Bidirectional Power and Data Flow via Enhanced Portal Based TSO-DSO Coordination

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***Abstract*—This paper presents enhanced coordination between TSOs and DSOs with regard to market related information and data infrastructures that can be developed using a cloud-based approach. The definition of use cases with regard to the levels of portal access is proposed and particular attention is given to the different time and space scales of data that is needed to provide harmonised access. The attributes of the information layer as defined in the Smart Grid Architecture Model (SGAM) are reflected in the formally defined use cases. Different access levels are demonstrated via the definition of use cases for a trusted cloud platform by considering harmonised access processes and role-based access control for security.**

Keywords— TSO-DSO Interoperability, Role-based Access Control, Use Case, SGAM.

I. Introduction

The integration of renewable energy and the continued transformation of distribution networks from passive to active mode of operation has increased the need for enhanced cooperation between DSOs and TSOs. Real-time data exchange is needed more by different stakeholders in order to optimise the generation, transmission and distribution within the electricity network, and the introduction of information technologies could facilitate such purposes by integrating new players within the operation of the power systems. However, a scalable data management mechanism is needed to be aligned with the flexibilities that are introduced by advanced ICT infrastructures.

The electricity market is increasingly reliant on intensive data management and the availability of that data at required periods and frequencies. An SGAM-based [1] approach requires a large amount of data that is organised through communication channels for different functions. The availability of data from a secure and scalable web portal offers high flexibility when dealing with daily operations in the electrical power system such as demand forecasting, voltage regulation, reactive power consumption and renewable energy integration. There are different scenarios that could represent the cooperation between different parties in the electrical power system, which could be addressed within an appropriate communication mechanism [1]. New market models are needed to represent the different market mechanisms in light of the changing nature of distribution networks. This gradual and continuous change with regard to distribution networks will result in more functional requirements that need to be organised through communication links and secure data exchange platforms.

This paper addresses the information exchange mechanisms and related ICT infrastructure for different stakeholders [2], [3]. It also considers one of the most reliable sources of data for EU member states with regard to power system operations and market access that is known as the Transparency Platform (TP) as operated by ENTSO-e. The TP was initially launched because of the European Regulation 543/2013 [4]. The data flow within the SGAM layers and electrical power system is illustrated and mapped through the framework of the smart grid. This paper demonstrates the different needs for stakeholders based on perspectives from several EU member states [2], [3].

II. Scope and Methodology

In this paper, portal access using a cloud based platform design is defined in order to enable a scalable mechanism for data exchanges between TSOs, DSOs and other stakeholders. In particular, different considerations are taken into account in order to enhance a portal-based TSO-DSO coordination via role-based access control. The scope of this paper includes the following tasks:

- Evaluating the possibility of using currently available infrastructures to implement selected use cases.
- Developing access infrastructure for the National Institute of Standards and Technology (NIST) domains and mapping it through SGAM.
- Studying different use cases for portal design and data exchange within a cloud based platform.
- Achieving portal access based on the actor operations in the energy market and network.
- Achieving regulatory access for reliability regarding the use of cloud based platform defined for all types of data based on the data type (businesses or technical data).

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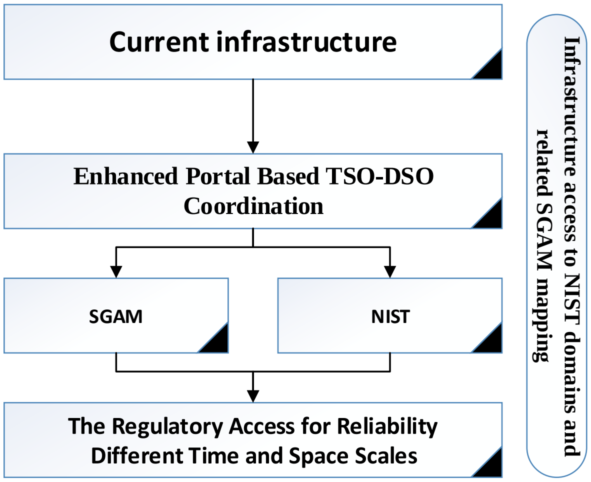

Figure 1. Scope and methodology

The proposed methodology shown in Fig. 1 relies on the adoption of secure cloud based infrastructure for data exchange in the power sector that could be evaluated and improved by addressing the gaps and shortages of the currently used techniques and tools.

III. DATA BOUNDARIES BETWEEN STAKEHOLDERS

A. *Roles Interactions between Stakeholders*

The use cases presented in the deliverables of TDX-ASSIST project [5]-[6] have different business and system perspectives for the interactions between the different stakeholders, drawing different data boundaries for the interacted roles and models of communications between the TSO-DSO and any other parties. In Fig 2., the different roles of the stakeholders are presented. In particular, the interactions between them are illustrated according to the perspective of TDX-ASSIST project, where each role type creates its own data scheme within the planned data practices.

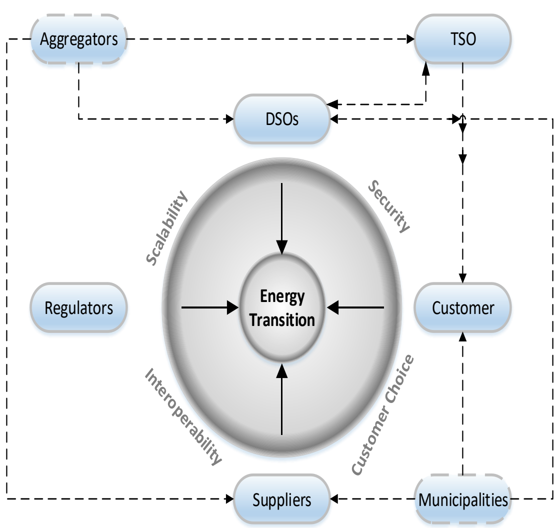

Figure 2. Interactions of roles according to the perspective of stakeholder collaboration [7].

The dashed lines in Fig.2 represent the interaction of the stakeholders according to the data exchange principles which aim to develop the aspects of ICT tools and techniques that are represented in the scalability, security and interoperability besides reaching the customer choice within a flexible approach. In particular, the data exchange process as well as the boundaries between the parties in Fig. 2 can be organised resorting to a data exchange platform capable of dealing with the following data [7]:

- Functional technical data such as the information that is handled by SCADA systems, in order the stakeholders can share technical information, such as, voltage measurements, active power management, congestion management, fault locations, and outages planning..
- Data handled by the market participants and related to the market mechanism, such as, market balancing and settlement, DSO-connected resources, generation reserves, and distributed flexibility resources.

B. *Data exchange platform*

In the last years, the data exchange in the electricity market has become a necessity due to the increasing needs for employing the DSO side and its flexibility resources within the market balancing and settlement process. In addition, the integration of the retail market within the wholesale market could be one of the main features for the future development of a common data exchange platform. Finally, the appearance of several new technologies, such as Electrical Vehicles (EVs), in the last mile of the network, has imposed new roles for the DSO, which is expected to reshape the traditional interaction between the TSO and DSO into a new sophisticated system

Several countries have evaluated the possibility of creating a centralised common platform for data exchanges between various stakeholders, such as the three cases that are analysed and recommended in the EG3 First Year Report [8], supporting the synergy between ICT and the energy sector, for the purpose of having more collaboration between the TSO, the DSO and any other party in the electricity market. The three scenarios that are offered by the EG3 First Year Report are as follows [8]:

- Case 1: The DSO acts as facilitator for the market by managing a data hub that provides the market with information in an equitable manner. In such scenario, the DSO is able to provide value added information related to the grid functionalities and operations.
- Case 2: The central hub for the data exchange is managed by a third party and an independent data platform.
- Case 3: A Data Access Point Manager (DAM) model, where the data is exchanged and accessed through any regulated participants in the market, is used. Within this context, the data flow is determined according to the regulated stakeholder and the boundaries of their linked roles. In this case, a wide range of aspects, such as, EV, distributed generation (DG), flexibility resources, and smart metering are covered.

The portal access is granted based on the business nature of the stakeholders in order to activate the functions given to each type of access. Fig. 3 shows the architecture designed for the stakeholders as well as for their functional data exchanges in order to allow each side to exchange the information based on its needs and according to the agreed frequency.

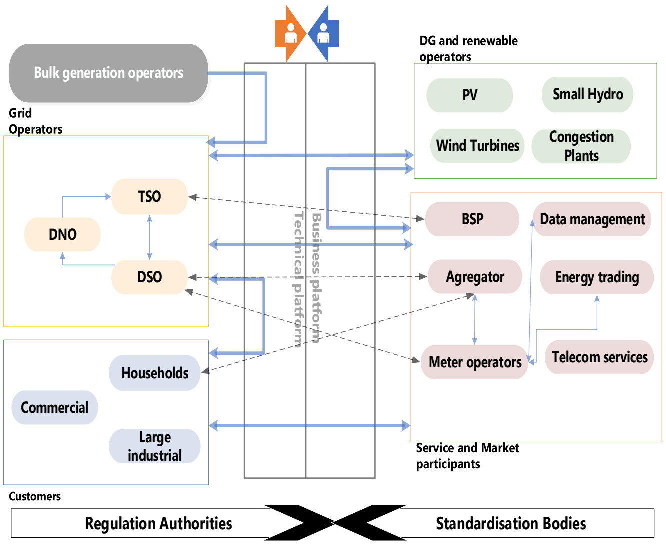

Figure 3. Channels for data exchange via the architecture based on the stakeholder in the network.

IV. DATA FLOW WITHIN THE NETWORK INFRASTURCTURE

Smart grid infrastructures are based on the free movement of the data flow between the different parts of the grid in order to ensure flexible and reliable services through the different stages of the operation of the network and within different time scales. In this way, a data management through the different sectors and stakeholders based on such infrastructure should allow flexible and reliable services by analysing and using the data coming from different sources like sensors and smart meters [9]. In addition, smart switches and routers are also used in the designed data flow providing the possibility of sending information as well as and signals to the operators regarding the detected faults and outages via their communication channels [10]. The data flow in the energy network is shown in Fig. 4.

The main aim of using a smart grid infrastructure for managing the data flow is to organise the integration process for the renewable energy within the context of the available energy utilities. Moreover, it helps to coordinate the generation and consumption processes between the DSOs, the TSOs and the generation sector within the context of the renewable energy, supporting the bidirectional behaviour for the data and energy flow. In addition, it also helps to overcome the technical and logistic challenges appearing when dealing with different stakeholders starting from the generation side and reaching the consumption side.

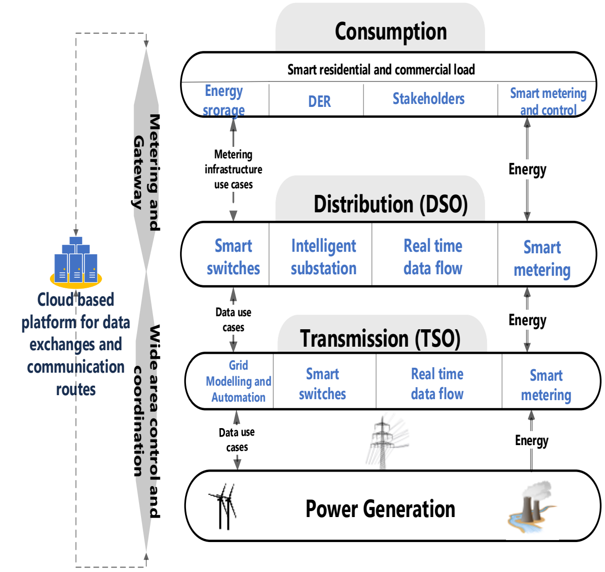

Figure 4. Bidirectional power and data flow within the smart grid value chain.

V. DATA FLOW WITHIN SMART GRID LAYERS

The smart grid layers, which are described in IEC 62559, interact with each other as shown in Fig. 5. The component layer represents the physical infrastructure in the smart grid containing the devices. In particular, this layer is responsible for dealing with the information, communication and functions of the other layers, including systems, components, applications, power system equipment, protection, tele-control devices, network infrastructure and intelligent devices, among others [11], [12]. The communication layer represents the communication channels and technologies that are used to communicate within specified techniques and standards, such as, TCP/IP and PLC. The information layer allows improving the exchange of the data models and types between the different stakeholders since it organises the information exchanges between the different parts according to their role and functions, e.g. CIM and EDIFACT. The function layer describes the different applications that are applied based on the role and type of task associated with each party. The logical functions in this layer are connected directly with the physical architecture of the data flow, such as service platforms for the supplier change process. Finally, the business layer defines the models based to their management roles allowing the standards of the used systems and models within the architecture of the smart grid to be enhanced. As shown in Fig. 5, all of the smart grid layers interact with each other through different systems, based on specific standards that create use cases and scenarios for data exchanges and business models in the process of coordination between the DSOs, TSOs and stakeholders [13].

Within the context of the conceptual model of the smart grid, the data flow passes through several communication of layers and security standards covering the following issues towards the interaction between the different stakeholders in the network [14]:

- Electric Storage
- Smart Substation Automation
- Blackout Prevention/ Energy Management System (EMS)
- High Voltage Direct Current (HVDC)/ Flexible Alternating Current Transmission System (FACTS)
- Distribution Automation
- Electro-mobility and Condition Monitoring
- Advanced Distribution Management
- Distributed Energy Resources
- Advanced Meter Infrastructure
- Demand Response and Load Management
- Smart Home and Building Automation

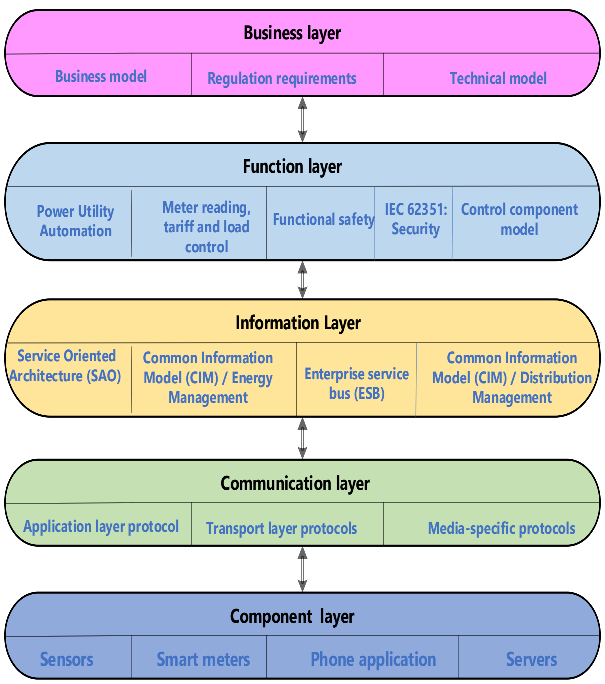

Figure 5. Energy management via smart grid layers: standards and data flow.

There are several standards that have been defined based on the conceptual model of the smart grid as well as on the data flow through this conceptual model. In particular, more than 100 IEC standards supporting the interaction between the different layers of the smart grid have been brought to light. As shown in Fig. 5, the core standards are mapped within the layers of the smart grid. The different core standards that are linked with the smart grid layer are as the followings [12]:

- IEC/TR 62357: Service Oriented Architecture (SAO)
- IEC 61850: Power Utility Automation
- IEC 62351: Security
- IEC 62056: Data exchange for meter reading, tariff and load control
- IEC 61970: Common Information Model (CIM)/ Energy Management
- IEC 61968: Common Information Model (CIM)/ Distribution Management
- IEC 61508: Functional safety of electrical/electronic/programmable electronic safety-related systems

VI. ACCESS INFRASTRUCTURE FOR (NIST) DOMAINS

The portal access is defined based on several factors that contribute in shaping the type and level of access. Usually, any access is defined based on the role and the function of the actor within a system. In Work Package 1 (WP1) and Work Package 2 (WP2) of TDX-ASISST project, several use cases accounting for the interaction between the TSOs, DSOs and other stakeholders based on the specified roles and standards, have been introduced. Nevertheless, the general access level for each stakeholder can be built on the design of the conceptual model of the smart grid adopted by NIST, which shows the interaction among different domains [12]-[14]. NIST proposes to divide the domains into seven domains, consisting of actors, systems, application and devices that contribute in the process of data exchanges through different interfaces and access levels. NIST domains are as follows [12]-[14]:

- Customers: This domain is represented in the end user that interacts with the distribution network, service providers, market and operation.
- Distribution: This domain deals with the sides of the customer, transmission, market and operations.
- Transmission: This domain deals with bulk generation, distribution side and operation team.
- Bulk generation: This domain mainly interacts with transmissions, operations and market.
- Operations: This domain deals with all of the other domains in the smart grid conceptual model.
- Service provider: This domain deals with the customers and operations within the domain of the market.
- Market: Within the market domain, all the other domains can interact with each other.

The different applications associated with each domain include several tasks that are assigned to different actors, being the domains capable of interacting with each other directly or indirectly through several layers of interfaces as shown in Fig. 6 [12].

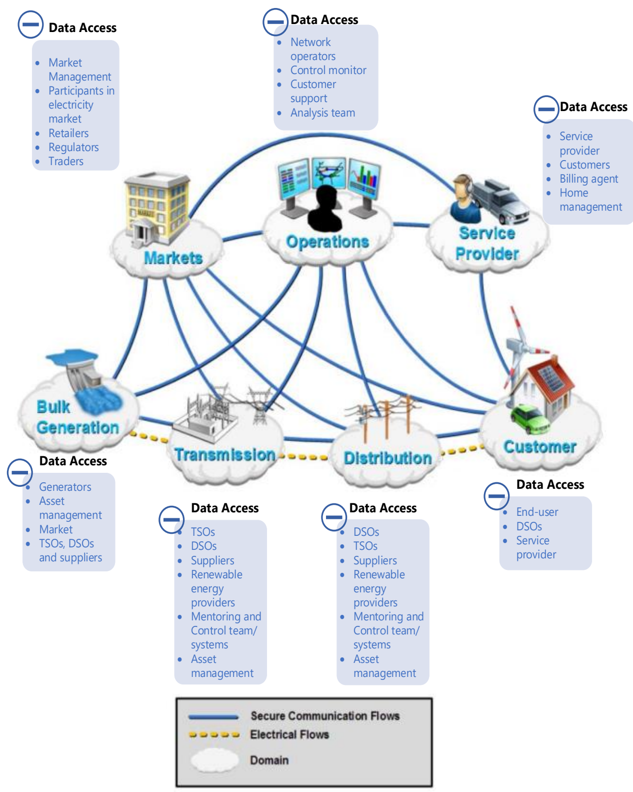

Figure 6. NIST smart grid conceptual model representing the different access based on the actor tasks and through secure communication flows [12].

VII. CONCLUSIONS AND FUTURE RESRECH

In recent years, the electricity sector unbundling has led to the need for new energy services, new market entrants and an increased electricity market efficiency and competitiveness. Within this context, different communication links and new services between the different unbundled sides are required, creating new needs for data exchanges and its frequency.

In this paper, a reliable data management mechanism facilitating the frequent data flow within the network stages based on a smart grid infrastructure has been proposed and developed. In order to do so, the data management for different use cases has been studied so that the basic requirements for the cloud based data portal design as well as its specifications could be identified and addressed. Based on these use cases, it has been observed that changing the landscape of the electricity network increases the need for information exchanges between different stakeholders, especially of the main players in the network, namely, the TSOs and the DSOs. In order to address such an issue, the proposed data management mechanism helps to coordinate the generation and consumption processes between the DSOs, the TSOs and the generation sector, supporting the bidirectional behaviour for the data and energy flow. In addition, it also helps to overcome the technical and logistic challenges appearing when dealing with different stakeholders starting from the generation side and reaching the consumption side. Future research will investigate the benefits of extending the web based portal design of the transparency platform using cloud-based approach.

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REFERENCES

[1] Santodomingo, R., et al. "*SGAM-based methodology to analyse Smart Grid solutions in DISCERN European research project*." 2014 IEEE International Energy Conference (ENERGYCON). IEEE, 2014.

[2] TDX- ASSIST Project – WP3 – D3.1 "Survey Report - Evolving data access needs" March, 2018

[3] TDX- ASSIST Project – WP3 – D3.2 "Data portal access " September, 2018

[4] European Commission. Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex 1 to Regulation (EC) No 714/2009 of the European Parliament and of the Council Text with EEA Relevance; 2013.<http://data.europa.eu/eli/reg/2013/543/oj.

[5] TDX- ASSIST Project - WP1, "*Coordination of Transmission and Distribution data eXchanges for renewables integration in the European marketplace through Advanced, Scalable and Secure ICT Systems and Tools - D1.1 STATE OF THE ART - TSO-DSO INTEROPERABILIT*," TDX- ASSIST Project., no. December, 2017.

[6] TDX- ASSIST Project- Work Package 2, "TDX-ASSIST D2.1: STATE OF THE ART – DSO-MARKET INTEROPERABILITY," no. December, 2017.

[7] Eurelectric, "*The Role of Distribution System Operators (DSOs) as Information Hubs*,"2010. [Online]. Available: http://www.eurelectric.org/media/44143/role_of_dsos_as_information_hubs_final_draft_10-06-10- 2010-200-0001-01-e.pdf

[8] Smart Grids Task Force, "*EG3 First Year Report: Options on handling Smart Grids Data*," no. January, p. 119, 2013.

[9] H. Daki, A. El Hannani, A. Aqqal, A. Haidine, A. Dahbi, "Big Data management in smart grid: concepts, requirements and implementation ", 2017.

[10] Siemens AG. "Communication network solutions for transmission and distribution grids". (2017). Retrieved from https://www.siemens.com/content/dam/webassetpool/mam/tag-siemens-com/smdb/energy-management/energy-automation-and-smart-grid/smart-communication/emdg-b90013-00-7600-160662-communication-network-solutions-br.pdf

[11] Force, Smart Grid Task. "EG3 first year report: options on handling smart grids data." Expert Group 3 (2013).

[12] International Electrotechnical Commission. "IEC smart grid standardization roadmap." (2010).

[13] Uslar, Gottschalk, Delfs "The Use Case and Smart Grid Architecture Model Approach", 2017

[14] EPRI, Report to NIST on the Smart Grid Interoperability Standards Roadmap", EPRI, Jun 17, 2009