evolvDSO

Development of methodologies and tools for new and evolving DSO roles for efficient DRES integration in distribution networks

evolvDSO

COOPERATION

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007–2013) under grant agreement n° 608732.

D1.3 - Preliminary assessment of the future roles of DSOs, future market architectures and regulatory frameworks for network integration of DRES

Document Information

Programme	FP7 – Cooperation / Energy
Project acronym	evolvDSO
Grant agreement number	608732
Number of the Deliverable	**D 1.3**
WP/Task related	WP1 / T1.3
Type (distribution level)	PU
Date of delivery	10-07-2014
Status and Version	Final, v1.0
Number of pages	83 pages
Document Responsible	Daan Six – VITO / EnergyVille
Author(s)	Enrique Rivero Puente, Daan Six, Ariana Ramos, Marijn Maenhoudt – VITO / EnergyVille Arnaud Ulian– ERDF
Reviewers	Valentina Alagna – ENEL Distribuzione Cyril Vuillecard – RTE Florian Chapalain and Joana Abreu Jackson – EDSO for Smart Grids Lutz Eckenroth and Oliver Franz – RWE Jacques Arbeille – Energy Pool Jan Kellermann – RWTH Aachen University

Revision History

Version	Date	Author/Reviewer	Notes
0.1	14/04/2014	Enrique Rivero Puente	First draft
0.2-0.3	15/04/2014	Enrique Rivero Puente / Daan Six	Draft for informal review after internal VITO / EnergyVille comments
0.4–0.6	25/4/2014	Enrique Rivero Puente et al./ all evolvDSO partners	First version including informal review comments – all evolvDSO
0.7	28/05/2014	Enrique Rivero Puente et al.	Draft for official review
0.8	18/06/2014	Enrique Rivero Puente et al.	Updated semi-final version after review
0.9	20/06/2014	Enrique Rivero Puente et al.	Final version for approval Management Board evolvDSO
0.9.3	30/06/2014	Enrique Rivero Puente et al.	Final version (second round of comments) for approval Management Board evolvDSO
0.9.4	4/07/2014	Enrique Rivero Puente et al.	Final version (third round of comments) for approval Management Board evolvDSO
0.9.5	7/07/2014	Enrique Rivero Puente et al.	Final version (updated with the correction of minor typos and layout) for approval Management Board evolvDSO
1.0	10/07/2014	Enrique Rivero Puente et al.	FINAL version

Executive Summary

The distribution network is being challenged by current trends. The capacity of Distributed Renewable Energy Sources (DRES) connected to the distribution network is increasing. Todays' consumers want to understand and make better use of their flexibility by embracing smart grid technologies. The amount of Electric Vehicles (EVs) on the road and public charging stations will see a major increase by 2020. All of these evolving and new uses of electricity increase the complexity of the management of the distribution system.

In the future, the core responsibilities of Distribution System Operators (DSOs) will not change. But the increased management complexity of the distribution system may hinder their fulfilment. 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.

The DSO needs to evolve from its former "fit and forget" approach towards an Active Distribution System Management approach to ensure the fulfilment of his responsibilities. This approach can guarantee 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-customer 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 implementation of an Active Distribution System Management approach will be of key importance to facilitate and support energy markets. DSOs have a privileged position. They 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. Therefore, the DSO as market facilitator will play a central role in enabling these flexibility sources to reach the market.

For the implementation of an Active Distribution System Management approach it is required that current roles evolve and new ones are created. These evolving and new 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.

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 report illustrates, by means of the role model, the potential (evolving and new) future roles envisioned at distribution system level. The definition of these roles, and related services, paves the way for the implementation of an Active Distribution System Management approach. This set of roles allows for an optimal management of flexibilities connected at distribution system level. By adopting these roles the DSO will facilitate and support current and potential new energy markets in the smart grid environment.

For the definition of this set of roles the report made use of relevant available literature. The report used two main inputs. The first is the Eurelectric document on "Active Distribution System Management: A key tool for the smooth integration of distributed generation". The second is from Smart Grid Task Force – Expert group 3 (SGTF – EG3) "Options on handling Smart Grids Data".

Figure 1 shows the potential (evolving and new) roles at distribution system level along with their main purpose. From the eight roles, only one is currently not defined in today's context. The Distribution Constraints Market Operator (Section 4.6) is a new role that performs activities that resemble the ones carried out by the TSO (e.g. contracting and activating flexibilities). Flexibility operators could offer these flexibilities -provided that they are directly connected to the distribution network- to the role so that they can be activated to relieve specific distribution network constraints. Flexibilities that are not offered to the Distribution Constraints Market Operator may be used for other purposes.

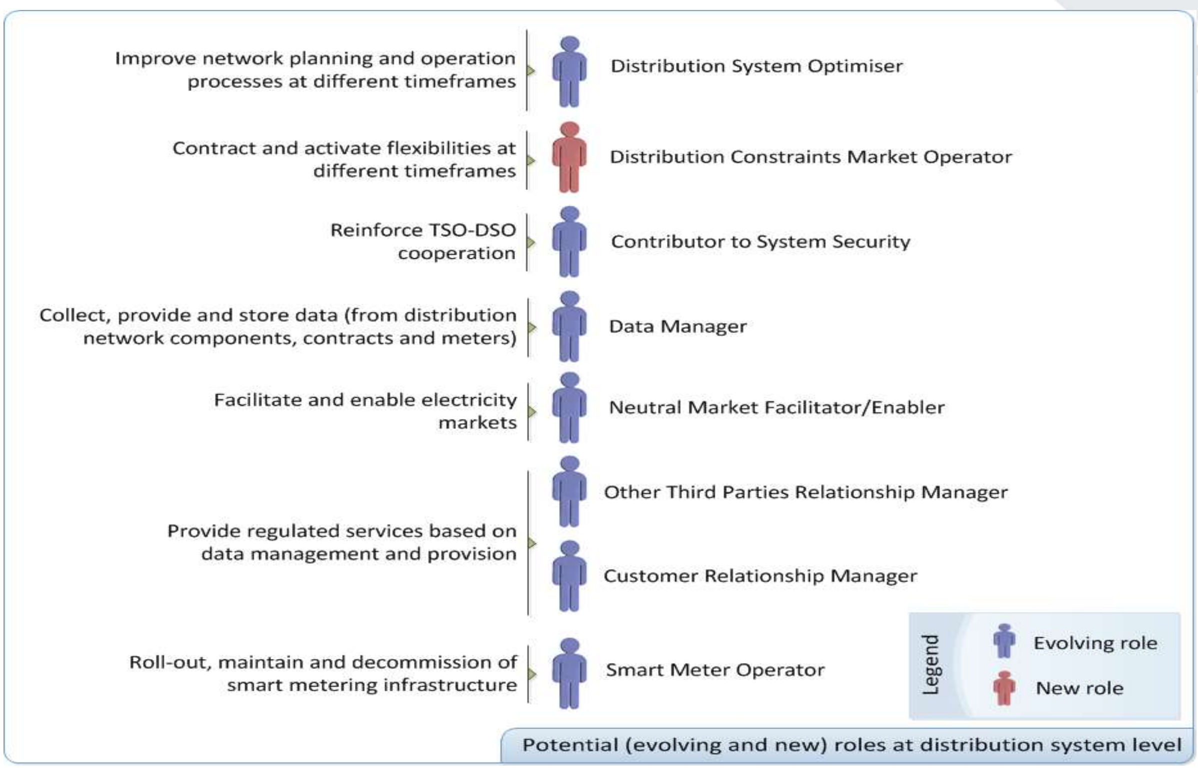

Figure 1 – Potential (evolving and new) roles at distribution system level

In order to deliver the services associated with the evolving and new roles to face all the challenges mentioned above, the DSO will have to improve his infrastructure, management procedures and internal policies. More precisely, he will have to implement new business processes or modify existing ones based on Active Distribution System Management schemes.

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.

Figure 2 shows the business processes implementing some of the most relevant services for DSOs, which are described in Business Use Cases within the project. These processes have been detailed in Business Use Cases according to the Use Case methodology in the evolvDSO report D2.1.

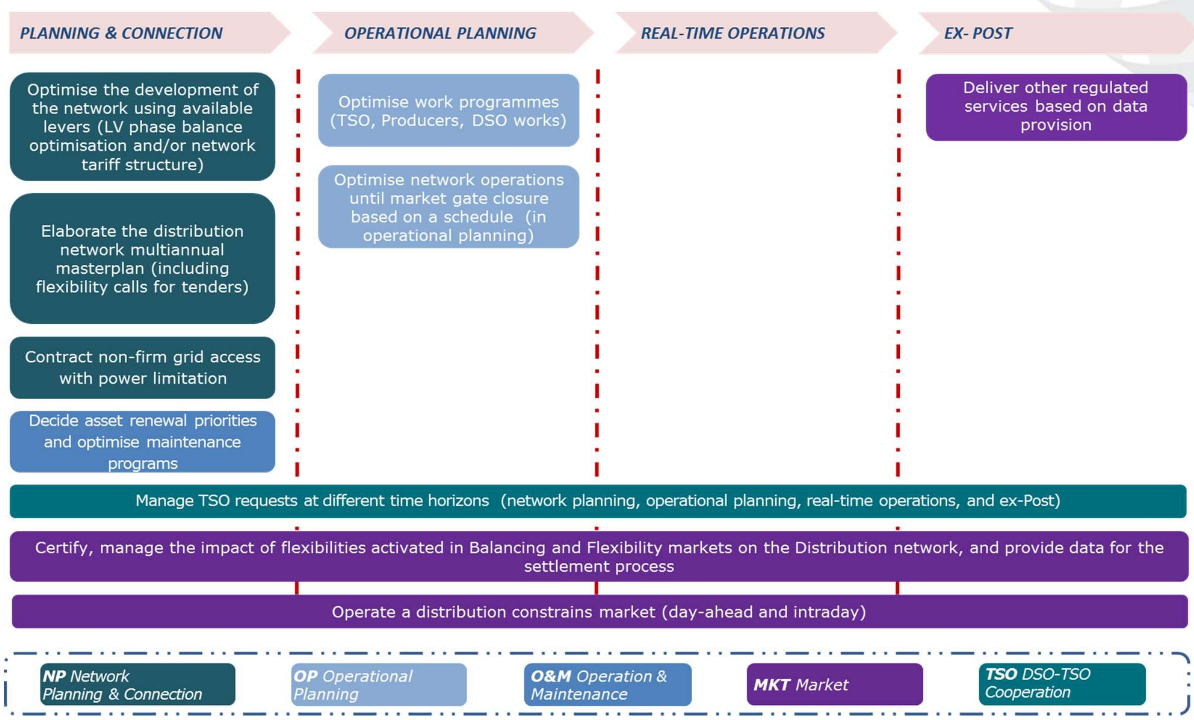

Figure 2 - Relevant services per domain and timeframe [1][2]

[1] The service "Manage TSO requests at different time horizons" (section 4.5.2) aims at providing cost-efficient local solutions (based on data exchange and/or actions) to system wide problems. This service may be provided to the TSO when market-based solutions cannot be used.

The current report presents a vision on the future roles required to provide the services needed to assist DSOs to fulfil their core responsibilities, facilitate the integration of DRES and the smart grid evolution into the distribution system, and ultimately generate benefits for the overall system.

For the realization of an Active Distribution System Management approach, the current regulatory framework would have to be adapted. As stated in (evolvDSO 2014b) "current market design and regulation does not promote DSOs to exploit the full potential of active grid management." The new paradigm 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. The adaptation of the current regulatory framework towards the evolution/creation of these roles would be highly influenced by the specific context of a particular system. The differences amongst the European distribution systems make it highly difficult to foresee a specific path for the evolution and/or creation of these future roles. Furthermore, it is expected that the roles and its related services would be adapted to the specific needs of the system in question.

Regulators should 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. In a smart grid environment, DSOs will need clear incentives that encourage and facilitate their advancement towards an 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).

---

[2] The service "Certify, manage the impact of flexibilities activated in Balancing and Flexibility markets on the Distribution network, and provide data for the settlement process" (section 4.4.2) registers flexibilities offered by flexibility operators at distribution system level and manages their potential impacts from the distribution system perspective.

Table of contents

List of Figures

List of Tables

Acronyms

Acronym	Description
BRP	Balance Responsible Party
BUC	Business Use Case
CEER	Council of European Energy Regulators
DER	Distributed Energy Resources
DG	Distributed Generation
DR	Demand Response
DRES	Distributed Renewable Energy Sources
DSO	Distribution System Operator
DSR	Demand Side Response
ESCO	Energy Service Company
ESCO	Energy Service Company
EV	Electric Vehicle
GS	Guaranteed standards
HV	High voltage
ICT	Information and Communications Technology
IT	Information technologies
LV	Low voltage
MV	Medium voltage
OS	Overall standards
PV	Photovoltaic
QoS	Quality of Service
RD&D	Research, Development and Demonstration
SDO	Standards development organisations
SGAM	Smart grid architecture model
SME	Small and Medium Enterprise
SoS	Security of Supply
TSO	Transmission System Operator

Acknowledgements

This report is not only the result of analysing literature and other publically available information. It represents the outcome of joint research efforts by the entire consortium, including specific information provided through several surveys, meetings and workshops, as well as through interesting group and bilateral discussions within the *evolv*DSO consortium.

Special thanks go to Pierre Barrier (ERDF) for his specific contributions to this deliverable. Furthermore, the authors wish to gratefully acknowledge the valuable input of all involved experts from the different partners within the *evolv*DSO consortium, being ENEL Distribuzione, cyber GRID, EDP Distribuçao, EDSO for Smart Grids, Energy Pool, ERDF, ESB, Energinet.DK, FGH, INESC Porto, INPG, RSE, RTE, RWE, RWTH Aachen University, UCD and VITO / EnergyVille.

1 Introduction

1.1 The evolvDSO project: target and objectives

Due to the increasing share of distributed renewable energy sources (DRES) and the increasingly pro-active demand for electricity, power systems and their mode of operation need to evolve. As a consequence, roles and responsibilities of stakeholders in the power system and the energy market are expected to change as well.

The evolvDSO project, for which the motivation is represented in Figure 3, will define future roles of Distribution System Operators (DSOs) based on future scenarios, and will address the associated main research and technology gaps to be solved for DSOs to efficiently fulfil their emerging and future roles in the European electricity systems. New tools and methods will be developed, encompassing a wide array of DSO activities related to planning, operations scheduling, real-time operations and maintenance. Selected methods and tools will be tested and validated to maximise their deployment, scalability and replication.

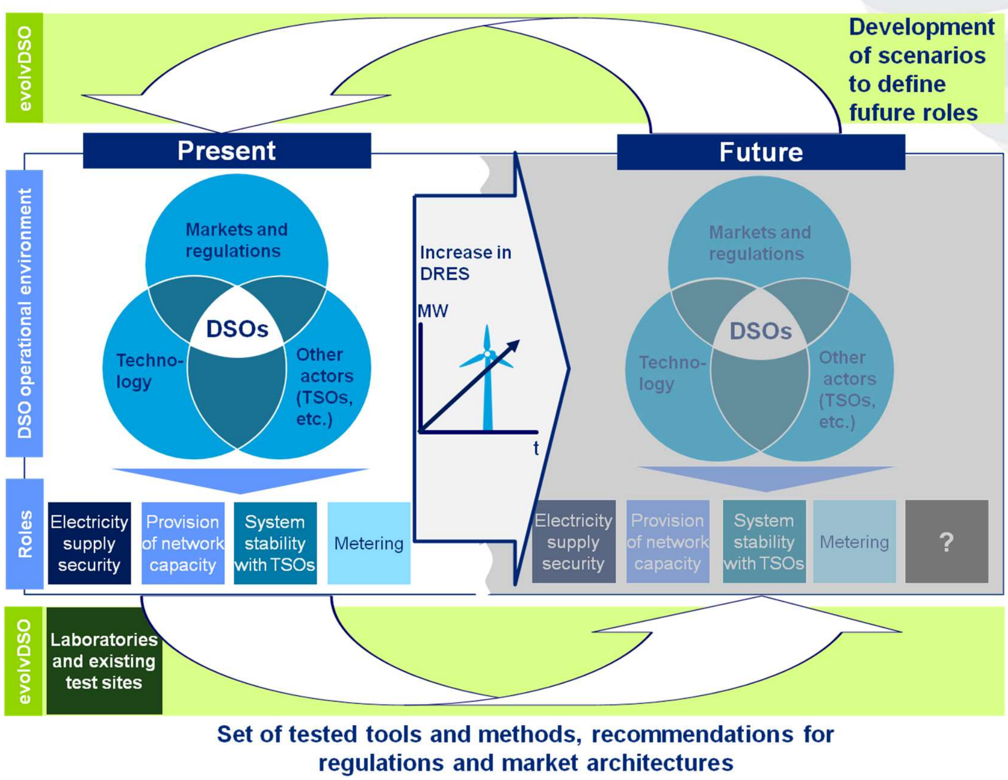

Figure 3 - The evolvDSO approach

The envisaged activities and associated work packages within the evolvDSO project are summarised in Figure 4. The output of the project consists of a final set of tools with impact assessment, recommendations and a roadmap, all three outcomes supported by both simulated and real-world data.

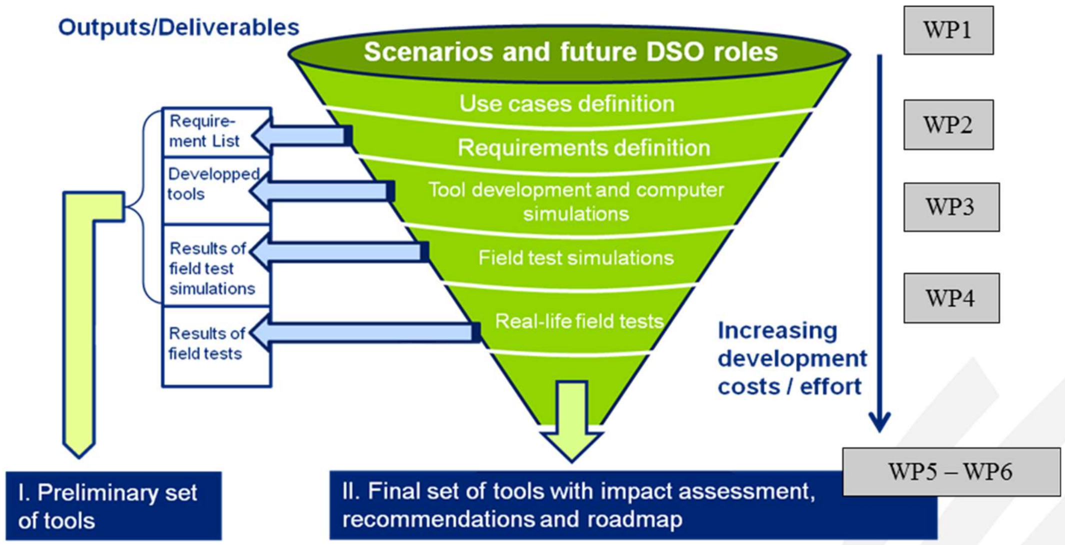

Figure 4 - Activities within the evolvDSO project

1.2 Introduction WP1 on scenarios, regulation and markets

This report was compiled in the framework of the first work package of the evolvDSO project. Within the evolvDSO project, the objectives of WP1 can be summarised as follows:

- Elaboration of a limited but representative set of scenarios describing the evolution of the power system (Task 1.1; Deliverable D1.1);
- Description of the current role of DSOs in the context of the current market and regulatory framework in Europe and current status of DRES integration (Task 1.2; Deliverable D1.2);
- Description of evolving and new roles of DSOs in light of expected scenarios with high penetration of DRES in the context of future market and regulatory frameworks (Task 1.3; Deliverables D1.3, i.e. this report, and D1.4);

1.3 Scope and objectives of this deliverable

The increase of DRES and the capabilities of smart grid technologies will open the door for innovation at the distribution system level. Innovations are driven by three key challenges DSOs face in order to guarantee the security and quality of supply: (1) connecting ever-growing intermittent generation capacity at distribution system level[3], (2) steady growth of peak load (in most European countries)[4], and (3) new and changing usages of electricity caused by the market participation of demand or EVs (EC TF for Smart Grids 2011). All

[3] Across Europe, DSOs operate different voltage levels (evolvDSO 2014b). For instance, in Germany and in Portugal, the distribution grid also includes the HV level of 110 kV and 60 kV, respectively.

[4] This challenge relates to the responsibility of the DSOs of maintaining the stability and well-functioning of the distribution grid.

challenges drive up network operation, maintenance and capacity expansion costs[5] to a level at which it might be more cost-efficient to empower consumers/prosumers to participate in the market by offering flexibility. For example, the daily stress imposed on the distribution grid is growing as, at certain periods and in certain regions, more power is injected compared with what is withdrawn at distribution system level (David Trebolle 2013), leading to more frequent voltage problems. In addition to this operational issue, the current setting of network codes, the EU 20/20/20 target and the energy efficiency directive 2012/27/EU put further pressure on distribution systems operators. This situation may impact DSOs' efforts to comply with the required Quality of Service (QoS) to grid users, and to ensure the safety of people and the protection of assets.

These challenges tend to dramatically impact the way DSOs, plan and operate their networks. More specifically, a higher level of cooperation between system operators (e.g. the provision of ancillary services, monitoring and reporting) and other stakeholders (i.e. DER, consumers, aggregators) must be provided in order to ensure efficient operation of the system as a whole. Cooperation is needed considering the gradual shift from unidirectional to reverse power flows, and associated local constraints, such as voltage quality (e.g. keep the voltage within boundaries), overcurrent and system balance problems.

The objective of the present report is to provide a conceptual description of the potential evolving and new roles and related services foreseen to appear at the distribution system level in the smart grid environment. These roles and related services are analysed in terms of their added value to all stakeholders (DSO, end user/prosumer, aggregator, TSO) and inherent regulatory challenges.

Figure 5 shows, from a general perspective, the path followed for the definition of future roles and related services. As the figure shows, current work from recognized institutions alongside with previous studies carried out by the evolvDSO consortium were used as input for this deliverable. These inputs were analysed in terms of the current responsibilities of DSOs. The analysis served to define the future roles of DSOs (outcome of this deliverable). Therefore, this report sets the framework for the definition of potential future roles and related services. A detailed description of the services and their implementation requirements is out of the scope of this report. However, within the evolvDSO project, business processes implementing some of the most relevant services and the functions supporting these processes will be described in detail in deliverables 2.1 (Business Use Cases) and 2.2 (System Use Cases), respectively. More information concerning the approach used for the definition of the current set of evolving and new roles and related services can be found in Section 1.4.

[5] As stated in (Eurelectric 2013) "Distributed generation does not reduce network costs. In fact, it may even increase them."

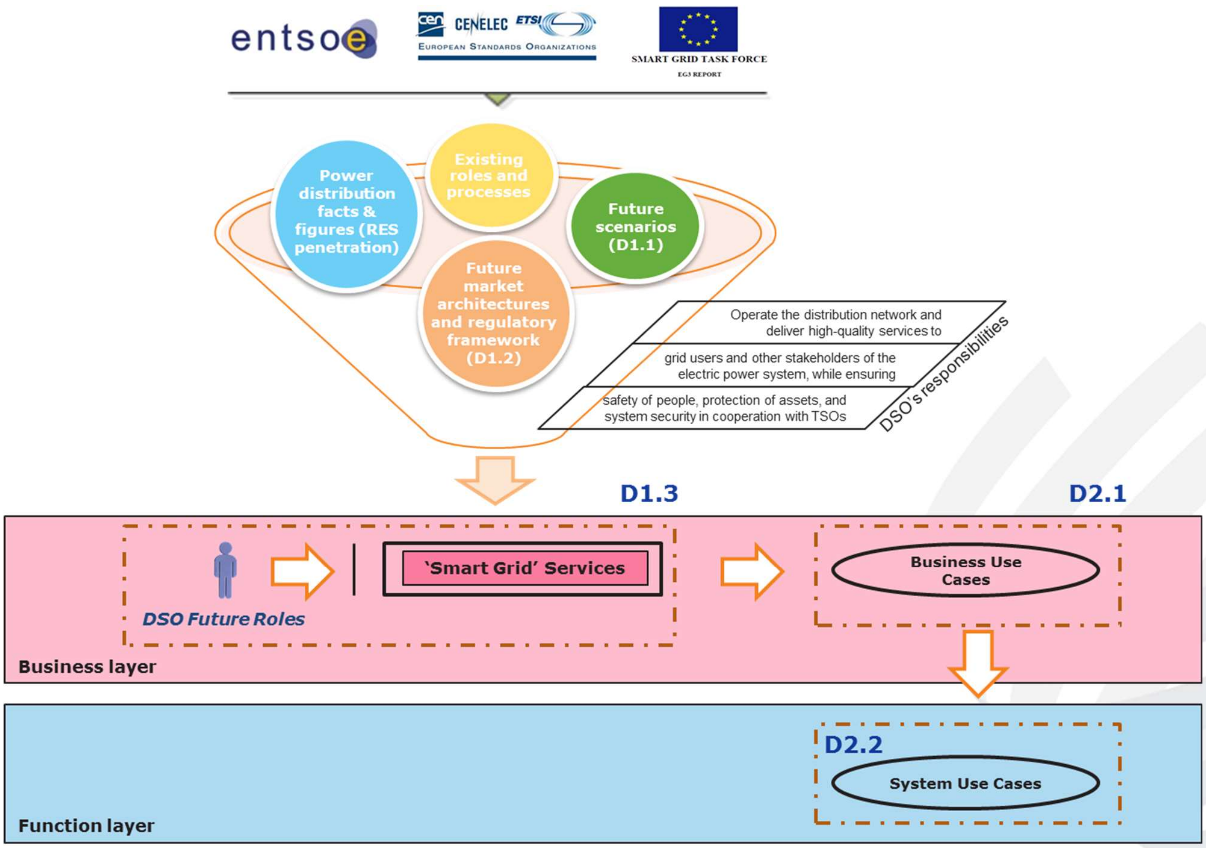

Figure 5 - Scope of D1.3

1.4 Approach

The present report makes use of existing roles and services (input provided by DSOs), the current market design and regulatory framework (evolvDSO 2014b), expected scenarios for (intermittent) distributed generation at distribution system level (evolvDSO 2014a), and available literature, specially the reports from Eurelectric "Active Distribution System Management: A key tool for the smooth integration of distributed generation" and the Smart Grid Task Force – Expert group 3 (SGTF – EG3) "Options on handling Smart Grids Data".

To characterise future roles, this report makes use of the ENTSO-E role model (ENTSO-E 2011). By implementing this model, the report paves the way for the definition of Business and System Use Cases. The role model from ENTSO-E allows for the characterization of the future roles in terms of the business processes found to be relevant for the evolution of the DSO within the power system. The interactions between roles are explained on the basis of the business processes "where the relevant role participates to satisfy a specific transaction. Business processes should be defined to satisfy the requirements of the roles and not of the parties."

This report is the result of interactions between partners and an analysis of the literature related to the DSOs' business models and activities, electricity market design, and European and national electricity regulations. The first interaction was through a survey. The survey provided the first view of the future roles and services expected to appear/be needed at the distribution system level. The partners then held several workshops. During which, they iteratively identified a list of 'roles' to be adopted by DSOs in the future and the associated 'services' they may or should deliver to other parties of the electric power system – such as TSO, grid user, or flexibility operator –, which are evolving or created with smart grid technologies and smart metering systems. More precisely, they strived to highlight the respective goals of these roles and services, which aim at ensuring DSOs responsibilities and ultimately bring value to the electric power system.

The partners then detailed in depth these services and the business processes implementing them. More specifically, first, the beneficiary of the service, i.e. to whom the service is delivered, was identified as well as other role(s) impacted by the service. Then, the provider(s) of the service, i.e. the role(s) allowing the delivery of the service through the collection/elaboration, processing, storage and/or provision of information, were identified.

Each DSO involved in the project then ranked the services, according to their level of priority, the level of priority of the associated tools supporting them, and their know-how of the "distribution network" domain. A short list of services whose business processes were to be described within the project in Business Use Cases was elaborated and shared with the partners. The Business Use Cases will be written by the DSOs with the support of their domain experts (D2.1). On the basis of the Business Use Cases analysis, System Use Cases will be identified and described in detail (D2.2). Business and System Use Cases will then lead to the development of innovative tools (objective of WP3). Apart from the key services identified, the full list of services will be publicly available on the project website.

Based on the outcome of these deliverables (i.e. D1.3, D2.1 and D2.2), an assessment of the regulatory framework is envisioned for D1.4. This assessment will provide advice to regulatory authorities so that roles and associated services could become a reality in the future. These recommendations will take into account the peculiarities of each system, and the current regulatory vision as well as its expected evolution.

The Use Case methodology is a proven method that particularly fits within the smart grid context and which is widely promoted in Europe and abroad by Standards Development Organisations (SDOs). The European Commission, SDOs, and business actors in the smart grid community agreed on the fact that the methodology is the best candidate for the description of a complex system like the smart grid. This methodology is designed to describe requirements of a given system (e.g. whole electric power system) or domain (e.g. distribution grid management domain), according to different layers, and ultimately facilitate interoperability. ENTSO-E, for example, uses it intensively to describe market business processes and network codes requirements.

The specific « objects » used by this methodology are the role, the service and the use case. The role is an external intended behaviour of a business party which cannot be shared. The service is a business transaction between two or several roles interacting to achieve a given goal, which is implemented by a business process. The Use Case is a specification of a set of actions performed by a system which yields an observable result that is of value for one or more actors or stakeholders of the system.

There are two types of Use Cases: Business Use Cases and System Use Cases. The former describes business processes and the interactions between roles. The latter describes the interactions at the system level (IT systems and operators). Table 1 shows what each type of Use Case describes and their corresponding actors.

	Description	Actors
Business Use Cases	A business process implementing a service	Roles, organisations or organisational entities
System Use Cases	A function or sub-function supporting one or several business processes	Information systems and persons (Operators of an information system)

Table 1 - Business and System Use Cases

Figure 6 shows the fitting of the Use Case methodology with the five layers of the Smart Grid Architecture Model (SGAM).

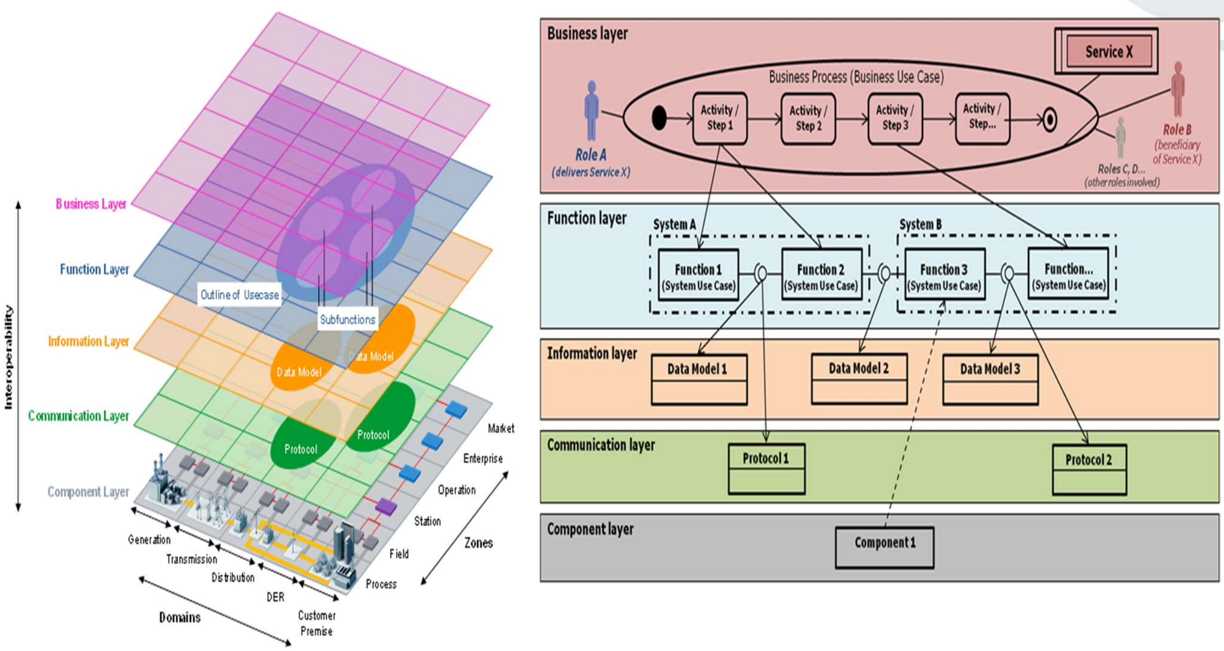

Figure 6 – SGAM and the Use Case methodology

The evolvDSO project will use this methodology to reach a homogeneous description of roles and services that is applicable at European distribution system level in a smart grid context.

1.5 Report structure

The document comprises the following chapters:

- Chapter 1 describes the overall framework of the evolvDSO project. It also explains the scope, objectives and approach used in this report.
- Chapter 2 introduces the definitions and actors.
- Chapter 3 outlines the challenges DSOs are facing and the approach they can take to bridge these challenges.
- Chapter 4 presents the evolving and new roles for the evolution of the DSO in a smart grid environment.
- Chapter 5 provides the main conclusions of the study.

2 Definitions and actors

2.1 Definitions

This section presents the definitions of the concepts used across the report. These definitions are based on (ENTSO-E 2011; Eurelectric 2014b; CEER 2013a) and serve as a starting point for the analysis of future roles and services.

2.1.1 Actor

An *actor* is anything in the system that can communicate. It may be a person (e.g. a customer), a device (e.g. a smart meter), software (e.g. SCADA), an organization (e.g. a DSO), or anything else acting on its own and having goals and responsibilities (IEC/PAS 62559 2008). The term shall not be mistaken with the concept of role defined below. An actor can adopt several roles, but a given role can only be taken by one actor.

2.1.2 Role

A *role* is an intended behaviour of a business party (actor) which cannot be shared. A business party when carrying out a business transaction takes on a certain role. A role defines how one business party interacts with other business parties while carrying out a given business transaction.

2.1.3 Service

A *service* is a business transaction between two or several roles interacting to achieve a given goal. A service has a provider, one or several beneficiaries, and may also impact other roles which are not direct beneficiaries. It is implemented by a business process. The concept is widely used within the power supply industry. The Council of European Energy Regulators (CEER) has elaborated a classification and a description of the current services delivered by DSOs in Europe within the public consultation paper on the quality of electricity and gas distribution services (CEER 2013a). It has identified two types of requirements for service standards:

- *"Guaranteed Standards* (GSs) refer to service quality levels which must be met in each individual case, so it will apply to 100% of the cases (the company's performance towards the customer). Minimum quality levels are oriented to the protection of customers, and can be combined with compensations in case of non-fulfilment."
- *"Overall Standards* (OSs) refer to service quality levels that must be met (for a given service), taking into account the whole activity of the company in a period of time. The Overall Standards are then, by their nature, not directly customer oriented since they do not apply to all customers but a percentage of the customers over a time."

Service standards are however implemented differently in each country, through:

- Regulation of the distribution activity and incentive regulation,
- DSO licence conditions or their absence,
- General terms and conditions (contracts).

The failure of the DSO to provide the level of service required by the standards entitles the customer to receive a compensation payment or may lead to the use of incentive regulation (reward or penalty) impacting DSOs' revenues.

2.1.4 Domain

A *domain* represents a delimited area that is uniquely identified for a specific purpose and where energy consumption, production or trade may be determined (ENTSO-E 2011). For the purpose of this report, five domains are used to classify the different services:

- Network planning and connection,
- Operational planning,
- Operation and maintenance,
- Market, and
- DSO-TSO cooperation.

These five domains provide an overall view of the links between the DSO activities, the future roles and the associated services DSOs may be able to perform in a smart grid environment.

2.1.5 Flexibility

Flexibility is the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the power system. Flexibility may be characterised by the amount of power modulation, the duration, the rate of change, the response time, the location, etc. (Eurelectric 2014b). Sources of flexibility may be found at the supply and demand sides across the power system (i.e. large scale sources to micro sources). From a market perspective, flexibility can be used for portfolio optimisation, balancing, and constraints management in transmission and distribution networks. This concept is highly related to Demand Side Response (DSR), Demand Side Management (DSM), and storage.

2.1.6 Demand Side Response

Demand Side Response (DSR) encompasses the changes the end consumer is willing to make to his electricity consumption pattern. The willingness to make these changes is a direct response to market signals or activated consumer's bids (submitted on their own (e.g. SMEs) or through an aggregator). These changes are voluntary adaptations of the end consumer's comfort and as such they must be remunerated. This behaviour is expected to lead towards a more efficient system in case remuneration procedures are well designed so that flexibilities are priced properly. This is of high importance when trying to avoid the creation of an opposite effect in which clients increase their consumption in anticipation of providing downward flexibility a short time later[6]. In order to establish a level playing field for DSR, a methodology for the definition of the baseline and measurement procedures must be defined (Smart Energy Demand Coalition 2013). This is not an easy task since one approach might not be suitable for a specific market or product (no "one size fits all" approach). In light of this, the Smart Energy Demand Coalition (SEDC) suggests to select the baseline methodology based on the following principles: balance accuracy, simplicity and integrity. In the same vein, the measurement procedures should account for the specific demand response approach implemented so that the demand response event is correctly registered (e.g. use of separate readings in the case of a prosumer).

2.2 Overview of actors in the electricity value chain

The following section describes main actors of the power system involved in the smart grid deployment, which are also taken into account in this deliverable. The list is not intended to be mutually exclusive nor collectively exhaustive. Many of the definitions correspond to the terms or definitions used by ENTSO-E.

2.2.1 Grid operators

Two grid operators are distinguished: the Distribution System Operator (DSO) and the Transmission System Operator (TSO).

The DSO, as defined by 2009/72/EC, is a natural or legal person responsible for operating, maintaining, and – if necessary – developing the distribution system in a given area, and – where applicable – its interconnections with other systems. The DSO as a regulated entity is subject to unbundling requirements. In the long term, the DSO ensures the ability of the distribution system to meet future demand for the distribution of electricity or gas. The DSO is responsible for the connection of grid users at the distribution level and for the connection of the DSOs within the TSO area of responsibility (control area).

The TSO, as defined by 2009/72/EC, is a natural or legal person responsible for operating, maintaining, and – if necessary – developing the transmission system in a given area, and – where applicable, its interconnections with other systems. The TSO as a regulated entity is subject to unbundling requirements. It is the responsibility of the TSO to safeguard the normal operation of the electric power system. In the long term, the TSO ensures the ability of the system to meet future demand for the transmission of electricity. Moreover, the TSO is responsible for connecting grid users at the transmission level and for connecting all DSOs within the TSO control area.

[6] Taken from the European Commission Communication, 2013, *"Delivering the internal electricity market and making the most of public intervention."*

2.2.2 Grid users

Two types of grid users can be identified: consumers and producers.

As defined by 2009/72/EC, a producer is a natural or legal person generating electricity, and contributing actively to voltage and reactive power control. A producer may be required to provide relevant data (e.g. information on outages, forecast, actual production levels) to the energy marketplace.[7]

A consumer is defined as a wholesale or final customer of electricity. The consumer is enabled to take an active part in the smart grid system, in which case it is referred to as a prosumer.

2.2.3 Flexibility operators

A *flexibility operator* (e.g. aggregator) is an intermediary service facilitator that, given the technologies available in its portfolio, combines different types of flexibility and makes them available to the market. Flexibility operators are expected to gain importance in the future by assisting DSOs in activating flexibilities in the most capillary parts of their network.

2.2.4 Balance Responsible Parties

A Balance Responsible Party (BRP)[8] is a party having a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible of the market balance area entitling the party to operate in the market. Only a BRP is allowed to nominate energy on a wholesale level (ENTSO-E 2011)

2.2.5 Service providers

Considering service providers, the document focuses on suppliers and Energy Service Companies (ESCOs).

A supplier, as defined by 2009/73/EC, is any natural or legal person who carries out the function of providing electricity to at least one end consumer. A supplier has a contractual agreement with the grid operator and with end customers relating to the supply of electricity. A supplier must be assigned with the metering points of the end consumer it supplies. In most European countries, end consumers can chose their supplier.

An ESCO is a natural or legal person that delivers energy services and/or other energy efficiency improvement measures in a user's facility or premises, and accepts some degree of financial risk in so doing. The payment for the services delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agreed performance criteria.

---

[7] This requirement may vary from country to country and, in most cases, depends on the size of the generation capacity.

[8] Equivalent to “Program responsible party” in the Netherlands, “Balance group manager” in Germany or “Market agent” in Spain (ENTSO-E 2011)

2.2.6 Regulatory authorities

A regulatory authority (also regulatory body or regulator) is a public authority responsible for exercising autonomous authority over electricity markets and the associated synchronous electricity grids. A more detailed description of regulatory authorities is found in Article 35(1) of Directive 2009/72/EC.

2.2.7 Markets

Several market elements can be identified: wholesale energy market, capacity remuneration mechanisms, balancing market (and to a broader extent the ancillary services markets).

The wholesale energy market refers to any market within the European Union on which wholesale energy products are traded.

Capacity remuneration mechanisms introduce a stimulus (i.e. remuneration) to investors which aims to ensure that a sufficient amount of capacity will be available in the future to meet demand. This remuneration is meant for the provision of an adequate level and mix of generation capacity in a system. Adequate capacity ensures security of supply in the long-term in a competitive manner. These mechanisms allow for the remuneration of both existing and newly introduced capacity (including Demand Response).

Currently, capacity remuneration mechanisms are only implemented in peripheral countries like Spain, Portugal, Sweden or Finland. However, capacity remuneration mechanisms have become subject of discussion and implementation in more member states, e.g. France, UK, and Belgium.

The balancing market refers to the entirety of institutional, commercial and operational arrangements that establish market-based management of the function of balancing/settlement within the framework of the European Network Codes. Efficient balancing markets ensure the security of supply at the least cost and can deliver environmental benefits by reducing the need for back-up generation.

An important aspect of balancing is the approach to procuring ancillary services. Ancillary services are a range of functions which TSOs contract so that they can guarantee system security. These include black start capability (the ability to restart a grid following a black-out); frequency response (to maintain system frequency with automatic and very fast responses); fast reserve (which can provide additional energy when needed); the provision of reactive power and various other services. The ancillary services market gives access to a broad range of services from a wide range of providers, including generators but also demand response (which involves customers changing their operating patterns to aid system balancing).

3 DSOs in an evolving environment

The paragraphs below provide an overall view of the current context of the distribution grid. The understanding of this context is of paramount importance to understand the challenges DSOs are facing. The operators of the distribution system are being challenged by current trends. Today, DSOs will have to adapt their way of managing the distribution network in order to ensure their continuity in the business by implementing an Active Distribution System Management approach.

3.1 Current context of the distribution system network

DSOs have historically designed and operated their network according to a "networks follow (predicted) demand" paradigm, by delivering energy flows in one direction from the primary substations to the end users. In the past, DSOs prevented local constraints (e.g. function of protection systems, overcurrent, voltage limits) by planning network investments and adjusting the configuration of the grid, in order to accommodate energy flows and meet peak loads. This method is known as the "fit and forget" approach as potential operational problems are solved in the planning phase.

Currently, several trends are being observed. The Distributed Energy Resources (DERs) – especially the ones based on renewable sources such as PV, wind or biomass/-gas – are constantly increasing their capacity penetration at distribution system level. In some regions, solar and wind power represent more than half of the total production capacity at the distribution network. Figure 7 shows the maximum level of voltage DSOs are responsible for, the installed capacity of renewable energy sources compared to total capacity (left) and the ratio this capacity has in respect to peak load (right) in the distribution network[9].

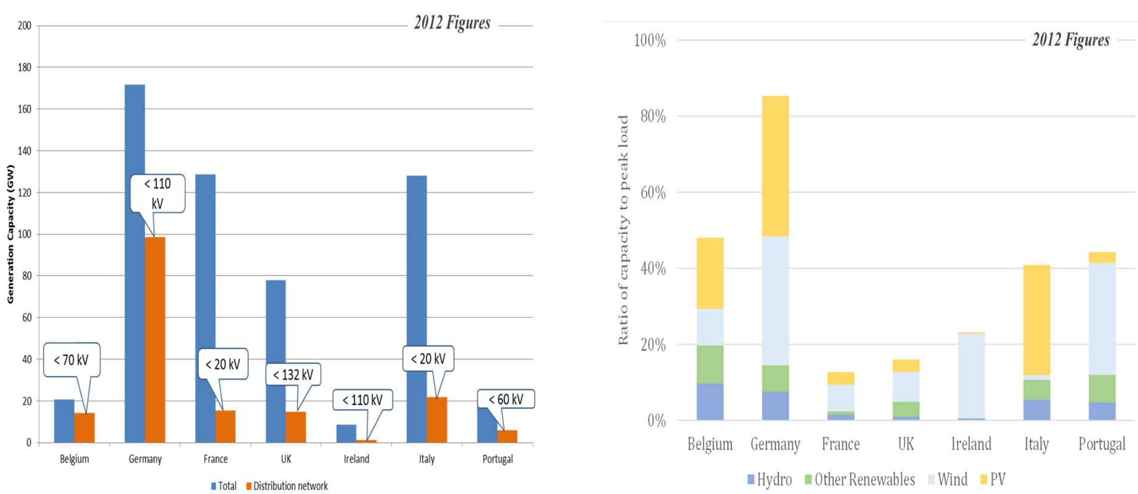

Figure 7 - Renewable Energy Sources in the distribution network

[9] For details refer to the D1.1 report of evolvDSO.

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. However, in the case smart technologies cause a shift in the cost structure of DSOs as CAPEX-heavy technologies are exchanged for more OPEX-heavy ones a suitable regulatory framework would be required.

The consumer (end-user) is at the heart of the changing environment. Consumers from different sizes and for different reasons are embracing smart grid technologies. Currently, it is seen that Small and Medium Enterprises (SMEs) and also home owners are starting to explore energy management systems, which are especially attractive for large consumer groups. One of the reasons for their adoption comes from the environmental awareness these consumers have in respect to the current and future challenges observed in the power system. In addition, consumers are looking for new ways to reduce their energy costs. They want to use energy more wisely. In order to do so, they are willing to learn more about their flexibility options. Consumers that understand their consumption pattern and make informed decisions about their targeted comfort level are the driving force of flexibility provision from the consumer side. As a result, Demand Side Management (DSM) may play a key role on facilitating consumer side flexibility to the electric power system.

The increased penetration of RES – which are mostly connected to the distribution network –, the rise of peak demand, and the development of new usages such as Demand Side Response programmes or Electric Vehicles, contribute to dramatically transform the power grid.

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). To illustrate this situation, 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. If the "network follows demand" approach does not require sophisticated control and supervision systems, it implies substantial network investments to integrate high shares of variable generation/load capacities and absorb peak demand, which constitutes one of the major drivers for network costs. 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.

Complementary to the power flows, constraints will occur more frequently, and are likely to be more critical and more complex to manage at both local and system levels (Eurelectric 2013). More in particular, the occurrence, duration, and depth of faults, variations in voltage, and network perturbations such as flickers will continuously increase. Constraints (e.g. bottlenecks), which may lead to generation feed-in or supply interruptions, will also appear more frequently. The growing number and diversity of production and consumption installations connected to the distribution grid will heighten the variability of power flows.

Ensuring grid connection and access, and restoring power supply after a fault on the network will therefore become more complex and require more precaution and time.

Europe's 20-20-20 objective in conjunction with the 2012/27/EU directive for energy efficiency will push further the integration of renewables at distribution system level. In light of this, end consumers will have more possibilities. The network will be in need of new sources of flexibilities and new ways to manage these sources.

3.2 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. These responsibilities are shared by all DSOs and do not vary according to regional and national regulations or market models – only the way they exercise those may differ from one country to another and one DSO to another.

As stated in (evolvDSO 2014b), to cope with these responsibilities, some DSOs are:

- Implementing models or 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 if a roll-out is called by national politics

The current context and the limitation of the distribution network design ("network follows demand" approach) may hinder the fulfilment of DSOs' responsibilities in the near future. Therefore, in the smart grid environment, this approach is not suitable for adapting to the current trends.

3.3 Challenges for European DSOs

The changing environment poses several challenges for DSOs in the following domains:

- QoS and system security
- Investments and innovation
- Increased complexity of the distribution system management
- Promote/facilitate the participation on electricity markets

To provide an adequate QoS and system security that complies with regulatory mandates, DSOs will need to be able to measure and estimate the system state with a higher accuracy than today. A better estimation of the system requires relevant data and know-how.

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.

The increasing complexity of managing the distribution system is due to:

- The **integration of Renewable Energy Sources** onto the distribution network and the fast development of decentralised production capacities, which are intermittent and non-predictable by nature;
- A **continuous growth of the peak load** (in most European countries);
- **New and changing uses of electricity**, with the development of Demand Response, the growth of Electric Vehicles, the implementation of Energy Demand Management policies and customer empowerment initiatives.

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. An optimal use of the different types of flexibilities would require modifications in the current frameworks (market and regulation). European and national regulatory authorities will be of key importance in these transformations and will also be impacted by them. This is because regulatory bodies have the overall goal of promoting a sustainable, secure, and competitive energy supply. One of the major issues regulators will have to solve refers to data ownership, privacy and security. This issue is of paramount importance to determine the roles and services for the future and the reach of smart meters' roll-out and smart meters' data management – if such a roll-out is undertaken.

The challenges previously stated have a strong impact on the capacity of DSOs to carry out their responsibilities. These challenges impact the way DSOs design, operate, and maintain their networks. The integration of more intermittent and variable generation capacities, combined with increased peak demand as well as other key factors, tend to intensify the need for network reinforcements and add complexity to the supervision and control of the distribution grid. These consequences may ultimately undermine the DSOs' ability to guarantee reliability of supply and quality of service to end-users. To sum up, current challenges tend to significantly modify the way DSOs operate. In adapting to these challenges, DSOs will have to become pro-active, which in some cases may require an in depth transformation.

3.4 Objectives of Active Distribution System Management

An Active Distribution System Operator must be able to maximise and provide services for the efficient and sustainable integration of the ever-increasing distributed energy resources (e.g. DRES, load, Storage, EV). These services aim at supporting the DSO in the fulfilment of his core duties, specially QoS and system security. In addition, DSOs should be able to share the profit and increase the value for all stakeholders by exploring the opportunities brought by the smart grid technologies.

By making use of the technological degrees of freedom and its (strategic) position in the smart grid environment and power system evolution, DSOs can provide regulated services that aim at maintaining system security. DSOs that implement an Active Distribution System Management approach would be in a good position to empower customers, electricity markets, and sustainable public policies by means of intelligent data processing and handling.

DSOs need to find new solutions to continue ensuring quality and security of supply at an affordable cost and in a non-discriminatory way, as traditional means will no longer be technically sufficient or economically viable. In addition to necessary investments on the network, the transformations previously stated urge the need for the development of an **Active Distribution System Management approach**. This approach, opposed to the purely passive one previously described or a 'reactive' one consisting of managing problems only in the operational phase, would allow for interaction between the network different timeframes (Eurelectric 2013):

- **Planning and connection**, with a range of network planning and access options enabling DSOs to optimise their investments,
- **Operational planning**, with technical tools that would allow DSOs to act in a flexible way on the fast changing system,
- **Real-time operations**, with the optimisation of demand and generation management and improved handling of emergencies and faults,
- **Evaluation and ex post control**, to facilitate electricity markets via data management and provision as well as provide new services to third party actors, but also to improve network planning and operation processes with the processed data.

The transition from passive to active distribution networks relies on the deployment of smart grid technologies and improved metering systems (e.g. by smart meters)[10], as well as on the modification of existing roles and business processes of the DSOs. Such evolutions will also tend to modify the relations between DSOs and the other actors of the electric power system, such as grid users, regulators, TSOs, suppliers, BRPs, and flexibility operators.

The use of this new approach would reduce or limit investment needs and increase security and quality of supply, and eventually bring value to all customers.

3.5 Impact of the Active Distribution Management approach

The transition towards an active distribution management requires that actors profit from the options brought by technology (technological degrees of freedom), the modification (creation) of current (new) responsibilities and the definition of an adequate framework (market and regulation).

[10] Dedicated metering points can also guarantee a sufficient observability of the grid.

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.

3.5.1 Network planning and operation processes

The ongoing development of smart grid technologies and the (at least) partial roll-out of smart metering systems[11] will allow DSOs to improve their understanding of and control over their network. This will enable them to make better use of the network in the end. It will thus contribute to ensuring the sustainability of the system, by managing/facilitating the growing peak load[12], the integration of more RES into the grid, and new usages of electricity among others. More especially, network planning and operation processes will significantly evolve. This evolution, supported by ICT and the relevant data that DSOs will collect, process, and store, will allow a higher controllability of the system.

The processing and management of the data obtained via network supervision and control systems, combined with smart metering systems, will allow DSOs to improve the development of the grid while limiting network costs. For instance, they will be able to analyse and modify the balance of single-phase meters, for meters already connected to the grid as well as for future connections. Time-of-Use tariffs may also be implemented and optimised to allow for a more constant grid usage. This could be achieved, for instance, by providing signals that give incentives for consumption at times of high RES-generation (in-feed) or by sending signals that discourage a high simultaneity of loads in the grid (e.g. EV charging).

Advanced analytics and extensive real-time supervision and control systems will enable DSOs personnel or their automated information systems to anticipate operational problems, and take faster and more relevant decisions. More accurate generation and load forecasts at both local and national levels, combined with operational planning tools, will help anticipate constraints with a high degree of certainty. With ICTs, DSOs will have a better knowledge of the grid topology and be able to detect and locate faults on the network with more accuracy and reactivity.

[11] Country dependent
[12] In countries where this is a challenge for DSOs

In addition to that, smart grid technologies will allow DSOs to optimise their maintenance processes, by deciding and modifying asset renewal priorities, maintenance programmes and operations based on the component's usage. Instead of only relying on pre-defined maintenance cycles, DSOs will dynamically update asset management programmes via the collection and analysis of network data. They may also decide to carry out urgent maintenance operations based on real-time data analysis. However, the increase of network components (e.g. ICT infrastructure) may cause additional maintenance efforts (costs and coordination) for the entity in charge of these components.

One of the management procedures that will change will be the constraints management (Eurelectric 2014b). As highlighted in (evolvDSO 2014b) "currently, most DSOs do not contract services for constraints resolution". In the smart grid environment, constraints management at distribution system level will be more relevant. For the resolution of potential and realised constraints (at all timeframes) DSOs will be in need of accurate forecasts, schedules of production, consumption units (incl. provisional schedules by aggregators), and of planned and non-planned outages. This information will help on the simulation and network calculations, which will lead to the detection of constraints and the selection of proper/adequate solutions (actions on production and consumption). Some of these solutions may require some adjustments to the quantities traded in the markets, thus affecting TSOs and aggregators. Therefore, in the evolving environment the DSO will be in need to closely interact with markets. If unforeseen constraints are detected in real time, the market may not provide the support needed to solve these constraints. In that case the DSO should be able to implement actions (e.g. activate flexibilities bought in advance to solve unforeseen constraints, exert interruptibility contracts) that help him forgo the constraint. After the detection and before the implementation of a solution the DSO, by means of accurate data, will reconstitute the flows and provide a new analysis to the TSO, aggregators and suppliers.

However, the opportunities brought by smart grid functions and smart metering data management will not solve all of the issues facing DSOs.

3.5.2 Flexibility Contracting for Network Constraints

In order to efficiently prevent/solve local specific operational problems and therefore fulfil their core responsibilities, "DSOs should be able to obtain flexibility from DG resources and consumers to solve grid constraints" (Mallet et al. 2014).

Flexibility can be defined as "modification of generation injection and/or consumption patterns, on an individual or aggregated level, in reaction to an external signal (price signal/network tariff/activation) in order to provide a service within the energy system. The parameters used to characterise flexibility include: the amount of power modulation, the duration, the rate of change, the response time, the location etc." (Eurelectric 2013).

These flexibilities of various types should be obtained and activated to solve specific grid constraints at different timeframes:

- Network development and planning, with a call for tender to contract flexibilities which could be activated near real-time operations to prevent constraints while limiting or deferring network reinforcement;
- Grid connection & access for decentralised producers and consumers, with non-firm access contracts allowing a temporary limitation of the feed-in or consumption power;
- Operational planning and real-time operations, with flexibility products to be purchased by DSOs on a day-ahead and intraday distribution flexibility market.

On the latest point, DSOs, by being able to operate a Distribution Constraints Market, could complement existing TSO-led balancing markets (Eurelectric 2014b). In this context, the cooperation between TSO and DSO would allow for the combined use of flexibilities. This collaboration can optimise the contracting and usage of flexibilities at both levels, transmission and distribution. This market, operated in strong coordination with the TSO and other markets, would allow DSOs to purchase flexibility offers per MV/LV transformer node. Flexibilities purchased through this market will be used to solve specific network constraints at distribution system level.

Via the analysis of the collected metered and network data, DSOs could determine, depending on the timeframe and the nature of the constraints[13], what solution is the most cost-efficient to ensure the stability of the network and quality of supply (network reinforcement, flexibility call for tender, call to the Distribution Constraints Market, etc.).

Nonetheless, all of these flexibilities should meet strict requirements and have a high level of reliability, in order to be considered as a secure alternative to network reinforcements or to allow network investment deferral.

3.5.3 Neutral Market Facilitator

DSOs are key contributors to the functioning of the electricity markets. They can have an influence in the level of competition and therefore support the efficient operation of Europe's electricity markets. However, according to (CEER 2013b) "there is limited progress on DSO unbundling in countries which have yet to fully transpose the 3rdPackage." This situation could hinder the adoption of a Neutral Market Facilitator role and as a consequence it could interfere with the realization of an efficient electricity market. Inasmuch it is of major importance to solve transposition issues in member states where the directive has yet to be fully implemented.

Currently, regulatory authorities are striving for the complete transposition of the unbundling requirements described in the Directive 2009/72/EC. Countries where regulators have implemented the full transposition of this directive would have independent DSOs with non-discriminatory and transparent objectives and subject to full unbundling requirements. These DSOs would then be legitimate entities to deliver services based on network, contractual and

[13] In addition to the interest rate applied to network investments

metered data in order to ensure a 'level playing field' for market participants. More precisely, DSOs should be actively involved in the three key timeframes of the market (Salon et al. 2013):

- Pre-qualification,
- Technical validation/activation of bids,
- Settlement.

DSOs that are actively involved in these key timeframes can support stakeholders in their operations. For instance, DSOs can support TSOs or market responsible parties in validating the participation of flexibilities connected at the distribution system level in the market and also flexibilities activated by suppliers on the distribution network for internal balancing.

In order to fully contribute to a technical and economic optimisation for all of the actors of the system, DSOs would also need to manage the impact on the distribution grid of the activation of flexibilities proposed or activated on neutral markets. The simultaneous activation of MV and LV flexibilities may in most cases have no impact for the transmission network operation. However, it may generate constraints (function of the protection systems, overcurrent, voltage limits) on the distribution network and force DSOs to take emergency actions in order to prevent faults. This scenario would have no consequences for some actors (TSO, flexibility operators, grid users) but would not be economically optimal from a system perspective. DSOs have a legitimate claim to propose adjustments regarding the conditions of activation of MV or LV flexibilities[14], as operators of the network to which the associated sites are connected. These adjustments could take different forms according to the nature of the constraint. In order to ensure the security of the grid, DSOs could for instance request flexibility operators to desynchronise the activation of flexibilities by a few minutes, to limit the flexibilities' power, to forbid their activation. In the case activation is forbidden, then an assessment of the consequences should be performed in order to determine if and how potential compensation should be provided.

They can also enhance their participation in the settlement process by reconstituting the power flows and verifying that the energy measured corresponds to the energy traded. DSOs would ensure transparency by publishing relevant data (e.g. effective consumption data) on a platform with an easy access to authorised customers and suppliers, and transmitting to the TSO relevant information to perform the imbalance settlement process.

3.5.4 Cooperation between TSOs and DSOs

The increased penetration of generation capacities, mostly connected to the distribution network, as well as the development of new usages of electricity will tend to intensify the need for cooperation between system operators at distribution and transmission level. If TSOs were traditionally responsible for the overall system stability and DSOs for operating their respective network, they will need to strengthen their coordination at different timeframes in order to ensure the security of the system. A stronger collaboration between

[14] In countries where the distribution network includes higher voltage levels (see footnote 3) the DSO may also propose adjustments regarding the conditions of activation of flexibilities connected to these voltage levels.

system operators will then allow for an optimal constraints management that takes into account local and system-wide needs. This enhanced coordination will in turn facilitate agreements (e.g. on reactive power exchange) that aim to provide a cost-efficient way to manage the electric power system at its different levels.

More precisely, exchange of structural and operational information between system operators and other actors (e.g. end-customers, flexibility operators) will be necessary. DSOs will also have to manage TSO requests at different timeframes, including network development, operational planning, and real-time operations, by exchanging structural and forecast data according to relevant European network codes. They will also contribute to system security by delivering regulated services to TSOs according to a cascading communication process, including services in case of emergency situations when market-based solutions cannot be used or turn out to be insufficient. Advanced ancillary services (e.g. coordinated PQ management) are examples of new services that DSOs could deliver to TSOs. As previously stated, DSOs will, as neutral market facilitators, support TSOs activities by participating in the pre-qualification of flexibilities offered by flexibility providers.

3.5.5 Data Management Services

Smart grid technologies and smart metering systems will allow DSOs to collect and process higher volumes of data, with more accuracy and more reactivity:

- Effective consumption and production data,
- Load and generation forecasts,
- Data related to quality of supply (power outages, voltage violations, etc.),
- Network data (e.g. network state, asset use).

DSOs will therefore be able to respond to the demands of external actors. For instance, they would be able to transmit detailed incentive regulation data to conceding authorities and/or to the regional or national regulator. They could also contribute to the transition towards carbon-free economy, by providing local authorities with various data which would support sustainable development and energy demand management public policies or measures, or urban planning and Smart City demands. DSOs may also share relevant data (e.g. consumption and/or production data of clients) with eligible parties. The process for sharing this information will have to comply with security and privacy regulations. These latter issues are of paramount importance for the construction of public platforms (open data) for the exchange of these types of information.

4 Evolving and future roles and related services

According to Article 25 of the Electricity Directive, DSOs are responsible for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity, for operating, maintaining and developing a secure, reliable and efficient electricity distribution system. When planning the network development, energy efficiency and demand side management measures or distributed energy resources that might supplant the need to upgrade or replace capacity shall be considered.

Regarding the scope of activities, all European DSOs have some responsibilities in common, whereas other tasks are part of the DSO business model in certain countries but not in others. Obviously, all DSOs operate the grid, even though it has to be recognised that concrete grid operation activities and complexities will also depend on operated voltage levels. In most member states, the meter is owned and managed by the distribution network operator, albeit this ‘traditional distribution network operator task’ has been opened for competition in a limited number of countries. Moreover, DSOs might have certain public service obligations such as supplier of last resort responsible for public lighting, etc.

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. In addition, new meter and appliance technologies provide consumers with the possibility to react to local and upstream generation patterns and prices[15]. These changes are driven by the newly emerging broad range of distributed energy resources, be it distributed generation, local storage, electric vehicles or demand response, and pose challenges for DSOs and their regulation alike (Ignacio Pérez-Arriaga et al. 2013). Challenges, foremost related to DG technologies, are already established facts and 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. For this to happen, evolving and new future roles and services have to be defined.

4.1 Overview

For the definition of the evolving and new roles this report made use of relevant available literature. The report used two main inputs. The first from Eurelectric “Active Distribution System Management: A key tool for the smooth integration of distributed generation”. The second from Smart Grid Task Force – Expert group 3 (SGTF – EG3) “Options on handling Smart Grids Data”.

The set of evolving and new future roles, described within this report, fulfil activities that are of paramount importance for the implementation of an Active Distribution System Management approach. Figure 8 shows these roles and highlights the evolving and new activities they are responsible for.

[15] Assuming these signals are supplied to the consumer.

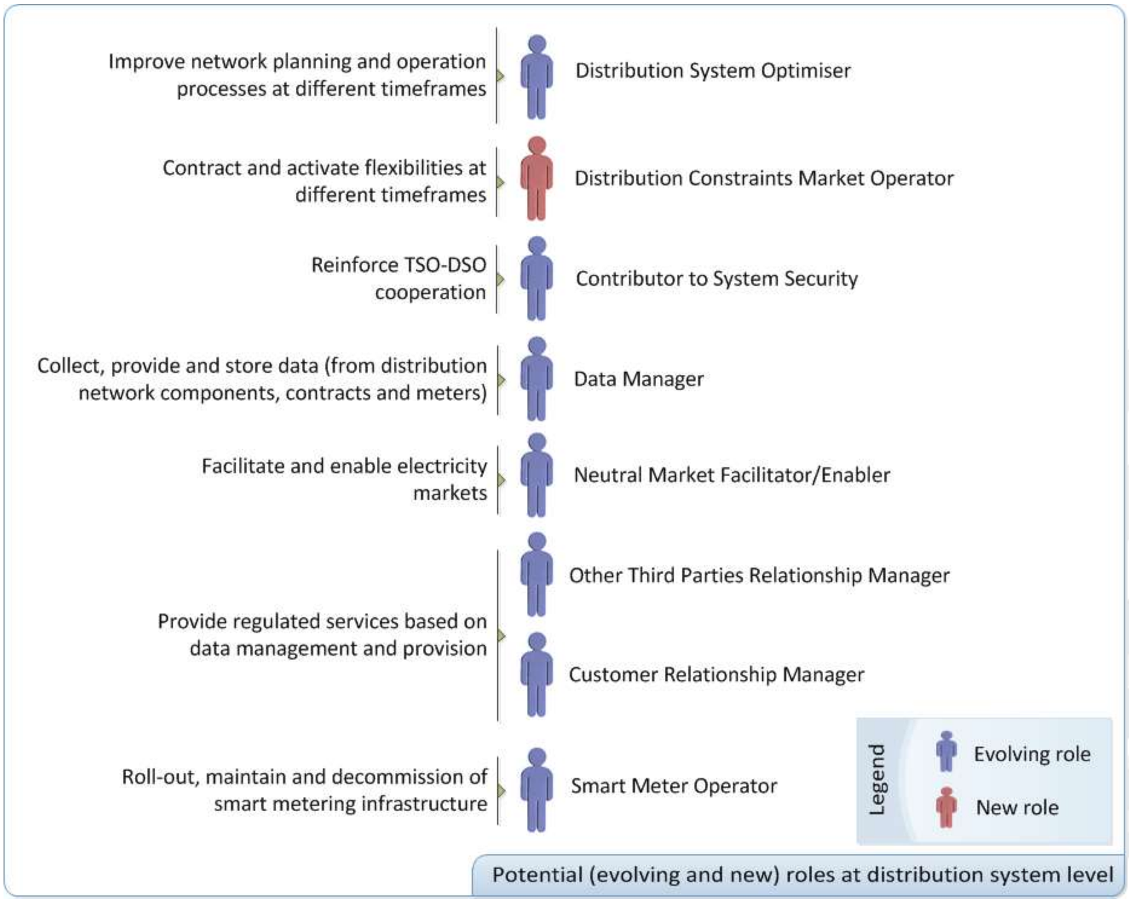

Figure 8 - Potential (evolving and new) roles at distribution system level and their activities

Out of the eight roles (Figure 8), only one is currently not defined in today's context. The Distribution Constraints Market Operator (Section 4.6) is a new role that performs activities that resemble the ones carried out by the TSO such as contracting and activating flexibilities. Flexibility operators could offer these flexibilities -provided that they are directly connected to the distribution network- to the role so that they can be activated to relieve specific distribution network constraints. Flexibilities that are not offered to the Distribution Constraints Market Operator may be used for other purposes.

Each role, in order to fulfil its responsibilities, provides services. The provision of these services serves to:

- Support the implementation of:
  - an Active Distribution System Management approach
  - a Market Facilitator approach,
- Contribute to system security

To support the implementation of an Active Distribution System Management approach it is required to improve « classical » network processes to provide the possibility of access to flexibility connected at distribution system level. Figure 9 shows the services provided by the Distribution System Optimiser and the Distribution Constraints Market Operator roles that support an Active Distribution System Management approach. As the figure shows, four activity domains are impacted by the implementation of this approach, namely network planning and connection, operational planning, operation and maintenance, and market.

The combination of both roles, the Distribution System Optimiser and the Distribution Constraints Market Operator, brings value to the distribution system. The former improves network processes by using novel methodologies to process new data (from the network, contracts and meters) at different timeframes. The latter, provides a platform to facilitate the access to flexibility directly connected to the distribution network. In addition, the adoption of these roles contributes to the realization of a Market Facilitator approach.

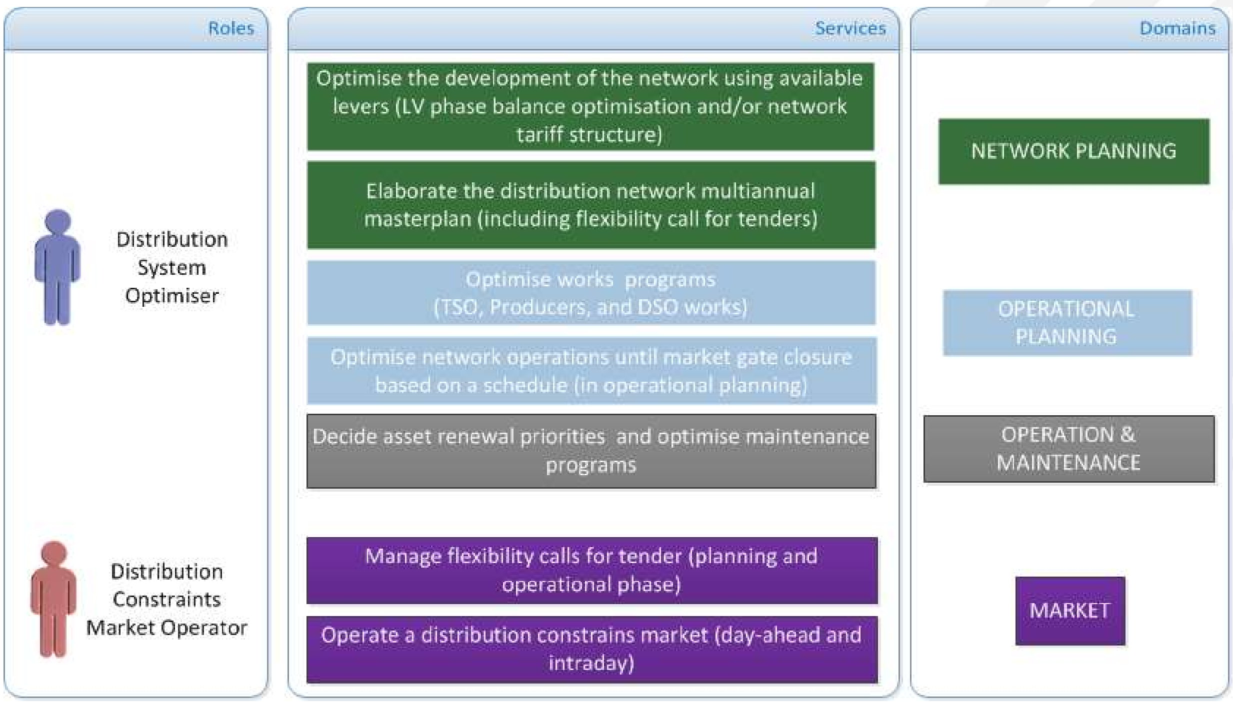

Figure 9 - Services for an Active Distribution System Management

To support the implementation of a Market Facilitator approach it is required to certify and manage the impact of flexibilities that are bid at the different electricity markets (section 4.4.2). By handling the impact of flexibilities new procurement mechanisms and regulated services could be provided. Figure 10 shows the services provided by the Neutral Market Facilitator/Enabler, Distribution Constraints Market Operator, Customer Relationship Manager and Other Third Parties Relationship Manager roles that support a market facilitator approach. The figure shows that the services which support a market facilitator approach impact two domains, namely the network planning and connection, and the market domains. In this context, the Distribution Constraints Market Operator role acts as market facilitator for the flexibilities that could solve local constraints at distribution system level.

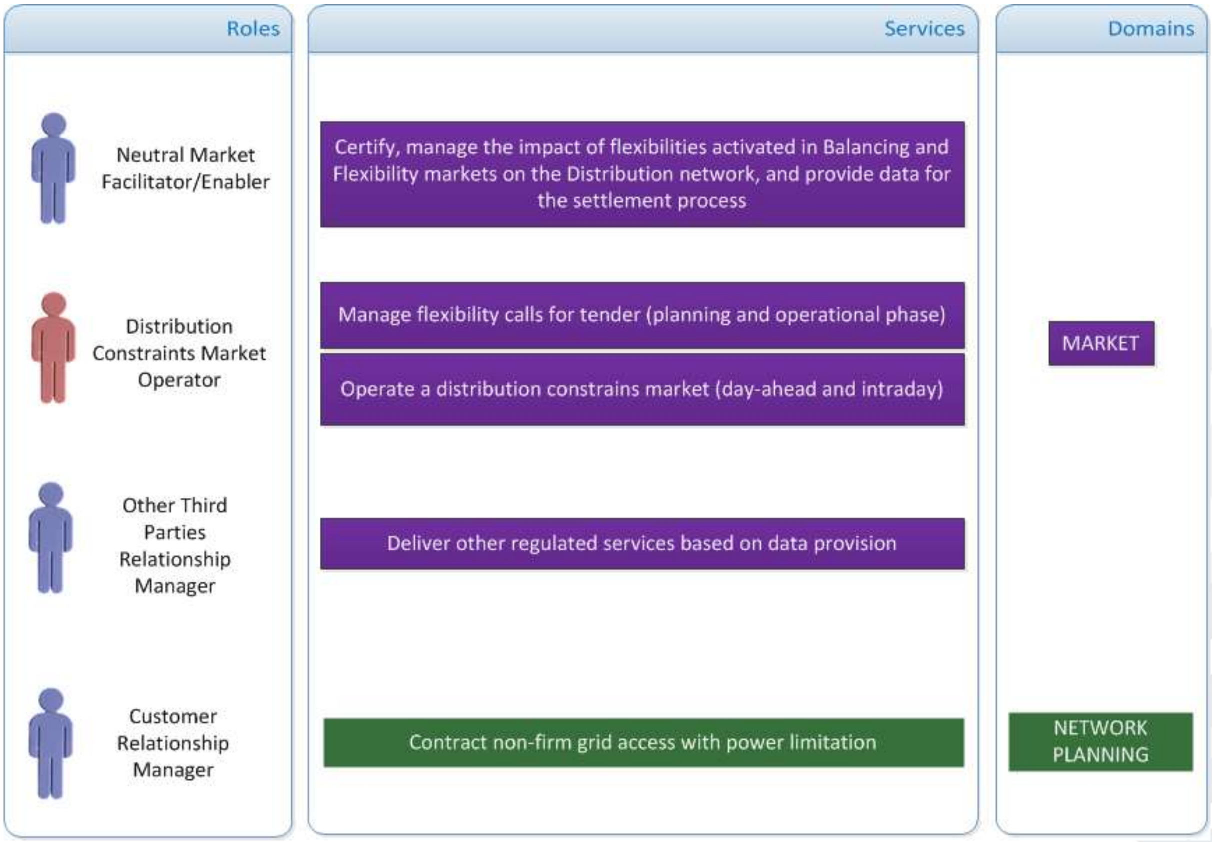

Figure 10 - Services for a Market Facilitator approach

To contribute to system security it is needed that network operators support each other. Figure 11 shows the service (section 4.5.2) provided by the Contributor to System Security role so as to enhance system security. This role is mainly based on the network codes related to System Operation, namely Operational Security Network (OS), Operational Planning and Scheduling (OPS), Load Frequency Control and Reserves (LFCR) and Operational Procedures in an Emergency (EP)[16]. The service provided by this role details the responses given to requests coming from the TSO. These responses are based on the different Network Codes and supported by the interaction this role has with the Distribution System Optimiser role.

[16] More information can be found in http://networkcodes.entsoe.eu/

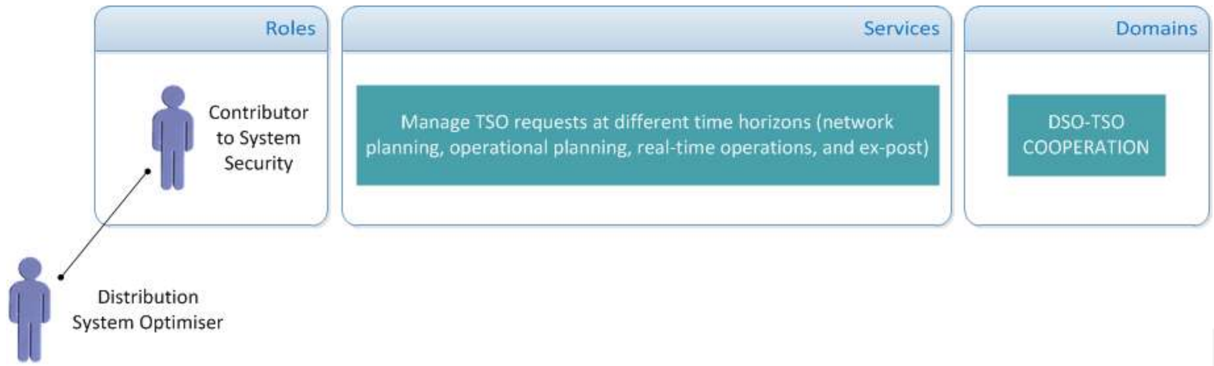

Figure 11 - Service for System Security

The provision of the services mentioned above may be realised across different timeframes, namely Planning and Connection, Operational Planning, Real-Time Operations and Ex-Post. Figure 12 shows the classification of these services by timeframe and by DSO's activity domain. As the figure shows services that fall into the market and DSO-TSO cooperation domains are provided throughout all timeframes.

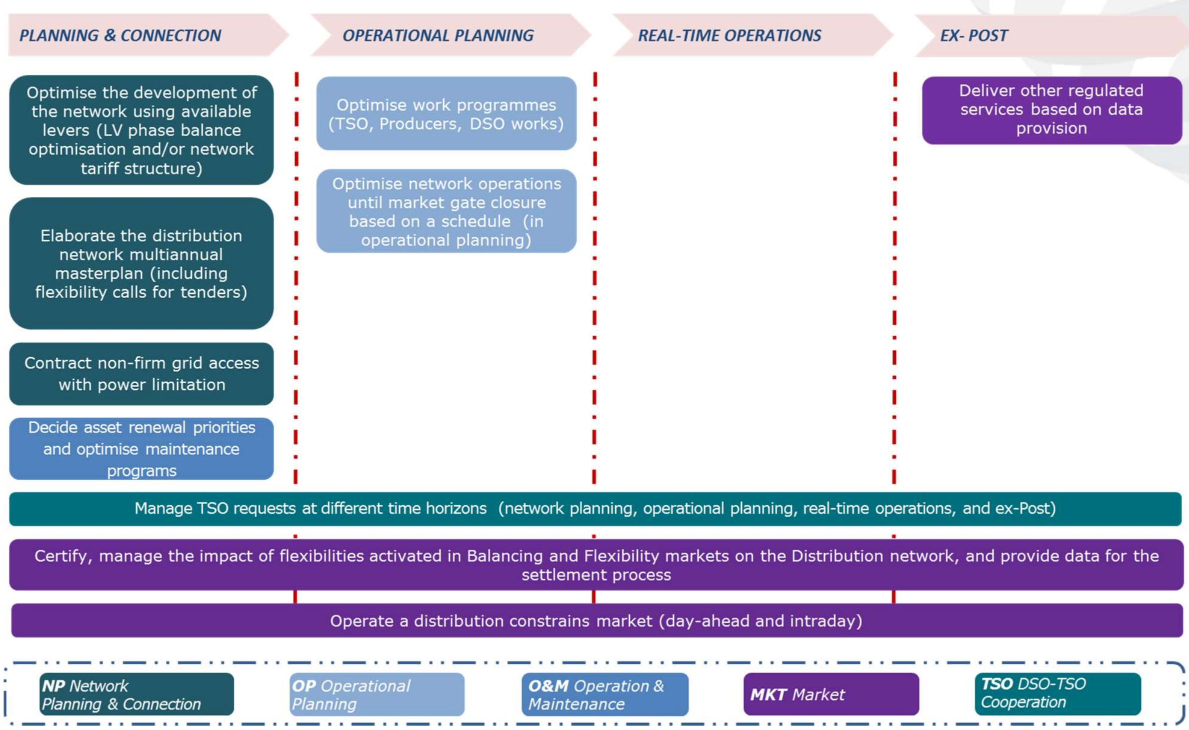

Figure 12 – Services per domain and per timeframe

For the provision of services, future roles would have to interact amongst each other. Figure 13 illustrates the interactions foreseen for the evolving and new roles. This figure shows that there is a strong cooperation (thick blue line) between the Distribution System Optimiser, the Data Manager and the Smart Meter Operator. This strong link allows the Distribution System Optimiser and the Data manager to provide support to all other evolving and new roles.

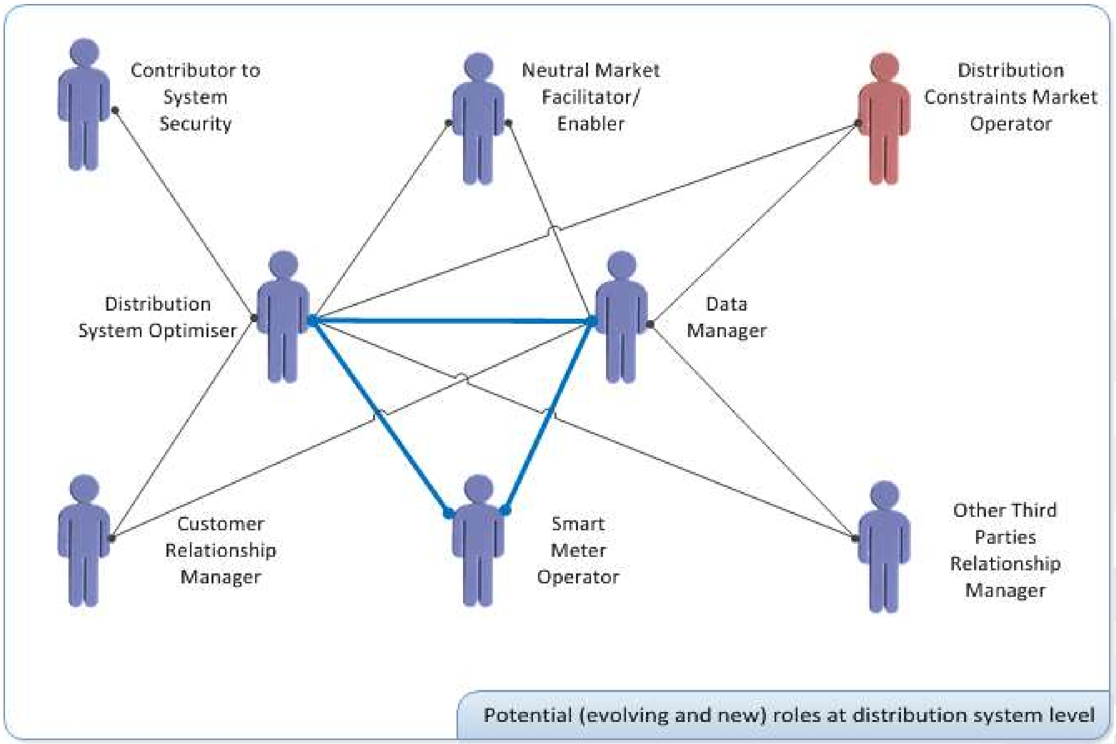

Figure 13 - Exemplary map of foreseen interactions amongst evolving and new roles

The interactions amongst evolving and new roles allow for the provision of services to other stakeholders (e.g. TSO, grid users, regulators). Figure 14 shows an overall view of the services (dotted lines) rendered to third parties, namely TSO, BRPs, flexibility operators, suppliers, grid users, regulators, providers and authorities. Note that only the most relevant services will be explained within this report.

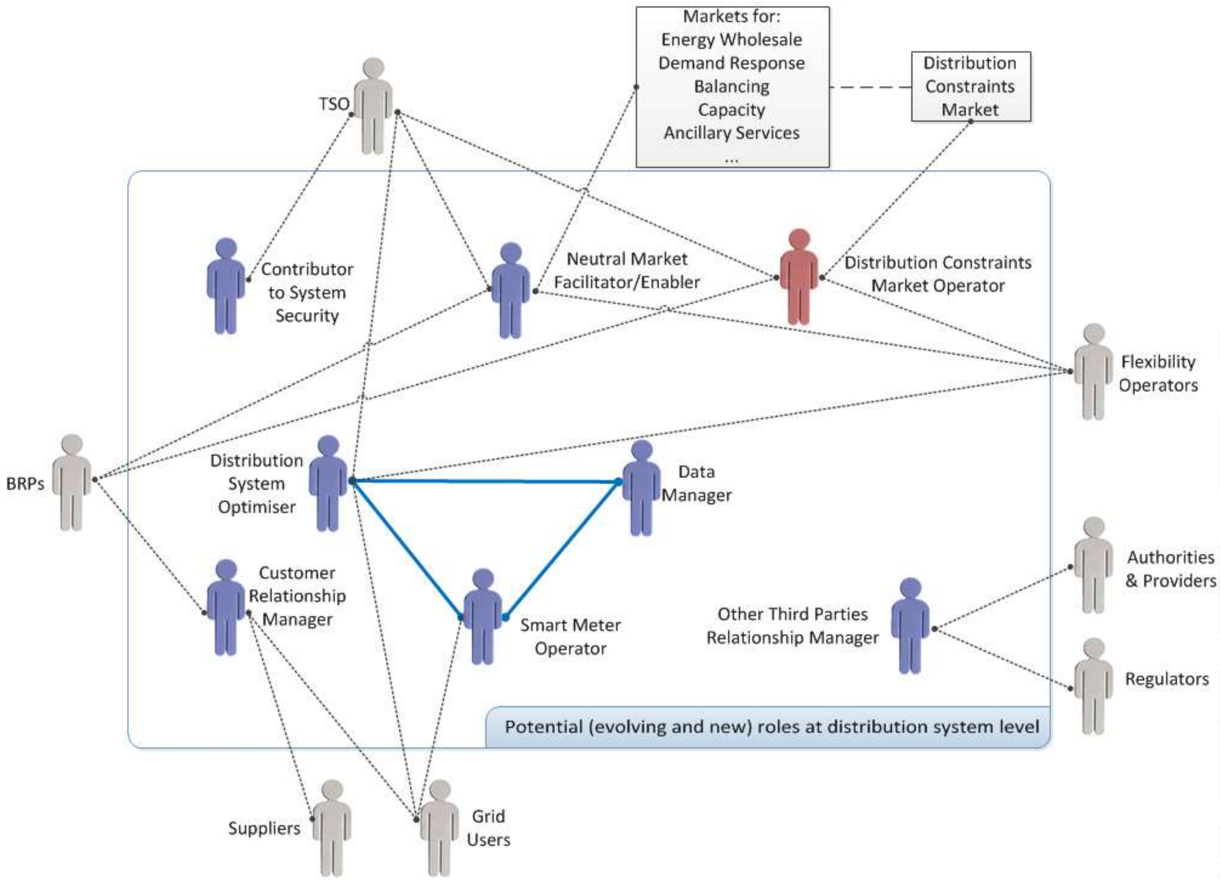

Figure 14 - Interactions amongst evolving and new roles and third party roles

These services may vary slightly or be completely new compared to current services rendered by DSOs. They may also vary between different national markets, as different structures apply (i.e. one national DSO or more than one DSO nationwide). All of the services associated with the evolving and new potential roles are enabled by smart-related technologies, and thus expected to be present in the smart grid environment. The Distribution System Optimiser and the Data Manager roles and related services can improve the way DSOs make use of their grid. These roles allow the DSO to make optimal use of demand and supply flexibility on a local level. This optimal use of flexibilities takes into account distribution and system-wide needs so that the trade-off of their impacts (and costs) is on the best interest of the power system and ultimately, the end-consumer.

Regulators across Europe would be required to adapt the general proposition of the roles and related services to the operating procedures specific to the system. Any implementation of the roles above mentioned should strive to take into account the potential impacts on competition and stakeholders, in order to minimise them. In this view, a clear model is preferred. The envisioned model should promote "a level playing field" for all participants in the electricity market.

The roles the DSO may be able to perform would come at different time horizons. This is because some roles may be closer to current activities / services delivered by the DSOs, while others are based on their future needs and capabilities.

The future roles identified have to be taken up by an existing or new business party and are strongly conditioned by the current regulatory framework. Changes to accommodate the regulatory framework to future roles may differ depending on the local distribution grid characteristics. In some cases, these changes may not represent a major effort and could be implemented in a relatively short timeframe, while, in other cases, structural or fundamental regulatory modifications may be required. Consequently, the proposed future roles are expected to appear at different time horizons.

Naturally, for the DSO to adopt this set of (evolving and new) roles, a clear set of regulatory rules and the full transposition of the directive 2009/72/EC (unbundling) are needed[17]. In order to support the evolution of the DSO, policy makers would have to adapt the current regulatory framework. This adaptation should promote a clear model for the DSOs to implement.

The evolution of the DSO in a smart grid environment will require a sound regulatory framework. As stated in (EC TF for Smart Grids 2011) "Policy makers should assist in promoting harmonisation and standardisation of data exchanges and customer processes at the European Union level as this would facilitate supplier switches and allow economies of scale." The efforts will also have to come from DSOs who "should move towards a unique identification of metering points to facilitate data exchanges".

To facilitate the evolution of the DSO in a smart grid environment the regulatory framework should provide clear support to DSOs' investment needs. In light of this, Eurelectric[18] recommends removing RD&D from efficiency targets set by the regulator, allowing a higher return on investments and a risk adjusted depreciation period for projects with significant risks and further encouraging financing of large scale smart grid demonstration projects. Eurelectric also recommends long-term policies that ensure a predictable investment environment for assets in the distribution network.

The following sections will introduce the evolving and new roles DSOs may be able to adopt in a smart grid environment. Along with the description of roles, related services will be presented from a general perspective[19]. Finally, the DSO is proposed as the actor that adopts the role. This proposition allows a first view of the benefits and challenges this situation may create.

[17] The evolvDSO report D1.4 will provide recommendations on the market and regulatory framework for DSOs' evolution.
[18] (Eurelectric 2014a)
[19] The services shown in Figure 12 will be further described in the evolvDSO reports D2.1 and D2.2. The former will give a detailed explanation of each business process and their requirements. The latter will provide the specifications for the development of several tools.

4.2 Distribution System Optimiser

4.2.1 Description and goals

A Distribution System Optimiser improves the development, operation, and maintenance of the distribution network by managing network constraints, including emergency situations and faults emerging on the distribution network, in a cost-efficient and non-discriminatory manner.

The main activity of this role is to improve network planning and operation processes, in order to optimise network investments and system management at different timeframes. In order to accomplish these tasks, the role implements a cost-efficient planning, operation, and maintenance of the distribution network by making use of the available flexibility connected at distribution system level. This flexibility may come from the network, the supply or demand side. By using this flexibility the Distribution System Optimiser improves the use of the existing network, mitigating the need for expensive distribution grid extensions that are only needed to accommodate for scarce peak load moments during the day. The Distribution System Optimiser is hence accountable for maintaining reliability of supply and quality of service in the network, while promoting the integration and usage of new generation and flexible resources. The Distribution System Optimiser is also responsible for guaranteeing transparent and non-discriminatory network access. This role is needed to fulfil the requirements imposed by the directive 2012/27/EU on energy efficiency and to maximise the use of local resources based on the capabilities smart grid technologies provide.

The Distribution System Optimiser has three sub-roles (Figure 15):

- Network Developer (long-term);
- Operational Planner (medium to short-term);
- Network Operator (real-time operations)

The Network Developer deals with the optimal expansion of the grid. This task focuses on the long-term evolution and adequacy of the distribution grid. This long-term vision requires the Distribution System Optimiser to develop and implement novel methodologies taking into account shorter operational timeframes. This is done in order to provide a network planning suitable for coping with current and future flexibility needs. Consequently, elaborating and optimizing the multiannual planning of the distribution network, work programmes and maintenance operations falls within the responsibilities of this task.[20]

The Operational Planner deals with all operational tasks up until real time. Operational tasks include load flow calculation, assessment of flexibility offers to solve constraints on the distribution network, forecasting, etc.[21] These operational system management tasks allow

[20] Ultimately, better planning would lead to an optimal use of the grid and to fewer constraints.
[21] For the realization of these operational tasks it is assumed that the DSO has already received offers from flexibility providers which are the sole responsible for assessing the value and availability of flexibilities. Once

the actor to (1) foresee possible events that may hinder the distribution of electricity, (2) optimise the scheduling of maintenance operations in cooperation with other actors (e.g. TSO and grid users), and (3) come up with contingency plans. The forecast of distributed generation and load connected to the distribution grid serves as input for simulations (e.g. system state, contingencies), and to anticipate possible network constraint/violations.

The Network Operator deals with (1) managing emergency situations and faults emerging on the distribution level in real-time, and (2) restoring the electricity service when interrupted. For this purpose, the Distribution System Optimiser maximises the local usage of power resources, taking into account the level of controllability of the connected resources, the maintenance plans and the network state based on real-time data. Ultimately, this sub-role, when operating the network, handles real-time situations that may put the system in jeopardy in a cost-efficient, non-discriminatory manner.

4.2.2 Services provided

The services provided are summarised in Table 2. The list is not intended to be extensive nor exhaustive, but rather to display the services expected to be of high impact on the evolution of this role. Each service is shortly described.

Services
Elaborate the distribution network multiannual masterplan (including flexibility calls for tenders)
Optimise the development of the network using available levers (such as LV phase balance optimisation and/or network tariff structure)
Optimise work programmes (TSO, Producers, DSO works)
Optimise network operations until market gate closure based on a schedule (in operational planning)
Decide asset renewal priorities and optimise maintenance programmes

Table 2 - Services provided by the Distribution System Optimiser

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

For the provision of this service the Distribution System Optimiser takes into account the presence of different types of flexibilities (e.g. flexible contracts, flexibility contracted through a call for tender, flexibility bid at electricity markets the role has access to). These flexibilities will be used to optimise the multiannual masterplan owing to the timeframe, Planning and Connection, and the domain, Network Planning and Connection, in which the service is provided (Figure 12). This masterplan is based on the current grid topology and on a forecast of future connections.

these flexibilities are offered to flexibility markets at distribution level, they enter in the scope of the Distribution System Optimiser.

To optimise the use of these flexibilities and hence future network investments (e.g. reinforcements) the Distribution System Optimiser does a probabilistic load flow to highlight the potential weaknesses of the current system for possible scenarios of the future grid utilisation. Once these potential weaknesses are identified, the role creates a priority list of actions/solutions (e.g. network reinforcements, new investments, flexible contracts, call for tender) to be implemented. These actions will ensure a secure and effective planning and operation of the distribution network.

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

One of the aims of this service is to improve DRES integration. The development of the distribution network can be optimised by evaluating and improving MV/LV network configurations. Improvements in MV/LV network configurations may come from levers already available in the system such as LV phase balance and/or network tariff structure[22]. The use of these levers is constrained by their availability and/or the allowances provided by the current national regulatory framework.

The Distribution System Optimiser may use these levers to reduce imbalances, etc. By making use of these levers the role optimises the development of the network in the planning phase owing to the timeframe, Planning and Connection, and the domain, Network Planning and Connection, in which the service is provided (Figure 12).

The network tariff structure may be optimised by the Distribution System Optimiser (if the regulatory framework allows it). The role could provide to regulatory authorities optimal options for the adaptation of the tariff structure (e.g. placement of peak/off-peak hours) and tariff components in order to make them more cost-reflective. The provision of the right incentives/signals to the grid user is highly relevant to promote a change in their behaviour towards the electric power system (Jargstorf et al. 2014).

Optimise network operations until market gate closure, based on a schedule (in operational planning)

This service relates to optimisation of network operations in medium-term (month and week ahead) and short-term (day-ahead and intraday) at operational planning. The Distribution System Optimiser makes use of the various data available (e.g. consumption and production forecasts, historical data, contracts, work programmes, flexibilities to be activated or proposed on electricity markets) to simulate the network state and identify potential constraints at distribution system level time-ahead of real-time operation. This information is

[22] The flexibility from maintenance works may also act as a lever. However, this general explanation will not include all possible levers. Other flexibilities such as market flexibilities are not considered as levers.

used to build a schedule (or call programme) of the flexibilities offered by flexibility providers[23].

Some constraints may arise after the schedule is built. Constraints identified after the specified deadline (e.g. at real-time) should be considered as emergency situations for which, other resources should be used due to realistic limits for the coordination with other parties (e.g. TSO, flexibility providers).

In order to select among the different types of flexibilities at the Distributor System Optimiser's disposal, a merit-order algorithm – i.e. the algorithm ordering the available flexibilities by their technical value and economic cost – must be in place. This algorithm creates the call programme or schedule of the available flexibilities selected for alleviating the foreseen network constraints. In this way, each of the flexibilities is assigned a utility value which varies over time depending on the probability of appearance of the foreseen constraint and the number of flexibilities remaining in the merit-order stack. This process should take place in coordination with the TSO so that the technical feasibility of the call programme can be assessed from a system-wide perspective. The coordination between network operators would ensure that flexibilities used at distribution level do not endanger system security for which the TSO is responsible.

Lastly, the actual activation of procured flexibility is only one (albeit novel) mechanism to alleviate network constraints during operation, besides e.g. on-load tap-changes, reactive power compensation, etc.

Optimise work programmes (TSO, Producers, DSO works)

This service deals with the optimization of the placement (i.e. timeframe) of works and maintenance operations. The Distribution System Optimiser, by receiving information concerning the works of the TSO and grid users, is able to enhance coordination with its own works programmes. The role will validate dated works proposals by optimising the programming of works at different voltage levels and by taking into account constraints likely to appear in the distribution network (e.g. faults, power limitations or planned cuts operated by the TSO, load transfers).

The coordination amongst the role, TSO and grid users serves the objective of reducing both distribution and transmission system constraints, optimising generation at both system levels, and improving overall system reliability by e.g. reducing down time.

The Distribution System Optimiser provides this service through the Operational Planning domain. The role, by providing this service, complies with system security rules and requirements.

[23] These may come from a "market" for flexibilities.

Although this service is already provided by the DSO to the TSO and grid users, it is expected to improve over time due to the capability of smart grid technologies to facilitate the exchange of information between grid operators and grid users.

Decide asset renewal priorities and optimise maintenance programmes

The service facilitates investment decisions and reduces ownership's cost of equipment installed on the distribution network.[24] Examples of the equipment may be primary substations, MV/LV transformers, MV and LV feeders, remote controlled switches, etc.

The provision of this service ensures network reliability in the long-term. The Distribution System Optimiser, when providing this service, will define long-term (multiannual) and medium-term (annual) maintenance strategies for a set of equipment types on the distribution network. The Distribution System Optimiser, with the help of smart grid technologies, provides the opportunity to move gradually from a scheduled maintenance to a preventive and condition-based maintenance.

By implementing a preventive maintenance programme the Distribution System Optimiser will be able to maintain the safety and reliability of the components. Moreover, the role would be able to minimise total life cycle cost (incl. the costs of maintenance and residual failures).

4.2.3 DSO in the role of the Distribution System Optimiser

Figure 15 provides an overview of the interactions foreseen between the Distribution System Optimiser and other roles. Overall, the Distribution System Optimiser interacts with other roles by performing the required studies (e.g. for new connections) and calculations (e.g. for load flow) using available data (e.g. generation and load forecasts) that support the provision of other services.

[24] By providing this service CAPEX and OPEX may be shifted, i.e. increase OPEX but less than what CAPEX were decreased beforehand.

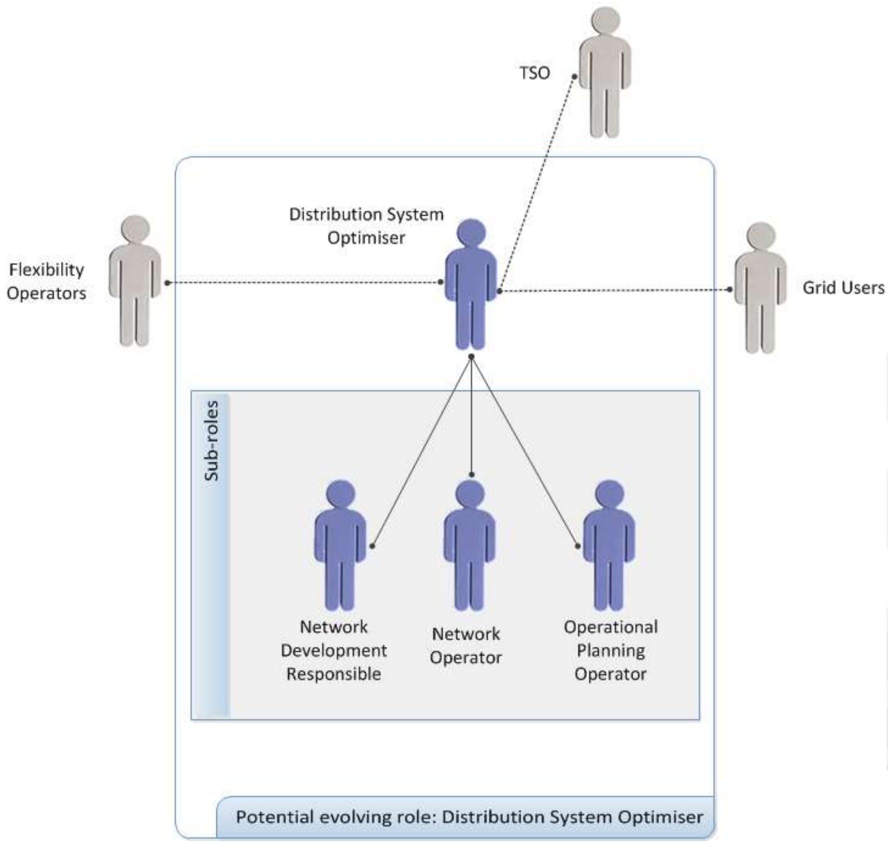

Figure 15 - Overview of the interactions of the Distribution System Optimiser role

From the description and goals of the Distribution System Optimiser (section 4.2.1), the role has close interactions, both on long term planning and during real-time emergency situations, with the TSO, grid users and flexibility operators. The Distribution System Optimiser also supports the Contributor to System Security by handling TSO requests at different time horizons, both in normal and emergency situations. Moreover, it supports the Neutral Market Facilitator/Enabler and Distribution Constraints Market Operator by calculating load flows.

Ensuring the reliability of the distribution system is currently the core responsibility of the DSO. In order to provide a responsive, reliable, and cost-effective system, the DSO must optimise the resources at its disposal. The Distribution System Optimiser is an evolution of the current role of the DSO because it takes into account the current needs of the system and tackles them by providing services (section 4.2.2) that are supported by novel tools[25]. In other words, this future role is not a leap forward, but an evolution of current DSO activities in order to carry out its core responsibilities in light of expected future challenges (Eurelectric 2013; Ignacio Pérez-Arriaga et al. 2013).

Network codes when by-passing the DSO as system operator, may negatively impact the management of the distribution grid (David Trebolle 2013). In this context, certain actions instigated by other parties can cause problems at the distribution system level. This situation

[25] To be developed in the framework of the evolvDSO project (WP3).

highlights the need for a stronger coordination between network operators at transmission and distribution system level. An enhanced coordination is required so that inefficiencies and potential unsecure measures are minimised. Network operators will have to jointly assess the impact of a given action in order to decide the best trade-off[26] for the system as whole. The Distribution System Optimiser role with the support of advanced metering capabilities and forecasting methodologies can provide a solution to this problem. The role increases the visibility of the DSO on state changes on the distribution system by taking into account e.g. TSO's requests on the calculations for the optimization of the distribution system. In doing so, the DSO will contribute to the enhancement of the collaboration with the TSO so that actions at one level will not jeopardise the "normal" operation at another level.

The DSO as Distribution System Optimiser can optimise the distribution network in a cost-efficient way through all the different timeframes. The adoption of this evolving role will support the provision (in collaboration with the Data Manager) of evolving and new services across the different domain activities. The DSO in its evolution towards the implementation of an Active Distribution System Management approach would have to become a Distribution System Optimiser to cost-efficiently elaborate the multiannual masterplan. This plan will set the framework for the optimisation of the distribution network at the planning, operational and maintenance stages.

In summary, the Distribution System Optimiser can make use of smart grid data to improve network management. This evolving role provides support to all other evolving and new roles. For instance, the DSO as Distribution System Optimiser facilitates system management by providing support to the Neutral Market Facilitator/Enabler when managing flexibility impacts.

Today, DSOs are responsible for the management of the distribution grid. They must do so in a cost-efficient manner while responding to regulatory needs and performance indicators. DSOs are also responsible for the integration of DRES (they must provide connection and access) and for the empowerment of DR (ability of consumers to provide flexibility).

DRES and DR will make the management of the distribution grid more complex. In light of this, the DSO should be able to manage/handle the increase in complexity by all means possible. Smart grid technologies provide opportunities and challenges for DSOs to actively manage their grid. An active management will require that the DSO makes use of the smart grid data to empower the decision making concerning the development, operation and maintenance of the distribution grid. In the smart grid environment, the DSO as Distributor System Optimiser is the first step towards an active system management.

[26] The economic trade-off should weight the cost of network reinforcements and the cost of cancelling orders/actions from other parties.

4.3 Data Manager

4.3.1 Description and goals

The Data Manager role ensures metered, network and contractual data procurement, management, and transmission. The role receives, aggregates, validates, processes, analyses, archives and provides data in a cost-efficient and secure way. The Data Manager serves the purpose of improving information exchange between all roles foreseen and between eligible parties (e.g. TSO, regulatory authorities, BRPs), and is therefore key for the creation of new services at the distribution system level (Eurelectric 2013).

The capabilities of smart grid technologies allow the collection and provision of data relevant for different stakeholders. This data would come from different sources such as the smart metering infrastructure and serve different objectives. The Data Manager is based on the assumption that large amounts of detailed data would be provided by the metering infrastructure in place. Currently, this is not the case in many European contexts. In light of this, the role may provide solutions to overcome barriers in information collection and handling for the development of smart grids (CEER 2011).

The role responds to directive 2012/27/EU on energy efficiency by providing the data required for the optimization of energy use to eligible parties. In order to optimise the use of flexibilities (e.g. demand response) large amounts of data from must be processed, analysed, and made available to eligible parties in a transparent and efficient manner. It is important to stress that the provision of data should be authorised in advance by customers, expressing clearly to which parties or roles this information can be provided.

Within the Data Manager three sub-roles were identified. Table 3 shows these sub-roles and provides a summary of the duties for each.

Sub-roles	ENTSO-E sub-roles	Responsibility
Metered Data Manager	Metered Data Collector	Reading data and controlling its quality
	Metered Data Responsible	Establishing and validating metered data Maintaining history for a Metering Point
	Metered Data Aggregator	Establishing and qualifying metered data Aggregating data based on a defined set of market rules
Network Data Manager		Handling technical and operational data (state of the network at different meshes, fault information…)
Contracts Data Manager		Handling contractual data

Table 3 - Summary of the responsibilities of the Data Manager (based on (ENTSO-E 2011))

Figure 16 shows the Data Manager role and sub-roles. The first sub-role is further decomposed in three sub-roles (ENTSO-E 2011). These three sub-roles are responsible for the collection, integrity and aggregation of metered data (e.g. data coming from the metering infrastructure). The last two sub-roles handle the data that comes from the network and contracts.

From Table 3 and Figure 16 it can be derived that 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[27] by suppliers. Network operators would use this type of metered data to elaborate load profiles and forecasts. This data will help them to manage their grid (e.g. to monitor their network state). An example of network data could be the archived network configurations. The Data Manager registers specific network configurations in his database. 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 activity domains (e.g. network planning, operational planning, near real-time operations) to enable them to optimise network operations or manage critical situations (e.g. emergencies)[28]. The Data Manager can provide this information to the Distribution System Optimiser so that he can decide which lever to use to ensure the operational security of the distribution network, such as the temporary limitation of the active power of an installation with non-firm grid access contract (section 4.8.2).

The management and coordination of information exchanged amongst system operators and grid users is of critical importance for the development of smart grids and the future roles expected at distribution system level. Currently, network codes do not support this coordinated exchange (David Trebolle 2013). The Data Manager could improve the cooperation between stakeholders by ensuring a coordinated and transparent information exchange. The provision of relevant data at the required timeframe and according to appropriate performance and security requirements (such as time of response, cybersecurity or data management issues for instance) can strengthen cooperation and enhance current processes.

[27] With a 10 to 30 minutes data granularity, for example.

[28] The optimisation of the system and therefore the most appropriate use of flexibilities are done in coordination with the TSO.

4.3.2 Services provided by the role

Table 4 shows two of the most relevant services provided by this role. Below the table, the explanation of this service is provided.

Services
Providing data needed for different markets or mechanisms (certification, technical validation and feedback)
Providing archived network state data for investment and maintenance decisions

Table 4 - Services provided by the Data Manager

Providing data needed for different markets or mechanisms (certification, technical validation and feedback)

This service is based on the assumption that the needs for relevant data will increase for stakeholders, especially market players, regulators and system operators. This process is currently in place although it is expected to evolve with increased quality of data. The process provides information to the actors (if not the same) adopting the "Neutral Market Facilitator / Enabler" and the "Distribution Constraints Market Operator" roles. The data provided supports these roles on the certification and validation of the bids offered through different market mechanisms. In addition, the data is used to provide feedback on the behaviour of resources and their utilization.

Providing archived network state data for investment and maintenance decisions

This service is a process expected to be enhanced by the quality of data coming from the smart metering infrastructure and additional sensors in the network. Currently, this business process is in place, but it lacks the detailed information needed for optimizing investment and maintenance decisions. This process aims at supporting the "Distribution System Optimiser" on the creation of an optimised masterplan (see 4.2.2). Data provided by this process is used to jointly evaluate the required investments and maintenance works.

4.3.3 DSO in the role of Data Manager

Figure 16 provides an overall view of the conceptualization of the Data Manager role. As the figure shows the Data Manager covers, through their sub-roles, the possible sources of data at the distribution system level.

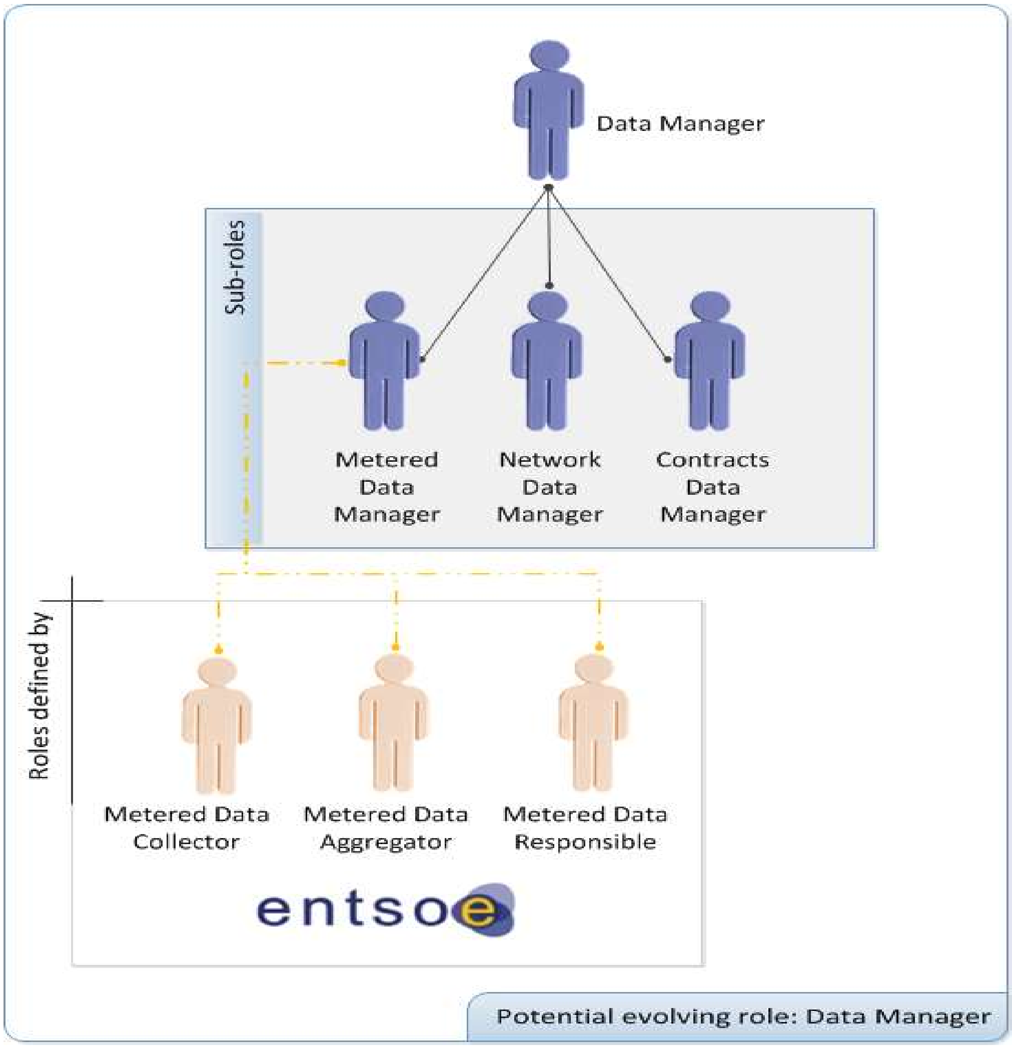

Figure 16 - Overview of the interactions of the Data Manager role

The Data Manager supports the services provided by the evolving and new future roles at distribution system level. This role has a very strong link with the Distribution System Optimiser (Figure 13). The availability of relevant data supports the Distribution System Optimiser in both his daily operational and long-term planning tasks. The Data Manager provides the possibility to optimise works and maintenance operations planning (section 4.2.2). Currently, this information is not widely available from outside plans. Moreover, the Data Manager supports future responsibilities/activities requiring data intensive tasks (e.g. creation of suitable and dynamic masterplan). The Data Manager also provides crucial support to the Customer Relationship Manager, by collecting raw data and processing it according to the request received. Lastly, the Data Manager provides support to other interactions that these future roles would have with other stakeholders (e.g. TSO, grid users, suppliers, regulators).

Data management is a pillar for an efficient development and operation of today's distribution system. In a smart grid environment, the Data Manager is a main supporter for all evolving and new future roles.

The Data Manager is highly relevant for the evolution of DSOs towards an active manager of the system. The DSO – by adopting this role – can use its expertise in mining large databases with a critical focus of network performance and better services respecting requirements of data security and privacy. Data management is a core activity for a DSO. The role allows the DSO to process large amounts of data from the metering infrastructure, network components and contracts.

In a smart grid environment, the data collected is highly relevant for the operation of the distribution network. However, it is not always possible to set a boundary between data for operational purposes and data for commercial purposes. The use this data has is what defines its type. In other words, data collected from the smart metering infrastructure could be used by the DSO to optimise the system while suppliers could make use of data originating from the same meter to create services for their customers.

The DSO as Data Manager becomes the central data hub and servant of demands for distribution system data (e.g. collected from meters, network and contracts). This scenario puts the DSO in a good position to support the implementation of other roles. Additionally, it would enable the DSO to improve existing processes and even create new ones (e.g. optimization of the network operation, creation of new retail products), for an efficient future distribution system.

Literature suggests that the DSO can adopt the Data Manager role (ECORYS 2014; Smart Grid Task Force 2013). Outcomes from an extended survey on the roles of the DSOs in a smart grid environment suggests that the Data Manager should be regulated so that access to data collected from different sources through the Smart Metering infrastructure could be provided to eligible parties in a non-discriminatory basis.

A third party can adopt the role of Data Manager (Smart Grid Task Force 2013). However, allowing another party to act as Data Manager could require additional effort from regulatory authorities. For instance, new regulatory rules and/or new mechanisms for their evaluation would have to be implemented. In this scenario, the DSO would have to request the information from an external party in order to carry out its core responsibilities. This would encumber the provision of certain services, e.g. the provision of locational signals in the role of Distribution System Optimiser. Moreover, the DSO would be highly dependent on the third party in terms of quality of data, interfacing issues, transaction costs related to data exchange, efficient flow of information, and compliance with fundamental non-functional requirements – such as security and performance requirements – which may be imposed by regulators.

Currently, different approaches are being (expected to be) implemented in Europe. For example, in the UK, retailers – who own the smart meters – are responsible for the collection, aggregation and processing of smart grid data. In Italy, the regulator is currently evaluating the option of attributing the Data Manager role to a third party. In Belgium, DSOs are striving for a central clearing house [29]. This technical platform aims at fostering the cooperation with

[29] Belgian DSOs involved in ATRIAS: ORES and Tecteo (Resa) in Wallonie, Sibelga in Brussels region and, Eandis and Infrax in Flanders. More information can be found at http://www.atrias.be

suppliers by managing the structure and exchange of data arising from the distribution network. Ultimately, DSOs will need to have access to the data originating at distribution system level disregarding the model used for Data Management. Choosing a suitable approach (in terms of management costs, availability, security and privacy of the data) for the Data Manager role is of key importance for the functioning of the distribution network.

In conclusion, the smart grid environment will allow for new uses of data. This data will be collected, stored, processed and served for different purposes. These processes will have to be done in a cost-efficient, transparent and non-discriminatory manner. In addition, this data will have to be protected and available to eligible parties across different time horizons.

The DSO is a regulated party that has to provide network connection and access under a non-discriminatory principle. In his daily tasks, the DSO requires frequent access to operational data. The quality and accessibility of the data is crucial for the DSO to perform certain tasks and moreover to support other evolving and new roles when providing services to other actors.

In the smart grid environment the management of data coming from the smart metering infrastructure will be crucial. Data must be managed in such a way that transaction costs are minimised, especially for data exchange. Within this environment, DSOs will be in need of large amounts of data for operational purposes. Operational data will be used for the management activities performed by DSOs. In light of this, access to the data is critical. Today, DSOs handle large amounts of operational data needed for the normal operation of the system.

The DSO as Data Manager can reduce transaction costs (e.g. through standardization, reducing the time and costs it takes to switch supplier) while securing the data. If DSOs are entitled as Data Managers, network, contractual and metered data would be securely provided to the authorised party in a non-discriminatory manner. Moreover, the DSO as Data Manager can use his know-how to provide a targeted approach when serving the data to the eligible party (e.g. pre-processed in a way that facilitates the creation of commercial products tailored to the capabilities of the distribution grid). To sum up, the DSO as Data Manager can facilitate and support the innovation of services and methods which will ultimately bring benefits for all stakeholders.

4.4 Neutral Market Facilitator/Enabler

4.4.1 Description and goals

The Neutral Market Facilitator/Enabler[30] administrates the exchange of market information and validates the market participation of market participants from a technical perspective in established markets. Traditionally this role aims to provide access to the network as well as to consumption information enabling market actors' transactions. Currently, it is evolving to also include the facilitation of flexibility services within the market. The DSO must validate the technical feasibility of flexibility resources within its network. This validation is done at three stages: the qualification of the flexibilities (in terms of potential constraints on the distribution network in case of activation of the flexibility resource)[31], the actual activation of the resource, and the control of the energy effectively consumed or produced (ex-post check).

The role is responsible for the certification (pre-qualification) of flexibility entities and flexibility perimeters. Market players have to respect certain administrative and technical requirements to be authorised to propose products on the different electricity markets. By certifying the participation and bids of market players the Neutral Market Facilitator/Enabler ensures the well-functioning of electricity markets and hence the system.

The Neutral Market Facilitator/Enabler does not perform any trading. The role only provides the means to promote information exchange between eligible and relevant stakeholders. In addition, the Neutral Market Facilitator would implement and update market mechanisms. Currently, the lack of these mechanisms is one of the barriers for the development of smart grids (CEER 2011).

4.4.2 Services provided by the role

Table 5 shows a highly relevant service provided by this role. Note that the list is not intended to be extensive nor exhaustive, but rather to display the services expected to be of high impact on the evolution of this role. Below the table the service is shortly elaborated.

Services
Certify, manage the impact of flexibilities activated in Balancing and Flexibility markets on the Distribution network, and provide data for the settlement process

Table 5 - Services provided by the Neutral Market Facilitator/Enabler

[30]The present report differentiates between the facilitation of markets (this section) and data management (section 4.3). In contrast with (Smart Grid Task Force 2013) where both activities are described within the market facilitator role.

[31] This qualification of flexibility refers to the listing of flexibilities that could solve a specific constraint at distribution system level. To be able to do so, flexibility operators ask to register flexibility units to the Neutral Market Facilitator. Once they are registered, flexibility operators can summit offers, which then can be sorted in relation to the specific distribution constraint they intend to solve.

The objective of the service is to pre-qualify from the point of view of the distribution network proposed flexibilities in balancing, flexibility markets and also flexibilities activated by suppliers on the distribution network for internal balancing purposes. This is done by simulating local constraints with the support of the Distribution System Optimiser. The Neutral Market Facilitator/Enabler also manages the impact of the activation of these flexibilities on the distribution grid and provides data for the settlement process.

To prevent local constraints the Neutral Market Facilitator/Enabler can modify proposed flexibilities. If local constraints appear at the simulation stage, the role may modify the proposed flexibility based on the impact it could represent for the "normal" functioning of the distribution network. In some cases, this modification will have to be coordinated with the relevant TSO. Ultimately, any modification should ensure that by activating the proposed flexibilities no additional local constraints are created. This in turn would guarantee that balancing and flexibility markets do not create new constraints on the distribution network.

For the technical validation of flexibility bids the Neutral Market Facilitator/Enabler will certify ex-ante the flexibility operators and perimeters belonging to the distribution network. This certification will be done in a transparent and non-discriminatory way. Given that the validation is done before the market is cleared, appropriate actions may be performed according to the system state. The system state may be broadcasted to eligible relevant stakeholders by means of a traffic light system. The "traffic light approach" (Eurelectric 2014b) may be used by DSOs to inform market players if they are unlimited in their actions ("green light") or if there are specific limits due to an expected grid state ("yellow or red light").

It is important to note the following:

- The Neutral Market Facilitator/Enabler is not responsible for clearing the market. The role only safeguards the administrative technical feasibility of available market bids to support the reliability of the system.
- This service is provided within the market domain and across the different timeframes (Figure 12).
- This service does not certify flexibilities on behalf of the TSO neither checks if the unit providing flexibility can deliver the expected active/reactive power.
- The service mainly deals with the registration aspects of the flexibility unit and its use from the distribution system management perspective. The Neutral Market Facilitator/Enabler registers all flexibilities that comply with the administrative package (i.e. technical requirements). If there is a need for a specific flexibility, the role would manage the impact of its activation on the distribution network[32].

[32] To manage the impact of the activation of a given flexibility (i.e. reduce/avoid potential negative impacts on the distribution network), the Neutral Market Facilitator/Enabler interacts with other roles such as the Distribution System Optimiser.

4.4.3 DSO in the role of Neutral Market Facilitator

Figure 17 gives an overview of interactions between the Neutral Market Facilitator/Enabler and third party roles. The Neutral Market Facilitator/Enabler is foreseen to interact mainly with the Distribution System Optimiser, the Data Manager, BRPs, the TSO (as market responsible), and Flexibility Operators. In addition, the role also has to interact with all established market mechanisms for energy, capacity, DR, ancillary services, etc.

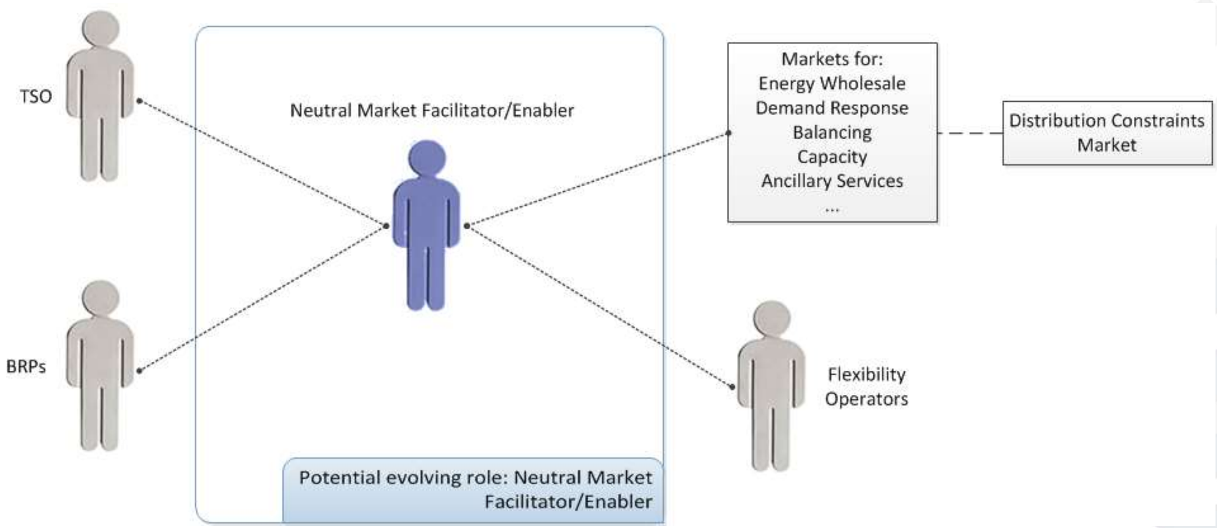

Figure 17 - Overview of interactions of the Neutral Market Facilitator/Enabler

The Neutral Market Facilitator/Enabler will facilitate relevant data exchange with stakeholders. For instance, the TSO receives the pre-qualification assessment report, and information on the provision of the resource (including information for the capacity market). Data related to the effective energy (generation/consumption) used, is fed back to the concerned Flexibility Operators.

The DSO as Neutral Market Facilitator/Enabler could present benefits for consumers (Smart Grid Task Force 2013), especially in combination with another evolving or new role. For example, the ex-post check can be reduced in complexity when the DSO adopts the role of Smart Meter Operator in combination with the Data Manager role, since relevant data for the settlement process is present at the DSO, transaction costs can be reduced.

Earlier reports have shone a light on the fact that current regulatory frameworks do not fully support the DSOs to take the role of Neutral Market Facilitator/Enabler (evolvDSO 2014b). The validation, from a technical point of view, of the flexibility programmes is necessary to ensure the security of the distribution network (including emergency situations) and to support the development of markets. This validation has to be done across the three market stages. By carrying out this validation the Neutral Market Facilitator/Enabler can propose adjustments regarding the activation of flexibilities proposed on the market during the planning phase, and it can inform the Distribution Constraints Market Operator about the technical validation of market bids.

For the provision of his services the Neutral Market Facilitator/Enabler must have access to relevant information concerning the flexibilities connected at distribution system level. The role has to be informed about units participating in reserve markets to verify if the activation of the flexibility will not cause constraints in the grid.

A Neutral Market Facilitator promotes the acquisition/procurement of flexibility at the best price possible. It increases participation which can improve the pricing of the flexibility. By increasing participation, the system has more flexibility options to choose from, competition may be improved and with that prices may tend to be lower, and use of resources can be optimised. The role fulfils the need of reaching and pre-assessing generation and consumption units that due to their capacity are not able to participate in the energy market by their own.

In the smart grid environment, DSOs will play a key role. They will have to participate in most of the interactions since most of the flexibility resources will be connected at the distribution grid. DSOs, in compliance of their responsibilities, will provide connection and access under a non-discriminatory principle. This situation makes them a candidate for taking up the role of Neutral Market Facilitator. The DSO as Neutral Market Facilitator can enhance the availability of resources of flexibility by providing the possibility to small generation and consumption units to participate in the market while limiting the possible impact the activation of the offered flexibility may produce.

The DSO as Neutral market facilitator could reduce the complexity of data exchange (supported by the Data Manager). By adopting this role the DSO would be able to manage flexibility offers taking into account the importance of standardization, locality, timing and transparency.

4.5 Contributor to System Security

4.5.1 Description and goals

The Contributor to System Security is responsible for the exchange of structural data (e.g. network structure and its evolution) and forecasts (e.g. load forecasts aggregated at primary substation) along with the TSO. It also manages the operational planning contracts. The goal of this role is to provide cost-efficient local solutions to system wide problems, by responding to the TSO's operational planning, scheduling and security requests (including emergency situations).

Regulated services (e.g. advanced ancillary services such as coordinated PQ management) for active and reactive power may be provided in accordance to a cascading communication process. In the context of reactive power, the role manages the provision of reactive power at grid's boundaries (i.e. DSO-TSO interfaces) with the sole purpose to support the mechanisms for voltage control at the transmission system level.

The role also tries to maximise the local usage of power resources in order to reduce losses. However, an integral evaluation must be put in place to evaluate the limits of local power in order to guarantee a more efficient network not only from technical but also from the economic standpoint. Transparency on which source of flexibility supports the system as a whole (i.e. distribution and transmission system) is hence a very important requirement in order for scarce flexibility resources to be used as efficient as possible. In emergency situations and once all market-based solutions have been used (or no longer available), the Contributor to System Security can curtail resources in real-time in order to respond to a load transfer request from the TSO. The role can thus be seen as a facilitator for providing flexibility for system security purposes towards the TSO.

4.5.2 Services provided

Table 6 shows a service of paramount importance provided by this role. The service is provided within the DSO-TSO cooperation domain and aims at improving system security. A short explanation of the service is provided below the table.

Service
Manage TSO requests at different time horizons

Table 6 - Services provided by the Contributor to System Security

The service is provided to reinforce the cooperation between TSO-DSO. The Contributor to System Security can support the TSO to maintain and improve system security. This support may be provided throughout all timeframes. The service provides cost-efficient local solutions (based on data exchange and/or actions) to system wide problems. These solutions may be used by the TSO (upon request) when market-based solutions cannot be used.

At Planning and Connection the Contributor to System Security and the TSO agree upon the long/medium/short term needs and possible solutions for the development of both grids. Some examples of possible constraints that will require development of grids are power demand to satisfy load growth, the decommissioning of existing equipment and balancing constraints.

On Operational Planning the Contributor to System Security and the TSO carry out network optimisation studies, agree upon National Plans[33] and network access and interconnections. The studies will serve to identify a network optimization possibility, regarding a closed loop configuration between TSO substations, through the DSO network. Once an optimization possibility is identified a formal request for joint analysis is presented. National Plans are reviewed and updated according to the needs of both systems. The Contributor to System Security will exchange data for the accurate characterization of their corresponding networks.

Near to Real-Time Operations the Contributor to System Security and the TSO perform analysis (e.g. power system protection) that lead to understand the behaviour of the network in real-time. At this timeframe operational protocols that define standards and procedures for the joint management of their networks are used. These protocols may cover network reconfiguration, planned and unplanned outages, facilities characterization and automation settings, characterization of generation at different voltage levels, energy shortage procedures, etc.

Ex-Post, the Contributor to System Security and the TSO cooperate to validate invoices of services provided to each other (e.g. delivery of active and reactive energy), to cross-check new connections and to support the settlement process. This cooperation is based on the exchange of relevant data collected from meters and/or contracts.

4.5.3 DSO in the role of Contributor to System Security

Figure 18 provides an overview of the interaction foreseen for the Contributor to System Security when providing services to the TSO.

[33] Such as the Automatic Under-Frequency Load-Shedding National Plan in Portugal.

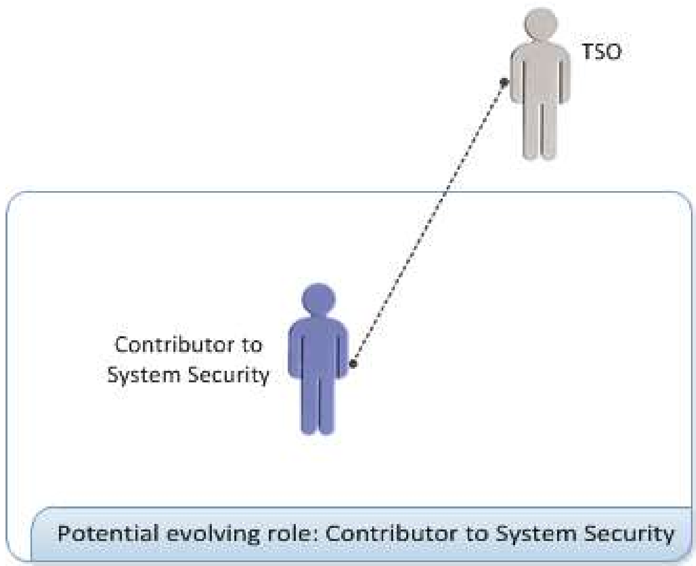

Figure 18 - Overview of the interactions of the Contributor to System Security role

The Contributor to System Security requires key services from the Distribution System Optimiser and Data Manager, such as the provision of load forecasts at a primary substation or the provision of work programmes (sections 4.2 and 4.3 respectively). In doing so, they support most of the services provided to parties such as the TSO, BRPs, etc.

Assuming the DSO as Contributor to System Security, cooperation between both transmission and distribution system operators opens up possibilities to ensure overall system security. However, current regulation across Europe does not support the DSO as contributor, since system security is currently the sole responsibility of the TSO. Historically, generation was mainly connected at transmission system level. Today, the environment is changing since generation capacity (especially the one based on renewable sources) is being connected to the distribution grid. In this context, DSOs would be in position to support the provision of services that could assist the TSO in easing the management of the power system. This situation would not change the fact that TSOs are (and will be) responsible for the well-functioning of the power system, but it highlights the potential support DSOs could provide to maintain system security. In light of this paradigm change, the implementation of this role would require regulatory changes. The degree of regulatory changes will depend on local grid topologies and issues concerning the allocation of the limited flexibility potential to solve grid constraints on both the distribution and (if requested by the TSO) transmission level. Also, novel approaches for the exchange of relevant information and coordination will be needed so that the foreseen services can be provided.

The Contributor to System Security will be strongly impacted by ENTSO-E Network Codes. Especially the network codes for "Operational Security" and "Operational Planning & Scheduling" will be affected, as they will require new exchanges of data between the TSO and DSO(s). Today, network codes do not fully consider all capabilities of the DSO. Concerning voltage control, network codes treat a DSO as system user rather than a system operator capable of improving system security (David Trebolle 2013). The Contributor to System Security could help to delimit responsibilities between system operators. The role could provide the system approach that is currently not being assigned to DSOs, which, in turn, improves the DSOs' visibility on system security issues. In the future, the DSO as Contributor to System Security may provide the TSO with more complex services to increase system security.

In summary, the system requires flexibility. A large portion of the units that currently and in the future can provide flexibility will be connected to the distribution grid. At these levels, generation and consumption units can provide the flexibility the system is in search for. The fact that these units might be sparsely distributed across the distribution grid highlights the potential DSOs would have on supporting the TSO to preserve a stable and secure system. In the smart grid environment, DSOs can complement the TSO by putting at his disposal flexibilities that could be used when market options for flexibilities are no longer possible. Furthermore, DSOs are in a good position to enhance overall system security since they can check/evaluate the impacts the activation of the flexibility resource may create (service offered by the Neutral Market Facilitator/Enabler role – see section 4.4.2).

The new and evolving uses of electricity may put system security at stake. The TSO as the overall responsible for system balancing will require access to all the flexibility the system can provide. The DSO as Contributor to System Security will reinforce cooperation between network operators by attending requests at all timeframes. Moreover, the DSO may enhance system security by providing regulated services, within the allowances of the regulatory framework, to the TSO. These regulated services will be based on the capability of the DSO to manage its grid.

4.6 Distribution Constraints Market Operator

4.6.1 Description and goals

In the near future, the power system will be in need of different sorts of flexibility, especially at distribution system level. Distributed generation and demand response may provide the flexibility needed at distribution system level, to cope with network constraints. A market centralising offered local flexibilities in order to solve specific network constraints on the distribution grid, is an option that may facilitate the provision and selection of these flexibilities in a cost effective and technically feasible manner.

The goal of the Distribution Constraints Market Operator is to select, contract and activate[34] flexibilities that may be used by the Distribution System Optimiser in case of local constraints. The role operates a dedicated market to solve specific distribution network constraints by contracting flexibilities offered by flexibility operators in advance, i.e. flexibilities may be offered and contracted at the mid- and short-term time horizons.[35] These flexibilities may also be offered and contracted at the planning and connection (long-term) timeframe through a call for tender. The flexibilities contracted by means of the distribution constraints market may be activated day-ahead or intraday. Their activation would depend on forecasts and contractual arrangements (e.g. availability, provision capability) and it would require a strong coordination with other markets and between grid operators.

The distribution constraints market is slightly different from the national markets and/or specific mechanisms currently operated by the TSO in some countries: the distribution constraints market discussed here involves local flexibilities that may be used in the vicinity of the network constraint in question. There are two choices to organise such market: either as (1) an extension of the existing TSO balancing market[36], or as (2) an independent market mechanism (but coordinated with the established markets).

The market for distribution constraints as an extension of the TSO balancing market allows grid operators to use a unique national market platform. The use of a unique platform facilitates the coordination between grid operators. Additionally, the use of a unique platform could simplify flexibility needs and procurement efforts (Eurelectric 2014b). For example, in situations when an overlapping of flexibilities needed for transmission and distribution system level occurs. In sum, the use of a unique platform can promote a more efficient use of flexibilities and flow of information (i.e. DSO-TSO cooperate in order to pool resources and avoid conflicts).

---

[34] Within this document the term "activate" refers to indirect control over the resource (evolvDSO 2014b). The "Distribution Constraints Market Operator" sends a signal to the aggregator or flexibility provider for the provision of the selected flexibility.

[35] The Distribution Constraints Market will not be used to contract flexibilities near real-time.

[36] Understood within the report as constraints management

The Distribution Constraints Market should be regulated. This condition applies disregarding if this market is implemented as a separate one or as an extension of the TSO balancing market. Regulators should impose regulatory price caps that aim to reduce the market power that may appear due to the local characteristics of the constraint. In addition, policy makers should monitor this market just as it is done with the markets managed by the TSO (balancing markets). In the same vein, a clear set of rules should be stated to support the well-functioning of this market (e.g. imposing the offering of available flexibility from flexibility operators to the market in order to promote liquidity) and to minimise potential conflicts with other roles such as Contributor to System Security as much as possible. In this latter issue, conflicts may appear if both roles compete for flexibilities. Note that flexibilities may come from the same source. However, they could be used to solve different issues.

4.6.2 Services provided

Table 7 shows two main services provided by this role. Each service is shortly described.

Services
Manage flexibility calls for tender (planning and operational phase)
Operate a distribution constrains market (day-ahead and intraday)

Table 7 - Services provided by the Distribution Constraints Market Operator

Flexibility calls for tender (planning and operational phase)

This specific service refers to the possibility to contract flexibilities at distribution level from flexibility operators via a call for tender process. The Distribution Constraints Market Operator does this in an attempt to mitigate the need for expensive network reinforcements.

The overall process is as follows. The Distribution System Optimiser decides to launch a flexibility call for tender when elaborating the masterplan. This need is communicated to the Distribution Constraints Market Operator which would manage the flexibility call for tender. The acquired flexibility – assuming a high availability and reliability – is then communicated to the Distribution System Optimiser which takes it into account when drafting the distribution network multiannual masterplan. These flexibilities are considered together with contingency plans in case the contracted flexibility is not provided during critical moments. This procedure ensures that at least existing levels of quality of supply are respected.

The service includes contracting with selected flexibility operators, agreeing upon the management of their response, and determining fair terms and conditions for the contract. Determining fair terms and conditions is complex, it must consider the duration of the contract, and the remuneration scheme towards flexibility providers. Contracting flexibility should indeed benefit society, not solely network operators or RES producers. Consequently, this service should be transparent.

In order to illustrate the service, consider the following example. Assume load flow calculations reveal that the Distribution System Optimiser will be constrained on a feeder in the future. It therefore launches a call for tender which reveals that some flexibilities adding up to 1 MW are more economical to contract with than network reinforcement. In this instance, if these flexibilities are reliable and can be provided with high availability during critical moments, they would be contracted by the Distribution Constraints Market Operator. The network would benefit from savings in network reinforcements if the complete reinforcement of the grid is a more expensive long-term investment.

Lastly, the call for tender to contract flexibilities is only one (albeit novel) mechanism to develop the network, besides e.g. the existing services of reinforcing the network, optimising the low voltage load phase balance and/or network tariff structure (within the regulatory framework), and implementing new grid connection contracts (e.g. limiting the amount of power to be fed at specific periods) with grid users. All these available levers should be included when formulating the multiannual distribution network development masterplan.

Distribution constrains market (day-ahead and intraday)

The Distribution Constraints Market Operator will operate a constraints market to solve specific distribution network constraints. This market will operate through the day-ahead to hours-ahead timeframes. The well-functioning of this market (i.e. liquidity) will be subject to the amount of flexibility that is offered by flexibility operators. It will as the longer term segments also are subject to the relationship between the constraint that needs to be managed and the amount of flexibility actually available, i.e. the relevant “market” might be very narrow. The flexibilities acquired at this market will be used to optimise the distribution network management (except for losses) at the lowest cost.

The distribution constraints market serves to select, purchase and activate flexibilities offers from units[37] connected at distribution system level. The selection and activation of flexibility offers are done by the Distribution System Optimiser. These offers are selected on the basis of their economic value and potential to solve specific network constraints.

The Distribution Constraints Market Operator receives, organises and manages the activation of flexibility offers[38]. The flexibility offers received are sent to the Distribution System Optimiser which performs all the calculations needed to create the merit order list. Then, the Distribution Constraints Market Operator executes the activation planning sent by the Distribution System Optimiser. When managing the activation of these flexibilities, the Distribution Constraints Market Operator can modify the activation planning and even modify the deactivation time of a currently activated flexibility offer.

[37] Generation or Load
[38] Once flexibility is needed, the Distribution Constraints Market Operator sends the signal to the flexibility operator/provider for its activation.

4.6.3 DSO in the role of Distribution Constraints Market Operator

Figure 19 provides an overview of the interactions foreseen for the Distribution Constraints Market Operator on the provision of services to third party roles. In general, the Distribution Constraints Market Operator is foreseen to interact with the Distribution System Optimiser, the Data Manager, BRPs, the TSO, and flexibility operators. This role also has to communicate with market operators of other markets (e.g. power exchanges for wholesale markets or TSOs for balancing markets).

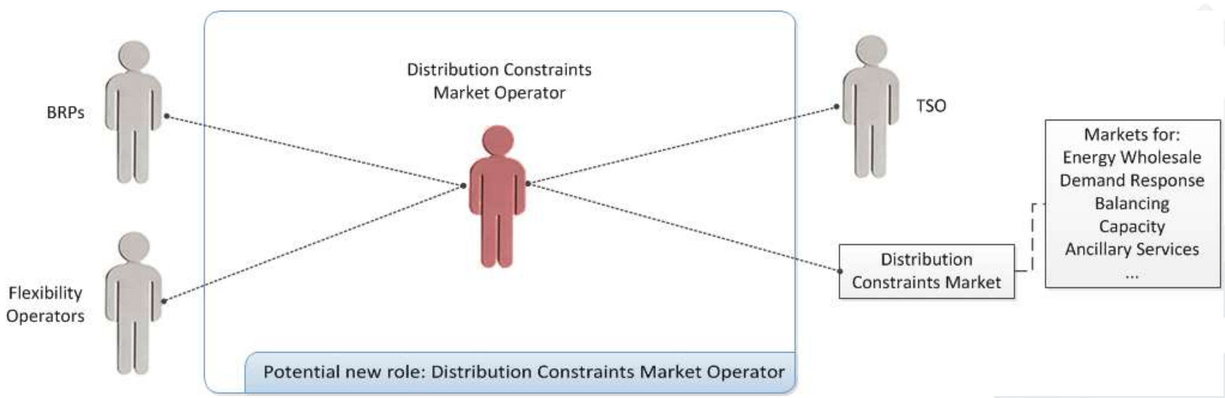

Figure 19 - Overview of the interactions of the Distribution Constraints Market Operator

The interaction with the Distribution System Optimiser supports the activation of flexibility programmes proposed on the distribution constraints market in coordination with the TSO (section 4.2.2), which in turn supporting the Distribution Constraints Market Operator on its interaction with flexibility operators. The Distribution Constraints Market Operator may also provide information on network reinforcements needed to the Distribution System Optimiser, especially if it activates bids in the same area more than initially envisioned in its long-term forecasts. The interaction with the Data Manager provides data needed for the operation of different markets (section 4.3.2). This process supports the pre-qualification of bids performed by the Neutral Market Facilitator/Enabler.

The Distribution Constraints Market Operator also needs to collaborate closely with BRPs and flexibility operators. This interaction serves to minimise the potential impact the activation of flexibilities may has on the BRPs' planned programmes. For the flexibility operators this interaction serves to optimise the use of flexibility offers across the different markets. As part of the interaction, the role provides information services concerning accepted and activated flexibilities in a certain balancing area.

If the role of Distribution Constraints Market Operator is taken by the DSO, flexibilities connected to the distribution network and offered to the constraints market by flexibility operators could be optimally selected and activated from a distribution system security and reliability point of view. Indeed, the technical validation of flexibility programmes (proposed at national markets) could then be evaluated by the DSO. The DSO needs to verify these flexibilities – from a technical perspective – in order to ensure that their activation would not violate regional boundaries on the distribution network. The technical validation of flexibility programmes is a complex task that requires a clear framework so that any distortion to the markets and competition is avoided.

The DSO as Distribution Constraints Market Operator can improve the interaction or cooperation with the TSO – for which the role demands a high level of coordination for the selection and activation of flexibilities. This improved collaboration will enhance system-wide network operations and allow network operators to solve unforeseen constraints with cost-efficient solutions such as the call for tender and the flexibilities offered at the distribution constraints market.

To sum up, flexibility is a limited resource[39]. Units that provide flexibility are distributed across the system and today, a high concentration of these units is being observed at distribution grid level. The DSO needs to reach these flexibilities in a cost-efficient way. An organised market mechanism may provide cheaper flexibility but this market should be regulated so that market inefficiencies are minimised and market power can be avoided.

The DSO as Distribution Constraints Market Operator allows for selection, contracting and activation of flexibility offers throughout all timeframes. The DSO in collaboration with the TSO could make use of these flexibilities to optimise flexibility needs at both networks.

The DSO is in the position to assess the flexibility that is required to solve the constraints as well as the impact the activation of flexibilities may create across the different national markets in a cost-efficient manner (reducing transaction costs since everything is in-house). Note that the impact is managed in collaboration with the Neutral Market Facilitator/Enabler.

For the implementation of both an Active Distribution System Management approach and a Neutral Market Facilitator approach the DSO would need to adopt the Distributor Constraints Market Operator role. By adopting this role the DSO can procure flexibility resources through a market mechanism that is adapted to the characteristics of the system (e.g. localised short term flexibility needs) and the units (e.g. location, capacity).

[39] Note that network operators will always have the option to curtail resources in situations when system stability may be in jeopardy. These situations must be reduced to a minimum since they generate effects that are more costly in the long run. Curtailment should not be seen as a flexibility option.

4.7 Smart Meter Operator

4.7.1 Description and goals

In most countries, a partial or a full roll-out of smart meters is being observed (evolvDSO 2014b). The Smart Meter Operator responds to this current trend by defining a clear set of responsibilities to ensure that the implementation, operation (e.g. software updates), maintenance and decommissioning of the smart meter infrastructure is done in a cost efficient manner. The role may provide a solution to risks related to interoperability and technology barriers for the development of smart grids (CEER 2011).

Currently, the penetration of smart meters across Europe varies widely from country to country[40]. While in Italy the penetration of smart meters is around 95% and in Nordic countries more than 70%, some EU member states have not yet started a roll-out and might not do so in the medium-term if national CBAs show negative results[41]. Nevertheless, improvements in smart meter penetration are expected by 2015, especially in Portugal, Spain, Ireland, and the UK.

The Smart Meter Operator is in charge of the administration of the smart metering system. The actor adopting this role must install, test, maintain, and decommission physical meters (ENTSO-E 2011). The Smart Meter Operator takes care of the information flow between the metering infrastructure (e.g. remote terminal unit, concentrators, metering points) and the communication system. The certification[42] of physical meters may be done by the actor adopting this role (e.g. DSOs in France) or by an independent third party (as it is done in Italy).

The scope of the role includes industrial, domestic and collective housing smart meters. Meters placed at EV charging stations may also be included.[43] The Smart Meter Operator is foreseen to adapt the parameters on the smart meter upon request, after notifying the grid user. For example, the Smart Meter Operator can increase the contracted power of the grid user if the Customer Relationship Manager requests it[44]. If this operation takes place the Data Manager must also be informed. Note that processing and storing metered and network data are not in the scope of the Smart Meter Operator. These activities are performed by the Data Manager (see 4.3.1). Hence, the Data Manager and Smart Meter Operator have strong links in terms of cooperation.

---

[40] http://www.sentec.co.uk/assets/download/471
[41] In some countries, like Germany, the roll-out of smart meters will not be extended to residential consumers in the near future given that their Cost-Benefit Analysis (CBA) was negative.
[42] e.g. checking that the meter is MID compatible
[43] However, this type of meters are out of the scope of the evolvDSO project
[44] Smart meters in Italy are equipped with this functionality. This allows the largest DSO to remotely modify the contracted power of a given grid user.

The Smart Meter Operator has the following sub-roles (Figure 20):

- Smart Meter Installation and Maintenance Operator
- Smart Meter System Administrator

The Smart Meter Installation and Maintenance Operator performs the activities required for the implementation and operation of the physical smart meter. It is thus in charge of the installation, maintenance, testing, certification (unless performed by a third party), and decommissioning of physical smart meters. Note that the set of responsibilities of the sub-role, and thus the role might depend on the way the model is implemented. The Smart Meter System Administrator manages the different metering points.

4.7.2 Services provided

Table 8 shows the services provided by this role. A short characterization for each service is provided below.

Services
Manage physical Smart Meters
Administrate metering points

Table 8 - Service provided by the Smart Meter Operator

Manage physical Smart Meters

This service is provided to the grid users. It concerns the roll-out and administration of the physical smart meters. The service can be decomposed in: installing, maintaining, testing, certifying (if applicable), and decommissioning physical smart meters.

Administrate metering points

This service answers to the need of modifying set points at the different metering points. It acts on the metering point upon request. The request may come from the Distribution System Optimiser (e.g. for load shedding) or from the Customer Relationship Manager (e.g. changing of contracted power). It must be noted that this service implies that the Data Manager is informed about any change.

4.7.3 DSO in the role of Smart Meter Operator

Figure 20 provides an overview of the interactions foreseen for the Smart Meter Operator on the provision of services to third party roles. The figure shows the interactions with grid users and authorities and service providers.

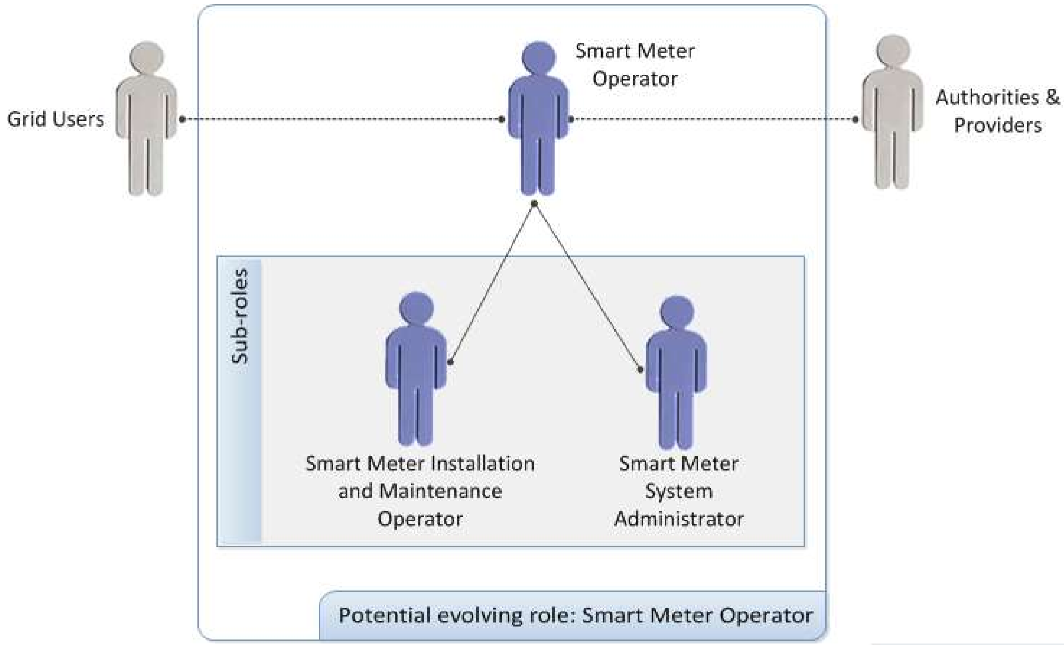

Figure 20 - Overview of interactions of the Smart Meter Operator

DSOs may be assigned with the Smart Meter Operator role due to their experience with the installation, maintenance, administration and decommissioning of legacy meters. On the other hand, across Europe, it is observed that national differences in the implementation of a Smart Meter Operator exist. For example, in Germany all meter operators, i.e. DSO and third parties will be obliged to roll-out such an infrastructure at eligible connections if the government decides to start a roll-out. However, the task of data processing is still managed by German DSOs, i.e. this activity has not been liberalised so all third parties have the duty to provide DSOs with their data. In the UK, smart meters have been rolled-out and are currently being managed and owned by suppliers[45]. These examples suggest that the Smart Meter Operator could be designed as a deregulated role, although such model might affect supplier switching as metering equipment might be required to switch as well.

In sum, this role is responsible for the roll-out, maintenance and decommissioning of smart metering infrastructure.

[45] http://www.meteroperators.org.uk/members.php

4.8 Customers Relationship Manager

4.8.1 Description and goals

The Customers Relationship Manager manages the various contracts and requirements at the distribution system level. These contracts and requirements relate to:

- Access contracts and requirements for grid users
- DSO-Supplier contracts and requirements
- DSO-BRP contracts and requirements

The Customer Relationship Manager is in charge of providing aggregated data needed for certain processes performed by third parties (e.g. TSO). For example, aggregated data is provided to the TSO for the imbalance settlement process.

The goal of the Customer Relationship Manager role is to manage contractual or legal relations with parties that exist in the electricity system, in general, and the retail market, in particular. This role takes care of the communication with grid users (consumers and producers), suppliers, BRPs, flexibility providers and the TSO.

The Customer Relationship Manager is not a new role, but one that will evolve with the new possibilities provided by smart grid technologies. These new possibilities may allow cost reductions and transparency improvements. In addition, the role can increase the efficiency and relevance of the data provided by internalizing the type of data requested (processing the data according to the functions and needs of the requester) and the expected use of the data.

Today, network codes do not fully consider certain roles such as the aggregator role (e.g. re-dispatching aggregators, demand aggregators, aggregators of active power reserve). In the future these types of players will increase. According to (David Trebolle 2013) this lack of consideration elevates the costs of dealing with DER[46]. The Customer Relationship Manager role can help to reduce this cost. Moreover, the role could in collaboration with the regulatory authorities provide the basis for the consideration of these roles within the network codes.

4.8.2 Services provided

Table 9 shows a relevant service provided by this role. This service is provided within the Network Planning and Connection domain at the Planning and Connection timeframe. A short explanation of this service is provided below the table.

Services
Contract non-firm grid access with power limitation

Table 9 - Services provided by the Customers Relationship Manager

[46] Small units below or equal 5 kW

The objective of the service is to offer new types of connection options. These new connection options are characterised by a temporary active power limitation (such as non-firm access), different from a firm connection offer. This offer is provided to grid users in exchange for reduced connection costs and time. By providing this service it is possible to optimise the decisions concerning network reinforcements.

The service allows the Customer Relationship Manager to obtain an additional lever from future connections to ensure the operational security of the distribution network. This lever is one of the options the Distributor System Optimiser could use to solve constraints without heavily relaying on network reinforcement, at least in the short term. The Distribution System Optimiser performs the load flow calculations and elaborates technical and commercial proposals, which are submitted to the grid users by the Customers Relationship Manager.

To provide this service measurement equipment should be installed. When the grid user signs a non-firm access contract, the Customers Relationship Manager is legitimate to request the installation of some controllability device at the premises of the grid user.

It must be pointed out that providing such a contract can have an impact on Balance Responsible Parties and Suppliers. This should be taken into account when defining the business processes required for the provision of the service.

4.8.3 DSO in the role of Customers Relationship Manager

Figure 21 provides an overview of the interactions foreseen for the Customers Relationship Manager on the provision of services to the different stakeholders.

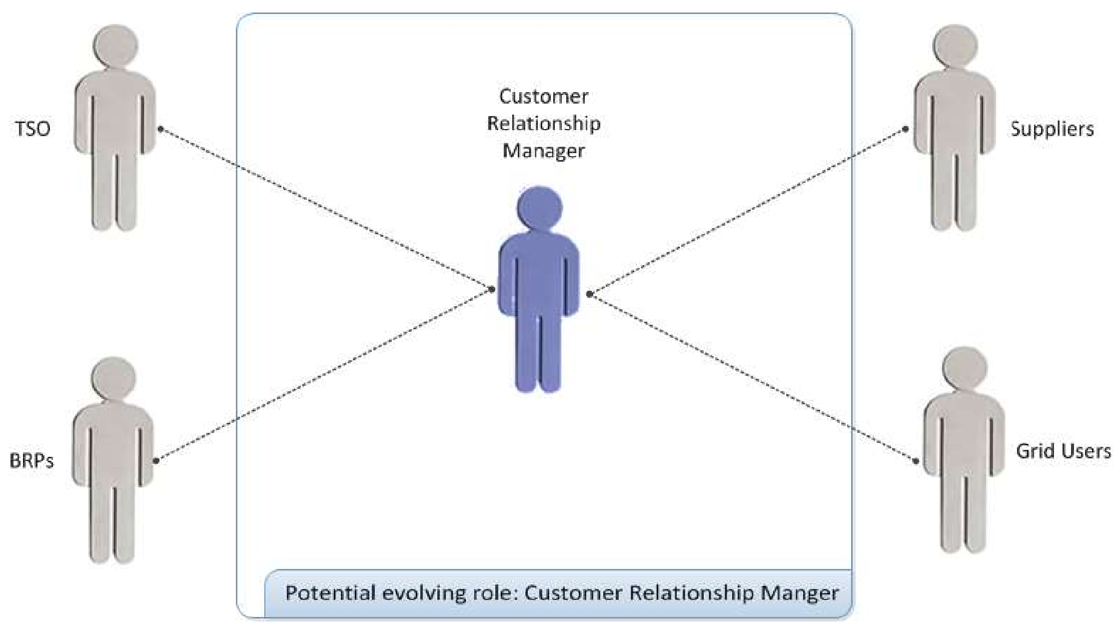

Figure 21 - Overview of the interactions of the Customers Relationship Manager

The interactions foreseen for the Customer Relationship Manager are mainly based on the exchange of data. The data is provided by the Distribution System Optimiser and the Data Manager. The Customer Relationship Manager then uses this information to provide the service to grid users, suppliers, TSOs, and BRPs. The flow of information – and hence the service – starts from a business process supported by the responsibilities of above-mentioned roles.

The DSO as Customers Relationship Manager provides a central point of contact for all requests. Parties served by the DSO would benefit from increased efficiency, relevancy and better understanding. The DSO when adopting this role would contract with producers and consumers[47] or only contract with suppliers[48]. The type of contract will depend on the allowances of the regulatory framework.

In summary, the role focuses on the possibility to provide actors of the electricity market with regulated services based on data management and provision.

47 In France, the biggest DSO contracts with producers and some important consumers.
48 As it is the case in Portugal. However, customer complains may be transmitted to the DSO.

4.9 Other Third Parties Relationship Manager

4.9.1 Description and goals

The Other Third Parties Relationship Manager role interacts with regulators, conceding authorities, local authorities, service providers amongst other third parties. The goal of this role is to manage contractual or legal relations with authorities and providers. For example, the role provides the regulator with information related to the operation of the network (e.g. quality of service, network investments), which is required by national legislation or regulation.

The Other Third Parties Relationship Manager role is not new, but it is expected to evolve with the deployment of smart meters and the subsequent collection of more accurate and detailed data. The role responds to directive 2012/27/EU on energy efficiency. The directive requires public bodies to present an exemplary role on energy efficiency. In order to do so, they must be able to access relevant information, thereby fulfilling their requirements in terms of energy efficiency and continuing to innovate.

The role is composed of the following sub-roles:

- Local Authorities Relationship Manager
- Conceding Authorities and Regulators Relationship Manager
- Third Parties Relationship Manager

The Local Authorities Relationship Manager is responsible for the requests coming from local authorities. The information requested by local authorities may be of a variety of sorts. For example, detailed information may be requested by local authorities for the planning of new housing developments or districts. The information exchange between local authorities and this sub-role would improve planning developments by reducing costs, delays on works and adaptations that could be corrected in advance. It should also help the local authorities to find adequate environmental concepts.

The Conceding Authorities and Regulators Relationship Manager handles the relationship with conceding authorities, in systems where the electricity distribution is operated as a concession. It provides necessary information to these authorities (generally local authorities), either frequently or at request. The sub-role is also in charge to exchange information related to network performance and investments, either of recurring nature or at request. Regulatory authorities use this information to assess the impact of regulatory indicators. In addition, the information allows regulatory authorities to test novel indicators and to evaluate the calibration of former indicators. Indeed, system transparency is enhanced with more detailed information available, which in turn results in better rules to use the network efficiently.

The Third Parties Relationship Manager interacts with service providers and other third parties by exchanging data relevant for the eligible party.

4.9.2 Services provided

Table 10 shows a relevant service provided by this role. This service is provided Ex-Post within the Market domain. A short description of the service is provided below the table.

Service
Deliver other regulated services based on data provision

Table 10 - Service provided by the Other Third Parties Relationship Manager

As described in the previous section, the Other Third Parties Relationship Manager can provide information relevant for local authorities to elaborate programmes in benefit of the local community (e.g. sustainable development and energy demand management policies, improve urban planning, fuel poverty). Regulatory authorities and/or conceding authorities would receive by means of this service, specific incentive regulation data. This data should be used to support the creation of an adequate regulatory framework.

The service provided by this role also deals with the supply of data related to smart grid trials to the energy regulatory authority. The regulator uses this data to perform a cost-benefit analysis of the demonstration projects in place. By making this data available to the regulatory authority, it would be possible to evaluate the performance of current regulatory measures and to propose additional adjustments or modifications. Currently, a similar service is in place in some countries. The difference with the existent service and the one proposed above are the level of detail at which the information is delivered (e.g. data could be available at a smaller time granularity or in a less aggregated form than currently available).

4.9.3 DSO in the role of Other Third Parties Relationship Manager

Figure 22 provides an overview of the interactions foreseen for the Other Third Parties Relationship Manager with third party roles on the provision of services. The role is foreseen to interact with local and conceding authorities, service providers and regulatory authorities, as other third parties. The role will also interact with the Distribution System Optimiser, and the Data Manager.

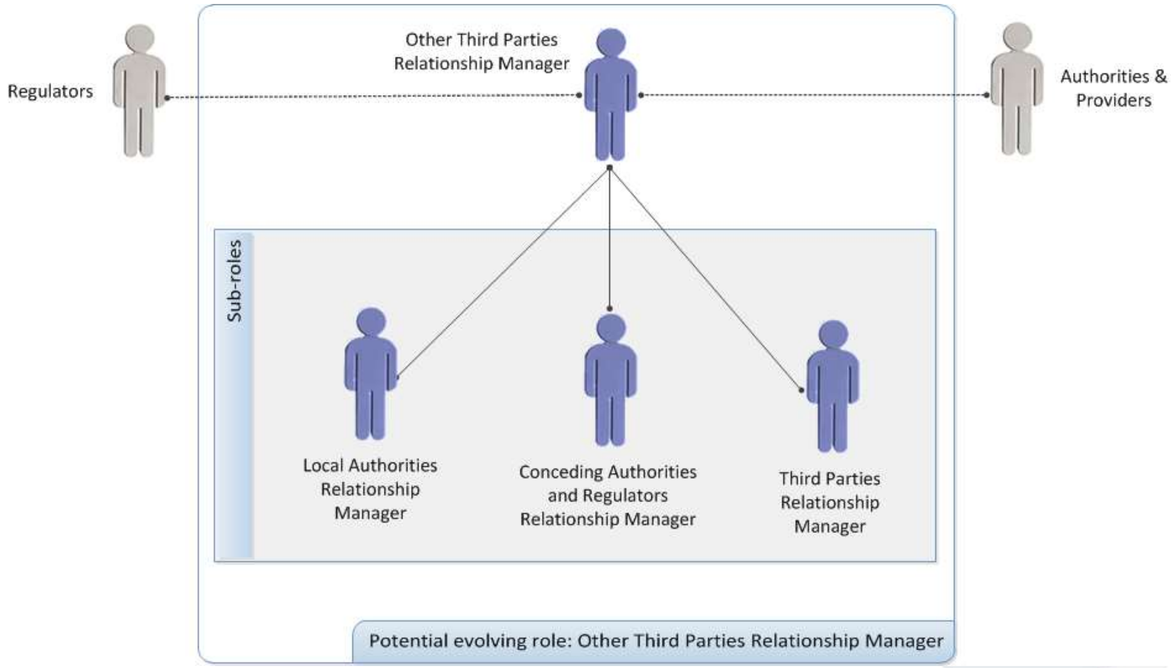

Figure 22 - Overview of the interactions of the Other Third Parties Relationship Manager

This role offers DSOs the opportunity to propose new services to different actors, with local authorities as the most interesting stakeholder. As the exclusive holder of the right to operate and maintain the distribution network in a given area, the DSO is well suited to provide information to these authorities, generally local authorities, either frequently or at request. The DSO would be able to ensure continuous feedback/flow of relevant information, to enhance consumer protection, and to continuously facilitate assessments, in a transparent way. For example, regulatory authorities could be enabled to systematically review customer protection, ensuring they are fit for purpose in a smart world.

This role may also be adopted in full or in part by a third party. However, this could require additional efforts from the regulatory authority (e.g. regulatory changes concerning smart grid data management or concerning potential issues regarding information misuse). In this scenario, regulators may be required to put in place new safeguards to protect customers from data misuse (including data protection and privacy issues). In this respect, protecting the interests of vulnerable low-income consumers becomes important to ensure that all customers are able to access the benefits of smart grids.

In brief, the role focuses on 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.

5 Conclusions

The core responsibilities of European DSOs will remain the same. DSOs, as stated in the European Electricity Directive 2009/72/EC (Article 25), will 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". However, as stated in this report, current trends impose challenges to DSOs.

These challenges may hinder DSOs to fulfil their core responsibilities. The management of the system will become more complex. The current "fit and forget" approach is no longer suitable to ensure a high quality of service and system security. Current challenges require that DSOs perform a more active approach across their activity domains in different timeframes.

To face current challenges DSOs need to implement an Active Distribution System Management approach. By implementing this approach DSOs may be able 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.

To implement an Active Distribution System Management approach DSOs will have to evolve. This evolution will require 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 across the power system and allow them to become Neutral Market Facilitators. Therefore, the definition of this set of roles and related services would help to handle in a cost-efficient way the new uses of electricity which tend to increase the management complexity of the distribution network.

The report describes seven evolving roles: Distribution System Optimiser, Data Manager, Neutral Market Facilitator/Enabler, Contributor to System Security, Smart Meter Operator, Customer Relationship Manager and Other Third Parties Relationship Manager. In addition, there is one new role: Distribution Constraints Market Operator.

The potential (evolving and new) roles presented in this report should be seen as a coherent whole. The roles show complex interactions. By interacting, evolving and new roles improve existing core DSO activities. They guarantee a secure, sustainable and efficient management of the distribution grid with high RES shares. As a whole, they allow to make optimal use of local resources of flexibility at different timeframes. Furthermore, these roles will be of key importance for the DSO in order to (1) facilitate and support energy markets, (2) integrate the ever-increasing renewable capacity (especially wind and solar) and (3) empower consumers.

The set of evolving and new roles and related services defined within this report serve different but complementary purposes. The evolution of the DSO requires implementing an Active Distribution System Management approach as well as a Neutral Market Facilitator approach. These approaches should be implemented while contributing to system security. The DSO will be able to implement an Active Distribution System approach by adopting the evolving role of Distribution System Optimiser and the new role of Distribution Constraints Market Operator. In the same fashion, a Neutral Market Facilitator approach can be implemented if the DSO is allowed to provide the services meant for the Neutral Market Facilitator/Enabler, the Distribution Constraints Market Operator, the Customer Relationship Manager and the Other Third Parties Relationship Manager. Naturally, these services would only be provided if the DSO adopts these roles. The DSO as Contributor to System Security will reinforce the cooperation between DSO-TSO. This improved cooperation will then maintain and could improve system security through all timeframes.

For the realization of an Active Distribution System Management approach and a Neutral Market Facilitator approach the current regulatory framework would have to be adapted. The adaptation of the framework would be highly influenced by the specific context of a particular system. Changes to accommodate the regulatory framework to evolving and new roles may differ in their form. These changes will depend on the local distribution grid characteristics. In some cases, these changes may not represent a major effort and could be implemented in a relatively short timeframe, while, in other cases, structural or fundamental regulatory modifications may be required. Consequently, it is expected that these roles and related services would be adapted to the specific needs of the system in question through different time horizons. This situation makes it highly difficult to foresee a specific path for the evolution and/or creation of these future roles.

For the provision of a sound regulatory framework the evolvDSO consortium recommends implementing regulatory incentives (1) adapted for non-conventional and long-term investments, and (2) suitable for promoting innovation. In addition, the consortium recommends the alignment of long-term policies and the definition of adapted efficiency targets. In a smart grid environment, a sound regulatory framework should reduce the investment risk of novel technologies while in tandem provide freedom to decide for the best solution to manage and develop the distribution grid.

The new paradigm 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 specific to the system. 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

CEER, 2011. *CEER status review of regulatory approaches to smart electricity grids*,

CEER, 2013a. Draft Advice on regulating the quality of distribution services Focus on connection, disconnection and maintenance – Electricity and Gas.

CEER, 2013b. *Status Review on the Transposition of Unbundling Requirements for DSOs and Closed Distribution System Operators*, Available at: www.energy-regulators.eu.

David Trebolle, 2013. Network Code on Operational Security - DSO Associations views on the final version of 27 February 2013.

EC TF for Smart Grids, 2011. Expert Group 3: Roles and Responsibilities of Actors involved in the Smart Grids Deployment.

ECORYS, 2014. The role of DSOs in a Smart Grid environment.

ENTSO-E, 2011. The Harmonised Electricity Market Role Model.

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

Eurelectric, 2014a. *Electricity Distribution Investments: What Regulatory Framework Do We Need?*,

Eurelectric, 2014b. Flexibility and Aggregation Requirements for their interaction in the market.

evolvDSO, 2014a. *Definition of a limited but representative number of future scenarios*, Deliverable 1.1, evolvDSO Project.

evolvDSO, 2014b. *Evaluation of current market architectures and regulatory frameworks and the role of DSOs*, Deliverable 1.2, evolvDSO Project.

IEC/PAS 62559, 2008. IntelliGrid methodology for developing requirements for energy systems.

Ignacio Pérez-Arriaga et al., 2013. *Think - From Distribution Networks to Smart Distribution Systems: Rethinking the Regulation of European Electricity DSOs*,

Jargstorf, J. et al., 2014. Economic Signals in Grid Tariffs for Residential Grid Users. In *EEM11*. International Conference on the European Energy Market (EEM). Cracow, Poland.

Mallet, P. et al., 2014. Power to the People!: European Perspectives on the Future of Electric Distribution. *IEEE Power and Energy Magazine*, 12(2), pp.51–64.

Salon, C., Huet, O. & Blanc, F., 2013. How DSO could facilitate system optimization in new market mechanisms for distributed resources. In *22nd International Conference and Exhibition on Electricity Distribution (CIRED 2013)*. pp. 1–4.

Smart Energy Demand Coalition, 2013. *A Demand Response Action Plan For Europe - Regulatory requirements and market models*,

Smart Grid Task Force, 2013. *EG3 First Year Report: Options on handling Smart Grids Data*,