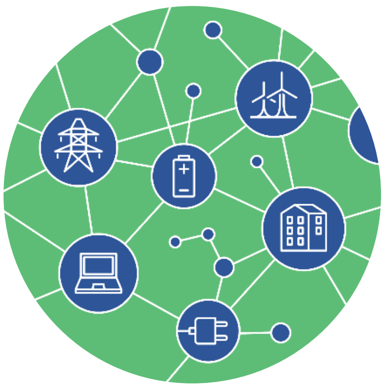
OSMOSE

OPTIMAL SYSTEM-MIX OF FLEXIBILITY
SOLUTIONS FOR EUROPEAN ELECTRICITY

IEC61850 ENTSO-E Profile introduction and Engineering Process Refinement

Task 7.1



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0 Executive summary

The Subtask 7.1.2 of OSMOSE aims at demonstrating an interoperable and efficient IEC61850 engineering process, through different specification and configuration tools and with an implementation in a demonstrator with products from different vendors. This engineering process defines a way to come from a general substation system specification to an engineered and working electrical substation.

This document serves as the first deliverable of the project and describes the IEC61850 engineering process, as it is proposed by the ENTSO-E[1] IEC61850 taskforce and further defined and enhanced by OSMOSE. It also introduces the ENTSO-E profile, its goal and role within OSMOSE. This profile consists of 2 parts, a data model part and an engineering process concept. This document focusses on the engineering process part of the profile, since it is the backbone of OSMOSE 7.1. More details about the ENTSO-E profile enhancements related to the datamodel will be available in deliverable 7.2 and 7.3.

An introduction provides more details about the drivers of the project and the different identified steps and participants.

The main drivers are improved efficiency and interoperability. The different steps within OSMOSE are:

- Engineering process definition
- Demonstration of the process
- Definition of the gaps and recommendations to the IEC61850 standard

Chapter 3 (+ Annex 1, 2 and 3) provides more details on the references used for creating the OSMOSE IEC61850 engineering process, the process itself and explains the main enhancements and extensions that are applied to existing references.

To enable the process, enhancements are needed at the level of the Substation Configuration Language (SCL). These enhancements need to be included in the different engineering software tools provided by the OSMOSE participants.

Chapter 5 provides a detailed comparison between the different engineering process and highlights the main benefits of the OSMOSE engineering process:

- Creation of machine readable specification and standards which
  - Improve the quality and re-usability since created and updated by tools
  - Allow creating specifications which are vendor independent and provide the flexibility to define or not physical allocation of functions
  - Enable automated testing in an early stage of the process
- Creation of project configurations based on machine readable specifications
  - Automate the configuration phase
  - Improve quality since no interpretation errors are possible
  - Allow users to compare in an automated way what is specified and offered

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[1] European Network of Transmission System Operators for Electricity: this organisation represents 42 TSO's from 35 country's – www.entso-e.eu

1 List of acronyms and abbreviations

This table lists the acronyms and technical words used in this document.

Acronym	Meaning
CID	Configured IED Description
DB	Data Base
DO	Data Object
Domain	A domain represents a group of functions within a specific protection or automation domain (as introduced by ENTSO-E IST)
End-User	Party responsible for exploiting the substation after a project is finished
ENTSO-E	European Network of Transmission System Operators for Electricity
ENTSO-E profile	Profile defined by the ENTSO-E IEC61850 taskforce, containing a data profile and engineering process concept
FTD	Function template description
Function	A function represents a group of subfunctions (as introduced by ENTSO-E IST)
ICD	IED configuration description
ICT	IED configuration tool
IED	Intelligent electronic device
IID	Instantiated IED description
ISD	IED Specification Description
IST	Interoperability specification tool (developed and hosted by ENTSO-E)
LN	Logical Node
Nsd file	Namespace Description
Data profile	Group of functions and subfunctions defined by an end-user representing all applications of this user
SA system	Substation Automation system
SCD	System configuration description
SCL	Substation Configuration Language
SCT	System configuration tool
SED	System exchange description
SPACS	Substation Protection Automation and Control System
SSD	System specification description

SST	System specification tool
STT	System testing tool
subfunction	A subfunction (as introduced by ENTSO-E IST) represents a functional building block of a substation protection and automation system, and contains one or more output and input signals (Output signals are mapped to an IEC61850-7-4 datamodel).
template	A container of a subset of functions and subfunctions,
User	Any party executing the engineering process, this can be for example a TSO or a system integrator
Vendor	Vendor of substation protection and automation IEDs
IEC61850	IEC61850 is an international standard defining Communication Networks and Systems for Power Utility Automation
IEC61850-6-100	SCL Function Modelling for Substation Automation (in preparation)
IEC61850-7-4	Basic communication structure for substation and feeder equipment – Compatible logical node classes and data classes

Table 1: Abbreviations and technical words

2 Introduction

2.1 Introduction on high voltage substations

A high voltage substation represents a node within a high voltage grid which transports electricity from the power plant (production) to the electricity consumers. The substation consists of a high voltage part, with primary equipment spread out in the different “bays”[2], interfaced through low voltage devices. A low voltage SPACS system consist of multiple hierarchical levels, with the control centre at the highest level to the process level which represents the interface with the high voltage equipment.

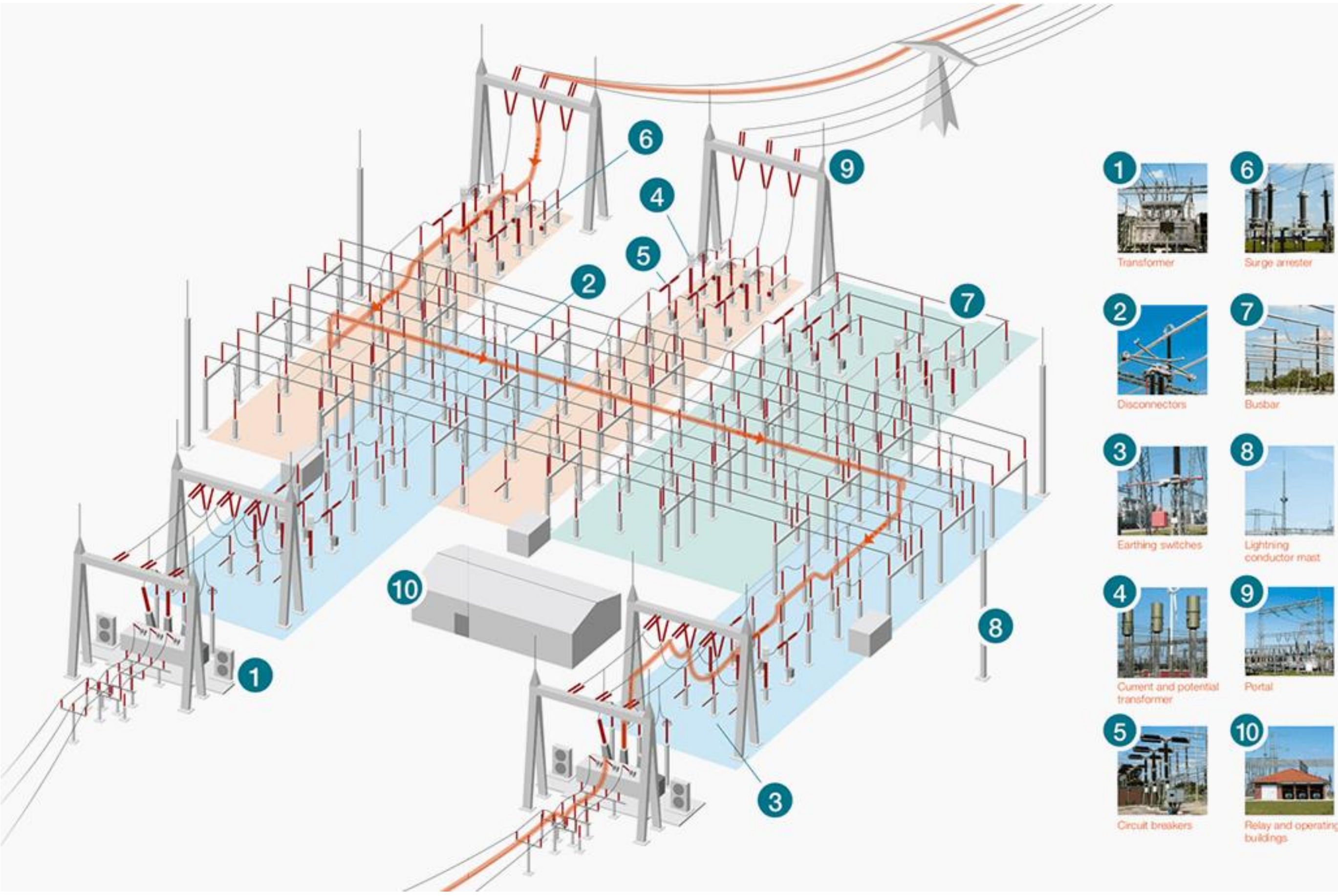

Figure 1 - High voltage substation example showing the electricity flow - image from https://electrical-engineering-portal.com/what-is-what-in-outdoor-hv-substation

[2] A bay represents a part of the high voltage substation with primary equipment linked to a specific asset as for example interconnection line, transformer, shunt reactor or energy storage facility.

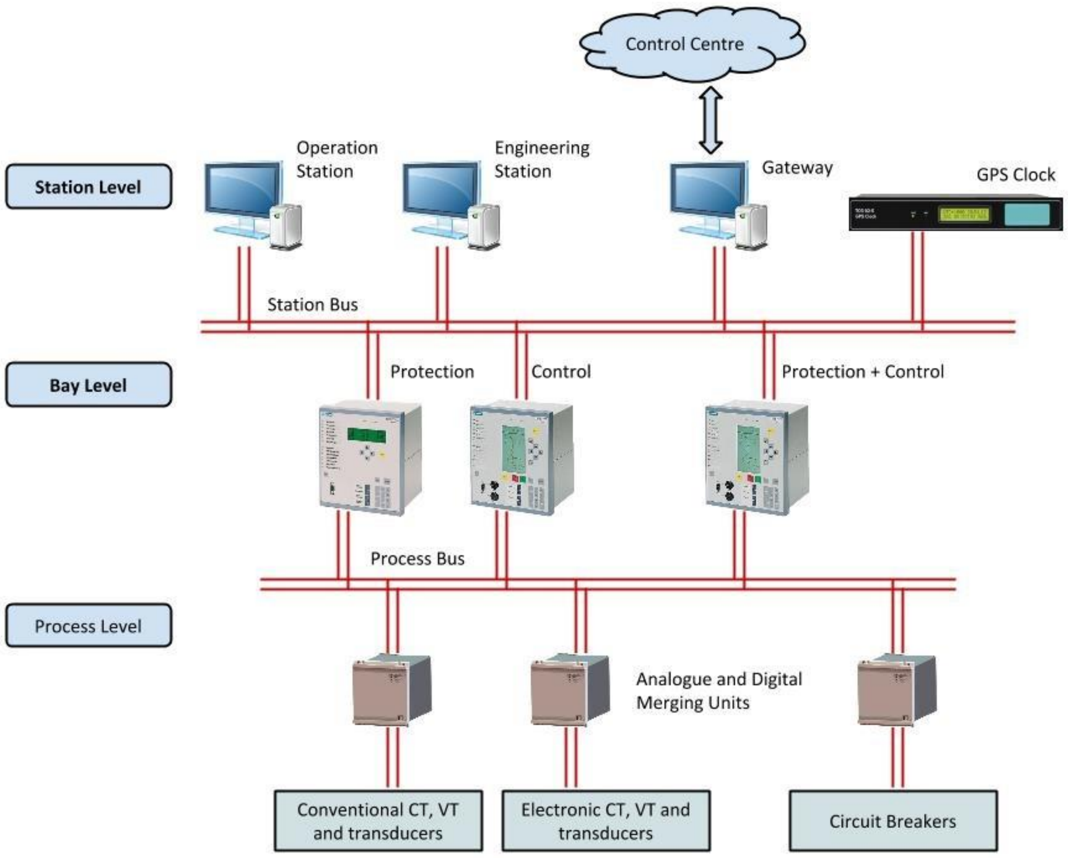

Figure 2 - Example of a low voltage system of a high voltage substation – image from https://myelectrical.com/notes/entryid/245/how-a-digital-substation-works

2.2 The IEC61850 standard scope of application[3]

The main parts of the IEC 61850 standard were first published from 2002 to 2005. The standard was the result of nearly ten years of work within IEEE/EPRI on Utility Communications Architecture (UCA) (IEEE-SA TR 1550) and within the working group “Substation Control and Protection Interfaces” of IEC Technical Committee 57. The initial scope of IEC 61850 was standardisation of communication in substation automation systems.
The first edition of the standard was primarily related to protection, control and monitoring.
From 2009 onwards the original parts of the IEC 61850 series have been updated and extended with now 35 documents describing the standard, technical specifications and technical reports.

- IEC TR 61850-1:2013 - Introduction and overview
- IEC TS 61850-2:2019 - Glossary
- IEC 61850-3:2013 - General requirements
- IEC 61850-4:2011 - System and project management
- IEC 61850-5:2013 - Communication requirements for functions and device models

[3] From IEC61850-1:2013

- IEC 61850-6:2009 + AMD1:2018 CSV- Configuration language for communication in electrical substations related to IEDs
- IEC 61850-7-1:2011 - Basic communication structure - Principles and models
- IEC 61850-7-2:2010 + AMD1:2020 CSV- Basic communication structure - Abstract communication service interface (ACSI)
- IEC 61850-7-3:2010 + AMD1:2020 CSV- Basic communication structure - Common Data Classes
- IEC 61850-7-4:2010 + AMD1:2020 CSV- Basic communication structure - Compatible logical node classes and data classes
- IEC 61850-7-410:2012 + AMD1:2015 CSV - Basic communication structure - Hydroelectric power plants - Communication for monitoring and control
- IEC 61850-7-420:2009 - Basic communication structure - Distributed energy resources logical nodes
- IEC TR 61850-7-500:2017 - Basic information and communication structure – Use of logical
- nodes for modeling application functions and related concepts and guidelines
- for substations"
- IEC TR 61850-7-510:2012 - Basic communication structure - Hydroelectric power plants - Modelling concepts and guidelines
- IEC 61850-8-1:2011 + AMD1:2020 CSV - Specific communication service mapping (SCSM) - Mappings to Manufacturing Message Specification MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
- IEC 61850-8-2:2018 - Specific communication service mapping (SCSM) - Mapping to Extensible Messaging Presence Protocol (XMPP)
- IEC 61850-9-2:2011 + AMD1:2020 CSV- Specific communication service mapping (SCSM) - Sampled values over ISO/IEC 8802-3
- IEC/IEEE 61850-9-3:2016 - Precision time protocol profile for power utility automation
- IEC 61850-10:2012 - Conformance testing
- IEC TS 61850-80-1:2016 - Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104
- IEC TR 61850-80-3:2015 - Mapping to web protocols - Requirements and technical choices
- IEC TS 61850-80-4:2016 - Translation from the COSEM object model (IEC 62056) to the IEC 61850 data model
- IEC TR 61850-90-1:2010 - Use of IEC 61850 for the communication between substations
- IEC TR 61850-90-2:2016 - Using IEC 61850 for communication between substations and control centres
- IEC TR 61850-90-3:2016 - Using IEC 61850 for condition monitoring diagnosis and analysis
- IEC TR 61850-90-4:2013 - Network engineering guidelines
- IEC TR 61850-90-5:2012 - Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118
- IEC TR 61850-90-7:2013 - Object models for power converters in distributed energy resources (DER) systems
- IEC TR 61850-90-8:2016 - Object model for E-mobility
- IEC TR 61850-90-12:2015 - Wide area network engineering guidelines

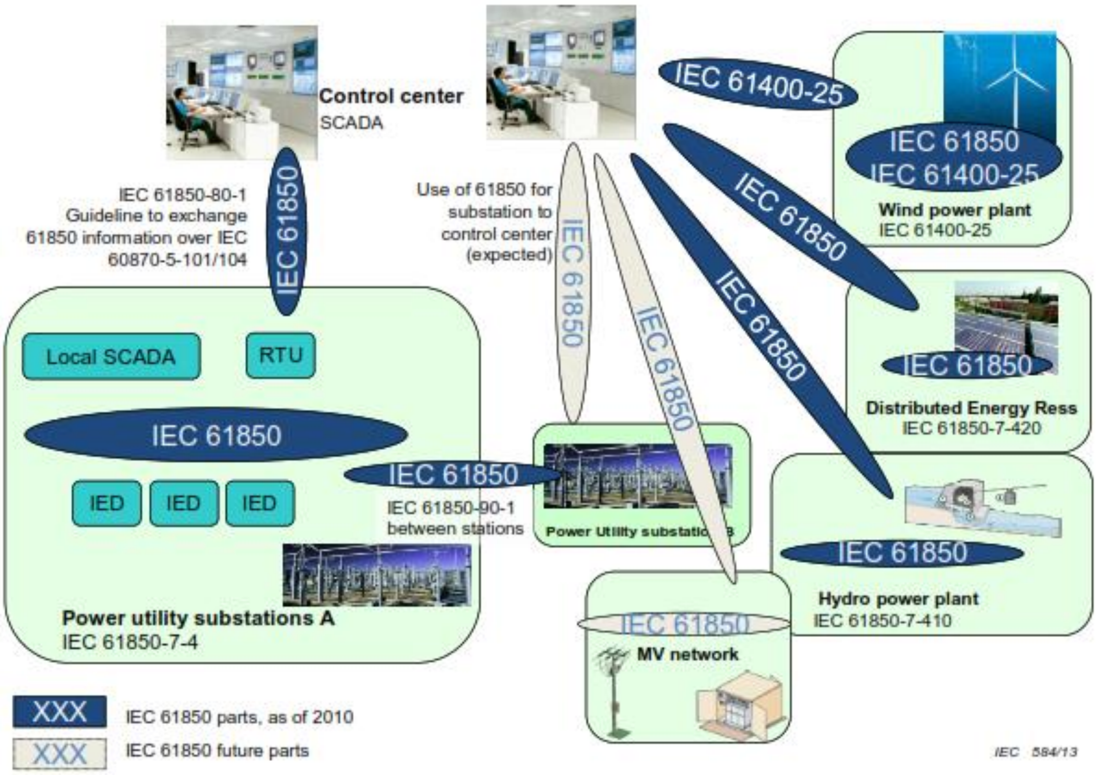

Figure 3 - IEC61850 application domain examples (from IEC61850-1 ed2.0)

2.3 OSMOSE Task 7.1 and IEC61850

The major goal of the task 7.1 of OSMOSE is to identify and address gaps in the IEC 61850 standard with a focus on interoperability, enabled by the engineering process.

The IEC 61850 standard defines three major elements:

- Abstract communication services and the mapping of those on a communication stack usable over Ethernet and TCP/IP
- Semantic data model to standardise the information from functions and process elements in the application domain
- A System Configuration Language (SCL) supporting standardized information exchange between various tools

The engineering process defines a way to come from a general substation system specification to an engineered and working substation. The IEC61850 engineering process focusses on the engineering of the communication of information between IEDs of different vendors.

Engineering of substation projects is a part of the day-to-day work of a lot of TSO’s and DSO’s (as an example: Elia has a team of more than 40 designers, working full time on engineering greenfield and brownfield substation protection and automation projects). It is very important for the users of this process that this process is efficient and compatible with IEDs of all vendors, to guarantee an optimal integration of multi-vendor systems.

In a first step, the desired engineering process has been defined as part of OSMOSE task 7.1.1. The process as described was refining an enhanced process already described by the ENTSO-E IEC 61850 task force[4] as part of the ENTSO-E profile (see 0 -

ENTSO-E Profile Introduction).

The presentation of this enhanced process is the scope of this deliverable.

In a second step, extensions to IEC 61850-6[5] will be defined in order to support this engineering process. In order to define and verify these extensions a demonstrator is build (hardware + software) based on a two substation configuration (see Figure 4) with each an interconnection and energy storage bay.

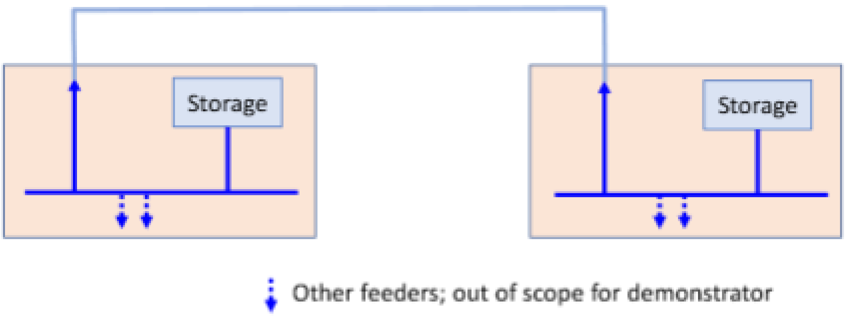

Figure 4 - Demonstrator Setup

Missing elements of IEC61850-6 are identified (see part 3.1) during the development of the engineering tools to support execution of each process step of the desired engineering process.

The vendors participating in the OSMOSE project task 7.1.1 will implement those extensions in their hardware and software products and the results shall then be demonstrated with the demonstrator[6].

The different vendors participating with hardware and software are listed below.

[4] Communicated to the market during Webinar 10-05-2016: https://youtu.be/Sukgplj-UjM, and presented during WG10 meeting – Joined session WG10/ENTSO-E in Rome 08/06/2016
[5] IEC61850-6: Configuration description language for communication in electrical substations related to IEDs Feedback is captured in taskforce WG10 IEC61850-6-100
[6] As specified in internal deliverable "Specification of Demonstrator" and part of Osmose deliverable 7.2

Component	Efacec	Ingeteam	Siemens	Helinks	Schneider
Protection device	1	1	1		
Bay controller	2	2			
System specification tool				x	x
System configuration tool	x	x	x	x	

Figure 5 - Participating vendors

Other participants are it4power (coordination and IEC61850 expert), Elia (coordination and user representation), REE (user representation), R&D Nester (demonstrator and meeting host) and Triangle Microworks (simulation and testing)

This document provides the description of the enhancements in the engineering process.

3 Enhanced IEC61850 engineering process

3.1 The scope of enhancements

The goal of the OSMOSE IEC61850 taskforce is to extend the current process concept elaborated by ENTSO-E and known by the industry, since this concept focusses on standardization and specification. The extensions cover the missing steps to provide an end to end solution (from IED database (DB) and System specification to Substation Automation working system) which covers all steps of a project or frame-agreement:

1. Concept / Standardisation
2. Specification
3. Selection and procurement
4. Configuration
5. Installation / Commissioning

Testing is a part of steps 2, 4 and 5 (see Annex 7.2). More details about each step are given in Part 5 of this document. Comparison between the classic and the enhanced engineering process

Below an image from IEC61850-6 is shown describing the different tools and files used to configure a system.

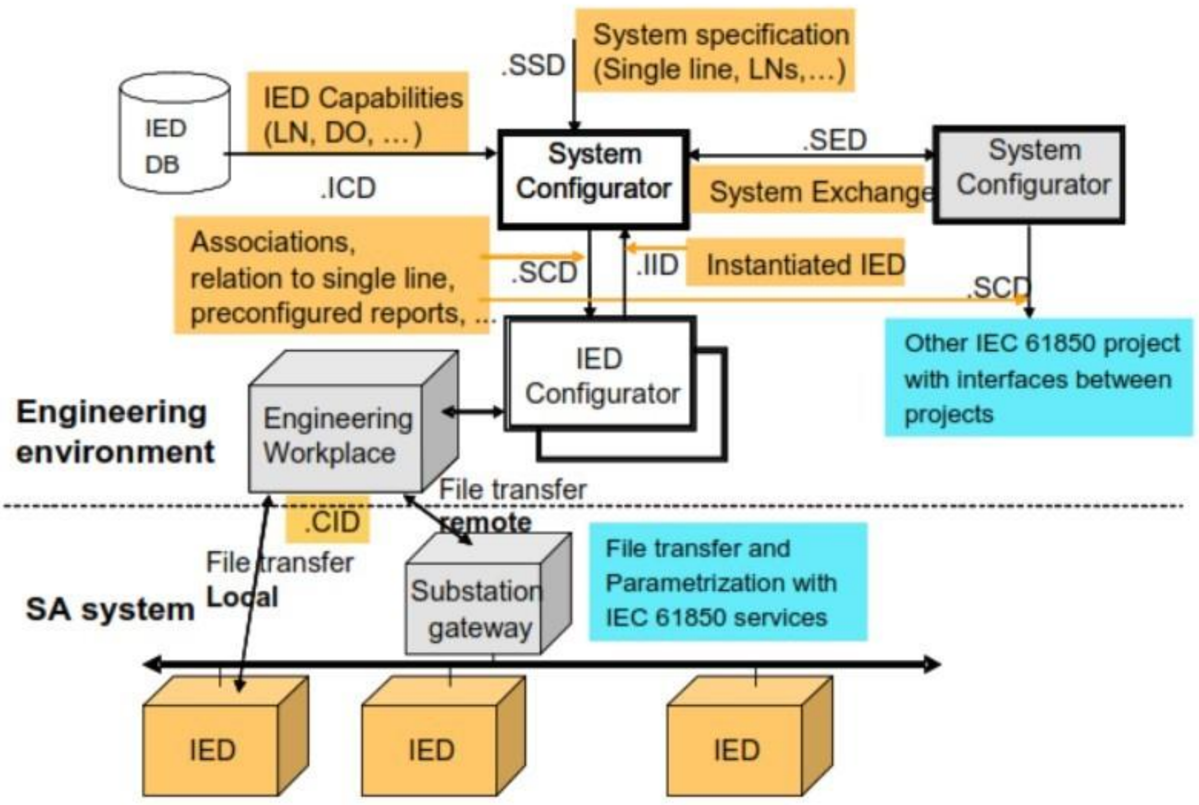

Figure 6 - Interactions between tools and devices supporting the IEC61850 engineering process as specified in IEC 61850-6:2009+AMD1:2018 figure 1

Figure 6 shows the interactions between the different tools (System Configurator, SCT, and IED Configurator, ICT) and equipment (IED) used in a substation automation system and the variants of SCL files to be used for that exchange. In the lower part, the substation automation system with the IEDs, the substation gateway and the engineering workplace are shown.

In the upper part, System Configurator (SCT) and IED configurator (ICT) are tool roles, introduced by IEC 61850-6. As an example (illustrated by Figure 6), the SCT receives an IED capability description file (ICD) from an IED database. An ICD file is one variant of an SCL file.

A more detailed graph of the engineering process, applied to a project or frame agreement environment, **before** the OSMOSE improvements is given in Annex 1.

While the principal engineering process was described in IEC 61850 initially, many details were not specified and left to the interpretation of the tool vendors. This resulted in a lack of interoperability (linked to the content and interpretation of the different SCL files in the tools) and efficiency[7]. Some of the issues were fixed with the latest revision of IEC 61850-6 (Edition 2.1, published in 2018). But still, gaps existed. Those gaps were mainly in the following areas:

- Support a concept of templates / library in order to support standardization efforts in utilities
- Support the possibility to define applications including information exchange already at specification independent from a future implementation with specific devices
- Enhance the semantic interpretation of the data model of a system and of devices

This has been recognized by the IEC working group (WG) 10 based on feedback from users including the ENTSO-E IEC 61850 task force. Therefore, within IEC TC57 / WG 10, a task force was created to address those issues in a technical report (planned publication IEC (TR) 61850-6-100) which will later lead to integration into the base standard.

The task 7.1 of the OSMOSE project is supporting the work done by that IEC task force by providing the requirements for the enhancements and verifying the proposed solutions with the demonstrator.

3.2 Engineering process improvements proposed by ENTSO-E

Based on feedback from the ENTSO-E IEC61850 taskforce, ENTSO-E made a proposal to enhance the engineering process[8] described in the IEC61850-6 standard, to make it more specific for concept and specification.

[7] As witnessed during the latest UCA interoperability tests in Charlotte, NC in 2019
[8] Communicated to the market during Webinar 10-05-2016: https://youtu.be/Sukgplj-UjM, and presented during WG10 meeting – Joined session WG10/ENTSO-E in Rome 08/06/2016

This is why ENTSO-E added at concept side the notion of function and subfunctions, optionally grouped in templates[9], and the idea of using these templates in a system specification tool. These improvements also concern dataflow between subfunctions (as shown by the blue arrows in Figure 7). In this way, the user has the possibility to define his concept in a library of functions and subfunctions (with predefined dataflow (in- and outputs) placeholders), which can be used (instantiated) in the next steps of the engineering process.

Additionally, the concept of "virtual IED" is introduced, which can be seen as a preliminary physical allocation of functions and subfunctions.

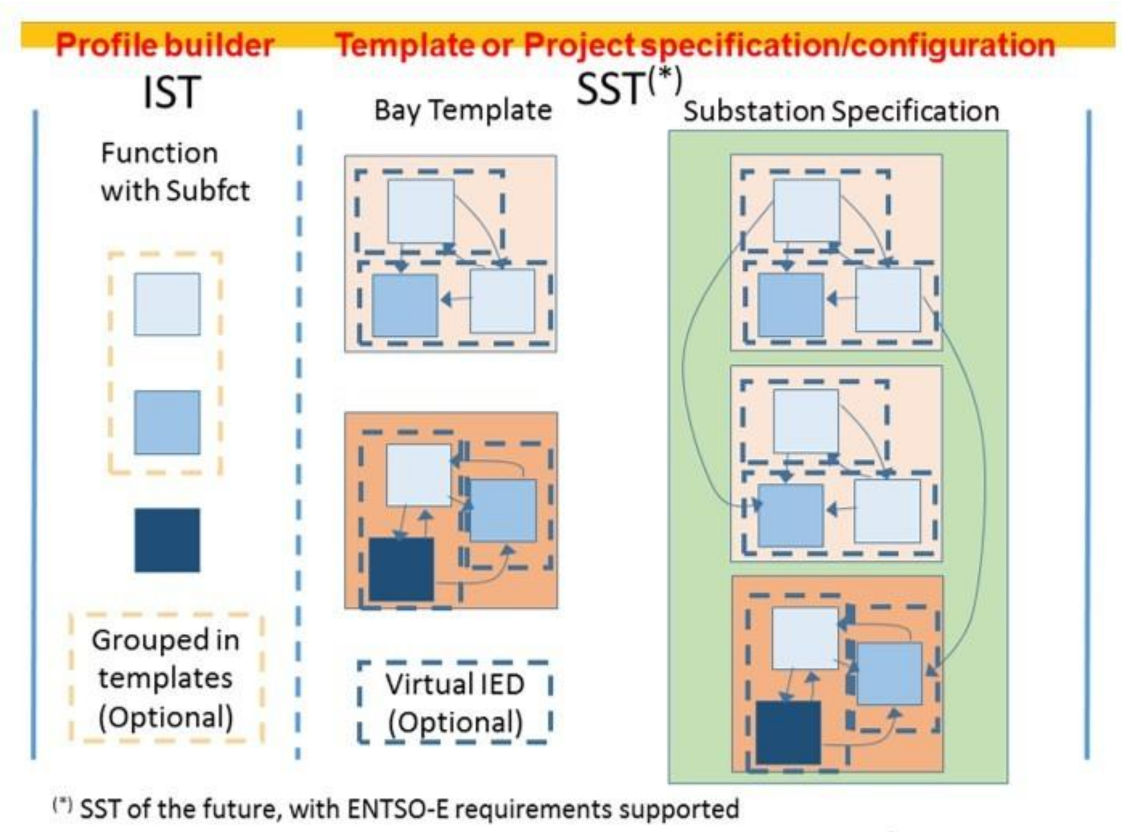

Figure 7 - Process concept proposed by ENTSO-E presented during WG10 meeting in Rome 06-2016; Process steps are shown from left to right – blue squares represent function/subfunction, orange squares represent bays, green square represents substation

An example of the template/domain/function/subfunction structure is shown below.

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[9] See table 1 for a definitions as introduced by ENTSO-E. Be aware within taskforce IEC61850-6-100 these definitions are reviewed

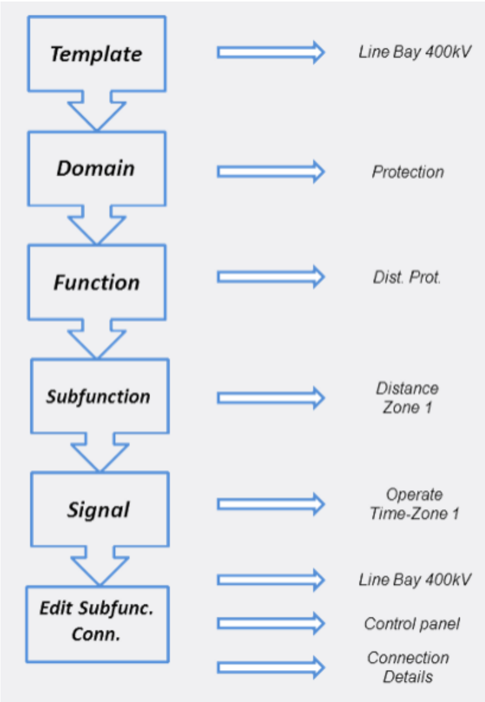


Figure 8 - Structure example from IST main page – used in OSMOSE demonstrator

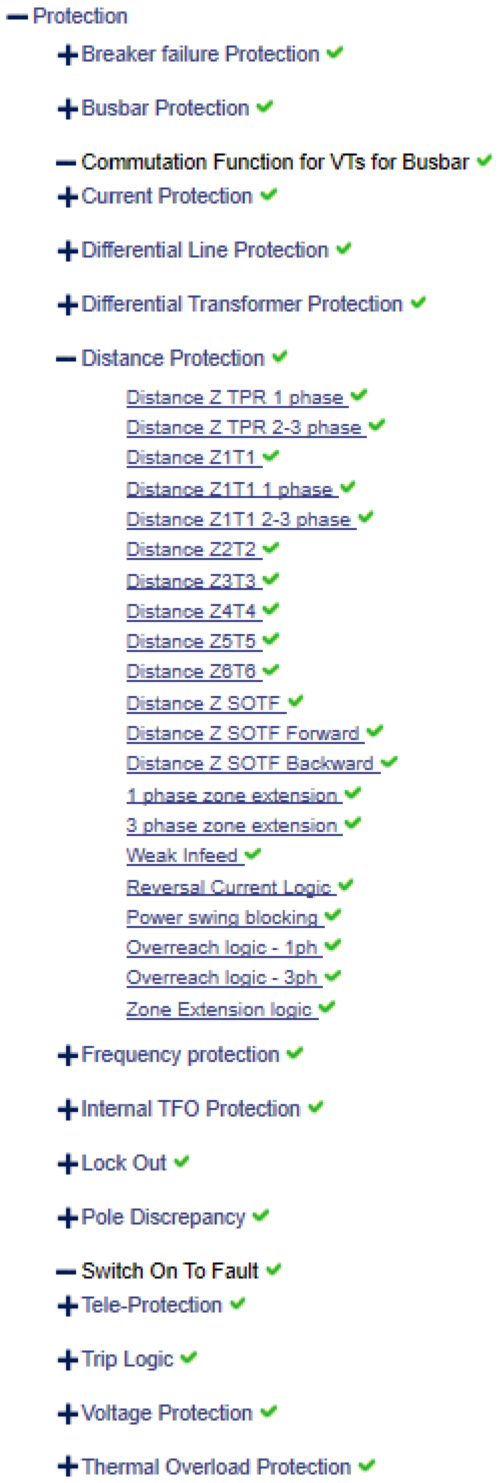


Figure 9 - Example of the Protection domain function and subfunction content for distance protection (from IST)

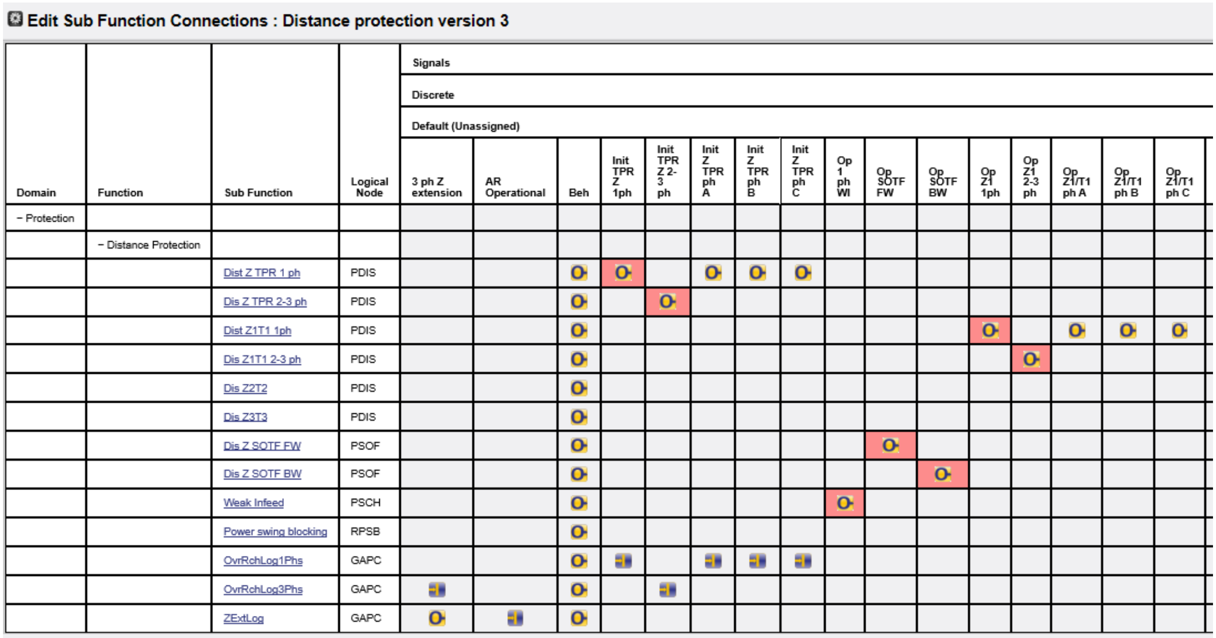


Figure 10 - Example of the design of subfunction in- and outputs within a user template (from IST) – gaps (signals without IEC61850-7-4 mapping) are highlighted in red

3.3 OSMOSE proposed engineering process

The OSMOSE IEC61850 taskforce merged the ENTSO-E exercise (limited to concept and specification) with the classic IEC61850 engineering process and added additional steps and refinements. The result is an engineering process, which exchanges machine-readable documents between all process steps, and provides solutions for users to do an optimal selection of IEDs. The enhancements result in an optimal efficiency, and a minimal risk of error.

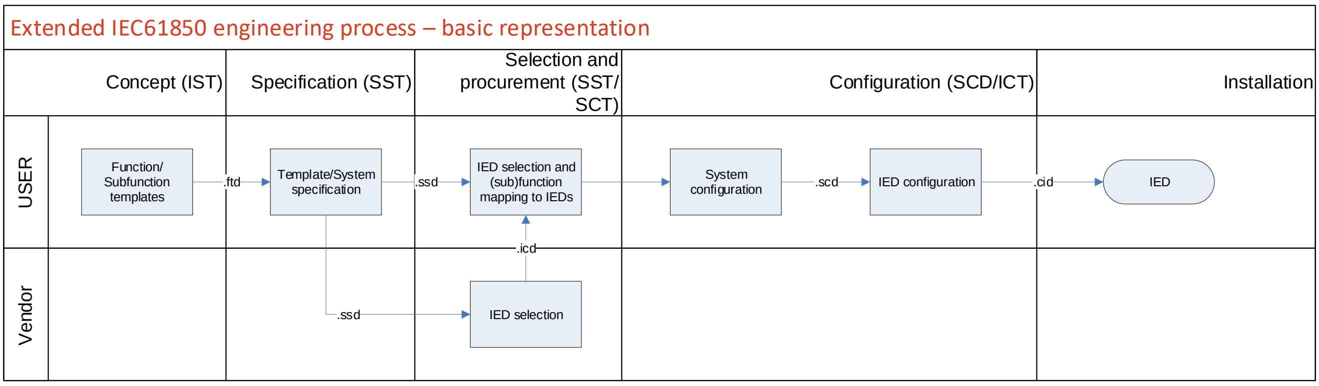


Figure 11 - Extended engineering process elaborated within OSMOSE – More details in Annex 7.2 (concept is referred to as “standardization”)

The detailed process is defined in annex 2. More details about each step are given in annex 3[10].

A detailed comparison between the previous and the proposed engineering process is given in 5- Comparison between the classic and the enhanced engineering process. The main enhancements are:

- At the concept side, to use a library of function/subfunction templates (called a “data profile”) as building blocks to create a user specification
- To allow in SCL the specification of domains, functions and subfunctions, and define signal flow between subfunctions in an .SSD file without allocation of the function to a (virtual) physical device (vendor independent).
- The OSMOSE IEC61850 taskforce built further on the idea of virtual IED and added the possibility of comparison between virtual IEDs and (a set of) real physical IEDs, during the selection process.

As part of the work done in OSMOSE Task 7.1., requirements and proposed enhancements of SCL are provided as input to the IEC61850 WG10 taskforces[11]. To test those in the demonstrator, the vendor participants in OSMOSE task 7.1 will integrate those enhancements in their products (tools and devices).

3.4 Specific Simplifications for the OSMOSE project

Since some other enhancements of the engineering process (not linked to interoperability and not part of the scope of OSMOSE task 7.1) are currently being discussed in IEC61850 WG10 taskforces and not yet available, these enhancements are mentioned but unfortunately not applied during the OSMOSE project. They provide additional efficiency gains, but are not discussed in OSMOSE, in order not to create an overlap. Within OSMOSE, a workaround is applied for these specific parts of enhancement listed hereafter:

- Logic definition in SCL (ongoing work in IEC61850-90-11)
- Bloc diagram documentation in SCL (no IEC61850 taskforce assigned)

Both elements are linked to specification step of the process, as shown in Annex 7.2

[10] Slides of the presentation given during the IEC61850 Global Conference – 10/2019
[11] These items will be part of the next deliverables of OSMOSE Task 7.1

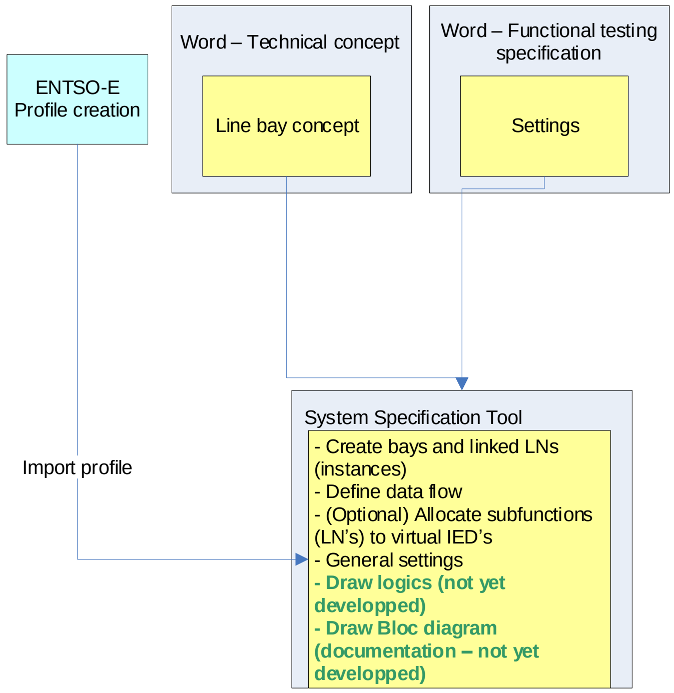


Figure 12 - Proposed process which includes logic specification and bloc diagram (in green) in the specification step

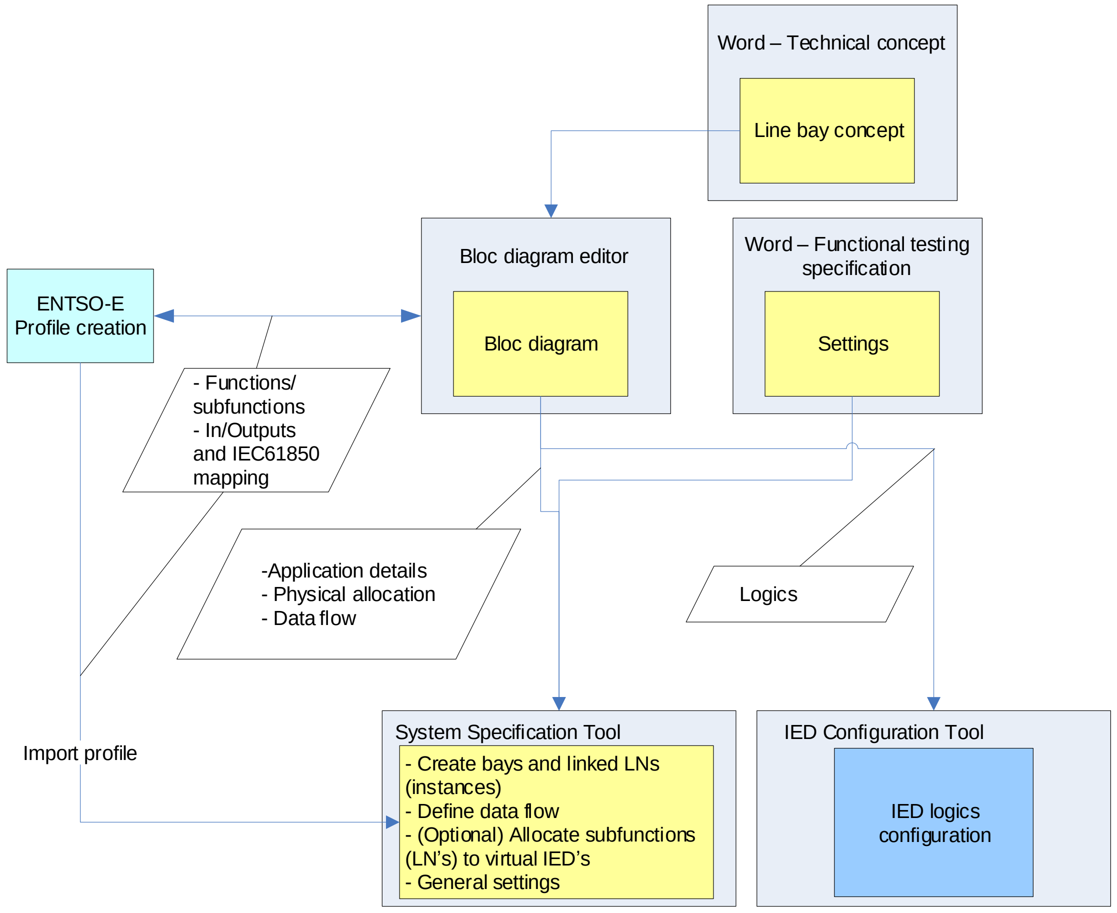


Figure 13 - Application of the process during OSMOSE project

4 ENTSO-E Profile Introduction

In 2015 an ENTSO-E IEC61850 Taskforce started working on a common data profile defining the superset of functions and subfunctions, including all contained signals, covering all protection and automation functions present in high voltage substations. The main goals are

- Providing input to the market by defining a common need in a machine readable way
- Providing input to IEC61850 WG10 by identifying gaps in the IEC61850-7-4 datamodel
- Sharing knowledge between TSO's

Additionally, a concept for an engineering process was defined to explain how the data profile should be used (see 3.2 Engineering process improvements proposed by ENTSO-E).

Both parts (data profile and engineering process concept) are considered as the ENTSO-E profile.

Participating TSO's are Elia, Amprion, REE, HOPS, FinnGrid, Swissgrid, RTE, JP Elektromreza Srbije and TenneT Germany.

A tool has been created to collect all user-defined data (see example of a signal in Figure 8): Interoperability Specification Tool for IEC61850[12].

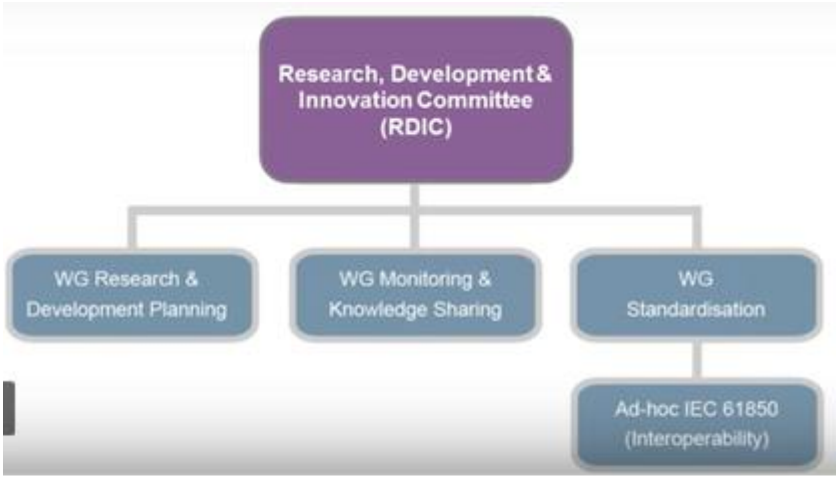


Figure 14 - IEC61850 Ah Group ENTSO-E organisational structure

In order to provide input for the first step in the engineering process (function/subfunctions templates), applied to the demonstrator, the content of the current state of the ENTSO-E profile is used, and where needed challenged, modified and extended.

As a result additional gaps in the IEC61850-7-4 standard have been identified and addressed in OSMOSE which will result into recommendations and feedback to the IEC61850 WG10.

[12] https://tomee-server.icss.de:8443/entsoeIST/

The full profile content used for the OSMOSE demonstrator is part of deliverables 7.2 and 7.3, as is the description and recommendations regarding identified gaps and extensions related to energy storage.

5 Comparison between the classic and the enhanced engineering process

In order to show and proof the advantages of the proposed engineering process, a detailed comparison between both processes is done for each process step.

1. Standardisation
2. Specification
3. Procurement / Comparison
4. Configuration
5. IED configuration and commissioning

First column: topic Second column: Classic engineering process execution (Annex 1) Third column: OSMOSE proposed engineering process execution (Annex 2) Fourth column: Benefits

Standardisation phase			**Benefits**
Task Description	Create library of signals and functions and map them to IEC61850 datamodel	Create a TSO profile which is a filtered set of the signals and functions available in the ENTSO-E profile Add specific signals (and map them) if missing in the ENTSO-E profile	- Centralized database to develop and maintain ENTSO-E profile in a sustainable way - Enables Knowledge share through TSOs exchanges and IEC 61850 model database incorporated for usage - Creation of TSO specification if it does not exists in any form - Enabler for new TSO's introducing IEC61850 - ENTSO-E member benefits of the ENTSO-E weight in standardization and market tenders (TSO gap --> ENTSO-E gap) - Reduction of cost for TSO specification build-up - ENTSO-e profile will act as a stronger and more visible
Tool	MS Office applications	IST (Interoperability specification tool) developed and hosted by ENTSO-E: • Database that is collecting TSO specification for data models and communication services in order to create ENTSO-e profile • Incorporated IEC 61850 model (nsd files) for easy mapping of the ENTSO-E members requirements and identify gaps in the IEC 61850 Standard • Exportable to System Specification Tools of the market in order to increase engineering process efficiency	

Output	Protocol Implementation Document containing a library of signals and functions used by the TSO and mapped to IEC61850 datamodel	TSO profile (optionally covered by multiple predefined (function- or bay-)templates) containing all signals and functions used by the TSO	requirement to the market/vendors (holding most comprehensive list of TSO specifications) - Gaps fixing process with direct impact on the time/cost spent on asset specification, procurement, engineering - Upgrade of TSO specification with support of wider pool of experts - Enabler for future standardization of TSO requirements in case of structural evolution of TSO business (merging process, ...) - When standardized, IST functions can be integrated in other market IEC61850 engineering tools, to make this process available for all users
Output format	MS office application format	SCL file (machine readable)	
Machine readable SCL output	NO	YES	
Ability to recover the output in next project / FA	NA since no machine readable output is generated	YES	
Effort	Big effort if no automation (custom) is applied	Toolset and database of ISTool allows the user to create templates in an efficient way	
Threats / Weaknesses	Since no machine readable output is generated very low efficiency	ENTSO-E should continue to support ISTool software or make it open source Efficiency gain is dependant of the software performance and user-friendliness ENTSO-E profile population demands large efforts from contributing TSO's	
Specification phase			**Benefits**
Task Description	Write SPACS concepts and specifications for tendering the system	Creating bay/system templates	- If ISD's (virtual IED instance in an SSD file) are used there is a possibility to add other IED information that could be machine readable aswell - Independence of physical allocation allows the user to only define the concept and boosts the ability to re-use this in the future - SSD testing allows to identify errors in a
Tool	MS Office applications	(Vendor) Independent system specification tool SSD testing tools	
Output	Specification document with annexes	System specification SCL file with optional physical allocation	
Output format	MS Office documents	SSD optionally containing ISD's	
Machine readable SCL output	NO	YES	

Ability to recover the output in next project / FA	NA since not machine readable	YES since the files describe the concept and are vendor independent	specification stage and not in project execution which improves global efficiency - Less risk of bad interpretation by a vendor since the SSD output is written in SCL language - Function templates of the IST profile can become logical devices instances in the SSD/ISD - Possibility to add settings on specification level
Effort	Big effort since al lot of text (creation + updates)	System specification tools allows the user to create in an efficient way system specification SSD and ISD files	
Threats / Weaknesses		Efficiency gain is dependent of the software performance and user-friendliness Interoperability between system specification tools from different vendors should be guaranteed It should be possible aswell to draw in a specification tool certain basic block logics in order to complete the system specification (cfr Elia Macro Functions)	
Procurement / comparison phase			**Benefits**
Task description	Vendor proposes ICD files based on the written specifications of the TSO. The TSO needs to validate proposal and check if the proposition meets the requirements	1- Comparing ICD to ISD and choose ICD: Comparison between delivered ICD's (vendor) and generated ISD files (TSO) in order to select an IED that covers all demanded functionalities 2- Choose ICD's to cover all subfunctions: Choosing ICD's to cover all functionalities of the SSD file	- Smaller effort, bigger efficiency - This step could transfer a part of the work from project to procurement stage --> after procurement a big part of engineering is already done - This step can boost standardisation in offer analysis documents - More flexibility for users to choose the solution they want
Tool	The vendor delivers ICD files, opening the file is possible with any XML viewer or a tool of the vendor Comparison with the specifications is manually done	System Configuration Tool or another specific tool to allow an independent analysis and comparison (preferably provided by a third party)	
Output	comparison report	Automatic generated comparison report	
Output format	MS Office documents	MS Office - PDF	
Effort	Big effort since comparison needs to be done manually	Small effort since supported by specific software	

Threats/ Weaknesses	- Vendor makes a concrete proposal, and defines his offered solution. This results in less flexibility for the user to evaluate alternative solutions - Vendor interpretation quality depends on the quality of the specification documents. Risk of bad interpretation - A lot of work has to be done when analyzing the demand (vendor) and comparing the offer to written specifications (TSO)		
Configuration phase			**Benefits**
Task description	Create and configure the system by using the chosen ICD's as input and an SCD as output	Create and configure the system by using the SSD and ICD's as input and an SCD as output	- Smaller effort since input files contained already a standard part of the configuration - Less need for the use of templates since a big part of it is already incorporated in the SSD - Validation/Comparison of the SCD (with SSD) allows to modify the SSD and update the system at specification stage
Tool	System Configuration Tool SCD testing and simulation tools	System Configuration Tool SCD testing and simulation tools	
Output	Validated System Configuration Description SCL file	Validated System Configuration Description SCL file	
Output format	SCL file	SCL file	
Machine readable SCL output	YES	YES	
Ability to recover the output in next project / FA	YES for future projects if a template approach is used	YES for future projects if a template approach is used Errors detected during SCD testing can serve as an input for an SSD update in order to avoid making the same errors in the future	
Effort	Big since the user needs to begin from scratch with the chosen ICD files	Small since the user already had the SSD (and ISD) as a starting point	
Threats / Weaknesses			
IED configuration and commissioning			**Benefits**
Task description	Importing SCD in IED configuration tool Configuration of the IED and full testing of the system	Importing SCD in IED configuration tool Configuration of the IED and full testing of the system	- Same effort as the classical process but lower error risk - Possibility to give direct

Tool	IED configuration tool System testing tools	IED configuration tool System testing tools	feedback to the specification (SSD)
Output	Commissioning of the system	Commissioning of the system	
Ability to recover the output in next project / FA		Errors detected during commissioning can serve as an input for an SSD update in order to avoid making the same errors in the future	
Effort	Identical to Osmose process but likely more errors since more parts of the process are performed manually	Identical to classic process but likely less errors since more parts of the process are software automated	
Treaths/ Weaknesses			

6 Conclusion

The engineering process, as it is proposed by the OSMOSE IEC61850 taskforce aims at improving engineering efficiency and quality (as described in Part 5) by building further on:

- Enhancement proposals of ENTSO-E
- The existing SCL language

The result is a generic process which can be applied to specify and engineer any system supporting SCL, outside the substation applications domain.

In a next step, OSMOSE will

1. Define the necessary SCL extensions required to execute the engineering process
2. Define the ENTSO-E profile enhancements and extension regarding gaps and energy storage
3. Implement this process in the participating engineering tools
4. Demonstrate the full process through a demonstrator setup
5. Provide input for standardization in IEC61850 WG10, in particular IEC61850-6-100 and IEC61850-7-4.

In order to make this process widely implemented it is necessary that

- The market embraces the idea that supporting interoperability is a selling point, not a constraint
- Users see the benefits of this process on long term and are willing to adopt to this engineering process, knowing that the impact on the company may be large
- IEC61850 standards provide the qualitative framework that allows the market to implement the engineering process

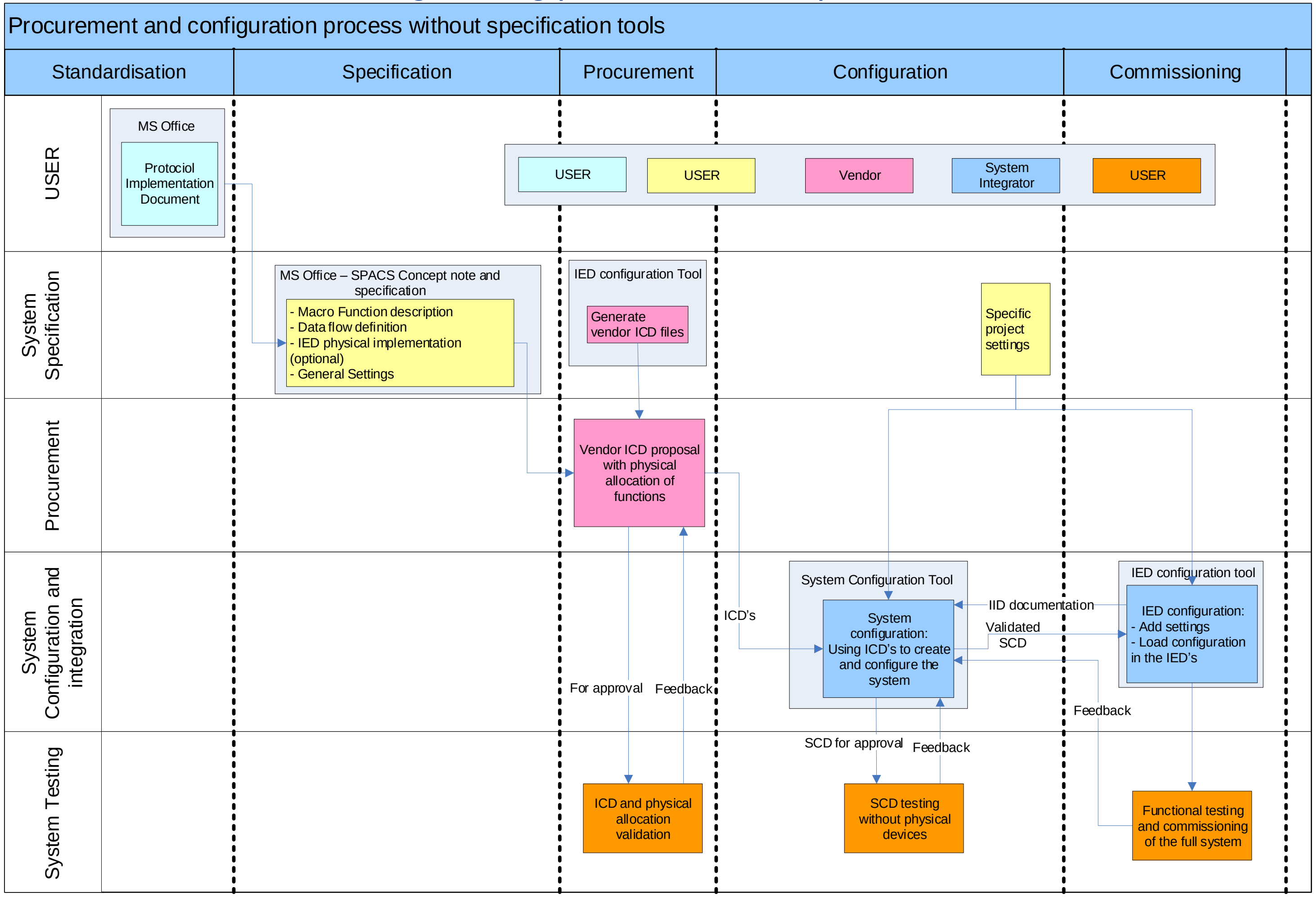
Other intitiatives that could enable and speed up the integration of this process in the industry

- Creation of test criteria for engineering software tools, to prove that they support (a specific part of) the process
- Creation of test criteria for IED configuration, to show that the configuration of (a specific part of) an IEDs is possible with this process

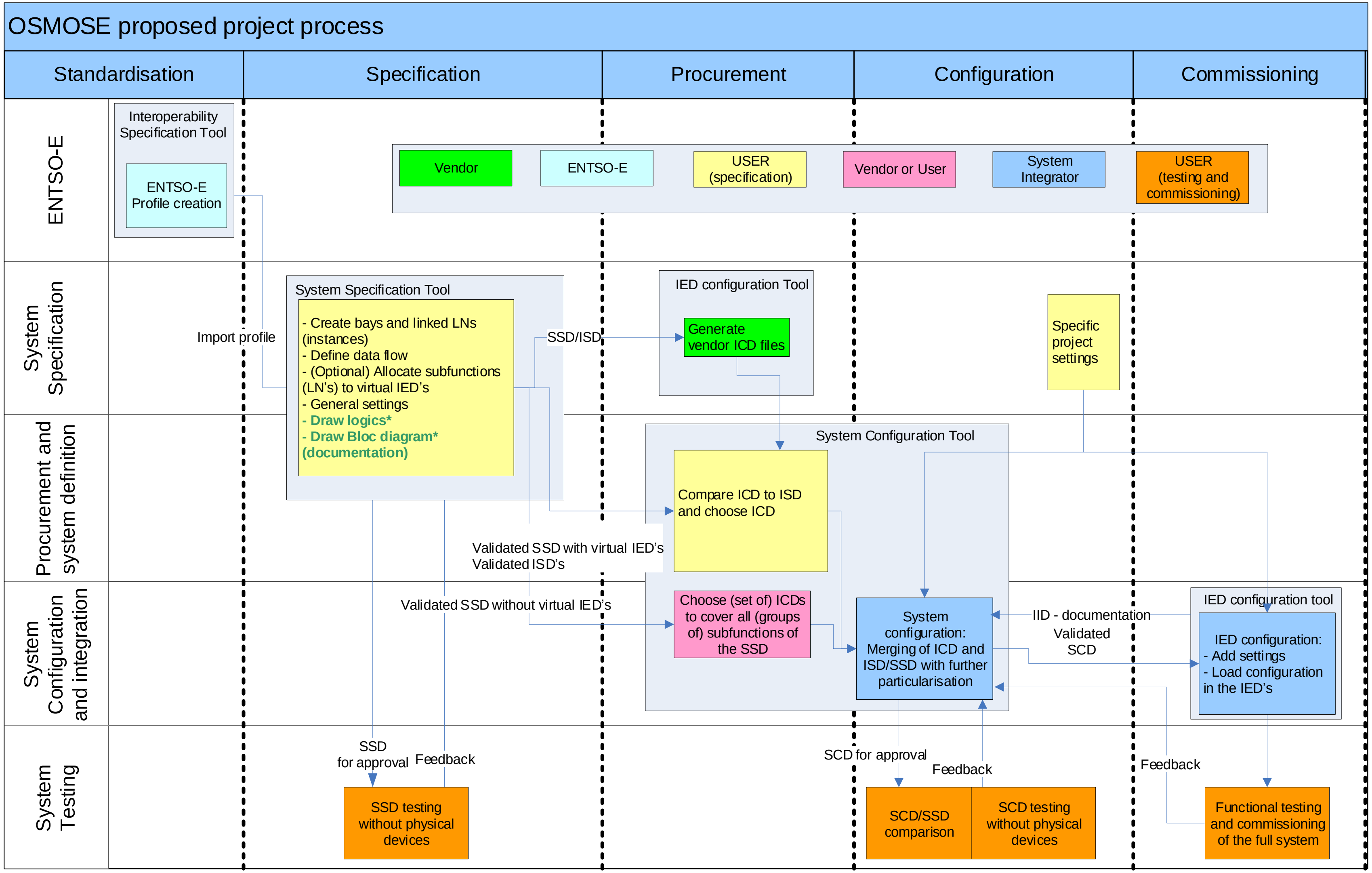
With the goal to create input for updating and extending UCA certification for engineering software tools.

7 Annexes

7.1 Annex 1: IEC61850 engineering process without specification tool



7.2 Annex 2: Engineering process proposed by OSMOSE



* Not implemented for OSMOSE project

7.3 Annex 3: Presentation given in London IEC61850 Global Conference October 2019

Osmose IEC61850 engineering process - Goal

- Create a full top down IEC61850 engineering process which covers all steps of a project
  - Concept
  - Specification
  - Selection and procurement
  - System configuration
  - IED configuration

- Use SCL files to exchange information between all project steps to guarantee
  - Optimal efficiency and quality
  - Make user requirements transparent for vendors
  - Make IED capabilities transparent for users

- Make it possible for users to create vendor independent system specifications
  - With integrated signal flow between functions
  - With optional physical allocation of functions in (virtual) IEDs

- With tools that allow easy decision making
  - Create the possibility for users to
    - Compare the specification to the vendor IED offer
    - Map a real IED to specified (virtual) IED

- Necessary SCL enhancements to support this will provide input for IEC61850-6-100 function modeling taskforce

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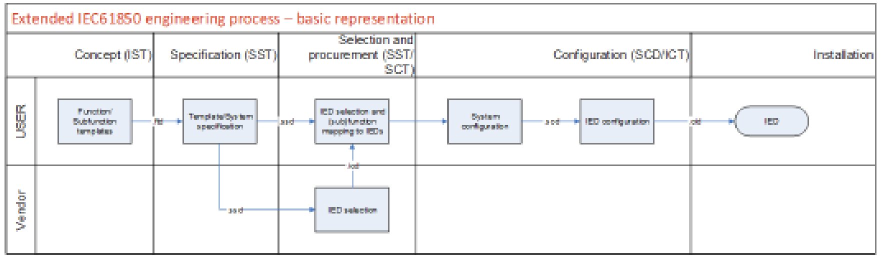
Osmose IEC61850 engineering process



- IST: ENTSO-E
- SST: Schneider / Helinks
- SCT: Ingeteam, Helinks, Efacec, Siemens
- IEDs: Siemens, Efacec, Ingeteam

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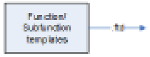
Osmose IEC61850 engineering process - 1: concept



- Function template library defining inputs and outputs of functions and subfunctions
  - Basic building blocks of the specification
  - .ftd = function template description
- Challenges:
  - Defining in SCL a way to document domains, functions and subfunctions

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Osmose IEC61850 engineering process - 2 : specification

- This steps defines the specification. This may be
  - Template (bay, substation)
  - Specification for a specific project
- .ssd (substation specification description) file containing
  - Instantiated functions and subfunctions
  - Signal flow between functions and subfunctions
  - Assignment of (sub)functions to bays and equipments
  - Optional physical allocation of (sub)functions in IEDs
- SCL challenges:
  - Creating a way to describe signal flow between (sub)functions

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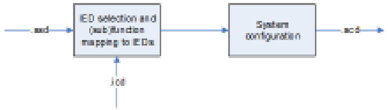
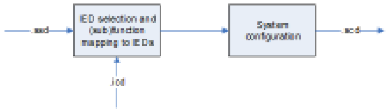
Osmose IEC61850 engineering process - 3 : selection and procurement



- Process inputs:
  - specification .ssd file
  - IED (pre-engineered) .icd files from different vendors
- Outputs:
  - Mapping of (sub)functions to real IEDs
  - Mapping of virtual IEDs to 1 or multiple real IEDs
- Selection tools for the user:
  - Comparison between (combination of) real IED(s) and (combination of) virtual IEDs

Osmose IEC61850 engineering process - 3 : selection and procurement



- SCL / Tool challenges:
  - Making the links between the real IED model and the instantiated (sub)functions
  - Replacing the virtual IED model by the real IED model (of 1 or multiple IEDs)
  - Configuration of signal flow (GOOSE, MMS) between real IEDs
- Advantage:
  - Output of the selection process is the pre-engineered template to start a project configuration
    - Leads to minimal effort during project configuration

To Remember

- Osmose shows that it is possible to create an efficient process from concept to execution with
    - Less total effort
    - Improved quality by using machine readable files along the full process

- Osmose leads to better understanding of what is necessary at concept and specification level to achieve a sustainable engineering process
    - Big efforts are necessary to convert what is existing in order to evolve to this process → is this acceptable?

- A tool to create vendor independent specification and perform the comparison and selection steps is needed, together with SCL extension to enable these functions

- Elia will profit from the experience and outcome of the Osmose project in their way to future engineering processes and IEC61850 substations