EVOLVDSO: ASSESSMENT OF THE FUTURE ROLES OF DSOS, FUTURE MARKET ARCHITECTURES AND REGULATORY FRAMEWORKS FOR NETWORK INTEGRATION OF DRES

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ABSTRACT

The implementation of an Active Distribution System Management approach will be of key importance to facilitate and support energy markets. DSOs can empower consumers to support the system. Consumers/prosumers could bring flexibility, originating from DG units and/or flexible loads, to the system through competitive and transparent mechanisms. This flexibility can help to integrate generation based on intermittent renewable sources.

This paper illustrates, by means of the role model, the potential (evolving and new) future roles envisioned at distribution system level which paves the way for the implementation of such approach. These roles will provide a level playing field by handling the increasing management complexity of the distribution system, so that an optimal use of flexibilities connected at distribution system level could lead to the provision of services the system requires.

By adopting these roles the DSO will facilitate and support current and potential new energy markets in the smart grid environment, thus bringing value for all the stakeholders.

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INTRODUCTION

The distribution network is being challenged by (1) the increasing capacity of Distributed Generation (DG), (2) end-users embracing smart grid technologies to offer their flexibility, (3) the continuous growth of the peak load in most European countries, (4) the expected increase of Electric Vehicles (EVs) to hit the road by 2020 along with public charging stations. All of these evolving and new uses of electricity increase the complexity of the management of the distribution system.

Current trends impose challenges that impact the ability of the DSO to carry out his responsibilities: 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.

DSOs need to evolve from its former "fit and forget" approach towards an Active Distribution System Management approach to ensure the fulfilment of DSOs' core responsibilities by taking advantage of the opportunities brought by smart grid technologies.

The exploration of these opportunities could lead to the provision of new regulated services, the facilitation of electricity markets, the empowerment of the end-customers and the creation of sustainable public policies for the cost-efficient integration of renewables. This evolution will allow DSOs to provide an adequate Quality of Service (QoS) and to enhance the Security of Supply (SoS) in a cost-efficient way.

The path towards an Active approach includes the following opportunities:

- The improvement of network planning and operation processes, in order to optimise network investments,
- The possibility to contract and activate flexibilities at different timeframes to solve specific network constraints,
- The reinforced cooperation between TSOs and DSOs,
- The ability to facilitate and enable electricity markets in a neutral and transparent way,
- The possibility to provide regulated services based on data management and provision, in order to facilitate national and local public policies and enable customer empowerment.

For the implementation of an Active Distribution System Management approach it is required that current roles evolve and new ones are created. A role is an external intended behaviour of a business party which cannot be shared, aiming at satisfying a specific transaction or service. A service can be defined as a business transaction between two or several roles interacting to achieve a given goal. Services are implemented by a business process.

This article illustrates, by means of the role model, the potential (evolving and new) future roles envisioned at distribution system level. This set of roles allows for an optimal management of flexibilities connected at distribution system level. The services provided by these roles assist DSOs to fulfil their core responsibilities,

facilitate the integration of DRES, pave the way for the smart grid evolution into the distribution system, and ultimately generate benefits for the overall system.

In this paper we describe the evolving environment in which DSOs are immersed, we illustrate the impacts of implementing an active distribution system management approach, and we introduce future potential roles at distribution system level.

DSOS IN AN EVOLVING ENVIRONMENT

The changing environment is characterised by the opportunities (smart) technology will bring. The available technology rapidly improves in the areas of metering, sensing, data management, control of resources (in a direct and indirect way), etc., allowing for new or faster tools to be developed. In coming years, smart grid technologies are expected to be ubiquitous. Their wide implementation is expected to decrease technology prices which in turn will help to make them more affordable.

Technological advances are reshaping today's electricity markets. More mature technologies for local renewable generation and decreased investment costs thereof, joint with national support schemes, led to a significant market penetration of distributed generation in many EU countries [1].

The newly emerging broad range of distributed energy resources, be it distributed generation (DG), local storage, electric vehicles or demand response, are driving current changes and posing challenges for DSOs and their regulation alike [2].

The consumer (end-user) is at the heart of the changing environment. Consumers are embracing smart grid technologies. New meter and appliance technologies provide them with the possibility to react to local and upstream generation patterns and prices. Consumers that embrace these technologies are looking for new ways to reduce their energy costs by using energy more wisely. To do so, they are willing to learn more about their flexibility options, understand their consumption pattern and make informed decisions about their targeted comfort level. To facilitate their involvement, service providers (e.g. aggregators) appear. They serve as intermediaries between consumers and markets.

The management of the distribution network is becoming more complex. The "network follows demand" approach may hinder DSOs to comply with the high standards of Quality of Service (QoS) and Security of Supply (SoS).

Currently, power flows are indeed operating in two directions and between a growing number of connected actors and devices. They become as a result less predictable. In addition, constraints will occur more frequently, and are likely to be more critical and more complex to manage at both local and system levels [3]. More in particular, the occurrence, duration, and depth of faults, variations in voltage, and network perturbations such as flickers will continuously increase.

To manage power flows and constraints DSOs would need to implement sophisticated control and supervision systems. Without these systems, connection costs and delays may rise significantly. Therefore, in light of the increasing management complexity of the distribution network driven in part by the variability of power flows, the use of the "network follows demand" approach could entail investments in network expansion and operational activities (e.g. maintenance) that turn out to be too heavy to be borne by system operators, customers, or decentralised producers.

Responsibilities of DSOs in a changing environment

DSOs responsibilities have fundamentally not been modified by the challenges facing the electric power system. Their core duties are still 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. More recently, the contribution to the transition towards a sustainable economy has emerged as an additional mission of DSOs, along with other actors of the electric power system.

To cope with these responsibilities, some DSOs are [4]:

- Implementing processes for smart grid data handling
- Forecasting generation and demand at distribution system level
- Contracting services for dealing with network constraints at distribution system level
- Participating in the energy market as BRPs to balance their energy losses
- Rolling-out smart metering infrastructure

Challenges for European DSOs

To explore the opportunities smart grid technologies bring it is necessary to reduce the uncertainty for investments and promote innovation on solutions and implementations. Technological developments and innovations represent both -opportunities and challenges- for the different actors and stakeholders of the electric power system.

Electricity markets will have to evolve and even new ones will have to be created in order to provide the system with the flexibility needed for its correct operation. In order to ensure an optimal use of the different types of flexibilities DSOs will be in need to work together with their national regulators since in most cases the creation of such markets would require

modifications in the current regulatory framework.

Challenges, foremost related to DG technologies, are already observable in many distribution systems. However, the same technologies that are causing substantial challenges already today can be exploited to establish a more efficient and also cleaner electricity system than our current one.

These challenges impact the way DSOs design, operate, and maintain their networks. In addition, they tend to intensify the need for network reinforcements and add complexity to the supervision and control of the distribution grid. As a result, they may undermine the DSOs' ability to guarantee reliability of supply and SoS to end-users. In adapting to these challenges, DSOs will have to become pro-active, which in some cases may require an in depth transformation.

AN ACTIVE DISTRIBUTION SYSTEM MANAGEMENT APPROACH

An Active Distribution System Operator must be able to provide services for the efficient and sustainable integration of the ever-increasing DG (e.g. DRES, storage, EV). In addition, DSOs should be able to increase the value for all stakeholders by making use of the technological degrees of freedom and its (strategic) position in the smart grid environment and power system evolution.

The path towards an active approach includes the following opportunities [5]:

- The improvement of network planning and operation processes, in order to optimise network investments,
- The possibility to contract and activate flexibilities at different timeframes to solve specific network constraints,
- The reinforced cooperation between TSOs and DSOs,
- The ability to facilitate and enable electricity markets in a neutral and transparent way,
- The possibility to provide regulated services based on data management and provision, in order to facilitate national and local public policies and enable customer empowerment.

EVOLVING AND NEW DSO ROLES IN A SMART GRID ENVIRONMENT

Figure 1 shows the potential (evolving and new) roles at distribution system level along with their main purpose.

Each role, in order to fulfil its responsibilities, provides key services to different stakeholders. These services support the implementation of an Active Distribution System Management approach, a Market Facilitator approach, and contribute to system security. More information on these services can be found in [6].

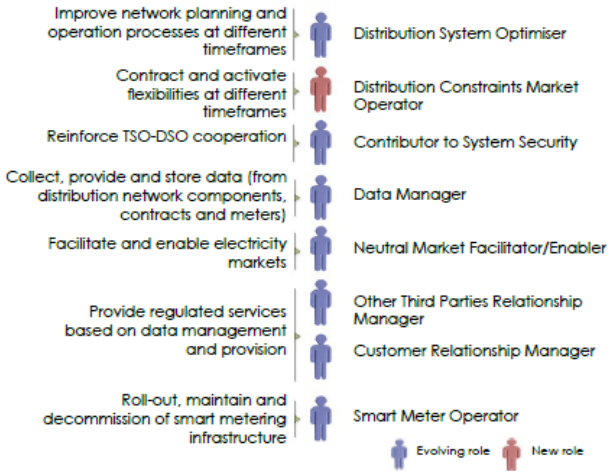

Figure 1 Potential roles at distribution system level

Distribution System Optimiser

A Distribution System Optimiser aims to improve the development, operation, and maintenance of the distribution network. The role accomplishes his task by managing distribution network constraints (incl. critical/emergency events) in a cost-efficient and non-discriminatory manner. This allows the optimisation of network investments and system management at different time horizons.

The role acts as a network developer, operational planner and network operator. As a network developer, it deals with the grid's optimal expansion focusing on its long-term evolution and adequacy. As an operational planner, its tasks include load flow calculations, assessment of flexibility offers, forecasting, etc. These tasks allow to foresee possible events that may hinder the distribution of electricity, optimise the scheduling of maintenance operations in cooperation with other actors (e.g. TSO and grid users), and come up with contingency plans. As network operator, it is in charge of real-time operation (including service restoration).

Data Manager

The Data Manager role controls metered, network and contractual data. It collects, validates, analyse, stores historical records and provides data originating from meters, network monitoring and sensing devises and contracts. The role supports and promotes the cost-efficient exchange of information among potential future roles, which could then pass this information to eligible parties (e.g. TSO, regulatory authorities, BRPs) in a coordinated, transparent and secure way. Therefore, it is key for the creation of new services at the distribution system level [3].

The Data Manager handles three types of data: metered data, network data and contractual data.

A (registered) load curve, as an example of metered data, could be used for billing purposes by suppliers. Network operators would use this data to elaborate load profiles and forecasts.

An example of network data could be the archived network configurations. These network configurations would serve to analyse changes in the grid configuration, to support load flow calculations and ultimately, to assist on the network development planning. In addition, network data could be used in operational planning to anticipate network operations, or for optimising maintenance activities with the development of failure predictive models, for instance.

Contractual data refers to the information that describes the connection point (e.g. subscribed power injection/withdrawal, peak power). This information is provided within the contractual agreement between the subscriber and the provider of the electricity service. Suppliers use this data for billing purposes while network operators would use this information across different domains (e.g. network planning, operational planning, real-time operations) to enable them to optimise network operations or manage critical situations (e.g. emergencies).

Metered, contracts and network data can be used to assess which lever to use to ensure the operational security of the distribution network, such as the temporary limitation of controllable resource capabilities (e.g. passive consumers, prosumers, storage facilities).

Neutral Market Facilitator

The Neutral Market Facilitator role promotes market participation of flexibilities directly connected to the distribution network. The role pre-qualifies flexibilities for their participation in established and potential new market mechanisms. To participate on the different electricity markets, market players must respect administrative and technical requirements. The pre-qualification aims to facilitate the offering of flexibility services and, includes the administrative validation of flexibility resources and perimeters.

A distinction between the market enabling (this role) and data management (data manager role) is proposed, in contrast with [7] where both activities are described within the market facilitator role.

Contributor to System Security

The Contributor to System Security role exchanges network planning and operation data (e.g. current network structure and its foreseen evolution, operation planning contracts, forecasts aggregated at primary substation) with the TSO. The role provides cost-efficient local solutions to system wide problems, by responding to the TSO's planning, scheduling and security requests (including emergency situations). Once all market-based solutions have been used (or are no longer available), the role can use idle flexibility (initially contracted by other roles and at the disposal of the actor adopting this role, which in this article is assumed to be the DSO) to respond to TSO's requests. In emergency situations, the role may curtail resources to respond to load transfer request demanded by the TSO.

Distribution Constraint Market Operator

The Distribution Constraints Market Operator is a new role that envisions to perform activities related to the contract and activation of flexibilities.

This role manages (competitive) mechanisms for the procurement of flexibilities directly connected to the distribution network. The role selects, contracts and activates flexibilities offered by flexibility operators (e.g. aggregators). The flexibilities procured would serve as a reserve that can be used across different time horizons, and mainly to treat unforeseen events (e.g. local constraints due to unforeseen weather conditions). The procurement of these flexibilities is done in coordination with the Distribution System Optimiser.

For the procurement of flexibilities, the role may use complementary mechanisms such as dedicated market and/or call for tender. The distribution constraints market operator receives the flexibility offers which are located close to the identified network constraint. The tender may be used to contract flexibilities for longer time horizons, while, the dedicated market accounts for the mid- to short-term flexibility reserve.

Flexibility operators could offer these flexibilities - provided that flexibility resources are connected to the distribution network- to the role so that flexibility can be activated to relieve specific distribution network constraints.

Smart Meter Operator

The Smart Meter Operator role administers the smart metering system. The role takes care of physical meters from installation to decommissioning, including the information flow between the metering infrastructure (e.g. remote terminal unit, concentrators, metering points), communication system and data warehouses. The role has the capability to configure smart meters (e.g. contracted power) and it works in close collaboration with the Data Manager.

Customer Relationship Manager

The Customers Relationship Manager role manages the various contracts and requirements including grid users' access and the legal arrangements among suppliers, BRPs and DSOs. The role coordinates contractual arrangements, postulates requirements, and provides

aggregated information to eligible parties. In other words, it takes care of the communication with existing players in the electricity system.

Other Third Party Relationship Manager

The Other Third Parties Relationship Manager role manages the communication with regulators, conceding and local authorities, service providers and other third parties. The role provides data required by current national legislation. The exchange of data may be initiated by a request from the interested (and eligible) party. Data related to accurate network performance (e.g. QoS indicators) or detailed network investments are examples of the information that may be provided. This information exchange has several purposes such as improve planning developments, avoid and/or reduce related costs and delays, facilitate the assessment of current and potential regulatory measures, evaluate pilots and R&D projects, etc.

CONCLUSION

The core responsibilities of European DSOs will remain the same. However, as stated in this article, current trends impose challenges to DSOs.

The "fit and forget" approach is no longer suitable to ensure a high QoS and reliability. In order to create value for all the stakeholders, DSOs are required to evolve towards an active Distribution Management approach that allows them to (1) improve network planning and operational processes, (2) contract and make optimal use of flexibilities offered by flexibility providers to solve specific network constraints, (3) reinforce TSO-DSO cooperation, (4) facilitate and enable electricity markets, and (5) provide regulated services (based on data management and provision) that may be used when market-based solutions are no longer suitable.

DSOs' evolution start with the adaptation of current roles and the creation of new ones. This evolving and new set of roles should enhance the participation of DSOs in key activities related to network management and market facilitation.

These roles should be seen as a coherent whole. As a whole, they allow to make optimal use of local resources of flexibility at different timeframes.

The realization of these roles and the promotion of a more efficient energy system require a sound regulatory framework. This regulatory framework would have to support/promote non-conventional investments and management mechanisms. DSOs in a smart grid environment will need clear incentives in order to promote and to facilitate their evolution towards a more Active Distribution System Management approach. Certainty on network investments and innovative management approaches will allow DSOs to exploit the full potential of the existing infrastructure so that current and future challenges are dealt with in the most cost-efficient manner (i.e. in the best interests of end users and other stakeholders active in the electric power system).

Regulators across Europe would be required to adapt the general proposition of these roles and related services to the operating procedures. Changes to accommodate the regulatory framework to evolving and new roles may differ in their form based on country and market specific features Any implementation of the roles above mentioned should take into account the potential impacts on competition and stakeholders. Ultimately, it is expected that regulatory authorities promote the definition of a clear model for the implementation of these roles and related services so that they generate benefits for all the stakeholders active in the electric power system. This model should reflect a coherent market and regulatory framework. By promoting this framework, policy makers will set adequate rules, incentives and unbundling requirements for the evolution of DSOs and other stakeholders.

REFERENCES

[1] evolvDSO, "Definition of a limited but representative number of future scenarios," Deliverable 1.1, evolvDSO Project, 2014.

[2] Ignacio Pérez-Arriaga, Sophia Ruester, Sebastian Schwenen, Carlos Batlle, and Jean-Michel Glachant, "Think - From Distribution Networks to Smart Distribution Systems: Rethinking the Regulation of European Electricity DSOs," Jun. 2013.

[3] Eurelectric, "Active Distribution System Management: A key tool for the smooth integration of distributed generation - findings and recommendations," 2013.

[4] evolvDSO, "Evaluation of current market architectures and regulatory frameworks and the role of DSOs," Deliverable 1.2, evolvDSO Project, Deliverable 1.2, 2014.

[5] evolvDSO, "Preliminary assessment of the future roles of DSOs, future market architectures and regulatory frameworks for network integration of DRES," Deliverable 1.3, evolvDSO Project, Deliverable 1.3, 2014.

[6] evolvDSO, "Business Use Cases Definition and Requirements," Deliverable 2.1, evolvDSO Project, 2014.

[7] Smart Grid Task Force, "EG3 First Year Report: Options on handling Smart Grids Data," Jan. 2013.