	Plan
UC4001	MDC: Retrieve Active Aggregators	MDC	Plan
UC4301	Gather Requested Smart Meter Data	MDC	Settle
UC4302	Send Requested Smart Meter Data to BRP	MDC	Settle
UC4303	Gather Requested Smart Meter Data	MDC	Settle
UC4304	Send Requested Smart Meter Data to DSO	MDC	Settle
UC4310	Send Outage and Capacity Reduction Periods	MDC	Settle

6 Message transport & descriptions

6.1 Scope

USEF defines the content of XML messages between role processes, as required for implementation of the USEF Market-based Coordination Mechanism described in Chapter 5, by means of the use cases detailed in Chapter 11. Each message has a unique recipient, identified by the Internet domain and USEF role of the participant. The message transfer mechanism is responsible for sending and receiving these messages.

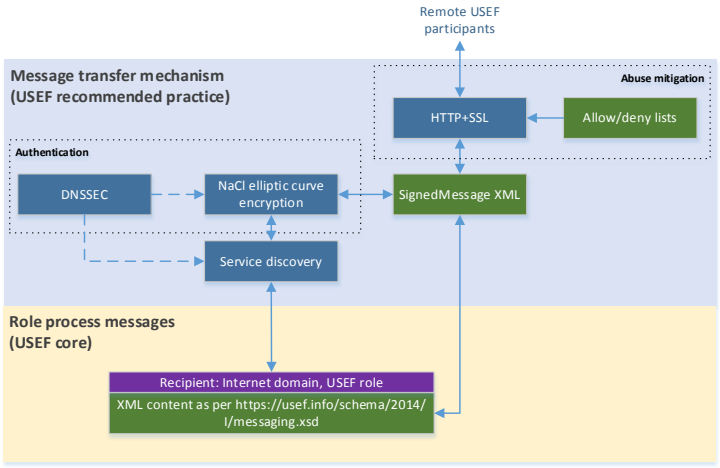


Figure 6-1: Relationship between the normative USEF XML messages (yellow pane) and the best-practice message transfer mechanism (light-blue pane).

When selecting a message transfer mechanism, local market conditions should be considered and the USEF Privacy and Security guidelines from Chapter 10 followed. From a strictly technical point of view, any messaging implementation that supports secure and reliable delivery of XML messages based on the USEF-defined recipient parameters can be used: possible standardized mechanisms include IEC CIM and ISO 15000 (ebXML).

Absent a de-facto standard for message exchange, USEF at this time outlines a recommended practice, described in section 6.2, as well as provides a reference implementation of this mechanism, which offers a reliable and secure foundation for operation of the USEF role processes.

6.2 Message transport mechanism

When implementing the USEF best-practice message transfer mechanism, the procedures outlined in this section apply.

6.2.1 Transport Protocol

To ensure reliable operation of the distributed USEF system, each participant must operate a message queue, both for outgoing and for incoming messages, in order to achieve fully asynchronous and decoupled operations. Communications between these queues must support the HTTP version 1.1 protocol over TLS[22]. Participants may implement different standardized secure protocols, such as AQMP-over-TLS or HTTP 2.0, but due to uncertainties about interoperability, any alternative protocols are optional and fallback to the common protocol must be supported.

[22] TLS is only used for transport privacy and limited server authentication (domain control validation), not client authentication. Server certificates should be obtained from a regular commercial CA and server configuration should follow best practices. In general, any server endpoint with a score better than 'B' on https://www.ssllabs.com/ssltest/ should be suitable for exchanging USEF messages.

6.2.2 Cryptographic Scheme (CS)

The USEF privacy and security guidelines require all participants to be able to securely transmit and authenticate messages. For these purposes, a transport-independent cryptographic scheme is specified, identified as Cryptographic Scheme Type 1 (CS1): implementation is a recommended practice for all implementations[23]. Based on NaCl[24], a public domain library with high-speed state-of-the-art security features and a purpose-built and straightforward programming interface[25], this scheme requires participants to generate two public/private key pairs:

Purpose	NaCl function	Private key bits	Public key bits
Digital signatures	crypto_sign_keypair	512	256
Authenticated message encryption	crypto_box_keypair	256	256

The resulting private keys must be securely stored using an operating system or language-supplied facility for that specific purpose (e.g. the Win32 Data Protection API, OS X Keychain service or JVM KeyStore).
In addition to being stored locally, the public keys are exchanged with other USEF participants. For that purpose, the keys are joined together in a single 64-byte array (signature key followed by encryption key), Base-64 encoded and prefixed by the constant cs1 and a period (indicating that the version 1 cryptographic scheme is used). For example:
cs1.V4lZrkYHq8FzneXxUML+QEMXMul3tBm+gPGoVDIZBA92VoWTu8/kRu2Zx72XOm1i/qwwoSgXjqSAqSa43myCaQ==
This public key string can be published in the DNS zone of the domain used in the associated entity address, or manually exchanged with other USEF participants. If DNS is used, implementation of DNSSEC is mandatory, as otherwise the key material would be completely untrusted. Implementations must use a DNSSEC validating resolver, which can either be built-in, or an external resolver on a fully trusted network.
When signing an outgoing message using the private digital signature key and NaCl's `crypto_sign` function, the result is an opaque blob: the sealed message. Unsealing this message, using the corresponding public digital signature key and `crypto_sign_open`, performs signature verification and returns the message plaintext. Since this all happens in the same API call, it is not possible to accidentally process an unsigned or incorrectly signed message.

6.2.3 Message exchange logic

The entire message exchange, from the client's outgoing message queue to the server's incoming message queue, using HTTP-over-TLS transport and the default cryptographic scheme, is visualized in detail in Figure 6-2.

23 If this recommendation is not followed, a compatible implementation should be provided in order to achieve USEF compliance.

24 Pronounced "salt" and available with extensive documentation from http://nacl.cr.yp.to/. Sodium, https://github.com/jedisct1/libsodium, is an extended NaCl derivative with Windows, OS X and Linux platform support and many available language bindings. Sodium is highly recommended for USEF-compliant implementations.

25 Whereas typical cryptographic libraries require several steps to implement message encryption or signing, with each step opening the door for fatal programming mistakes, NaCl offers simple high-level functions which take care of everything, dramatically reducing the risk of inadvertent implementation errors.

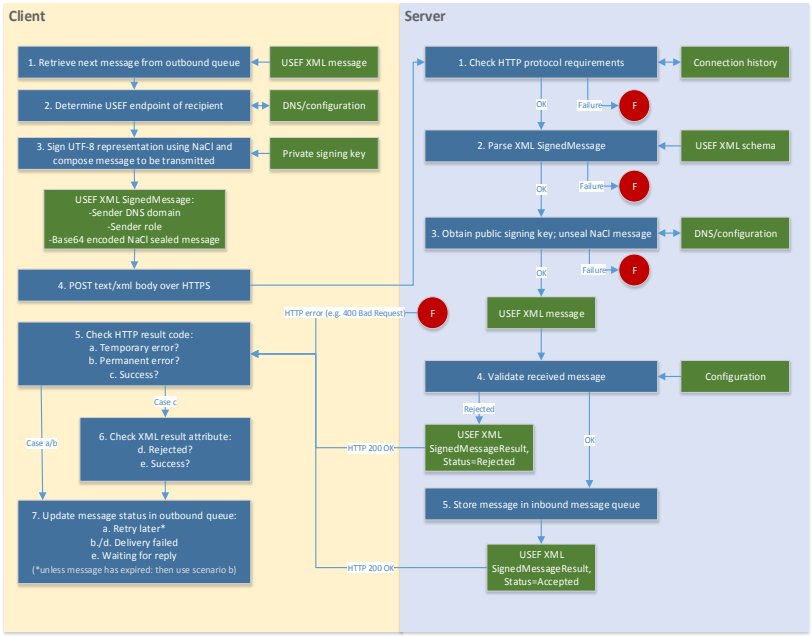


Figure 6-2: End-to-end USEF message exchange

Messages go through the following stages between retrieval from the client's outgoing message queue and delivery to the server's inbound message queue:

6.2.4 Service discovery

In the service discovery stage, DNS[26] is used to discover the capabilities as well as the endpoint host name and IP address of the remote participant. Assuming the Internet domain name of the remote participant is example.com, the relevant DNS records are as follows:

_usef.example.com	TXT record specifying the version of the USEF specification implemented by this participant, e.g. 2015
_*role*._usef.example.com	TXT record containing up to two[1] space-separated Base-64 encoded public key strings for the specified role, where ***role*** is one of the values AGR, BRP, CRO or DSO. This data is only queried if (part of) the outgoing message needs to be encrypted
_http._*role*._usef.example.com	CNAME record indicating the HTTP endpoint receiving messages for the specified role. This label must not have any resource records of other types (with the exception of the mandatory DNSSEC-related records[2]) and the alias should resolve to an A or AAAA record[3]. On the endpoint host, the implementation must listen on the well-known IANA-assigned TCP port for HTTP-over-TLS, i.e. 443. The implementation may listen on port 80 as well, but only for purposes such as supporting the HTTP/2 connection upgrade mechanism and never for unencrypted message exchange.

26 Each USEF participant is responsible for publishing its own endpoint and public key information in a self-managed DNS zone. To prevent man-in-the-middle interference with the published information, use of DNSSEC is mandatory for such zones.

The message will remain in the service discovery stage until all required data is available, or a participant-configurable and possibly message-class specific timeout timer expires. A DNS reply must have the NOERROR status, as well as syntactically valid and DNSSEC-authenticated content, in order to be considered usable: other status codes such as SERVFAIL/NXDOMAIN as well as connection failures or invalid record contents are considered temporary errors, in which case the lookup will be retried later within the timeout period.

To prevent transient Internet connectivity or participant configuration issues from inhibiting message exchange, the timer value used for such a period should be at least one hour for routine messages. If service discovery fails due to inability to collect all required data within this timeout period, the delivery of the message fails. Such messages are removed from the outgoing queue and returned to the sending process, indicating a transport error. Note that, although message queue implementations may inform the sending process about delivery delays, only the final success or failure status is authoritative.

When retrying failed requests, the implementation must implement an exponential back off mechanism to prevent undue load on the remote service. The implementation should set a reasonable maximum delay interval based on local factors, such as network capacity.

For test situations or small-scale deployments where service discovery via DNS is too cumbersome, or requires unreasonable amounts of additional work, participants should be able to specify service information in a local configuration file.

Since activities on the energy market are most likely regulated by a national oversight bodies, and such organizations are natural candidates for running the authoritative DNS zone for accredited market participants, implementations are encouraged to support a list of DNS suffixes that correspond to the zones maintained by such regulators, and to automatically query these zones. For example, if energy.authority.test is on the DNS suffix list, this zone is queried for _usef.example.com.energy.authority.test in order to determine if example.com is an authorized market participant.

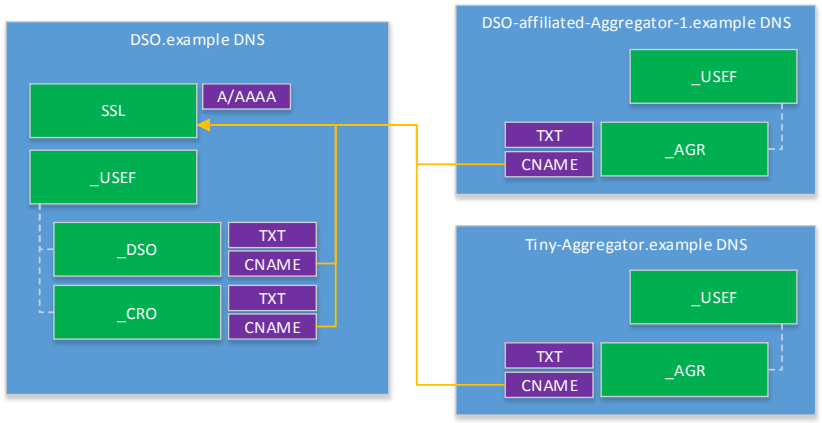


Figure 6-3 - Example of the DNS relationships between a single USEF endpoint and multiple zones

An example of an anticipated DNS setup is shown in Figure 6-3: here, an incumbent DSO (using the Internet domain `DSO.example`) operates a USEF endpoint, named `SSL.DSO.example`. The DNS entries for the USEF DSO and CRO role processes that underpin the DSO's core business both refer to this endpoint, ultimately leading to an IP/port combination usable for submitting USEF messages to.

In order to offer differentiated services to various customer segments, the DSO has also set up various aggregators, each operating its own web site and Internet domain. One of these aggregators is shown in the diagram. Instead of operating its own USEF endpoint, this aggregator delegates this responsibility to its parent company, by pointing its USEF DNS records at the `SSL.DSO.example` endpoint.

The second aggregator shown in the diagram is an independent market participant, but lacks sufficient scale to warrant running its own USEF endpoint. Instead, it outsources that task to the DSO. Note that, due to the sensitive data included in some USEF messages, strong contractual as well as technological safeguards (such as full-message encryption) are required to correctly apply the USEF privacy and security guidelines.

Using a single USEF endpoint as shown here has a number of advantages, mostly related to the fact that only a single SSL certificate and IP address are required to operate the endpoint: requiring unique instances of these would be complex and expensive, especially if the DSO runs tens or even hundreds of segment-specific aggregators.

There are, of course, disadvantages as well: unless network-level measures are taken to prevent this, a single endpoint also means a single point of failure, and shared hosting scenarios that do not ultimately involve only a single legal entity require special attention to the protection of message contents.Using a single USEF endpoint as shown here has a number of advantages, mostly related to the fact that only a single SSL certificate and IP address are required to operate the endpoint: requiring unique instances of these would be complex and expensive, especially if the DSO runs tens or even hundreds of segment-specific aggregators.
There are, of course, disadvantages as well: unless network-level measures are taken to prevent this, a single endpoint also means a single point of failure, and shared hosting scenarios that do not ultimately involve only a single legal entity require special attention to the protection of message contents.

6.2.5 Transmission

Once a valid service endpoint is available, the message enters the transmission stage[27]. The implementation will now, for a reasonable amount of time (which is again at least one hour for routine messages, employing exponential back off), attempt to deliver the message to the remote participant.
Messages are sent using a HTTP POST operation with the text/xml[28] content type, the UTF8 character set and content-length indication. The request URI depends on the USEF implementation level and host name listed in DNS by the recipient. For USEF 2015 and the host `example.com`, it will be https://example.com/USEF/2015/SignedMessage.
Message content consists of a simple wrapper message, specified as `SignedMessage` in the USEF XML XSD, available for download from the public USEF web site[29] at https://usef.info/schema/2015/messaging.xsd and documented in section 6.4
All usual protocol conventions should be followed during this stage. For example, when using HTTP version 1.1, redirects (responses with status code 3***xx***) should be honored in order to support load balancing. Any server errors (responses with status code 5xx) as well as unknown response status codes and connection timeouts and resets should be considered temporary failures and delivery should be re-attempted later within the timeout period. Only client success or failure messages (responses with status code 200 or a non-ambiguous[30] 4***xx*** status code, respectively) should be considered final. This is standard HTTP 1.1 behavior, as fully described in IETF RFC 2616 [10].

6.2.6.1 Error handling

In the transmission stage, the guidelines for error handling are as follows:
Until the point that the message has been successfully validated against the USEF XML schema, errors are communicated using transport protocol mechanisms, e.g. HTTP status codes. For the HTTP protocol, the following error conditions are common (note that, depending on the server and libraries used, some of these may be handled automatically):

Condition	Status code	Error type
Missing Content-Length header	411 Length Required	Permanent (E cannot be resolved without changes to the sending implementation)
Invalid Content-Type header (not text/xml) or character set (default: utf-8)	400 Bad Request	Permanent
Originating IP address is sending messages at a rate exceeding receiver policy	429 Too Many Requests	Temporary
Body XML cannot be parsed or is not compliant with USEF XML schema	400 Bad Request	Permanent

27 For messages containing non-public information, this stage transition may also include encryption of message sections using the public encryption key of the remote participant.

28 The USEF specification uses XML, since this format is already widely used in the rather conservative energy market, and enjoys wide and mature tooling support (particularly in the area of schema authoring and validation). Unlike other XML-based initiatives (such as WS-*), lightweight implementations are considered key, and alternate serialization formats (such as JSON) should be viable as well, despite being out of scope of this specification. If any such alternate message formats are implemented, fallback to XML must be provided as needed, or such implementations will not be USEF-compliant.

29 Please note that USEF makes no warranties whatsoever as to the uninterrupted availability of its web site, and that production services should not rely on the schema being hosted at this location for purposes such as validation: a local copy should be used instead.

30 The prime example of an ambiguous HTTP status code is 404 Not Found: since this is commonly returned by front-end servers in case of temporary back-end issues, USEF implementations are encouraged to consider this a temporary error.

Failed to look up the sender's public signature key in DNS	419 Authentication Timeout	Temporary (message can be processed when DNS is corrected/replicated)
Invalid signature (inner XML message cannot be unsealed, for example due to NaCl's crypto_sign_ open function failing)	401 Unauthorized	Permanent (since no authorization schemes that would allow the request to be resubmitted are available, unless private arrangements between sender and recipient exist)
Unsealed body XML cannot be parsed or is not compliant with the USEF XML schema	400 Bad Request	Permanent

Once a message has been determined to be valid USEF XML, errors are reported using a USEF XML reply message, defined as SignedMessageReply in the USEF XML schema and documented in section 6.4, with a successful transport disposition (e.g. HTTP status code 200 OK). Possible results in this stage are:

Condition	Result / Status attributes	Disposition
Despite being parsed and validated successfully, an invalid field was present in the message, or the message is of a type the implementation can't process	Rejected / InvalidMessage	Permanent error
The SenderDomain or SenderRole of the message body do not match the values specified in the SignedMessage wrapper	Rejected / InvalidSender	Permanent error
Messages from this SenderDomain/SenderRole are not accepted for policy reasons	Rejected / BarredSender	Permanent error
This endpoint does not handle messages for the RecipientDomain or RecipientRole specified	Rejected / UnknownRecipient	Permanent error
Sender re-used a MessageID for a message with different content (also see below)	Rejected / DuplicateIdentifier	Permanent error
Sender retransmitted a message that was already received and processed successfully (as determined by a sufficiently collision-free hash, such as SHA-256, of its entire content)	Accepted / AlreadySubmitted	Success
Sender successfully transmitted a message	Accepted / Submitted	Success

As in the service discovery stage, messages for which transmission permanently fails are removed from the outgoing queue and returned to the sending process, indicating a transport error.

6.2.6.2 Common Message Metadata

The USEF XML message obtained after successfully verifying the signature will have a root node corresponding to its message type, which must contain a **MessageMetadata** child node with the attributes defined in section 6.4.3, which the implementation may use to assign the correct topic and such for its local inbound queue when storing the message.

6.2.6 Awaiting reply

If message transmission succeeds, the implementation starts waiting for a reply from the remote service. Although replies to some messages can be expected right away, other USEF messages may only elicit a response several hours later. In any case, responses are always decoupled from requests, and implementations should be strictly asynchronous, correlating requests and responses using their conversation identifier.
Because of the asynchronous nature of message exchange, a process needs to be in place for handling messages that do not receive

a (timely) reply. When preparing a new message, the implementation should specify the message class, as well as the time period within which a reply is expected. The following message classes are defined:

Routine	Messages for which a reply is desired, but not required: absent a reply, the system is able to continue to operate in a steady state without further side-effects. Expired outgoing messages are simply discarded.
Transactional	Messages intended to cause a permanent change in the state of the system for which no steady state alternative is available (e.g. in the settlement phase). Expired outgoing messages cannot be discarded, but need to be put on a list of non-complete transactions to be manually reviewed and, after resolving the underlying issue with the remote participant, to be resent.
Critical	Messages that are transactional, but also need timely handling. For example: DSO flex order messages received for timeslots which are already in the operations phase. Expired messages need immediate operator attention, possibly after notification via an out-of-band mechanism (e.g. text message to a mobile phone). Otherwise, handling is the same as for transactional messages.

Incoming replies are validated using the steps outlined in the transmission stage. In case a reply is rejected, the pending outgoing message remains in the awaiting reply stage, until it expires and any additional manual processing is completed.
Messages for which ultimately no reply is received are returned to the sending process, indicating expiry.

6.2.7 Service process message error handling

Since the message exchange process is responsible for transparently handling most, if not all, transient error conditions, service processes have no need for routine error recovery. In fact, any transport errors reported to the service layer are of such a severe nature that they most likely cannot be corrected without implementation or configuration changes:

- Malformed messages
- Entity address or signing key misconfigurations

Expired message, despite following manual recovery procedures for non-routine messages (for routine messages, no recovery is required by design, but logging may definitely be appropriate)
The suggested error handling strategy for service processes is to mark the affected remote participant (i.e. not try to exchange any future messages with it) and to emit a diagnostic message indicating that manual intervention is required. After the issue is investigated and resolved, the configuration can be manually updated to re-enable the participant.

6.3 Entity Address

In USEF messages, there is often a requirement for a globally unique identity for certain entities. To meet this requirement, USEF defines the Entity Address (EA). Each EA consists of a prefix, indicating the addressing scheme, followed by the actual address. Currently, two addressing schemes are supported:

- The European Article Number (EAN), commonly used to uniquely identify connection points in the electricity network, and as such a natural identifier for such entities in USEF as well. Example of an EA using this scheme: ean.871685900012636543
- The USEF type 1 entity address (EA1), designed to allow participants to generate unique identifiers for themselves and entities managed by them, without relying on a central authority.

6.3.1 EA1 addressing scheme

The USEF type 1 EA is structured analogous to the iSCSI IQN. Paraphrasing IETF RFCs 3720 and 3271 [11]: the EA does not define any new naming authorities, but uses Internet domain names to ensure global uniqueness. Furthermore, the EA is constructed to give an organizational naming authority the flexibility to further subdivide the responsibility for name creation to subordinate naming authorities.
This makes the EA format slightly unwieldy, but since bandwidth and storage space are not expected to be significant constraints in any USEF implementation, this is considered to be an acceptable tradeoff for not requiring a central authority.
Syntactically, an EA is a variable-length 7-bit printable ASCII text string containing up to 255 characters. For example:

```
ea1.2013-11.info.usef.test:001:002.090807002a&b#
    <- naming authority -> < unique identifier >
```

Mostly taken from IETF RFC 3720 [12], below are the semantics of the various parts of this EA:

ea1	Constant, indicating this is a type 1 USEF entity address
2013-11	A date code, in yyyy-mm format. This date must be a date during which the naming authority owned the domain name used in this format, and should be the first month in which the domain name was owned by this naming authority at 00:01 GMT of the first day of the month. This date code uses the Gregorian calendar. All four digits in the year must be present. Both digits of the month must be present, with January == "01" and December == "12". The dash must be included.
info.usef.test	The reversed domain name of the naming authority (person or organization) creating this entity address
001:002.090807002a&b#	A locally unique string, which may contain product types, serial numbers, host identifiers, or software keys (specifically: it may include colons to separate organization boundaries). With the exception of the colon prefix, the owner of the domain name can assign everything after the reversed domain name as desired. It is the responsibility of the entity that is the naming authority to ensure that the names it assigns are worldwide unique.

6.4 Message catalog

USEF messages consist of XML, use UTF-8 encoding, and should validate against the USEF schema corresponding to the specification version implemented by a participant. The current version of this schema, as well as all historic production versions are available for download from the USEF web site, with https://usef.info/schema/2015/messaging.xsd corresponding to this specification version.
Message types can be differentiated using the name of their root node.
To allow extensibility as well as forward and backward compatibility of XML messages, the USEF schema allows additional elements in each defined sequence, as long as these elements have an explicit, non-default XML namespace.

6.4.1 SignedMessage

The SignedMessage element represents the secure wrapper used to submit USEF XML messages from the local message queue to the message queue of a remote participant. It contains minimal metadata (which is distinct from the common metadata used for all other messages), allowing the recipient to look up the sender's cryptographic scheme and public keys, and the actual XML message, as transformed (signed/sealed) using that cryptographic scheme.

XML representation summary

```
<SignedMessage
    SenderDomain  =  InternetDomain
    SenderRole    =  ("AGR" | "BRP" | "CRO" | "DSO" | "MDC")
    Body          =  base64Binary
/>
```

SenderDomain	The Internet domain of the USEF participant sending this message. Upon receiving a message, the recipient should validate that its value matches the corresponding attribute value specified in the inner XML message, once un-sealed: if not, the message must be rejected as invalid.
SenderRole	The USEF role of the participant sending this message: AGR, BRP, CRO, DSO or MDC. Receive-time validation should take place as described for the SenderDomain attribute above.

Body	The Base-64 encoded inner XML message contained in this wrapper, as transformed (signed/sealed) using the sender's cryptographic scheme. The recipient can determine which scheme applies using a DNS or configuration file lookup, based on the combination of SenderDomain and SenderRole.

6.4.2 SignedMessageReply

The SignedMessageReply element represents the status message returned by the receiving implementation when a SignedMessage containing a valid and schema-conformant inner XML message has been POSTed to it. It allows the sending implementation to determine whether the receiver has successfully stored the message in its message queue.

XML representation summary

```
<SignedMessageReply
    MessageID  =  UUID
    Result     =  ("Accepted" | "Rejected")
    Status     =  ("InvalidMessage" | "InvalidSender" | "UnknownRecipient" |
                   "BarredSender" | "DuplicateIdentifier" | "AlreadySubmitted" |
                   "Submitted")
/>
```

MessageID	Message identifier this reply applies to, obtained from the inner XML message's MessageID attribute.	
Result	Indication whether the receiving implementation successfully stored the message in its inbound message queue or not.	
Status	More detailed indication of the reason for the acceptance or rejection of the message.	
	InvalidMessage	Despite being schema-compliant, the syntax, type or semantics of the message were unacceptable for the receiving implementation.
	InvalidSender	There is a mismatch between the SenderDomain/Role combination in the message wrapper and the inner XML message.
	UnknownRecipient	The RecipientDomain and/or RecipientRole specified in the inner XML message is not handled by this endpoint.
	BarredSender	This endpoint is explicitly blocking messages from this sender.
	DuplicateIdentifier	The MessageID attribute of the inner XML message is not unique, and has already been used for a message with different content. This message has been rejected.
	AlreadySubmitted	The MessageID attribute of the inner XML message is not unique, but since the message content is the same as that of a previously accepted message, this copy can be considered to be successfully submitted as well.
	Submitted	The message has been accepted.

6.4.3 MessageMetadata

The MessageMetadata element contains mandatory metadata which is common for each non-wrapper USEF message. This element is always included as part of a message and never transmitted by itself.

XML representation summary

```
<MessageMetadata
    SenderDomain     =    InternetDomain
    SenderRole       =    ("AGR" | "BRP" | "CRO" | "DSO" | "MDC")
    RecipientDomain  =    InternetDomain
    RecipientRole    =    ("AGR" | "BRP" | "CRO" | "DSO" | "MDC")
    TimeStamp        =    dateTime
    MessageID        =    UUID
    ConversationID   =    UUID
    Precedence       =    ("Critical" | "Routine" | "Transactional")
    ValidUntil       =    dateTime
/>
```

SenderDomain	The Internet domain of the USEF participant sending this message. When receiving a message, its value should match the value specified in the SignedMessage wrapper: otherwise, the message must be rejected as invalid. When replying to this message, this attribute, combined with the SenderRole, is used to look up the USEF endpoint the reply message should be delivered to.
SenderRole	USEF role of the participant sending this message: AGR, BRP, CRO, DSO or MDC. When receiving a message, its value should match the value specified in the SignedMessage wrapper: otherwise, the message must be rejected as invalid.
RecipientDomain	Internet domain of the participant this message is intended for. When sending a message, this attribute, combined with the RecipientRole, is used to look up the USEF endpoint the message should be delivered to.
RecipientRole	USEF role of the participant this message is intended for: AGR, BRP, CRO, DSO or MDC.
TimeStamp	Date and time this message was created, including the time zone (ISO 8601 formatted as per http://www.w3.org/TR/NOTE-datetime).
MessageID	Unique identifier (UUID/GUID as per IETF RFC 4122) for this message, to be generated when composing each message.
ConversationID	Unique identifier (UUID/GUID as per IETF RFC 4122) used to correlate responses with requests, to be generated when composing the first message in a conversation and subsequently copied from the original message to each reply message.
Precedence	Indication of the importance and impact of the message: Routine, Transactional or Critical. Used to determine time-out values during message exchange and the level of error notification used in the sending implementation.
ValidUntil	Optional absolute date and time (ISO 8601 formatted, including time zone) this message expires. Used by implementations to determine if a pending message should still be processed.

6.4.4 TestMessage

TestMessage does not have any content (other than the mandatory message metadata) and may be used by implementations for (connectivity) testing purposes.

XML representation summary

```
<TestMessage
    <MessageMetadata…/> (mandatory)
/>
```

6.4.5 TestMessageResponse

Upon receiving a TestMessage, the receiving implementation must reply with a TestMessageResponse. Like the TestMessage itself, the TestMessageResponse does not have any content (other than the mandatory message metadata).

XML representation summary

```
<TestMessageResponse
    <MessageMetadata…/> (mandatory)
/>
```

6.4.6 Connection

The Connection entity is used in Common Reference-related messages. For updates, it is used either by a DSO to register the Connections belonging to a Congestion Point, by a BRP to indicate which Connections are part of its coverage area, or by an Aggregator to indicate on which Congestion Points it represents customers. In queries, it is used to inform Aggregators about the BRP(s) responsible for their Connections. This element is always included as part of a message and never transmitted by itself.

XML representation summary

```
<Connection
    EntityAddress   = EntityAddress
    IsCustomer      = boolean
    BRP-Domain      = InternetDomain
    AGR-Domain      = InternetDomain
/>
```

EntityAddress	Entity Address of the referenced Connection.
IsCustomer	Indication whether the referenced Connection is represented by the Aggregator performing the Common Reference update. Ignored if the SenderRole of the message is not AGR.
BRP-Domain	Internet domain of the BRP for this Connection. Optional, only included in CommonReferenceQueryResponse messages sent to Aggregators in response to BRP queries.
AGR-Domain	Internet domain of the Aggregator for this Connection. Optional, only included in CommonReferenceQueryResponse messages sent to BRPs in response to Aggregator queries.

6.4.7 CommonReferenceUpdate

CommonReferenceUpdate is used by the DSO to declare a Congestion Point and registering the Connection(s) associated with it (or, if the Connection count is 0, to delete the Congestion Point). BRPs use CommonReferenceUpdate to register themselves are responsible for the Connections listed in the message. Aggregators use CommonReferenceUpdate to declare whether they represent customers on the Connection(s) listed in the message.
Note that there is no start date attribute for updates: any valid change will take effect immediately. This is a deliberate design decision, intended to keep the Common Reference implementation as straightforward as possible. Implementations of the DSO and/or Aggregator role will most likely store start/end date fields for Congestion Point-related data, as well as a history of changes. None of this local data is reflected in the Common Reference, though, and implementations are responsible for sending updates only when they become applicable.

XML representation summary

```
<CommonReferenceUpdate
    Entity              = ("CongestionPoint" | "Aggregator" | "BRP")
    EntityAddress       = EntityAddress
    <MessageMetadata…/>   (mandatory)
    <Connection…/>        (0...n)
/>
```

Entity	Indication which type of entity is being updated: CongestionPoint for DSO-originated updates, Aggregator for AGR-originated updates, BRP for BRP-originated updates.
EntityAddress	Entity Address of the CongestionPoint entity being updated. Not included (and ignored if present) for Aggregator and BRP entity updates.

6.4.8 CommonReferenceUpdateResponse

Upon receiving and processing a CommonReferenceUpdate message, the receiving implementation must reply with a CommonReferenceUpdateResponse, indicating whether the update was handled successfully.

XML representation summary

```
<CommonReferenceUpdateResponse
    Result              = ("Accepted" | "Rejected")
    EntityAddress       = EntityAddress
    Message             = string
    <MessageMetadata…/>   (mandatory)
/>
```

Result	Indication whether the update was accepted or rejected.
EntityAddress	For CongestionPoint updates: Entity Address of the CongestionPoint for which the update was accepted or rejected (this will always match the EA specified in the corresponding CommonReferenceUpdate message; it is included to simplify implementation).
Message	In case the update was rejected, this attribute must contain a human-readable description of the failure.

6.4.9 CommonReferenceQuery

CommonReferenceQuery is used by DSOs to discover which Aggregators represent which number of Connections on its registered Congestion Point(s). Aggregators use CommonReferenceQuery to discover which DSOs they should be supplying D-prognoses to, based on the Congestion Point(s) they represent Connections on. Meter Data Companies use this message to discover Congestion Point and Aggregator information for the Connections they supply metering data for to DSOs.

XML representation summary

```
<CommonReferenceQuery
    Entity              = ("CongestionPoint" | "Aggregator" | "BRP")
    EntityAddress       = EntityAddress
    <MessageMetadata…/>   (mandatory)
    <EntityAddress…/>     (0...n)
/>
```

Entity	Indication which type of entity is being queried.
EntityAddress	Entity Address of the entity for which query results should be returned. Optional: if omitted, results for all applicable entities will be returned.

6.4.10 Aggregator

One or more Aggregator elements may be included in CongestionPoint elements and indicate which Aggregators represent which number of Connections on a Connection Point. This element is always included as part of a message and never transmitted by itself.

XML representation summary

```
<Aggregator
    Domain           = InternetDomain
    ConnectionCount  = integer
/>
```

Domain	Internet domain of the Aggregator. If absent, this element represents the number of connections not represented by an Aggregator.
ConnectionCount	Number of Connections represented by the Aggregator on this Congestion Point.

6.4.11 CongestionPoint

The CongestionPoint element is used in CommonReferenceQueryResponse messages. A DSO registers its Congestion Points with associated connections, allowing an Aggregator to determine on which Congestion Points it represents customers. This element is always included as part of a message and never transmitted by itself.

XML representation summary

```
<CongestionPoint
    EntityAddress   = EntityAddress
    DSO-Domain      = InternetDomain
    <Connection…/>  (0...n)
    <Aggregator…/>  (0...n)
/>
```

EntityAddress	Entity Address of the Congestion Point.
DSO-Domain	Internet domain of the DSO responsible for this Congestion Point. Optional, only included in CommonReferenceQueryResponse messages sent to Aggregators.

6.4.12 CommonReferenceQueryResponse

Upon receiving and processing a CommonReferenceQuery message, the receiving implementation must reply with a CommonReferenceQueryResponse, indicating whether the query executed successfully, and if it did, including the query results. Most queries will return zero or more Congestion Points: responses to Aggregator-originated queries with Entity=BRP will consist of zero or more Connections.

XML representation summary

```
<CommonReferenceQueryResponse
    Result                  =  ("Success" | "Failure")
    Message                 =   string
    <MessageMetadata…/>     (mandatory)
    <CongestionPoint…/>     (0...n)
    <Connection…/>          (0...n)
/>
```

Result	Indication whether the query was executed successfully or failed.
Message	In case the query failed, this attribute must contain a human-readable description of the failure reason.

6.4.13 PTU

The PTU element represents one or more Program Time Units and is used by Prognosis and Flex-related messages. This element is always included as part of a message and never transmitted by itself.
Each PTU includes a Power value, the sign of which is used to distinguish between production and consumption, from the perspective of the Prosumer. A positive value indicates that power flows towards the Prosumer (consumption), a negative value indicates flow towards the grid (production).
For FlexRequests, the single Power value is insufficient, since it would be impossible to make a distinction between a request for the reduction of the amount of energy produced (two minus signs, thus a positive value) and the indication of room for more consumption (a positive value as well). Hence, each PTU also includes an indicator, Disposition, to distinguish between these situations. Note that a request is always relative to an earlier prognosis, and the intent of the party sending the request can only be determined by taking into account whether the net outcome of the PTU is expected to be production or consumption:

Prognosis Power	FlexRequest Power	FlexRequest Disposition	Intended meaning
Negative	Negative	Requested	Production should be increased
Negative	Negative	Available	Production can be increased
Negative	Positive	Requested	Production should be reduced
Negative	Positive	Available	Production can be reduced
Positive	Negative	Requested	Consumption should be reduced
Positive	Negative	Available	Consumption can be reduced
Positive	Positive	Requested	Consumption should be increased
Positive	Positive	Available	Consumption can be increased

Also note that all scenarios have valid alternative realizations: a reduction in production by 100 can also be accomplished by an increase in consumption by that amount. The resulting flexibility offer for the PTU will have the same Power value in both cases.

XML representation summary

```
<PTU
Disposition    =  ("Available" | "Requested")
Power          =  integer
Start          =  integer
Duration       =  integer
Price          =   CurrencyAmount
/>
```

Disposition	Optional, used only for FlexRequest messages: indication whether the Power specified for this PTU represents available capacity or a request for reduction/increase.
Power	Power specified for this PTU in Watts. Also see the important notes about the sign of this attribute in the main documentation entry for the PTU element.
Start	Number of the first PTU this element refers to. The first PTU of a day has number 1.
Duration	The number of the PTUs this element represents. Optional, default value is 1.
Price	The price offered or accepted for supplying the indicated amount of flexibility in this PTU. Only valid for FlexOffer and FlexOrder messages; the currency associated with this amount is included in the main part of those messages.

6.4.14 Prognosis

Prognosis messages are used to communicate A-plans and D-prognoses between USEF participants. Prognosis messages always contain a full list of PTUs for the Period they apply to, even if a Prognosis is sent after the start of the Period, when one or more PTUs are already in the operate or settlement phase. Receiving implementations should ignore the information supplied for those PTUs.

XML representation summary

```
<Prognosis
    Type                    =  ("A-Plan" | "D-Prognosis")
    PTU-Duration            =  duration
    Period                  =  Period
    TimeZone =              =  TimeZoneName
    CongestionPoint         =  EntityAddress
    Sequence                =  long
    <MessageMetadata…/>     (mandatory)
    <PTU…/>                 (0...n)
/>
```

Type	Indication of the kind of prognosis this message represents: A-plan or D-prognosis.
PTU-Duration	ISO 8601 time interval (minutes only, for example PT15M) indicating the duration of the PTUs referenced in this message. Although the PTU length is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant PTU duration.
Period	Day (in yyyy-mm-dd format) the PTUs referenced in this message belong to.
TimeZone	Time zone ID (as per the IANA time zone database, http://www.iana.org/time-zones, for example: Europe/Amsterdam) indicating the UTC offset that applies to the Period referenced in this message. Although the time zone is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant UTC offset.
CongestionPoint	Entity Address of the Congestion Point this prognosis applies to. Required for D-prognoses, prohibited for other prognosis types.
Sequence	Sequence number of this message, which should be incremented each time a new revision of a prognosis is sent. To ensure unique incrementing sequence numbers, use of the format yyyymmddHHMMSSssss (year, month, day, hour, minutes, seconds and milliseconds, respectively) is highly recommended.

6.4.15 FlexOrderStatus

The FlexOrderStatus entity is used in PrognosisResponse messages to indicate the status of a previously submitted FlexOrder. If used, this element is included as part of a PrognosisResponse message (where it may occur multiple times) and never transmitted by itself.

XML representation summary

```
<FlexOrderStatus
    Sequence      = long
    IsValidated   = boolean
/>
```

Sequence	Sequence of the previously submitted FlexOrder.
IsValidated	Indication whether the Prognosis that was just received reflects this previously submitted FlexOrder.

6.4.16 PrognosisResponse

Upon receiving and processing a Prognosis message, the receiving implementation must reply with a PrognosisResponse, indicating whether the prognosis was syntactically and semantically valid, and, in case any FlexOrder messages have previously been sent for any PTU in the Period the Prognosis applies to, a FlexOrderStatus indication for each of those orders.

XML representation summary

```
<PrognosisResponse
    Result                = ("Accepted" | "Rejected")
    PrognosisSequence     = long
    Message               = string
    <MessageMetadata…/>   (mandatory)
    <FlexOrderStatus…/>   (0...n)
/>
```

Result	Indication whether the prognosis was accepted or rejected. A receiving implementation may reject a prognosis if it's syntactically invalid, uses a PTU duration or time zone that deviates from what is normal for the market, is for a unknown Congestion Point or from an Aggregator that is not listed in the Common Reference, does not contain a full list of PTUs for the Period it applies to, contains absurd power values, applies to a Period for which all PTUs are already pending settlement, or if a Prognosis of the same type and from the same originator with a higher sequence number was already processed previously.
PrognosisSequence	Sequence number of the prognosis which was accepted or rejected (this will always match the sequence number of the corresponding Prognosis message; it is included to simplify implementation).
Message	In case the update was rejected, this attribute must contain a human-readable description of the failure.

6.4.17 FlexRequest

FlexRequest messages are used by BRPs and DSOs to request flexibility from Aggregators. In addition to one or more PTU elements with Disposition=Requested, indicating the actual need to reduce consumption or production, the message should also include the remaining PTUs for the current Period where Disposition=Available, so the receiving Aggregator can decide whether time-shifting load is an option to meet the needs of the requesting party.

XML representation summary

```
<FlexRequest
    PTU-Duration           = duration
    Period                 = Period
    TimeZone         = TimeZoneName
    CongestionPoint  = EntityAddress
    Sequence         = long
    ExpirationDateTime     = dateTime
    PrognosisOrigin  = InternetDomain
    PrognosisSequence      =  long
    <MessageMetadata…/>    (mandatory)
    <PTU…/>                (0...n)
/>
```

PTU-Duration	ISO 8601 time interval (minutes only, for example PT15M) indicating the duration of the PTUs referenced in this FlexRequest message. Although the PTU length is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant PTU duration.
Period	Day (in yyyy-mm-dd format) the PTUs referenced in this FlexRequest message belong to.
TimeZone	Time zone ID (as per the IANA time zone database, http://www.iana.org/time-zones, for example: Europe/Amsterdam) indicating the UTC offset that applies to the Period referenced in this message. Although the time zone is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant UTC offset.
CongestionPoint	Entity Address of the Congestion Point this FlexRequest message applies to. Optional: if left out (which is only legal for BRP FlexOffers), it applies to all BRP Connections.
Sequence	Sequence number of this message, which should be incremented each time a new revision of a FlexRequest message is sent. To ensure unique incrementing sequence numbers, use of the format yyyymmddHHMMSSssss (year, month, day, hour, minutes, seconds and milliseconds, respectively) is highly recommended.
ExpirationDateTime	Date and time, including the time zone (ISO 8601 formatted as per http://www.w3.org/TR/NOTE-datetime) until which the FlexRequest message is valid.
PrognosisOrigin	The Internet domain of the USEF participant that sent the Prognosis message (more specifically: the D-Prognosis) this request is based on.
PrognosisSequence	Sequence number of the D-Prognosis this request is based on. The combination of PrognosisOrigin and PrognosisSequence should be unique.

6.4.18 FlexRequestResponse

Upon receiving and processing a FlexRequest message, the receiving implementation must reply with a FlexRequestResponse, indicating whether the flex request was processed successfully.

XML representation summary

```
<FlexRequestResponse
    Sequence         = long
    Result                 = ("Accepted" | "Rejected")
    Message          = string
    <MessageMetadata…/> (mandatory)
/>
```

Sequence	Sequence number of the FlexRequest that has been received.
Result	Indication whether the flex request was accepted or rejected. Rejection is allowed in case the FlexRequest is not based on our latest Prognosis, a FlexRequest from the same participant for the indicated period with a higher sequence number was already accepted previously, the FlexRequest does not contain any PTUs with Disposition=Requested, or in case those PTUs do not cover the entire Period, no PTUs with Disposition=Available are included.
Message	In case the request was rejected, this attribute must contain a human-readable description of the reason.

6.4.19 FlexOffer

FlexOffer messages are used by Aggregators to make DSOs and BRPs an offer for providing flexibility. A FlexOffer message contains a list of PTUs, with for each PTU the change in consumption or production offered, plus the price for this amount of flexibility. FlexOffer messages should only be sent once a FlexRequest message has been received and must never be sent unsolicited. Note that multiple FlexOffer messages may be sent based on a single FlexRequest: for example, one offer that exactly matches the power reduction requested, plus one with a different amount of reduction, with more favorable pricing.
When responding to a BRP-originated FlexRequest, an Aggregator may send an empty FlexOffer message (i.e. a message not containing any PTU elements) in order to indicate that no flexibility is available and the submitted A-plan is expected to be approved as-is.

XML representation summary

```
<FlexOffer
PTU-Duration         = duration
Period               = Period
TimeZone             = TimeZoneName
CongestionPoint      = EntityAddress
Sequence             = long
ExpirationDateTime   = dateTime
FlexRequestOrigin    = InternetDomain
FlexRequestSequence  = long
Currency             = ISO4217Currency
<MessageMetadata…/>  (mandatory)
<PTU…/>              (0...n)
/>
```

PTU-Duration	ISO 8601 time interval (minutes only, for example PT15M) indicating the duration of the PTUs referenced in this FlexOffer message. Although the PTU length is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant PTU duration.
Period	Day (in yyyy-mm-dd format) the PTUs referenced in this FlexOffer message belong to.
TimeZone	Time zone ID (as per the IANA time zone database, http://www.iana.org/time-zones, for example: Europe/Amsterdam) indicating the UTC offset that applies to the Period referenced in this message. Although the time zone is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant UTC offset.
CongestionPoint	Entity Address of the Congestion Point this FlexOffer message applies to. Optional: if left out (which is only legal for BRP FlexOffers), it applies to all BRP Connections.
Sequence	Sequence number of this message, which should be incremented each time a new revision of a FlexOffer message is sent. To ensure unique incrementing sequence numbers, use of the format yyyymmddHHMMSSssss (year, month, day, hour, minutes, seconds and milliseconds, respectively) is highly recommended.

ExpirationDateTime	Date and time, including the time zone (ISO 8601 formatted as per http://www.w3.org/TR/NOTE-datetime) until which the FlexOffer message is valid.
FlexRequestOrigin	The Internet domain of the USEF participant that sent the FlexRequest this offer is based on.
FlexRequestSequence	Sequence number of the FlexRequest message this request is based on. The combination of FlexRequestOrigin and FlexRequestSequence should be unique.
Currency	ISO 4217 code indicating the currency that applies to the prices listed for each PTU.

6.4.20 FlexOfferResponse

Upon receiving and processing a FlexOffer message, the receiving implementation must reply with a FlexOfferResponse, indicating whether the flex offer was processed successfully.

XML representation summary

```
<FlexOfferResponse
    Sequence                = long
    Result                  = ("Accepted" | "Rejected")
    Message                 = string
    <MessageMetadata…/>     (mandatory)
/>
```

Sequence	Sequence number of the FlexOffer that has been received.
Result	Indication whether the flex offer was accepted or rejected. Rejection is allowed in case no matching FlexRequest can be found, or the FlexOffer does not contain a valid price for each PTU with Disposition=Requested in the corresponding FlexRequest.
Message	In case the offer was rejected, this attribute must contain a human-readable description of the reason.

6.4.21 FlexOfferRevocation

The FlexOfferRevocation message is used by the Aggegator to revoke a FlexOffer previously sent to a DSO or BRP. It voids the FlexOffer, even if its validity time has not yet expired, even if a FlexOrder has already been issued based on this offer. The FlexOffer should exist and have been previously acknowledged, though, and may NOT apply to a period of which one PTU is already in the operate phase.

XML representation summary

```
<FlexOfferRevocation
    Sequence                = long
    <MessageMetadata…/>     (mandatory)
/>
```

Sequence	Sequence number of the FlexOffer message that is being revoked: this FlexOffer must have been accepted previously.

6.4.22 FlexOfferRevocationResponse

Upon receiving and processing a FlexOfferRevocation message, the receiving implementation must reply with a FlexOfferRevocationResponse, indicating whether the revocation was handled successfully.

XML representation summary

```
<FlexOfferRevocationResponse
    Sequence                = long
    Result                  = ("Accepted" | "Rejected")
    Message                 = string
    <MessageMetadata…/>     (mandatory)
/>
```

Sequence	Sequence number of the FlexOffer that a revocation message was received for.
Result	Indication whether the revocation was accepted or rejected. Rejection is only allowed in case the FlexOffer is unknown (it is the responsibility of the sending party not to revoke FlexOffer messages which have not yet been accepted) or if it applies to a period of which a PTU is already in the Operate phase (at which time USEF explicitly forbids revocation).
Message	In case the revocation was rejected, this attribute must contain a human-readable description of the reason.

6.4.23 FlexOrder

FlexOrder messages are used by DSOs and BRPs to purchase flexibility from an Aggregator based on a previous FlexOffer. A FlexOrder message contains a list of PTUs, with, for each PTU, the change in consumption or production to be realized by the Aggregator, plus the accepted price to be paid by the DSO or BRP for this amount of flexibility. This PTU list should be copied from the FlexOffer message without modification: Aggregator implementations will (and must) reject FlexOrder messages where the PTU list is not exactly the same as offered.

XML representation summary

```
<FlexOrder
    PTU-Duration            = duration
    Period                  = Period
    TimeZone                = TimeZoneName
    CongestionPint          = EntityAddress
    Sequence                = long
    ExpirationDateTime      = dateTime
    FlexOfferOrigin         = InternetDomain
    FlexOfferSequence       = long
    Currency                = ISO4217Currency
    OrderReference          = string
    <MessageMetadata…/>     (mandatory)
    <PTU…/>                 (0...n)
/>
```

PTU-Duration	ISO 8601 time interval (minutes only, for example PT15M) indicating the duration of the PTUs referenced in this FlexOrder message. Although the PTU length is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant PTU duration.
Period	Day (in yyyy-mm-dd format) the PTUs referenced in this FlexOrder message belong to.
TimeZone	Time zone ID (as per the IANA time zone database, http://www.iana.org/time-zones, for example: Europe/Amsterdam) indicating the UTC offset that applies to the Period referenced in this message. Although the time zone is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant UTC offset.

CongestionPoint	Entity Address of the Congestion Point this FlexOrder message applies to. Optional: if left out (which is only legal for BRP FlexOffers), it applies to all BRP Connections.
Sequence	Sequence number of this message, which should be incremented each time a new revision of a FlexOrder message is sent. To ensure unique incrementing sequence numbers, use of the format yyyymmddHHMMSSssss (year, month, day, hour, minutes, seconds and milliseconds, respectively) is highly recommended.
ExpirationDateTime	Date and time, including the time zone (ISO 8601 formatted as per http://www.w3.org/TR/NOTE-datetime) until which the FlexOrder message is valid.
FlexOfferOrigin	The Internet domain of the USEF participant that sent the FlexOffer this order is based on.
FlexOfferSequence	Sequence number of the FlexOffer message this order is based on. The combination of FlexOfferOrigin and FlexOfferSequence should be unique.
Currency	ISO 4217 code indicating the currency that applies to the prices listed for each PTU.
OrderReference	Order number assigned by the BRP or DSO originating the FlexOrder. To be stored by the Aggregator and used in the settlement phase.

6.4.24 FlexOrderResponse

Upon receiving and processing a FlexOrder message, the receiving implementation must reply with a FlexOrderResponse, indicating whether the update was handled successfully. FlexOrderResponse messages must always be sent with Precedence=Critical.

XML representation summary

```
<FlexOrderResponse
    Sequence                = long
    Result                  = ("Accepted" | "Rejected")
    Message                 = string
    <MessageMetadata…/>     (mandatory)
/>
```

Sequence	Sequence number of the FlexOrder that has just been received.
Result	Indication whether the order was accepted or rejected. Rejection is only allowed in case the FlexOrder was already accepted previously, can not be found, or does not exactly match the contents of the corresponding FlexOffer.
Message	In case the order was rejected, this attribute must contain a human-readable description of the reason.

6.4.25 SettlementMessage

The SettlementMessage is sent by DSOs and BRPs on a regular basis (typically monthly) to AGRs in order to initiate settlement. It includes a list of all FlexOrders placed by the originating party during the settlement period.

XML representation summary

```
<SettlementMessage
    TimeZone                    = TimeZoneName
    PeriodStart                 = Period
    PeriodEnd                   = Period
    Reference                   = string
    PTU-Duration                = duration
    Currency                    = ISO4217Currency
    <MessageMetadata…/>         (mandatory)
    <FlexOrderSettlement…/>     (0...n)
/>
```

TimeZone	Time zone ID (as per the IANA time zone database, http://www.iana.org/time-zones, for example: Europe/Amsterdam) indicating the UTC offset that applies to the Period referenced in this message. Although the time zone is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant UTC offset.
PeriodStart	First day (in yyyy-mm-dd format) of the settlement period this message applies to.
PeriodEnd	Last day (in yyyy-mm-dd format) of the settlement period this message applies to.
Reference	Settlement reference, assigned by the BRP or DSO originating the SettlementMessage.
PTU-Duration	ISO 8601 time interval (minutes only, for example PT15M) indicating the duration of the PTUs referenced in this message. Although the PTU length is a market-wide fixed value, making this assumption explicit in each message is important for validation purposes, allowing implementations to reject messages with an errant PTU duration.
Currency	ISO 4217 code indicating the currency that applies to all amounts (flex price, penalty and net settlement) in this message.

6.4.26 FlexOrderSettlement

The FlexOrderSettlement element contains settlement details for a single FlexOrder placed by the party originating the message during the settlement period.

XML representation summary

```
<FlexOrderSettlement
    Period                  = Period
    PrognosisOrigin         = InternetDomain
    PrognosisSequence       = long
    OrderReference          = string
    CongestionPoint         = EntityAddress
    <PTU-Settlement…/>      (0...n)
/>
```

Period	Day (in yyyy-mm-dd format) the FlexOrder refers to to.
PrognosisOrigin	The Internet domain of the USEF participant that sent the Prognosis message (more specifically: the D-Prognosis) the FlexOrder is based on. As with the other attributes of the parent element, it is included for the convenience of the receiving party
PrognosisSequence	The sequence number of the Prognosis message (more specifically: the D-Prognosis) the FlexOrder is based on.

OrderReference	Order reference assigned by the BRP or DSO when originating the FlexOrder.
CongestionPoint	Entity Address of the Congestion Point the FlexOrder applies to.

6.4.27 PTU-Settlement

The PTU-Settlement element contains settlement details for a single PTU (or set of identical PTUs) belonging to the FlexOrder placed by the party originating the message during the settlement period.

XML representation summary

```
<PTU-Settlement
    Start                = integer
    Duration             = integer
    PrognosisPower       = integer
    OrderedFlexPower     = integer
    Price                = CurrencyAmount
    ActualPower          = integer
    DeliveredFlexPower   = integer
    PowerDeficiency      = integer
    Penalty              = CurrencyAmount
    NetSettlement        = CurrencyAmount
/>
```

Start	Number of the first PTU this element refers to. The first PTU of a day has number 1.
Duration	The number of the PTUs this element represents. Optional, default value is 1.
PrognosisPower	Power originally forecast (as per the referenced Prognosis message) for this PTU in Watts.
OrderedFlexPower	Amount of flex power ordered (as per the referenced FlexOrder message) for this PTU in Watts.
Price	The price accepted for supplying the ordered amount of flexibility in this PTU, as per the referenced FlexOrder message.
ActualPower	Actual amount of power for this PTU in Watts, as measured/determined by the DSO or BRP and allocated to the AGR.
DeliveredFlexPower	Actual amount of flex power delivered for this PTU in Watts, as determined by the DSO or BRP.
PowerDeficiency	Optional (default zero) amount of flex power sold but not delivered for this PTU in Watts, as determined by the DSO or BRP.
Penalty	Optional (default zero) penalty due a non-zero PowerDeficiency.
NetSettlement	Net settlement amount for this PTU: Price minus Penalty, if applicable.

6.4.28 SettlementMessageResponse

Upon receiving and processing a SettlementMessage, the receiving implementation must reply with a SettlementMessageResponse, indicating whether the initial message was handled successfully. In case a SettlementMessage is rejected, the sender of the original message should consider all FlexOrderSettlement elements in that message to be disputed.

XML representation summary

```
<SettlementMessageResponse
```

```
    Reference                       = string
    Result                          = ("Accepted" | "Rejected")
    Message                         = string
    <MessageMetadata…/>             (mandatory)
    <FlexOrderSettlementStatus…/> (0...n)
/>
```

Reference	Reference included in the SettlementMessage that has just been received.
Result	Indication whether the message was accepted or rejected. Wholesale rejection is only allowed in case a SettlementMessage covering a given period was already accepted previously, or contains invalid data. If one or more settlement items included in the message are not in accordance with the recipient's accounting, the message should still be accepted, and the dispute communicated using the appropriate FlexOrderSettlementStatus elements.
Message	In case the message was rejected, this attribute must contain a human-readable description of the reason.

6.4.29 FlexOrderSettlementStatus

Each FlexOrderSettlementStatus element indicates whether the settlement details included in the corresponding FlexOrderSettlement element are accepted or disputed by the recipient of the FlexSettlementMessage.

XML representation summary

```
<FlexOrderSettlementStatus
    OrderReference          = string
    Disposition             = ("Accepted" | "Disputed")
/>
```

OrderReference	Order reference assigned by the BRP or DSO when originating the FlexOrder.
Disposition	Indication whether the aggregator accepts the settlement details provided by the DSO or BRP (and will invoice accordingly), or disputes these details. Handling disputed flex orders is a manual process outside the USEF scope.

6.4.30 MeterDataQuery

MeterDataQuery is used by customers of a Meter Data Company to query per-Connection, per-PTU power consumption/production values for a specified period.

XML representation summary

```
<MeterDataQuery
    DateRangeStart          = Period
    DateRangeEnd            = Period
    QueryType               = ("Any" | "Usage" | "Events")
    <MessageMetadata…/>     (mandatory)
    <Connections…/>         (0...n)
/>
```

DateRangeStart	First day (in yyyy-mm-dd format) of the date range for which metering data is requested.
DateRangeEnd	Last day (in yyyy-mm-dd format) of the date range for which metering data is requested.
QueryType	Requested meter data: per-PTU usage, metering events (capacity reduction, outages, etc.), or any available data.

6.4.31 MeterData

The MeterData entity encapsulates metering data for a single day, as indicated by the Period attribute. It is always included as part of a MeterDataQueryResponse message and never transmitted by itself.

XML representation summary

```
<MeterData
    Period                          =  Period
    <ConnectionMeterData…/>         (0...n)
    <ConnectionMeterEvent…/>        (0...n)
/>
```

Period	Day (in yyyy-mm-dd format) the returned meter data entries apply to.

6.4.32 Connections

This element is used in meter data queries to represent a group of connections, linked to a parent (Congestion Point or BRP).

XML representation summary

```
<Connections
    Parent                  =  EntityAddress
    <EntityAddress…/>       (0...n)
/>
```

6.4.33 ConnectionMeterEvent

The ConnectionMeterEvent entity encapsulates a metering event for the single connection identified by the EntityAddress attribute. It is always included as part of a MeterDataQueryResponse message and never transmitted by itself.

XML representation summary

```
<ConnectionMeterEvent
    EntityAddress           =  EntityAddress
    EventType               =  ("CapacityManagement" | "ConnectionInterruption"
                               "ConnectionResumption")
    EventData               =  integer
    EventDateTime           =  dateTime
/>
```

EntityAddress	Entity Address of the Connection the metering event applies to.
EventType	Event type: ConnectionInterruption (feed from DSO to Connection was fully interrupted); ConnectionResumption (feed from DSO to Connection was restored); CapacityManagement: the maximum usage of the Connection was set to the value indicated in the EventData attribute. A CapacityManagement event without a specified maximum usage (missing EventData attribute) indicates the end of capacity management.
EventData	Optional, only included for EventType=CapacityManagement: the maximum usage specified for the Connection in Watts.
EventDateTime	The date/time, local to the time zone specified in the message metadata, the event occurred.

6.4.34 ConnectionMeterData

The ConnectionMeterData entity encapsulates metering data for the single connection identified by the EntityAddress attribute. It is always included as part of a MeterDataQueryResponse message and never transmitted by itself.

XML representation summary

```
<ConnectionMeterData
    EntityAddress          = EntityAddress
    EntityCount            = integer
    AGR-Domain             = InternetDomain
    <PTU-MeterData…/>      (0...n)
/>
```

EntityAddress	Entity Address of the Connection the metering data applies to. Optional, and only included in MDC responses to BRPs: for MDC responses to DSOs, the PTU-MeterData elements are aggregated by AGR.
EntityCount	Optional: in case EntityAddress is not specified, this attribute indicates the number of connections represented by the aggregated consumption data.
AGR-Domain	Optional: if the Connection the metering data applies to is represented by an Aggregator, its Internet domain is included here.

6.4.35 PTU-MeterData

The PTU-MeterData entity includes metering data for the PTU indicated. It is always included as part of a MeterDataQueryResponse message and never transmitted by itself.

XML representation summary

```
<PTU-MeterData
Power          = integer
Start          = integer
Duration       = integer
/>
```

Power	Power consumed (negative value) or produced (positive value) for this PTU in Watts.
Start	Number of the first PTU this element refers to. The first PTU of a day has number 1.
Duration	The number of the PTUs this element represents. Optional, default value is 1.

6.4.36 MeterDataQueryResponse

Upon receiving and processing a MeterDataQuery message, the receiving implementation must reply with a MeterDataQueryResponse, indicating whether the query executed successfully, and if it did, including the query results. Most queries will return zero or more MeterData entries, each encapsulating metering data for a single day in the requested period.

XML representation summary

```
<MeterDataQueryResponse
```

```
    Result                  =  ("Success" | "Failure")
    Message                 =  string
    DateRangeStart          =  Period
    DateRangeEnd            =  Period
    QueryType               =  ("Any" | "Usage" | "Events")
    <MessageMetadata…/>     (mandatory)
    <MeterDataSet…/>        (0...n)
/>
```

Result	Indication whether the query was executed successfully or failed.
Message	In case the query failed, this attribute must contain a human-readable description of the failure reason.
DateRangeStart	First day (in yyyy-mm-dd format) of the date range for which metering data was requested, copied from the request.
DateRangeEnd	Last day (in yyyy-mm-dd format) of the date range for which metering data was requested, copied from the request.
QueryType	Requested meter data, copied from the request.

6.4.37 MeterDataSet

This element is used in meter data responses to represent a group of meter data entries, linked to a parent (Congestion Point or BRP).

XML representation summary

```
<MeterDataSet
    EntityAddress               =  EntityAddress
    <MeterData…/>    (0...n)
/>
```

6.5 UDI Data Structures and Messages

6.5.1 ConnectionPortfolio

The ConnectionPortfolio element encapsulates one or more Connection elements and represents the aggregator portfolio for a given congestion point.

XML representation summary

```
<ConnectionPortfolio
    EntityAddress           =  EntityAddress
    <Connection…/>   (0...n)
/>
```

EntityAddress	Entity address of the congestion point for this portfolio (as also used to register the congestion point in the Common Reference).

6.5.2 Connection

This element links a Connection, identified by its Entity Address, to an aggregator-specific profile and encapsulates zero or more UDI endpoints present behind the connection.

XML representation summary

```
<Connection
Profile              = string
EntityAddress        = EntityAddress
<UDI…/>              (0...n)
/>
```

Profile	Aggregator-defined profile string, used for customer segmentation and any other purposes envisioned by those responsible for its assignment. At the very least, the aggregator should be able to determine the parameters to use for non-controlled load forecasts for the connection based on this value.
EntityAddress	Entity address of the connection (as also used to register it in the Common Reference).

6.5.3 UDI

The UDI element represents a USEF Device Interface endpoint: it defines its network-specific address, USEF device type and DTU duration. It encapsulates one or more DevicePeriod elements.

XML representation summary

```
<UDI
    Profile                 = ("SmartAppliance" | "ElectricVehicle" | "LocalGeneration"
|                               "Storage" | "BEMS")
    Endpoint                = string
    DTU-Duration            = duration
    <DevicePeriod…/>        (0...n)
/>
```

Profile	USEF device category, which indicates the load profile: SmartAppliance — Appliance, such as a smart grid-enabled washing machine. ElectricVehicle — EV charging station or similar. LocalGeneration — Local energy generation, for example using photovoltaic cells. Storage — Capability to store energy for later use, for the explicit reason of introducing flexibility. BEMS — Building Energy Management System, a composite device which provides an aggregation of UDI and/or non-UDI ADS.
Endpoint	Network-specific address of the UDI endpoint: this can, for example, be the IP address and port combination the endpoint is reachable on. The recommended transport mechanism is HTTP-over-TLS (with mutual authentication)-over-IPv6, with appropriate IP security and filtering, but any suitable mechanism may be used.
DTU-Duration	ISO 8601 time interval (minutes only, for example PT1M) indicating the duration of the Device Time Units used by this UDI endpoint. The PTU duration (which is a market-wide fixed value) should be evenly divisible by the DTU duration. For example: if the PTU duration is 15 minutes, the DTU duration can be either 1, 3, 5 or 15 minutes.

6.5.4 DevicePeriod

The DevicePeriod element encapsulates all UDI events and per-DTU power consumption/forecast values for the specified date for the UDI endpoint it is associated with.

XML representation summary

```
<DevicePeriod
    Date                    =  date
    <UDI-Event…/>           (0...n)
    <DTU…/>                 (0...n)
/>
```

Date	Day (in yyyy-mm-dd format) the events and DTUs included in this element belong to.

6.5.5 UDI-Event

The UDI-Event element describes an energy consumption or production event, which can either be planned (i.e. the result of an end-user request, setting or preference) or on-demand (to be triggered based on an incentive in order to assist with load steering). If the aggregator can assert any kind of influence over an event, the capabilities (shift, reduce, increase and/or interrupt) and constraints of that influence are included as part of the event.

XML representation summary

```
<UDI-Event
    ID                          =  string
    DeviceSelector              =  string
    Type                        =  ("Consumption" | "Production" |
                                    "OnDemandConsumption" |
                                    "OnDemandProduction")
    StartDTU                    =  integer
    EndDTU                      =  integer
    Priority                    =  ("High" | "Low" | "Normal")
    Power                       =  string
    FinishBeforeDTU             =  integer
    StartAfterDTU               =  integer
    <ShiftCapability…/>         (optional)
    <ReduceCapability…/>    (optional)
    <IncreaseCapability…/> (optional)
    <InterruptCapability…/>     (optional)
/>
```

ID	Event identifier: an endpoint-specific string uniquely identifying the event within the period. It may include a device identifier.
DeviceSelector	Optional string, indicating which specific device controlled by the UDI endpoint this event relates to
Type	UDI event type: Consumption — Planned energy consumption, which can possibly be time-shifted, increased, reduced or interrupted based on an incentive for load steering purposes. Production — Planned energy production, which can possibly be influenced based on an incentive for load steering purposes. OnDemandConsumption — On-demand consumption, which can be triggered based on an incentive for explicit load steering purposes. OnDemandProduction — On-demand production, which can be triggered based on an incentive for explicit load steering purposes.

StartDTU	Currently planned, possible or actual start time of the event, expressed as a DTU. For continuous events that span the entire day, the StartDTU value should be 1; for events with a yet-unknown start time, the earliest expected StartDTU should be specified.
EndDTU	Currently planned, possible or actual end time of the event, expressed as a DTU. Event duration can be calculated by subtracting the StartDTU value from the EndDTU value; for continuous events that span the entire day, this duration will be the total number of DTUs in a day.
Priority	Priority of the event, from the point of view of the customer controlling the ADS. Changes in power consumption or production for low-priority events is unlikely to affect or even be noticed by the customer, and should thus be considered by the aggregator first, whereas load steering for high-priority events is much more noticeable or even disruptive.
Power	Power consumption or production, in Watts, associated with the event. If a single integer power value is provided, this is the average power consumption for each DTU in the event. A comma-separated list of per-DTU average integer power values can be provided as well, for events that have significant variations in power between DTUs.
FinishBeforeDTU	DTU by which time the process should be finished, according to user settings/preferences or technical requirements. If the FinishBeforeDTU attribute is blank or not specified, no constraint on process completion time exists.
StartAfterDTU	DTU specifying the earliest time the process can be started, according to user settings/preferences (for example, the preference not to have a noisy washer start in the middle of the night) or technical requirements (for example: the device can only operate during daylight hours). If the StartAfterDTU attribute is blank or not specified, no constraint on process start time exists.

6.5.6 IncreaseCapability

The IncreaseCapability element indicates that the process is capable of temporarily increasing its production or consumption. If consumption is increased, the expectation is that this will reduce future consumption by a certain amount as well (which will then be reflected in future prognoses by the endpoint).

XML representation summary

```
<IncreaseCapability
    PowerStep              = integer
    MaxPower               = integer
    MaxDTUs                = integer
    DurationMultiplier     = integer
/>
```

PowerStep	Power amount (in Watts) indicating the granularity with which consumption or production can be increased.
MaxPower	Power amount (in Watts) indicating the power ceiling to which consumption or production can be increased.
MaxDTUs	The maximum number of Device Time Units the process can increase its power consumption or production. This constraint may be included by the UDI endpoint for technical reasons (when the device associated with the event is a buffer, for example), or, in combination with the event's StartDTU to realize a 'increase should stop before...' preference.

6.5.7 InterruptCapability

The InterruptCapability element describes the ability of the process associated with the UDI event it is part of to be interrupted.

XML representation summary

```
<InterruptCapability
    MaxDTUs          = integer
    Type             = ("Full" | "None" | "Per-DTU")
/>
```

MaxDTUs	The maximum number of Device Time Units the process can interrupt its power consumption or production. This constraint may be included by the UDI endpoint for technical reasons (if the device associated with the event is a freezer, for example), or based on user settings/preferences (for example, when the device is responsible for climate control). Note that interrupting the process increases its duration, and that the parent FinishBeforeDTU attribute, if specified, may further limit the period during which process interruptions can be requested.
Type	The extent to which the process described by this event can be interrupted. Full The process can be interrupted at any time. None The process cannot be interrupted at all (this has the same effect as not including the InterruptCapability element in the UDI-Event element at all). Per-DTU The process can only be interrupted during the DTUs included in the comma-separated DTU list in the element value.

6.5.8 ReduceCapability

The ReduceCapability element indicates that the process is capable of temporarily reducing its production or consumption.

XML representation summary

```
<ReduceCapability
    PowerStep              = integer
    MinPower               = integer
    MaxDTUs                = integer
    DurationMultiplier     = decimal
/>
```

PowerStep	Amount (in Watts) indicating the granularity with which consumption or production can be decreased.
MinPower	Amount (in Watts) indicating the power floor to which consumption or production can be reduced.
MaxDTUs	The maximum number of Device Time Units the process can reduce its power consumption or production. This constraint may be included by the UDI endpoint for technical reasons (if the device associated with the event is a freezer, for example), or based on user settings/preferences (for example, when the device is responsible for climate control).
DurationMultiplier	Decimal value, indicating the amount by which the total duration of the process will increase for each PowerStep by which consumption or production is decreased.

6.5.9 ShiftCapability

Presence of the ShiftCapability element indicates that this event can be time-shifted, i.e. the aggregator can request a StartDTU that differs from the currently planned start time, subject to the constraints of the parent StartAfterDTU and FinishBeforeDTU attributes, if specified.

XML representation summary

```
<ShiftCapability
/>
```

6.5.10 DTU

The Device Time Unit element contains the forecast and actual average power values for the given DTU, if available.

XML representation summary

```
<DTU
   Start                          = integer
   ForecastAveragePower           = integer
   ActualAveragePower             = integer
/>
```

Start	DTU sequence number.
ForecastAveragePower	Forecast average power consumption or production in Watts during this DTU (optional).
ActualAveragePower	Realized average power consumption or production in Watts during this DTU (optional).

6.5.11 DeviceMessage

The DeviceMessage element encapsulates a UDI control message, containing one or more DeviceRequests to be sent to an endpoint.

XML representation summary

```
<DeviceMessage
    <Authenticator…/>       (mandatory)
    <DeviceRequests…/>      (mandatory)
/>
```

6.5.12 Authenticator

The Authenticator element contains all information required for the UDI endpoint to validate that the DeviceMessage originates with an authorized sender. UDI does not specify the content of this element, but does recommend use of the USEF elliptic curve message signature mechanism to generate a detached signature of the UTF-8 encoded content of the DeviceRequests element.

XML representation summary

```
<Authenticator
Value  = string
Type   = string
/>
```

Value	Implementation-specific string containing the authentication value, for example a Base-64 encoded signature.
Type	Implementation-specific string indicating the type of the authentication value: for example, 'Password' or 'Signature'.

6.5.13 DeviceRequests

The DeviceRequests element encapsulates the detailed shift, reduce, increase, interrupt and/or report requests to be processed by the UDI endpoint.

XML representation summary

```
<DeviceRequests
    EndPoint                = string
    DeviceSelector          = string
    <ShiftRequest…/>        (0...n)
    <ReduceRequest…/>       (0...n)
    <IncreaseRequest…/>     (0...n)
    <InterruptRequest…/>    (0...n)
    <ReportRequest…/>       (0...n)
/>
```

EndPoint	Network-specific address of the UDI endpoint, as included in the aggregator portfolio.
DeviceSelector	Optional string, indicating which specific device controlled by the UDI endpoint the requests included in this message relate to.

6.5.14 ShiftRequest

The ShiftRequest element is included in a device message in order to request the device to time-shift its consumption or production to start in the indicated DTU.

XML representation summary

```
<ShiftRequest
    ID        = string
    EventID   = string
    Date      = date
    StartDTU  = integer
/>
```

ID	Identifier string, which should be unique within the device message. It is echoed in the response message to allow the sending party to determine the outcome of the request.
EventID	Identifier string, obtained from the UDI endpoint in an earlier report and subsequently included in the aggregator portfolio, indicating which event this time-shift request relates to.
Date	Day (in yyyy-mm-dd format) the time-shift request applies to.
StartDTU	DTU at which the event should start.

6.5.15 ReduceRequest

The ReduceRequest element is included in a device message in order to request the device to reduce its consumption or production with an indicated amount of power during a certain time period.

XML representation summary

```
<ReduceRequest
```

```
    ID         =  string
    EventID    =  string
    Date       =  date
    StartDTU   =  integer
    EndDTU     =  integer
    Power      =  integer
/>
```

ID	Identifier string, which should be unique within the device message. It is echoed in the response message to allow the sending party to determine the outcome of the request.
EventID	Identifier string, obtained from the UDI endpoint in an earlier report and subsequently included in the aggregator portfolio, indicating which event this reduction request relates to. Optional: if not included or blank, the device should attempt to reduce its consumption or production as much as possible during the time indicated.
Date	Day (in yyyy-mm-dd format) the reduction request applies to.
StartDTU	DTU in which the device should start reducing its consumption or production. Optional: if not included or blank, the device should attempt to reduce its consumption or production as much as possible during the time indicated.
EndDTU	DTU in which the device should stop reducing its consumption or production. Optional: if not included or blank, the device should continue to reduce its consumption or production for as long as possible during the period indicated.
Power	Amount of power in Watts (positive integer) by which the device should attempt to reduce its consumption or production. Optional: if not included or blank, the device should reduce its consumption or production as much as possible.

6.5.16 IncreaseRequest

The IncreaseRequest element is included in a device message in order to request the device to increase its consumption or production with an indicated amount of power during a certain time period.

XML representation summary

```
<IncreaseRequest
    ID         =  string
    EventID    =  string
    Date       =  date
    StartDTU   =  integer
    EndDTU     =  integer
    Power      =  integer
/>
```

ID	Identifier string, which should be unique within the device message. It is echoed in the response message to allow the sending party to determine the outcome of the request.
EventID	Identifier string, obtained from the UDI endpoint in an earlier report and subsequently included in the aggregator portfolio, indicating which event this increase request relates to. Optional: if not included or blank, the device should attempt to increase its consumption or production as much as possible during the time indicated.
Date	Day (in yyyy-mm-dd format) the increase request applies to.
StartDTU	DTU in which the device should start increasing its consumption or production. Optional: if not included or blank, the device should attempt to increase its consumption or production as much as possible during the time indicated.
EndDTU	DTU in which the device should stop increasing its consumption or production. Optional: if not included or blank, the device should continue to increase its consumption or production for as long as possible during the period indicated.

Power	Amount of power in Watts (positive integer) by which the device should attempt to increase its consumption or production. Optional: if not included or blank, the device should increase its consumption or production as much as possible.

6.5.17 InterruptRequest

The InterruptRequest element is included in a device message in order to request the device to cease its consumption or production during a certain time period.

XML representation summary

```
<InterruptRequest
    ID          =  string
    EventID     =  string
    Date        =  date
    DTUs        =  string
/>
```

ID	Identifier string, which should be unique within the device message. It is echoed in the response message to allow the sending party to determine the outcome of the request.
EventID	Identifier string, obtained from the UDI endpoint in an earlier report and subsequently included in the aggregator portfolio, indicating which event this interruption request relates to. Optional: if not included or blank, the device should attempt to interrupt its consumption or production if at all possible during the time(s) indicated.
Date	Day (in yyyy-mm-dd format) the interruption request applies to.
DTUs	DTU(s) during which the device should cease its production or consumption. This can be a single DTU, a comma-separated DTU list (e.g. 10,11,12), or a DTU interval (e.g. 10-12).

6.5.18 ReportRequest

The ReportRequest element is included in a device message in order to request the device to report its actual or forecast consumption or production for a given time period.

XML representation summary

```
<ReportRequest
    ID          =  string
    Date        =  date
    DTUs        =  string
/>
```

ID	Identifier string, which should be unique within the device message. It is echoed in the response message to allow the sending party to determine the outcome of the request.
Date	Day (in yyyy-mm-dd format) the report request applies to.
DTUs	DTU(s) for which the device should report its production or consumption values, if available. This can be a single DTU, a comma-separated DTU list (e.g. 10,11,12), or a DTU interval (e.g. 10-12).

6.5.19 DeviceMessageResponse

The DeviceMessageResponse element encapsulates the reply of an UDI endpoint to the DeviceMessage it just received.

XML representation summary

```
<DeviceMessageResponse
Disposition                = ("Accepted" | "Rejected" | "Unknown")
ErrorMessage               = string
<DeviceRequestStatus…/>    (0...n)
/>
```

Disposition	Overall result of the message processing: Accepted if the message was successfully processed, Rejected if the message could not be processed due to being malformed, failed authentication, etc. If the message is rejected, the reason for rejection should be included in the ErrorMessage attribute.
ErrorMessage	Human-readable error message in case the DeviceMessage could not be processed.

6.5.20 DeviceRequestStatus

The DeviceRequestStatus element indicates the processing result of each line item of the corresponding request. Results of reporting requests are included in DevicePeriod element(s), each containing the events and forecasts for one requested period.

XML representation summary

```
<DeviceRequestStatus
ID                  = string
Disposition         = ("Accepted" | "Rejected" | "Unknown")
<DevicePeriod…/>    (0...n)
/>
```

ID	Identifier string, as included in the Request element this status response applies to.
Disposition	Result of processing the Request element this status response applies to: Accepted if the request was processed successfully; Rejected if the request could not be processed due to being invalid, conflicting with user settings, or any other reason; Unknown if the result cannot be determined at this time.

Appendix 1 Examples

Flex settlement calculation examples

Settlement between BRP and Aggregator

For a specific PTU we assume:

- The Aggregator has specified a total load in its initial A-plan corresponding with 100 MWh
- During one or more flex requests, flexibility has been acquired by the BRP, corresponding with a total of 20 MWh; yielding an agreed A-plan corresponding with 120 MWh
- The table below shows how different realizations are settled. The realization is specified by the allocation for this PTU.
  In this example the following (illustrative) prices are applied:
  - Flex price equals 7 € / MWh
  - A-plan deviation penalty equals 11 € / MWh

Allocation (MWh)	Flex realized (MWh)	Delivered flex quantity (MWh)	Flex paid (€)	A-plan deviation (MWh)	Imbalance quantity (MWh)	Penalty raised (€)	Settlement (€)
130	30	20	140	10	10	-110	30
120	20	20	140	0	0	0	140
110	10	10	70	-10	10	-110	-40
100	0	0	0	-20	20	-220	-220
90	-10	0	0	-30	30	-330	-330

Table 6-2: Example calculation for flex settlement BRP – Aggregator

Elaboration of the calculations performed in the table:

1. **Allocation** shows possible results of the realization of the portfolio of the Aggregator
2. The **flex realized** equals the allocation minus the initial A-plan
3. The **delivered flex quantity**, represents the flexibility that is both acquired (therefore maximum of 20) and delivered
4. The flex paid equals the delivered flex quantity times the flex price
5. The A-plan deviation equals the allocation minus the agreed A-plan
6. The Imbalance quantity equals the absolute value of the A-plan deviation, since we assume the penalty to be symmetrical. This also ensures that aggregating the A-plan deviation over the PTUs will not even out.
7. The penalty raised equals the imbalance quantity times the penalty
8. The settlement price equals the sum of the flex paid and penalty raised.
9. The monthly totals of the elements **Delivered flex quantity, Imbalance quantity** and **Settlement** are sent to the Aggregator.

Settlement between DSO and Aggregator

For a specific PTU we assume:

- The Aggregator has specified a total load of 10 MW in its initial D-prognosis
  - During one or more flex requests, a total of 2 MW of flexibility has been acquired by the DSO, yielding a final D-prognosis of 8 MW
- The table below shows how different realizations are settled. The realization is specified by the allocation, representing the average power during one specific PTU for one congestion point. In this example the following (illustrative) prices are applied:
  - Flex price equals 7 € / MW
  - D-prognosis deviation penalty equals 11 € / MW (single sided)

Allocation (MW)	Flex realized (MW)	Delivered flex quantity (MW)	Flex paid (€)	D-prognosis deviation (MW)	Power deficiency quantity (MW)	Penalty raised (€)	Settlement (€)
7	3	2	14	-1	0	0	14
8	2	2	14	0	0	0	14
9	1	1	7	1	1	-11	-4
10	0	0	0	2	2	-22	-22
11	-1	0	0	3	3	-33	-33

Table 6-3: Example calculation for flex settlement DSO – Aggregator

Elaboration of the calculations performed in the table:

1. Allocation shows possible results of the realization of the portfolio of the Aggregator
2. The flex realized equals the D-prognosis associated with the flex offer minus the allocation
3. The delivered flex quantity, represents the flexibility that is both acquired (therefore maximum of 2) and delivered. Passive 4. contributions (as in the row with allocation=7) are not rewarded.
4. The flex paid equals the delivered flex quantity times the flex price
5. The D-prognosis deviation equals the allocation minus the final D-prognosis
6. The Power deficiency quantity equals the D-prognosis deviation, where negative deviations are set to 0 since these are not penalized. This also ensures that aggregating the D-prognosis deviation over the PTUs and congestion points will not even out.
7. The penalty raised equals the power deficiency quantity times the penalty
8. The settlement price equals the sum of the flex paid and penalties raised.
9. The monthly totals of the elements Delivered flex quantity, Power deficiency quantity and Settlement are sent to the Aggregator.

Appendix 2 Glossary

A-plan	Aggregator-plan
ADS	Active Demand & Supply
AGR	Aggregator. Role whose goal it is to maximize the value of flexibility, taking into account customer needs, economical optimization and grid capacity.
BEMS	Building Energy Management System
BRP	Balance Responsible Party
C&I	Commercial & Industry
Common Reference	Information about the Energy grid and the involved parties, which needs to be unambiguously available to all participating parties.
Congestion Point	Point in de grid where the grid capacity is not always sufficient to distribute the requested amount of energy
CSO	Charging Station Operator/Charge Spot Operator
D-prognosis	Prognosis regarding the Distribution of energy
DAC	Dynamically Allocated Cluster
DNO	Distribution Network Operator
DSO	Distribution System Operator
E-program	Energy Program – aggregated (daily) energy transactions of a BRP to be provided to the TSO
EmSP	E-mobility Service Provider
ENTSO-E	European Network of Transmission System Operators for Electricity
ESCo	Energy Service Company
EV	Electric Vehicle
FlexOffer	Flexibility Offer, response to a Flexibility Request
FlexOrder	Flexibility Order, a response to a Flexibility Offer
FlexRequest	Flexibility Request
Grid	Network for the transport and distribution of energy
MCM	Market-based Coordination Mechanism
MCF	Measurement Correction Factor
MDC	Meter Data Company
P&S	Privacy & Security
Prosumer	A consumer which is capable of producing energy as well
PTU	Program Time Unit – smallest energy trading period used in utilities
SAU	Standard Annual Usage – synthetic energy profile of retail customer
SEC	Smart Energy Collective
Settlement	Determining the energy production and consumption and used flexibility as preparation for the billing process.
Supplier	Has a contractual relationship with Prosumers to source, supply and invoice energy
TSO	Transmission System Operator
USEF	Universal Smart Energy Framework

Appendix 3 Bibliography

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