Northern Cluster Demonstrator:

TSO-DSO Coordination module description and implementation

D7.4

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

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Dissemination Level		
PU	Public	x
CO	Confidential, only for members of the consortium (including the Commission Services)	
CI	Classified, as referred to in Commission Decision 2001/844/EC	

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Issue Record

Planned delivery date	30.11.2022
Actual date of delivery	30.11.2022
Status and version	V1.0

Version	Date	Author(s)	Notes
0.1	23.09.2022	Kalle Kukk (Elering), Ele-Kaja Gildemann (Cybernetica), Anibal Sanjab (VITO)	Proposal for structure.
0.2	31.10.2022	Kalle Kukk (Elering), Ele-Kaja Gildemann (Cybernetica), Anibal Sanjab (VITO), Luciana Marques (VITO), Taisto Treumann (Cybernetica), Marko Petron (Cybernetica), Kaja Trees (Elering)	Version sent for WP7 review.
0.3	14.11.2022	Kalle Kukk (Elering), Ele-Kaja Gildemann (Cybernetica), Anibal Sanjab (VITO), Luciana Marques (VITO), Taisto Treumann (Cybernetica), Marko Petron (Cybernetica), Ivars Zikmanis (AST)	Comments collected from WP7 partners and content updates provided by authors.
0.4	15.11.2022	Kalle Kukk (Elering), Ele-Kaja Gildemann (Cybernetica), Anibal Sanjab (VITO), Luciana Marques (VITO), Taisto Treumann (Cybernetica), Marko Petron (Cybernetica)	Version sent to project reviewers.
0.5	30.11.2022	Kalle Kukk (Elering), Ele-Kaja Gildemann (Cybernetica), Anibal Sanjab (VITO), Luciana Marques (VITO), Taisto Treumann (Cybernetica), Marko Petron (Cybernetica)	Includes reviewers' comments and answers to the comments.
0.6	30.11.2022	Kalle Kukk (Elering)	Clean version for submission to EC.

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About OneNet

OneNet will provide a seamless integration of all the actors in the electricity network across Europe to create the conditions for a synergistic operation that optimises the overall energy system while creating an open and fair market structure.

The project OneNet (One Network for Europe) is funded through the EU's eighth Framework Programme Horizon 2020. It is titled "TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation" and responds to the call "Building a low-carbon, climate resilient future (LC)".

While the electrical grid is moving from being a fully centralized to a highly decentralized system, grid operators have to adapt to this changing environment and adjust their current business model to accommodate faster reactions and adaptive flexibility. This is an unprecedented challenge requiring an unprecedented solution. For this reason, the two major associations of grid operators in Europe, ENTSO-E and EDSO, have activated their members to put together a unique consortium with over 70 partners.

The key elements of the project are:

1. Definition of a common market design for Europe: this means standardized products and key parameters for grid services which aim at the coordination of all actors, from grid operators to customers;
2. Definition of a Common IT Architecture and Common IT Interfaces: this means not trying to create a single IT platform for all the products but enabling an open architecture of interactions among several platforms so that anybody can join any market across Europe; and
3. Large-scale demonstrators to implement and showcase the scalable solutions developed throughout the project. These demonstrators are organized in four clusters coming to include countries in every region of Europe and testing innovative use cases never validated before.

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List of Abbreviations and Acronyms

Acronym	Meaning
API	Application Programming Interface
BRP	Balance Responsible Party
BSP	Balance Service Provider
BUC	Business Use Case
CA	Consent Administrator
CIM	Common Information Model
CM	Congestion Management
COBA	Coordinated Balancing Area
DEP	Data Exchange Platform
DER	Distributed Energy Resources
DSO	Distribution System Operator
ECCo SP	ENTSO-E Communication & Connectivity Service Platform
EU	European Union
EUPL	European Union Public Licence
FCT	Flexibility Call for Tender
FR	Flexibility Register
FSP	Flexibility Service Provider
HEMRM	Harmonised Electricity Market Role Model
HTTPS	Hypertext Transfer Protocol Secure
ID	Identifier
IEC	International Electrotechnical Commission
IEGSA	Interoperable pan-European Grid Service Architecture
IP	Internet Protocol
IT	Information Technology
JSON	Javascript Object Notation
kW	Kilowatt
LT-P-C	Long-term active capacity product
LT-P-C/E	Long-term active capacity/energy product
mFRR	manual Frequency Restoration Reserve
MO	Market Operator
MW	Megawatt; Middleware
NEMO	Nominated Electricity Market Operator
NFR	Non-Functional Requirement
NRT-P-E	Near-real-time active energy product

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OWASP	Open Web Application Security Project
PO	Purchase Offer
PTDF	Power Transfer Distribution Factor
RES	Renewable Energy Sources
REST	REpresentational State Transfer
RP	Resource Provider
SGAM	Smart Grid Architecture Model
SO	System Operator
ST-P-C	Short-term active capacity product
ST-P-E	Short-term active energy product
SUC	System Use Case
T&D CP	TSO-DSO Coordination Platform
TSO	Transmission System Operator
UI	User Interface
USEF	Universal Smart Energy Framework
WP	Work Package

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Executive Summary

The overarching goal of the TSO-DSO Coordination Platform (T&D CP) is to enable the seamless, TSOs-DSOs coordinated procurement of flexibility for system services (through different flexibility products, and for delivering different grid services) to meet the needs of participating system operators in the most efficient way. This yields a reduced cost to the operators (translated in lower bills to consumers) and a fair participation and remuneration of flexibility service providers (FSPs). A regionally aligned TSO-DSO coordination process makes the access to individual national markets more understandable and easier for FSPs.

The review of 7 earlier projects and frameworks, including 29 use cases in total, enabled to identify 13 unique processes related to TSO-DSO coordination, appearing in 96 occasions. For example, these processes include coordinated bid, input information for grid prequalification, and publication of prequalification results. Based on these, system use cases (SUCs) related to T&D CP were discussed and identified. Eventually, three relevant SUCs remained.

The grid qualification SUC focuses on the prequalification phase – this is the early check of resources, before they are allowed to participate in bidding, to reveal the obvious issues that could be caused in the grid due to their future activation. The bid optimisation SUC selects the most optimal set of bids for activation and at the same time ensures that the bids causing additional issues in the grid would not be selected. The flexibility call for tender opening SUC enables informing other concerned parties (Market Operators, System Operators) about the new tender when launched by a System Operator.

The technical description of the T&D CP provides the high-level architecture. Coordination Platform is built as modules and developed in an API-driven way to support incremental integration with several stakeholders and numerous different purposes. This provides necessary flexibility for adding support for new products and new markets integration needs.

In the coordinated procurement of flexibility, the platform aims at meeting the needs of the different system operators – by procuring flexibility which can be offered from assets connected within different systems and at different voltage levels – while capitalizing on the value stacking potential of the offered flexibility (thereby using the same bid to simultaneously meet different services and/or different system operators' needs). These needs are met optimally, i.e., at least possible cost, while ensuring not only that the needs of the operators are met, but also that this procurement process does not lead to the creation of other operational issues within the grid (i.e., combining the concepts of bid optimisation and grid impact assessment).

This is carried out through the optimisation module0. The optimisation module receives the system needs of the operators, their network representations, and product procurement requirements, as well as the bids submitted by the FSPs, and, for each product, automatically returns the optimal set of bids to (fully or partially) purchase in order to meet the system needs in an optimal and grid impact-aware manner. The module allows

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different types of bids to be submitted, ranging from simple bids (including fully divisible, partially divisible, and non-divisible bids) to complex bids (including multipart – parent/children bids – and exclusive bids). This helps accommodating different types of technologies that flexibility services providers may possess, and by this virtue, encourages FSPs and consumer participation.

Indeed, by the standardized optimal clearing of the market (based on a clear and automatic methodology), the optimization module enables a transparent, explainable, and fair choice of bid purchasing, which also further drives flexibility service providers' and consumers' participation. In this respect, 0this deliverable introduces the developed and implemented concept of optimisation-based market clearing, the way the grid-impact assessment is incorporated in the market clearing process through the use of power transfer distribution factors, and the different types of bids considered.

Then, the input/output data specification of the optimization module (detailing the inputs' needs and the generated outputs of the module) are introduced, while introducing and differentiating between the different products considered. Here, the API, enabling the connection between the T&D CP and the optimisation module is also introduced. Then, several test runs, considering the different flexibility products, are presented. These test runs are based on inputs provided by the different participating system operators in the Northern demonstrator, and reflect the demo settings, and, hence, highlight the functionality and performance of the module.

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1 Introduction

This deliverable explains the status of use cases, software development, optimisation algorithm and test scenarios related to T&D CP at month 26 of OneNet project, i.e., before full-scale testing and demonstration of the solution. As the scope is centred around T&D CP hereby, it primarily concerns Market Operators (MOs) and System Operators (SOs). The processes linked to the FSPs are part of the flexibility register, which are explained in deliverable 7.2. However, also T&D CP is designed to support customer-centric approach.

According to Grant Agreement:

- „The coordination process for multiple network flexibilities is optimised by adding real-time information about the network state and topology …“
- „… allowing multiple needs to be covered by the same flexibility trades – called value stacking.“
- „Simplifying and standardizing the processes for a variety of flexibility markets …“
- „… TSO-DSO coordination engine will ensure that these can be used to the benefit of the entire energy system …“

T&D CP has three main tasks:

1. to ensure that flexibility activations do not cause congestions in any network level, i.e., setting continuously (from prequalification until activation) constraints on the flexibility bids to complete grid prequalification (considering thermal limits, voltage requirements);
2. to prioritize flexibility bids/activations that are not only economical but also technically cost-effective, and;
3. to maximise the use of flexibility by doing value stacking, i.e., to find the most optimal mix of available flexibilities to be activated by running optimisation algorithm based on socio-economic value.

The Northern demonstrator develops further the network operator coordination and network information processing already achieved with power transfer distribution factor (PTDF) matrixes in INTERRFACE project to a more granular level with increased level of automation.

The TSO-DSO coordination will require the collective sharing of accurate network information of multiple network operators to complete real-time and forecasted network state calculation. Constraint setting and optimisation requires information about the state of networks, available flexibility bids (incl. location information), and flexibility activation requests of SO.

For data exchanges, platforms like Estfeed, ECCo SP and IEGSA, already proven in INTERRFACE and EU-SysFlex projects. will be utilized. This must work with existing SO network models and systems, and can utilize the data

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and functionalities developed for the Flexibility Register. Flexibility Register (FR) is another major component of Northern Demonstrator and is presented in detail in deliverable 7.2.

The solution must be able to perform its calculations in a given time period and to provide to the TSO/DSO opportunity to make automated decisions as well as to provide to the SO variety of options for a manual decision making. There should be options for SO to use the developed TSO-DSO coordination solution to perform necessary calculations based on given needs and limitations as well as to be flexible enough for SO to decide to perform calculation on its side and give TSO-DSO coordination solution only the final decisions.

T&D CP should be designed and operated having customer-centric approach in mind. This would lead to increased liquidity and competition in balancing, congestion management and other flexibility markets. Ensuring the opportunity for end-user to participate individually or via aggregator in the market, several needs and challenges can be identified:

- Lowering market entry barriers;
- TSO-DSO (and TSO-TSO, DSO-DSO) coordination need;
- Ensuring regional market rules and processes;
- Harmonisation of flexibility products;
- Availability of sub-meter and near-real-time data;
- Data management and consent management supporting private data exchange;
- Attractiveness of demand response for customers;
- Single platform for all market participants to trade flexibility services in a transparent and cost-effective way.

1.1 Methodology

The task started with analytical phase, primarily based on findings of INTERRFACE and EU-SysFlex projects and in coordination with horizontal OneNet Work Packages (WPs): WP2 – Products and services definition in support of OneNet, WP3 – Integrated and coordinated markets for OneNet, WP4 – Integrated System Operation for OneNet, WP5 – Open IT Architecture for OneNet, WP6 – Reference IT Implementation for OneNet.

High-level business and technical options were discussed and summarized in Northern demonstrator Business Use Case (BUC) [1] corresponding to business layer of Smart Grid Architecture Model (SGAM) [2]. One common BUC for all participating countries and for all flexibility phases (from customer onboarding and prequalification to activation and settlement) was described.

SUCs were defined quite in the beginning of the project and several new iterations were provided after that based on the intermediate findings and results. The SUCs of T&D CP describe the specific aspects of TSO-DSO

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coordination – grid qualification, bid optimisation and selection, flexibility calls for tender. SUCs correspond to function layer of SGAM. Both BUC and SUCs are based on IEC 62559 methodology [3].

HEMRM (Harmonised Electricity Market Role Model) [4] was used for role definitions, however, few additional roles were proposed. For sequence diagrams and architectural view, the Enterprise Architect was used.

Data semantics table containing all relevant data objects and their parameters, and preliminary data model corresponding to information and communication layers of SGAM were generated early in the project and constantly updated. Later on, the translation of these to CIM (Common Information Model) [5] compliant model was undertaken.

A comprehensive algorithm was developed for grid qualification and bid optimisation processes based on PTDF matrices. Agile development of the T&D CP software was applied, in close collaboration with other components, specifically with Flexibility Register.

1.2 Review of previous projects

Both BUCs and SUCs potentially relevant for TSO-DSO coordination in the flexibility market from the following projects and frameworks were reviewed:

- Active System Management report by CEDEC, E.DSO, ENTSO-E, Eurelectric and GEODE [6]
- COORDINET deliverable 1.5 [7]
- ebIX® overview [8]
- EU-SysFlex deliverable 5.2 [9]
- INTERRFACE demo area 1 [10]
- SmartNet deliverable 1.3 [11]
- TDX-ASSIST use cases [12]
    - USEF framework – processes are not described in sufficient detail, therefore not reviewed further [13]. Figure 1.1 depicts examples of use case analysis for TSO-DSO coordination. Red ovals indicate relevant *processes* inside each use case and were indexed with same capital letters for similar processes throughout all the use cases.

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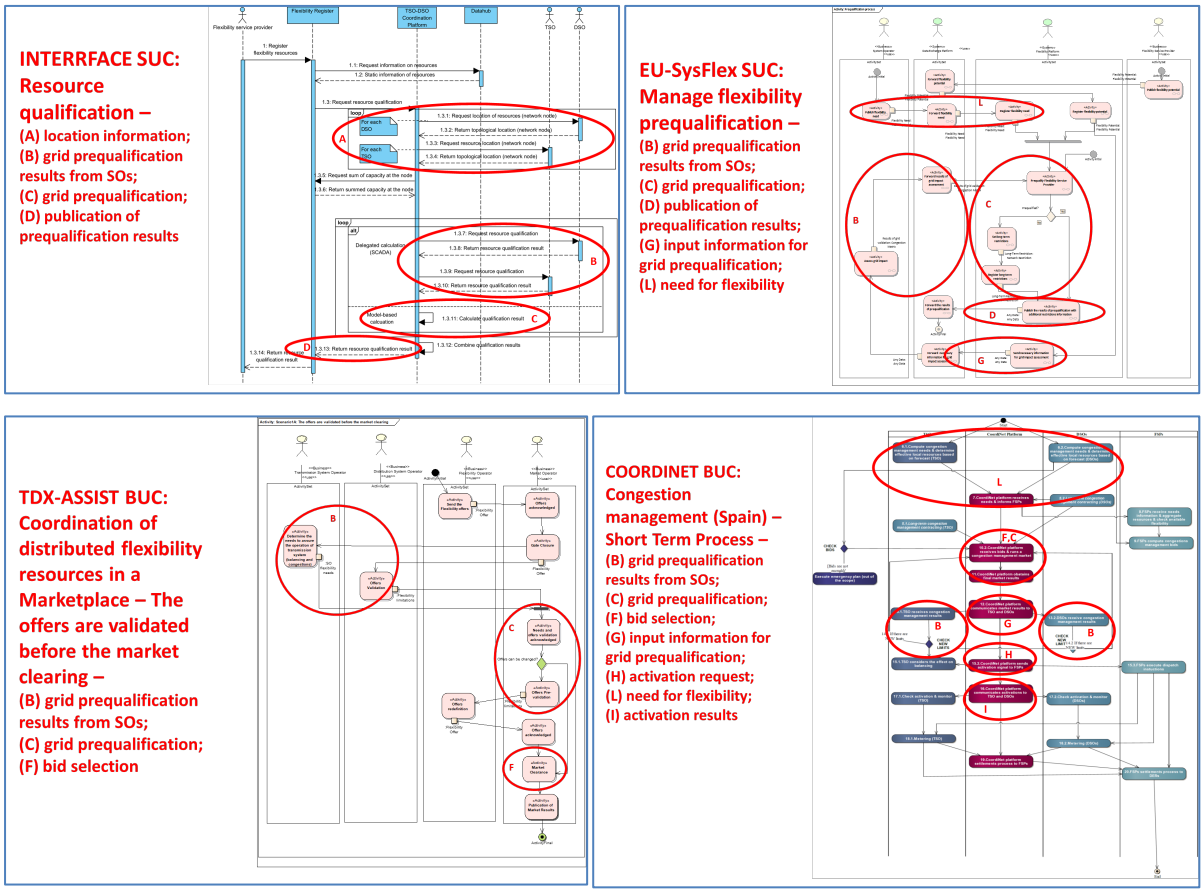

Figure 1.1 Analysis of TSO-DSO coordination use cases – illustrative examples from INTERRFACE, EU-SysFlex, TDX-Assist and COORDINET projects

Main criterion for picking potentially relevant SUCs was the involvement of TSO/DSO itself in the process or introduction of a "dedicated central component". Such component may have different functionalities, performed by different roles/actors (like market operator, system operator, third party) and have different names (like TSO-DSO Coordination Platform, Flexibility Platform, CoordiNet Platform). Summary of the TSO-DSO coordination processes based on earlier projects and frameworks:

(A) location information – information about the resource location vis-a-vis grid topology provided by the SO;

(B) grid prequalification results from SOs – prequalification performed by SOs themselves;

(C) grid prequalification – prequalification performed by the dedicated central component (not by each SO individually);

(D) publication of prequalification results – provision of prequalification results by the dedicated central component to other parties;

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(E) coordinated bid – flexibility bid generated by the dedicated central component[1];

(F) bid selection – bid selected for activation by the flexibility buyer or by the market operator (MO) or by the dedicated central component;

(G) input information for grid prequalification – information sent by SO to the dedicated central component or via the central component to another SO to perform prequalification process;

(H) activation request – request sent by one market party to another market party, which ultimately should lead to the activation of a resource;

(I) activation results – the dedicated central component is informed about the actual activations or the components informs others (SOs) about the activation signals sent;

(J) neutralizing counter-trade – trade via dedicated central component to correct the imbalance caused by the selection of a bid for congestion management;

(K) get trading results – selected bids reported to the dedicated central component;

(L) need for flexibility – buyer of flexibility informs the dedicated central component about its current or future flexibility needs;

(M) Information exchange with European platforms (MARI, PICASSO, TERRE, Baltic COBA, NEMOs like NordPool) - bids and other relevant information sent to regional/European platform for further optimisation.

In total, 7 projects and frameworks, including 29 use cases were reviewed. Among these use cases, 13 unique processes could be identified, appearing in 96 occasions (Figure 1.2).

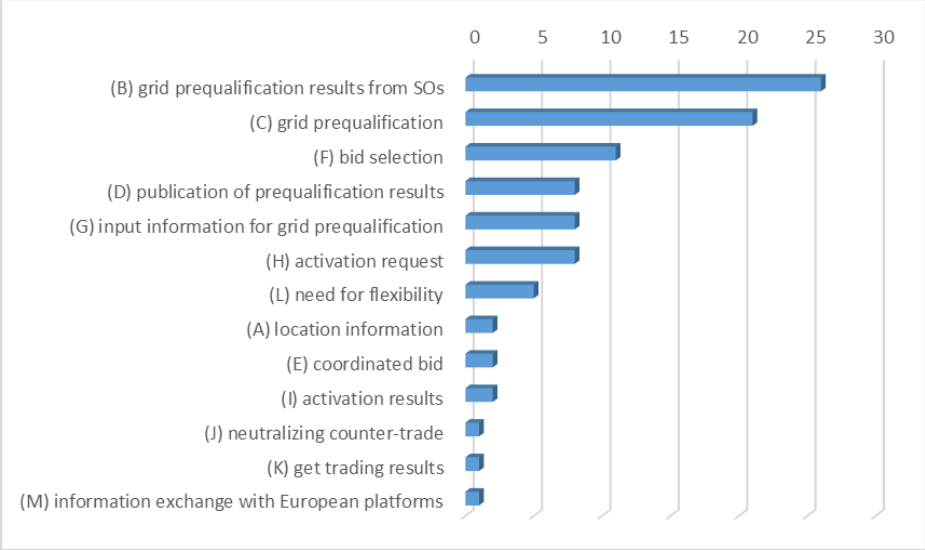

Figure 1.2 Number of appearances of TSO-DSO coordination processes in the projects and frameworks reviewed

[1] Initial idea of one of the reviewed projects, but not elaborated further.

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Table 1.1 summarises the 13 TSO-DSO coordination processes, including the associated roles as mentioned in the reviewed projects and frameworks.

Table 1.1 Summary of processes in review projects and frameworks

Functionality/process	Information provider Business role / System role	Information receiver Business role / System role
(B) grid prequalification results from SOs	TSO, DSO, TSO-DSO Coordination Platform, Pre-Operation planning	TSO, DSO, TSO-DSO Coordination Platform, MO / Flexibility Platform, CoordiNet Platform, DER owner
(C) grid prequalification	TSO-DSO Coordination Platform, MO / Flexibility Platform, CoordiNet Platform	TSO, TSO-DSO Coordination Platform, Flexibility Platform
(F) bid selection	Buyer of flexibility, TSO, TSO-DSO Coordination Platform, MO / Flexibility Platform, CoordiNet Platform	Buyer of flexibility (TSO, DSO), BRP, FSP, MO, Flexibility Platform
(G) input information for grid prequalification (A) location information	TSO, DSO, Flexibility Platform, CoordiNet Platform	DSO, TSO-DSO Coordination Platform, SO
(D) publication of prequalification results	TSO, DSO, TSO-DSO Coordination Platform, Flexibility Platform	FSP, BSP, Flexibility register,
(H) activation request	Buyer of flexibility (TSO, DSO), BRP, FSP, Flexibility Platform, CoordiNet Platform	FSP, BSP, TSO, DSO, Bid forwarding service, Flexibility Platform
(L) need for flexibility	Buyer of flexibility (TSO, DSO, BRP, FSP)	Flexibility Platform, CoordiNet Platform
(E) coordinated bid	TSO-DSO Coordination Platform	MO
(I) activation results	Bid forwarding service, CoordiNet Platform	TSO, DSO, TSO-DSO Coordination Platform
(J) neutralizing counter-trade	TSO-DSO Coordination Platform	MO
(K) get trading results	MO	TSO-DSO Coordination Platform
(M) information exchange with European platforms	TSO	European Balancing Platform

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1.3 Overview of relevant flexibility products

One of the key aspects of Northern demonstrator is the identification of common products. "Common" means that the products are usable by both TSOs and DSOs, they are usable for different needs (balancing, congestion management), and they are usable in all participating countries. Three aspects are selected to define the products. First, the timeframe of procurement – the product can be long-term (LT), short-term (ST) or near-real-time (NRT). Second, product can be used for procuring capacity (availability) (C) or energy (E). Third, product can be used for procuring active power (P) or reactive power (Q).

Figure 1.3 summarises the initial selection of products and their interconnections in the energy market (in the figure, "TD" means that the flexibility can be connected to both transmission and distribution network; "A" means availability product[2]). Table 1.2 lists the final selection of products to be demonstrated.

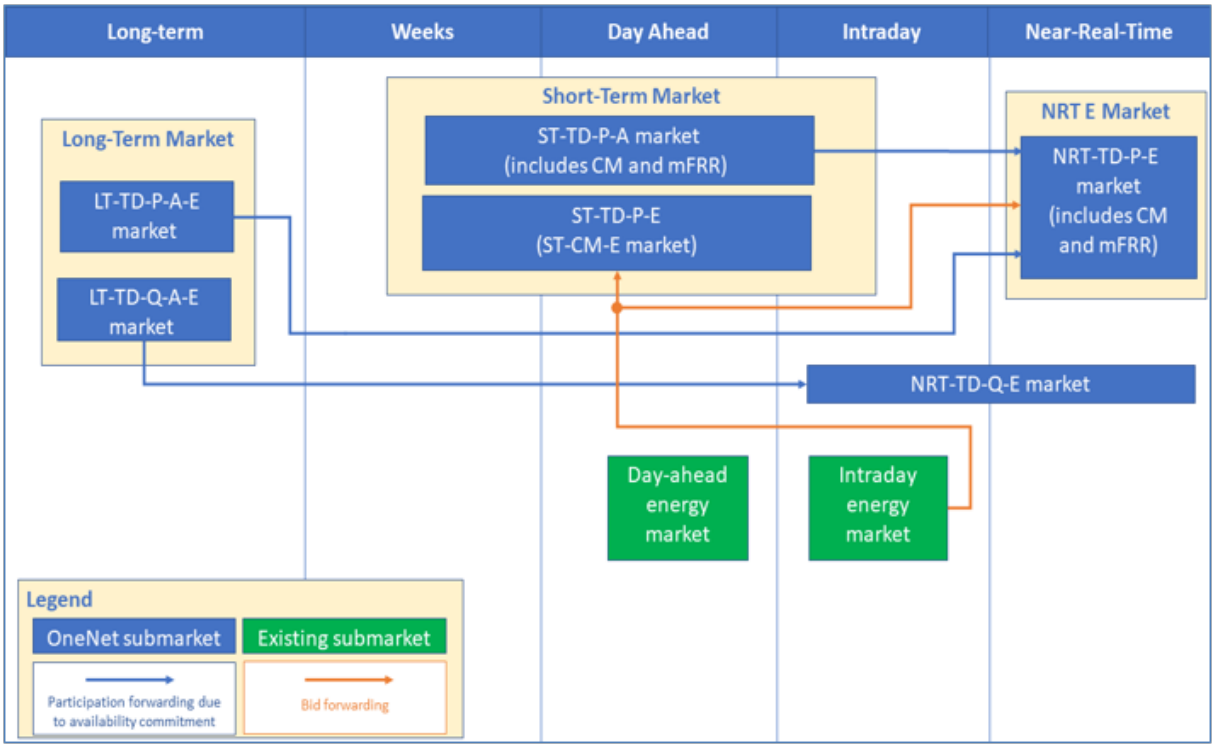

Figure 1.3 Overview of Northern demonstrator Market Architecture [14]

[2] The term "availability" (A) is used in the source of Figure 1.3. However, the rest of this deliverable uses the term "capacity (C) instead. In the current context the meaning is the same in both cases.

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Table 1.2 Northern demonstrator products and mapping to OneNet Harmonised Products, modified from [15]

Northern demonstrator product	Description	OneNet Harmonised Product
NRT-P-E (Near-Real-Time Active Energy)	Energy product used by SOs responsible for frequency and congestion management. Single product for frequency restoration and congestion management. Procured in near-real-time (15min). Activated manually.	Corrective local active. The product is consistent with mFRR
ST-P-E (Short-Term Active Energy)	Procured day to a month ahead. Active power energy product. Used by SOs for congestion management.	Predictive short term local active
ST-P-C (Short-Term Active Capacity)	Procured day to a month ahead. Active power capacity product. Used by SOs for congestion management and frequency.	Predictive short term local active
LT-P-C (Long-Term Active Capacity)	Procured months to years ahead. Active power capacity product. Used by SOs for congestion management.	Predictive long-term local active
LT-P-C/E (Long-Term Active Capacity/Energy)	Procured months to years ahead. Active power product with simultaneous procurement of capacity and energy. Used by SOs for congestion management.	Predictive long-term local active

1.4 Structure of the deliverable

Chapter 2 reviews the SUCs of T&D CP, including the scope, objective, narrative, sequence diagrams, step-by-step processes, roles involved, functional requirements and high-level data description.

Chapter 3 describes the technical aspects of the coordination platform, including architecture, non-functional requirements, data model, integrations within the demonstrator as well as within OneNet Framework, and product-specific processes on T&D CP.

Chapter 4 presents the optimisation algorithm of the coordination platform, including motivation and fundamentals of optimisation-based market clearing, Power Transfer Distribution Factor based approach to grid impact assessment, bid formats from simple to complex linked bids, optimisation module, and optimisation features per flexibility product.

Chapter 5 summarises country-by-country approaches to implementation of the coordination platform. Chapter 6 concludes.

Appendices include full texts of SUCs, extract from data semantics table, overview of non-functional requirements, example data for optimisation of each reviewed product and an example of CIM compliant data profile.

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2 Use cases of the Coordination Platform

The review of previous TSO-DSO coordination related use cases in Chapter 1.2 was the basis for elaborating Northern demonstrator's SUCs. Main advances of the SUCs described in this chapter include:

- Linking all TSO-DSO coordination processes to a single technical solution – T&D CP;
- Designing the solution in the way which satisfies all the countries and system operators participating in the demonstrator;
- Describing product-agnostic processes;
- Using the same algorithm for grid qualification (in procurement and activation phases) and bid optimisation.

Eventually three use cases were identified: Grid qualification of resource; Bid optimisation; and Flexibility call for tender opening. Grid qualification SUC focuses on the prequalification phase – this is the early check of resources, before they are allowed to participate in bidding, to reveal the obvious issues caused in the grid due to their future activation. Bid optimisation SUC selects the most optimal set of bids for activation and at the same time ensures that the bids causing additional issues in the grid would not be selected. Flexibility call for tender opening SUC enables to inform other concerned parties (MOs, SOs) about the new tender when launched by an SO. Full texts of use cases are in Appendices A, B and C.

2.1 Scope, objective, narrative and conditions

2.1.1 Grid qualification of resource

Scope: Qualification of flexibility resources from grid capacity perspective in prequalification phase.

Objective: Solution developed to facilitate multilateral flexibility market through improved TSO-DSO coordination, also enabling cross-border marketplace. The objective of grid impact assessment is to avoid congestions by setting restrictions on the activation of flexibilities which would cause congestion in grids.

Grid qualification of a flexibility resource may take place in prequalification, procurement and activation phases. In this use case, a focus is given on grid qualification in the prequalification phase. It is worth mentioning that qualification in procurement phase is integral part of bid optimisation and, as such, part of the bid optimisation SUC. In the activation phase, grid qualification would not be feasible for near-real-time product due to time constraints and not necessary in capacity products. For the activation of short-term and long-term products, the grid impact assessment in activation phase is also integrated into optimisation process (and therefore addressed in bid optimisation SUC).

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Grid impact assessment is central activity of grid qualification process. Two alternatives are possible. First, concerned SO identifies grid restrictions (constraints) by itself. If the first alternative is applied, there is no need for T&D CP involvement – rather the Flexibility Register provides resource information to the SO and collects the grid restrictions information from it. Therefore, this alternative is not part of this SUC.

Second alternative is that restrictions are calculated by T&D CP. This approach is part of this SUC. For second alternative, a dedicated algorithm is needed which calculates the grid restrictions based on input information. Input information to be made available to T&D CP includes resource information, network topology and node limitations. The objective is to determine in which network node the activation of the resource would violate the node limitation. The impact assessment is a continuous process. In prequalification phase normally structural congestions should be considered, while in procurement and activation phases also dynamic congestions. Resource Provider's consent is needed by T&D CP to have access to private information, e.g., related to resource information and flexibility bid.

Assumptions:

1. Solutions for consent management for sharing private data are in place in all countries of the region.
2. T&D CP is integrated with other relevant systems of the concerned stakeholders and countries (e.g., Flexibility Register).
3. It is evident that congestions occur in a concerned grid area.
4. The concerned SOs for grid impact assessment are predefined.
5. Alternative 1 of grid qualification does not require the involvement of T&D CP.

Prerequisites:

1. Cross-border acknowledgement of consents is enabled – consents given in one country are recognised in other country, with the same consent resource provider can grant access to data to different roles in different countries, FSP can provide aggregation services to resource providers located in different countries, resource provider has access to consent services provided in another country.
2. Information about concerned flexibility resources as well as relevant grid information is available.

Sequence diagram of the grid qualification SUC is presented in Figure 2.1.

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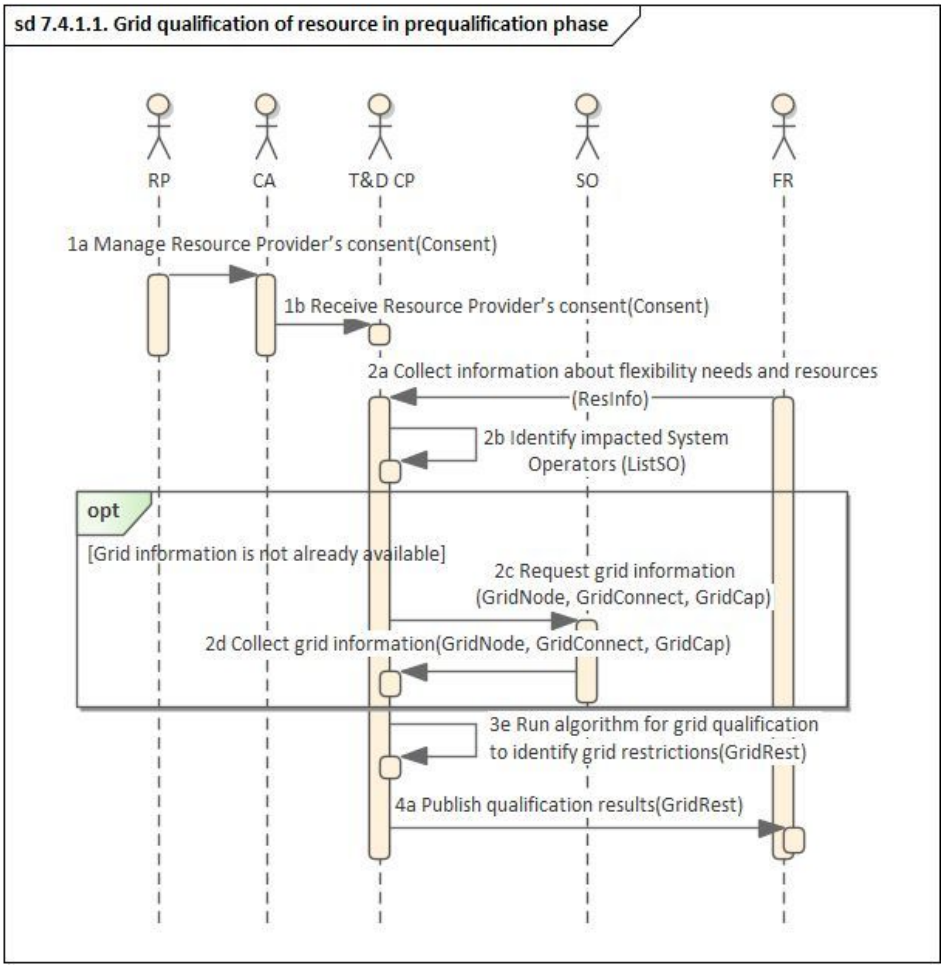

Figure 2.1 Grid qualification of resource in prequalification phase

2.1.2 Bid optimisation

Scope: Optimising the flexibility bids based on minimising total costs, avoiding further issues in the grids and enabling value-stacking.

Objective: Tool and algorithm developed for optimising flexibility bids to facilitate multilateral flexibility market through improved TSO-DSO coordination, also enabling cross-border marketplace.

An algorithm performs bid optimisation processes for both capacity and energy products. Besides flexibility bids, also purchase offers and grid information are necessary inputs for the algorithm that enables to perform bid optimisation[3]. Optimising means matching flexibility bids and purchase offers in the most economical way which takes into account total costs for the SO(s) and synergies (value-stacking). This step can be repeated

[3] See Chapter 4 for details about the optimisation.

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continuously if necessary and feasible. The latter is relevant in case of ST-P-E and LT-P-C/E product whereby there is sufficient time before activation to re-optimise if meanwhile some bids have been reported as unavailable.

The optimisation of the market clearing takes into consideration the effects on all the grids involved, to ensure that any combinations of bids purchased would not lead to any operational issues for any of the grids involved. That could be achieved following a PTDF approach, and as such, grid qualification in the procurement phase and bid optimisation are performed within the same optimisation process.

After the optimisation, remaining bids and bids earmarked for balancing only need to be shared with relevant European platform (MARI, PICASSO). If bids were not selected for congestion management purposes, TSO-DSO coordination platform forwards them to relevant European balancing platform after checking if such bids still comply with European balancing requirements and if they would not cause internal congestions. Bids can be tagged by FSP to be used for balancing only, congestion management only, or for both.

The information about cleared bids as the result of optimisation will be sent to relevant MOs who interact directly with the FSPs. MOs are expected to request the FSPs to activate the resources exactly according to the optimisation results. Other optimisation results beside cleared bids will be also generated and can be made available to SOs – total cost of the cleared bids, updated grid flows, new imbalance position[4].

Assumptions:

1. Solutions for consent management for sharing private data are in place in all countries of the region.
2. Value-stacking is allowed in legislation, i.e., same resources and bids can be used simultaneously for more than one flexibility service and/or for more than one SO.
3. Timing allows value-stacking while sharing the concerned bids also with European platform.
4. Secondary trading is enabled.
5. T&D CP is integrated with other relevant systems of the concerned stakeholders and countries (e.g., Flexibility Register).
6. Location of the issue in the grid and location of the flexibility resource matters from the total cost perspective and from the feasibility (i.e., are there resources available to solve the issue) perspective.
7. The concerned SOs for grid impact assessment are predefined.
8. Counter balancing is solved through the Purchase Offer process whereby SOs can define the desired imbalance position.

Prerequisites:

[4] See Section 4.4.2 for more details.

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1. Grid qualification of flexibility bids in procurement phase has to come together with bid optimisation. This is checked by the T&D CP.
2. The optimisation follows only if 'product prequalification' of the concerned resource had been successful. This is checked by the Flexibility Register.
3. Information about concerned flexibility bids and flexibility purchase offers as well as relevant grid information is available.
4. Cross-border acknowledgement of consents is enabled – consents given in one country are recognised in other country, with the same consent resource provider being able to grant access to data to different roles in different countries, FSP can provide aggregation services to resource providers located in different countries, resource provider has access to consent services provided in another country.

Sequence diagram of the bid optimisation SUC is presented in Figure 2.2 (the abbreviation "opt" means that the implementation of concerned steps is optional).

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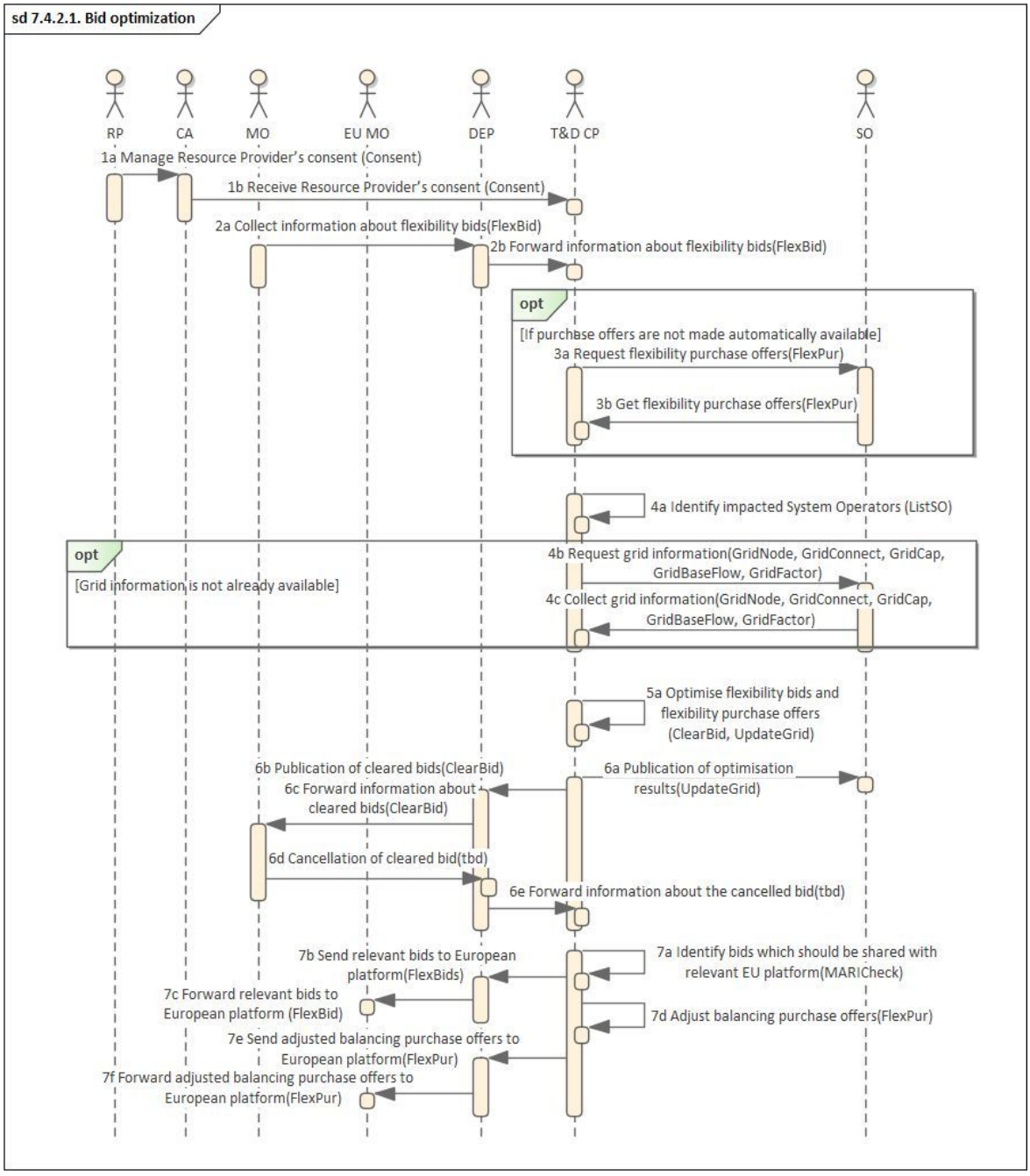

Figure 2.2 Bid optimisation

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2.1.3 Flexibility call for tender opening

Scope: Opening flexibility call for tender and sharing information about ongoing calls with market and system operators.

Objective: Facilitate coordinated trading by centralising information about active calls for tender.

A call for tender of flexibility services is used in case of capacity products and it covers, in addition to product specifications, particular periods (week ahead, day ahead, intraday, etc.), location, quantity. The call for tender is initiated by the SO who needs the flexibility. Information about all calls is collected and stored centrally at T&D CP and made available to concerned MOs and SOs.

Sequence diagram of the tender opening SUC is presented in Figure 2.3. Two alternatives in the figure mean that information can be made available to already known MOs automatically ("publish") or to new MOs entering the market based on their request.

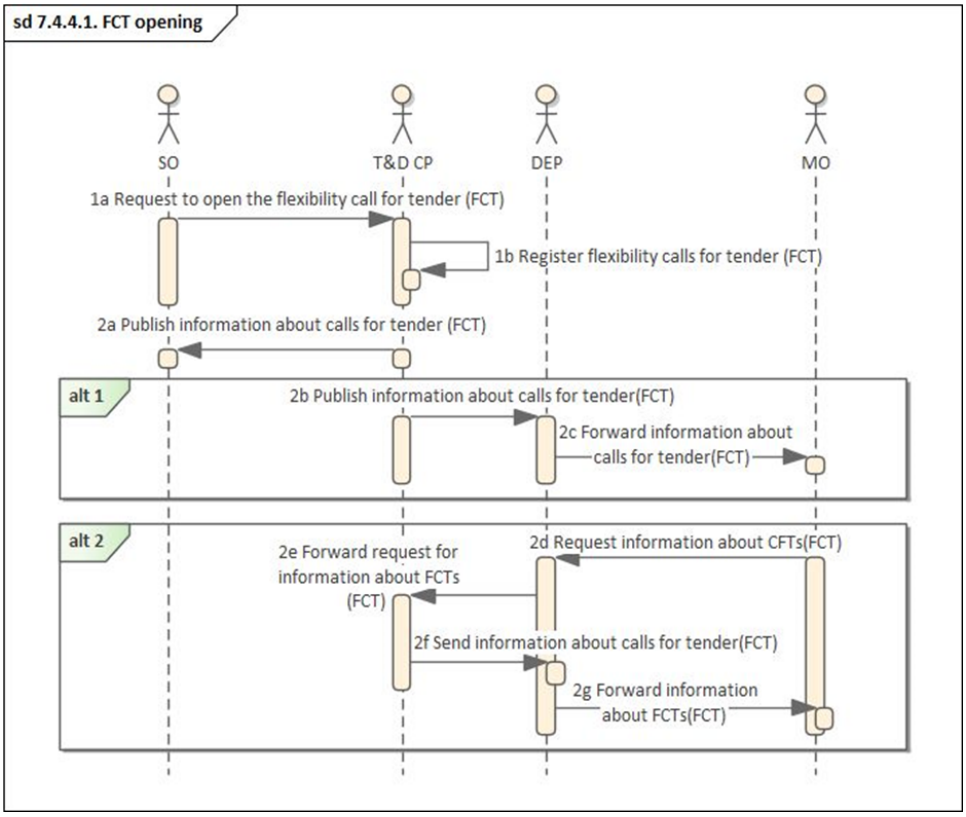

Figure 2.3 Flexibility call for tender opening

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2.2 Overview of Coordination Platform processes

Figure 2.4 depicts all the processes (exchanged information) between T&D CP and other roles/systems based on the SUCs described in Section 2.1.

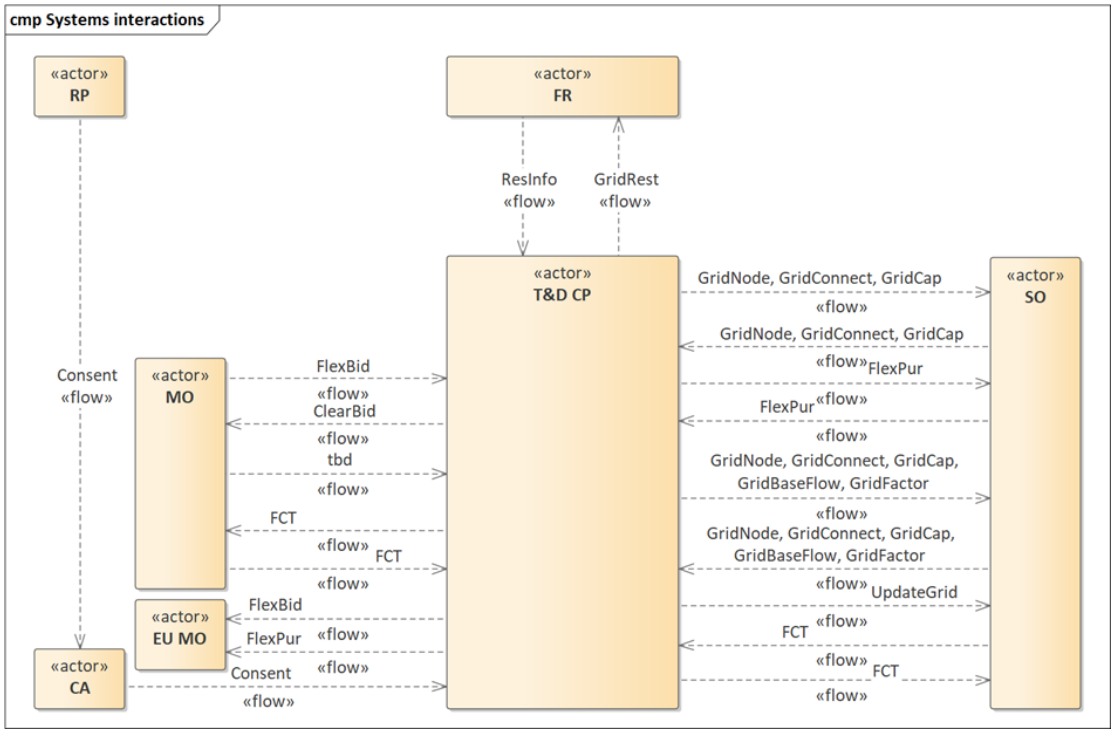

Figure 2.4 Processes of TSO-DSO Coordination Platform within OneNet Northern demonstrator

2.3 Roles involved

Table 2.1 gives the overview of all business roles and system roles used in T&D CP SUCs described in Section 2.1. Business roles applied are harmonised roles as defined in HEMRM [4] and complemented with recent proposals through joint effort in BRIDGE Initiative [16] to amend and introduce additional roles.

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Table 2.1 Business and system roles within OneNet Northern demonstrators' TSO-DSO coordination SUCs

Actor (role) name	*Type*	*Description*	*Further information specific to this use case*
TSO-DSO Coordination Platform (T&D CP)	System	System that is designed to find the best value-stack of available flexibilities to be activated (optimisation process) as well as to avoid, through grid impact assessment, the activation of flexibilities which either do not contribute to solving system needs or even worsen the situation (constraint setting process).	
Flexibility Register (FR)	System	System that stores information about flexibility assets, results of qualification (both product and grid), market results, grid information and the results of the settlement as well as aggregates flexibility information as well as allocates access rights to the various actors and controls the level of access.	Based on BRIDGE proposal for Flexibility Register Operator definition
System Operator (SO)	Business	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.	HEMRM definition
Market Operator (MO)	Business	A market operator is a party that provides a service whereby the offers to sell electricity **or electricity flexibility** are matched with bids to buy electricity **or electricity flexibility**.	HEMRM definition with extensions (in bold) proposed by BRIDGE. Includes also TSOs and DSOs performing the role of MO
European Market Operator (EU MO)	Business	Specific type of market operator responsible for operating European balancing platform (e.g., MARI).	
Resource Provider (RP)	Business	A role that manages a resource and provides production/consumption schedules for it, if required.	HEMRM definition
Consent Administrator (CA)	Business	A party responsible for administrating a register of consents for a domain. The Consent Administrator makes this information available on request for entitled parties in the sector.	HEMRM definition
Data Exchange Platform (DEP)	System	A communication platform whose basic functionality is to secure data transfer (routing) from data providers (e.g. data hubs, FSPs, TSOs, DSOs) to the data users (e.g. TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g. cryptographic hash of the data requested). The DEP does not store core energy data (e.g. meter data, grid data, market data) while these data can be stored by data hubs.	BRIDGE proposal

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2.4 Functional requirements

Table 2.2 gives the overview of all functional requirements used in T&D CP SUCs described in Section 2.1.

Table 2.2 Functional requirements within OneNet Northern demonstrator TSO-DSO coordination SUCs

Requirement ID	Requirement name	Requirement description
ConnectSO	Data exchange with System Operator	The ability to exchange data with SO's relevant system(s)
ConnectMO	Data exchange with Market Operator	The ability to exchange data with MO's relevant system(s), incl. with European platforms
ConnectFR	Data exchange with Flexibility Register	The ability to exchange data with Flexibility Register's relevant system(s)
ConnectCA	Data exchange with Consent Administrator	The ability to exchange data with CA's relevant system(s)
DataSec	Security of data exchange	Exchange of sensitive data needs to be protected
DataStore	Storing of relevant data	Storing capability of grid qualification results, optimisation results and flexibility calls for tender needs to be ensured
ConsMan	Consent management	The ability to give, obtain, process and store Resource Providers' consents

2.5 Data description

Table 2.3 gives the overview of all business objects used in T&D CP SUCs described in Section 2.1. Preliminary description of these objects is presented in Appendix D.

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Table 2.3 Business objects within OneNet Northern demonstrator TSO-DSO coordination SUCs

Information exchanged, ID	Name of information	Description of information exchanged
Consent	Customer Consent	Permission of data owner to use its private data.
ResInfo	Resource Information	FSP's future potential to provide the flexibility.
GridNode	Grid Node	Information about the grid nodes.
GridConnect	Grid Connecting Element	Information about the elements such as lines connecting the grid nodes.
GridCap	Grid Element's Capacity	Maximum power flow of a grid element.
GridBaseFlow	Grid Element's Base Flow	Power flow over a grid element before flexibility activation.
GridFactor	Grid Element's Sensitivity Factor	Matrix of sensitivity factors indicating the impact of power injection/withdrawal at a node onto the flows over related grid lines.
FlexBid	Flexibility Bid	Offer made by FSP for selling flexibility.
FlexPur	Flexibility Purchase Offer	Offer made by SO for buying flexibility. Includes current and desired imbalance position, total cost cap.
FCT	Flexibility Call for Tender	Flexibility call specification for a specific product.
GridRest	Grid Restrictions	Constraints assigned to flexibilities which cannot be (fully or partially) activated without causing congestions in the grid.
ClearBid	Cleared Bid	Cleared bids as the result of optimisation per relevant MO.
UpdateGrid	Updated Grid Information and Procurement Cost	Updated status of the network, total cost, and optimisation status as the result of optimisation per relevant SO.
MARICheck	MARI eligibility Check	Non-cleared bids as the result of optimisation, but eligible to be forwarded to MARI platform.
ListSO	List of impacted System Operators	List of SOs who should send the grid information and be addressed in grid qualification process.

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3 Technical description of the Coordination Platform

3.1 Architecture

High-level architecture of the software components of the T&D CP is presented on Figure 3.1.

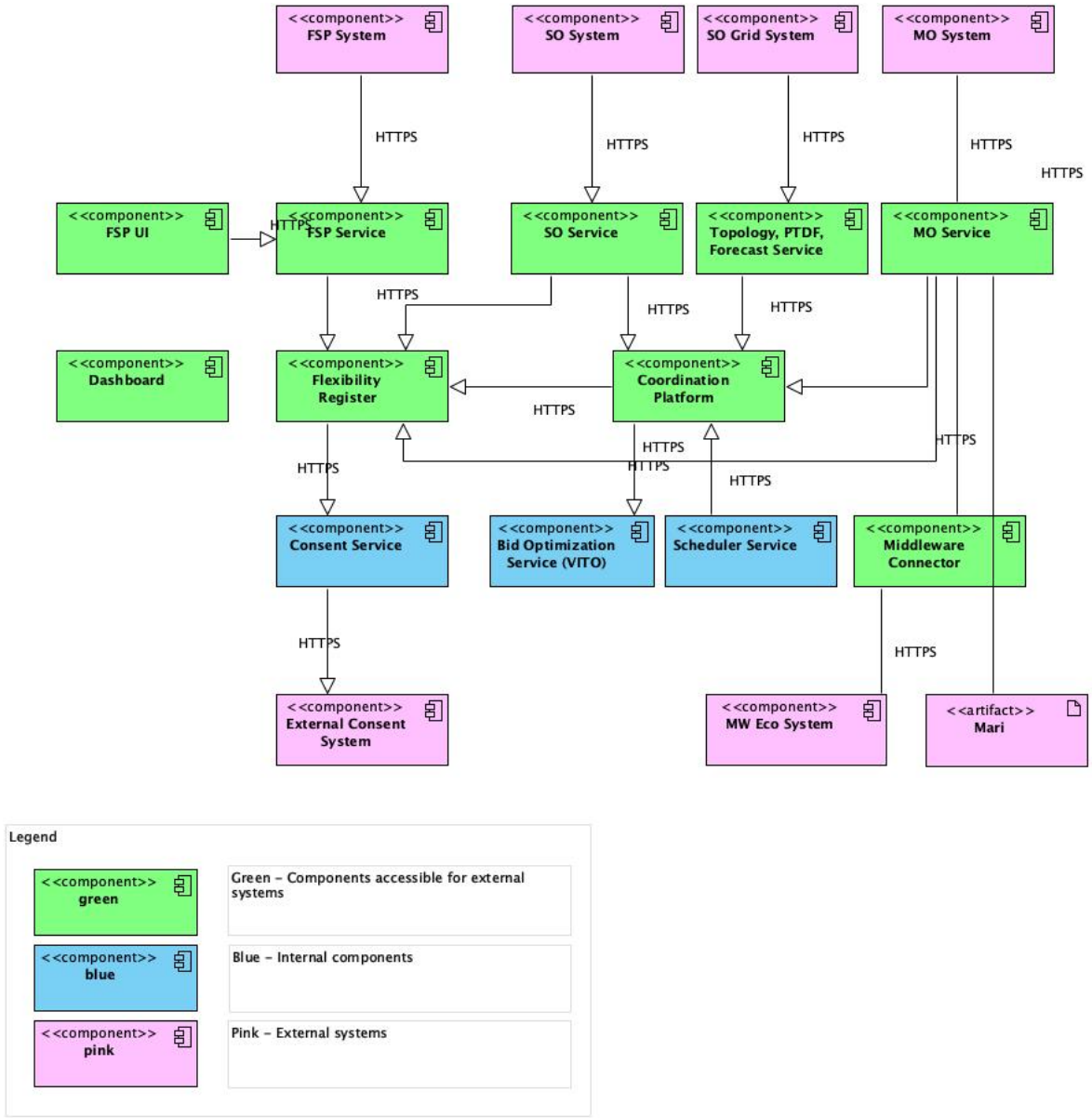

Figure 3.1 T&D CP components

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T&D CP is one of the main components of the Flexibility Platform developed in the Northern Demonstrator as part of the OneNet project. T&D CP main aim is to offer interfaces to MOs and SOs, enabling those actors and their systems to integrate with the platform for grid information management and flexibility procurement information exchange purposes. MOs can integrate to T&D CP either directly or through the OneNet Middleware ecosystem interface that is created in the scope of the OneNet project WP6 work. In addition, the MO Services API enables integrating with other potential flexibility trading platforms like MARI.

Coordination Platform is built highly modularized, enabling to easily extend the functionalities when new Flexibility Market or Product specific requirements emerge. The main components of the T&D CP are the following:

- Grid system component, managing the SOs topology, forecasts, and PTDF matrices information exchange with SOs;
- SO Services API that provides endpoints to SOs for exchanging information about their flexibility needs, flexibility calls for tender as well as purchase offers for flexibility procurement purposes;
- MO Services API that provides endpoints to MOs for exchanging information about the available bids for Optimisation, and activation orders after successful clearing of bids, but also gives MOs access to flexibility needs and open calls for tender information;
- Internal Schedule service that triggers different activities for flexibility procurement and verification processes based on flexibility product defined specifics;
- OneNet Middleware ecosystem connector that allows Market Operators integrate to T&D CP services without integrating directly to T&D CP.

3.2 Non-functional requirements

The functional requirements of the T&D CP are defined by the SUCs described in Chapter 2. Coordination Platform non-functional requirements (NFRs) for performance, configurability and other expectations are described in Appendix E.

3.3 Data model

T&D CP conceptual data model covers the needs to managing information about each SO topology, forecasts and PTDFs information as well as handling information about Flexibility Needs, Calls for Tender, Purchase Offers, Bids, Activation Orders, and Delivered Flexibilities calculated by Flexibility Register.

T&D CP high level conceptual data model is described on figure 3.2.

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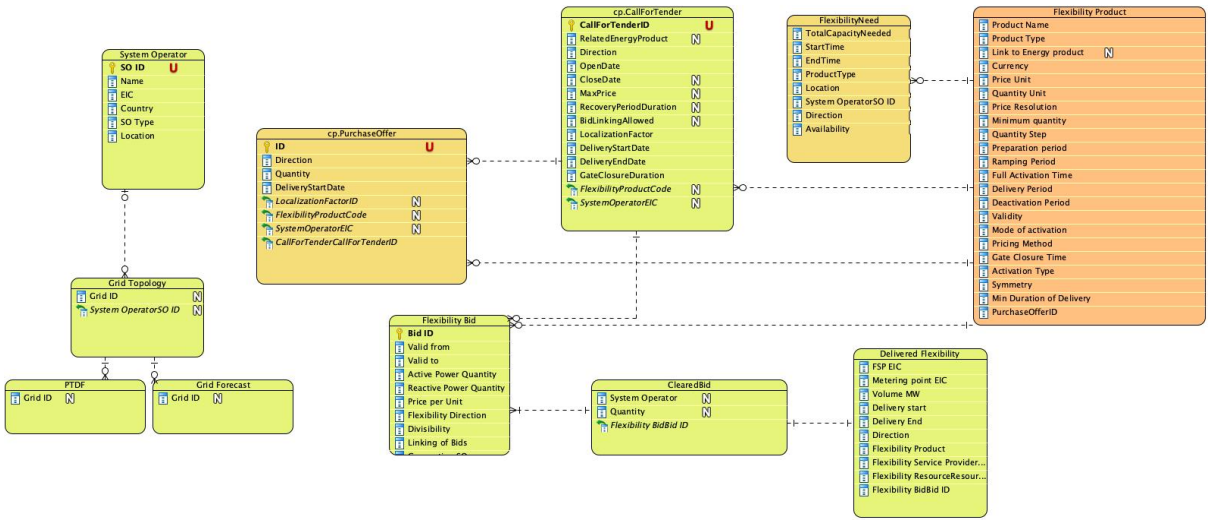

Figure 3.2 Conceptual data model for TSO-DSO Coordination Platform

On top of the internal data model, T&D CP supports CIM-data formats for external integrations with MOs, SOs and different external systems like MARI. Translation between the external CIM-data formats and other potential data formats provided by any stakeholder is done during T&D CP and stakeholder system integration.

CIM data formats supported by the T&D CP are described in Table 3.1. An example of Bid CIM profile is described in Appendix K.

Table 3.1 CIM data formats names

Data Object	CIM element	Namespace
Grid topology		
Grid sensitivity		
Grid forecast		
Flexibility Need		
Flexibility Call for Tender		
Bid	ReserveBid_MarketDocument	xmlns="urn:ebix.eu:ProofOfConcept:1:0"
Purchase Offer		
Cleared Bid	AllocationResult_MarketDocument	xmlns="urn:ebix.eu:ProofOfConcept:1:0"
Verification result		

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3.4 Integrations

Several components need to be integrated – T&D CP and Flexibility Register as core components with each other, and in addition with external parties like SOs, MOs, FSPs, data hubs, CA. All these components can act as data providers and data users.

T&D CP offers MOs and SOs and other relevant parties like data hubs and consent administrators a list of services with specific input and output data formats. Integrations are done using 3 possible methods:

- T&D CP specific data format
- CIM data format
- Stakeholder-specific data format, where needed

Stakeholder specific integrations for Northern Demonstrators are described in the Chapter 5. T&D CP provides 3 types of integration services:

- **T1:** Sending info to the platform through REST API to T&D CP
- **T2:** Receiving info from the platform
- **T3:** Providing info to the platform on demand

The list of services provided for stakeholders for integration is grouped by the stakeholder role. Preliminary MO-specific APIs and services are listed in Table 3.2 and SO-specific APIs and services in Table 3.3. These tables include APIs for both T&D CP and Flexibility Register.

Table 3.2 MO APIs and services

API	Description
MO-T1-FSP: Request list of qualified FSPs	REST API for authenticated MOs to request a list of FSPs who have valid resource groups to provide flexibility for specific flexibility products and have agreed to offer their services to that MO
MO-T1-BIDVAL: Request bid validation	REST API for MO to validate the bid by calling FR bid validation service. Bids are not saved in the system for optimisation or other purposes.
MO-T1-BIDS: Send bids for Optimisation	REST API for MO to provide bids for flexibility trading optimisation. Bids are saved in the system for optimisation and verification purposes.
MO-T1-FCT: Request FCT information	REST API to enable MOs to receive information about open Flexibility Call for Tenders, to decide whether they will ask for bids from FSPs.
MO-T2-FCT: Receive Flexibility Call for Tender info	An MO specific API (provided separately by each MO) to receive timely information about open Flexibility Call for Tenders.
MO-T2-FN: Receive Flexibility Need info	An MO specific API (provided separately by each MO) to receive timely information about new Flexibility Needs.
MO-T2-AO: Receive Cleared Bids info	An MO specific API (provided separately by each MO) to receive the result of bids optimisation process.

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MO-T2-CAO: Receive Counteraction Order	An MO specific API (provided separately by each MO) to receive the info about counter activation orders.
MO-T1-AO: Provide MARI/OTHER Activation Orders	REST API to accept MARI (or other) platform market bids activated outside of the OneNet Platform.
MO-T2-VER: Receive verification results	An MO specific API (provided separately by each MO) to receive the info about verification results for previously cleared bids.
MO-T1-MAR: Receive Market Outcome info	REST API for authenticated MOs to provide information to the platform about concluded trades.
MO-T2-CON: Receive Counter activation Need info	An MO specific API (provided separately by each MO) to receive the info about counter activation needs.

Table 3.3 SO APIs and services

API	Description
SO-T1-GRID: Send grid info	REST API for authenticated SOs to upload grid-specific information: current topology (nodes, connections), sensitivity factors, capacities and forecasts information.
SO-T1-FN: Send Flexibility Need info	REST API for authenticated SOs to provide new Flexibility Needs information that will be distributed to MOs and FSPs.
SO-T1-FCT: Send Flexibility Call for Tender info	REST API for authenticated SOs to open new Calls for Tender information that will be distributed to MOs.
SO-T1-PO: Send Purchase Offer info	REST API for authenticated SOs to provide Purchase Offers information that will be used as input for actual bids optimisation.
SO-T1-RG: Request qualified resource groups' info	REST API for authenticated SOs to ask information about potential resources to be used for offering flexibility.
SO-T2-FORE: Receive updated Forecast info	An SO specific API (provided separately by each SO) to receive the updated forecast information after bid optimisation is performed, considering the cleared bids effect on the network.
SO-T2-AO: Receive Cleared Bids info	An SO specific API (provided separately by each SO) to receive the result of bids optimisation process.
SO-T2-MO: Receive Market Outcome	An SO specific API (provided separately by each SO) to receive the market outcome info.
SO-T2-OPT: Receive Optimisation	An SO specific API (provided separately by each SO) to receive the rest of the results of bids optimisation process.
SO-T2-VER: Receive verification results	An SO specific API (provided separately by each SO) to receive the result of the delivered flexibility verification calculation process.
SO-T3-GRIDQ: Provide resource grid qualification result	An SO specific API (provided separately by each SO) to give the Platform information about resource grid qualification.
SO-T2-RG: Provide resource group testing input	An SO specific API (provided separately by each SO) to give the Platform information about resource grid qualification.
SO-T1-RGR: Send resource group testing result	REST API for authenticated SOs to provide resource group testing result.
SO-T3-METER: Provide metering data on demand (datahub)	An SO specific API (provided separately by each SO) to give the Platform metering data that is used for delivered flexibility verification.
SO-T3-CONSENT: Provide metering point owner consent info on demand (datahub)	An SO specific API (provided separately by each SO) to give the OneNet Platform valid consent information that is needed to allow processing metering data on the platform

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3.5 Product-specific processes on T&D CP

The functional requirements for T& D CP are described in the SUCs in Chapter 2. These requirements are translated into system functionalities and processes. High level overview of the functionalities and processes supported by the T&D CP:

a) Grid topology management - Collecting, maintaining, and provisioning topology and baseflows information for resource prequalification as well as bid Optimisation and clearing for activation processes;

b) Grid qualification of resource - Qualification of flexibility resources from grid capacity perspective is done on the T&D CP in different phases – prequalification and procurement of capacity or energy. The objective of grid impact assessment is to avoid congestions by setting restrictions on the activation of flexibilities which would cause congestion in grids. Grid impact assessment is central activity of grid qualification process. There are two alternatives possible for grid qualification. Firstly, concerned SOs can identify grid restrictions (constraints) by itself and provide the results to T&D CP through SO services API. Secondly, an alternative qualification service to calculate network restrictions is done by the TSO-DSO Coordination Platform.

c) Flexibility Needs, Flexibility Call for Tenders and Purchase Offers management - Sharing information from System Operators about their implicit and explicit flexibility needs and commitments to purchase flexibility to other market stakeholders – MOs and FSPs. On T&D CP, the SOs can indicate their flexibility procurement needs in different forms:

   a) Providing an indicative Flexibility Need - A flexibility need is an indication from an SO for readiness to purchase flexibility of specific products and can cover, in addition to product specifications, specific time, location, and quantity. A published flexibility need is an indication from an SO who needs the flexibility but is not a commitment to procure. Published flexibility needs are aimed to help MOs surface more suitable flexibility service providers. A published flexibility need is an indication for collecting specific bids but is not used as a system activity trigger in any processes.

   b) Providing a binding Flexibility Call for Tender - A Call for Tender of flexibility services is provided for specific products (mainly capacity reservation) and covers, in addition to product specifications, info about specific periods (week ahead, day ahead, intraday, etc.), location, quantity for flexibility procurement needs. The call for tender is initiated by the SO who needs the flexibility through SO Services API. Information about all calls is collected and stored centrally on the CP and made available to concerned MOs.

   c) Providing explicit Purchase Offers - A Purchase Offer (PO) is a commitment from SO to purchase certain flexibility. A PO provides specific information about the product, direction, quantity, time

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when flexibility is needed, and the cost SO is ready to take. A Purchase Offer is used in the bids' Optimisation process as one critical input, to match identified congestion issues on available grid information with bids received from MOs. For capacity reservation products, an explicit PO is not needed from the SO, instead, PO is automatically created based on the initial information the SO has provided in the Flexibility Call for Tender.

4. Bid Optimisation – Optimising the selection of bids for procurement based on the impact on grid as well as the economic value. Optimisation is done in an external Optimisation engine, which is detailed in chapter 0, and T&D CP role is to collect the necessary input information (grid, forecasts, PTDFs, bids, and purchase offers), pass it to the Optimisation engine, receive the Cleared bids and other Optimisation results, and forward the decision to the relevant market stakeholders (MOs, SOs). T&D CP compiles the input from grid topology, bids, received purchase offers and FCT where applicable.
5. Bid selection for activation - Selection of bids for energy activation Optimisation based on previously performed capacity reservation Optimisation process results. Cleared bids are communicated to MOs to create Activation Orders for FSPs.
6. Verification results communication – After the activated bids flexibility is triggered, delivered flexibility quantities and deviations are calculated on a regular basis by verification process. The result of this process is communicated from T&D CP to MO, who performs respective remuneration and penalties calculation and communication to related parties (FSPs and SOs).

Specific flexibility procurement-related activities have different characteristic needs, dependent on what capacity or energy product is being procured. In order to handle those specifics in a timely manner, there is a central Scheduler service implemented on the T&D CP. This Scheduler service main goal is to coordinate and triggers specific steps like bid Optimisation, and verification calculation processes.

Each flexibility product defined and offered by different MOs represents the demand from SOs and has its own specific technical details and timeline that results in a slight modification in the procurement procedure, both in the interaction between MO and T&D CP, as well as the steps concluded for the potential capacity reservation and actual energy activation process.

Those product-specific processes are:

- **NRT-P-E:**
  - NRT-P-E Flexibility product delivery need can be expressed by the SO by submitting a Flexibility Need to the relevant energy market (optional).
  - Flexibility Product Purchase offers are submitted by the SO to the T&D CP at the latest 23,5 minutes before the expected flexibility activation time.
  - Optimisation to clear bids for activation order is performed close to the actual activation time.

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- Verification of the delivered flexibility according to Cleared bid activation order and actual delivery calculated from the metering data baseline, with deviation as a difference between activation order and actual delivery.

- **ST-P-E:**
  - ST-P-E Flexibility product delivery need is expressed explicitly by the System Operator by submitting a Flexibility Need to the relevant energy market.
  - A virtual gate closure for collecting bids is agreed to happen 1 hour before the expected delivery time.
  - Flexibility Product Purchase offers are submitted by the SO to the T&D CP at the latest 60 minutes before expected flexibility activation time.
  - Optimisation to clear bids for activation order is performed close to the actual activation time.
  - Counter Activation needs are forwarded to MO and recalculated grid information is forwarded to SO ahead of time.
  - Verification of the delivered flexibility according to Cleared bid activation order and actual delivery calculated from the metering data baseline, with deviation as a difference between activation order and actual delivery.
- **ST-P-C:**
  - Flexibility product delivery need is expressed explicitly by the SO by submitting a Flexibility Call for Tender.
  - MO will submit the capacity bids before the Gate closure time.
  - Actual bidding on the energy market will be checked by the MO, the reservation settlement and actual delivery verification is not part of the platform functionality.
- **LT-P-C:**
  - Flexibility product delivery need is expressed explicitly by the SO by submitting a Flexibility Call for Tender.
  - MO will submit before the Gate closure time.
  - The actual bidding and delivery on the energy market is checked by the MO, the reservation settlement and actual delivery verification is not part of the platform functionality.
- **LT-P-C/E:**
  - Flexibility product delivery need is expressed explicitly by the SO by submitting a Flexibility Call for Tender.
  - MO will submit before the Gate closure time.
  - The procurement and optimisation process consists of 2 separate phases:

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- In the first phase the SO will publish their Flexibility Call for Tender and ask MO to provide bids to reserve some capacity.
- In the second phase, the SO will provide Purchase Offers ahead of time to indicate their readiness and need for actual activation of energy, based on which another optimisation round will be performed to decide the actual quantity to be activated.

- The reservation settlement is done by MO, but the actual delivery verification is calculated as part of the platform verification process and delivered flexibility deviation is calculated as a difference between the metering data baseline and the activation phase cleared bids activation order quantity.

3.6 Integration to OneNet Framework

One of the main objectives of OneNet project is to enable secure, standard and scalable cross-platform data exchange between European energy sector stakeholders at all levels, from TSOs to DSOs, from small consumers to large producers regardless of physical location.

The technical solution for this purpose is the OneNet Framework, which facilitates platforms integration and cooperation. OneNet Framework contains OneNet Middleware as main component and OneNet Connectors that are included as software packages to every exact platform maintaining the connectivity to potential stakeholders.

The WP7 T&D CP enables communication with MOs connected to OneNet Framework, including following processes:

- Bids collection and forwarding to Coordination Platform for optimisation;
- Cleared bids forwarding to Market Operator

Figure 3.3 depicts Northern demonstrator's participation in OneNet Framework.

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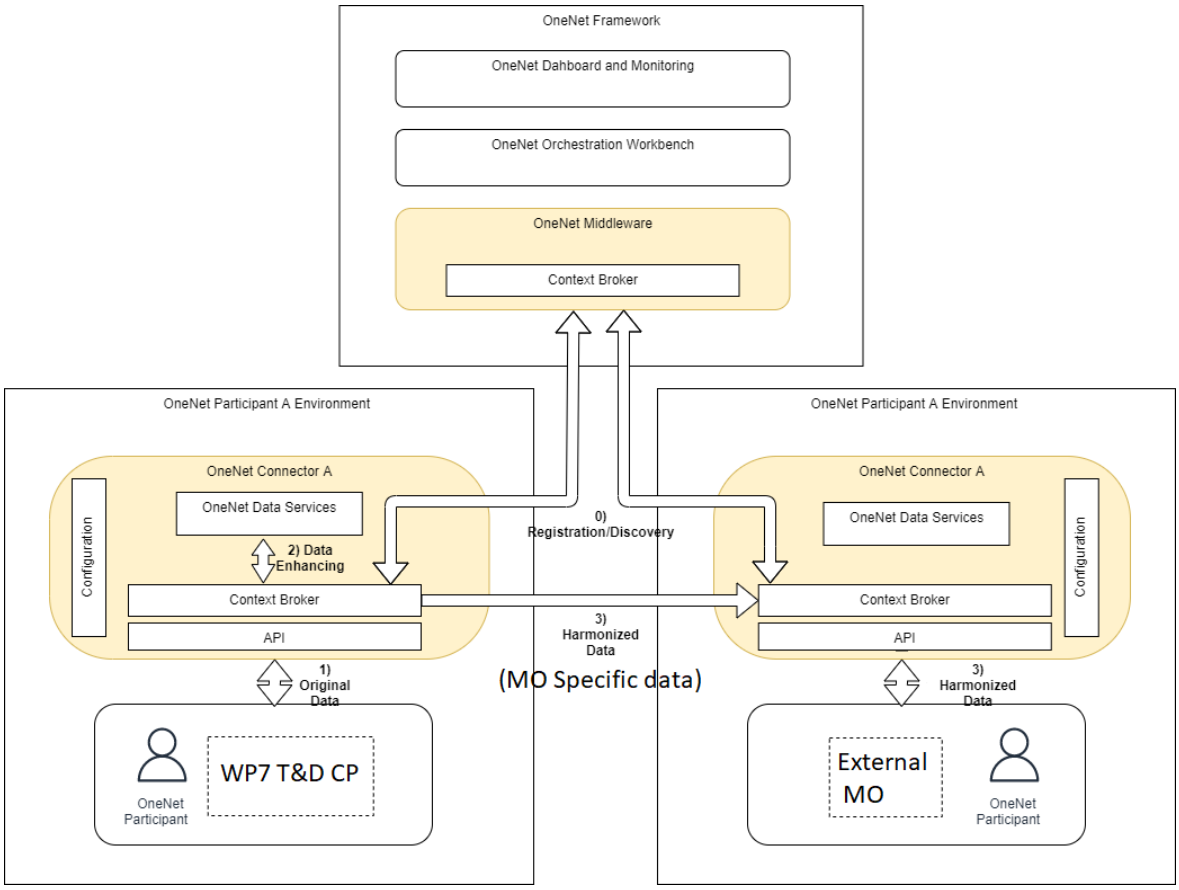

Figure 3.3 Northern demonstrator's participation in OneNet Framework

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4 Optimisation algorithm of the Coordination Platform

4.1 Optimisation-based market clearing: motivation and fundamentals

The Northern Demonstrator is a joint effort between TSOs and DSOs to set-up efficient and coordinated flexibility markets. To support this goal, an optimisation-based market clearing is proposed and implemented which enables the optimal and coordinated flexibility procurement by all related SOs while meeting the operational limits of all participating grids. The objective of this model is to maximise the procurement efficiency, in other words, to minimise the SOs' total cost when purchasing bids, while providing an adequate remuneration to the FSPs, while abiding by the grids' operational limits and the FSPs technical requirements. At the end, the optimisation provides a solution which is cost-efficient, guarantees the networks' reliability/security, and respects any FSPs' limitations. The optimisation module is developed using a general and scalable methodology, described in Figure 4.1 which allows its application to different products (energy, capacity, multiple time frames) and flexibility needs (congestion management and balancing).

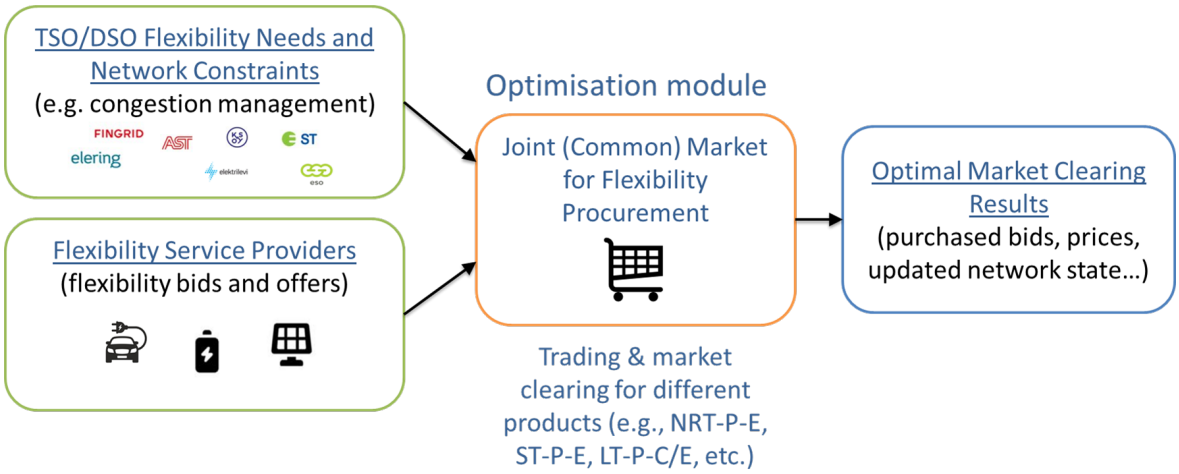

Figure 4.1 General overview of the optimisation module

More specifically, the optimisation-based market clearing quantifies the value of a bid in meeting the flexibility need (e.g. congestion management, imbalance settlement) by its power flow calculated effect on the flows over all the lines in the system. This approach is based on the use of ***Power Transfer Distribution Factors (PTDFs)***. With that methodology, the optimisation module ensures that the purchased flexibility meets the services needs of the interconnected system, (i.e., congestion management, or balancing, for which the flexibility market is set up) while, importantly, not causing other network operational issues (in any of the systems jointly procuring flexibility). This implies that the grid qualification process is optimally embedded in the

flexibility procurement process - as first described in the Bid Optimisation use case in Section 2.1.2. As a result of this process, the list of optimally cleared bids is not a simple traditional Merit Order List, but rather a set of optimally selected bids which considers concurrently each bid's price and its impact on each network component. More details on this methodology are given in Section 4.2 and Section 4.3.

To run the optimisation-based market clearing, two sets of inputs are needed: 1) TSOs/DSOs flexibility needs and network constraints (this element will be split in Section 4.4.1.1 into the purchase offer input and the network representation input); 2) FSPs bids and offers to fulfil the flexibility needs. Both are detailed in Section 4.4.1. The list of inputs will vary depending on the product being procured (e.g. NRT-P-E, ST-P-E, LT-P-C, etc.), where the distinctions are explained in Section 4.5 together with market clearing examples. Moreover, the results of the module, which include the cleared bids, the total procurement cost, and the updated status of the network after activating the selected bids, are detailed in Section 4.4.2. Finally, the integration of the optimisation module with the T&D platform is described in Section 4.4.3.

4.2 Grid impact assessment: a Power Transfer Distribution Factor based approach

In order to quantify the impact of clearing a bid in the networks' components, the optimisation-based market clearing uses ***PTDFs***, which are also known as sensitivity matrices or impact factors [17]. PTDFs are calculated based on a linearisation of power flow equations [18] and capture how the flow over each line in the system changes when an injection over a certain bus changes, and are applicable to both radial and meshed systems. The mathematical representation of PTDFs is shown in Figure 4.2 (where $\boldsymbol{X}$ is the PTDF matrix for a system composed of L lines and N nodes), which shows, as an example, how the flow over line 1, denoted by F_1, changes when the injections over each node (i.e., P_1, P_2, …, P_N) changes.

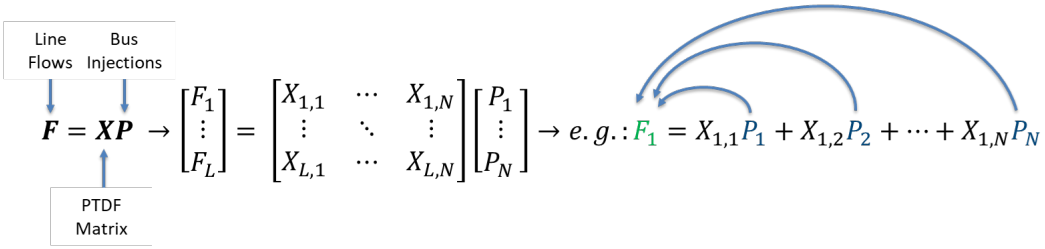

Figure 4.2 Mathematical Representation of PTDFs

where $\boldsymbol{X}$ is the PTDF matrix, while $\boldsymbol{F}$ and $\boldsymbol{P}$ are the vectors of line flows and nodal power injections, respectively.

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To illustrate the application of PTDFs matrices in bids selection, consider the network in Figure 4.3 Consider that there is a flexibility need of 2 MW over line L (i.e., congestion management), and two bids are available to fulfil the need (see Table 4.1). A simple Merit Order List to resolve the 2 MW need would select Bid A, as it is the cheapest bid in nominal terms (i.e., 45 €/MW as compared to 50 €/MW, for bid B). However, the PTDF described in row "Impact w.r.t L" shows that the impact of clearing Bid A on reducing the line flow over line L is lower than the impact of clearing Bid B, hence, requiring purchasing less power from bid B than from bid A to resolve the 2 MW congestion need over line L (as shown in the row labelled "Need quantity (MW)" showcasing how much power would need to be purchased from each bid to meet the 2 MW line flow reduction need over line L). Therefore, when coupling the needed quantity to be purchased, with the price of each bid, Bid B is a better match to fulfil the flexibility need over line L, rendering the purchasing of 2.22 MW from Bid B the most optimal result.

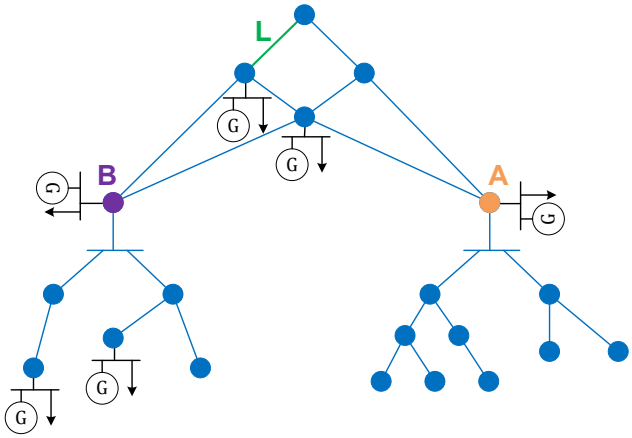

Figure 4.3 Example of network with flexibility need in line L

Table 4.1 Example data

	Bid A	Bid B
Bid Price (€/MW)	45	50
Offered quantity (MW)	5	5
Impact w.r.t $\boldsymbol{L}$	0.7	0.9
Needed quantity (MW)	2.86	2.22
Total cost (€)	128.57	111.11

It is noted here that this simplified example is added to introduce the use of PTDFs in the developed optimisation-based market clearing module. In the actual implementation (as detailed further in the remainder of this chapter), the effect of the activation of any portion of any bid on the flow of any line (on the transmission and distribution levels) is taken into account in the optimal decision of which bids to purchase and at which

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level. The goal is to resolve the already existing congestions, without leading to the creation of new ones, and doing so at the least possible cost. The current setting in the demonstration focuses primarily on the lines' congestion management (i.e., focusing on line flows and their capacity limits). Hence, the current implementation does not focus on voltage issues. However, voltage requirement can be readily incorporated in the optimisation module using similar sensitivity matrices as the PTDFs.

In principle, as detailed in Section 4.4, the PTDFs are part of the inputs to be communicated to the optimization module for every market clearing session (i.e., every market time unit), hence, the module can accommodate the reception of a different PTDF matrix for each grid for every different market time unit. However, in practice, the SOs can assess whether their grid state has changes significant enough to communicate a new set of PTDFs, or to use the one already in place form the previous market time unit.

4.3 Bid formats: from simple to complex linked bids

In order to represent flexibility service providers' constraints when providing flexibility, and to harmonize the bids with other markets (e.g. MARI [19]), different types of bids are integrated in the Northern demonstrator[5]. Simple bids define the smallest element in the structure of bids, and they can be of three types (fully divisible, indivisible, or partially divisible), depending on their divisibility property and minimum quantity requirement. Those three types are depicted in Figure 4.4 in which:

a) Represents fully divisible bids, that can be cleared from 0 to the offered maximum volume (thus, not including any minimum bid clearing quantity requirement);
b) Represents indivisible bids, that can only be cleared at the offered volume (all or nothing); and
c) Represents partially divisible bids that can be cleared from the minimum quantity requirement to the offered volume.

[5] Here we mention that the flexibility market implemented in the Northern demonstrator focuses on a setting in which flexibility service providers offer to deviate from their anticipated (or at instances, scheduled) injection/consumption levels to provide flexibility as a service to the grid (by generating and injecting more or less power, or consuming more or less power). This type of flexibility offering is captured through the submitted bids. This type of market-based flexibility provision is different than other implicit flexibility procurement mechanisms which can be put in place through, e.g., connection agreements (limiting the injection or consumption levels of a connected resorce/aggregation of resources) or through response to communicated price signals and tariffs.

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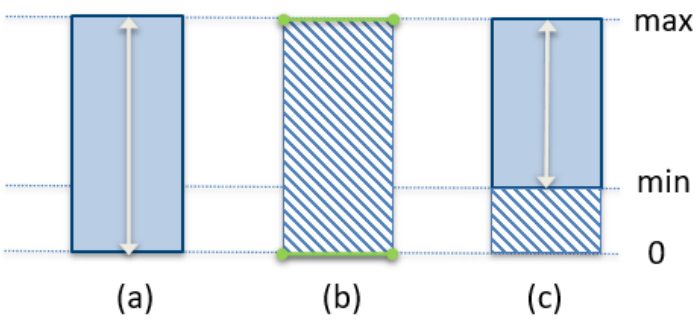

Figure 4.4 Types of simple bids considered

Complex bids group together simple bids, which are associated in two defined ways (exclusive or multipart), depending on the technical and/or economic constraints of the FSPs' energy assets. For instance, exclusive bids can be used to model start-up costs with different prices and quantities, and multipart bids can be used to model technical dependencies between assets (e.g., one resource can only be cleared after another one).

Exclusive bids are composed by a group of simple, indivisible bids and their clearing rule is that at most one of the group's bids can be activated, which means that the activation of one bid excludes the activation of the other bids inside the exclusive group. The simple bids within the exclusive group can have different quantities and prices, but must be of same direction (i.e., all must be upward or all must be downward) and must be of type "indivisible". One should notice that ENTSO-E rules for the MARI platform are slightly different from the ones described here (e.g., simple bids in exclusive set can have different direction and different types) [19].

Multipart bids (parent-children bids) are composed by one simple bid tagged as parent and a group of simple bids tagged as children. Their clearing rule is that children bids can only be purchased at any level if the parent bid is purchased (at any level, i.e., no requirement of fully purchasing the parent bid, unless that bid is of type "indivisible"). The components of multipart bids, regardless of their tag, can be of any simple bid type and can have different prices and quantities, but all must be of same direction (i.e., all must be upward or all must be downward). Also in the case of multipart bids, ENTSO-E rules for the MARI platform are different from the ones described here (e.g., the clearing order of the complex bids depends on the simple bids prices) [19].

4.4 Optimisation module

4.4.1 Input data

To be able to optimally select the bids while performing the grid impact assessment (through the PTDF methodology) and respecting FSPs' restrictions (by the rules on bids' types), three sets of inputs are needed by the optimisation module when clearing the market: Purchase Offer, Network Data, and Bid Data. For each

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market session (e.g., procuring flexibility capacity for the congestion management of the Latvian TSO-DSO network for the next year), these three datasets have to be provided to the optimisation module. Depending on the product being procured, fields in the datasets are mandatory, optional, or not applicable. In this section, the main aspects of the datasets are described[6], while the distinctions due to the targeted product are presented in Section 4.5.

4.4.1.1 Purchase Offer

The Purchase Offer is a dataset with the fundamental information to launch the market clearing optimisation for a specific market session. It includes the product type (i.e., NRT-P-E, ST-P-E, ST-P-E-rec, ST-P-C, LT-P-C/E-res, LT-P-C/E-act, LT-P-C), the start and end date of the procurement, the imbalance position of the interconnected systems (which indicates if a balancing need is to be included), a total cost cap for the market session, and the expected number of hours of activations of the bids. This dataset consists of a subset of two business objects of the Coordination Platform: Flexibility Call for Tender and Purchase Offer (see Figure 3.2).

4.4.1.2 Network Data

The Network Data includes multiple datasets – representing the network topology, characteristics, and operational status and limits – which serves to define the grids' operational limits and grids' impact assessment of purchasing bids. As the Northern demonstrator is a regional flexibility market, one transmission system operator (or a collection of TSOs through a joint regional network representation) connected to one/multiple distribution system operators can jointly procure flexibility. Therefore, datasets for transmission and distribution networks are provided separately, which are then interconnected by the optimisation module based on the physical interconnection in place. However, for some products/markets, only one network information is provided, in which case the description of interconnections would no longer be necessary.

As described in Section 4.2, the grid model considered in the optimisation module allows the representation of any type of network, either radial or meshed. To define the congestion needs, the grid's operational limits, and the impact of clearing bids on the grids' components, each system operator must provide three sets of input network data:

- A list of the nodes of the network, including additional information for each entry as whether the node is a slack bus, and whether the node is connected to another network (to indicate interconnections, if applicable).

[6] More information on the datasets needed by the optimisation module is available at: https://onenetmarketclearing.vito.be/docs.

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- A list of the lines of the network, including the nodes they are connecting, their capacity, their forecasted flows, and if they should be checked for congestions (to which we refer as “critical” lines). Lines can also represent other network components (e.g., transformers).
- A flow sensitivity matrix (PTDF), which must be calculated considering the impact of increasing the injection at nodes on the flows over the lines.

The datasets explained in this section are constructed from the information provided in four business objects of the Coordination Platform: System Operator, Grid Topology, PTDF, and Forecast (see Figure 3.2).

4.4.1.3 Bid data

Bid data includes the information of the bids sent to the market session to fulfil the congestion and/or balancing needs of the system operators procuring flexibility. Following the description in Section 4.3, bid data is composed by three tables as follows:

- A list of simple bids, which includes location information (system and node), sense (if upward or downward), price, offered quantity, type (fully divisible, partially divisible, fully divisible), and minimum quantity (if bid type is partially divisible). All simple bids must be provided in this list, including the components of complex bids.
- A list of the exclusive bids, including the set of simple bids forming the exclusive group (indicated by their IDs). The simple bids in each exclusive bid will be checked according to the definitions in Section 4.3 and will be cleared following the market clearing rule.
- A list of multipart bids, each including the ID of the simple bid tagged as parent and the IDs of the simple bids tagged as children. All simple bids in each multipart bid will be checked according to the definition in Section 4.3 and will be cleared following the market clearing rule.

It is important to notice that not all bid types are included in all market sessions, since products can define which types of bids are allowed (e.g., complex bids are not permitted in the LT-P-C/E procurement). Therefore, only the simple list of bids is always mandatory, while the other two lists are optional or not applicable.

The datasets explained in this section are constructed from the information provided in the business object Flexibility Bid of the Coordination Platform (see Figure 3.2).

4.4.2 Optimisation output

For each market session, thus each set of inputs sent to the optimisation module, the following outputs are returned to the T&D Coordination Platform:

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- A list of cleared bids, each including some of the input fields to identify the bid (e.g., ID and system) and the cleared quantity. This list is composed by simple bids only, including the ones inside complex bids (as complex bids are just a group definition to include technical/economic constraints of the FSPs, and what is really cleared are the simple bids inside these groups).
- The total cost of the procurement, calculated according to the list of cleared bids. If applicable and depending on the product, reservation and activation costs can be returned in addition to the total cost.
- A list of updated flows over lines, each including some of the input fields to identify the line (e.g., ID and system), the flow over the line after activating the cleared bids, and the overflow over the line (in case the bids procured are not sufficient to completely resolve the congestion need).
- A list of updated flow over interface lines, each including some of the input fields to identify the interconnection (e.g., systems IDs that are connected through the line), the flow over the interface line after activating the cleared bids, and the overflow over the interface line (in case the bids procured are not sufficient to completely solve the congestion need). This list is only returned if the market session considered an interconnected system (multiple transmission/distribution system operators jointly procuring flexibility).
- The new imbalance position, calculated according to the list of cleared bids and the initial imbalance position (if applicable per product/market specification).
- The optimisation status, which indicates if all congestions were resolved by the cleared bids, if there is still congestion due to lack of input bids, if there is still congestion due to the total cost cap imposed by the system operators, or if the optimisation returned an error (due to inputs not complying with the data specifications).
- The timestamp, which is an informative field replicated from the Purchase Offer.

The Northern demo employs a common market setting [20][21], in which the different SOs jointly procure flexibility to meet their grid needs (e.g., congestion management at different grid levels and balancing, e.g., mFRR). The effect on the imbalance position and the congestion management process can also be regulated through inputs from the SOs (as highlighted in Section 4.4.1, limiting the impact on the caused system imbalance (if needed), and specifying the lines over which congestions are to be managed (i.e., critical lines). Those specifications (the initial line flows, capacities, and overflows; the criticality of the lines; the initial imbalance position and allowed variation range; and the network models and their PTDFs) enable the identification of each SOs' flexibility needs. The total cost incurred for this jointly procured flexibility can then be split among the participating SOs, depending on their flexibility needs that were met in the market, in a settlement period after the market clearing. Different methods can be employed to split those costs as introduced and analysed in [22]. For example, the split of costs can be done proportionally based on the flexibility needs of each SO.

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4.4.3 API and platform integration

The optimisation module is part of the T&D Coordination Platform explained in Chapter 3, and the integration between both is depicted in Figure 4.5 This integration is done through an API, hosted within VITO's premises, which receives the information needed for each market session/run, internally clears the market (runs the optimisation process), and sends back the results to the webhook provided by the T&D Coordination Platform. More specifically, to run each optimisation-based market clearing, the T&D Coordination Platform gathers the information needed from the different market participants – e.g., network and purchase offer data from system operators (SOs), bids data from market operators (MOs) – and translates it to the tables/sets specified in Section 4.4.1. Afterwards, the platform sends the three datasets (together with a unified request ID) to the API, which checks if the inputs respect the specification. If those are accepted, then a "run_market_clearing" command can be sent to start the market optimisation. When results are ready, the API sends them back to the T&D Coordination platform using the provided webhook. For security purposes, every day a token must be required before starting the market optimisation. Moreover, authorized users of the API (as the T&D Coordination platform) can directly register the webhook for receiving results.

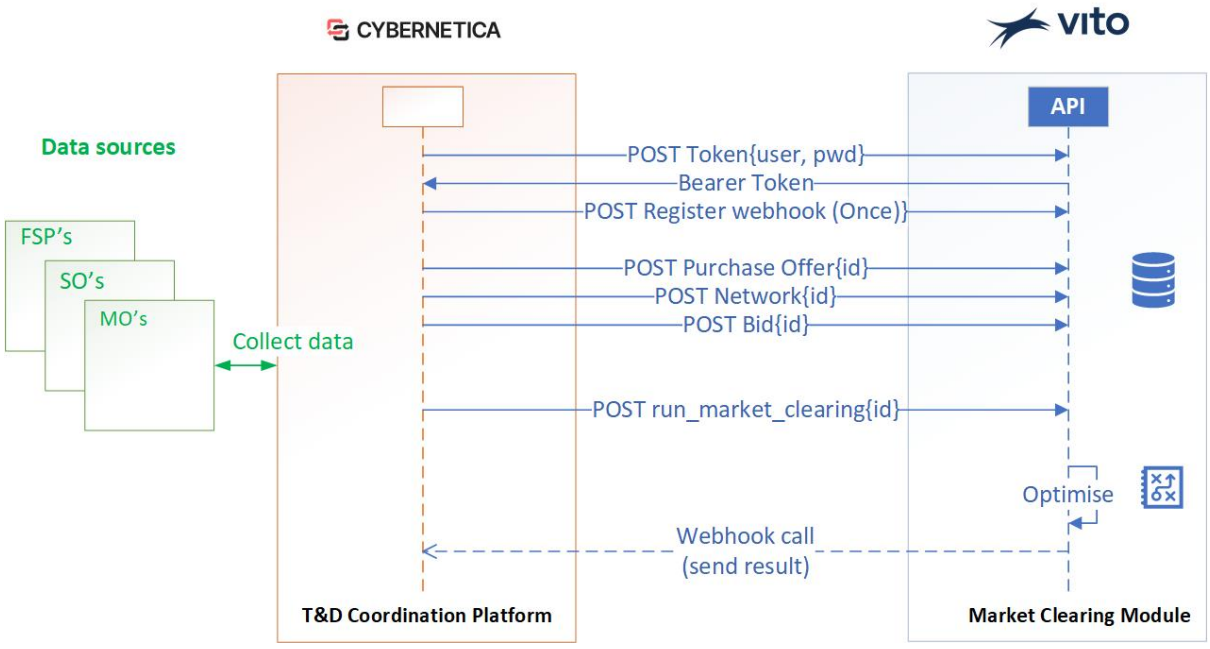

Figure 4.5 API and T&D Coordination platform integration

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4.5 Optimisation per product

As mentioned in Section 4.4, the optimisation module is run for each market session, thus for each market clearing call to purchase flexibility using a specific product (see about Northern demonstrator flexibility products in Section 1.3). In the Northern demo, multiple products are available to fulfil different needs of the system operators (e.g., NRT-P-E product is an energy product to procure active power in the near-real time for congestion management and/or balancing). Depending on the product, the optimisation model to clear the market is different, to consider the requirements of the SOs when procuring the specific product. In this section, those distinctions are presented, together with examples of market runs.

4.5.1 Near-real-time active energy product

The near-real-time active energy (NRT-P-E) product is an energy product to procure active power in the near-real time. Transmission and distribution system operators can jointly purchase flexibility bids using this product, for congestion management and/or balancing in the interconnected system. To be able to perform this function, the following specifications apply to the inputs of the NRT-P-E product optimisation-based market clearing runs:

- The Purchase Offer type is NRT-P-E.
- Given that this is a near-real time product, the imbalance position of the (interconnected) system must be provided in the Purchase Offer.
- The market clearing can be run for a single system or for an interconnected system.
- Node, Line, and PTDF information must be provided for each of the systems participating in the market call. For instance, if a single system is procuring the flexibility through the NRT-P-E alone, one table Node, one table Line, and one table PTDF are provided, without information about interfaces. On the other hand, if a transmission system and a distribution system are procuring the flexibility together, multiple tables Nodes, Lines, and PTDF are provided. In the last case, the interface between the systems is also provided.
- Only one slack node must be indicated in only one of the systems, to allocate the imbalances. This slack node must be well-defined in the PTDF (must have impact factors of 0 in the PTDF matrix).
- The product allows the three types of simple bids, and the two types of complex bids. Thus, the simple bids table must be provided, while complex bids tables are optional (depending on whether there were FSPs bidding complex bids).

To illustrate the market clearing of the NRT-P-E product, the following example is presented, which uses data provided by FINGRID created for demo purposes. A quick description of the data and an analysis of the results

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are given here, but all input datasets (purchase offer, network data, and bids data) and optimisation outputs are included in Appendix F: NRT-P-E example data.

The example consists of an 11-nodes transmission network connected to a one-node distribution network (i.e., a one-node representation of a distribution grid interconnection to the transmission system), which is depicted in Figure 4.6 and represents the interconnected grid status before the market clearing. In this figure, the grey node is the slack, and it is part of the transmission network. The forecasted imbalance of the interconnected system is provided in the Purchase Offer, and its value is 466.8 MW. No further imbalance is allowed in this example, thus the limits min and max of the imbalance position are also defined as 466.8 MW in the purchase offer, meaning that the market is cleared for congestion management only. The blue nodes are the other nodes of the transmission system, while the green node is part of the distribution system. The values over the lines are the forecasted flows (in MW), and red lines indicate congestion (forecasted flow surpasses line's capacity). For the transmission network, a 14x11 PTDF matrix is provided, to describe the impact of clearing bids in the flows over the lines. The distribution network does not have lines (one-node only), thus no PTDF is provided for this system.

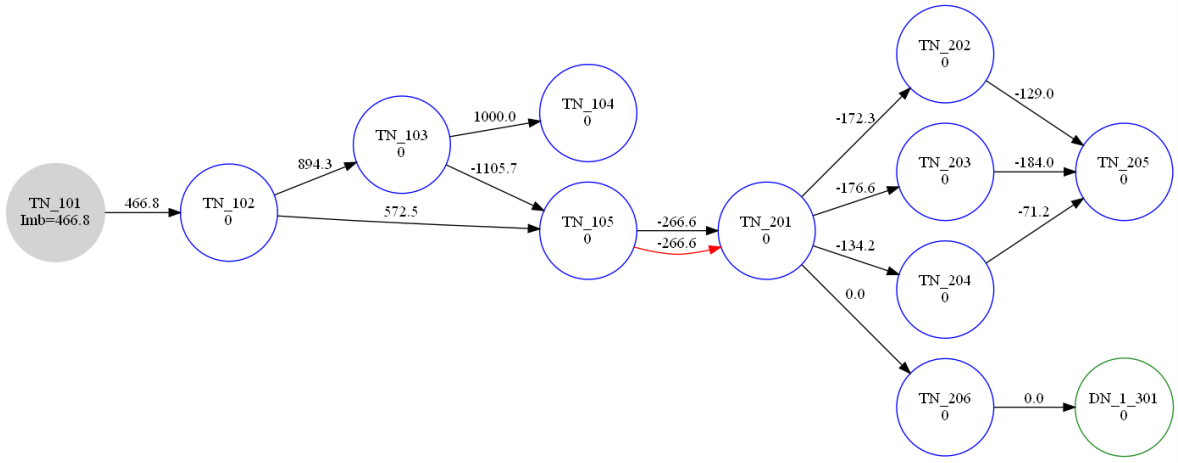

Figure 4.6 NRT-P-E example data for market clearing

The grey node is the slack and is part of the transmission network. The value inside the slack node indicates the forecasted imbalance of the interconnected system. Blue nodes are part of the transmission system. The green node is part of the distribution system. The values over the lines are the forecasted flows. The red line has congestion.

To solve the forecasted congestion, 32 simple bids are available in the different nodes of the interconnected system. Some of them are grouped in exclusive or multipart bids. With the purchase offer, network data and bids data, the market is optimally cleared and the result is shown in Figure 4.7 In the figure, the number in the

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nodes (circles) shows the cumulative amount of flexibility bids purchased from every node (positive for upward flexibility, negative for downward flexibility). The numbers shown on the lines/edges are the resulting flows considering the initial flows and the activation of the purchased flexibility from the nodes. 11 bids are cleared to be able to resolve all the forecasted congestion in the interconnected system without exceeding any other operational limits of the system. A total amount of 347.96 MW of upward flexibility and 347.96 MW of downward flexibility are selected. One can notice that the cleared quantity of upward and downward are equal in order to keep the same imbalance position. The total cost of this market session is 20,013.81 €, lower than the total cost cap of 50,000 €.

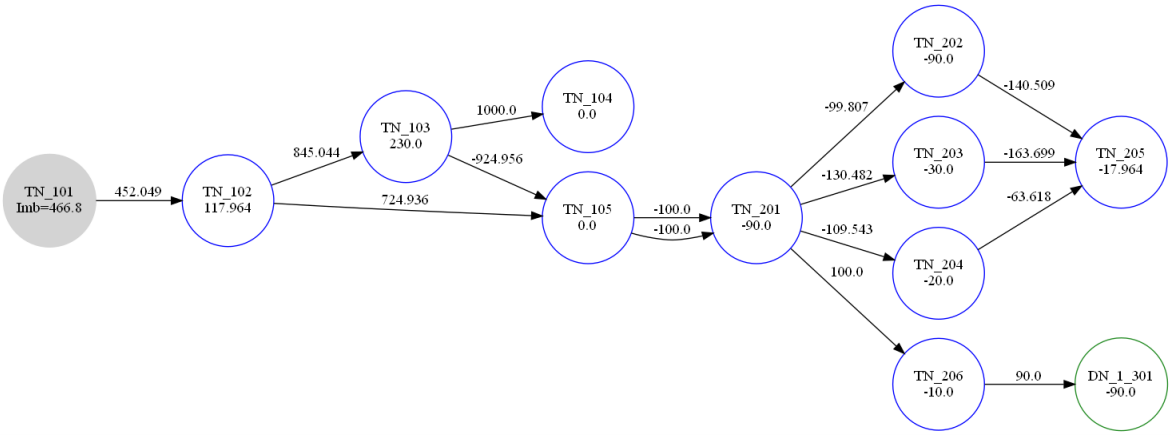

Figure 4.7 Result of the market clearing of the NRT-P-E example

All congestion is resolved, without an impact on the imbalance position. Values over the lines are the resulting flows after activating the cleared bids. Values inside the nodes are the total purchased flexibility in the node (positive for upward and negative for downward).

4.5.2 Short-term active energy product

The short-term active energy (ST-P-E) product is an energy product to procure active power in the short time. Transmission and distribution system operators can jointly purchase flexibility bids using this product, for congestion management and/or balancing the interconnected system. To be able to perform this function, the following specifications apply to the inputs of ST-P-E product runs:

- The Purchase Offer type is ST-P-E.
- Given that this is a short-term product, the imbalance position of the (interconnected) system can be provided in the Purchase Offer, but it is not mandatory. If not provided, the optimisation considers that no imbalance is foreseen, and that there are no imbalance limits for the system (i.e., the congestion management can create positive/negative imbalances).
- The market clearing can be run for a single system or for an interconnected system.

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- Node, Line and PTDF information must be provided for each of the systems participating in the market call. For instance, if a single system is procuring the flexibility through the ST-P-E alone, one table Node, one table Line, and one table PTDF are provided, without information about interfaces. On the other hand, if a transmission system and a distribution system are procuring the flexibility together, multiple tables Nodes, Lines, and PTDF are provided. In the last case, the interface between the systems is also provided.
- Only one slack node must be indicated in only one of the systems. This slack node must be well-defined in the PTDF (must have impact factors of 0 in the PTDF matrix). Even if the imbalance position is not explicitly provided, it is still necessary to define the slack node for managing imbalances during the optimisation process.
- The product allows two types of simple bids (fully divisible and fully indivisible), and no complex bids. Thus, only simple bids table must be provided.

To illustrate the market clearing of the ST-P-E product, the following example is presented, which uses the same data provided by FINGRID applied to the NRT-P-E product in Section 4.5.1. A quick description of the data and an analysis of the results are given here, focusing on the differences from the NRT-P-E example, but all input datasets (purchase offer, network data, and bids data) and optimisation outputs are included in Appendix G: ST-P-E example data.

The example consists of the same interconnected transmission-distribution network of the NRT-P-E example. Only the forecasted imbalance is different: in the ST-P-E example, no imbalance position is provided and no limit for the after-clearing imbalance is imposed. The interconnected network status before the market clearing is shown in Figure 4.8

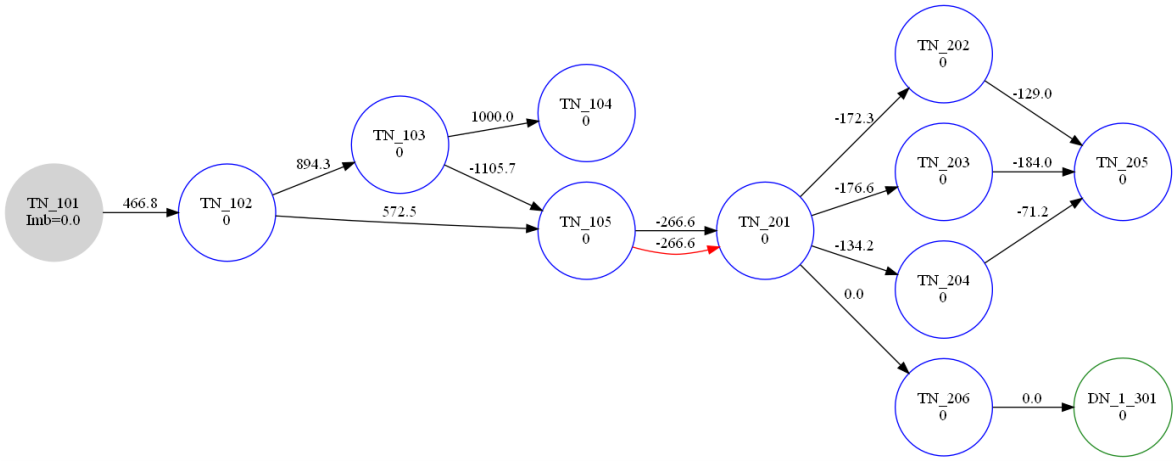

Figure 4.8 ST-P-E example data for market clearing

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The grey node is the slack and is part of the transmission network. The value inside the slack node indicates the forecasted imbalance of the interconnected system (which is 0 for this case). Blue nodes are part of the transmission system. Green node is part of the distribution system. Values over the lines are the forecasted flows. The red line has congestion.

To solve the forecasted congestion, 32 simple bids are available in the different nodes of the interconnected system, and they are of type fully divisible and fully indivisible. Partially divisible bids and complex bids are not allowed by this product. With the purchase offer, network data and bids data, the market is optimally cleared and the result is shown in Figure 4.9 In the figure, the number in the nodes (circles) shows the cumulative amount of flexibility bids purchased from every node (positive for upward flexibility, negative for downward flexibility). The numbers shown on the lines/edges are the resulting flows considering the initial flows and the activation of the purchased flexibility from the nodes. Differently from the NRT-P-E example, only 7 bids are cleared to be able to resolve all the forecasted congestion in the interconnected system without exceeding any other operational limits of the system. A total amount of 353.539 MW of downward flexibility is selected. No upward bid is cleared, because the imbalance position can be impacted in this example: one can notice that the final imbalance allocated to the grey node in the figure equals the total amount of purchased downward flexibility. This aspect also means a lower total procurement cost (of 4,970.78 €) to solve the same congestion as the one in the NRT-P-E example. No total cost cap was imposed in this example.

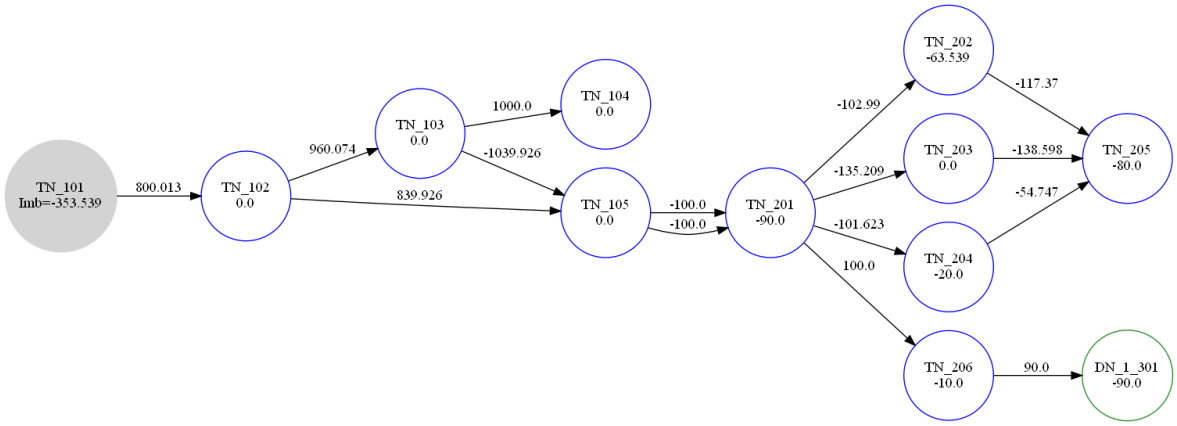

Figure 4.9 Result of the market clearing of the ST-P-E example
All congestion is resolved, with an impact on the imbalance position (shown in the grey node). Values over the lines are the resulting flows after activating the cleared bids. Values inside the nodes are the total purchased flexibility in the node (positive for upward and negative for downward).

Linked to the ST-P-E product, an artificial product to re-calculate the grid state is available, and it is called ST-P-E recalculate (ST-P-E-rec). This product is used to return the flows over the lines and interface lines after one

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or more bids that were purchased during the ST-P-E run are no longer available. The goal from this calculation is to have a measurement of the remaining need, due to the unavailability of a cleared bid, to be used as input in another market run (e.g., in another ST-P-E call, or in an NRT-P-E call). Therefore, the ST-P-E-rec run always requires the same network data as the one provided for its corresponding ST-P-E counterpart. Moreover, the bids input of the ST-P-E-rec is the output of the corresponding ST-P-E run, without the bids dropped out from the market in the meantime. To be able to calculate the new grid status, the cleared amount (dispatch) of each bid must be provided as well.

To illustrate the use of the ST-P-E-rec "artificial" product, the following example is presented. It is built from the ST-P-E example provided earlier in this section. Given the nature of this product, all network data is the same as the one of the ST-P-E examples (included in Appendix G: ST-P-E example data). As a result, the network state before the run of the ST-P-E-rec is identical to the ST-P-E one, which is presented in Figure 4.8 To easy the presentation of results and the explanation of ST-P-E-rec specifications, both purchase offer and bids data are provided here, in Table 4.2 and Table 4.3 respectively.

Table 4.2 Purchase offer data of ST-P-E-rec example

Type	Timestamp	Imbalance Position (MW)	Total Cost Cap (€)
ST-P-E-rec	Same as the corresponding ST-P-E • Start: 2022-06-30T04:00:00.000Z • End: 2022-07-30T04:00:00.000Z	Same as the corresponding ST-P-E. It was not provided for ST-P-E, thus optimisation uses default values. Only "actual" should be provided, as the goal is to recalculate all network state (including imbalance) • Actual: 0	Should not be provided, because the ST-P-E-rec is not a market clearing, but rather a grid state recalculation.

Table 4.3 List of bid inputs of ST-P-E-rec example

Bid 14, which was cleared in the ST-P-E, is no longer available. The other bids from the output of the ST-P-E are available. Field "dispatch" is included in the bids table to allow the recalculation.

Id	System Id	Node Id	Sense	Price	Quantity	Bid Type	Dispatch
14	TN	201	DOWNWARD	15	90	FullyDivisible	0.00
16	TN	202	DOWNWARD	10	60	FullyDivisible	60.00
18	TN	202	DOWNWARD	20	30	FullyDivisible	3.54
24	TN	204	DOWNWARD	18	20	FullyIndivisible	20.00
26	TN	205	DOWNWARD	17	20	FullyDivisible	80.00
28	TN	206	DOWNWARD	15	70	FullyDivisible	10.00
32	DN_1	301	DOWNWARD	12	90	FullyDivisible	90.00

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With those inputs, the optimisation module recalculates the grid state, and results are shown in Figure 4.10 In the figure, the number in the nodes (circles) shows the cumulative amount of flexibility bids dispatched in every node (positive for upward flexibility, negative for downward flexibility), following the input column "dispatch" in the bids table. The numbers shown on the lines/edges are the resulting flows considering the initial flows and the dispatch of the input bids from the nodes. Given that bid 14 is no longer available, line connecting nodes TN_105 and TN_201 has again congestion, overflow is of -44.981 MW (i.e., 44.981 MW when reversing the reference flow direction). The imbalance position is also affected: it becomes -263.54 MW, instead of the -353.539 MW of the ST-P-E result. The extended list of outputs is provided in Appendix H: ST-P-E-rec example data.

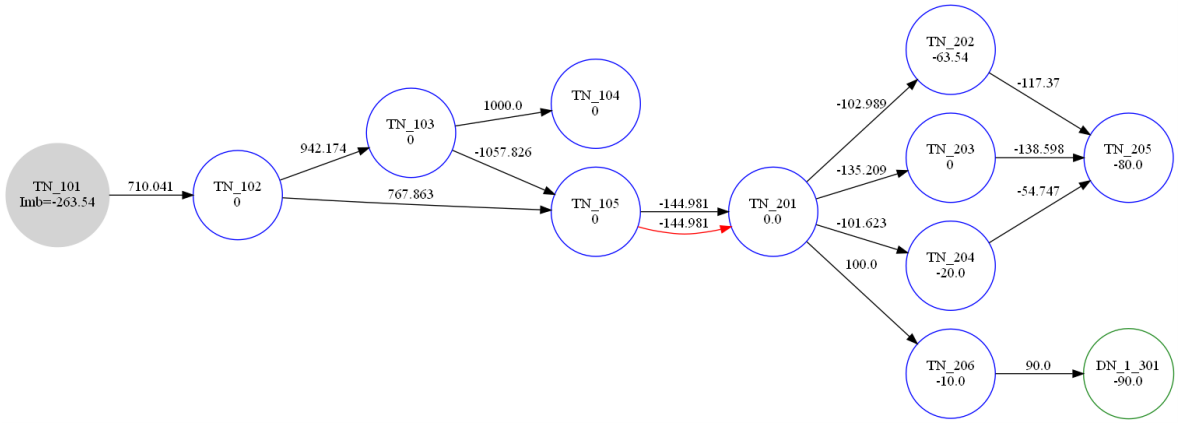

Figure 4.10 Result of the ST-P-E-rec

Congestion appears in line connecting nodes TN_105 and TN_201 due to the unavailability of one of the cleared bids of the corresponding ST-P-E run. Imbalance position is also affected. Values over the lines are the resulting flows considering the activation (dispatch) of the input bids. Values inside the nodes are the total activated/dispatched flexibility in the node (positive for upward and negative for downward).

4.5.3 Long-term active capacity/energy product

The long-term active capacity/energy (LT-P-C/E) product is a capacity and energy product to procure active power in the long term. It is designed for the needs of distribution system operators to optimally reserve capacity for congestion management and to also optimally activate the capacity reserved when needed. As the product is focused on DSOs, only one system operator purchases flexibility at the time, thus no interconnected systems are considered for this product. The LT-P-C/E has two phases (reservation and activation), which are optimised separately. In the reservation phase, the input specifications are as follows:

- The Purchase Offer type is LT-P-C/E-res (reservation).

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- Given that this is a long-term product, the imbalance position of the system is not considered and should not be provided in the Purchase Offer.
- An additional input is included in the Purchase Offer to account for the expected cost of activation when reserving the bids: expected number of hours of activation for the product.
- The market clearing is run for a single system, thus one table Node, one table Line and one table PTDF must be provided, for the system participating in the market call. No interface information is needed.
- No slack node needs to be indicated, as the imbalances are not considered in this product.
- As this is a capacity product, the base flow is the expected flow over the lines to be managed during the period indicated in the Purchase Offer timestamp. For instance, a peak value can be used.
- The product allows only fully indivisible bids, and none of the types of complex bids. Thus, simple bids table is the only one provided.
- Bids have reservation and activation prices.

To illustrate the market clearing of the LT-P-C/E product, reservation stage, the following example is presented, which uses data provided by ESO created for demo purposes. A quick description of the data and an analysis of the results are given here, but all input datasets (purchase offer, network data, and bids data) and optimisation outputs are included in Appendix I: LT-P-C/E-res example data.

The example consists of a 6-nodes radial distribution network, which is depicted in Figure 4.11 and represents the grid status before the market clearing. In this figure, only blue nodes are present, because only one system is considered per market run. No grey node is included, as the product does not account for imbalances. The values over the lines are the forecasted flows (in kW), and the red line indicates congestion (forecasted flow surpasses line's capacity). A 5x6 PTDF matrix is provided to describe the impact of clearing bids in the flows over the lines.

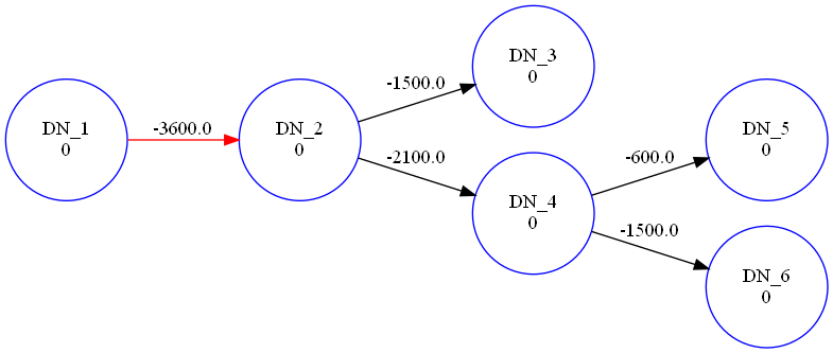

Figure 4.11 LT-P-C/E, reservation stage, example data for market clearing
Values over the lines are the forecasted flows. The red line has congestion.

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To solve the forecasted congestion, 18 simple bids are available in the different nodes of the system. With the purchase offer, network data and bids data, the market is optimally cleared and the result is shown in Figure 4.12 In the figure, the number in the nodes (circles) shows the cumulative amount of flexibility capacity reserved from every node (positive for upward flexibility, negative for downward flexibility). The numbers shown on the lines/edges are the resulting flows considering the initial flows and the activation of all the capacity reserved from the nodes. Two bids are reserved to be able to resolve all the forecasted congestion in the system without exceeding any other operational limits. A total amount of 32 kW of downward flexibility is selected. The cost of the market clearing is divided in three: expected activation cost of 80.80 €, total reservation cost of 40.60 €, and total cost (activation + reservation) of 121.40 €. No total cost cap was imposed in this example.

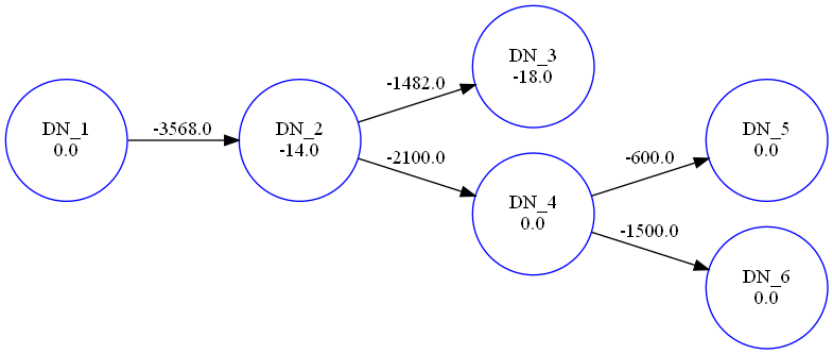

Figure 4.12 Result of the market clearing of the LT-P-C/E, reservation stage, example
All congestion is resolved if the reserved bids are activated. Values over the lines are the resulting flows after activating the reserved bids. Values inside the nodes are the total purchased capacity in the node (positive for upward and negative for downward).

In the shorter term, when the distribution system operator has a better estimate of the congestion, it can send the more accurate flows over the lines and the reserved bids to the optimisation module in order to optimally select the different reserved capacities which should be activated to resolve the congestion. In this phase, the input specifications are similar to the reservation ones:

- The Purchase Offer type is LT-P-C/E-act (activation).
- The imbalance position of the system is not considered and should not be provided in the Purchase Offer.
- As this is the activation phase, no expected number of hours of activation is needed in the Purchase Offer.
- The market clearing is run for a single system, thus one table Node, one table Line and one table PTDF must be provided, for the system participating in the market call. No interface information is needed.
- No slack node needs to be indicated, as the imbalances are not considered in this product.

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- As this is the activation step of the reserved capacity, the base flows should be the updated and estimated flows over the lines of interest.
- The list of bids must be the list of selected bids of the reservation step (i.e., the capacity that was reserved at the reservation stage). Only fully indivisible bids are allowed in the reservation stage, thus only this type of bids is considered as input of the activation as well.
- The list of bids must also be updated according to the limitation on the number of hours it has been already activated (since the beginning of the reservation contracted period) and on the number of consecutive hours of activations. Those updates are done outside of the optimisation module (in the T&D CP).
- Only activation prices are provided in the activation stage, given that the reservation cost is already paid in the LT-P-C/E-res stage.

To illustrate the market clearing of the LT-P-C/E product, activation stage, the same example of the reservation stage is used. Most of the inputs are the same as for the LT-P-C/E-res example, but, for completeness, all input datasets (purchase offer, network data, and bids data) and optimisation outputs are included in Appendix J: LT-P-C/E-act example data.

The example consists of the same 6-nodes radial distribution network of the LT-P-C/E-res example, but base flows are updated, to consider the new estimate of the flexibility need. This new grid status before the market clearing is depicted in Figure 4.13 In this figure, the values over the lines are the forecasted flows (in kW), and the red line indicates congestion (forecasted flow surpasses line's capacity).

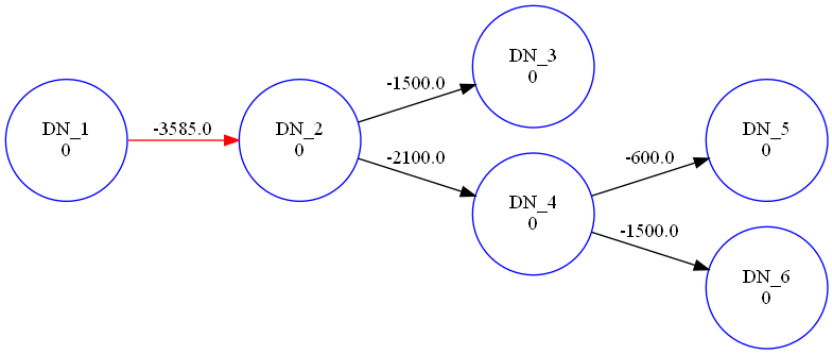

Figure 4.13 LT-P-C/E, activation stage, example data for market clearing
Values over the lines are the forecasted flows. The red line has congestion.

The two selected bids from the reservation stage are sent to the optimisation module for clearing the activation stage. The activation of 18 kW of one out of the two bids is enough to fulfil the congestion need. The new status of the grid, considering this activation, is shown in Figure 4.14 In the figure, the number in the nodes

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(circles) shows the cumulative amount of flexibility cleared from every node (positive for upward flexibility, negative for downward flexibility). The numbers shown on the lines/edges are the resulting flows considering the initial flows and the activation of the cleared bids from the nodes. In this case, only the total cost is returned, which corresponds to the activation cost and is €6.12. A total cost cap could be imposed to the LT-P-C/E, activation stage, even different from the reservation stage, but is not provided in this example.

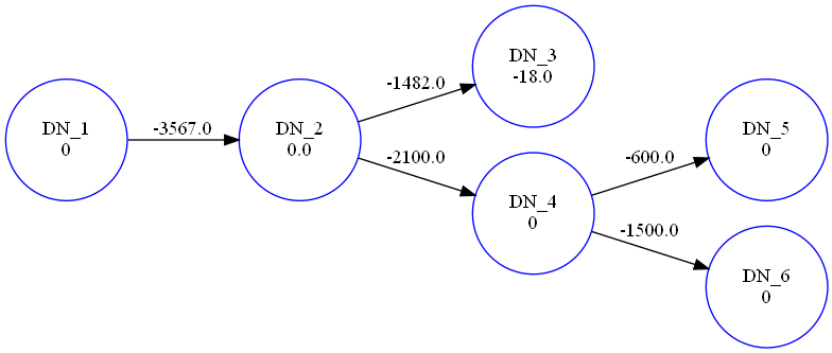

Figure 4.14 Result of the market clearing of the LT-P-C/E, activation stage, example

All congestion is resolved by the activation of one out of the two reserved bids. Values over the lines are the resulting flows after activating the cleared bids. Values inside the nodes are the total purchased flexibility in the node (positive for upward and negative for downward).

4.5.4 Long-term active capacity product

The long-term active capacity (LT-P-C) product is a capacity product to procure active power in the long term. Transmission and distribution system operators can jointly reserve flexibility bids using this product, for congestion management and/or balancing the interconnected system. To be able to perform this function, the following specifications apply to the inputs of LT-P-C product runs:

- The Purchase Offer type is LT-P-C.
- Given that this is a long-term product, the imbalance position of the (interconnected) system can be provided in the Purchase Offer, but it is not mandatory. If not provided, the optimisation does not consider the effects on the imbalance position as part of the process (i.e., the congestion management can create positive/negative changes to the imbalance position).
- The market clearing can be run for a single system or for an interconnected system.
- Node, Line and PTDF information must be provided for each of the systems participating in the market call. For instance, if a single system is reserving the flexibility through the LT-P-C alone, one table Node, one table Line, and one table PTDF are provided, without information about interfaces. On the other hand, if a transmission and distribution systems are reserving the flexibility together, multiple Node, Lines, and PTDF tables are provided. In the last case, the interface between the systems is also provided.

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- Only one slack node must be indicated in only one of the systems. This slack node must be well-defined in the PTDF (must have impact factors of 0 in the PTDF matrix, which reflect that this node absorbs the system imbalance). Even if the imbalance position is not explicitly provided, it is still necessary to define the slack node, because the optimisation can generate imbalances that need to be allocated to the slack node.
- The product can be used for congestion management and/or balancing, depending on the imbalance position and congestion needs in the (interconnected) network.
- The product allows the three types of simple bids (fully divisible, fully indivisible and partially divisible), and no complex bids. Thus, only simple bids table must be provided.

To illustrate the market clearing of the LT-P-C product, the following example is presented, which uses another set of data provided by FINGRID, also created for demo purposes. A quick description of the data and an analysis of the results are given here, but all input datasets (purchase offer, network data, and bids data) and optimisation outputs are included in Appendix L: LT-P-C example data.

The example consists of a 15-node transmission network, which is depicted in Figure 4.15 and represents the forecasted grid status before the market clearing. In this figure, the grey node is the slack, and no imbalance is forecasted/allocated to it (the value is 0 MW). In fact, the idea of this example is to reserve capacity for both congestion management and balancing, thus the imbalance limits are set to min = max = 100 MW, meaning that, after the market clearing, a 100 MW of upward capacity is reserved for balancing. The values over the lines are the forecasted flows (in MW), and red lines indicate congestion (forecasted flow surpasses line's capacity). A 21x15 PTDF matrix is provided for this transmission network, to describe the impact of clearing bids on the flows over the lines.

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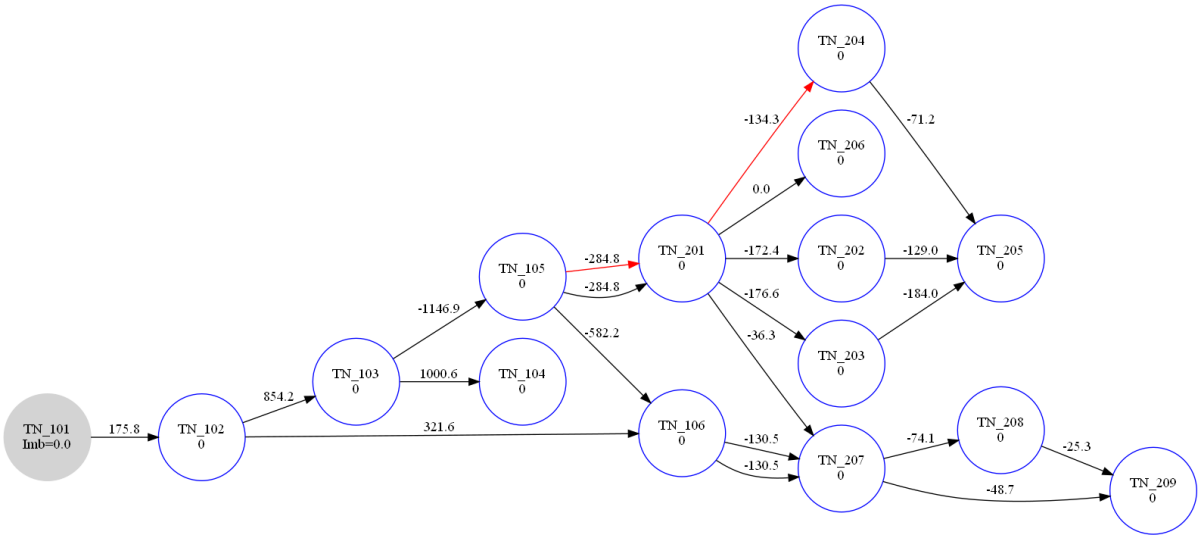

Figure 4.15 LT-P-C example data for market clearing

Only one (transmission) system is considered. The grey node is the slack. The value inside the slack node indicates the forecasted imbalance of the system (which is 0 for this case). Values over the lines are the forecasted flows. The red lines have congestion.

To solve the forecasted congestion and balancing need, 32 simple bids are available in the different nodes of the transmission system, and they are of type fully divisible, fully indivisible, and partially divisible. Complex bids are not allowed by this product. With the purchase offer, network data and bids data, the market is optimally cleared and the result is shown in Figure 4.16 In the figure, the number in the nodes (circles) shows the cumulative amount of flexibility bids reserved from every node (positive for upward flexibility, negative for downward flexibility). The numbers shown on the lines/edges are the resulting flows considering the initial flows and the activation of all reserved bids from the nodes. To be able to reserve balancing capacity and congestion management capacity, the market session selects 6 bids, 201.87 MW of downward capacity and 301.87 MW of upward capacity. The total cost of this reservation is 15,962.88 €. No total cost cap was imposed in this example.

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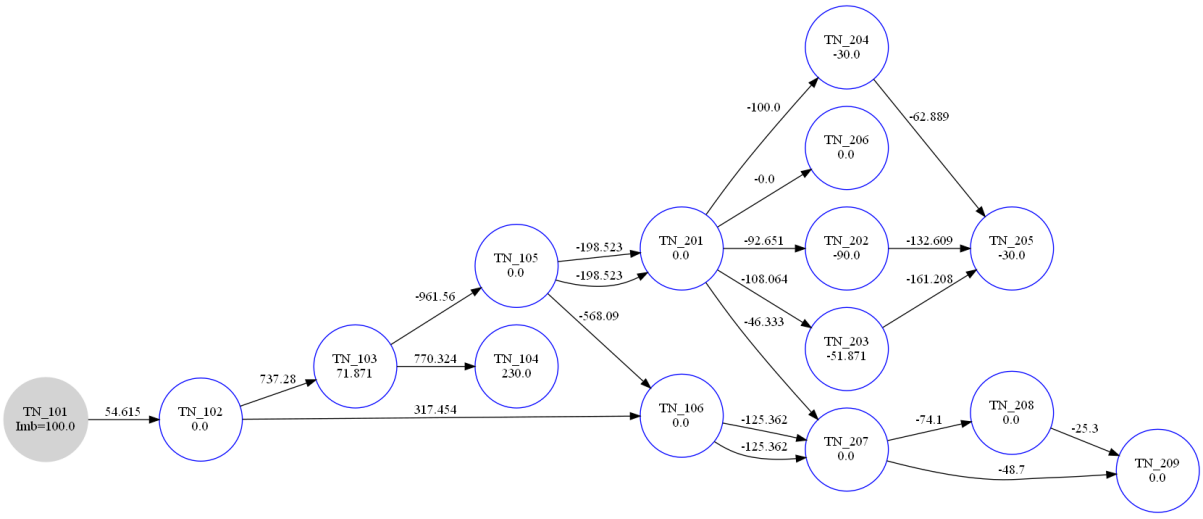

Figure 4.16 Result of the market clearing of the LT-P-C example

All congestion is resolved, with an impact on the imbalance position (shown in the grey node). Values over the lines are the resulting flows if all reserved bids are activated. Values inside the nodes are the total purchased capacity in the node (positive for upward and negative for downward).

4.5.5 Short-term active capacity product

The short-term active capacity (ST-P-C) product is a capacity product to procure active power in the short term[7]. Its market clearing optimisation process is similar to the LT-P-C explained in Section 4.5.4, apart from the timestamp (LT-P-C is used for long term while the ST-P-C is used for the short term).

[7] The ST-P-C product is in the process of development within WP7 at the time of writing. Hence, this section reports on the most recent state of development, which can still include changes before final implementation.

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5 Implementation of the Coordination Platform

This chapter describes the overall demonstration plans for the Northern demonstrator. The implementations are not exactly the same in each participating country. The specific implementation plans for each country, and how the Coordination Platform supports each Northern demonstrator's stakeholder and country's specific plans are described here.

The Northern Demonstrator is an integrated effort by TSOs, DSOs, MOs, aggregators, technology providers, and research centres from Finland, Estonia, Latvia, Lithuania, Sweden, Norway, Belgium, and the UK. The Northern Demonstrator enables market-driven flexibility uptake by networks in a coordinated way.

The demonstration shows the network balancing and congestion management needs in a range of use cases. The high-level implementation in each country includes several steps:

- Collecting necessary input data about the grid
- Prequalification process of flexibility resources
- Flexibility (energy and capacity) trading process for both reservation and activation of flexibility
- Delivered flexibility verification process (handled by FR)

The products to be demonstrated by stakeholders are short- and long-term energy and capacity products are listed in Table 5.1.

Table 5.1 Country-by-country demonstration of products

Product code	Country	Description
LT-P-C	Estonia	Long term active power product for capacity reservation from the market
LT-P-C/E	Latvia, Lithuania	Long term active power product for capacity reservation from the market and following energy product activations
NRT-P-E	Estonia, Latvia, Lithuania, Finland	Near real-time active energy product
ST-P-C	Latvia Estonia (tbc)	Short term active power product for capacity reservation from the market
ST-P-E	Finland	Short term active energy product

5.1 Estonian implementation

The Estonian implementation includes integration with the Flexibility Register and TSO-DSO Coordination Platform and taking advantage of the algorithms for resource group formation, grid qualification, bid optimisation, and delivered flexibility verification and deviation calculation processes developed during the

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project. Integrations with existing and/or simulated components are created. To some extent, partners' internal systems development is planned, for example, the system for collecting and providing relevant grid information.

Products demonstrated are:

- NRT-P-E (near-real-time active energy product) trading for activation
- LT-P-C (long-term active power capacity product) capacity trading for reservation

Stakeholders in the Estonian implementation are Elering (TSO) and Elektrilevi (DSO). System integrations in the Estonian implementation are indicated in Table 5.2.

Table 5.2 Estonian T&D CP implementation of the demonstrator

Process	Activity	Details
Grid info upload	Accept Grid topology (nodes and lines)	REST API
Grid info upload	Accept PTDF matrices, forecasts	REST API
Bidding preparation	Provide the list of registered FSPs / prequalification of a FSP, product and grid to MO	REST API
Bidding preparation	Validate received bids	REST API
Trading preparation	Collect Flexibility Calls for Tenders	REST API
Trading preparation	Send info about open Calls for Tender to MOs	Not applicable
Trading preparation	Provide info about open Calls for Tender to MOs	REST API
Bidding preparation	Collect Bids for Optimisation	REST API
Optimisation input	Collect Purchase Offers for Optimisation	REST API
Optimisation input	Generate Purchase Offers for reserved capacity bids optimisation based on FCT	T&D CP internal
NRT-P-E Optimisation	Scheduler start: T0-24M, Collect valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
ST-P-E Optimisation	Scheduler start: T0-115M, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	Not applicable
LT-P-C Optimisation	Scheduler start: at FCT Gate Closure Time, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
LT-P-C/E Optimisation	Scheduler start: At T0-24M, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the Optimisation module for Optimisation process	Not applicable
Optimisation	Run Optimisation for Bids and Purchase offers	T&D CP internal

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ST-P-E Optimisation	Recalculate grid information based on activated bids	Not applicable
Optimisation	Distribute recalculated grid information to SO	Elering API
MARI (balancing)	Send bids to MARI	Simulated
MARI (balancing)	Send Adjusted balancing POs to MARI	Simulated
Reservation and Activation	Communicate Cleared Bids for Activation to MOs	Elering API?
Reservation and Activation	Communicate Cleared bids for Capacity Reservation to MOs	Elering API?
Reservation and Activation	Communicate Cleared bids for Reserved Capacity Energy Activation to MOs	Not applicable
Reservation and Activation	Receive trade confirmation about which bids are going to be activated from MO	Not applicable
ST-P-E activation	Calculate Counter Activation need (sum of confirmed bids quantity)	Not applicable
ST-P-E activation	Communicate Counter Activation Order to MO	Not applicable
Middleware (bids and cleared bids)	Accept Bids through Middleware	Not applicable
Middleware (bids and cleared bids)	Send Activation Orders through Middleware	Not applicable

5.2 Latvian implementation

The Latvian implementation includes integration with the Flexibility Register and TSO-DSO Coordination Platform and taking advantage of the algorithms for resource group formation, grid qualification, bid Optimisation, and delivered flexibility verification and deviation calculation processes developed during the project. Integrations with existing and/or simulated components are created. Some internal systems development is planned, for example, the system for collecting and providing relevant grid information.

Products demonstrated are:

- NRT-P-E (near-real-time active energy product) trading for activation
- ST-P-C (short-term active power capacity product) capacity trading for reservation
- LT-P-C/E (long-term active power capacity product) trading for capacity reservation and energy activation

Stakeholders active in the Latvian implementation are AST (TSO), ST (DSO), Piclo (MO). System integrations in Latvian implementation are described in Table 5.3.

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Table 5.3 Latvian T&D CP implementation of the demonstrator

Process	Activity	Details
Grid info upload	Accept Grid topology (nodes and lines)	REST API
Grid info upload	Accept PTDF matrices, forecasts	REST API
Bidding preparation	Provide the list of registered FSPs / prequalification of a FSP, product and grid to MO	Not applicable
Bidding preparation	Validate received bids	REST API
Trading preparation	Collect Flexibility Calls for Tenders	REST API
Trading preparation	Send info about open Calls for Tender to MOs	Not applicable
Trading preparation	Provide info about open Calls for Tender to MOs	REST API
Bidding preparation	Collect Bids for Optimisation	REST API
Optimisation input	Collect Purchase Offers for Optimisation	REST API
Optimisation input	Generate Purchase Offers for Reserved Capacity Energy bids Optimisation	T&D CP internal
NRT-P-E Optimisation	Scheduler start: T0-24M, Collect valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
ST-P-E Optimisation	Scheduler start: T0-115M, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to optimisation module for Optimisation process	Not applicable
LT-P-C Optimisation	Scheduler start: at FCT Gate Close time, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
LT-P-C/E Optimisation	Scheduler start: At T0-24M, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
Optimisation	Run Optimisation for Bids and Purchase offers	T&D CP internal
ST-P-E Optimisation	Recalculate grid information based on activated bids	Not applicable
Optimisation	Distribute recalculated grid information to SO	REST API; AST API
MARI (balancing)	Send bids to MARI	Simulated
MARI (balancing)	Send Adjusted balancing POs to MARI	Simulated
Reservation and Activation	Communicate Cleared Bids for Activation to MOs	Piclo API; AST API
Reservation and Activation	Communicate Cleared bids for Capacity Reservation to MOs	Piclo API; AST API
Reservation and Activation	Communicate Cleared bids for Reserved Capacity Energy Activation to MOs	Piclo API
Reservation and Activation	Receive trade confirmation about which bids are going to be activated from MO	Not applicable
ST-P-E activation	Calculate Counter Activation need (sum of confirmed bids quantity)	Not applicable

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ST-P-E activation	Communicate Counter Activation Order to MO	Not applicable
Middleware (bids and cleared bids)	Accept Bids through Middleware	Not applicable
Middleware (bids and cleared bids)	Send Activation Orders through Middleware	Not applicable

5.3 Lithuanian implementation

The Lithuanian implementation includes integration with the Flexibility Register and TSO-DSO Coordination Platform and taking advantage of the algorithms for resource group formation, grid qualification, bid Optimisation, and delivered flexibility verification and deviation calculation processes developed during the project. Integrations with existing and/or simulated components are created. Some internal systems development is planned, for example, the system for collecting and providing relevant grid information.

Products demonstrated are:

- NRT-P-E (near-real-time active energy product) trading for activation
- LT-P-C/E (long-term active power capacity product) trading for capacity reservation and energy activation

Stakeholders active in the Lithuanian implementation are Litgrid (TSO), ESO (DSO), Piclo (MO). System integrations in the Lithuanian implementation are described in Table 5.4.

Table 5.4 Lithuanian T&D CP implementation of the demonstrator

Process	Activity	Details
Grid info upload	Accept Grid topology (nodes and lines)	REST API
Grid info upload	Accept PTDF matrices, forecasts	REST API
Bidding preparation	Provide the list of registered FSPs / prequalification of a FSP, product and grid to MO	Not applicable
Bidding preparation	Validate received bids	REST API
Trading preparation	Collect Flexibility Calls for Tenders	REST API
Trading preparation	Send info about open Calls for Tender to MOs	Piclo API
Trading preparation	Provide info about open Calls for Tender to MOs	REST API
Bidding preparation	Collect Bids for Optimisation	REST API
Optimisation input	Collect Purchase Offers for Optimisation	REST API
Optimisation input	Generate Purchase Offers for Reserved Capacity Energy bids Optimisation	T&D CP internal
NRT-P-E Optimisation	Scheduler start: T0-24M, Collect valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal

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ST-P-E Optimisation	Scheduler start: T0-115M, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	Not applicable
LT-P-C Optimisation	Scheduler start: at FCT Gate Closure time, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
LT-P-C/E Optimisation	Scheduler start: At T0-24M, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
Optimisation	Run Optimisation for Bids and Purchase offers	T&D CP internal
ST-P-E Optimisation	Recalculate grid information based on activated bids	Not applicable
Optimisation	Distribute recalculated grid information to SO	Litgrid API
MARI (balancing)	Send bids to MARI	Simulated
MARI (balancing)	Send Adjusted balancing POs to MARI	Simulated
Reservation and Activation	Communicate Cleared Bids for Activation	Litgrid API?
Reservation and Activation	Communicate Cleared bids for Capacity Reservation to MOs	Piclo API
Reservation and Activation	Communicate Cleared bids for Reserved Capacity Energy Activation to MOs	Piclo API
Reservation and Activation	Receive trade confirmation about which bids are going to be activated from MO	Not applicable
ST-P-E activation	Calculate Counter Activation need (sum of confirmed bids quantity)	Not applicable
ST-P-E activation	Communicate Counter Activation Order to MO	Not applicable
Middleware (bids and cleared bids)	Accept Bids through Middleware	Not applicable
Middleware (bids and cleared bids)	Send Activation Orders through Middleware	Not applicable

5.4 Finnish implementation

The Finnish implementation will include integration with the Flexibility Register and TSO-DSO Coordination Platform and taking advantage of the algorithms for resource group formation, grid qualification, bid Optimisation, and delivered flexibility verification calculation processes developed during the project. Integrations with existing and/or simulated components are created. Some internal systems development is planned, for example, the system for collecting and providing relevant grid information.

Products demonstrated are:

- NRT-P-E (near-real-time active energy product) trading for activation
- ST-P-E (short-term active power energy product) trading for activation

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Stakeholders active in the Finnish implementation are Fingrid (TSO), KSOY (DSO), Vattenfall (FSP), Enerim (Aggregator), Nordpool (MO). System integrations in the Finnish implementation are described in Table 5.5.

Table 5.5 Finnish T&D CP implementation of the demonstrator

Process	Activity	Details
Grid info upload	Accept Grid topology (nodes and lines)	REST API
Grid info upload	Accept PTDF matrices, forecasts	REST API
Bidding preparation	Provide the list of registered FSPs / prequalification of a FSP, product and grid to MO	REST API
Bidding preparation	Validate received bids	REST API
Trading preparation	Collect Flexibility Calls for Tenders	Not applicable
Trading preparation	Send info about open Calls for Tender to MOs	
Trading preparation	Provide info about open Calls for Tender to MOs	Not applicable
Bidding preparation	Collect Bids for Optimisation	REST API
Optimisation input	Collect Purchase Offers for Optimisation	REST API
Optimisation input	Generate Purchase Offers for Reserved Capacity Energy bids Optimisation	Not applicable
NRT-P-E Optimisation	Scheduler start: T0-24M, Collect valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
ST-P-E Optimisation	Scheduler start: T0-115M, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module O for Optimisation process	T&D CP internal
LT-P-C Optimisation	Scheduler start: at FCT Gate Close time, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
LT-P-C/E Optimisation	Scheduler start: At T0-24M, T&D CP collects valid bids, purchase offers and latest grid information as the inputs and sends these to the optimisation module for Optimisation process	T&D CP internal
Optimisation	Run Optimisation for Bids and Purchase offers	T&D CP internal
ST-P-E Optimisation	Recalculate grid information based on activated bids	T&D CP internal
Optimisation	Distribute recalculated grid information to SO	Fingrid API?
MARI (balancing)	Send bids to MARI	Simulated
MARI (balancing)	Send Adjusted balancing POs to MARI	Simulated
Reservation and Activation	Communicate Cleared Bids for Activation to MOs	Nordpool API
Reservation and Activation	Communicate Cleared bids for Capacity Reservation to MOs	Not applicable
Reservation and Activation	Communicate Cleared bids for Reserved Capacity Energy Activation to MOs	Not applicable

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Reservation and Activation	Receive trade confirmation about which bids are going to be activated from MO	REST API
ST-P-E activation	Calculate Counter Activation need (sum of confirmed bids quantity)	T&D CP internal
ST-P-E activation	Communicate Counter Activation Order to MO	*Nordpool API TBD*
Middleware (bids and cleared bids)	Accept Bids through Middleware	Not applicable
Middleware (bids and cleared bids)	Send Activation Orders through Middleware	Not applicable

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6 Conclusions

The primary goal of the Northern demonstrator, T&D CP being one principal part of it, is to allow open flexibility trading for energy market stakeholders. The purpose of the flexibility trading is to support TSOs' and DSOs' needs to solve the network congestions and frequency issues in the most optimal way, while enabling market operators and flexibility service providers to seamlessly provide their services in the most relevant and economical ways. Fulfilling these goals requires flexible facilitation of these stakeholders' systems integration to the central platform for timely and accurate information exchange and supply-demand optimal matching purposes. The main function of the T&D CP module is to create an interconnected collaboration platform for market operators and system operators.

The main outcomes of the elaboration of the T&D CP use cases are as follows:

- A primary driver in developing the SUCs is to facilitate multilateral flexibility market through improved TSO-DSO coordination, also enabling a cross-border marketplace.
- The grid qualification of resource SUC describes the qualification of flexibility resources from a grid capacity perspective in the prequalification phase. The objective of grid impact assessment is to avoid congestions by setting restrictions on the activation of flexibilities which would cause congestion in the grids.
- The bid optimisation SUC describes the optimisation of flexibility bids based on minimising total costs, avoiding further issues in the grids and enabling value-stacking.
- The flexibility call for tender opening SUC describes the opening of flexibility call for tender and sharing information about ongoing calls with market and system operators.
- A harmonised approach to role definition is used by applying HEMRM, complemented with recent proposals through joint effort in BRIDGE Initiative to amend and introduce additional roles.
- The description of data to be exchanged between the roles involved a detailed identification of Business Objects, their attributes, attribute values per product and additional explanations. Such approach enables the translation of the data semantics to CIM compliant profiles.

For the OneNet WP7 Northern Demonstrator's technical implementation, several important principles have been adopted:

- **Modularization** – all the software components are arranged as a collection of microservices where each service fills a single purpose and provides important function for the application. This allows flexible system development, as well as flexible business processes support by adding or removing specific steps in the process when new products are defined and included for specific flexibility needs.

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- **Common Information Models** – using CIM profiles in the Application Programming Interfaces enables standardised, straightforward and clear data exchange capabilities between different actors independent from their source systems, e.g., between system operators and market operators from different countries.
- **Security** – data ownership and data privacy requirements are strictly followed in order to make sure data processing is done in a compliant way.
- **Interoperability** – For MOs T&D CP allows integration both directly to T&D CP through CIM profiles or custom integration as well as through the common integration with Middleware data exchange protocols.
- **Low integration barrier for both operators and providers** – as seen from the functionalities and processes descriptions, T&D CP has lots of services which makes navigation among the services complex. To lower integration work effort there are dedicated integration APIs for every role – thus MOs and SOs can see and use services tailored for their needs only.
- **Flexibility** – T&D CP supports country-specific data exchange integrations as well as product-specific and country-specific business rules. Despite the CIM format in use, there are still lots of dedicated integration points the platform should send data or collect data from. T&D CP is built up to support a wide range of integration needs. The same applies to business rules. Having a common product model and processes for all Northern countries, country-specific business rules are still easy to add when needed.

The optimisation-based market-clearing module enables the optimal, coordinated, and efficient procurement of flexibility by different SOs, through the trading of different products. The salient features of the optimisation-based market-clearing module are as follows:

- Enables the optimal purchasing of flexibility, leading to the least possible system cost.
- Enables a structured, standardized, and automated clearing of the market, enabling a transparent market clearing, which encourages FSP and consumer participation.
- Enables the system operators to control several aspects of the algorithm through tunable parameters (inputs): such as the effects of congestion management on the system's imbalance position. In this regard, the algorithm provides the system operator with the choice to purely focus on congestion management, balancing, or congestion management AND balancing, while the balancing position can be constrained within a range.
- Enables the system operator to impose a total cost cap (which would reflect the alternative cost of procuring flexibility through other means, e.g., network reinforcement).

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- Encourages and capitalizes on the value stacking potential of flexibility, whereby a flexibility bid is used to concurrently meet the needs of multiple system operators, resulting in reduced system costs, and increases value potential for flexibility service providers.
- Embeds the grid impact assessment as part of the market clearing, so that the algorithm not only chooses the optimal set of bids to purchase to meet the SOs' flexibility needs, but also ensures that this flexibility – when activated – does not lead to violation of other network constraints.
- Enables the trading of 6 different products that differ in nature (capacity vs. energy) and timescales (long-term, short-term, and near real-time).
- Enables a seamless integration with the T&D CP platform through a developed API.
- Enables the clearing of the market (when trading any of the products) in a reliable and time-efficient manner.

Those key features of the optimisation-based market clearing module have been showcased in this report through the presentation of several test examples (using data by the different system operators mirroring their demonstration settings as part of the Northern demo).

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Appendices

Appendix A: Grid qualification SUC

Use Case: Grid Qualification of Resource

1. Description of the use case

1.1. Name of use case

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
7.4.1	Flexibility market, TSO-DSO coordination	Grid Qualification of Resource

1.2. Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	5.05.2021	Kalle Kukk, Kaja Trees, Kristjan Kuhi	First draft	For T7.4 discussion
2	26.05.2021	Kalle Kukk	Changes based of 6 May T7.4 discussion and comments provided until 26 May; further missing information added (short description, KPIs, conditions, references, requirements)	For T7.4 partners' review
3	29.06.2021	Kalle Kukk	Changes based of 29 June T7.4 discussion and comments provided until 29 June	For T7.4 partners' review before inclusion in MS report
4	9.07.2021	Kalle Kukk, Kaja Trees, Kristjan Kuhi	Updated diagrams, 'complete description' added	For inclusion in milestone report
5	24.11.2021	Kalle Kukk	Removal of previous scenario #2, inclusion of 'OneNet system', other updates	For T7.4 partners' review
6	3.12.2021	Kalle Kukk, Kaja Trees, Kristjan Kuhi	Updated diagrams, cleaned up version	For WP5
7	14.10.2022	Kalle Kukk	Full review based on recent developments, incl. removal of initial scenario #3, updating processes and business objects	For T7.4 partners' review
8	15.11.2022	Kalle Kukk, Kaja Trees, Luciana Marques	Updated content and sequence diagram	To be included in D7.4

1.3. Scope and objectives of use case

Scope and objectives of use case	
Scope	Qualification of flexibility resources from grid capacity perspective in prequalification phase.
Objective(s)	Solution developed to facilitate multilateral flexibility market through improved TSO-DSO coordination, also enabling cross-border marketplace. The objective of grid impact assessment is to avoid congestions by setting restrictions on the activation of flexibilities which would cause congestion in grids.
Related business case(s)	Northern regional flexibility market

1.4. Narrative of Use Case

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Narrative of use case
Short description
Grid qualification of a flexibility resource may take place in prequalification, procurement and activation phases. In this use case, a focus is given on grid qualification in the prequalification phase. It is worth mentioning that qualification in procurement phase is integral part of bid optimisation and, as such, part of the bid optimisation SUC. In the activation phase, grid qualification would not be feasible for near-real-time product due to time constraints and not necessary in capacity products. For the activation of short-term and long-term products, the grid impact assessment in activation phase is also integrated into optimisation process (and therefore addressed in bid optimisation SUC). Grid impact assessment is central activity of grid qualification process. Two alternatives are possible. First, concerned SO identifies grid restrictions (constraints) by itself. If the first alternative is applied, there is no need for T&D CP involvement – rather the Flexibility Register provides resource information to the SO and collects the grid restrictions information from it. Therefore, this alternative is not part of this SUC. Second alternative is that restrictions are calculated by T&D CP. This approach is part of this SUC. For second alternative, a dedicated algorithm is needed which calculates the grid restrictions based on input information. Input information to be made available to T&D CP includes resource information, network topology and node limitations. The objective is to determine in which network node the activation of the resource would violate the node limitation. The impact assessment is a continuous process. In prequalification phase normally structural congestions should be considered, while in procurement and activation phases also dynamic congestions. Resource Provider's consent is needed by T&D CP to have access to private information, e.g., related to resource information and flexibility bid.
Complete description
7.4.1.1 Grid qualification of resource in prequalification phase • 1.a. Manage Resource Provider's consent: Resource Provider can give consent through Consent Administrator. • 1.b. Receive Resource Provider's consent: T&D CP needs consent to have access to RP's private data on resource information. • 2.a. Collect information about flexibility resources: Resource information from Flexibility Register. • 2.b. Identify impacted System Operators: List of SOs who should send the grid information and be addressed in grid qualification process. The concerned SOs are predefined (see assumption #4). • 2.c. Request grid information (CONDITIONAL): Requesting grid information from impacted SOs (in case this information is not already available). • 2.d. Collect grid information: Grid information from impacted SOs. • 3.a. Run algorithm for grid qualification to identify grid restrictions: Identification of grid restrictions (constraints) as calculated by T&D CP algorithm based on grid impact assessment of resource. • 4.a. Publish qualification results: Qualification results are stored at the Flexibility Register.

1.5. Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
	Performance of grid qualification algorithm	Grid qualification algorithm should deliver the results as soon as required Formula: t_p/t_a t_p = planned time for results' delivery t_a = actual time of results' delivery Unit: % Target value: 1	Improve TSO-DSO coordination in flexibility market.
	Number of conflicts resulting from flexibility product activation	In the uncoordinated way of flexibility activation in the existing market, activation of flexibility product by one SO may lead to conflicts (e.g. new congestions) in	Avoid congestions by setting appropriated restrictions.

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		another SO grid area. The aims is to decrease the number of such conflicts by performing the grid qualification process Formula: N_C N_C = Number of conflicts resulting from flexibility product activation Unit: # Target value: 0	

1.6. Use case conditions

Use case conditions	
Assumptions	
1	Solutions for consent management for sharing private data are in place in all countries of the region.
2	T&D CP is integrated with other relevant systems of the concerned stakeholders and countries (e.g., Flexibility Register).
3	It is evident that congestions occur in a concerned grid area.
4	The concerned SOs for grid impact assessment are predefined.
5	Alternative 1 of grid qualification does not require the involvement of T&D CP.
Prerequisites	
1	Cross-border acknowledgement of consents is enabled – consents given in one country are recognised in other country, with the same consent resource provider can grant access to data to different roles in different countries, FSP can provide aggregation services to resource providers located in different countries, resource provider has access to consent services provided in another country.
2	Information about concerned flexibility resources as well as relevant grid information is available.

1.7. Further information to the use case for classification/mapping

Classification information
Relation to other use cases
Other system use cases related to TSO-DSO coordination, Flexibility Register, Customer on-boarding and Market Operator
Level of depth
Prioritisation
Generic, regional or national relation
Nature of use case
System use case
Further keywords for classification

1.8. General remarks

General remarks

2. Diagrams of use case

Diagram(s) of use case

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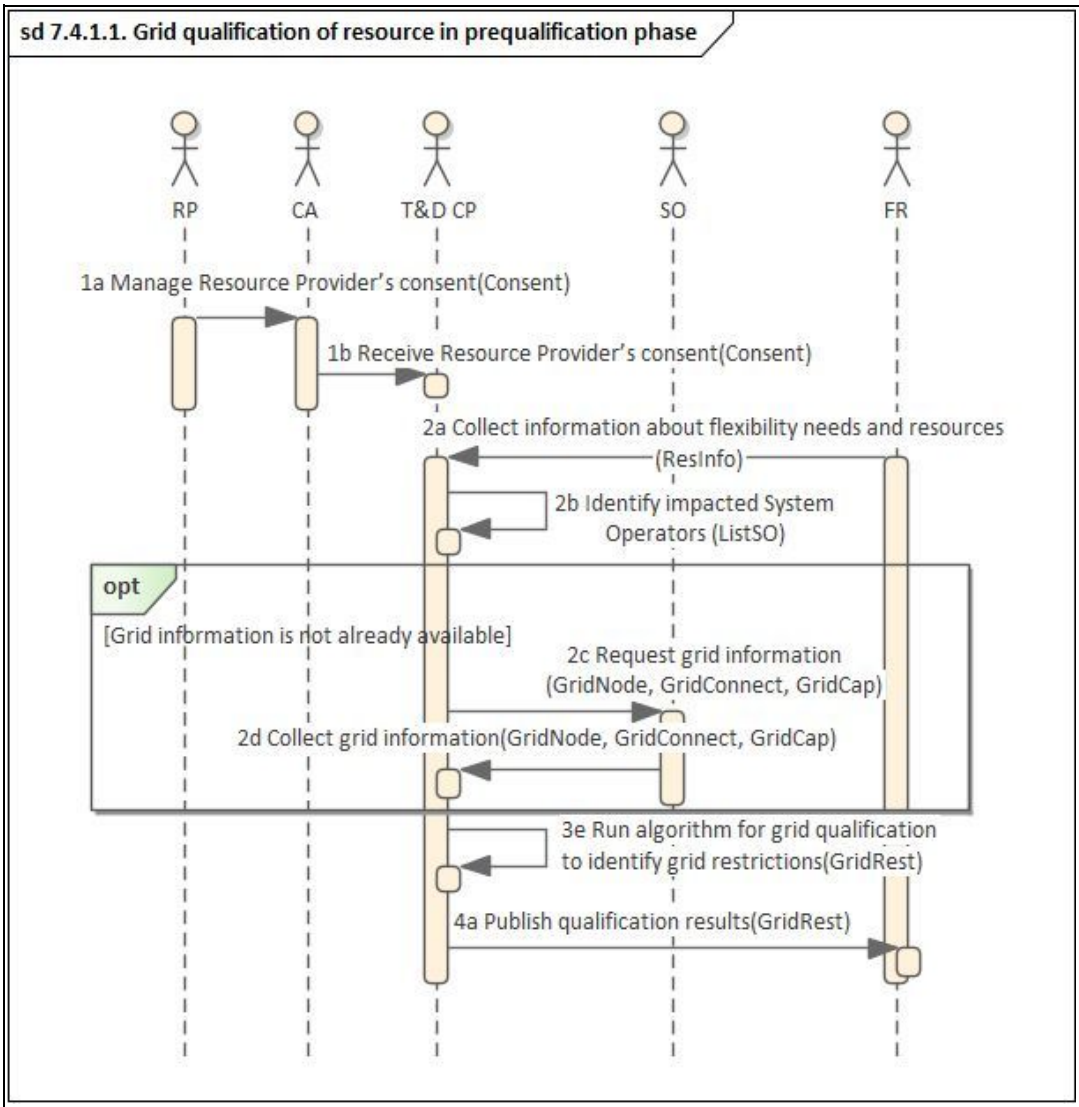

3. Technical details

3.1. Actors

Actors			
Grouping		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
TSO-DSO Coordination Platform (T&D CP)	System	System that is designed to avoid, through grid impact assessment, activation of flexibilities which either do not contribute to solving system needs or even worsen the situation (constraint setting process) as well as to find the best value-stack of available flexibilities to be activated (optimization process).	

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Flexibility Register (FR)	System	System that stores information about flexibility assets, results of qualification (both product and grid), market results, grid information and the results of the settlement as well as aggregates flexibility information as well as allocates access rights to the various actors and controls the level of access.	Based on BRIDGE proposal for Flexibility Register Operator definition.
System Operator (SO)	Business	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.	HEMRM definition.
Resource Provider (RP)	Business	A role that manages a resource and provides production/consumption schedules for it, if required.	HEMRM definition.
Consent Administrator (CA)	Business	A party responsible for administrating a register of consents for a domain. The Consent Administrator makes this information available on request for entitled parties in the sector.	HEMRM definition.

3.2. References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Report	EU-SysFlex deliverable 5.2		Investigation of relevant use cases	Horizon2020 project EU-SysFlex	https://eu-sysflex.com/wp-content/uploads/2020/10/EU-SysFlex-Task-5.2-D5.2-FINAL.pdf
2		INTERRFACE task 5.3		Investigation of relevant use cases	Horizon2020 project INTERRFACE	
3	Report	CoordiNet deliverable 1.5		Investigation of relevant use cases	Horizon2020 project CoordiNet	https://private.coordinet-project.eu//files/documentos/5d724207ca982Coordinet_Deliverable_1.5.pdf
4		TDX-ASSIST		Investigation of relevant use cases	Horizon2020 project TDX-ASSIST	
5	Report	SmartNet deliverable 1.3		Investigation of relevant use cases	Horizon2020 project SmartNet	http://smartnet-project.eu/wp-content/uploads/2016/12/D1.3_20161202_V1.0.pdf
6	Report	Overview of energy flexibility services		Investigation of relevant use cases	ebIX®	https://mwgstorage1.blob.core.windows.net/public/Ebix/ebIX%20Overview%20of%20energy%20flexibility%20services%20-%20v1r0A%2020200106.pdf
7	Report	An integrated approach to Active System Management		Investigation of relevant use cases	CEDEC, E.DSO, ENTSO-E, Eurelectric, GEODE	https://www.entsoe.eu/Documents/Publications/Position%20papers%20and%20reports/TSO-DSO_ASM_2019_190416.pdf

4. Step by step analysis of use case

4.1. Overview of scenarios

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Scenario conditions						
No.	*Scenario name*	*Scenario description*	*Primary actor*	*Triggering event*	*Pre-condition*	*Post-condition*
7.4.1.1	Grid qualification of resource in prequalification phase		T&D CP			

4.2. Steps – Scenarios

Scenario								
Scenario name		7.4.1.1. Grid qualification of resource in prequalification phase						
Step No	*Event*	*Name of process/activity*	*Description of process/activity*	*Service*	*Information producer (actor)*	*Information receiver (actor)*	*Information exchanged (IDs)*	*Requirement, R-IDs*
1.a		Manage Resource Provider's consent	Resource Provider can give consent through Consent Administrator.		RP	CA	Consent	ConsMan DataSec
1.b		Receive Resource Provider's consent	T&D CP needs consent to have access to RP's private data on resource information.		CA	T&D CP	Consent	ConsMan ConnectCA DataSec
2.a		Collect information about flexibility resources	Resource information from Flexibility Register.		FR	T&D CP	ResInfo	ConnectFR DataSec
2.b		Identify impacted System Operators	List of SOs who should send the grid information and be addressed in grid qualification process. The concerned SOs are predefined (see assumption #4).		T&D CP	T&D CP	ListSO	
2.c		Request grid information (CONDITIONAL)	Requesting grid information from impacted SOs (in case this information is not already available).		T&D CP	SO	GridNode GridConnect GridCap	ConnectSO DataSec
2.d		Collect grid information	Grid information from impacted SOs.		SO	T&D CP	GridNode GridConnect GridCap	ConnectSO DataSec
3.a		Run algorithm for grid qualification	Identification of grid restrictions (constraints) as		T&D CP	T&D CP	GridRest	QualAlg DataStore

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		to identify grid restrictions	calculated by T&D CP algorithm based on grid impact assessment of resource.					
4.a		Publish qualification results	Qualification results are stored at the Flexibility Register.		T&D CP	FR	GridRest	ConnectFR DataSec

5. Information exchanged

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
Consent	Customer Consent	Permission of data owner to use its private data.	
ResInfo	Resource Information	FSP's future potential to provide the flexibility.	
GridRest	Grid Restrictions	Constraints assigned to flexibilities which cannot be (fully or partially) activated without causing congestions in the grid.	
GridNode	Grid Nodes	Information about the grid nodes.	
GridConnect	Grid Connecting Elements	Information about the elements such as lines connecting the grid nodes.	
GridCap	Grid Element Capacity	Maximum power flow of a grid element.	
ListSO	List of impacted System Operators	List of SOs who should send the grid information and be addressed in grid qualification process.	

6. Requirements (optional)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
FUNCTIONAL	Functional requirements	
Requirement R-ID	***Requirement name***	***Requirement description***
ConsMan	Consent management	The ability to give, obtain, process and store Resource Providers' consents
ConnectCA	Data exchange with Consent Administrator	The ability to exchange data with Consent Administrator's relevant system(s)
ConnectFR	Data exchange with Flexibility Register	The ability to exchange data with Flexibility Register
ConnectSO	Data exchange with System Operator	The ability to exchange data with System Operator's relevant system(s)
DataSec	Security of data exchange	Exchange of sensitive data needs to be protected
DataStore	Storing of relevant data	Storing capability of grid qualification results needs to be ensured
Categories ID	***Category name for requirements***	***Category description***
NON-FUNCTIONAL	Non-functional requirements	
Requirement R-ID	***Requirement name***	***Requirement description***

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QualAlg	Grid qualification algorithm	Algorithm to perform required number of calculations within required period of time with required accuracy
ConnectXX	Connection conditions with other system	API, speed of data exchange and other relevant parameter to be defined
OpenSource / EUPL	Access to source code	Access to source code, unlimited rights to manage and further develop any system components. European Union public licence: Introduction to the EUPL licence | Joinup (europa.eu)

7. Common terms and definitions

Common terms and definitions	
Term	***Definition***

8. Custom information (optional)

Custom information (optional)		
Key	***Value***	***Refers to section***

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Appendix B: Bid optimisation SUC

Use Case: Bid Optimisation

1. Description of the use case

1.1. Name of use case

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
7.4.2	Flexibility market, TSO-DSO coordination	Bid Optimisation

1.2. Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	5.05.2021	Kalle Kukk, Kaja Trees, Kristjan Kuhi	First draft	For T7.4 discussion
2	26.05.2021	Kalle Kukk	Changes based of 6 May T7.4 discussion and comments provided until 26 May; further missing information added (short description, KPIs, conditions, references, requirements)	For T7.4 partners' review
3	29.06.2021	Kalle Kukk	Changes based of 29 June T7.4 discussion and comments provided until 29 June	For T7.4 partners' review before inclusion in MS report
4	9.07.2021	Kalle Kukk, Kaja Trees, Kristjan Kuhi	Updated diagram, 'complete description' added	For inclusion in milestone report
5	24.11.2021	Kalle Kukk, Anibal Sanjab	Removal of bid ranking steps, merging with procurement phase grid qualification process, inclusion of 'OneNet system', other updates	For T7.4 partners' review
6	3.12.2021	Kalle Kukk, Kaja Trees, Kristjan Kuhi	Updated diagram, cleaned up version	For WP5
7	14.10.2022	Kalle Kukk	Full review based on recent developments, incl. updating processes and business objects	For T7.4 partners' review
8	15.11.2022	Kalle Kukk, Kaja Trees, Luciana Marques	Updated content and sequence diagram	To be included in D7.4

1.3. Scope and objectives of use case

Scope and objectives of use case	
Scope	Optimising the flexibility bids based on minimising total costs, avoiding further issues in the grids and enabling value-stacking.
Objective(s)	Tool and algorithm developed for optimising flexibility bids to facilitate multilateral flexibility market through improved TSO-DSO coordination, also enabling cross-border marketplace.
Related business case(s)	Northern regional flexibility market

1.4. Narrative of Use Case

Narrative of use case
Short description

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An algorithm performs bid optimisation processes for both capacity and energy products. Besides flexibility bids, also purchase offers and grid information are necessary inputs for the algorithm that enables to perform bid optimisation. Optimising means matching flexibility bids and purchase offers in the most economical way which takes into account total costs for the SO(s) and synergies (value-stacking). This step can be repeated continuously if necessary and feasible. The latter is relevant in case of ST-P-E and LT-P-C/E product whereby there is sufficient time before activation to re-optimise if meanwhile some bids have been reported as unavailable.
The optimisation of the market clearing takes into consideration the effects on all the grids involved, to ensure that any combinations of bids purchased would not lead to any operational issues for any of the grids involved. That could be achieved following a PTDF approach, and as such, grid qualification in the procurement phase and bid optimisation are performed within the same optimisation process.
After the optimisation, remaining bids and bids earmarked for balancing only need to be shared with relevant European platform (MARI, PICASSO). If bids were not selected for congestion management purposes, TSO-DSO coordination platform forwards them to relevant European balancing platform after checking if such bids still comply with European balancing requirements and if they would not cause internal congestions. Bids can be tagged by FSP to be used for balancing only, congestion management only, or for both.
The information about cleared bids as the result of optimisation will be sent to relevant MOs who interact directly with the FSPs. MOs are expected to request the FSPs to activate the resources exactly according to the optimisation results. Other optimisation results beside cleared bids will be also generated and can be made available to SOs – total cost of the cleared bids, updated grid flows, new imbalance position.

Complete description

- 1.a. Manage Resource Provider's consent: Resource Provider can give consent through Consent Administrator.
- 1.b. Receive Resource Provider's consent: T&D CP needs consent to have access to RP's private data on flexibility bid.
- 2.a. Collect information about flexibility bids: MO submits all bids to T&D CP.
- 2.b. Forward information about flexibility bids: OneNet system (DEP) is applied to facilitate data exchange with MOs.
- 3.a. Request flexibility purchase offers (CONDITIONAL): Purchase offers need to be requested if these are not made available automatically (pushed).
- 3.b. Get flexibility purchase offers: System Operator submits purchase offer.
- 4.a. Identify impacted System Operators: List of SOs who should send the grid information and be addressed in grid qualification process. The concerned SOs are predefined (see assumption #7).
- 4.b. Request grid information (CONDITIONAL): Grid information from impacted SOs (in case this information is not already available).
- 4.c. Collect grid information: Grid information from impacted SOs.
- 5.A. Optimise flexibility bids and flexibility purchase offers: Optimising bids by matching flexibility bids and purchase offers in most economical way taking into account synergies (value-stacking), while not creating further conflicts in grid. This step is repeated continuously if time allows.
- 6.a. Publication of optimisation results: Sending relevant information to SOs.
- 6.b. Publication of cleared bids: Sending relevant information to MOs.
- 6.c. Forward information about cleared bids: OneNet system (DEP) is applied to facilitate data exchange with MOs.
- 6.d. Cancellation of cleared bid: For some products the time window allows the cancellation of initially cleared bids. If a bid is cancelled then the optimisation needs to be repeated: loop back to step 5.a.
- 6.e. Forward information about the cancelled bid: OneNet system (DEP) is applied to facilitate data exchange with MOs.
- 7.a. Identify bids which should be shared with relevant EU platform: EU platforms like MARI, TERRA, PICASSO. Relevant only for NRT-P-E product.
- 7.b. Send relevant bids to European platform. Bids for balancing need to be sent to relevant EU platform at right time.

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- 7.c. Forward relevant bids to European platform: OneNet system (DEP) is applied to facilitate data exchange with MOs.
- 7.d. Adjust balancing purchase offers: TSOs' balancing purchase offers need to be adjusted taking into account the optimisation results.
- 7.e. Send adjusted balancing purchase offers to European platform: Adjusted balancing purchase offers need to be sent to relevant EU platform at right time.
- 7.f. Forward adjusted balancing purchase offers to European platform: OneNet system (DEP) is applied to facilitate data exchange with MOs.

1.5. Key performance indicators (KPI)

Key performance indicators			
ID	***Name***	***Description***	***Reference to mentioned use case objectives***
	Performance of bid optimisation algorithm	Bid optimisation algorithm should deliver the results as soon as required. Formula: t_p/t_a t_p = planned time for results' delivery t_a = actual time of results' delivery Unit: % Target value: 1	Improve TSO-DSO coordination in flexibility market.

1.6. Use case conditions

Use case conditions	
Assumptions	
1	Solutions for consent management for sharing private data are in place in all countries of the region.
2	Value-stacking is allowed in legislation, i.e., same resources and bids can be used simultaneously for more than on flexibility service and/or for more than one SO.
3	Timing allows value-stacking while sharing the concerned bids also with European platform.
4	Secondary trading is enabled.
5	T&D CP is integrated with other relevant systems of the concerned stakeholders and countries, e.g., Flexibility Register).
6	Location of the issue in the grid and location of the flexibility resource matters from the total cost perspective and from the feasibility (i.e., are there resources available to solve the issue) perspective.
7	The concerned SO for grid impact assessment are predefined.
8	Counter balancing is solved through the Purchase Offer process whereby SO can define the desired imbalance position.
Prerequisites	
1	Grid qualification of flexibility bids in procurement phase has to come together with bid optimisation. This is checked by the T&D CP.
2	The optimisation follows only if 'product prequalification' of the concerned resource had been successful. This is checked by the Flexibility Register.
3	Information about concerned flexibility bids and flexibility purchase offers as well as relevant grid information is available.
4	Cross-border acknowledgement of consents is enabled – consents given in one country are recognised in other country, with the same consent resource provider being able to grant access to data to different

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	roles in different countries, FSP can provide aggregation services to resource providers located in different countries, resource provider has access to consent services provided in another country.

1.7. Further information to the use case for classification/mapping

Classification information
Relation to other use cases
Other system use cases related to TSO-DSO coordination, Flexibility Register, Customer onboarding and Market Operator
Level of depth
Prioritisation
Generic, regional or national relation
Nature of use case
System use case
Further keywords for classification

1.8. General remarks

General remarks

2. Diagrams of use case

Diagram(s) of use case

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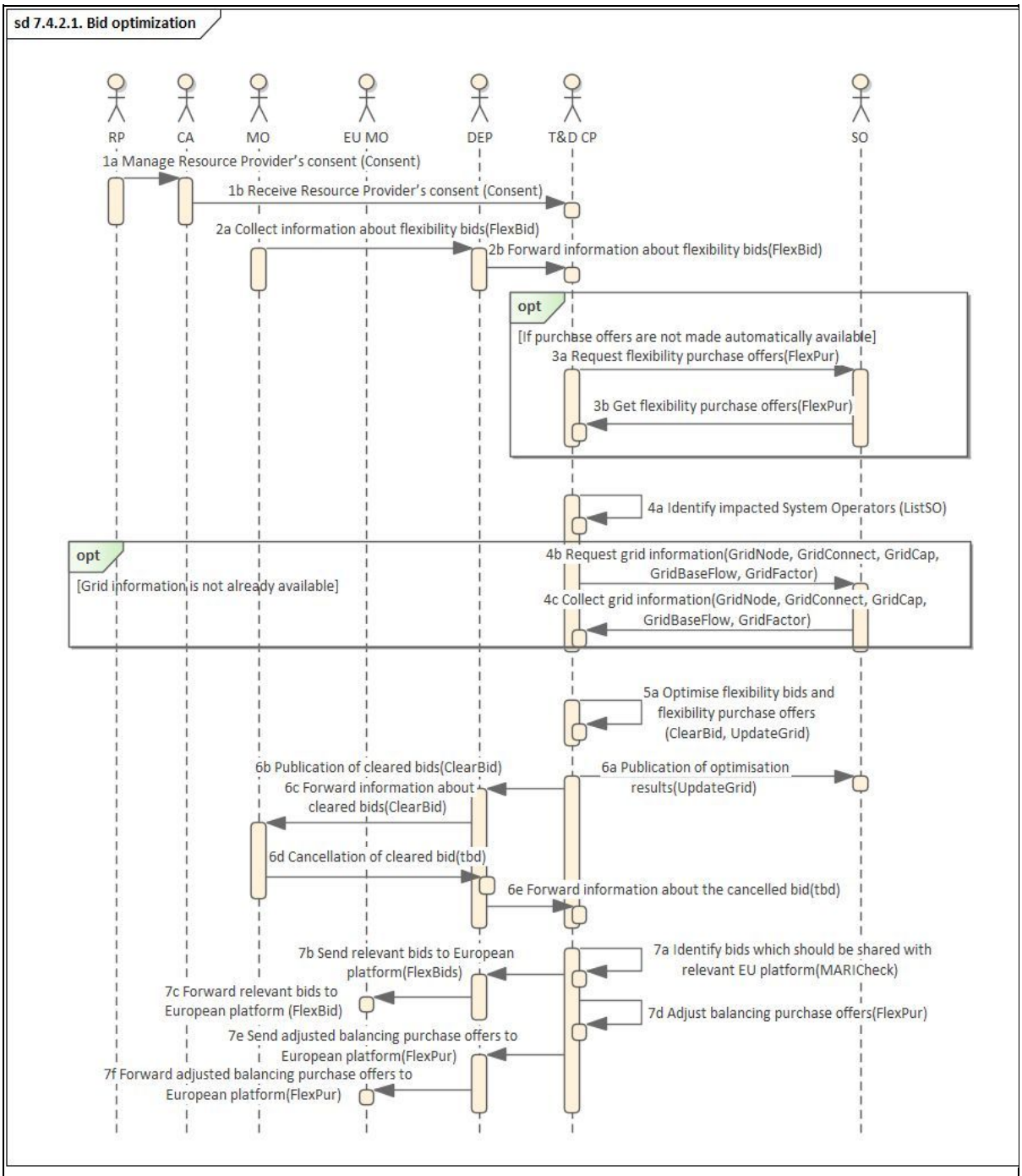

3. Technical details

3.1. Actors

Actors	
Grouping	***Group description***

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Actor name	*Actor type*	*Actor description*	*Further information specific to this use case*
TSO-DSO coordination platform (T&D CP)	System	System that is designed to avoid, through grid impact assessment, activation of flexibilities which either do not contribute to solving system needs or even worsen the situation (constraint setting process) as well as to find the best value-stack of available flexibilities to be activated (optimization process).	
System Operator (SO)	Business	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.	HEMRM definition.
Market Operator (MO)	Business	A market operator is a party that provides a service whereby the offers to sell electricity **or electricity flexibility** are matched with bids to buy electricity **or electricity flexibility**.	HEMRM definition with extensions (in bold) proposed by BRIDGE. Includes also TSOs and DSOs performing the role of MO.
European Market Operator (EU MO)	Business	Specific type of market operator responsible for operating European balancing platform (e.g., MARI).	
Resource Provider (RP)	Business	A role that manages a resource and provides production/consumption schedules for it, if required.	HEMRM definition.
Consent Administrator (CA)	Business	A party responsible for administrating a register of consents for a domain. The Consent Administrator makes this information available on request for entitled parties in the sector.	HEMRM definition.
Data Exchange Platform (DEP)	System	A communication platform the basic functionality of which is to secure data transfer (routing) from data providers (e.g., data hubs, flexibility service providers, TSOs, DSOs) to the data users (e.g., TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g., cryptographic hash of the data requested). The DEP does not store core energy data (e.g., meter data, grid data, market data) while these data can be stored by data hubs.	BRIDGE proposal.

3.2. References

References						
No.	*Reference Type*	*Reference*	*Status*	*Impact on use case*	*Originator / organisation*	*Link*
1	Report	EU-SysFlex deliverable 5.2		Investigation of relevant use cases	Horizon2020 project EU-SysFlex	https://eu-sysflex.com/wp-content/uploads/2020/10/EU-SysFlex-Task-5.2-D5.2-FINAL.pdf

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2		INTERRFACE task 5.3		Investigation of relevant use cases	Horizon2020 project INTERRFACE	
3	Report	CoordiNet deliverable 1.5		Investigation of relevant use cases	Horizon2020 project CoordiNet	https://private.coordinet-project.eu//files/documentos/5d724207ca982Coordinet_Deliverable_1.5.pdf
4		TDX-ASSIST		Investigation of relevant use cases	Horizon2020 project TDX-ASSIST	
5	Report	SmartNet deliverable 1.3		Investigation of relevant use cases	Horizon2020 project SmartNet	http://smartnet-project.eu/wp-content/uploads/2016/12/D1.3_20161202_V1.0.pdf
6	Report	Overview of energy flexibility services		Investigation of relevant use cases	ebIX®	https://mwgstorage1.blob.core.windows.net/public/Ebix/ebIX%20Overview%20of%20energy%20flexibility%20services%20-%20v1r0A%2020200106.pdf
7	Report	An integrated approach to Active System Management		Investigation of relevant use cases	CEDEC, E.DSO, ENTSO-E, Eurelectric, GEODE	https://www.entsoe.eu/Documents/Publications/Position%20papers%20and%20reports/TSO-DSO_ASM_2019_190416.pdf

4. Step by step analysis of use case

4.1. Overview of scenarios

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
7.4.2.1	Bid Optimisation		T&D CP			

4.2. Steps – Scenarios

Scenario								
Scenario name		7.4.2.1. Bid Optimisation						
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.a		Manage Resource Provider's consent	Resource Provider can give consent through Consent Administrator.		RP	CA	Consent	ConsMan DataSec
1.b		Receive Resource Provider's consent	T&D CP needs consent to have access to RP's private data on flexibility bid.		CA	T&D CP	Consent	ConsMan ConnectCA DataSec
2.a		Collect information about flexibility bids	MO submits all bids to T&D CP.		MO	DEP	FlexBid	ConnectMO DataSec

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2.b		Forward information about flexibility bids	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	T&D CP	FlexBid	ConnectMO DataSec
3.a		Request flexibility purchase offers (CONDITIONAL)	Purchase offers need to be requested if these are not made available automatically (pushed).		T&D CP	SO	FlexPur	ConnectSO DataSec
3.b		Get flexibility purchase offers	System Operator submits purchase offer.		SO	T&D CP	FlexPur	ConnectSO DataSec
4.a		Identify impacted System Operators	List of SOs who should send the grid information. The concerned SOs are predefined (see assumption #7).		T&D CP	T&D CP	ListSO	
4.b		Request grid information (CONDITIONAL)	Grid information from impacted SOs (in case this information is not already available).		T&D CP	SO	GridNode GridConnect GridCap GridBaseFlow GridFactor	ConnectSO DataSec
4.c		Collect grid information	Grid information from impacted SOs.		SO	T&D CP	GridNode GridConnect GridCap GridBaseFlow GridFactor	ConnectSO DataSec
5.a		Optimise flexibility bids and flexibility purchase offers	Optimising bids by matching flexibility bids and purchase offers in most economical way taking into account synergies (value-stacking), while not creating further conflicts in grid. This step is repeated continuously if time allows.		T&D CP	T&D CP	ClearBid UpdateGrid	QualAlg DataStore
6.a		Publication of optimisation results	Sending relevant information to SOs		T&D CP	SO	UpdateGrid	ConnectSO DataSec

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6.b		Publication of cleared bids	Sending relevant information to MOs		T&D CP	DEP	ClearBid	ConnectMO DataSec
6.c		Forward information about cleared bids	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO FR (tbd)	ClearBid	ConnectMO DataSec
6.d		Cancellation of cleared bid	For some products the time window allows the cancellation of initially cleared bids. If a bid is cancelled then the optimisation needs to be repeated: loop back to step 5.a.		MO	DEP	Tbd	ConnectMO DataSec
6.e		Forward information about the cancelled bid	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	T&D CP	tbd	ConnectMO DataSec
7.a		Identify bids which should be shared with relevant EU platform	EU platforms like MARI, TERRA, PICASSO. Relevant only for NRT-P-E product.		T&D CP	T&D CP	MARICheck	
7.b		Send relevant bids to European platform	Bids for balancing need to be sent to relevant EU platform at right time.		T&D CP	DEP	FlexBid	ConnectMO DataSec
7.c		Forward relevant bids to European platform	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	EU MO	FlexBid	ConnectMO DataSec
7.d		Adjust balancing purchase offers	TSOs' balancing purchase offers need to be adjusted taking into account the optimisation results.		T&D CP	T&D CP	FlexPur	
7.e		Send adjusted balancing purchase offers to European platform	Adjusted balancing purchase offers need to be sent to relevant EU		T&D CP	DEP	FlexPur	ConnectMO DataSec

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			platform at right time.					
7.f		Forward adjusted balancing purchase offers to European platform	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	EU MO	FlexPur	ConnectMO DataSec

5. Information exchanged

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
FlexBid	Flexibility Bid	Offer made by Flexibility Service Provider for selling flexibility.	
GridNode	Grid Node	Information about the grid nodes.	
GridConnect	Grid Connecting Element	Information about the elements such as lines connecting the grid nodes.	
GridCap	Grid Element's Capacity	Maximum power flow of a grid element.	
GridBaseFlow	Grid Element's Base Flow	Power flow over a grid element before flexibility activation.	
GridFactor	Grid Element's Sensitivity Factor	Matrix of sensitivity factors indicating the impact of power injection/withdrawal at a node onto the flows over related grid lines.	
FlexPur	Flexibility Purchase Offer	Offer made by System Operator for buying flexibility. Includes current and desired imbalance position, total cost cap.	
ClearBid	Cleared Bid	Cleared bids as the result of optimisation per relevant MO.	
UpdateGrid	Updated Grid Information and Procurement Cost	Updated status of the network, total cost, and optimisation status as the result of optimisation per relevant SO.	
ListSO	List of impacted System Operators	List of SOs who should send the grid information and be addressed in grid qualification process	
Consent	Customer Consent	Permission of data owner to use its private data.	
MARICheck	MARI eligibility Check	Non-cleared bids as the result of optimisation, but eligible to be forwarded to MARI platform.	

6. Requirements (optional)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
FUNCTIONAL	Functional requirements	
Requirement R-ID	***Requirement name***	***Requirement description***
ConnectSO	Data exchange with System Operator	The ability to exchange data with System Operator's relevant system(s)
ConnectMO	Data exchange with Market Operator	The ability to exchange data with Market Operator's relevant system(s), incl. with European platforms
ConnectCA	Data exchange with Consent Administrator	The ability to exchange data with Consent Administrator's relevant system(s)

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ConsMan	Consent management	The ability to give, obtain, process and store Resource Providers' consents
DataSec	Security of data exchange	Exchange of sensitive data needs to be protected
DataStore	Storing of relevant data	Storing capability of optimisation results needs to be ensured
Categories ID	***Category name for requirements***	***Category description***
NON-FUNCTIONAL	Non-functional requirements	
Requirement R-ID	***Requirement name***	***Requirement description***
QualAlg	Bid ranking and optimisation algorithm	Algorithm to perform required number of calculations within required period of time with required accuracy
ConnectXX	Connection conditions with other system	API, speed of data exchange and other relevant parameters to be defined
OpenSource / EUPL	Access to source code	Access to source code, unlimited rights to manage and further develop any system components. European Union public licence: Introduction to the EUPL licence | Joinup (europa.eu)

7. Common terms and definitions

Common terms and definitions	
Term	***Definition***

8. Custom information (optional)

Custom information (optional)		
Key	***Value***	***Refers to section***

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Appendix C: Call for tender opening SUC

Use Case: Flexibility Call for Tender Opening

1. Description of the use case

1.1. Name of use case

Use case identification		
ID	***Area(s)/Domain(s)/Zone(s)***	***Name of use case***
7.4.3	Flexibility market, TSO-DSO coordination	Flexibility Call for Tender Opening

1.2. Version management

Version management				
Version No.	***Date***	***Name of author(s)***	***Changes***	***Approval status***
1	2.06.2021	Kalle Kukk	First draft	For T7.4 partners' review
2	9.07.2021	Kalle Kukk, Kaja Trees, Kristjan Kuhi	Diagram and 'complete description' added	For inclusion in milestone report
3	24.11.2021	Kalle Kukk	Inclusion of 'OneNet system'	For T7.4 partners' review
4	3.12.2021	Kalle Kukk, Kaja Trees, Kristjan Kuhi	Updated diagram, cleaned up version	For WP5
5	15.11.2022	Kalle Kukk, Luciana Marques	Updated content	To be included in D7.4

1.3. Scope and objectives of use case

Scope and objectives of use case	
Scope	Opening flexibility call for tender and sharing information about ongoing calls with market and system operators.
Objective(s)	Facilitate coordinated trading by centralising information about active calls for tender.
Related business case(s)	Northern regional flexibility market

1.4. Narrative of Use Case

Narrative of use case
Short description
A call for tender of flexibility services is used in case of capacity products and it covers, in addition to product specifications, particular periods (week ahead, day ahead, intraday, etc.), location, quantity. The call for tender is initiated by the SO who needs the flexibility. Information about all calls is collected and stored centrally at T&D CP and made available to concerned MOs and SOs
Complete description
• 1.a. Request to open the flexibility call for tender • 1.b. Register flexibility calls for tender • 2.a. Publish information about calls for tender: This information helps other system operators to understand if they would like to open similar call. • 2.b. Alt.1 – Publish information about calls for tender: Information can be published to all subscribed market operators • 2.c. Alt.1 – Forward information about calls for tender: OneNet system (DEP) is applied to facilitate data exchange with MOs. • 2.d. Alt.2 – Request information about calls for tender: If market operator has not previously subscribed it can request the information

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- 2.e. Alt.2 – Forward request for information about calls for tender: OneNet system (DEP) is applied to facilitate data exchange with MOs.
- 2.f. Alt.2 – Send information about calls for tender
- 2.g. Alt.2 – Forward information about calls for tender: OneNet system (DEP) is applied to facilitate data exchange with MOs.

1.5. Key performance indicators (KPI)

Key performance indicators			
ID	*Name*	*Description*	*Reference to mentioned use case objectives*

1.6. Use case conditions

Use case conditions	
Assumptions	
Prerequisites	

1.7. Further information to the use case for classification/mapping

Classification information
Relation to other use cases
Other system use cases related to TSO-DSO coordination, Flexibility Register, Customer onboarding and Market Operator
Level of depth
Prioritisation
Generic, regional or national relation
Nature of use case
System use case
Further keywords for classification

1.8. General remarks

General remarks

2. Diagrams of use case

Diagram(s) of use case

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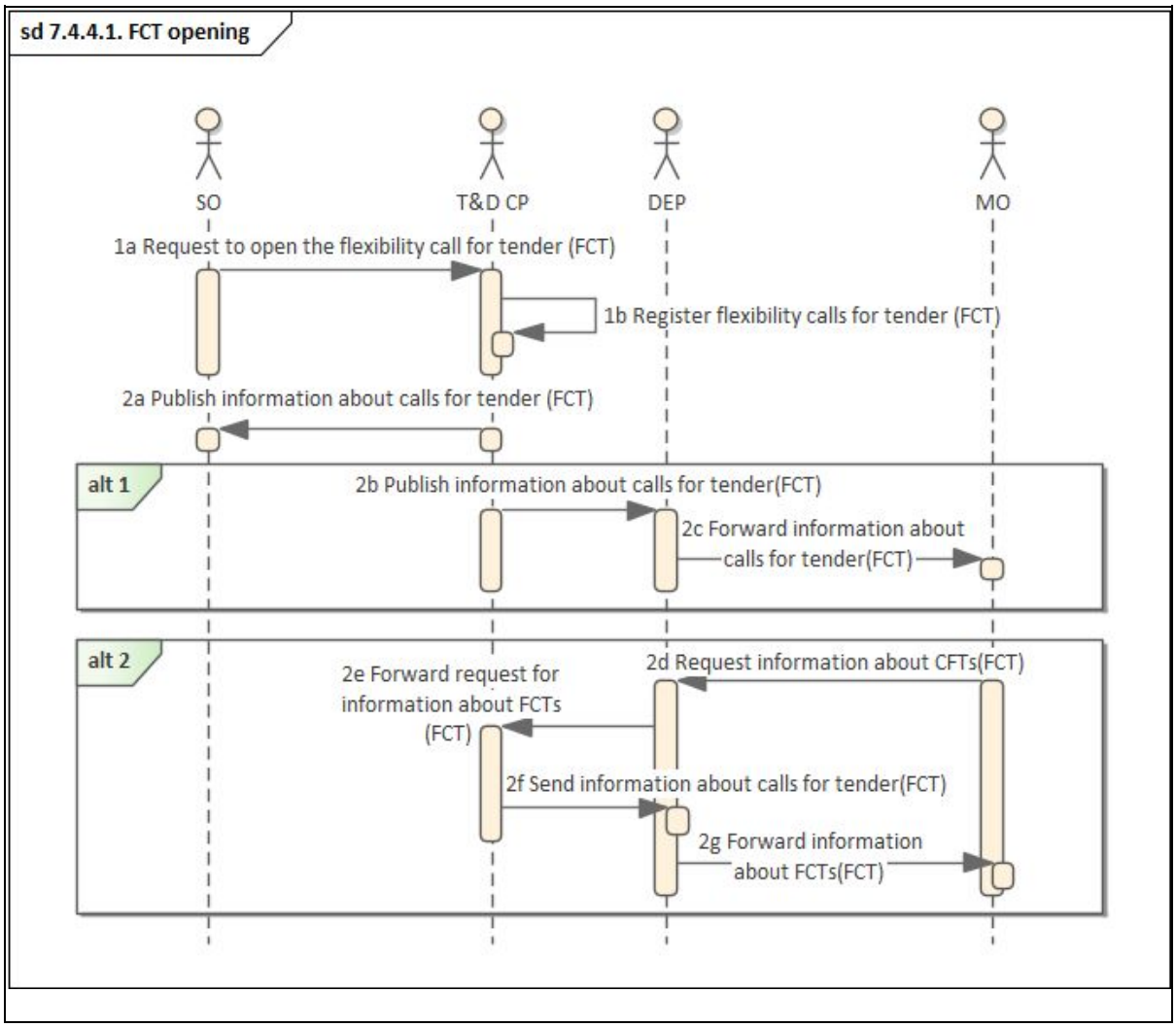

3. Technical details

3.1. Actors

Actors			
Grouping		***Group description***	
Actor name	***Actor type***	***Actor description***	***Further information specific to this use case***
TSO-DSO coordination platform (T&D CP)	System	System that is designed to avoid, through grid impact assessment, activation of flexibilities which either do not contribute to solving system needs or even worsen the situation (constraint setting process) as well as to find the best value-stack of available flexibilities to be activated (optimization process).	
System Operator (SO)	Business	A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for	HEMRM definition.

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		ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.	
Market Operator (MO)	Business	A market operator is a party that provides a service whereby the offers to sell electricity **or electricity flexibility** are matched with bids to buy electricity **or electricity flexibility**.	HEMRM definition with extensions (in bold) proposed by BRIDGE. Includes also TSOs and DSOs performing the role of MO.
Data Exchange Platform (DEP)	System	A communication platform the basic functionality of which is to secure data transfer (routing) from data providers (e.g., data hubs, flexibility service providers, TSOs, DSOs) to the data users (e.g., TSOs, DSOs, consumers, suppliers, energy service providers). DEP stores data related to its services (e.g., cryptographic hash of the data requested). The DEP does not store core energy data (e.g., meter data, grid data, market data) while these data can be stored by data hubs.	BRIDGE proposal.

3.2. References

References						
No.	***Reference Type***	***Reference***	***Status***	***Impact on use case***	***Originator / organisation***	***Link***
1	Report	EU-SysFlex deliverable 5.2		Investigation of relevant use cases	Horizon2020 project EU-SysFlex	https://eu-sysflex.com/wp-content/uploads/2020/10/EU-SysFlex-Task-5.2-D5.2-FINAL.pdf
2		INTERRFACE task 5.3		Investigation of relevant use cases	Horizon2020 project INTERRFACE	
3	Report	CoordiNet deliverable 1.5		Investigation of relevant use cases	Horizon2020 project CoordiNet	https://private.coordinet-project.eu//files/documentos/5d724207ca982Coordinet_Deliverable_1.5.pdf
4		TDX-ASSIST		Investigation of relevant use cases	Horizon2020 project TDX-ASSIST	
5	Report	SmartNet deliverable 1.3		Investigation of relevant use cases	Horizon2020 project SmartNet	http://smartnet-project.eu/wp-content/uploads/2016/12/D1.3_20161202_V1.0.pdf
6	Report	Overview of energy flexibility services		Investigation of relevant use cases	ebIX®	https://mwgstorage1.blob.core.windows.net/public/Ebix/ebIX%20Overview%20of%20energy%20flexibility%20services%20-%20v1r0A%2020200106.pdf
7	Report	An integrated approach to		Investigation of relevant use cases	CEDEC, E.DSO, ENTSO-E,	https://www.entsoe.eu/Documents/Publications/Position%20papers%20and%20repor

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		Active System Management			Eurelectric, GEODE	ts/TSO-DSO_ASM_2019_190416.pdf

4. Step by step analysis of use case

4.1. Overview of scenarios

Scenario conditions						
No.	***Scenario name***	***Scenario description***	***Primary actor***	***Triggering event***	***Pre-condition***	***Post-condition***
7.4.4.1	FCT opening		T&D CP			

4.2. Steps – Scenarios

Scenario								
Scenario name		7.4.4.1. FCT opening						
Step No	***Event***	***Name of process/activity***	***Description of process/activity***	***Service***	***Information producer (actor)***	***Information receiver (actor)***	***Information exchanged (IDs)***	***Requirement, R-IDs***
1.a		Request to open the flexibility call for tender			SO	T&D CP	FCT	ConnectSO DataSec
1.b		Register flexibility calls for tender			T&D CP	T&D CP	FCT	DataStore
2.a		Publish information about calls for tender	This information helps other system operators to understand if they would like to open similar call.		T&D CP	SO	FCT	ConnectSO DataSec
2.b		*Alt.1* – Publish information about calls for tender	Information can be published to all subscribed market operators.		T&D CP	DEP	FCT	ConnectMO DataSec
2.c		*Alt.1* – Forward information about calls for tender	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	FCT	ConnectMO DataSec
2.d		*Alt.2* – Request information about calls for tender	If market operator has not previously subscribed it can request the information.		MO	DEP	FCT	ConnectMO DataSec
2.e		*Alt.2* – Forward request for information about calls for tender	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	T&D CP	FCT	ConnectMO DataSec
2.f		*Alt.2* – Send information about calls for tender			T&D CP	DEP	FCT	ConnectMO DataSec

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2.g		*Alt.2* – Forward information about calls for tender	OneNet system (DEP) is applied to facilitate data exchange with MOs.		DEP	MO	FCT	ConnectMO DataSec

5. Information exchanged

Information exchanged			
Information exchanged, ID	***Name of information***	***Description of information exchanged***	***Requirement, R-IDs***
FCT	Flexibility Call for Tender	Flexibility call specification for a specific product.	

6. Requirements (optional)

Requirements (optional)		
Categories ID	***Category name for requirements***	***Category description***
FUNCTIONAL	Functional requirements	
Requirement R-ID	***Requirement name***	***Requirement description***
ConnectSO	Data exchange with System Operator	The ability to exchange data with System Operator's relevant system(s)
ConnectMO	Data exchange with Market Operator	The ability to exchange data with Market Operator's relevant system(s), incl. with European platforms
DataSec	Security of data exchange	Exchange of sensitive data needs to be protected
DataStore	Storing of relevant data	Storing capability of flexibility calls for tender needs to be ensured
Categories ID	***Category name for requirements***	***Category description***
NON-FUNCTIONAL	Non-functional requirements	
Requirement R-ID	***Requirement name***	***Requirement description***
ConnectXX	Connection conditions with other system	API, speed of data exchange and other relevant parameters to be defined
OpenSource / EUPL	Access to source code	Access to source code, unlimited rights to manage and further develop any system components. European Union public licence: Introduction to the EUPL licence | Joinup (europa.eu)

7. Common terms and definitions

Common terms and definitions	
Term	***Definition***

8. Custom information (optional)

Custom information (optional)		
Key	***Value***	***Refers to section***

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Appendix D: Data semantics table

Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
ResInfo	Resource Information							FSP's future potential to provide the flexibility.
	Document ID	Code	ID	ID	ID	ID	ID	
	Document version	Number	Number	Number	Number	Number	Number	
	Document creation date and time	Data and time	date, time	date, time	date, time	date, time	date, time	
	Sender ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Sender role	Code	Code	Code	Code	Code	Code	
	Receiver ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Receiver role	Code	Code	Code	Code	Code	Code	
	Flexibility service provider ID	Code	EIC	EIC	EIC	EIC	EIC	Business registry code.
	Resource ID		FR defines (Resource dependent)	FR defines (Resource dependent)	FR defines (Resource dependent)	FR defines (Resource dependent)	FR defines (Resource dependent)	The ID assigned by the OneNet system.
	Main metering point ID	EIC	EIC	EIC	EIC	EIC	EIC	ID of the main meter to which the resource is attached.
	Sub-metering point ID		FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	ID of the sub-meter to which the resource is attached.
	Recovery time	Hours		FSP defines (Resource dependent)				Used for Capacity product activation phase, to make sure maximum required recovery period is considered when sending reserved bids into activation optimization.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Resource Type	Load, Generation, Storage	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	
	Flexible reactive power	Amount (MVAr)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	The amount of flexibiltiy resource reactive power that can be delivered as a product.
	Flexible active power	Amount (MW)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	The amount of flexibiltiy resource active power that can be delivered as a product.
	Preparation period	Minutes	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	Preparation period is time between sending activation signal and start of ramping period or deactivation period. The activation requires normally some preparation on FSP side especially if its done manually.
	Ramping period	Minutes	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	Ramping period is time before the start of delivery period. FSP has to reach its full delivery capacity requested by system operator within this period.
	Full activation time	Minutes	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	The period between the activation request by the SO and the corresponding full delivery of the concerned product.
	Deactivation period	Minutes	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	The period for ramping from full delivery to a set point, or from full withdrawal back to a set point.
	Minimum duration of delivery period	Minutes	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	The minimum possible continuous delivery period.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Maximum duration of delivery period	Minutes	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	The maximum possible continuous delivery period.
	(Future proposal) Rebound effect	Y/N	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	
	(Future proposal) Rebound effect delay	Minutes	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	The time after activation till rebound effect starts.
	(Future proposal) Rebound effect quantity	Amount	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	The power quantity of the rebound effect defined in delivered quantity measurement value.
	Expiration date (optional)	Date and time						Maximum time during which the potential is prequalified
	Localization factor (optional)	Array of Address / geographical coordinates / EIC / GSRN / other (biding zone etc.)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP defines (Resource dependent)	FSP provides address and/or geographical coordinates of the meter or sub-meter participating in flexibility delivery. If this is not provided by FSP then it can participate in balancing only and not in congestion management.
	Baseline type	Ex-ante / ex-post	FSP defines	FSP defines	FSP defines	FSP defines	FSP defines	FSP indicates whether it is obliged to provide ex-ante baseline (schedule) for a given metering point before activation.

Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
FCT	Flexibility Call for Tender							Flexibility call specification for a specific product.
	Document ID	Code	ID	ID	ID	ID	ID	
	Document version	Number	Number	Number	Number	Number	Number	
	Document creation date and time	Data and time	date, time	date, time	date, time	date, time	date, time	
	Sender ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Sender role	Code	Code	Code	Code	Code	Code	
	Receiver ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Receiver role	Code	Code	Code	Code	Code	Code	
	Opening System operator ID	EIC	EIC	EIC	EIC	N/A	N/A	ID of the system operator who had initiated the opening of FCT.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Product name	Acronym	LT-P-C	LT-P-C/E	ST-P-C	N/A	N/A	LT-P-C/E (Long Term Active Capacity/Energy) is procured months to years ahead. Used by SOs for congestion management, frequency and adequacy. LT-Q-C (Long Term Reactive Capacity) is used by SOs for voltage control on HV, MV and LV levels. ST-P-C (Short Term Active Capacity) is procured day to a month ahead. Used by SOs for congestion management and frequency.
	Minimum price	EUR	EUR	EUR	EUR	N/A	N/A	Requirements to the price offered by FSP. Unit depending on product (capacity or energy).
	Maximum price	EUR	EUR	EUR	EUR	N/A	N/A	Requirements to the price offered by FSP. Unit depending on product (capacity or energy).
	Total cost Cap	EUR	EUR	EUR	EUR	N/A	N/A	
	Direction	UP / DOWN	SO defined	SO defined	SO defined	N/A	N/A	Regulating up / regulating down. Regulating up is increase in generation or decrease in demand. Regulating down is decrease in generation or increase in demand.
	Maximum consecutive delivery hours (optional)	Minutes	SO defined / N/A	360	SO defined / N/A	N/A	N/A	
	Recovery period (optional)	Unit (minutes, hours)	SO defined / N/A	N/A	SO defined / N/A	N/A	N/A	Minimum duration between the end of deactivation period and the following activation.
	Linking of bids	Y/N	SO defined	SO defined	SO defined	N/A	N/A	Defines whether linking of bids is allowed.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Linking of bid types (optional)	TBD	SO defined / N/A	SO defined / N/A	SO defined / N/A	N/A	N/A	Defines the types of links allowed.
	Bid types	FullyDivisible (FD), FullyIndivisible(FI), PartiallyDivisible (PD)	FD/FI/PD	FI	FD/FI/PD	N/A	N/A	Linking of bids is allowed or not. Linking of bids can be allowed inside same imbalance settlement period. E.g. bid 2 can be activated only in case bid 1 is activated. If bid 1 is not activated, then bid 2 is unavailable.
	Localization factor	Array of Address / geographical coordinates / EIC / GSRN / other (biding zone etc.)	SO defined	SO defined	SO defined	N/A	N/A	System operator defines location in its network where the service is required. This can be general for balancing e.g. country, but for congestion management e.g. node, line specific.
	Link to energy product (optional)	Acronym	ST-P-E / NRT-P-E / N/A	N/A	NRT-P-E / N/A	N/A	N/A	Specifies the delivery of the capacity product delivery. SO can request it to be delivered in the form of energy bids in a specific energy market or directly. **Example**, LT-P-C could be delivered as mFRR bids under NRT-P-E or as aFRR bids under a new product type (e.g. RT-P-E) or directly without other market interaction.
	Opening date	Date and time	SO defined	SO defined	SO defined	N/A	N/A	Beginning of the auction. This is the date when FSPs can start to submit the bids.
	Closing date	Date and time	SO defined	SO defined	SO defined	N/A	N/A	End of the auction. This is the final date for bid submission. In case of ST-P-C the closing date can be left open.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Gate closure time	Date and time	N/A	N/A	SO defined	N/A	N/A	Relevant in case of ST-P-C whereby the single FCT may include several consecutive bid submission periods.
	Minimum delivery period (Optional)	Minutes	SO defined / N/A	SO defined / N/A	SO defined / N/A	N/A	N/A	(Offered new attribute for review!) Defines minimum service delivery period of the FSP's resources.
	Start of service date and time	Date and time	SO defined	SO defined	SO defined	N/A	N/A	The date when service delivery, i.e. activation of flexibilities will start.
	End of service date and time	Date and time	SO defined	SO defined	SO defined	N/A	N/A	The date when service delivery, i.e. activation of flexibilities will end.
FlexBid	Flexibility Bid							Offer made by Flexibility Service Provider for selling flexibility.
	Document ID	Code	ID	ID	ID	ID	ID	Unique sequence of characters that represents a certain document. Used for communication with other systems and platforms.
	Document version	Number	Number	Number	Number	Number	Number	Numerical value starting from 1 where each edition of the specific document increases the value by 1. Used for communication with other systems and platforms.
	Document creation date and time	Data and time	date, time	date, time	date, time	date, time	date, time	Moment specified by date and time when document was created. Used for communication with other systems and platforms.
	Sender ID	EIC	EIC	EIC	EIC	EIC	EIC	Code that identifies the sender (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Sender role	Code	Code	Code	Code	Code	Code	Code that identifies the sender role.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Receiver ID	EIC	EIC	EIC	EIC	EIC	EIC	Code that identifies the receiver (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Receiver role	Code	Code	Code	Code	Code	Code	Code that identifies the receiver role.
	Flexibility service provider ID	EIC	EIC	EIC	EIC	EIC	EIC	Business registry code.
	Resource Group OneNet ID	Code	Resource Group ID	Resource Group ID	Resource Group ID	Resource Group ID	Resource Group ID	Resource Group ID given and used by OneNet platform once FSP creates a resource group. This ID can be used as a reference during qualification and after qualification as reference for BID, activation of BID and settlement of BID.
	Bid ID	Code	ID	ID	ID	ID	ID	ID for market identifying the bid.
	Product name	Acronym	LT-P-C	LT-P-C	ST-P-C	ST-P-E	NRT-P-E	LT-P-C/E (Long Term Active Capacity/Energy) is procured months to years ahead. Used by SOs for congestion management, frequency and adequacy. LT-Q-C (Long Term Reactive Capacity) is used by SOs for voltage control on HV, MV and LV levels. ST-P-C (Short Term Active Capacity) is procured day to a month ahead. Used by SOs for congestion management and frequency. ST-P-E (Short Term Active Energy) is procured day to a month ahead. Used by SOs for congestion management. NRT-P-E (Near Real Time Active Energy) is used by SOs responsible for frequency and congestion management. Procured in near-real-time (15min). Activated manually. NRT-Q-E (Near Real Time Reactive Energy) is

Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
								used by SOs for voltage control on HV, MV and LV levels. Procured from intra-day to near-real-time (15min).
	Price (optional)	Amount	N/A	FSP defined	N/A	FSP defined	FSP defined	Bid energy price, defining the price of resource activation per quantity.
	Reservation price (optional)	Amount	FSP defined	FSP defined	FSP defined	N/A	N/A	Bid reservation price, defining the price for the resource availability per quantity.
	Quantity	Amount	FSP defined	FSP defined	FSP defined	FSP defined	FSP defined	The total offered power amount.
	Direction	UP / DOWN	FSP defined	FSP defined	FSP defined	FSP defined	FSP defined	Regulating up / regulating down. Regulating up is increase in generation or decrease in demand. Regulating down is decrease in generation or increase in demand.
	Minimum quantity (optional)	Amount	FSP defined / N/A	FSP defined / N/A	FSP defined / N/A	FSP defined / N/A	FSP defined / N/A	Minimum quantity required by the specific bid only if bid is partially divisible.
	Linking of bids type (optional)	Technical / Conditional / Other/ N/A	Other / N/A	Other / N/A	Other / N/A	N/A	Technical / Conditional / Other/ N/A	Defines bid linkage type.
	List of linked bids (optional)	ID	ID	ID	ID	N/A	ID	Provides list of linked market bid IDs.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Bid types	FullyDivisible (FD), FullyIndivisible(FI), PartiallyDivisible (PD)	FD/FI/PD	FD/FI/PD	FD/FI/PD	FD/FI/PD?	FD/FI/PD	
	(Optional) Exclusive Block ID	Code	ID	ID	ID	ID	ID	ID to identify the exclusive block order this bid is part of. If bid is not part of any exclusive block order, then leave blank.
	(Optional) Multipart ID	Code	ID	ID	ID	ID	ID	ID to identify the multipart order this bid is part of. If bid is not part of any multipart order, then leave blank
	(Optional) Parent or Child	Parent/Child	Parent/Child	Parent/Child	Parent/Child	Parent/Child	Parent/Child	If bid in multipart, then it is necessary to define if it is parent or child. An MP has only one parent bid and one or more children bids
	Start of time interval	Date and time	FSP defined	FSP defined	FSP defined	FSP defined	FSP defined	The date when service delivery, i.e. activation of flexibilities will start.
	Run time			FSP defined				
	End of time interval	Date and time	FSP defined	FSP defined	FSP defined	FSP defined	FSP defined	The date when service delivery, i.e. activation of flexibilities will end.
FlexPur	Flexibility purchase offer							Offer made by System Operator for buying flexibility.
	Document ID	Code	ID	ID	ID	ID	ID	Unique sequence of characters that represents a certain document. Used for communication with other systems and platforms.
	Document version	Number	Number	Number	Number	Number	Number	Numerical value starting from 1 where each edition of the specific document increases the value by 1. Used for communication with other systems and platforms.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Document creation date and time	Data and time	date, time	date, time	date, time	date, time	date, time	Moment specified by date and time when document was created. Used for communication with other systems and platforms.
	Sender ID	EIC	EIC	EIC	EIC	EIC	EIC	Code that identifies the sender (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Sender role	Code	Code	Code	Code	Code	Code	
	Receiver ID	EIC	EIC	EIC	EIC	EIC	EIC	Code that identifies the receiver (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Receiver role	Code	Code	Code	Code	Code	Code	
	System operator ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Quantity	Amount	SO defined	SO defined	SO defined	SO defined	SO defined	
	Product name	Acronym	LT-P-C	LT-P-C/E	ST-P-C	ST-P-E	NRT-P-E	LT-P-C/E (Long Term Active Capacity/Energy) is procured months to years ahead. Used by SOs for congestion management, frequency and adequacy. LT-Q-C (Long Term Reactive Capacity) is used by SOs for voltage control on HV, MV and LV levels. ST-P-C (Short Term Active Capacity) is procured day to a month ahead. Used by SOs for congestion management and frequency. ST-P-E (Short Term Active Energy) is procured day to a month ahead. Used by SOs for congestion management. NRT-P-E (Near Real Time Active Energy) is used by SOs responsible for frequency and congestion

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
								management. Procured in near-real-time (15min). Activated manually. NRT-Q-E (Near Real Time Reactive Energy) is used by SOs for voltage control on HV, MV and LV levels. Procured from intra-day to near-real-time (15min).
	Localization factor	Array of Address / geographical coordinates / EIC / GSRN / other (biding zone etc.)	SO defined	SO defined	SO defined	SO defined	SO defined	
	Start of delivery	Date and time	SO defined	SO defined	SO defined	SO defined	SO defined	Defines the start of the delivery period.
	End of delivery	Date and time	SO defined	SO defined	SO defined	SO defined	SO defined	Defines the end of the delivery period.
	Actual system imbalance	Amount	N/A	N/A	N/A	N/A?	TSO defined	The actual system imbalance for the MTU period.
	Minimum system imbalance	Amount	N/A	N/A	N/A	N/A?	TSO defined	The minimum allowed imbalance for the MTU period.
	Maximum system imbalance	Amount	N/A	N/A	N/A	N/A?	TSO defined	The maximum allowed imbalance for the MTU period.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Total Cost Cap (optional)	Value	SO defined	SO defined	SO defined	SO defined	SO defined	A value (in €) corresponding to the maximum total cost the system operators are willing to collectively pay to purchase the service (e.g. congestion management) for this particular market session. The total cost is one value for all system operators together, as the problem is solved jointly (TSO and DSOs needs at once). Value is optional: if not provided, the optimization uses a default large number.
	Expected number of activated hours	Hours	N/A	SO defined	N/A	N/A	N/A	
ClearBid	Cleared Bids							Cleared bids as the result of optimisation per relevant MO.
	Document ID	Code	ID	ID	ID	ID	ID	Unique sequence of characters that represents a certain document. Used for communication with other systems and platforms.
	Document version	Number	Number	Number	Number	Number	Number	Numerical value starting from 1 where each edition of the specific document increases the value by 1. Used for communication with other systems and platforms.
	Document creation date and time	Data and time	date, time	date, time	date, time	date, time	date, time	Moment specified by date and time when document was created. Used for communication with other systems and platforms.
	Sender ID	EIC	EIC	EIC	EIC	EIC	EIC	Code that identifies the sender (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Sender role	Code	Code	Code	Code	Code	Code	

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Receiver ID	EIC	EIC	EIC	EIC	EIC	EIC	Code that identifies the receiver (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Receiver role	Code	Code	Code	Code	Code	Code	
	Resource Group ID	Codes	ID	ID	ID	ID	ID	IDs of resource groups cleared as part of each cleared bid.
	Bid ID	Codes	ID	ID	ID	ID	ID	IDs of each cleared bid.
	System operator ID	EIC	EIC	EIC	EIC	EIC	EIC	Purchasing system operator ID.
	Bid types	FullyDivisible (FD), FullyIndivisible(FI), PartiallyDivisible (PD)	FD/FI/PD	FD/FI/PD	FD/FI/PD	FD/FI/PD?	FD/FI/PD	
	Product name	Acronym	LT-P-C	LT-P-C/E	ST-P-C	ST-P-E	NRT-P-E	
	Cleared price	Amount	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Cleared price of each bid. In case of marginal pricing it is the same price for all cleared bids.
	Cleared quantity	Amount	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Quantities of each cleared bid.
	Direction	UP / DOWN	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Optimization outcome specified	Direction per each cleared bid.
	FSP ID	EIC	EIC	EIC	EIC	EIC	EIC	IDs of FSPs attached to each cleared bid.
	MO ID	EIC	EIC	EIC	EIC	EIC	EIC	ID of relevant Market Operator who is entitled to get the list of cleared bids.
MARICheck	MARI eligibility check							Non-cleared bids as the result of optimisation, but eligible to be forwarded to MARI platform.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Document ID	Code	N/A	N/A	N/A	N/A	ID	Unique sequence of characters that represents a certain document. Used for communication with other systems and platforms.
	Document version	Number	N/A	N/A	N/A	N/A	Number	Numerical value starting from 1 where each edition of the specific document increases the value by 1. Used for communication with other systems and platforms.
	Document creation date and time	Data and time	N/A	N/A	N/A	N/A	date, time	Moment specified by date and time when document was created. Used for communication with other systems and platforms.
	Sender ID	EIC	N/A	N/A	N/A	N/A	EIC	Code that identifies the sender (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Sender role	Code	Code	Code	Code	Code	Code	
	Receiver ID	EIC	N/A	N/A	N/A	N/A	EIC	Code that identifies the receiver (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Receiver role	Code	Code	Code	Code	Code	Code	
	Resource Group ID	Codes	N/A	N/A	N/A	N/A	ID	IDs of resource groups of each MARI eligible bid.
	Bid ID	Codes	N/A	N/A	N/A	N/A	ID	IDs of each MARI eligible bid.
	FSP ID	EIC	N/A	N/A	N/A	N/A	EIC	IDs of FSPs attached to each MARI eligible bid.
	Checked quantity	Amount	N/A	N/A	N/A	N/A	Optimization outcome specified	Quantities of each MARI eligible bid.
	Price	Amount	N/A	N/A	N/A	N/A	FSP defined	Bid energy price, defining the price of resource activation per quantity.

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Direction	UP / DOWN	N/A	N/A	N/A	N/A	FSP defined	Regulating up / regulating down. Regulating up is increase in generation or decrease in demand. Regulating down is decrease in generation or increase in demand.
	Linking of bids type (optional)	Technical / Conditional / Other/ N/A	N/A	N/A	N/A	N/A	Technical / Conditional / Other/ N/A	Defines bid linkage type.
	List of linked bids (optional)	ID	N/A	N/A	N/A	N/A	ID	Provides list of linked market bid IDs.
	Bid types	FullyDivisible (FD), FullyIndivisible(FI), PartiallyDivisible (PD)	N/A	N/A	N/A	N/A	FD/FI/PD	
	(Optional) Exclusive Block ID	Code	N/A	N/A	N/A	N/A	ID	ID to identify the exclusive block order this bid is part of. If bid is not part of any exclusive block order, then leave blank.
	(Optional) Multipart ID	Code	N/A	N/A	N/A	N/A	ID	ID to identify the multipart order this bid is part of. If bid is not part of any multipart order, then leave blank
	(Optional) Parent or Child	Parent/Child	N/A	N/A	N/A	N/A	Parent/Child	If bid in multipart, then it is necessary to define if it is parent or child. An MP has only one parent bid and one or more children bids
	Start of time interval	Date and time	N/A	N/A	N/A	N/A	FSP defined	The date when service delivery, i.e. activation of flexibilities will start.
	End of time interval	Date and time	N/A	N/A	N/A	N/A	FSP defined	The date when service delivery, i.e. activation of flexibilities will end.
UpdateGrid	Updated Grid Information and Procurement Cost							Updated status of the network, total cost, and optimisation status as the result of optimisation per relevant SO.
	Document ID	Code	ID	ID	ID	ID	ID	
	Document version	Number	Number	Number	Number	Number	Number	

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Document creation date and time	Data and time	date, time	date, time	date, time	date, time	date, time	
	Sender ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Sender role	Code	Code	Code	Code	Code	Code	
	Receiver ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Receiver role	Code	Code	Code	Code	Code	Code	
	Total Cost	Amount						The total cost of the procured bids
	Total Expected Activation Cost	Amount	N/A		N/A	N/A	N/A	The total expected activation cost of the procured bids (only applies to the LT-P-C/E product, and its reservation stage)
	Total Reservation Cost	Amount	N/A		N/A	N/A	N/A	The total expected activation cost of the procured bids (only applies to the LT-P-C/E product, and its reservation stage)
	Optimisation Status	Code						Result of the optimisation. Possible values are: - ALL CONGESTION RESOLVED - CONGESTION PARTIALLY RESOLVED (COST CAP REACHED) - CONGESTION PARTIALLY RESOLVED (INSUFFICIENCY OF BIDS) - MODEL IS INFEASIBLE OR UNBOUNDED - MODEL RETURNED AN UNKNOWN ERROR - ERRONEOUS DATA (DATA ENTRY VIOLATES INPUT SPECIFICATION) - PRODUCT ORDER TYPE NOT SUPPORTED - PROBLEM WHEN READING BIDS DATA (BID DATA FORMAT VIOLATES INPUT SPECIFICATION) - PROBLEM WHEN READING NETWORK DATA (NETWORK DATA FORMAT VIOLATES INPUT SPECIFICATION)

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Start of delivery	Date and time	SO defined	SO defined	SO defined	SO defined	SO defined	Defines the start of the delivery period.
	End of delivery	Date and time	SO defined	SO defined	SO defined	SO defined	SO defined	Defines the end of the delivery period.
	Grid element ID	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	ID represents any element in the SOs system. This represents a line, transformer or smaller element in the system.
	System operator ID	EIC	EIC	EIC	EIC	EIC	EIC	Name and business registry code
	From grid element	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	Used for network connecting elements such as lines to indicate from which node ID line is connected.
	To grid element	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	EIC / GSRN / Other	Used for network connecting elements such as lines to indicate to which node ID line is connected.
	Grid element resulting power flow	Amount	MW	MW	MW	MW	MW	Informs what is the resulting power flow over line if cleared bids are activated
	Line Overflow	Amount	MW	MW	MW	MW	MW	Flow exceeding the line capacity after the market clearing.
	TN System operator ID (optional)	EIC	EIC	N/A	EIC	EIC	EIC	TN system operator ID (to indicate the interface lines) - does not apply to LT-P-C/E product, or if only TN system is considered
	DN System operator ID (optional)	EIC	EIC	N/A	EIC	EIC	EIC	DN system operator ID (to indicate the interface lines) - does not apply to LT-P-C/E product, or if only TN system is considered
	Interface line resulting power flow (optional)	Amount	MW	N/A	MW	MW	MW	Informs what is the resulting power flow over interface line if cleared bids are activated - does not apply to LT-P-C/E product, or if only TN system is considered
	Interface Line Overflow (optional)	Amount	MW	N/A	MW	MW	MW	Flow exceeding the interface line capacity after the market clearing - does not apply to LT-P-C/E product, or if only TN system is considered

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	New imbalance position	Amount	MW	N/A	MW	MW	MW	New imbalance position of the interconnected system after the market clearing (after the optimization is completed).
-								
GridNode	Grid Node							Information about the grid nodes.
-	systemId	Code						
-	nodes	GridNode						
GridNode								
	id	Code						
	root	Boolean						If DN node is root, it is connected to the higher voltage/meshed (TN) system
	slack	Boolean						Indicates if a grid element (node) is the slack bus or not
	name	String						Optinonal, for information only
	type	String						Optinonal, for information only
	location	String						Optinonal, for information only
GridConnect	Grid Connecting Element							Information about the elements such as lines connecting the grid nodes.
-	systemId	Code						
-	connections	GridConnection						
GridConnection								
	id	Code						
	fromNodeId	Code						
	toNodeId	Code						
	name	String						Optinonal, for information only
GridCap	Grid Element's Capacity							Maximum power flow of a grid element.
-	systemId	Code						

Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
- - - GridCapacity	startDateTime	Data and time						
	endDateTime	Data and time						
	capacities	GridCapacity						
	connectionId	Code						
	value	Decimal Nubmer						
GridBaseFlow	Grid Element's Base Flow							Power flow over a grid element before flexibility activation.
- - - - GridBaseFlow	systemId	Code						
	startDateTime	Data and time						
	endDateTime	Data and time						
	baseflows	GridBaseFlow						
	connectionId	Code						
	activePowerFlowForecastKW	Decimal Number						
GridFactor	Grid Element's Sensitivity Factor							Matrix of sensitivity factors indicating the impact of power injection/withdrawal at a node onto the flows over related grid lines.
- - - - GridFactor	systemId	Code						
	startDateTime	Data and time						
	endDateTime	Data and time						
	factors	GridFactor						
	assessedConnectionId	Code						
	influencingNodeId	Code						
	sensitivity	Decimal Nubmer						

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
GridRest	Grid Restrictions							Constraints assigned to flexibilities which cannot be (fully or partially) activated without causing congestions in the grid.
	Document ID	Code	ID	ID	ID	ID	ID	Unique sequence of characters that represents a certain document. Used for communication with other systems and platforms.
	Document version	Number	Number	Number	Number	Number	Number	Numerical value starting from 1 where each edition of the specific document increases the value by 1. Used for communication with other systems and platforms.
	Document creation date and time	Data and time	date, time	date, time	date, time	date, time	date, time	Moment specified by date and time when document was created. Used for communication with other systems and platforms.
	Sender ID	EIC	EIC	EIC	EIC	EIC	EIC	Code that identifies the sender (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Sender role	Code	Code	Code	Code	Code	Code	
	Receiver ID	EIC	EIC	EIC	EIC	EIC	EIC	Code that identifies the receiver (SO, MO, OneNet plat. etc.) of the message. Used for communication with other systems and platforms.
	Receiver role	Code	Code	Code	Code	Code	Code	
	Resource Group ~~OneNet~~ ID	Code	ID	ID	ID	ID	ID	Resource Group ID given and use by OneNet platform once FSP creates a resource group. This ID can be used as a reference during qulification and after qualification as reference for BID, activation of BID and settlement of BID.
	Main metering point ID	EIC	EIC	EIC	EIC	EIC	EIC	ID of the main meter.

Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	System operator ID	EIC	EIC	EIC	EIC	EIC	EIC	Name and business registry code
	Restriction	Y/N	Grid assessment result	Grid assessment result	Grid assessment result	Grid assessment result	Grid assessment result	
	Maximum Quantity	Amount (MW)	FSP resource defined	FSP resource defined	FSP resource defined	FSP resource defined	FSP resource defined	
	Restricted Quantity (optional)	Amount (MW)	Grid assessment result	Grid assessment result	Grid assessment result	Grid assessment result	Grid assessment result	This shows how much of the quantity is restricted (not usable). If maxium quantity (MQ) is 10 and restricted quantity (RQ) is also 10, then this resource cannot be used in the market. If MQ = 10 and RQ = 7, then only 3 MW can be offered to the market.
	Direction	UP / DOWN	Grid assessment result	Grid assessment result	Grid assessment result	Grid assessment result	Grid assessment result	Regulating up / regulating down. Regulating up is increase in generation or decrease in demand. Regulating down is decrease in generation or increase in demand.
Consent	Resource Provider Consent							Permission of data owner to use its private data.
	Document ID	Code	ID	ID	ID	ID	ID	
	Document version	Number	Number	Number	Number	Number	Number	
	Document creation date and time	Data and time	date, time	date, time	date, time	date, time	date, time	
	Sender ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Sender role	Code	Code	Code	Code	Code	Code	
	Receiver ID	EIC	EIC	EIC	EIC	EIC	EIC	
	Receiver role	Code	Code	Code	Code	Code	Code	
	Main metering point ID	EIC	EIC	EIC	EIC	EIC	EIC	ID of the main meter.
	Consented person's ID	Code	ID	ID	ID	ID	ID	

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Business object	Content of business object	Units	Values per product					Semantics
			LT-P-C	*LT-P-C/E*	*ST-P-C*	*ST-P-E*	*NRT-P-E*	
	Purpose of consent	Text	Consent defined	Consent defined	Consent defined	Consent defined	Consent defined	
	Consented data	Text	Consent defined	Consent defined	Consent defined	Consent defined	Consent defined	
	Flexibility Contract ID	code	ID	ID	ID	ID	ID	
	Agreement validity period start time	Date and time	Agreement specified	Agreement specified	Agreement specified	Agreement specified	Agreement specified	Time from which agreement between resource and FSP had been established.
	Agreement validity period end time	Date and time	Agreement specified	Agreement specified	Agreement specified	Agreement specified	Agreement specified	Time till established agreement between resource and FSP is valid.
ListSO	List of impacted System Operators							List of SOs who should send the grid information and be addressed in grid qualification process
	Localization factor	Array of Address / geographical coordinates / EIC / GSRN / other (bidding zone etc.)						
	Impacted SO IDs	List of SO IDs						

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Appendix E: Non-functional requirements

Requirement ID	Category	Subcategory	Description
NFR 1	General	General	• All developed components must serve a single functionality • End-of-life (EOL) term (in case it is known and determined) for all technology components, platforms and third-party components must exceed 3 years. • It must be possible to run multiple instances of a service in parallel, without affecting the functionality of the system as a whole - both from redundancy and performance perspective. • Should external components fail, other functionalities must remain usable.
NFR 2	Documentation	Software deployment (installation) guide	Documentation must include the following: • System requirements, pre-requisites (other server software or libraries required by application – including their versions) in step-by-step format. • Upgrade guide from the latest version running on production – in step-by-step format. • Installation guide (100% install) – in step-by-step format. • External resources and configuration guide.
NFR 3	Documentation	Configuration guide	Documentation must include the following: • Lists containing locations for all configuration files and configuration tables. • Configuration examples. • Description of settings specific to test environment.
NFR 4	Documentation	Maintenance and help guide	Documentation must include a list of maintenance tasks.
NFR 5	Documentation	Changelog	Documentation must include the following: • References to all of the development requests created within the current version. • All changes in configuration (regardless of the technology that was used for those changes), for example: - changes in application configuration itself,

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Requirement ID	Category	Subcategory	Description
			- webserver request/response header changes, - RabbitMQ configuration application needs, - etc. • Extra steps needed for introducing a new release. • Changes in user permissions (role or privilege).
NFR 6	Documentation	Deployment diagram	Documentation must include the following: • Deployment diagram must be realized as a block diagram visualizing: - Relationships between different information systems components. - Integrations with other systems. • Logical names that describe the primary function of the unit must be used instead of actual network names when naming boxes that are used to visualize servers.
NFR 7	Documentation	API documentation	Documentation must include the following: • API technical description; • Authentication guide; • QuickStart guide; • Endpoint definitions; • Code snippets; • Example responses.
NFR 8	API	N/A	• OpenAPI 3.0 must be used; • All personally identifiable information has to be annotated in API schemas. • API documentation must include validatable object schemas for input and output. • Code must be generated from API specification. • API must meet 100% automated tests coverage
NFR 9	SECURITY	N/A	• Authentication credentials (username, password, etc.) of all interfaces must be encrypted in transit. • The authentication system must enable to lock and unlock user accounts manually or based on a predetermined account lockout policy.

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Requirement ID	Category	Subcategory	Description
			• User ID lock and unlock functions must be performed via dedicated UI and/or API with specific credentials. • Any executable containing business logic must not need privileged system level accounts (root, LOCALSYSTEM, etc.) or need to be granted similar permissions for its regular everyday work. • System credentials in plain text must only be stored in the configuration files that are needed to start up the application. • Configuration files stored in repository must not contain any passwords. • The client session must also be ended on server side. • Client session timeout length must be configurable. • To avoid cross-site request forgery attacks, UI requests should contain verification (e.g. Bearer Token), which is validated when receiving data from user. • Input validation must be done via server-side validation using API description documentation (e.g. JSON Schema, OpenAPI). • All input data must be validated in the back-end. • For Web-based UI solutions, at least the latest version of OWASP top 10 application security risks must be mitigated. • All Internet-facing web interfaces must: - adhere to the latest version of OWASP Application Verification Standard Level 1 for applications that display public data; - adhere to Level 2 for applications that process confidential data and require client authentication. • All Internet-facing web interfaces must use HTTPS with a trusted certificate issued by a publicly accessible Certification Authority. • A single session must always be validated against single client (IP, Browser). • Authentication process must give the user all new session tokens; session tokens must not be reused. • If Information System allows file upload from user: - All file uploads must require prior authentication of the user. - All file types must be verified via a magic number check.

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Requirement ID	Category	Subcategory	Description
			- All uploaded files must be scanned using anti-malware software. - After verification, the verified files must be renamed for storage before saving them into the file system. - Maximum file size must always be set and checked by the Information System. • All client requests must go through server-side authentication and authorization checks before they are processed. Client-side controls must not be relied upon.
NFR 10	AVAILABILTY AND PERFORMANCE	N/A	• Page response time must be less than a second. • If page response time is more than a second, the system must display a loading indicator for the user. • For bigger datasets, pagination should be used. • Service API endpoint must respond within 3 seconds for 80% of times, no request should remain without a response for longer period than 14 seconds • All components must be scalable horizontally and/or vertically.
NFR 11	CONFIGURABILITY	N/A	• Software must be configurable using configuration objects. Objects that contain program code in addition to configuration parameters cannot be considered to be configuration files. As an alternative, the configuration can be stored in the database table. In that case, whole configuration must be located in the same table and there must not be any non-configuration related data stored on that table. Configuration must be stored in key-value format. • All the parameters must be described with a comment on the previous line before occurrence of the parameter, or on the separate field (in case of the database table). • Delivered program code must not contain passwords that have been used in development nor references to the development resources. • Changes in the application's configuration should not require its recompilation or re-installation. • There must not be the need to configure the same parameter twice under one software component. For example, if web-application connects to the database, then the database connection must be configurable only in one location. • By default, each application must have separate configuration objects.

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Requirement ID	Category	Subcategory	Description
			• Business-configuration must be part of the deployment package, while admin-configuration samples must be delivered separately and cannot be overwritten with new deployment. • Application must support hostnames as address configuration, application must always support hostname resolution. • Every application parameter must be in configuration object. • All configuration parameter key names should mirror their use.
NFR 12	LOGGING	General	• If logging level is not specified then all events must be logged on INFO level. • Default log levels are: - FATAL level - Only messages indicating stop of process must be logged on FATAL level; - ERROR level - Only messages that require actions taken from administrator (either to restore normal operation or to notify business users/developer) must be logged with ERROR log level; - WARN level - Designates potentially harmful situations; - INFO level - Designates informational messages that highlight the progress of the application at coarse-grained level; - DEBUG level - Designates fine-grained informational event data that are most useful to debug an application; - TRACE level - Designates finer-grained informational event data than the DEBUG with all possible technical data. • Preliminary logging configuration must be provided. • Log messages must be saved in a structured format that would make it possible to perform log-based analysis and alerting, using third party tools. • Sensitive personal information must not be included in any logs. • If log file is not created then application must stop.
NFR 13	LOGGING	Logging of user activities	• User activities must be logged from all parts of information systems handling identifiable user request. A separate log appender have to be used for such logs. • All errors displayed to user (defined and non-defined) must be logged. • Logging requirements for the back-end:

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Requirement ID	Category	Subcategory	Description
			- in the back-end all token creations must be logged with user information and users IP; - any request received from the front end with user information; - any requests published (pushed) to the front end with user information. • Logging requirements for the front-end: - UI must be able to log specific user activities concretely defined for each UI application separately with user information; - UI must log error messages including error dialogues presented to user with user information.
NFR 14	MONITORING	N/A	• Web application must have a separate health status page, that displays information in machine readable format. Must contain at least all outgoing connectivity details according to component model. • All the checks on the page must be executed asynchronously. • Regular polling of the monitoring page (once per 20 seconds max) must not degrade system performance and total response time of the monitoring page must also not exceed 20 seconds (timeouts that can be configured by administrator, must be implemented for every check on the page). Every single check must be marked as failed when its configurable timeout is reached. Single check timeout must not exceed 5 seconds by default. • If application does not have a user interface, then separate health page should exist. • Headless patch processes, which is not intended to work continuously, must push its version and state info into Prometheus push-gateway. • Every application must provide its info page, that displays information in machine readable format. Must contain at least version, build time and artifact ID.

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Appendix F: NRT-P-E example data

In this appendix, all datasets of the NRT-P-E example are given. As a reminder, three types of input data must be provided to the optimisation module, for any market run: Purchase Offer, Network Data, and Bids Data. No line or PTDF tables are provided for the distribution system, because it is a one-node system. The complete set of outputs is also given.

- Purchase Offer data:

Type	Timestamp	Imbalance Position (MW)	Total Cost Cap (€)
NRT-P-E	• Start: 2020-04-30T04:00:00.000Z • End: 2020-04-30T04:15:00.000Z	• Actual: 466.8 • Min: 466.8 • Max: 466.8	50,000

- Node TN data:

Id	System Id	Slack
101	TN	Yes
102	TN	No
103	TN	No
104	TN	No
105	TN	No
201	TN	No
202	TN	No
203	TN	No
204	TN	No
205	TN	No
206	TN	No

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- Line TN data (row in red shows the line with congestion):

Id	System Id	From Node Id	To Node Id	Capacity (MW)	Critical	Base Flow (MW)
1	TN	101	102	1850	1	466.8
2	TN	102	103	1850	1	894.3
3	TN	102	105	1850	1	572.5
4	TN	103	104	1850	1	1000
5	TN	103	105	1850	1	-1105.7
6	TN	105	201	400	1	-266.6
7	TN	105	201	100	1	-266.6
8	TN	201	202	250	1	-172.3
9	TN	201	203	250	1	-176.6
10	TN	201	204	250	1	-134.2
11	TN	201	206	100	1	0
12	TN	202	205	250	1	-129
13	TN	203	205	250	1	-184
14	TN	204	205	250	1	-71.2

- PTDF TN data:

Line\Node	101	102	103	104	105	201	202	203	204	205	206
1	0	-1	-1	-1	-1	-0.9997	-0.9177	-0.9251	-0.8928	-0.8388	-0.9997
2	0	0	-0.5006	-0.5006	-0.2001	-0.1989	-0.1801	-0.182	-0.1746	-0.1631	-0.1989
3	0	0	-0.4995	-0.4995	-0.7999	-0.8007	-0.7377	-0.7431	-0.7182	-0.6757	-0.8007
4	0	0	0	-1	0	0	0	0	0	0	0
5	0	0	0.4994	0.4994	-0.2001	-0.1989	-0.1801	-0.182	-0.1746	-0.1631	-0.1989
6	0	0	0	0	0	-0.4998	-0.4589	-0.4625	-0.4464	-0.4194	-0.4998
7	0	0	0	0	0	-0.4998	-0.4589	-0.4625	-0.4464	-0.4194	-0.4998

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8	0	0	0	0	0	0	-0.6804	-0.104	-0.1471	-0.2892	0
9	0	0	0	0	0	0	-0.1523	-0.7501	-0.1797	-0.3515	0
10	0	0	0	0	0	0	-0.085	-0.0709	-0.566	-0.1982	0
11	0	0	0	0	0	0	0	0	0	0	-1
12	0	0	0	0	0	0	0.2644	-0.1137	-0.1607	-0.3152	0
13	0	0	0	0	0	0	-0.1672	0.1872	-0.1973	-0.3854	0
14	0	0	0	0	0	0	-0.0958	-0.0799	0.3717	-0.2225	0

- Node DN data:

Id	System Id
301	DN_1

- Interface/interconnection data:

(From) System Id	(From) Node	(To) System Id	(To) Node Id	Interface Capacity (MW)	Base Interface Flow (MW)
TN	206	DN_1	301	100	0

- Simple bids data:

Id	System Id	Node Id	Sense	Price (€/MW)	Quantity (MW)	Bid Type	Minimum Quantity (MW)
1	TN	102	UPWARD	51	150	FullyDivisible	
2	TN	102	DOWNWARD	12	240	FullyIndivisible	
3	TN	102	UPWARD	45	180	PartiallyDivisible	50
4	TN	103	DOWNWARD	10	200	PartiallyDivisible	40

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5	TN	103	UPWARD	42	230	PartiallyDivisible	30
6	TN	103	DOWNWARD	14	160	PartiallyDivisible	20
7	TN	104	UPWARD	58	170	FullyIndivisible	
8	TN	104	DOWNWARD	19	210	FullyIndivisible	
9	TN	104	UPWARD	55	30	FullyIndivisible	
10	TN	105	DOWNWARD	16	40	FullyIndivisible	
11	TN	105	UPWARD	48	60	FullyIndivisible	
12	TN	105	DOWNWARD	16	70	PartiallyDivisible	10
13	TN	201	UPWARD	41	90	FullyDivisible	
14	TN	201	DOWNWARD	15	90	FullyDivisible	
15	TN	201	UPWARD	40	120	FullyDivisible	
16	TN	202	DOWNWARD	10	60	FullyDivisible	
17	TN	202	UPWARD	43	20	FullyDivisible	
18	TN	202	DOWNWARD	20	30	FullyDivisible	
19	TN	203	UPWARD	46	20	PartiallyDivisible	5
20	TN	203	DOWNWARD	20	30	PartiallyDivisible	15
21	TN	203	UPWARD	57	60	PartiallyDivisible	15
22	TN	204	DOWNWARD	19	20	FullyIndivisible	
23	TN	204	UPWARD	44	70	FullyIndivisible	
24	TN	204	DOWNWARD	18	20	FullyIndivisible	
25	TN	205	UPWARD	52	80	FullyDivisible	
26	TN	205	DOWNWARD	17	80	FullyDivisible	
27	TN	205	UPWARD	53	80	FullyDivisible	
28	TN	206	DOWNWARD	15	70	FullyDivisible	
29	TN	206	UPWARD	51	40	FullyDivisible	
30	TN	206	DOWNWARD	14	90	FullyIndivisible	
31	DN_1	301	UPWARD	43	40	FullyDivisible	
32	DN_1	301	DOWNWARD	12	90	FullyDivisible	

- Exclusive bids data:

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Id	Bids Id
1	7, 9
2	22, 24, 30

- Multipart bid data:

Id	Parent Bid Id	Children Bids Id
3	1	3, 5, 11

- Cleared bids:

Id	System Id	Request Sense	Bid Type	Price (€/MW)	Dispatch (MW)
1	TN	Upward	FullyDivisible	51	0.01
3	TN	Upward	PartiallyDivisible	45	117.95
5	TN	Upward	PartiallyDivisible	42	230.00
14	TN	Downward	FullyDivisible	15	90.00
16	TN	Downward	FullyDivisible	10	60.00
18	TN	Downward	FullyDivisible	20	30.00
20	TN	Downward	PartiallyDivisible	20	30.00
24	TN	Downward	FullyIndivisible	18	20.00
26	TN	Downward	FullyDivisible	17	17.96
28	TN	Downward	FullyDivisible	15	10.00
32	DN_1	Downward	FullyDivisible	12	90.00

- Updated flows over lines:

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Line Id	System Id	From Node	To Node	Flow (MW)	Overflow (MW)
1	TN	101	102	452.0492	0
2	TN	102	103	845.0439	0
3	TN	102	105	724.9361	0
4	TN	103	104	1000	0
5	TN	103	105	-924.956	0
6	TN	105	201	-100	0
7	TN	105	201	-100	0
8	TN	201	202	-99.8069	0
9	TN	201	203	-130.482	0
10	TN	201	204	-109.543	0
11	TN	201	206	100	0
12	TN	202	205	-140.509	0
13	TN	203	205	-163.699	0
14	TN	204	205	-63.6181	0

- Updated flows over interface lines:

System Id (TN)	System Id (DN)	Flow (MW)	Overflow (MW)
TN	DN_1	90	0

- *Other results:*

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Total Cost (€)	Optimisation status	New Imbalance Position (MW)	Timestamp
20,013.81	ALL CONGESTION RESOLVED	466.80	• Start: 2020-04-30T04:00:00.000Z • End: 2020-04-30T04:15:00.000Z

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Appendix G: ST-P-E example data

In this appendix, all datasets of the ST-P-E example are given. As a reminder, three types of input data must be provided to the optimisation module, for any market run: Purchase Offer, Network Data, and Bids Data. Because the ST-P-E example uses the same network data of the NRT-P-E example, only the different inputs are included here. The complete set of outputs is also given.

- *Purchase offer data:*

Type	Timestamp	Imbalance Position (MW)	Total Cost Cap (€)
ST-P-E	• Start: 2022-06-30T04:00:00.000Z • End: 2022-07-30T04:00:00.000Z	Not provided. Optimisation uses default values: • Actual: 0 • Min: unlimited • Max: unlimited	Not provided. Optimisation assumes total cost is unlimited

- Same network datasets as in the NRT-P-E example. Line DN and PTDF DN are not provided because the distribution system has only one node.

- Simple bids data:

Id	System Id	Node Id	Sense	Price (€/MW)	Quantity (MW)	Bid Type
1	TN	102	UPWARD	51	150	FullyDivisible
2	TN	102	DOWNWARD	12	240	FullyIndivisible
3	TN	102	UPWARD	45	180	FullyDivisible
4	TN	103	DOWNWARD	10	200	FullyDivisible
5	TN	103	UPWARD	42	230	FullyDivisible
6	TN	103	DOWNWARD	14	160	FullyDivisible
7	TN	104	UPWARD	58	170	FullyIndivisible

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8	TN	104	DOWNWARD	19	210	FullyIndivisible
9	TN	104	UPWARD	55	30	FullyIndivisible
10	TN	105	DOWNWARD	16	40	FullyIndivisible
11	TN	105	UPWARD	48	60	FullyIndivisible
12	TN	105	DOWNWARD	16	70	FullyDivisible
13	TN	201	UPWARD	41	90	FullyDivisible
14	TN	201	DOWNWARD	15	90	FullyDivisible
15	TN	201	UPWARD	40	120	FullyDivisible
16	TN	202	DOWNWARD	10	60	FullyDivisible
17	TN	202	UPWARD	43	20	FullyDivisible
18	TN	202	DOWNWARD	20	30	FullyDivisible
19	TN	203	UPWARD	46	20	FullyIndivisible
20	TN	203	DOWNWARD	20	30	FullyIndivisible
21	TN	203	UPWARD	57	60	FullyIndivisible
22	TN	204	DOWNWARD	19	20	FullyIndivisible
23	TN	204	UPWARD	44	70	FullyIndivisible
24	TN	204	DOWNWARD	18	20	FullyIndivisible
25	TN	205	UPWARD	52	80	FullyDivisible
26	TN	205	DOWNWARD	17	80	FullyDivisible
27	TN	205	UPWARD	53	80	FullyDivisible
28	TN	206	DOWNWARD	15	70	FullyDivisible
29	TN	206	UPWARD	51	40	FullyDivisible
30	TN	206	DOWNWARD	14	90	FullyIndivisible
31	DN_1	301	UPWARD	43	40	FullyDivisible
32	DN_1	301	DOWNWARD	12	90	FullyDivisible

- Output of the optimisation module:

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- Cleared bids:

id	System Id	Request Sense	Bid Type	Price (€/MW)	Dispatch (MW)
14	TN	Downward	FullyDivisible	15	90.00
16	TN	Downward	FullyDivisible	10	60.00
18	TN	Downward	FullyDivisible	20	3.54
24	TN	Downward	FullyIndivisible	18	20.00
26	TN	Downward	FullyDivisible	17	80.00
28	TN	Downward	FullyDivisible	15	10.00
32	DN_1	Downward	FullyDivisible	12	90.00

- Updated flows over lines:

Line Id	System Id	From Node	To Node	Flow (MW)	Overflow (MW)
1	TN	101	102	800.01	0.00
2	TN	102	103	960.07	0.00
3	TN	102	105	839.93	0.00
4	TN	103	104	1000.00	0.00
5	TN	103	105	-1039.93	0.00
6	TN	105	201	-100.00	0.00
7	TN	105	201	-100.00	0.00
8	TN	201	202	-102.99	0.00
9	TN	201	203	-135.21	0.00
10	TN	201	204	-101.62	0.00

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11	TN	201	206	100.00	0.00
12	TN	202	205	-117.37	0.00
13	TN	203	205	-138.60	0.00
14	TN	204	205	-54.75	0.00

- Updated flows over interface lines:

System Id (TN)	System Id (DN)	Flow (MW)	Overflow (MW)
TN	DN_1	90	0

- Other results:

Total Cost (€)	Optimisation status	New Imbalance Position (MW)	Timestamp
4,970.78.81	ALL CONGESTION RESOLVED	-353.54	• Start: 2022-06-30T04:00:00.000Z • End: 2022-07-30T04:00:00.000Z

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Appendix H: ST-P-E-rec example data

In this appendix, all datasets of the ST-P-E-rec example are given. Even though this is an artificial product, three types of input data must be provided to the optimisation module, for any recalculation run: Purchase Offer, Network Data, and Bids Data. Purchase Offer and Bids Data for this example were provided together with its explanation in Section 4.5.2. Network data is the same as the one for the corresponding ST-P-E run, which is provided in

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Appendix G: ST-P-E example data. Thus here only the complete set of outputs is given.

- "Cleared" bids (same as input):

Id	System Id	Request Sense	Bid Type	Price (€/MW)	Dispatch (MW)
14	TN	Downward	FullyDivisible	15	0.00
16	TN	Downward	FullyDivisible	10	60.00
18	TN	Downward	FullyDivisible	20	3.54
24	TN	Downward	FullyIndivisible	18	20.00
26	TN	Downward	FullyDivisible	17	80.00
28	TN	Downward	FullyDivisible	15	10.00
32	DN_1	Downward	FullyDivisible	12	90.00

- Updated flows over lines (red row highlights the congestion due to the unavailable bid):

Line Id	System Id	From Node	To Node	Flow (MW)	Overflow (MW)
1	TN	101	102	710.04	0.00
2	TN	102	103	942.17	0.00
3	TN	102	105	767.86	0.00
4	TN	103	104	1000.00	0.00
5	TN	103	105	-1057.83	0.00
6	TN	105	201	-144.98	0.00
7	TN	105	201	-144.98	-44.98
8	TN	201	202	-102.99	0.00

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9	TN	201	203	-135.21	0.00
10	TN	201	204	-101.62	0.00
11	TN	201	206	100.00	0.00
12	TN	202	205	-117.37	0.00
13	TN	203	205	-138.60	0.00
14	TN	204	205	-54.75	0.00

- Updated flows over interface lines:

System Id (TN)	System Id (DN)	Flow (MW)	Overflow (MW)
TN	DN_1	90	0

- Other results:

Total Cost (€)	Optimisation status	New Imbalance Position (MW)	Timestamp
Not applicable	CONGESTION PARTIALLY RESOLVED (INSUFFICIENCY OF BIDS)	-263.54	• Start: 2022-06-30T04:00:00.000Z • End: 2022-07-30T04:00:00.000Z

Appendix I: LT-P-C/E-res example data

In this appendix, all datasets of the LT-P-C/E, reservation stage, example are given. As a reminder, three types of input data must be provided to the optimisation module, for any market run: Purchase Offer, Network Data, and Bids Data. Only one system is considered per LT-P-C/E run, thus one Node table, one Line table and one PTDF table are provided. The complete set of outputs is also given.

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- Purchase offer data:

Type	Timestamp	Expected Number of Hours of Activation	Imbalance Position	Total Cost Cap (€)
LT-P-C/E-res	• Start: 2023-04-30T04:00:00.000Z • End: 2023-12-30T04:00:00.000Z	10	Not applicable. Imbalances are not considered in this product.	Not provided. Optimisation assumes total cost is unlimited

- Node data (slack information not needed):

Id	System Id
1	DN
2	DN
3	DN
4	DN
5	DN
6	DN

- Line data (row in red shows the line with congestion):

Id	System Id	From Node Id	To Node Id	Capacity (kW)	Critical	Base Flow (kW)
L-1	DN	1	2	3570	1	-3600
L-2	DN	2	3	2890	1	-1500
L-3	DN	2	4	2890	1	-2100
L-4	DN	4	5	2890	1	-600

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L-5	DN	4	6	3570	1	-1500

- PTDF data:

Line\Node	1	2	3	4	5	6
12	0	-1	-1	-1	-1	-1
23	0	0	-1	0	0	0
24	0	0	0	-1	-1	-1
45	0	0	0	0	-1	0
46	0	0	0	0	0	-1

- Simple bids data:

Id	System Id	Node Id	Sense	Price (€/kW)	Price Reservation (€/kW)	Quantity (kW)	Bid Type
1	DN	1	UPWARD	0.51	1	75	FullyIndivisible
2	DN	1	DOWNWARD	0.32	1.9	103	FullyIndivisible
3	DN	1	UPWARD	0.45	2	62.5	FullyIndivisible
4	DN	2	DOWNWARD	0.21	1.7	128	FullyIndivisible
5	DN	2	UPWARD	0.42	1.5	57.5	FullyIndivisible
6	DN	2	DOWNWARD	0.14	1.1	14	FullyIndivisible
7	DN	3	UPWARD	0.58	1.6	42.5	FullyIndivisible
8	DN	3	DOWNWARD	0.34	1.4	18	FullyIndivisible
9	DN	3	UPWARD	0.55	2.5	20.5	FullyIndivisible
10	DN	4	DOWNWARD	0.47	1.2	24	FullyIndivisible
11	DN	4	UPWARD	0.51	1.2	15	FullyIndivisible
12	DN	4	DOWNWARD	0.41	0.79	10	FullyIndivisible
13	DN	5	UPWARD	0.41	1.3	23	FullyIndivisible

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14	DN	5	DOWNWARD	0.69	0.14	58	FullyIndivisible
15	DN	5	UPWARD	0.4	2.6	21.5	FullyIndivisible
16	DN	6	DOWNWARD	0.13	3.2	41	FullyIndivisible
17	DN	6	UPWARD	0.14	3	40	FullyIndivisible
18	DN	6	DOWNWARD	0.41	1.2	102.5	FullyIndivisible

- Cleared (reserved) bids:

Id	System Id	Request Sense	Bid Type	Dispatch (kW)	Activation Price (€/kW)	Reservation Price (€/kW)
6	DN	Downward	FullyIndivisible	14	0.14	1.1
8	DN	Downward	FullyIndivisible	18	0.34	1.4

- Updated flows over lines:

Line Id	System Id	From Node	To Node	Flow (kW)	Overflow (kW)
L-1	DN	1	2	-3568	0
L-2	DN	2	3	-1482	0
L-3	DN	2	4	-2100	0
L-4	DN	4	5	-600	0
L-5	DN	4	6	-1500	0

- Other results:

Procurement Costs (€)	Optimisation status	New Imbalance Position	Timestamp
• Activation: 80.80	ALL CONGESTION RESOLVED	Not applicable	• Start: 2023-04-30T04:00:00.000Z

• Reservation: 40.60 • Total: 121.40			• End: 2023-12-30T04:00:00.000Z

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Appendix J: LT-P-C/E-act example data

In this appendix, all datasets of the LT-P-C/E, activation stage, example are given. As a reminder, three types of input data must be provided to the optimisation module, for any market run: Purchase Offer, Network Data, and Bids Data. Only one system is considered per LT-P-C/E run, thus one Node table, one Line table and one PTDF table are provided. The complete set of outputs is also given.

- Purchase offer data:

Type	Timestamp	Imbalance Position	Total Cost Cap (€)
LT-P-C/E-act	• Start: 2023-04-30T04:00:00.000Z • End: 2023-12-30T04:00:00.000Z	Not applicable. Imbalances are not considered in this product.	Not provided. Optimisation assumes total cost is unlimited

- Similar network datasets of the LT-P-C/E-res example.

- Line data (row in red shows the line with congestion):

Id	System Id	From Node Id	To Node Id	Capacity (kW)	Critical	Base Flow (kW)
L-1	DN	1	2	3570	1	-3585
L-2	DN	2	3	2890	1	-1500
L-3	DN	2	4	2890	1	-2100
L-4	DN	4	5	2890	1	-600
L-5	DN	4	6	3570	1	-1500

- Simple bids data:

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Id	System Id	Node Id	Sense	Price (€/kW)	Quantity (kW)	Bid Type
6	DN	2	DOWNWARD	0.14	14	FullyIndivisible
8	DN	3	DOWNWARD	0.34	18	FullyIndivisible

- Cleared bids:

Id	System Id	Request Sense	Bid Type	Dispatch (kW)	Activation Price (€/kW)
8	DN	Downward	FullyIndivisible	18	0.34

- Updated flows over lines:

Line Id	System Id	From Node	To Node	Flow (kW)	Overflow (kW)
L-1	DN	1	2	-3567	0
L-2	DN	2	3	-1482	0
L-3	DN	2	4	-2100	0
L-4	DN	4	5	-600	0
L-5	DN	4	6	-1500	0

- Other results:

Total Cost (€)	Optimisation status	New Imbalance Position	Timestamp
6.12	ALL CONGESTION RESOLVED	Not applicable	• Start: 2023-04-30T04:00:00.000Z • End: 2023-12-30T04:00:00.000Z

Appendix L: LT-P-C example data

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In this appendix, all datasets of the LT-P-C example are given. As a reminder, three types of input data must be provided to the optimisation module, for any market run: Purchase Offer, Network Data, and Bids Data. Only one transmission system is considered in this example, thus one table Node, one table Line, and one table PTDF are provided. The complete set of outputs is also given.

- Purchase offer data:

Type	Timestamp	Imbalance Position (MW)	Total Cost Cap (€)
LT-P-C	• Start: 2020-04-30T04:00:00.000Z • End: 2020-10-30T04:00:00.000Z	• Actual: 0 • Min: 100 • Max: 100	Not provided. Optimisation assumes total cost is unlimited

- Node data:

Id	System Id	Slack
101	TN	Yes
102	TN	No
103	TN	No
104	TN	No
105	TN	No
106	TN	No
201	TN	No
202	TN	No
203	TN	No
204	TN	No
205	TN	No
206	TN	No
207	TN	No

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208	TN	No
209	TN	No

- Line data (row in red shows the line with congestion):

Id	System Id	From Node Id	To Node Id	Capacity (MW)	Critical	Base Flow (MW)
1	TN	101	102	1850	1	175.8
2	TN	102	103	1850	1	854.2
3	TN	102	106	1850	1	321.6
4	TN	103	104	1850	1	1000.6
5	TN	103	105	1850	1	-1146.9
6	TN	105	106	1850	1	-582.2
7	TN	105	201	400	1	-284.8
8	TN	105	201	200	1	-284.8
9	TN	106	207	400	1	-130.5
10	TN	106	207	400	1	-130.5
11	TN	201	202	250	1	-172.4
12	TN	201	203	250	1	-176.6
13	TN	201	204	100	1	-134.3
14	TN	201	206	100	1	0
15	TN	201	207	250	1	-36.3
16	TN	202	205	250	1	-129
17	TN	203	205	250	1	-184
18	TN	204	205	250	1	-71.2
19	TN	207	208	250	1	-74.1
20	TN	207	209	250	1	-48.7
21	TN	208	209	250	1	-25.3

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- PTDF data:

Line\Node	101	102	103	104	105	106	201	202	203	204	205	206	207	208	209
1	0	-1.0008	-1.0065	-1.0077	-1.001	-1.0007	-1.0019	-0.9197	-0.9271	-0.8948	-0.8406	-1.0019	-0.9949	-0.9648	-0.9561
2	0	0	-0.5048	-0.5054	-0.2013	-0.1509	-0.1977	-0.1792	-0.181	-0.1738	-0.1624	-0.1977	-0.1595	-0.1546	-0.1532
3	0	0	-0.5008	-0.5014	-0.7988	-0.8489	-0.8034	-0.7398	-0.7453	-0.7202	-0.6774	-0.8034	-0.8346	-0.8094	-0.802
4	0	0	0	-1.0012	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0.4957	0.4963	-0.2011	-0.1507	-0.1975	-0.179	-0.1808	-0.1736	-0.1623	-0.1975	-0.1593	-0.1545	-0.1531
6	0	0	0.4989	0.4995	0.7958	-0.1517	0.746	0.6868	0.692	0.6686	0.6289	0.746	0.0498	0.0483	0.0478
7	0	0	0	0	0	0	-0.4726	-0.4338	-0.4373	-0.422	-0.3964	-0.4726	-0.1052	-0.1021	-0.1011
8	0	0	0	0	0	0	-0.4726	-0.4338	-0.4373	-0.422	-0.3964	-0.4726	-0.1052	-0.1021	-0.1011
9	0	0	0	0	0	0	-0.028	-0.0258	-0.026	-0.0252	-0.0237	-0.028	-0.3919	-0.3801	-0.3766
10	0	0	0	0	0	0	-0.028	-0.0258	-0.026	-0.0252	-0.0237	-0.028	-0.3919	-0.3801	-0.3766
11	0	0	0	0	0	0	0	-0.6806	-0.1041	-0.1472	-0.2893	0	0	0	0
12	0	0	0	0	0	0	0	-0.1522	-0.7501	-0.1796	-0.3514	0	0	0	0
13	0	0	0	0	0	0	0	-0.0852	-0.0711	-0.5664	-0.1984	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0
15	0	0	0	0	0	0	0.0545	0.0504	0.0508	0.0491	0.0463	0.0545	-0.2107	-0.2044	-0.2025
16	0	0	0	0	0	0	0	0.2643	-0.1137	-0.1607	-0.3153	0	0	0	0
17	0	0	0	0	0	0	0	-0.167	0.1872	-0.1971	-0.3853	0	0	0	0
18	0	0	0	0	0	0	0	-0.0958	-0.08	0.3714	-0.2227	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.7785	-0.4511
20	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.1913	-0.5099
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1956	-0.4661

- Simple bids data:

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Id	System Id	Node Id	Sense	Price (€/MW)	Quantity (MW)	Bid Type	Minimum Quantity (MW)
1	TN	102	UPWARD	51	150	FullyDivisible	
2	TN	102	DOWNWARD	12	240	FullyIndivisible	
3	TN	103	UPWARD	45	180	PartiallyDivisible	50
4	TN	103	DOWNWARD	10	200	PartiallyDivisible	40
5	TN	104	UPWARD	42	230	PartiallyDivisible	30
6	TN	104	DOWNWARD	14	160	PartiallyDivisible	20
7	TN	105	UPWARD	58	170	FullyIndivisible	
8	TN	105	DOWNWARD	19	210	FullyIndivisible	
9	TN	106	UPWARD	55	30	FullyIndivisible	
10	TN	106	DOWNWARD	16	40	FullyIndivisible	
11	TN	201	UPWARD	48	60	FullyIndivisible	
12	TN	201	DOWNWARD	16	70	PartiallyDivisible	10
13	TN	202	UPWARD	41	90	FullyDivisible	
14	TN	202	DOWNWARD	15	90	FullyDivisible	
15	TN	203	UPWARD	40	120	FullyDivisible	
16	TN	203	DOWNWARD	10	60	FullyDivisible	
17	TN	204	UPWARD	43	20	FullyDivisible	
18	TN	204	DOWNWARD	20	30	FullyDivisible	
19	TN	205	UPWARD	46	20	PartiallyDivisible	5
20	TN	205	DOWNWARD	20	30	PartiallyDivisible	15
21	TN	206	UPWARD	57	60	PartiallyDivisible	15
22	TN	206	DOWNWARD	19	20	FullyIndivisible	
23	TN	207	UPWARD	44	70	FullyIndivisible	
24	TN	207	DOWNWARD	18	20	FullyIndivisible	
25	TN	208	UPWARD	52	80	FullyDivisible	
26	TN	208	DOWNWARD	17	80	FullyDivisible	
27	TN	209	UPWARD	53	80	FullyDivisible	

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28	TN	209	DOWNWARD	15	70	FullyDivisible	
29	TN	301	UPWARD	51	40	FullyDivisible	
30	TN	301	DOWNWARD	14	90	FullyIndivisible	
31	TN	301	UPWARD	43	40	FullyDivisible	
32	TN	301	DOWNWARD	12	90	FullyDivisible	

- Cleared bids:

Id	System Id	Request Sense	Bid Type	Price (€/MW)	Dispatch (MW)
3	TN	Upward	PartiallyDivisible	71.8706	45
5	TN	Upward	PartiallyDivisible	230	42
14	TN	Downward	FullyDivisible	90	15
16	TN	Downward	FullyDivisible	51.8706	10
18	TN	Downward	FullyDivisible	30	20
20	TN	Downward	PartiallyDivisible	30	20

- Updated flows over lines:

Line Id	System Id	From Node	To Node	Flow (MW)	Overflow (MW)
1	TN	101	102	54.61547	0
2	TN	102	103	737.2803	0
3	TN	102	106	317.4544	0
4	TN	103	104	770.324	0
5	TN	103	105	-961.56	0
6	TN	105	106	-568.09	0
7	TN	105	201	-198.523	0
8	TN	105	201	-198.523	0

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9	TN	106	207	-125.362	0
10	TN	106	207	-125.362	0
11	TN	201	202	-92.6513	0
12	TN	201	203	-108.064	0
13	TN	201	204	-100	0
14	TN	201	206	0	0
15	TN	201	207	-46.333	0
16	TN	202	205	-132.609	0
17	TN	203	205	-161.208	0
18	TN	204	205	-62.8894	0
19	TN	207	208	-74.1	0
20	TN	207	209	-48.7	0
21	TN	208	209	-25.3	0

- Other results:

Total Cost (€)	Optimisation status	New Imbalance Position (MW)	Timestamp
15,962.88	ALL CONGESTION RESOLVED	100	• Start: 2020-04-30T04:00:00.000Z • End: 2020-10-30T04:00:00.000Z

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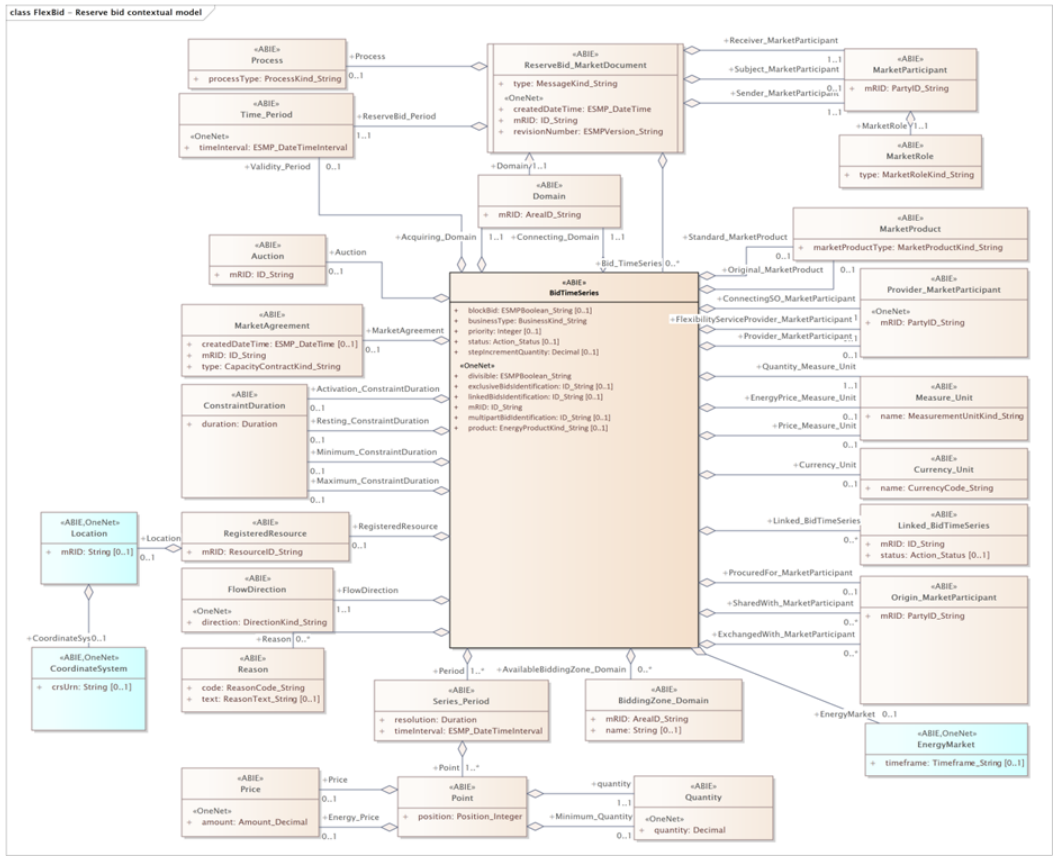
Appendix K: CIM profile for Bid

In this appendix, Bid CIM profile is brought as an example for CIM profiles defined for Northern Demonstrator.



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Example Bid CIM document:

```
<?xml version="1.0" encoding="UTF-8"?>
<ReserveBid_MarketDocument>
    <mRID>mRID</mRID>
    <revisionNumber>revisionNumber</revisionNumber>
    <type>type</type>
    <createdDateTime>2022-10-21T14:10:47.131+03:00</createdDateTime>
    <receiver_MarketParticipant.mRID codingScheme="NLV">receiver.mRID</receiver_MarketParticipant.mRID>
    <receiver_MarketParticipant.marketRole.type>receiver.type</receiver_MarketParticipant.marketRole.type>
    <sender_MarketParticipant.mRID codingScheme="A01">{{testMOId}}</sender_MarketParticipant.mRID>
    <sender_MarketParticipant.marketRole.type>sender.type</sender_MarketParticipant.marketRole.type>
    <domain.mRID codingScheme="NCS">domain.mRID</domain.mRID>
    <Bid_TimeSeries>
        <mRID>bid.mRID</mRID>
        <divisible>FULLYDIVISIBLE</divisible>
        <businessType>NRT_P_E</businessType>
        <linkedBidsIdentification>string</linkedBidsIdentification>
        <multipartBidIdentification>string</multipartBidIdentification>
        <exclusiveBidsIdentification>string</exclusiveBidsIdentification>
        <status>
            <value>string</value>
        </status>
        <stepIncrementQuantity>0</stepIncrementQuantity>
        <product>string</product>
        <flowDirection.direction>UP</flowDirection.direction>
        <price_Measure_Unit.name>KWH</price_Measure_Unit.name>
        <quantity_Measure_Unit.name>string</quantity_Measure_Unit.name>
```


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```
        <validity_Period.timeInterval>
            <start>2022-10-21T15:00Z</start>
            <end>2022-10-21T15:15Z</end>
        </validity_Period.timeInterval>
        <standard_MarketProduct.marketProductType>string</standard_MarketProduct.marketProductType>
        <acquiring_Domain.mRID codingScheme="A01">acquiring.domain.mRID</acquiring_Domain.mRID>
        <registeredResource.mRID codingScheme="NCY">{{testResourceGroupId}}</registeredResource.mRID>
        <registeredResource.location.mRID>resource.location.mRID</registeredResource.location.mRID>
        <registeredResource.location.coordinateSystem.crsUrn>CoordinateSystem</registeredResource.location.coordinateSyst
em.crsUrn>
        <original_MarketProduct.marketProductType>string</original_MarketProduct.marketProductType>
        <connecting_Domain.mRID codingScheme="A01">connecting.domain.mRID</connecting_Domain.mRID>
        <currency_Unit.name>EUR</currency_Unit.name>
        <Period>
            <timeInterval>
                <start>2022-10-21T10:00Z</start>
                <end>2022-10-21T10:15Z</end>
            </timeInterval>
            <resolution>PT15M</resolution>
            <Point>
                <position>0</position>
                <price.amount>0</price.amount>
                <minimum_Quantity.quantity>0</minimum_Quantity.quantity>
                <minimum_Price.amount>0</minimum_Price.amount>
                <maximum_Price.amount>0</maximum_Price.amount>
                <cleared_Price.amount>0</cleared_Price.amount>
                <totalCostCap_Price.amount>0</totalCostCap_Price.amount>
```


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                <cleared_Quantity.quantity>0</cleared_Quantity.quantity>
                <checked_Quantity.quantity>0</checked_Quantity.quantity>
                <quantity.quantity>0</quantity.quantity>
            </Point>
        </Period>
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        <auction.paymentTerms>auction.paymentTerms</auction.paymentTerms>
        <energyMarket.timeframe>string</energyMarket.timeframe>
        <preparation_ConstraintDuration.duration>PT15M</preparation_ConstraintDuration.duration>
        <ramping_ConstraintDuration.duration>PT15M</ramping_ConstraintDuration.duration>
        <fullActivation_ConstraintDuration.duration>PT15M</fullActivation_ConstraintDuration.duration>
        <delivery_ConstraintDuration.duration>PT15M</delivery_ConstraintDuration.duration>
        <minimumDelivery_ConstraintDuration.duration>PT15M</minimumDelivery_ConstraintDuration.duration>
        <maximumConsequtiveDelivery_ConstraintDuration.duration>PT15M</maximumConsequtiveDelivery_ConstraintDuration.dura
tion>
        <recovery_ConstraintDuration.duration>PT15M</recovery_ConstraintDuration.duration>
        <deactivation_ConstraintDuration.duration>PT15M</deactivation_ConstraintDuration.duration>
        <gateClosure_DateAndOrTime.dateTime>2022-10-21T10:00:00Z</gateClosure_DateAndOrTime.dateTime>
        <openingDate_DateAndOrTime.dateTime>2022-10-20T10:00:00Z</openingDate_DateAndOrTime.dateTime>
        <closingDate_DateAndOrTime.dateTime>2022-10-21T10:00:00Z</closingDate_DateAndOrTime.dateTime>
        <end_DateAndOrTime.dateTime>2022-10-22T10:00:00Z</end_DateAndOrTime.dateTime>
        <provider_MarketParticipant.mRID codingScheme="NPT">{{testFSPId}}</provider_MarketParticipant.mRID>
        <marketAgreement.mRID>marketAgreement.mRiD</marketAgreement.mRID>
        <marketAgreement.type>string</marketAgreement.type>
    </Bid_TimeSeries>
    <reserveBid_Period.timeInterval>
        <start>2022-10-21T10:00Z</start>
```


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```
        <end>2022-10-21T10:15Z</end>
    </reserveBid_Period.timeInterval>
</ReserveBid_MarketDocument>
```


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