THE evolvDSO PROJECT: KEY SERVICES FOR THE EVOLUTION OF DSOS' ROLES

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ABSTRACT

The upward trend of DRES, the increase of peak load -in certain countries-, the proliferation of schemes to empower consumers and energy efficiency, are among the challenges posed to DSOs. To face these challenges DSOs cannot longer rely on traditional "fit and forget" approach. Therefore, DSOs need to find new solutions to continue ensuring quality and security of supply at an optimal cost and in a non-discriminatory way. In their effort to continue fulfilling their responsibilities under high quality standards, DSOs may provide adapted services (based on the opportunities brought by smart grid technologies) to manage the increasing complexity of the distribution system.

This paper reports results from a study, within the evolvDSO project, examining key services associated with the potential new roles of DSOs. These services are provided across different business domains of DSOs and aim to face current challenges in a cost-efficient manner. For the description of these services, the study implements the use case methodology. Using this methodology, ten services were identified as key for the evolution of DSOs. From the description of these services it is highlighted the need for information management and a stronger collaboration between DSO-TSO.

In conclusion, DSOs play a central role. By providing these services, they can create a level playing field for all market participants while contributing to system security by ensuring the reliability of the distribution network.

The evolvDSO project describes potential future DSO roles, related services and their requirements for the development of novel tools. This project received funding from the European Union Seventh Framework Programme under grant agreement n° 608732.

INTRODUCTION

European Distribution System Operators (DSO) operate their business in a changing environment. This environment pose significant challenges [1]: (1) the integration of ever-increasing Distributed Renewable Energy Sources (DRES), (2) the continuous growth of the peak load in most European countries, (3) the upward trend of Demand Response (DR) programs and Electric Vehicles (EV), (4) the evolution of electricity markets, (5) the continuous adaptation of regulatory frameworks, and (6) the technological developments and innovations such as the roll-out of smart meter infrastructures.

In view of these challenges, DSOs responsibilities will not fundamentally change [2]. However, these challenges are expected to significantly transform the way they operate in order to fulfil their core responsibilities. DSOs have to develop, operate, and maintain the network in order to deliver high-quality services to grid users and other stakeholders of the Electric Power System, while ensuring safety of people, assets' most efficient use and system security in cooperation with TSOs. Additionally, DSOs are considered (in most countries) key to facilitate the participation of distributed resources into the market. More recently, the contribution to the transition towards a sustainable economy has emerged as an additional mission of DSOs. These responsibilities are shared by all DSOs in Europe and do not vary according to regional and national regulations or market models – only the way they exercise their duties may differ from one country to another and one DSO to another.

DSOs have historically designed and operated their network by planning network investments and adjusting the configuration of the grid, in order to accommodate energy flows and meet peak loads. Energy flows were thought to be in one direction, from the Primary Substations (PS) to the end users. However, increased penetration of DRES – which are in majority connected to the distribution network –, the rise of peak demand, and the introduction of DR programs and/or EVs, contribute to make energy flows less predictable. The bi-directionality of these flows, the growing number of connected actors and devices, and the additional degrees of freedom brought by DR significantly increase the management complexity of the distribution grid [3]. These degrees of freedom may create a situation in which end-users' load profiles deviate from historical average. Such scenario will make constraints occur more frequently and with them the occurrence, duration, and depth of faults, variations in voltage, and network perturbations such as flicker.

As traditional means will no longer be technically sufficient or economically viable to face these challenges, DSOs need to find new solutions to continue ensuring quality and security of supply at an optimal cost and in a non-discriminatory way. DSOs are expected to adapt to this environment by implementing new and evolving business processes in order to develop an Active Distribution System Management approach. The use of this approach would optimise network investments and increase security and quality of supply, bringing value to all grid users.

An active management approach will create value by (1) improving network planning, operation and maintenance processes, (2) enabling to contract and activate flexibilities at different time horizons to solve specific network constraints, (3) strengthening TSO-DSO cooperation, (4) (continuously) facilitating and enabling electricity markets in a neutral and transparent way, (5) empowering the provision of regulated services based on data management.

Ten priority business processes designed to implement the key services associated with the future, evolving and new, DSO Roles have been identified. These processes are derived from current work done within the evolvDSO project. We present these business processes across five DSOs business domains: network planning, operational planning, operation and maintenance, market and DSO-TSO cooperation. For the description of these services we have used the use case methodology. This methodology was chosen because (1) its widespread consensus as robust methodology for the description of the evolutions impacting the electric power system in a smart grid context, (2) it allows DSOs to contribute to the ongoing European-wide work on the elaboration of network rules and the definition of new market models, (3) it ensures a complete compatibility with standardisation work.

The current paper is organised as follows: first, we present a brief introduction of the use case methodology and its implementation in the current work. Then, we describe the business processes whose implementation would optimise distribution grid management and facilitate the integration of DRES connected to the distribution network. Finally, we conclude by presenting the key points from the analysis performed on the business use cases.

METHODOLOGY

The use case methodology was firstly developed for software and systems engineering in the 1980's and 1990's and has since been extended to business process modelling. It has extensively been used within the power supply industry for Smart Grid standardisation purposes by international and European Standardisation Organisations and projects, such as IEC, M/490 Smart Grid-Coordination Group, EPRI, and NIST. Furthermore, it has also been used and is currently been deployed in several Smart Grid projects in Europe, such as ADDRESS, Grid4EU, IGREENGrid and evolvDSO.

The use case methodology in the smart grid context has three main parts: a conceptual model, a description of interoperability layers and a role model.

The conceptual model can be defined as the grouping of roles and actors (e.g. systems, components, operators) within coherent domains related to a general system. It provides a high-level reference architecture model and proposes a decomposition of a system in domains and sub-domains. This facilitates the description of Smart Grid systems and interoperability analysis. The roles and systems of each domain interact with each other, as well as with the roles and systems of other domains.

The description of the interoperability layers is based on the Smart Grid Architecture Model (SGAM). The SGAM aims at representing Smart Grid systems in five layers – business objectives and processes, functions, information exchange and models, communication protocols, and components – as well as the interactions between them. In this paper we will focus on the business layer.

The use of a role model helps to define the business processes. A role may be defined as "an intended behaviour of a business party" (actor) which "cannot be shared" [1]. It is associated with responsibilities. A business party, when carrying out a business transaction, takes on a certain role. According to ENTSO-E Role Model [4], "the objective of decomposing the electricity system into a set of autonomous roles and domains is to enable the construction of business processes where the relevant role participates to satisfy a specific transaction (service). Business processes should be designed to satisfy the requirements of the roles and not of the parties."

In the use case methodology, roles interact with each other within a role model, which represents all of the interactions between the different roles and domains of a given system. The purpose of a role model is to share a common understanding and facilitate communication and the development of information exchanges.

This methodology is a collective bargaining process which is based on a pragmatic approach. It is designed to involve and actively engage different stakeholders. This is done in order to provide an exhaustive and accurate list of requirements for the system under study. The use case methodology is particularly appropriate for describing DSOs services, business processes, and functions evolving with smart grid technologies and smart metering systems as it allows domain experts to brainstorm new requirements.

A business use case describes business processes and their activities/steps, their execution within different domains and zones, as well as their interactions with functions. Use cases are designed to describe 'user requirements', i.e. all of the functional and some of the non- functional requirements of a given system – whether it is a business process or a function [5]. They "define 'what' is needed without reference to any specific designs or technologies" [6].

The business processes described in this paper were created in three steps. In the first step, roles and associated services were identified via an iterative process. For this iterative process we used potential future scenarios [7], surveys [8], workshops, and current literature related to the DSOs business model and activities, electricity market design, and European and national electricity regulations.

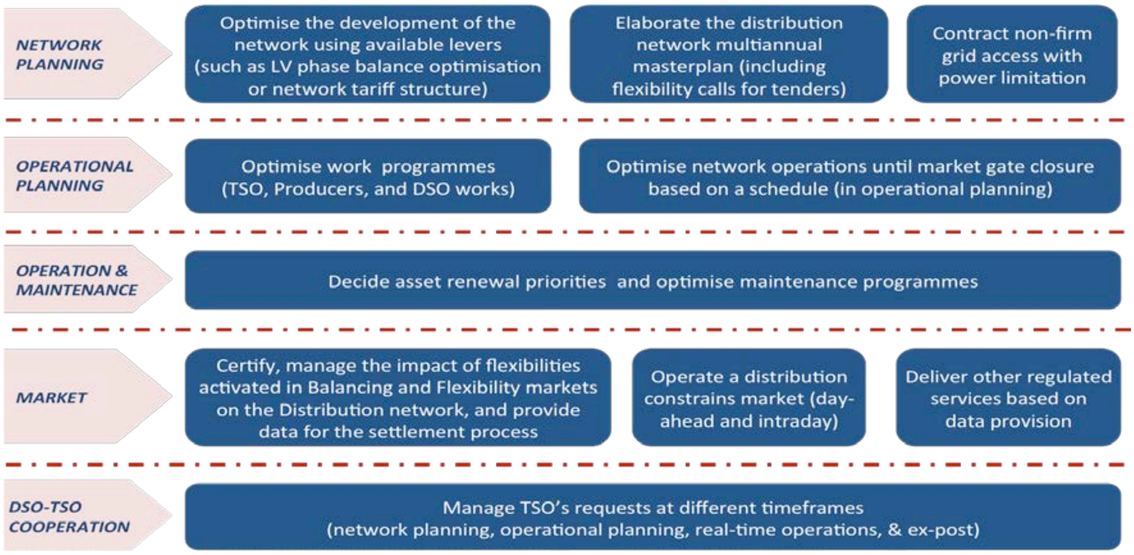

Figure 1: key services

As second step, these services and the business processes implementing them were described in detail with the identification of the beneficiary and the provider(s) of the service. The DSO role model contributed to highlight the interactions within the DSO and the interactions with other actors of the electric power system.

In the third step, DSOs ranked these services. The ranking was based on the priority level of implementation (short to medium-term basis), the level of priority of the associated tools supporting the services (according to degree of implementation), and their know-how and level of expertise on the domain.

Figure 1 shows the set of ten services ordered into five business domains to facilitate their definition and understanding [5].

SERVICES FOR THE EVOLUTION OF DSOS

Ten services for the evolution of DSOs classified per domain will be presented. These services are explained assuming the DSO is the service provider.

Network Planning and Connection domain

Optimise the development of the network using available levers (LV phase balance optimisation and/or network tariff structure)

The service use load flow calculations based on archived metered, network and weather data to optimise tap changers set points at LV/MV, grid connection phase of single-phase meters at LV, and placement of peak/off-peak tariffs. This optimisation will help to prevent network constraints and increase grid capacity in the long-term. The use of these levers is expected to improve Quality of Supply (QoS) (reducing voltage violations), reduce technical losses, and increase asset life expectancy. The service does not use market-based flexibilities, but only network related flexibilities. Moreover, the service does not optimise network configuration through near real-time operation (via breakers, remotely or by sending workers on the field).

Elaborate the multiannual distribution network masterplan (including flexibility calls for tenders)

The service elaborates the distribution network multiannual masterplan using probabilistic load flow calculations in order to highlight potential weaknesses of the current system. Solutions to solve these constraints include the possibility to contract additional long-term flexibilities connected to the distribution network with flexibility operators and/or grid users via a call for tenders.

Contract non-firm grid access with power limitation

The service manages the grid connection and access contract process with a grid user, in order to limit the active power of the site (feed-in or consumption – such as DG or an industrial/tertiary consumer – on a dedicated or pre-existing feeder, for all installations on the HV and/or MV network) a given number of hours per year to prevent constraints on the distribution network as alternative to network reinforcement and as a way to optimise network use and investments. The limitation of active power of residential customers is out of the scope of this service. The service allows the grid user to connect and/or to have access to the distribution network while minimising its connection costs and time, and potential economic losses.

Operational planning domain

Optimise work programmes (TSO, Producers, and DSO works)

The service optimises work programmes on the EHV, HV and MV networks. These work programmes relate to the installation, maintenance, and repair of network assets – including works determined by the TSO, HV and/or MV producers, and the DSO. The optimisation consists in (1) analysing the feasibility of the works, including the possibility to contract flexibilities, and (2) coordinating works by defining work programmes shared among the TSO, producers, and the DSO. The optimisation aims at minimising the impact of work programmes (incl. financial impact) on the system by taking into account the respective constraints of the actors, and maximise renewable energy inflows.

Optimise network operations until market gate closure based on a schedule (in operational planning)
The service anticipates and optimises network operations in medium-term (month and week ahead) and short-term (day ahead and intraday) operational planning. To anticipate the operating points based on local load and generation forecasts, it first identifies and then qualifies the risks of constraints on the distribution network (PS, MV network, and HV network if managed by the DSO), especially in case of DRES and/or in the presence of flexibility operators. The process defines the network configuration in order to satisfy the contractual commitments, with the use of several optimisation levers, which aim at solving detected constraints according to a merit order. The service takes into consideration for all timeframes the work programmes and real-time network constraints (faults, transmission limitation or transmission outage, load transfers), which then uses to evaluate the impact on the operating points. In this way, the service validates, from a technical perspective, flexibility offers proposed or activated in the balancing market and energy markets.

Operation and Maintenance domain

Decide asset renewal priorities and optimise maintenance programmes
The service decides asset renewal priorities and optimises maintenance programmes in the planning phase, based on the network assets analysis and the development of failure predictive and condition-based maintenance models. The service allows for a preventive and condition-based maintenance facilitating investment decisions and reducing cost of ownership for distribution assets (incl. Telecommunication assets).

Market domain

Certify, manage the impact on the Distribution network of flexibilities activated in Balancing and Energy markets, and provide data for the settlement process
The service certifies flexibility operators and flexibility perimeters including sites connected to the distribution network. It also qualifies all kind of flexibilities offers at distribution system level on day ahead and intraday markets to ensure that their activation do not create network constraints, and if it is the case, propose modifications regarding their conditions of activation. After actions have been implemented, the service provides the corresponding data for the settlement process.

Operate a distribution constrains market (day-ahead and intraday)
This service is used to solve specific distribution network constraints at the lowest cost by purchasing distribution flexibility offers proposed on a new distribution constraints market. The DSO manages the distribution constraints market through three major actions: certification, reception and management. First, the DSO certifies distribution flexibility operator to allow its participation to the distribution constraints market. Second, it receives distribution flexibility offers at different timeframes and orders them. Third, it manages the activation of these offers.

Deliver other regulated services based on data provision
The service transmits relevant data in response to the demand of external and eligible actors respecting relevant data privacy issues. The data includes, but is not limited to, individual consumption and production data and relevant information for authorities. The former can be used to empower grid users and enable authorised third parties (e.g. suppliers, service providers) to access data of their clients. The latter may be used to enable local authorities to elaborate sustainable development and energy demand management policies, improve urban planning, or reduce fuel poverty, for instance.

TSO-DSO Cooperation domain

Manage TSO requests at different timeframes (network planning, operational planning, real-time operations, and ex-post)
The service strengthens the interaction with the TSO at different timeframes (network planning, operational planning, real-time operations, & ex-post). This is done by (1) enforcing a reliable data exchange, (2) coordinating maintenance actions, and (3) jointly controlling the execution of resources connected to the HV and/or MV network that allows the DSO to respond to operational requests from the TSO.

CONCLUSIONS

DSOs' evolution has already started and will continue to impact their roles, business model and business processes. To respond to current challenges (integration of DRES, growth of peak load...) DSOs may use the opportunities brought by smart grid technologies to provide services that create value for all stakeholders of the power system.

As defined in Article 25 1-7 of Electricity Directive 2009/72/EC, the "distribution system operator shall be responsible for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity, for operating, maintaining and developing under economic conditions a secure, reliable and efficient electricity distribution system in its area with due regard for the environment and energy efficiency." European DSOs must continue to fulfil these responsibilities in a changing environment.

This paper introduces ten services that DSOs may provide in response to current challenges. These key services are derived from current work done within the evolvDSO project. The services were classified across five DSOs business domains: network planning, operational planning, operation and maintenance, market and DSO-TSO cooperation. For the description of these services the use case methodology was used. This methodology was chosen because of its suitability to represent complex systems characteristics, the possibility to contribute to the elaboration of network rules and the definition of new market models, and its ability to ensure compatibility with standardisation work.

Providing these services paves the way to implement an active distribution system management approach. An active management of the distribution grid will allow DSOs to improve planning, operation, and maintenance processes. In addition, the approach should allow DSOs to make the most efficient use of all flexibilities connected at distribution system level leading to an optimal management of the distribution network. To this regard, DSOs may be allowed to (1) contract flexibilities in the planning phase to optimise network investments, (2) offer non-firm grid access options with power limitation to grid users to facilitate the integration of DRES, and (3) purchase flexibilities to solve unforeseen local network constraints in operational phase.

Moreover, acting as a neutral market facilitator, DSOs will play a relevant role in supporting TSOs and market participants through all market stages.

Regarding information management, the definition of these services highlighted the importance of technical data handling. DSOs need this data when fulfilling demanding requirements in terms of performance, data management and security. Ensuring the operational security of the distribution network will increasingly require DSOs, acting as independent parties with non-discrimination and transparency objectives, to be able to collect, process, and provide network and metered data at different timeframes, with ever-decreasing response times and ever-increasing privacy and security standards.

In respect to collaboration, these services underline the need for reinforced cooperation with other stakeholders in general, and with the TSO and flexibility operators in particular. DSOs have to ensure the reliability of the distribution network. In order to do so, DSOs need to strengthen the collaboration with the TSO. This will also contribute to maintain system security. An enhanced and stronger collaboration can be achieved by implementing effective information exchanges across all time horizons. To this end, web portals and standardised data models may be implemented.

The description of these services contributes to a broader objective: the description of the evolutions impacting the electric power system in a smart grid context. The definition of these services allowed the evolvDSO project to further investigate the innovative functions supporting the business processes, as well as their associated tools and methodologies to contribute to make this evolution a reality. In future work, the evolvDSO project will assess the implications of the provision of these services as well as the potential regulatory barriers to their implementation.

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