Business use case development for TSO–DSO interoperable platforms in large-scale demonstrations

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Abstract: Recent changes in national and European-wide regulation for distribution system operator and transmission system operator (TSO–DSO) and energy consumer coordination foster flexibility provision for system services. In this context, many existing and new energy market participants need to adapt to newly developed platform-based service provision. To facilitate communication between different stakeholders and better identify future infrastructural changes, such as modern flexible electric grid components or advanced communication architectures, the Smart Grid Architecture Model (SGAM) is applied. This study describes the most relevant system services and market models and presents an exemplary application of the SGAM methodology based on three large-scale pilots in Spain, Greece, and Sweden.

1 Introduction

Traditional power systems are going through significant changes: distributed energy resources (DERs), such as distributed generation, storage, or flexible loads are already providing system services to support the active grid operation both at the distribution and transmission level. In addition, new responsibilities emerge for the grid operators, most significantly in the distribution system [1]. These recent developments require clear and efficient coordination between transmission and distribution system operators as well as flexibility providers, including third-party aggregators that group DER to coordinate response and provide services.

According to the Clean Energy for all Europeans package, this enhanced coordination and information exchange is necessary to ensure the optimal utilisation of resources, the secure and efficient operation of the system, and to facilitate market development (Article 32(2) of the Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019.). Nevertheless, national regulatory frameworks across Europe still impose important barriers to the achievement of these objectives [1].

The CoordiNet project aims at demonstrating how distribution system operators (DSOs) and transmission system operators (TSOs) shall act in a coordinated manner to procure and activate system services most reliably and efficiently through the implementation of demonstrators in three countries: Greece, Spain, and Sweden. In each demo activity, different products are being tested, in different time frames and relying on the provision of flexibility with different types of resources and in different network and market conditions which are intended to be replicable and scalable at the European level.

To accomplish this main objective, a standardised process is followed and presented in this paper to:

(i) Define and test a set of standardised products for system services [2], including the reservation and activation process for the use of the assets and finally, the settlement process.
(ii) Demonstrate to which extent coordination schemes between TSO/DSO will lead to a cheaper, more reliable, and more environmentally friendly electricity supply to consumers.

(iii) Develop business use cases (BUCs) applying the standardised IEC 62559-2 use case methodology, supporting the fostering of a common understanding of functionalities, actors, and processes across different technical committees and different organisations [3].

This paper presents these initial tasks developed in the first 6 months of the CoordiNet project to identify the functions, components, and development needs for platforms necessary for the demonstration sites. These developments will pave the way for the interoperable development of a pan-European market that will allow all market participants to provide energy services and opens up new revenue streams for consumers providing system services.

2 Market-based provision of system services

To facilitate the definition of the business use cases, one needs to define common services and products that are subject to trading in a coordinated manner. Thus, the developed business use cases are separated based on which system service is desired, and under which regulatory framework it applies.

2.1 System services and products

In the present work, four services are considered: balancing, congestion management, voltage control, and controlled islanding. To enable a market-based provision of these system services, products for system services need to be defined. For each of these services, one or more standard products have been defined adhering to the principles of technology-neutrality. The product definition is based on standard and commonly defined attributes (such as delivery period, full activation time, etc.). These product attributes can vary throughout the different BUCs for testing purposes, to identify the most appropriate ranges. In addition, for some system services (e.g. congestion management) products are being adapted to local circumstances. However, where possible, common product attributes for different services (e.g. congestion management and balancing) are proposed such that joint procurement of different services on a common market can be

targeted. Depending on the system service, a capacity and/or energy product is considered.

The identification of the product attributes and translation of the different needs to standard products, are either defined in the network codes, taken from literature or real examples, and/or a result of discussions among the CoordiNet project partners [2].

2.2 Categorisation of coordination schemes

To enable a market-based provision of the above-mentioned system services, coordination schemes have been identified which define the roles and responsibilities of each system operator, when procuring and using system services [4]. From proposed coordination schemes resulting from recent analysis in CoordiNet [2] based on outcomes of earlier projects, such as SmartNet [5], and recent literature on the topic [6–9], a general consensus is, that there is no coordination scheme that would suffice to realise all desired services and mechanisms, due to different local circumstances, market constraints, and regulatory conditions.

Therefore, a categorisation structure is introduced that helps to map coordination schemes by grouping similar coordination needs together, based on four classification layers (see the layers in dark blue in Fig. 1). The first classification identifies the flexibility needs that need to be addressed. These needs can be central when referring to a certain control area as a whole (often operated by a single TSO); they can be local when it is linked to a specific geographic location, or they can be both central and local.

The second classification layer looks at who is searching for an answer to these needs and thus to who buys the flexibility. This can be the TSO, the DSO, commercial parties, or local energy market participants, such as active prosumers or aggregators, in the following referred to as *peers*. The number of buyers in a market gives a lead to different market architectures. This brings us to the third classification which considers the number of markets. Either there can be one single market or there can be multiple markets. Finally, the last classification layer looks at whether the TSO has access to DER (distributed resources). DER refers to all grid users (generation, storage, and demand) connected to the distribution system. In this context, we assume access is granted if these DERs can participate in the relevant market(s) following a market-based approach.

The four classification layers, result in seven groups of coordination possibilities. The proposed coordination schemes and resulting market models are service-agnostic such that they can be applied to different services or a combination of services, always maintaining a SO-viewpoint.

The *Local* market model specifies markets for a local need only, without paying attention to, or explicitly coordinating with, a central market (if it exists). *Central* markets in which flexibility services are solely procured to answer a central need for flexibility, in an isolated manner. The buyer will always be the TSO and the DSO is not participating to serve his own needs. *Common* market models address both a local and a central need. In this model, resources are automatically shared, and both system operators procure flexibility on one single market. *Integrated* flexibility

markets differ from the *Common* in the sense that market access is also open to other market stakeholders and thus not only for the system operators. All parties are allowed to acquire flexibility in one integrated market. A *Multi-level* market is similar to the *Common*, apart from the fact that the needs of the different system operators can be procured via distinguished markets. Local and central needs are therefore resolved via a combination of *Local* and *Central* markets. An important feature of these markets is that in addition to the DSO, the TSO also has access to DER, connected to the distribution system, to address the flexibility needs.

Bids from DER that are not selected and not procured at the *Local* market, can be forwarded to the *Central* one, together with bids from resources connected to the transmission grid. If this would not be the case, and the TSO has no access to DER, a *Fragmented* market model is proposed. This means that connected resources at the distribution level can solely provide flexibility to the *Local* one. Thus, the TSO could only procure flexibility services from assets connected to the transmission system. Finally, we refer to a *Distributed* model, when we consider both local and central needs but allow only peers as buyers and providers in the market.

3 CoordiNet business use cases

After the analysis of the market-based provision of identified system services, four BUCs were developed per demo country, as summarised in Fig. 2. Dashed objects indicate that testing, e.g. capacity products for balancing in the Spanish demonstration in Murcia, Albacete, Malaga, and Cadiz areas is tentative only, while energy products for grid balancing through the central market, considering small RES, large generators, aggregators, larger consumers, and storages are tested. The procurement is based on day-ahead, intraday, and near real-time markets. The Greek DSO tests storage systems to support voltage control in the Mesogeia area, and will potentially use the storage capacity for congestion management in Kefalonia in a later stage.

The current grid and market situation, objectives of energy market actors, and geographical specifications are described for each of the business use cases in greater detail using UML and Sequence diagrams [10].

4 Approach

The developed BUCs are defined using a top-down approach, such that first grid needs and business interests were determined.

Thus, during and after the project, the relevant energy market participants can develop their systems step-by-step to achieve the business framework. This process can be described as vertical progress through the SGAM layers. The mapping to the SGAM logic facilitates the communication between the different parties from a different technical background.
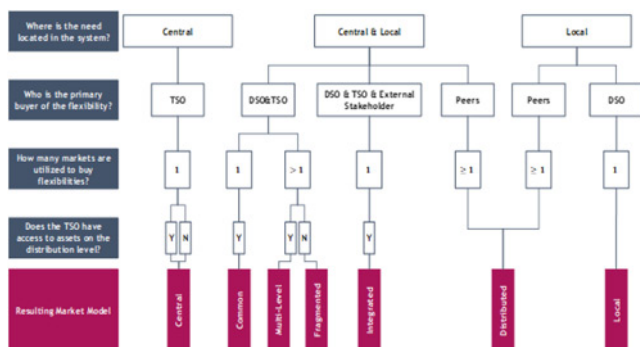

Fig. 1 Coordination schemes

Fig. 2 Overview of business use cases, sorted per system service: balancing, congestion management, controlled islanding, voltage control (from top to bottom) [10]

In this paper, we pick one example BUC and identify how a change of the market model alone, can affect the requirements on the component layer as shown in Fig. 3. The component layers were defined, based on the grid operators' inputs.

Flexible resources connected to the low-voltage and medium-voltage distribution grids can provide flexibility to the TSO or regional DSO, to reduce congestion costs due to the limited subscription level of the regional DSO. The central platform at the transmission domain is involved in terms of an optional forwarding of the unused bids to the Reserves Market for mFRR. However, Fig. 3 shows that most components relevant for the CoordiNet platform are allocated to the regional and local distribution domains. The DSO can collect data from field devices at customer domain and weather stations through the SCADA system (operational measures), initiate load forecasts (flexibility evaluation), and place bids on the day-ahead market (market operation), when an overrun of the subscription level is anticipated.

As consequence, the DSOs face the need to update or reinforce their existent communication and computation infrastructure to enable such functionalities to support congestion management through flexibilities at the distribution level, while the TSOs hardly need to change their grid operation routines in the described scenario.

In a *Distributed* market, such congestions can also be solved in a *peer-to-peer* manner. In that case, e.g. generators avoid being forced out by trading capacities locally, bypassing the DSO's operational activities. Fig. 4 allows a comparison of the two briefly described BUCs, which both target congestion management through two different market models.

Fig. 4 shows a reduced version of the SGAM, describing the top (business) and the bottom (component) layer. Yet, a qualitative comparison can be made, in which domains and zones the selected market models may affect the Hardware and Software infrastructure of the different actors, specifically revealing which actors will need to adapt existing infrastructure in a near future to participate in the presented platform-based communication and trading. The non-exhaustive comparison shall show that the creation of SGAM is beneficial to foster discussions of different stakeholders during the crucial development phase for future market models with extensive integration of flexibilities at transmission and distribution levels.

5 Conclusion

The presented paper points out current incentives to develop modern and flexible energy markets with the active contribution of TSOs and DSOs to facilitate the market participation for smaller units to provide flexibility for system services. The coordination schemes are defined using four classifications: who the buyer is, where the most common system needs occur, and how the need can be met through a market-based provision.

The system services, products, and coordination schemes lead to four market models that are focused on within the CoordiNet project. The identified market models are core elements of the presented BUCs. The Swedish BUC example shows, how the SGAM facilitates to express the development of future market schemes considering different interoperable layers.

6 Acknowledgments

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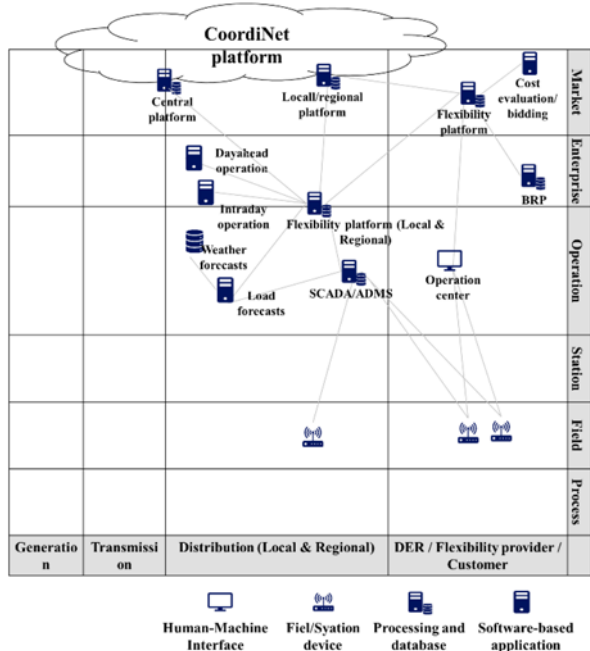
Fig. 3 *BUC SE-1a congestion management from DSO side using a multi-level market model*
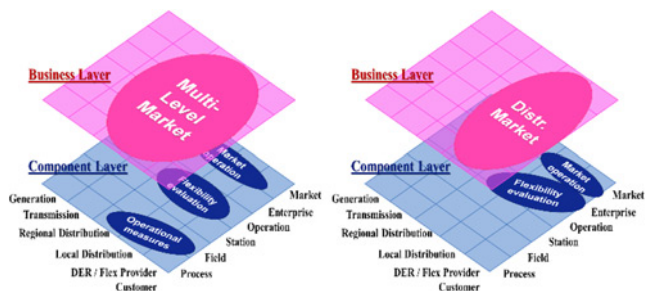

Fig. 4 *Comparison of BUC SE-1a (left) and BUC SE-1b (right) to contrast the domains at business and component layer for a multi-level and distributed market for the provision of the same system service*

CIRED, Open Access Proc. J., 2020, Vol. 2020, Iss. 1, pp. 672–674

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