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Design and Development of Enhanced Data Exchange to Enable Future TSO-DSO Interoperability

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SUMMARY

The research project presented in this paper aims to design and develop novel Information and Communication Technology (ICT) tools and techniques that facilitate scalable and secure information systems and data exchange between Transmission System Operators (TSOs) and Distribution System Operators (DSOs). The three novel aspects of ICT tools and techniques to be developed in the project are: scalability – ability to deal with new users and increasingly larger volumes of information and data; security – protection against external threats and attacks; and interoperability – information exchange and communications based on existing and emerging international smart grid ICT standards. The projects consists of formal definitions of TSO-DSO Business Use Cases (BUCs) and System Use cases (SUCs) that can have several scenarios based on the technical and business communication between the TSOs, DSOs and other stakeholders. The BUCs are described using agnostic terminology that is invoked by business and system actors (people or external systems), often working in collaboration to achieve a specific goal that provides clear definitions for the value of the system and business actors. Different BUCs and SUCs are modelled in this project to represent relevant scenarios that contributes in improving interoperability, security and scalability between TSOs and DSOs as well as between DSOs and other market participants such as the Significant Grid Users (SGUs) and Renewable Energy Sources (RES). The penetration of RES within the boundaries of the DSOs is implemented to reflect the possibilities of providing flexibility resources that contribute in the market scenarios and their potentials to relax the operational constraints. Specific BUCs scenarios will be developed for practical demonstration to verify the compliance with existing national market design.

KEYWORDS

Transmission System Operators (TSOs) - Distribution System Operators (DSOs) – Interoperability - Information Systems - Common Information Model (CIM) – Use Cases

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1 INTRODUCTION

This paper presents the design and development of novel Information and Communication Technology (ICT) tools and techniques that can facilitate scalable and secure information systems and data exchange between Transmission System Operators (TSOs) and Distribution System Operators (DSOs) [1]. The paper addresses three novel aspects in the development of ICT tools and techniques development: scalability – ability to deal with new users and increasingly larger volumes of information and data; security – protection against external threats and attacks; and interoperability – information exchange and communications based on existing and emerging international smart grid ICT standards [1]. In addition, the formal specification of standardised uses cases [2,3] will be described from the perspective of the Smart Grid Architecture Model (SGAM) [4].

The integration of renewable energy and the continued transformation of distribution networks from passive to active modes of operation have increased the requirement for cooperation between DSOs and TSOs that reflects smart grid development. Data exchange across different time horizons is increasingly needed by different stakeholders in order to optimise the generation, transmission and distribution across the electricity network as a whole, and the introduction of novel ICT tools could facilitate this purpose by enabling the integration of new stakeholders within the operation of the network. Furthermore, big data management mechanisms also need to be aligned with the flexibilities that are introduced by advanced ICT infrastructure [1,10,11,12]. This paper considers one of the most reliable sources of data in EU countries for power system operation and related markets that is known as the Transparency Platform (TP) and is operated by ENTSO-e [5]. The TP was launched as a consequence of European Regulation 543/2013 [6]. The data flow within the SGAM reference layer model [4,7] and associated electrical power networks can be mapped via the framework of the smart grid.

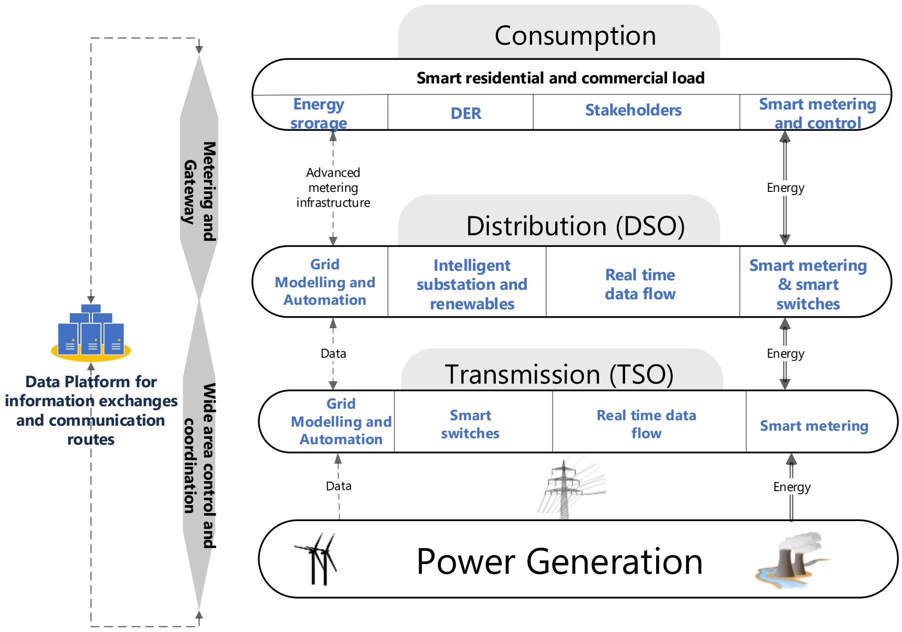

Figure 1: Bidirectional power and data flow within the smart grid value chain

As described in Figure 1 the development of smart grid ICT infrastructure is based on the free movement of data between the different parts of the grid in order to ensure flexible and reliable services throughout the different stages of the operation of the network and within different time scales.

The paper mainly focusses on enhanced TSO-DSO interoperability, but will also consider DSO interaction with other market-participants, such as DSOs, Aggregators, Distributed Energy Resource Operators and Micro-grid Operators [1]. Furthermore, the design and development of information or data access portals that enable business processes involving relevant actors in the electrical power sector will also be presented [1]. The paper also presents details of the research and development that will be needed to ensure that greater levels of TSO-DSO interoperability can be realized, and to also harmonise a wider range of standardisation activities that are presently underway or complete [1].

2 OVERVIEW

The data exchange and coordination between TSOs and DSOs is mapped through the various layers of SGAM in order to regulate the journey of data from the source until the final receiver. The application of SGAM concept in this project reflects the bidirectional behaviour of the data exchanges between the different stakeholder and system components starting from the generation and ending at the last mile of the network. The scenarios of market interactions have been demonstrated through different business and system Use Cases that consist of various situations for exchanging data between several actors based on standardised communications. Furthermore, the SGAM layers interact with each other through different systems and according to specific standards that support the creation of use cases [7] and scenarios for data exchanges and business models relating to coordination between the DSOs, TSOs and stakeholders as seen in Figure 2.

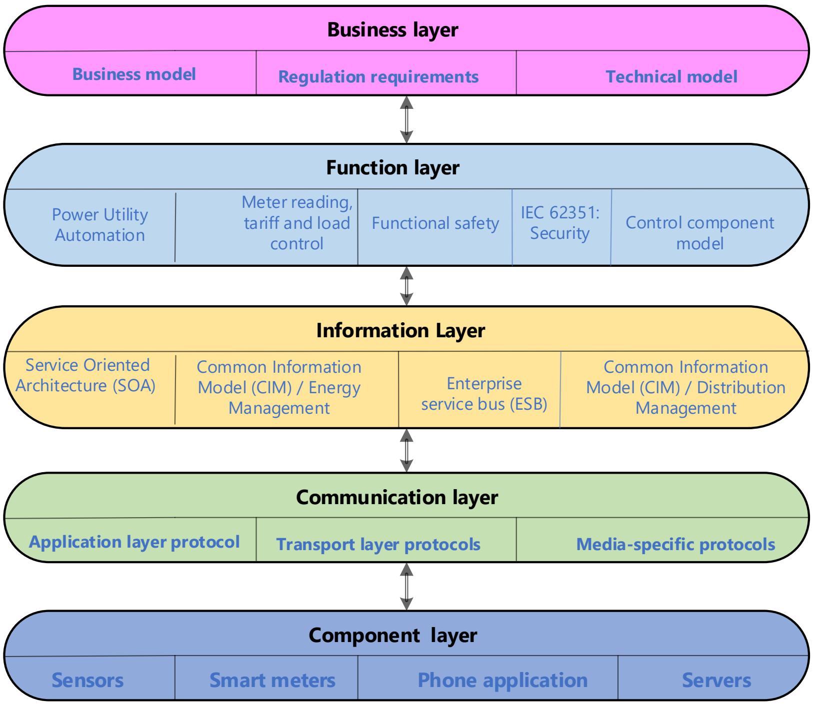

Figure 2: Energy management through SGAM layers: standards and data flow

There are several key standards that were defined according to the conceptual model of the smart grid and associated data flows as well as more than 100 IEC standards have been established that support the interaction between the different layers of the smart grid. The core standards are mapped within the layers of the smart grid as seen in Figure 2. The different core standards that are linked with the smart grid layer are as the followings [8]:

- IEC/TR 62357: Service Oriented Architecture (SOA)
- IEC 61850: Power Utility Automation
- IEC 62351: Security
- IEC 62056: Data exchange for meter reading, tariff and load control
- EC 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

2.1 Use case methodology

The Use Case methodology IEC 62559 has been developed in the context of the M/490 mandate [9] from the EC to CEN, CENELEC and ETSI [4] in particular as seen in Figure 3. The developers needed to have a common way of documenting future applications of so called smart grid technologies in order to determine the existence of standardization gaps. In this context, a range of experts with various technical and organizational backgrounds had to integrate their relevant workforce, knowledge and efforts.

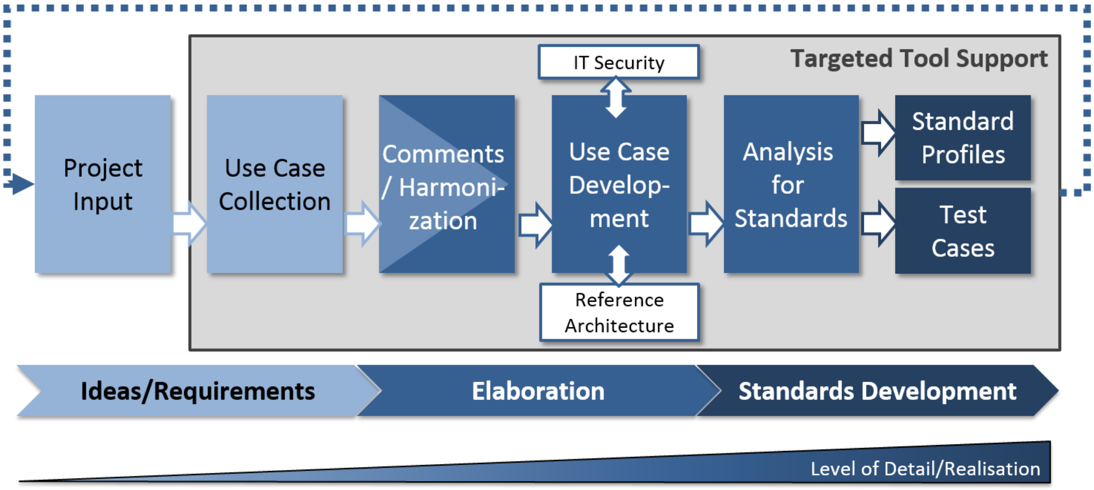

Figure 3: M/490 idea of Use Case management processes [7]

It is believed that 40% of translation time is spent in terminology research. A database or different terminology management tools will effectively reduce this time and also facilitate the work of in-country reviewers if your company has employed one. In-country reviewers are providing final quality check of all content. They are generally experts in the product and/or content and are native of the target country. In order to cope with those requirements from European Commission, the IEC 62559 template was used to properly collect terminology in the context of Smart Grid standards, technologies and solutions [2]. It proved to be a success, the "sustainable processes group" was able to build a repository with future Smart grid Use Cases, harmonize them between requirements form individual member countries and then feedback information to the standardization bodies in order to make IEC create proper standards for the future needs of the Smart Grid. The process as well as the resulting set of tooling and methods has been presented in depth [7]. The template has proven to be the basis for all work done in the M/490 mandate [9] and can be seen as the state-of-the-art in documenting requirements for power systems and related communications.

In summary, the most important aspects of a Use Case to be elicited for requirements definition are as follows:

- The goal of the Use Case, which is usually its name. e.g. "Utility remotely connects or disconnects customer".
- The narrative. A short English text version of the Use Case narrative.
- The actors. An actor is anything that communicates with the system, e.g. a "customer" or a "meter".

- The assumptions that the Use Case is based on. These can constitute requirements in and of themselves.
- The contracts and preconditions that exist between the actors.
- The triggering event that led to the scenario taking place.
- The steps. A numbered list of events that tell the story in detail.

2.2 Use Case Design and Interaction

The prospect of DSO involvement in relevant markets and the related contribution towards operational and planning activities is covered in this project by designing different Use Cases that reflect the active modes of the DSO and the existence of RES within its operational boundaries [10]. Furthermore, TSO-DSO coordination is presented in this project through different BUCs that reflect the interactions of actors in power markets [11], and the communication of applications is represented through the SUCs [12]. The Use Case design and related interactions are illutrated as in Figure 4. Within the research project, the Work Packages 1 and 2 have interdependencies that also relate to the documenting the Use Cases. In certain instances, the Use Cases can be regarded as having the same technical solution that considers different payloads or changes in voltage levels. Figure 4 shows the agreed dependencies seen from both Work Package perspectives [10,11].

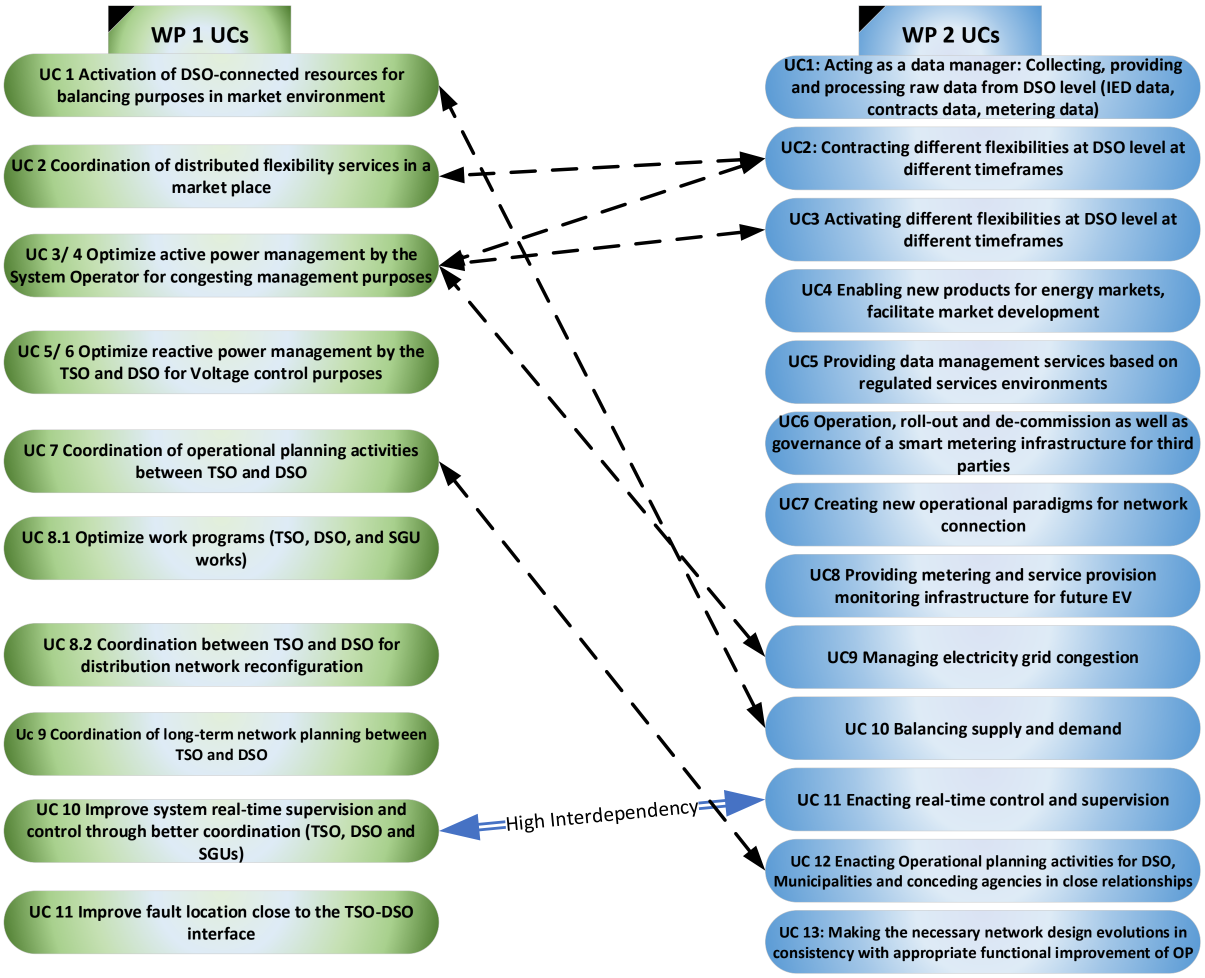

Figure 4: Interdependencies and commonalities between WP 1 and 2 BUC

The Use Case approach based on the IEC System Committee for Smart Energy does provide a meaningful as well as structured way to elicit requirements for the TDX-ASSIST project. In addition, it has proven to be used in different context as well as toolchains.Various Use Cases have proven to be relevant for both Work Packages and their future evaluation will be aligned between the DSO to market as well as DSO-TSO levels. The Use Cases provide a meaningful way for requirements elicitation which will then be part of the SGAM modeling of the technologies and, finally, provide the important inputs for the system architecture to be developed in TDX-ASSIST [1]. It is worth noting that BUCs may target issues related with power system operation, operational planning and long-term planning activities simultaneously, especially when inter-temporal dependencies do exist as described in Figure 5. The Use Cases are modelled and designed based on the Common Information Model (CIM) and CIM profiles will be implemented practically at a later stage of the project in order to verify the business and system objectives of the Use Cases.

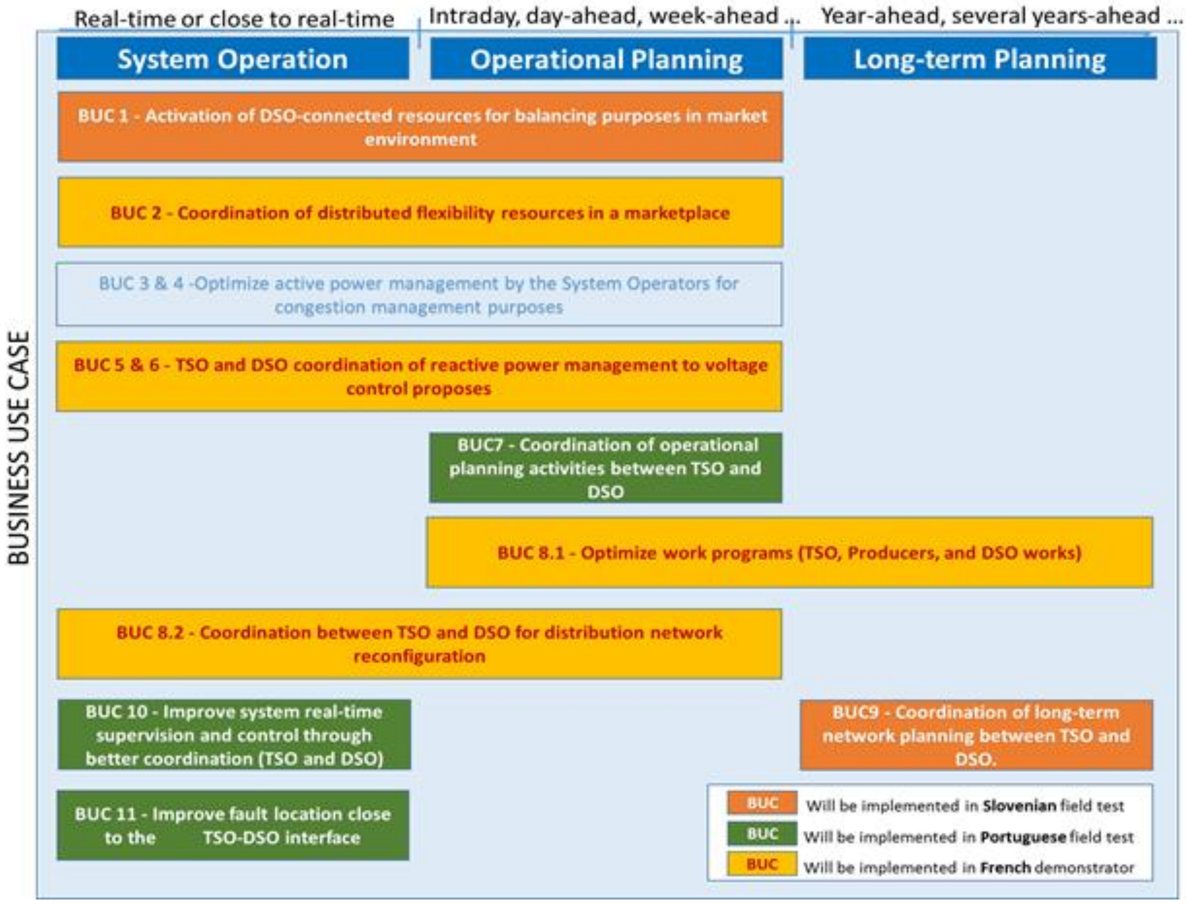

Figure 1: Business Use Cases in the scope of TDX-ASSIST and their different time frames.

Use Case repositories will be developed in order to harmonize energy market data exchanges based on relevant IEC standards. Furthermore, the project will contribute to the development of cyber security standards that must be adopted in the context of information exchange between TSO, DSO and Market participants:

- IEC 62351 series: Cyber Security
- ISO/IEC 27019
- IEC 62443

The observability area between the TSOs is defined sufficiently with regard to power system operation and related markets. However, observability areas between TSOs and DSOs needs to be defined and clarified in terms of common data sets for interoperability purposes. Therefore, observability areas between TSOs and TSOs is also addressed within the design of the Use Cases and a common data set will be provided from different perspectives through the evaluation process of the project.

3 CONCLUSIONS

The topological straucture of power distribution systems has been changing from radial to bidirectional flows. Consequently, the current infrastructure and business management strategies require major changes in order to enable DSOs to have a wider operational impact and to interact more significantly with TSOs. DSOs are required to take greater overall operational responsibilities such as participation in balancing mechanisms and managing markets associated with DER. Such scenarios impose new data exchange procedures that has the potential to enable flexible interaction between TSOs and DSOs in relation to electricity markets. The TDX-ASSIST project aims to provide enhanced TSO-DSO collaboration tools and secure data exchange across the whole system value chain. The proposed ICT tools have the potential to provide greater access and support with regard to cross-border trading and near to real time balancing. Validation of such new business models resulting from the cooperation between different stakeholders is provided through the concept of Use Cases and CIM profiling.

4 ACKNOWLEDGMENT

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