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WP 4

Fully Interoperable Systems

Deliverable D4.3

Existing standards and Gap analysis for the proposed frequency and voltage control solutions

20/01/2017

ID&Title	**D4.3** Existing standards and Gap analysis for the proposed frequency and voltage control solutions	Number of pages:	138

Short description (Max. 50 words):

This deliverable examines the landscape of ICT standards for Smart Grid, proposing a methodology for improving their evaluation and classification. Starting from this approach, then it examines the use cases proposed by the D4.2, identifies the standards for their information and communication layers and applies to them the evaluation methodology.

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Executive summary

The aim of this deliverable is to support the future implementation of the ELECTRA use cases, identifying the information and communication layer standards that can sustain the information exchange between the actors involved in these use cases.

The starting points for this work are: a common **definition** of the word “standard” (which sometimes is used as tautology, calling standards each specification its producer asserts to be a standard), the identification of the main **resources** for finding the needed standards and of a **methodology** for executing this mapping. What resulted from this process was that, even if a very good analysis of the European landscape of SG standards is provided from the Smart Grid Coordination Group (which involves CEN, CENELEC and ETSI), this work is not thought for designers defining SG use cases. So, a different approach for complementing the SGCG from the point of view of the designer is needed.

On this basis, a methodology was defined and a tool was implemented with the aim of providing a more rich set of information about the standards to the designers, so that they can be aware of the features of these standards before deciding if it is the one they need. This tool was the basis for providing the ELECTRA designer with:

- Tables showing the features of the standards that map their informative exchange needs,
- An assessment of them, enabling the understanding of its strengths and weakness.

The second part of the work illustrated in this deliverable is the analysis of the use cases provided by D4.2 for defining the information and communication layers of their SGAM modelling (starting from the function layer and making hypotheses on the component one).

The standards identified by this analysis were examined by the tool and the results of this assessment are provided in an appendix attached to this document.

Terminologies

Definitions

Architecture	Fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution [1]
Reference Architecture	A Reference Architecture describes the structure of a system with its element types and their structures, as well as their interaction types, among each other and with their environment. Describing this, a Reference Architecture defines restrictions for an instantiation (concrete architecture). [1]
Interoperability	The ability of two or more systems or components to exchange information and to use the information that has been exchanged [2]
SGAM Architecture	A reference Architecture for Smart Grid Interoperability developed by the Smart Grid Coordination Group
Standard	A set of specification: • From a recognized process of definition by a **recognized standard body** • Public, formal and not ambiguous • Auto-consistent (in particular not dependent by proprietary elements)

Abbreviations

BRC	Balance Restoration Control
BSC	Balance Steering Control
CAMSS	Common Assessment Method for Standards and Specification
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CIM	IEC Common Information Model
DER	Distributed Energy Resources
DMS	Distribution Management System
EAT-SGIS	ELECTRA Assessment Tool for Smart Grid Interface Standards
EC	European Commission
EMS	Energy Management System
ESO	European Standardisation Organisation
ETSI	European Telecommunications Standards Institute
FCC	Frequency Containment Control
FRAND	Fair, Reasonable And Non-Discriminatory
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IOP	Interoperability
IRPC	Inertia Response Power Control
ISO	International Organization for Standardization
PPVC	Post Primary Voltage Control
PVC	Primary Voltage control
SDO	Standard Development Organization
SGAM	Smart Grid Architecture Model

SGIMM	Smart Grid Interoperability Maturity Model
SGCG	Smart Grid Coordination Group
VPP	Virtual Power Plant (VPP stays for technical VPP / cVPP stays for commercial VPP)

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1 Introduction: the role of Interoperability standards in the Smart Grid

Interoperability plays a key role in Smart Grid design processes. Indeed, as more and more ICT components are being connected to the physical electrical infrastructure, interoperability is a key requirement for a robust, reliable and secure Smart Grid infrastructure. Although the majority of Smart Grid equipment is based on (inter)national or local standards, this has not yet resulted in an interoperable Smart Grid infrastructure [3]. For achieving Smart Grid system interoperability there is the need of system specifications, use of standards and testing under applications of profiles.

Thus, adoption of standards represents an efficient contribution towards interoperability issues since:

- A standard exists and, when released, is deemed mature and the user can adopt it without re-inventing the wheel. This implies reduction of costs for design, development and maintenance of applications;
- A standard provides guidelines and reference models well tested in the reference domain;
- When a new stakeholder wants to take part to the communication there is little additional cost.

On the other hand, the use of standards does not assure interoperability. Indeed [4]:

- Often, specifications allow for some degrees of freedom that cause ambiguity and redundancy in the exchanged data;
- Often, specifications only cover a part of the requirements (basing on the Pareto rule);
- Usually standardization processes are slow and requirements evolve rapidly;
- A standard can be an effective tool for interoperability only when its adoption reaches a critical mass, so that new users are sure that by adopting it they are able to communicate in interoperable way with other actors.

Relating to the last issue, it is important to note that the huge set of available standards could be a strong barrier in the achievement of the critical mass. Figure 1 shows the issues that can hinder interoperability when using standards.

Three kinds of barriers can be identified:

1. Lacking of suitable standards: indeed standardization needs long time and it is not able to meet quickly the requirements;
2. Use of different standards for the same transaction: this implies that different standards are available and no one of them is adopted diffusely enough to become the reference one;
3. Use of the same standard in different way: this is typically due to huge flexibility and ambiguity of specifications.

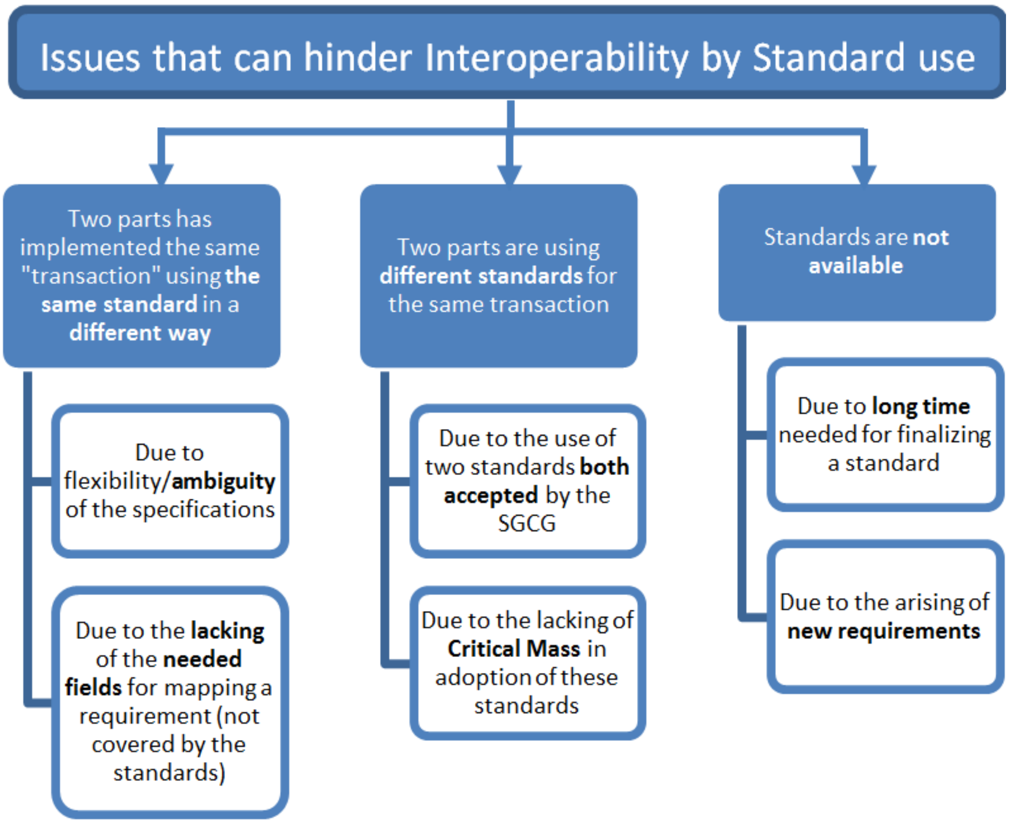


Figure 1 - Issues that can hinder Interoperability

In particular, in the Smart Grid context, this problem is amplified by the huge set of standards already existing (and in continuous expansion by the work of various technical groups all over the world). The Smart Grid Coordination Group (SGCG) has identified, at the moment, a list of 538 standards potentially useful in Smart Grid applications and this list is said not to be exhaustive[1].

So, the aim of this deliverable is to help ELECTRA in defining the set of ICT standards for exchange of information within the Use Cases defined in ELECTRA D4.2 and to identify, if any, possible standard gaps for these use cases.

More in details, the document has the following structure:

- In the first part ("The EAT-SGIS tool") the general problem of managing the huge set of ICT Interoperability standards for the Smart Grids will be analysed and the design and development of a tool for helping the use case designer in this task will be shown.
- In the second part ("Standards for the use cases"), the analysis of ELECTRA Use Cases for finding the needed ICT Interoperability standard will be faced.
- In the last part ("Future perspectives related to ICT solution applicable to the Smart Grid domain") some ideas about these future perspectives are outlined.
- In the Appendix ("List of standards"), the list of standards evaluated using the previous tools will be reported. The complete Appendix containing the evaluation schedules will be provided separately for space reason.

[1] "The standards listed in this report represent a selection according to the rules set in section 6.2.1 and 760 6.2.2. The list is not comprehensive" page 20 of [9]

2 The EAT-SGIS tool

2.1 The landscape of European ICT standards for the Smart Grids

2.1.1 Definition of "Standard"

The basic definition of the word "standard" is provided by ISO: "a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose" [5].

Unfortunately the previous definition would involve a lot of so called *de-facto* or industry standards, which often are proprietary specifications, never approved by official recognized Standard Development Organizations (SDOs). This recognition is really important, since SDOs are third parties without personal or economic interests in the definition of a standard and their involvement assure the openness of the standardization process and avoid vendor lock-in of the users.

Therefore, the definition can be restricted specifying that a set of specifications, to be recommended as a standard, has to have the following features:

- Recognized processes for the definition of the specifications in the context of a standardization body;
- Public (even if available for a fee), formal and not ambiguous description of the specifications;
- Auto-consistency (in particular it is not dependent on proprietary elements);
- Stakeholders' (full) consensus.

In any case some specification covering the listed features only in a partial manner could be considered for example, if the specifications are under development or if the specifications were built by an organization that is not a standardization body, but is planning to put them in a formal process of standardization in a standardization organization, but this has to be explicated.

2.1.2 From the M490 Mandate to the SGCG

In March 2011, the European Commission emitted a Standardization Mandate European Standardisation Organisations (ESOs) to support European Smart Grid deployment. This mandate is known as M490 and had the objective "to develop or update a set of consistent standards within a common European framework that integrating a variety of digital computing and communication technologies and electrical architectures, and associated processes and services, that will achieve interoperability and will enable or facilitate the implementation in Europe of the different high level Smart Grid services and functionalities…" [6].

For answering to this mandate, the three European reference SDOs (CEN, CENELEC and ETSI) constituted the Smart Grid Coordination Group (SGCG).

The result of the SGCG group work is a set of document which contains among other things:

- A <u>reference architecture</u>, called **Smart Grid Architecture Model (SGAM)** [7];
- A <u>set of reference standards</u>, released in a first version [8] and in a final version [9];
- A <u>tool</u> delivered as an Excel sheet (**IOP tool**) that includes the list of **538** standards potentially useful in Smart Grid applications.

In particular, in the IOP tool, each standard is described by its acronym, title and short abstract and each standard is located within SGAM architecture.

More specifically, for each standard the tool not only indicates SGAM interoperability layers, domains and zones but, also, crosscutting topics (i.e., data modelling, telecommunication, security, connecting DER, power quality, functional safety) and testing issues. Moreover, some useful filters in this Excel tool are available that enable the user to find standards which fulfil the chosen filters. At present, the tool contains 342 and 177 standards that can be placed on the Communication and Information Interoperability layers, respectively.

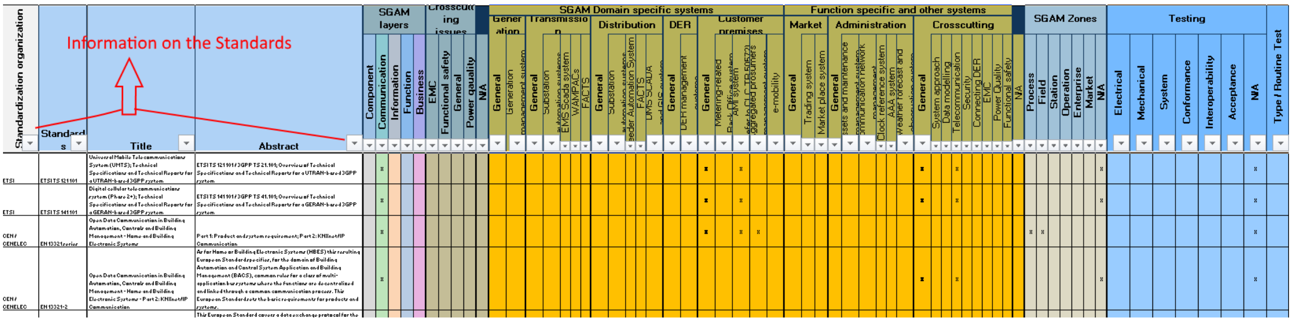


Figure 2 - Layout of the IOP Tool

Moreover, the other SGCG results are the following reports[2]:

- Applying, testing and refining the Smart Grid Architecture Model;
- Overview of SG-CG Methodologies;
- Methodologies to facilitate Smart Grid system interoperability through standardization, system design and testing;
- Smart Grid Information Security.

2.2 The problem of standards evaluation and classification

2.2.1 Use of SGCG results from the use case designer point of view

As seen in the previous paragraph, the SGCG results provide a lot of information to navigate the huge set of SG interoperability standards, but these instruments were created having as target the standardization community. An interesting question is how they can be used by an ELECTRA (and more general, by Smart Grid) designer for understanding what standards can satisfy the needs of a use case.

So, let us consider the following situation: a designer, involved in the implementation of a Smart Grid system use case, wants to identify the information layer standards more suited to satisfy its needs, using, as reference, mainly the SGCG "set of standards" document.

[2] The reports can be found here: http://www.cencenelec.eu/standards/Sectors/SustainableEnergy/SmartGrids/Pages/default.aspx

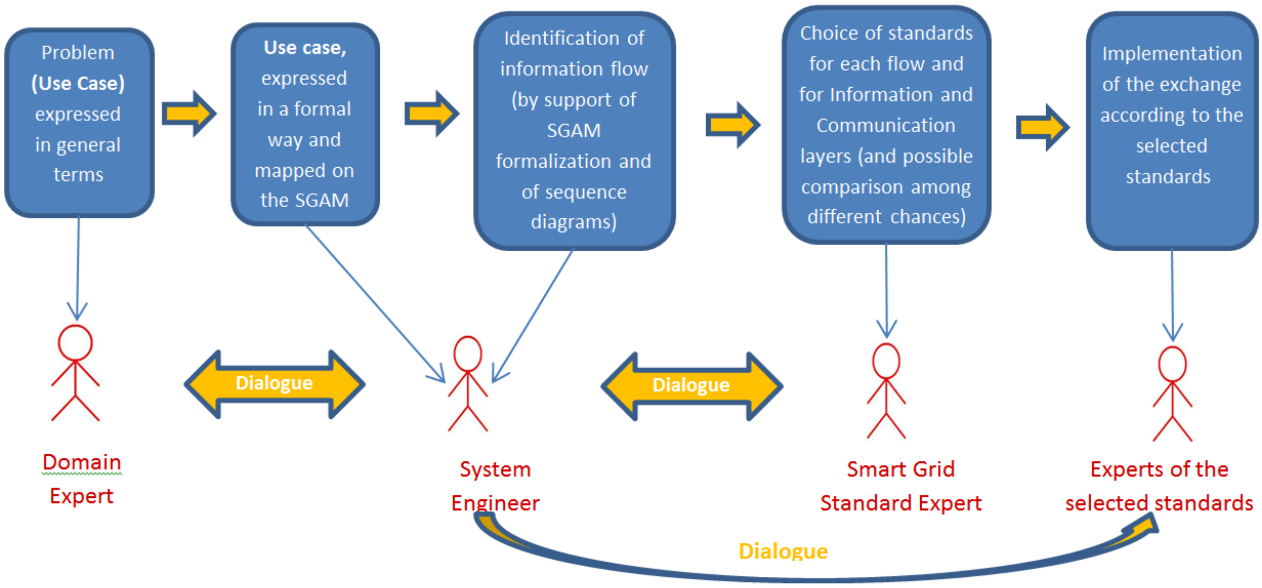


Figure 3 - The ideal path from Use Case to Standard choice

For examining the problem the "Flexible load" use case, provided within the SGAM toolbox documentation [10], will be used. This use case involves a user equipped with a Combined Heat and Power Plant (CHP), a Heat Pump (HP) and storage for thermal energy. If the user uses the CHP, he/she produces both electric and thermal energy and this reduces the load to the distribution system. If the user uses the Heat Pump, he/she consumes electricity for generating thermal energy, so this increases the load of the distribution system. So, in this use case, the Distribution System Operator wants to use this potential flexibility, offering dynamic prices to the user, valid for a 24 hour window.

In the example documentation, UML diagrams and SGAM mapping can be found. What is interesting, some information exchanges are identified (see Figure 4)[3] for the SGAM Information layer. The involved actors are:

- Distribution Management System (DMS): a system which provides applications to monitor and control a distribution grid from a centralized location, typically the control centre;
- Energy Management System (EMS): a facility specific system that is operating various energy consuming or producing systems in the domain of the facility.

[3] Please note that, if we want to look at the SGAM communication layer, we should look also at the Component layer diagram

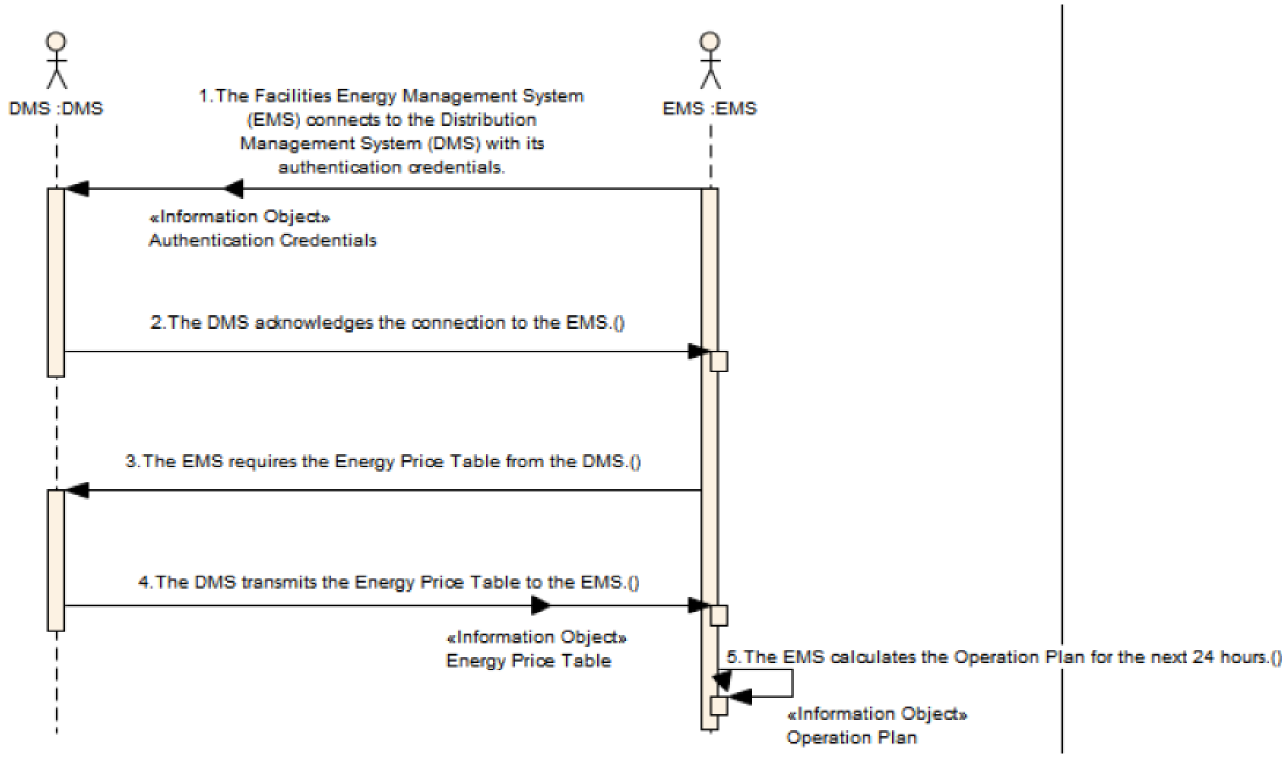


Figure 4 - Sequence diagram for the Operation plan Primary Use case, within the Flexible Load use case

Some more detailed information about the exchanged messages can be found in the following table:

Table 1 - Information objects for the previous sequence diagram

Element	Notes
«Information Object» **Authentication Credentials**	• User • Password • Policy….
«Information Object» **Energy Price Table**	The Energy Price Table contains information for 24 h. It has to be transmitted until a certain time; otherwise the table from the previous day is valid. It consists of prices for 30 min time slots.

The second kind of information exchange (Energy Price Table) is really complex, from the point of view of the standard selection. Indeed, using SGCG resources for finding standards applicable for this information exchange, this is what can be found:

- Consulting the “SGCG Set of standard document”, the use case nearest to our needs (exchange of Price table between DMS and the EMS of a flexible user) seems to be the primary use case called “Receiving metrological or price information for further action by consumer or CEM” in the use case cluster “Demand and production (generation) flexibility”. For it, as can be seen in table 10 on page 36 of the SGCG document (see figure below), both Information and Communication level standards are categorized as “coming” ones:

Use case cluster	Primary use cases	AVAILABLE	COMING	Not yet
Demand and production (generation) flexibility	Receiving metrological or price information for further action by consumer or CEM		CI	
	Generation forecast (from remote)		C	I
	Generation forecast (from local)		C	I
	Participating to electricity market	I	CI	
	Managing energy consumption or generation of DERs via local DER energy management system bundled in a DR program		CI	
	Managing energy consumption or generation of DERs and EVSE via local DER energy management system to increase local self-consumption			
	Registration/deregistration of DER in DR program		CI	

Figure 5 - According to this table, the needed standards are not yet available

But, reading the rest of the text, it cannot be understood which standards, among the mentioned ones, are the coming standards for the referred use case.

So it is necessary to take a look at the list of selected standards for searching information about each of them and understanding which of them can be used for the aims of the analysed use case.

At the end of this complex analysis, the standards that need to be better studied for understanding if they can enable the needed exchange are those in Table 2.

Table 2 - Standard identified looking at SGCG "set of standards" document for the analysed use case

Standard	Short description
IEC 61850-90-15	Integration of DER in the grid: it describes the requirements for data interfaces for integration and data models for the interfaces [11]. The above description could suggest that this standard could provide the needed fields about prices, but continuing to read, it seems suited only for electric features for DERs and so prices could be, probably, not provided for. Unfortunately, specifications are available only against payment and no other information for clarifying this point has been found. But looking at the paper "Integration of DER systems into the Electrical Power System with a generic IEC 61850 interface" [12], the following sentence: "Market platform registry has not been included into the standard IEC61850 90-15" may be a proof that is not suited for price tables
IEC 61968	The IEC 61968 standard, taken as a whole, defines interfaces for the major elements of an interface architecture for distribution systems within a utility enterprise. Part 1: Interface Architecture and General Recommendations, identifies and establishes requirements for standard interfaces based on an Interface Reference Model (IRM). Parts 3 through 9 of IEC 61968 define interfaces relevant to each of the major business functions described by the Interface Reference Model. (STARGRID Information Tool[4], 2015)

- Using the SGCG Interoperability IOP tool: as seen in paragraph 2.1.2, the IOP tool is an Excel sheet which lists the SG interoperability standards identified by the SGCG. The tool has some filters which can be used for narrowing down the search. In this case, selecting:
  - the Information layer;

[4] STARGRID Smart Grid Standardisation Information Tool, http://stargrid.iwes.fraunhofer.de/#/page/document?id=IEC_61968

- o the Market Zone;

the resulting list presents 18 standards (Figure 6). Reading the short description columns, it results that some of them are clearly out of scope (for example IETF RFC 3584, which purpose is to describe coexistence between version 3 and 2 of the Internet Standard Network Management i.e. the coexistence between SNMPv3, SNMPv2 and SNMPv1 protocols or IETF RFC 4789, which specifies how SNMP messages can be transmitted over IEEE 802 networks). For most of them it is not so clear if they are within the scope. One of them seems more near to our needs (for example IEC 62325, CIM extension for markets, which, moreover, is the only one with a cross in the "data model" column of cross-cutting issues).

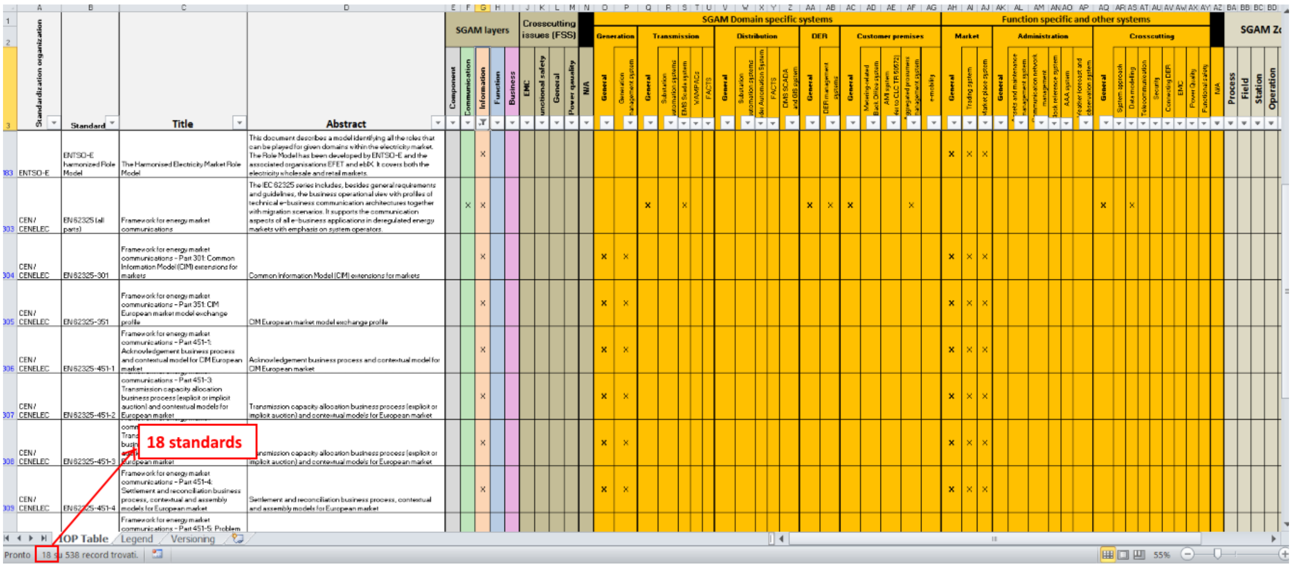


Figure 6 - Use of the IOP tool for the selected use case

The second selection could be made removing the market layer filter and inserting a filter on "Function specific and other systems" in the column Market – General. In this way 14 standards are selected (10 in common with the previous selection).

At least three of the additional four specifications seem really interesting: IEC 61968 (which represents a group of standards for information exchanges between electrical distribution systems), IEC 61970 (which represents standards of API for EMS) and ENTSO-E Market Data Exchange.

So, combining the two SGCG sources some potentially useful standards can be identified, but in order to understand if they are really the needed ones other information is required: further analysis is necessary and considering that many of this specifications are available only against payment, further search on the Web is needed (hoping to find the required information).

Moreover, some other specifications could be used for expressing the tariffs: SEP and OpenADR. Moreover, there is also the OASIS EMIX specification which could be used for the same aim. This is not amazing, since the "SGCG set of standards" document explicitly admits to be not exhaustive. Moreover, these are specifications born in the USA and still not standardized in Europe. More in details:

- **SEP** is the **Smart Energy Profile**, developed by ZigBee Smart Alliance. SEP 2.0 (that is IEEE P2030.5) "provides the guidelines in which the devices should communicate with one another. It defines various device properties that can be manipulated. […] A metering system, or **pricing system**, is an example of an application-specific function set" [13]. Its last version is the 2.0. Moreover, SEP 2 differs from OpenADR since "SEP2 is focused on Home Area Network Devices (HAN) while OpenADR is designed for high level communications between the AMI Systems, utilities communications networks and ISOs[5]". In any case, it is interesting to note that SEP declares explicitly that M/441 of European Commission has been taken into account in the definition of its specification [14] .

- **OpenADR** is also a USA standard (developed by Open ADR Alliance on the base of OASIS Energy Interoperation Standard) and it is not still standardized by official SOs. In any case its developers are in contact with IEC and its standardization is going on, as can be read in the OpenADR Alliance web site news [15].
- **EMIX** is a standard developed by OASIS and also this one is based in the USA [16]. Moreover it is (just) mentioned by the "SGCG set of standards" document about DER EMS and VPP market operation.

Trying to compare the found standards the following results have been got:

Table 3 - Example of comparison among identified standards

Parameter	IEC 61968	SEP 2.0	OpenADR 2.0	EMIX
Scope	Information Exchange between Electrical Distribution Systems. The IEC 61968 series of standards is intended to facilitate ***inter-application*** *integration* of a utility enterprise that needs to connect disparate applications that are already built or new (legacy or purchased applications) This series of standards is intended to support applications that need to exchange data every few seconds, minutes, or hours rather than waiting for a nightly batch run. Part 8: specifies the information content of a set of message types that can be used to support many of the business functions related to Customer Service. The information about tariffs is in **part 11**. **But being it a part of CIM, it does not provide XML messages, but abstract UML models.**	It defines an application protocol that maps the IEC 61968 Common Information Model. It defines the higher layers of ISO stack and do not provides information on the lower ones. It provides XML schema, the application protocol and the WADL (which are the Web Application Description Language for the RERS Web Services)	It is a Demand Response Standard providing data models, exchange patterns and interfaces for definition of standard Demand Response signals. This is the solution that IEC-62746 is considering for interface between Commercial Grid actor role (Retailer, Aggregator) and Active customer.	It defines an information model to exchange Price and Product information for power and energy markets. Product definition includes quantity and quality of supply as well as attributes of interest to consumers distinguishing between power and energy sources. It is anticipated to be used for information exchange in a variety of market-oriented interactions.

[5] ISO is the USA terms for referring to Independent System Operators, which are organizations that "operates a region's electricity grid, administers the region's wholesale electricity markets, and provides reliability planning for the region's bulk electricity system" (https://pure.ltu.se/portal/files/37136211/CoAP_SEP2_final.pdf)

Parameter	IEC 61968	SEP 2.0	OpenADR 2.0	EMIX
	XML has to be built starting from UML. There are some examples on the internet about UML to XML conversion. However, using EMIX seems more suitable.			
Actors	Main actors are application inside DSO, but it can be used for Demand Side Management	Mainly devices of the Home Area Network	Energy Markets, Independent System Operators (ISO), utilities, Distributed Energy Resources.	Energy Markets
Prices information?	Only UML diagrams and not its implementation	Yes	Yes	Yes
Base technologies	UML	REST Web Services, HTTP, Web Application Description Language (WADL), XML or EXI (for Payload), Transport **authentication** and **encryption** using TLS over HTTP.	It uses the data models provided by **EMIX**.	XML technologies
Interoperability tests	No	Under development	Provided against payment	No
Standardized by…	IEC	ZigBee Alliance, which is not an official Standard Organization, but an open, non-profit association of members. Anyone can join to the alliance and it comprises businesses, universities and government agencies.	OpenADR alliance. It is not an official Standard Organization, but it was "formed 2010 by industry stakeholders to build on the foundation of technical activities to support the development, testing, and deployment of commercial OpenADR and facilitates its acceleration and widespread adoption	OASIS is a non-profit consortium that drives the development, convergence and adoption of open standards for the global information society. It is an **International Standards Organizations**
Maturity	It is a mature standard	It is at its second realise	It is at its second realise	It is at its first realise
Openness	It is open but **only some parts** are **freely** available (8 and 11, for example)	It is open and freely available	Specification is open and freely available	Specification is open and freely available
Coherence With SGAM	It can be mapped on SGAM and it is present in the SGCG Set of Standards	It is **not present in the SGCG set of standards**, but it take in account the SGCG work and it provide, among the other things, a data model coherent with IEC 61968	It is not present in the SGCG set of standards, but IEC is working on its standardization.	It is quoted by the SGCG documents, but it is not clear if it can be taken in consideration

So, after a first analysis, it could make sense to use EMIX (which is, to some extent, considered in the "SGCG set of standards") or the SEP 2.0, if we prefer to maintain the reference to CIM.

2.2.2 Some considerations

Looking at the development of this simple example, some remarks on the use of the SGCG resources for the selection of standards can be formulated (from the use case designer point of view):

- The use cases presented in the “SGCG set of standards” document [9] are really general and high level ones, so the use case under development could not be found inside the “set of standards”
  - This can imply the need for understanding how much the “SGCG set of standards” use cases could be used as reference for the use case under development;
- It is not so easy to map requirement from a use case on “set of standards” structure
- Once the list of suggested standards for the use case has been identified, it is not certain that the standards that satisfy the initial requirement (for example the exchange of a certain kind of information) are directly linked in the “SGCG set of standards”. So extra-knowledge about the standards is needed;
- The IOP tool can help in this work but the information provided by this excel sheet about the content of a standard is too scarce for representing the definitive solution;
- This extra-knowledge could be already owned by a designer who is analysing the use case. But considering that more than 400 standards are listed in the document, it is possible that the use case designer does not know the standards (in particular, in our task, the figure of the Expert of certain Standards could be absent). So this information has to be searched. But:
  - a lot of them are available only against payment;
  - if the specifications are not available (for example, being not free, one would prefer to understand if they are the right ones, before buying them), it is not obvious that the needed information for understanding if the standards are not the right one should be find in the Web;
  - specifications are long, complex and the needed information could be drowned within them;
- Standards not mentioned in the SGCG resources could be useful for our aims (especially when the official ones are not yet available, this choice could be better than using a proprietary format). So, further information about them would be useful.

A different approach for complementing the SGCG from the point of view of the designer would be really necessary. The idea is to be able to provide a more rich set of information about the standards to the designers so they can be aware of the features of these standards before deciding if they are really needed. At this aim it would be useful to be able to provide for the designers:

- a table showing the features of a standard;
- an assessment of the standard enabling the understanding of its strengths and weakness (and the comparison among different standards in a uniform way).

In order to fulfil this requirement the problems of ICT standards assessment, of designing and development of a tool for executing this assessment and also of collecting features of the assessed ICT standards were faced in this task.

2.2.3 Parameters for ICT standard assessment: general considerations

Some parameters could be observed for each standard for evaluating how much the previous problems could affect a specification.

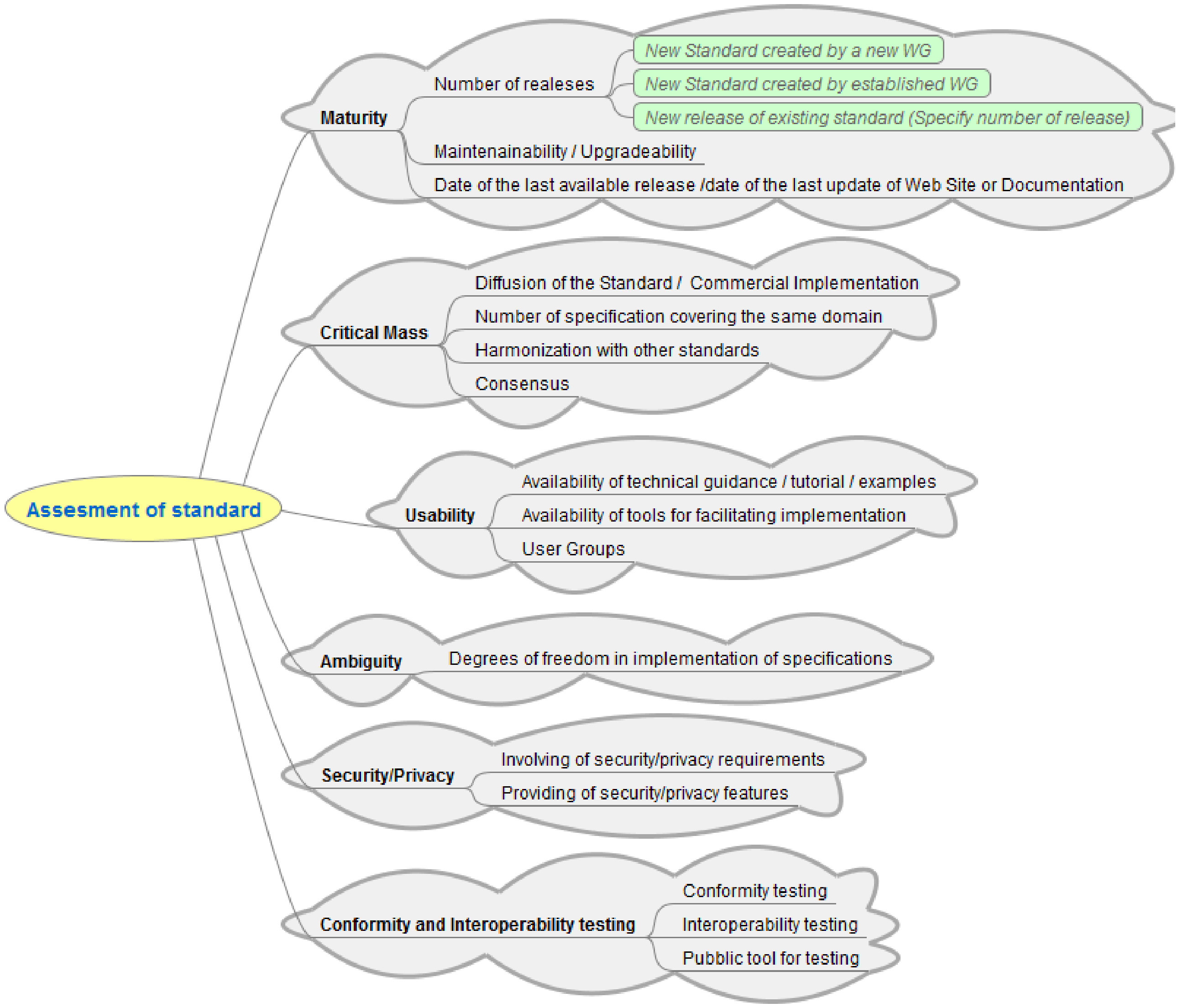


Figure 7 - Parameters for assessment of standards from the Interoperability point of view

Table 4 - List of the parameters for assessing the ICT standards from the Interoperability point of view

Problem	Parameter	Relation	Where information could be found
Maturity	**Number of the release**	A standard at his first release has, potentially, inside it a certain number of problems that need to be solved. It is interesting also to check how much are changing the releases in time and, overall, if the retro-compatibility is assured.	This information can be easily found in the documentation of the standard. In addition to the number of the release, the following classification could be useful: 1. *New Standard created by a new WG* 2. *New Standard created by*

Problem	Parameter	Relation	Where information could be found
			established WG 3. *New release of existing standard (Specify number of release)*
	Maintainability /Upgradeability	This information could give an idea of the rapidity of reaction in case of problems within the specifications or of the delivery of a new release.	It is **not so easy** to get this information. It would require a deep knowledge of the standard, but an indication about this point is the existence of a permanent group for this purpose.
	Data of the last available release / date of the last update of Web Site or Documentation	If a specification which would lie without updates (at least updated documents or news on the Web Site), this could be an indication that the interest for this standard is lost and that it would be better to use another one (in any case this one is only a possible interpretation and not a certainty).	This information can be easily found on the Web Site.
	Maturity according to the "SGCG set of standard" document	This document is the main reference for this work. In any case, being it delivered on the 2014, this information has to be checked	Available on the SGCG document
Critical Mass	**Diffusion of the standard**	If the standard is really diffused, the problem of critical mass would not subsist. In has to take in account also the number of **commercial implementations**, if known.	Some official data could be presented on the official Web Site of the standard (unfortunately, there is no objective way for getting this diffusion, since they are "self-certificate" data). For example, about Multispeak, it is said that it is "in use at hundreds of utilities" [17].
	Number of specification covering the same domain	If there are a lot of alternative standards that can cover the same requirements, the number of users could be dispersed among the various standards.	This information could be extracted from the "SGCG set of standards" document.
	Harmonization with other standards	If the standard is involved in a harmonization process with other similar specifications, it could gain interoperability and increase the number of implementations.	This point can be found in the Web Site or analysing, at higher level, the activities of the various Committees and Standardization Organizations.
	Consensus	If the consensus process is open to all interested parties the stakeholders could be more motivated in participating and then using it.	This can be seen in the documentation of the standard.

Problem	Parameter	Relation	Where information could be found
Usability	**Availability of technical guidance, tutorial and examples**	The official specifications are usually written in a hardly usable and understandable way for the users. This can increase the probability of misunderstanding in their application. The presence of guidance, tutorial and examples can help the user in implementing the specification in the right way.	They can be present in the Web Site, but also in some user group or in other Web Sites.
	Availability of tools for facilitating implementation	For some standards, tools for facilitating the implementation exist. For example, for CIM there is the CIMtool available at http://wiki.cimtool.org/index.html. If these tools are free and/or official this point can be still more significant.	They can be present in the Web Site, but also in some user group or in other Web Sites.
	User Groups	The existence of user groups ensures the existence of a community interested in the use of the standard, where documents, presentations, forums where questions can be asked and so no.	They can be linked in the Web Site, but have usually independent Web Sites.
Ambiguity	**Degrees of freedom in implementation of specifications**	If there are too many degrees of freedom different users can use the same standards in very different ways and this can really hinder interoperability	For Information level standard the presence of too many not typified fields or too many free fields or too many optional fields or fields that can be used in different ways and so on can be indicators for this excess of ambiguity
Security/ Privacy	**Involving of Security/ Privacy requirement**	Even if this point is not related to Interoperability, the Smart Grid context need to assure security and privacy features. If these issues are considered in the requirements for the design of the standard, this would add interest to the standard itself	This information should be found on the official Web Site/Documentation
	Providing of security/ Privacy features	See the previous point	This information should be found on the official Web Site/Documentation
Conformity and Interoperability testing	**Conformity tests**	Conformance testing is "the act of determining to what extent a single implementation conforms to the individual requirements of its base standard." So it checks the	This information should be found on the official Web Site.

Problem	Parameter	Relation	Where information could be found
		correct implementation of the standard. [18]	
	Interoperability tests	"Interoperability testing should be performed to verify that communicating entities within a system are interoperable, i.e. they are able to exchange information in a **semantically** and **syntactically** correct way. During interoperability testing, entities are tested against peer entities known to be correct. (profiles)". [18] For example, Multispeak provides both these kinds of tests (http://www.multispeak.org/ProductTesting/Pages/ComplianceandInteroperabilityTesting.aspx)	This information should be found on the official Web Site
	Public testing tools	The availability of public tools for executing tests will allow a user to test its own implementation in an easy way (they could be services, tools, certified services, and so on). In some cases, they could be able to give a **certification**. In this case they weight still more in the assessment of the standard. For example, EDINE, the Netherlands format for Electric Market exchange (http://www.tennet.eu/nl/customers/procedures-and-regulations/edine.html), provides a test facility for this purpose.	This information should be found on the official Web Site

The relation between the problems identified in Figure 1 (- Issues that can hinder Interoperability) and parameters in Figure 7 are highlighted in the following figure:

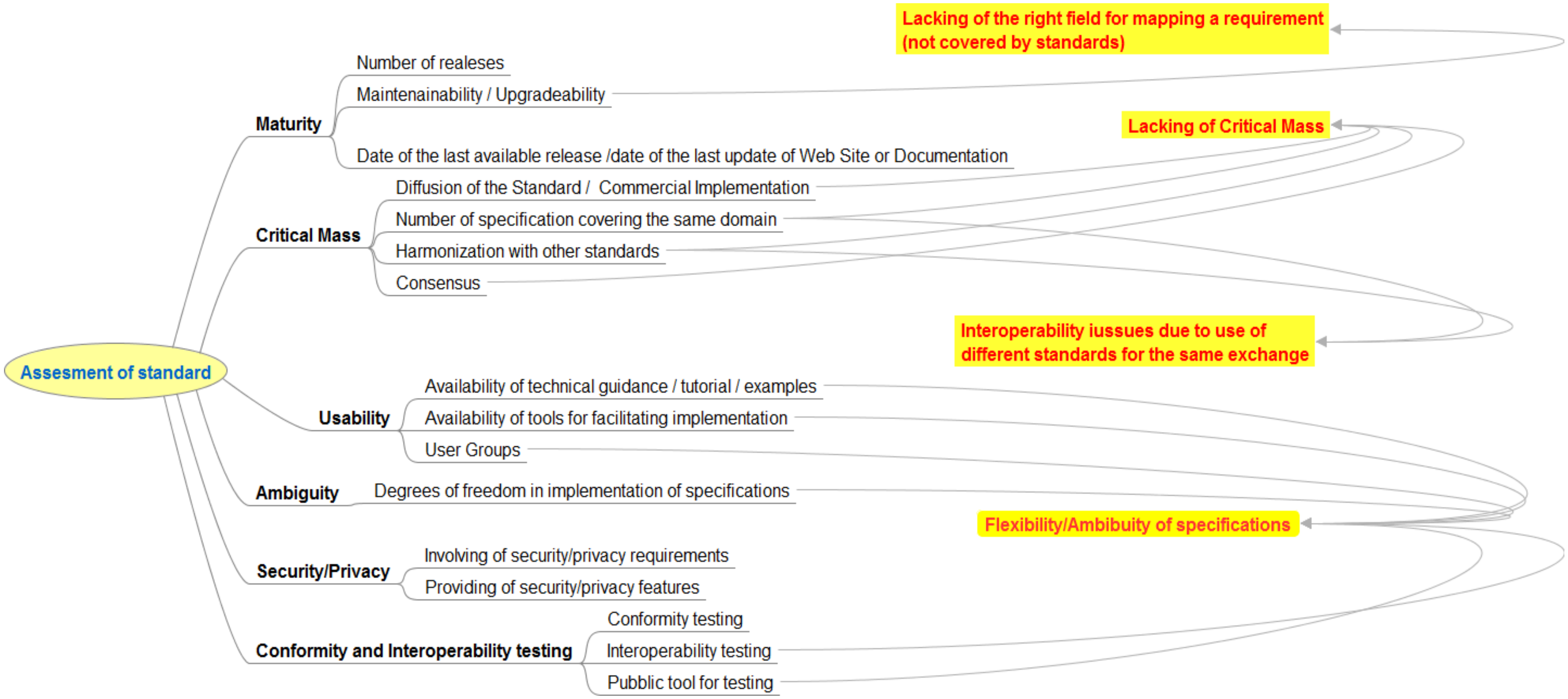


Figure 8 - Relation about issues and parameters

2.3 Design and development of the EAT-SGIS tool

2.3.1 Search for a reference method: CAMSS

It would be useful to have a reference method for assessing and classifying the ICT interoperability standards. For this aim, a set of Maturity Models was examined. Among them were the Enterprise Interoperability Maturity Model [19] and the Smart Grid Interoperability Maturity Model (SGIMM) [20], but this kind of methodologies seems more suited for evaluating complete interoperability frameworks and the use of standards is considered only as an element for this evaluation.

Fortunately, a specific method exists for assessment of ICT standards. It is called **CAMSS (Common Assessment Method for Standards and Specification)** and is born from an initiative of the European Commission's IDABC programme[6] to “initiate, support and coordinate the collaboration between volunteer Member States in defining a Common Assessment Method for Standards and Specifications and to share the assessment study results for the development of eGovernment services” [21].

CAMSS was developed for responding to:

- The decision No. 922/2009/EC of the European Parliament and of the Council, in particular about articles 3(a) ("the establishment and improvement of common frameworks in support of cross-border and cross-sectorial interoperability") and 4 ((a) "technological neutrality and adaptability;" (b) "openness;" and (c) "reusability;") [22];
- The action 23 of the Digital Agenda (“Provide guidance on ICT standardization and public procurement") [23].

So the CAMSS is thought to be a tool for Public Administration choices of standards to be adopted (especially for **e-government** and **e-procurement**) and so it offers **a step-by-step process** in which the assessment of the standard is submitted, a panel of experts is defined and the experts who execute the assessment are selected.

What is interesting for the T4.3 aims is that CAMSS defines an evaluation schema for the standards and an Excel tool for executing this evaluation.

The evaluation schema considers a set of categories for evaluating the standard. The categories are the following:

1. Applicability
2. Maturity
3. Openness
4. Intellectual property rights (IPR)
5. Market support
6. Potential
7. Coherence

Each of them is split in subcategories as shown by Figure 9.

[6] IDABC stands for Interoperable Delivery of European eGovernment Services to public Administrations, Business and Citizens and is a Community programme managed by the European Commission's Directorate-General for Informatics [47].

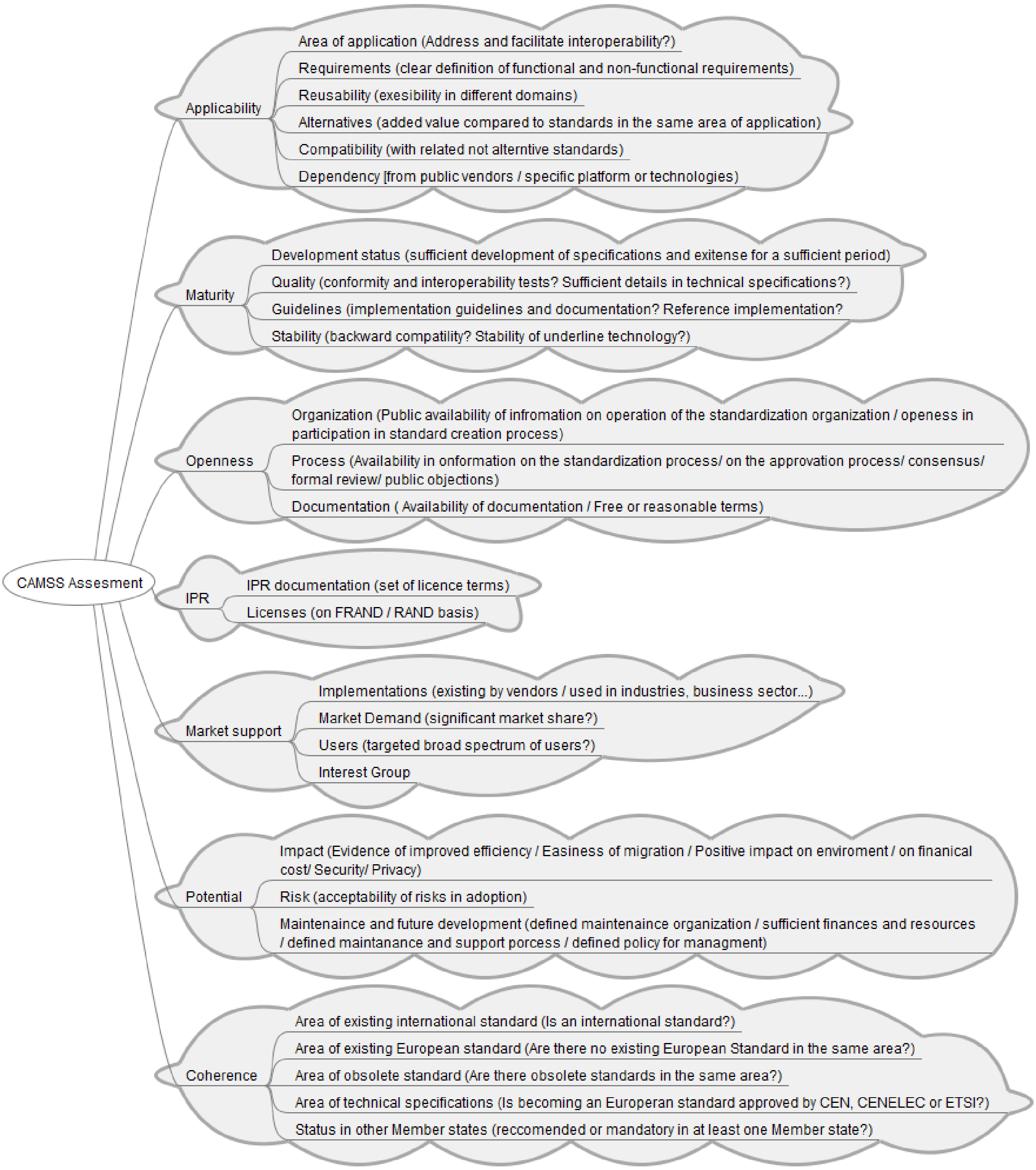
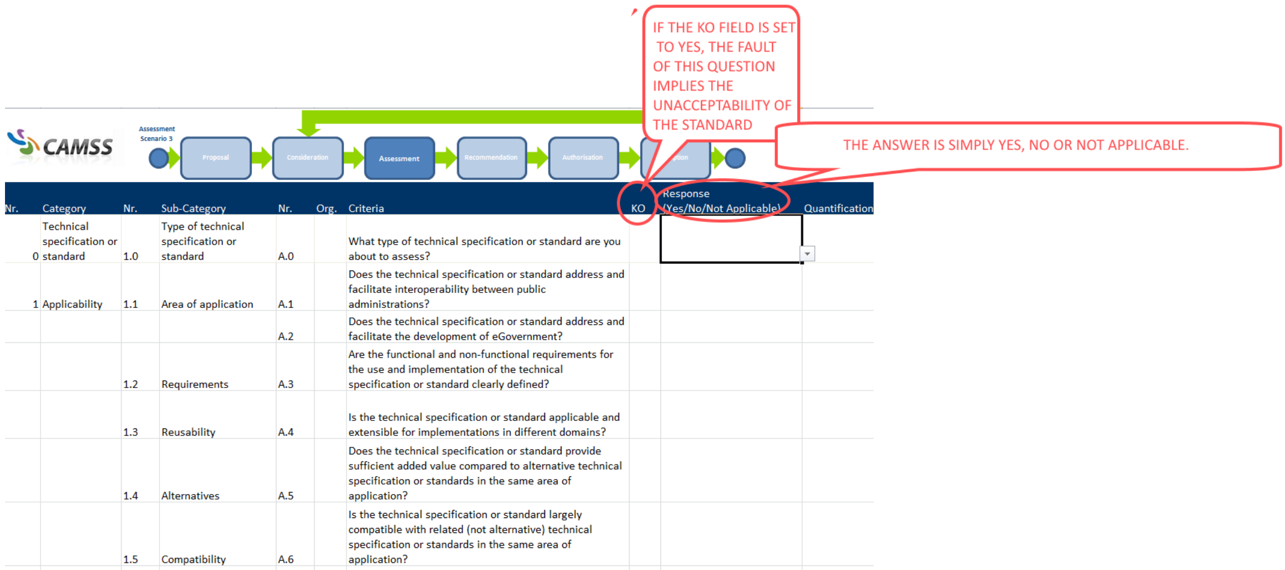


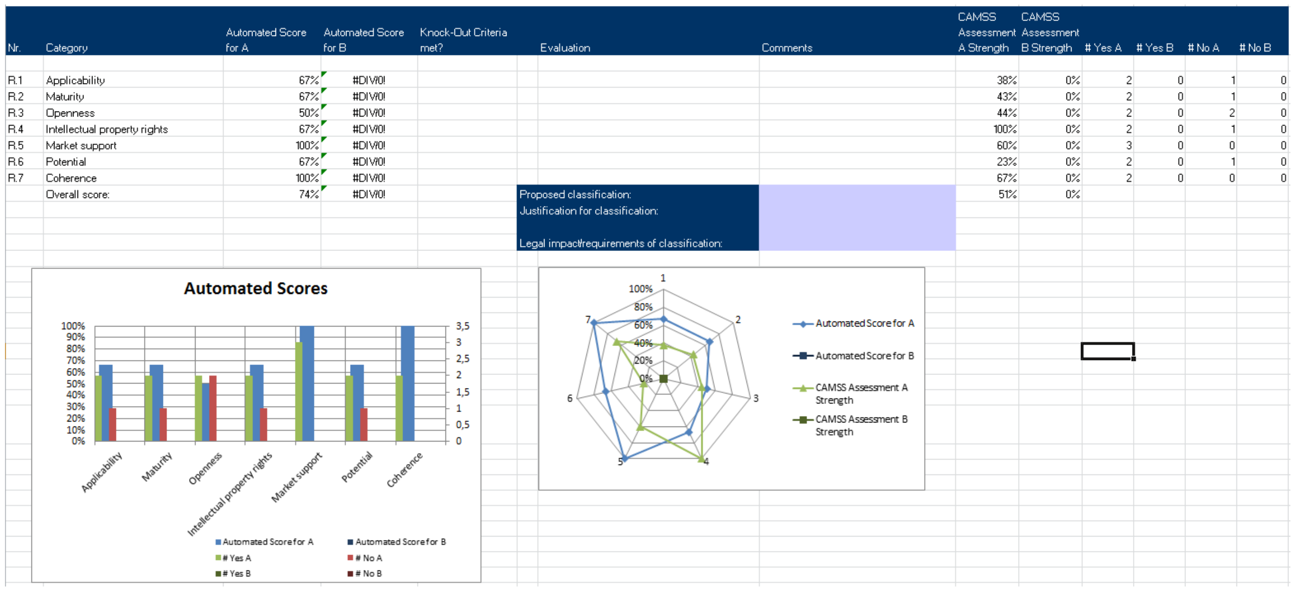
Figure 9 - Categories and subcategories for assessment of standards according to CAMSS

The core of the excel tool is a questionnaire which asks, for each subcategory, a set of questions (see Figure 10) and, at the end, shows the summary of the assessment [21].



Nr.	Category	Nr.	Sub-Category	Nr.	Org.	Criteria	KO	Response (Yes/No/Not Applicable)	Quantification
0	Technical specification or standard	1.0	Type of technical specification or standard	A.0		What type of technical specification or standard are you about to assess?			
1	Applicability	1.1	Area of application	A.1		Does the technical specification or standard address and facilitate interoperability between public administrations?			
				A.2		Does the technical specification or standard address and facilitate the development of eGovernment?			
		1.2	Requirements	A.3		Are the functional and non-functional requirements for the use and implementation of the technical specification or standard clearly defined?			
		1.3	Reusability	A.4		Is the technical specification or standard applicable and extensible for implementations in different domains?			
		1.4	Alternatives	A.5		Does the technical specification or standard provide sufficient added value compared to alternative technical specification or standards in the same area of application?			
		1.5	Compatibility	A.6		Is the technical specification or standard largely compatible with related (not alternative) technical specification or standards in the same area of application?			

Figure 10 - A part of the screen from the questionnaire in the CAMSS Excel tool



Nr.	Category	Automated Score for A	Automated Score for B	Knock-Out Criteria met?	Evaluation	Comments	CAMSS Assessment A Strength	CAMSS Assessment B Strength	# Yes A	# Yes B	# No A	# No B
R.1	Applicability	67%	#DIV/0!				38%	0%	2	0	1	0
R.2	Maturity	67%	#DIV/0!				43%	0%	2	0	1	0
R.3	Openness	50%	#DIV/0!				44%	0%	2	0	2	0
R.4	Intellectual property rights	67%	#DIV/0!				100%	0%	2	0	1	0
R.5	Market support	100%	#DIV/0!				60%	0%	3	0	0	0
R.6	Potential	67%	#DIV/0!				23%	0%	2	0	1	0
R.7	Coherence	100%	#DIV/0!				67%	0%	2	0	0	0
	Overall score:	74%	#DIV/0!		Proposed classification:		51%	0%				
					Justification for classification:							
					Legal impact/requirements of classification:							

Figure 11 - The final Assessment calculated on the base of answers in the questionnaire

In Figure 11, the final assessment screen is shown. The **score** is calculated for each category as the ratio of number of "yes" and the number of the total number of defined ("yes" and "no") answers. So, the "not applicable" answers do not contribute to this calculation. Moreover, the **strength** of the evaluation is calculated as the ratio of the number of answered questions and the total number of questions. For example, in the figure above the usability has a score equal to 67%, but the number of answered questions is only 3 of the 8 available questions, so the assessment in not so strong (38%). Both of them (score and strength) are shown in the graph. Moreover, the input of two different assessments is allowed.

The Proposal of classification is not automatically defined and can be inserted choosing one of the following values:

- Discarded
- Observed

- Accepted
- Recommended
- Mandatory

Unfortunately, being designed for e-government and not for Smart Grid context, CAMSS cannot be used “as is” for the aim of this task. But it provides a strong reference for developing a specific methodology and a corresponding tool for ELECTRA aims.

2.3.2 Adaptation of CAMSS methodology for T4.3 aims

The elements of CAMSS that can be adapted for the ELECTRA T4.3 are:

- The evaluation method/questionnaire: this adaptation requires a check of the categories, subcategories and of the questionnaire for understanding what can be used as it is and what needs to be modified.
- The use of an excel tool for collecting the information about the standards and for having a uniform assessment template.

The advantages of the use of CAMSS are the following:

- we do not have to re-invent the wheel,
- the assessment of the standards will be made on the basis of a tested and strong reference model and the result will be, as much as possible, uniform with a European level defined method.

The first needed step is to understand how the initially proposed set of parameters (see paragraph 2.2.3) can be mapped on the CAMSS set of categories. Figure 12 shows a comparison between CAMSS categories/subcategories and the initially proposed possible set of parameters of a standard from interoperability point of view.

Figure 12 - Comparison between CAMSS Assessment and initially proposed parameters

In the following table (Table 5) a look is taken to the map between these two sets of parameters, in order to understand if something is still lacking in the CAMSS model:

Table 5 - Mapping of the initial set of parameters to CAMSS

Category / Subcategory in the initial set	Category / Subcategory in CAMSS	Comments
Maturity	**Maturity**	The concept is the same
Number of releases	*Not present*	It should be added in some way (even if it has a structure different from Yes/No/Not Applicable)
Maintainability/Upgradability	It is not in the **Maturity** category, but in the **Potential** one and also with **Applicability**/Reusability subcategory.	
Date of last updates	*Not present*	It should be added. In order to add it with a Yes/No field, the question could ask if there were updates in the last X years (were X has to be fixed in a reasonable way. It could be 3, for example)
Critical Mass	The category that maps this one is **Market support**	The name will be changed in Market support

Category / Subcategory in the initial set	Category / Subcategory in CAMSS	Comments
Diffusion of the standards/Number of implementations	It is split in two subcategories: **Market support**/Implementations and **Market support**/Market Share	
Number of specifications covering the same domain	It is mapped in the **Coherence** category by two subcategories: Area of existing European Standards and Area of obsolete standard	
Harmonization with other standards	*Not present*	It has to be added (maybe in the **Potential** category)
Consensus	This concept is inside the **Openness** category of CAMSS	
Usability	This concept matches more or less with the **Applicability** one in CAMSS	
Availability of technical guidance/ tutorial/ examples	It is split between **Openness**/Documentation and **Maturity**/Guidelines subcategories	
Availability of tools for facilitating implementation	*Not present*	It has to be added
Ambiguity	*Not present*	It has to be added (maybe in the **Applicability** field)
Security/Privacy	It is put involved in the questions about **Potential**/Impact subcategory	These two concept should be put more in evidence
Conformity and Interoperability testing // Public tool for testing	This is assessed within the **Maturity**/Quality subcategory	These concepts need to be better spilt

On the base of the previous considerations, in the following table (Table 6) the original questionnaire for CAMSS is adapted for ELECTRA.

The information about the CAMSS original questionnaire is available there:

https://joinup.ec.europa.eu/community/camss/wiki/camss-05-detailed-camss-criteria

Further on, considering that the aim of T4.3 is not only assessment but also collection of Smart Grid interoperability standards, the adapted ELECTRA tool should give in output a complete schedule about it: some additional fields with information that will be added in the schedule have to be inserted.

Special attention has to be paid to the coherence concept used in CAMSS. It is defined by the following sentence: “The technical specifications are coherent as they do not conflict with European standards, that is to say they cover domains where the adoption of new European standards is not foreseen within a reasonable period, where existing standards have not gained market uptake or where these standards have become obsolete, and where the transposition of the technical specifications into European standardization deliverables is not foreseen within a reasonable period.” [21]

This definition seems rather far from the ELECTRA needs, since it is about a different context and assessment of new standards.

In the ELECTRA context, what should be evaluated should be the "coherence with SGAM" (and in particular with its information and communication layers) verifying that the standard has a position in the reference model and checking if the standard has been inserted in the First List of Standards and, if not, checking that no other available standards have been identified as available in the same coordinates of the SGAM reference model. So the following questions from the CAMSS will be deleted:

1. Area of existing European standard: are there existing European standards which cover the same areas as the technical specification or standard being assessed?
2. Area of obsolete European standard: does the technical specification or standard cover areas different from areas addressed by obsolete European standards?
3. Area of technical specification under consideration: Does the technical specification or standard cover areas different from areas addressed by technical specifications being under consideration to become a European standard?

Moreover, the **Openness** and the **IPR** categories have been judged too complex and far from the ELECTRA aims. So the first has been simplified and the second deleted, while a more interesting question about IPR (that is "Is the technical specification or standard licensed on a royalty-free basis?") has been inserted into Openness category.

Some further explanation has to be added about question 10 (about "compatibility"). In CAMSS the original question asks: "*is the technical specification or standard largely compatible with related (not alternative) technical specification or standards in the same area of application?*".

In order to understand if this question made sense in the ELECTRA context, a reference definition of compatibility was searched. According to ISO/IEC, **compatibility** is defined as the "suitability of products, processes or services for use together under specific conditions to fulfil relevant requirements without causing unacceptable interactions[7]."So, from the point of view of the ISO/IEC definition the question could be interpreted as: "if I need to use different standards together for implementing a use case, could I meet problems?"

Two kinds of examples of this interpretation:

- If the examined standard is an information layer standard, what are the compatible communication layer standards?
    - For example, the IEC 61850 can be mapped on MMS (IEC 61850-8-1) but in future will be compatible also with SOAP, OPC XML DA, IEC 60870-5-104 and DNP3
- A more complex way for looking and the problem could involve the compatibility of different standards, belonging to the same layer, for using them together in the same use case, but this seems too complex to be really considered.

So, if the standards that cover SGAM information layer are considered, of course it can be asked about possible communication standards that can be employed on the SGAM communication layer. Moreover, it is important to remind that the SGAM communication layer involves protocols placed on different layers of the general 7-layers ISO/OSI reference model. Therefore, it is possible to ask about possible communication profiles (or stacks of standard protocols) including standard application layer protocols that can be used together with the assessed standard (located on the SGAM information layer).

[7] http://www.electropedia.org/iev/iev.nsf/display?openform&ievref=901-01-13

For example, let us consider IEC 61850. Assessing this standard using our Excel tool it should be indicated that it covers both information and communication SGAM layers. Specifically, IEC 61850-7-3 and 7-4 define data models (i.e. CDC) of a given interface (or a given server) and these parts should be located on SGAM information layer. On the other hand, IEC 61850-7-2 defines abstract communication services (i.e. ACSI) and, consequently, this part should be located on SGAM communication layer even though this standard does not define communication protocol (it defines an abstract communication solution that can be mapped to a real ISO/OSI application layer standardized protocol -MMS for example - this is shown in IEC 61850-8-1). Moreover, IEC 61850-8-1 part depicts possible communication stacks that can be applied. If client-server communication architecture is considered, different 7-layer protocol stacks can be used with MMS protocol at the top (i.e. ISO profile and TCP/IP profile). But if publisher-subscriber communication architecture and GOOSE messages are considered, the communication stack is reduced to Ethernet that is used at L2/L1.

So, If COSEM data model is considered, then theoretically any application protocol can be used, but the standardized solution foresees DLMS protocol at the top of any possible standardized protocol stack (i.e. DLMS + TCP/IP + Ethernet, DLMS+HDLC+RS 232, etc.).

Conclusions:

1. If a standard covering SGAM information layer is considered then the tool will ask about examples of possible communication profiles that include standardized communication protocols and can be used in practice with the assessed standard.
2. If a standard covering SGAM communication layer is considered, then the tool also can ask about possible communication profiles which include the assessed standardized protocol and other standard protocols located at different ISO/OSI layers.

The ELECTRA questionnaire for assessment of standards, produced starting from the CAMS questionnaire, is shown in Table 6.

Table 6 - ELECTRA Questionnaire for assessment of standards and its derivation from CAMSS (for details see Sheet 4: Questionnaire on Figure 15)

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
Coherence with SGAM	*Is the standard coherent with the SGAM Architecture (and in particular does it refers to its Communication and Information Layers) and First List of Standard?*	Coordinates on the SGAM Reference Model	*The standard must have a defined position within the SGAM Reference Model* [24]	1	Does the technical specification or standard have a defined position within Communication and/or Information layers in the SGAM reference model?	*New question* *This is a **KO** question.* *The reference to Information and Communication layers will be checked in the Standard Features sheet (see Figure 6) and this information could be evaluated in terms of Coherence with SGAM category, for avoiding duplications of questions*
			The standard should be considered in the SGCG set of standards from the SGCG [25]	2	Has the standard been considered in the SGCG set of standards from SGCG?	*New question*
		Alternative standards	*In case the standards cover the interesting SGAM layers but is not in the SGCG document, are there other standards occupying the same coordinates?*	3	Is this technical specification or standard the only available technical specification or standard for the specified SGAM coordinates?	*New question* *This question is hidden in the case the answer to question 1 is different from "Yes"*
Applicability	*A technical specification or standard should be **usable** and **easy implementable***	Focus on interoperability for Smart Grid	*The use of standards do not assure interoperability: if this feature is well specified in the aims of the standard, the problem is certainly addressed by it*	4	Does the technical specification or standard address interoperability between the involved actors/components?	*Original Sub-Category was "Area of application". This was replaced with "Focus on interoperability"* *Original question was about interoperability between public administrations.* *The question has been modified replacing PA with "the involved actors"*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
				5	Does the technical specification or standard address and facilitate the development of Smart Grid?	*Modified question: the original one askes about development of e-Government*
		Requirements	*The functional and non-functional requirements for using and implementing the technical specification or standard are addressed.*	6	Are the functional and non-functional requirements for the use and implementation of the technical specification or standard specification clearly defined?	*Original question*
		Reusability	*The level of reusability of the technical specification or standard in the same or other areas of application is addressed.*	7	Is the technical specification or standard applicable and extensible for implementations in different domains, zones and interoperability layers according to SGAM framework?	*Original question*
		Ambiguity	*If there are too many degrees of freedom different users can use the same standards in very different ways and this can really hinder interoperability*	8	Is the ambiguity of the specifications well addressed? (that means, for example, that there are not too many not typified fields or too many free fields or too many optional fields or fields that can be used in different ways)	*New question and new Subcategory*
		Alternatives	*Technical specification or standard adds value compared to alternative technical specification or standards in the same area of application?*	9	Does the technical specification or standard provide sufficient added value compared to alternative technical specification or standards in the same area of application?	*Original question.* *In a comment field it will be important to write what are the alternatives standards. This will be automatically pasted in the final page.* *This question is hidden if the answer to question 3 is different from "Yes*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
		Compatibility	*The compatibility of the technical specification or standard with other (not alternative) technical specification or standards in the same area of application is addressed.* *This question took to an interesting discussion (see paragraph 1.3.2)*	10	The question change on the base of the involvement of the information layer: 1) "Is there at least one communication profile including standardized communication protocols that either includes or can be used together with the assessed technical specification or standard without causing unacceptable interactions (or technical problems)?", in the case the INFORMATION LAYER is checked in the Standard features sheet 2) "Is there at least one communication profile which includes the assessed standardized protocol and other standard protocols located at different ISO/OSI layers?", otherwise?	*Modified question.* *In a comment field it will be important to write what are these compatible standards*
		Harmonization	*A huge harmonization process with one or more alternative standards is ongoing*	11	Is a harmonization process with one or more alternative standards ongoing/planned?	*New question / New Subcategory* *In a comment field it will be important to insert information about the harmonization process*
		Dependencies	*'Dependencies' addresses the degree of independence of the technical specification or standard from specific vendor products, platforms or technologies.*	12	Is the technical specification or standard largely independent from specific vendor products?	*Original question* *In a comment field it will be important to write what are the products from which it is dependent, if any*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
				13	Is the technical specification or standard largely independent from specific platforms or technologies?	*Original question* *In a comment field it will be important to write what are the products from which it is dependent, if any*
		Geographical basis	*The applicability of a standard could be influenced from its geographical origin, since USA, Europe, China and so on have different electric grid and different issues and priority in developing their Smart Grid*	14	Is it possible to apply this technical specification or standard in Europe without modifications?	*New question* *It is not, the Geographical reference has to be inserted*
Maturity	*A technical specification or standard should in itself be mature enough for adoption.*	Development status	*The current development status of the technical specification or standard in the development cycle is addressed.*	15	Has the technical specification or standard been sufficiently developed and in existence for a sufficient period to overcome most of its initial problems?	*Original question* *A field automatically filled with information previously inserted about the number of releases so that it could be an help for the editor of the questionnaire*
		Quality	*The level of detail in the technical specification or standard and the conformance of implementations are addressed.*	16	Are there existing or planned publicly available mechanisms/tools to assess conformity of the implementations of the technical specification or standard (e.g. conformity tests, certifications)?	*Original question*
				17	Are there existing or planned publicly available mechanisms/tools to assess interoperability of the implementations (Interoperability tests)	*New question* *If YES, the comment field will be activated to write where such mechanisms/tools are defined and/or available (or who is planning to develop such mechanisms/tools)*
				18	Does the technical specification or standard have sufficient detail, consistency and completeness for the use and	*Original question*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
					development of products?	
		Guidelines	*The existence of implementation guidelines or reference implementations is addressed.*	19	Does the technical specification or standard provide available implementation guidelines and documentation for the implementation of products?	*Original question*
				20	Does the technical specification or standard provide available tutorials and/or examples for the implementation of products	*New question.* *The answer to this question will affect also the score of the openness category*
				21	Does the technical specification or standard provide a reference (or open source) implementation?	*Original question*
				22	Are tools for facilitating implementation made available?	*New question* *If YES, in a comment field it will be important to write where such mechanisms/tools are defined and/or available (or who is planning to develop such mechanisms/tools)*
		Stability	*The level of change to the technical specification or standard and the stability of underlying technologies are addressed.*	23	Does the technical specification or standard address backward compatibility with previous versions?	*Original question*
				24	Have the underlying technologies for implementing the technical specification or standard been proven, stable and clearly defined?	*Original question* *In a comment field it will be important to insert information about these underlying technologies*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
		Vitality of the standard	*If a specification which would lie without updates (at least updated documents or news on the Web Site), this could be an indication that the interest for this standard is lost and that it would be better to use another one*	25	Were there updates in the specifications or in the documentation or, at least on the Web Site in the last 3 years?	*New question*
Openness	*A technical specification or standard should be sufficiently open and available to be relevant for adoption*	~~Organisation~~	~~*The level of openness for participating in the standardisation organisation is addressed.*~~		~~Is information on the terms and policies for the establishment and operation of the standardisation organisation publicly available?~~	*Deleted, in order to simplify the approach for ELECTRA purposes*
					~~Is participation in the creation process of the technical specification or standard open to all relevant stakeholders (e.g. organisations, companies or individuals)?~~	*Deleted, in order to simplify the approach for ELECTRA purposes*
		Organisation	If the organization is one of the official recognized Standard Development Organization (like CEN, CENELEC, ETSI, EAC, NIST, OASIS, …), all the Categories about Openness are certainly satisfied	26	Is the standardizing organization an official recognized Standard Development Organization (SDO), like CEN, CENELEC, ETSI, EAC, NIST, , …?	*New Question*
		Process	*The level of openness regarding the development and decision-making process for the technical specification or standard is addressed.*	27	Is information on the standardization process publicly available?	*Original question*
					~~Information on the decision making process for approving technical specification or standards is publicly available?~~	*Deleted, in order to simplify the approach for ELECTRA purposes*
					~~Are the technical specification or standards~~	*Deleted, in order to simplify the*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
					approved in a decision making process which aims at reaching consensus?	*approach for ELECTRA purposes*
					Is the technical specification or standards reviewed using a formal review process with all relevant external stakeholders (e.g. public consultation)?	*Deleted, in order to simplify the approach for ELECTRA purposes*
					All relevant stakeholders can formally appeal or raise objections to the development and approval of technical specifications or standards?	*Deleted, in order to simplify the approach for ELECTRA purposes*
		Documentation	*The accessibility and availability of the documentation of the technical specification or standard is addressed.*	28	Relevant documentation of the development and approval process of technical specification or standards is publicly available (e.g. preliminary results, committee meeting notes)?	*Original question*
				29	Is the documentation of the technical specification or standard publicly available for implementation and use on reasonable terms?	*Original question*
Intellectual property rights	*A technical specification or standard should be licensed on (F)RAND[8] terms or even on a royalty-free basis in a way that allows implementation in different products.*	IPR Documentation	*The availability of the information concerning the ownership rights of the technical specification or standard is addressed.*		Is the documentation of the IPR for technical specification or standards publicly available?	*Deleted, in order to simplify the approach for ELECTRA purposes* *Also the IPR Category has been deleted for the same reason*

[8] FRAND (or RAND) stays for "Fair, Reasonable And Non-Discriminatory" and means a licensing obligation that is often required by standards organizations for members that participate in the standard-setting process [48]

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
		Licences	~~*For the 'licences' within the intellectual property rights, a (fair) reasonable and non-discriminatory ((F)RAND) or even royalty-free basis is addressed for the use and implementation of the technical specification or standard.*~~		~~Is the technical specification or standard licensed on a (F)RAND basis?~~	*Deleted, in order to simplify the approach for ELECTRA purposes*
				30	Is the technical specification or standard licensed on a royalty-free basis?	*Original question, now moved in the Openness Category*
Market support	*A technical specification or standard should have sufficient market acceptance and support*	Implementations	*The existence of proven and best practice implementations for the technical specification or standard is addressed, in different domains and by different vendors.*	31	Has the technical specification or standard been used for different implementations by different vendors/suppliers?	*Original question* *Some official data could be presented on the official Web Site of the standard (unfortunately, there is no objective way for getting this diffusion, since they are "self-certificate" data).*
				32	Has the technical specification or standard been used in different electric power industry applications?	*Original question* *Some official data could be presented on the official Web Site of the standard (unfortunately, there is no objective way for getting this diffusion, since they are "self-certificate" data).* *For example, about Multispeak, it is said that it is "in use at hundreds of utilities" (McNaughton, 2007).* *If the number of commercial implementations is know it should be added in a comment field*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
		Market demand	*The penetration and acceptance of products implementing the technical specification or standard in the market is addressed.*	33	Do the products that implement the technical specification or standard have a significant market share of adoption?	*Original question*
		~~Users~~	~~*For the 'users', the diversity of the end-users of the products implementing the technical specification or standard is addressed.*~~		~~Do the products that implement the technical specification or standard target a broad spectrum of end-uses?~~	*This question seems not so useful for SG aims and can be deleted*
		Interest groups	*The degree of support from one of more interest/user groups is addressed.*	34	Has the technical specification or standard a strong support from one or more interest/user groups?	*Slightly modified question: the original one asked about a significant number of interest groups, but also only one is important. Moreover now the question asks also about users groups.* *In a comment field it will be important to insert information about these Interest/User Groups*
Potential	*A technical specification or standard should have sufficient and positive future consequences, evolution and impact for being adopted by public administrations.*	Impact	*The minimization of the consequences of using and adopting the technical specification or standard is addressed. The consequences can be evaluated and described in terms of different aspects.*	35	Is there evidence that the adoption of the technical specification or standard positively impacts organizational processes?	*Original question* *This evidence could be searched, for example, within Case Studies made available by the Standard Organization*
				36	Is there evidence that the adoption of the technical specification or standard positively impacts the migration of current systems?	*Original question* *This evidence could be searched, for example, within Use Cases made available by the Standard Organization*
					~~Is there evidence that the adoption of the technical specification or standard positively~~	*This question seems not to be useful for SG aims and can be deleted*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
					~~impacts the environment?~~	
					~~Is there evidence that the adoption of the technical specification or standard positively impacts the financial costs?~~	*This question seems not to be useful for SG aims and can be deleted*
				37	Is the security addressed by the requirements/specifications of this standard (for example by adopting an existing secure protocol…)?	*The Original question was:* "Is there evidence that the adoption of the technical specification or standard positively impacts the security?" *and seems to be too subjective for the T4.3 aims. Being the kind of analysed standards well defined in this context it seems better to have a more specific question* *In a comment field it will be important to insert information about these security features*
				38	Is the privacy addressed by the requirements/specifications of this standard (for example by adopting an existing privacy protocol…)?	*The Original question was:* "Is there evidence that the adoption of the technical specification or standard positively impacts the privacy?" *and seems to be too subjective for the T4.3 aims. Being the kind of analysed standards well defined in this context it seems better to have a more specific question* *In a comment field it will be important to insert information about these privacy*

Category	Description	Sub-Category	Description	N.	Criteria (Question)	Comments
						features
					~~Is there evidence that the adoption of the technical specification or standard positively impacts the administrative burden?~~	*This question seems not to be useful for SG aims and can be deleted*
					~~Is there evidence that the adoption of the technical specification positively impacts the disability support?~~	*This question seems not to be useful for SG aims and can be deleted*
		~~Risks~~	~~*The level of uncertainty is addressed for using and adopting the technical specification or standard*~~		~~Are the risks related to the adoption of the technical specification acceptable?~~	*Deleted, since the question seems to be too general with respect to our SG purposes*
		Maintenance and future developments	*For the 'maintenance' and future developments, the support and the planned or existing actions to maintain, improve and develop the technical specification or standard in the long term are addressed.*	39	Does the technical specification or standard have a defined maintenance organisation?	*Original question*
					~~Does the maintenance organisation for the technical specification or standard have sufficient finances and resources for the long term?~~	*It would not be possible to answer this question for ELECTRA engineers. The question is too much detailed for SG ELECTRA purposes and has been deleted*
					~~Does the technical specification or standard have a defined maintenance and support process?~~	*This question is too much detailed for SG ELECTRA purposes and has been deleted*
					~~Does the technical specification or standard have a defined policy for version management?~~	*This question is too much detailed for SG ELECTRA purposes and has been deleted*

With respect to the original CAMSS Questionnaire, a lot of changes were made, so that only 21 of the original 52 questions are used as they were:

Table 7 - Modifications made in ELECTRA to the original CAMSS questionnaire

Modification with respect to the original CAMSS Questionnaire	
Number of total initial CAMSS questions	52
Number of questions in ELECTRA questionnaire	39
Number of questions without changes	21
Number of deleted questions	24
Number of modified questions	7
Number of new questions	11
Number of new Subcategories	3
Number of new Categories	1
Number of deleted Subcategories	4
Number of deleted Categories	2

2.3.3 The EAT-SGIS tool for collecting information about Smart Grid Standards

In order to facilitate the work of standard experts which have to provide the needed information to the use case designer an Excel tool was designed and implemented for enabling the collection of information on and assessment of standards. This tool has been named *EAT SGIS (ELECTRA* Assessment Tool for Smart Grid Interface Standards) Tool.

The tool was designed as a *GUI prototyping Open Source tool*, called *Pencil*. The figures shown in the following page are realized using it.

The EAT-SGIS tool has 6 sheets.

- Sheet 1: Introduction

The starting page of the tool (Figure 13) contains the information about who has filled it and the date (in order to be able to take into account different versions of a collection of data). Moreover it is required if the editor has a direct knowledge of the standards (in the sense that she/he was a user of the standard also before studying it for filling out the questionnaire). In the case of negative answer, the strength of the evaluation will be diminished off the 10% with respect of the calculated value.

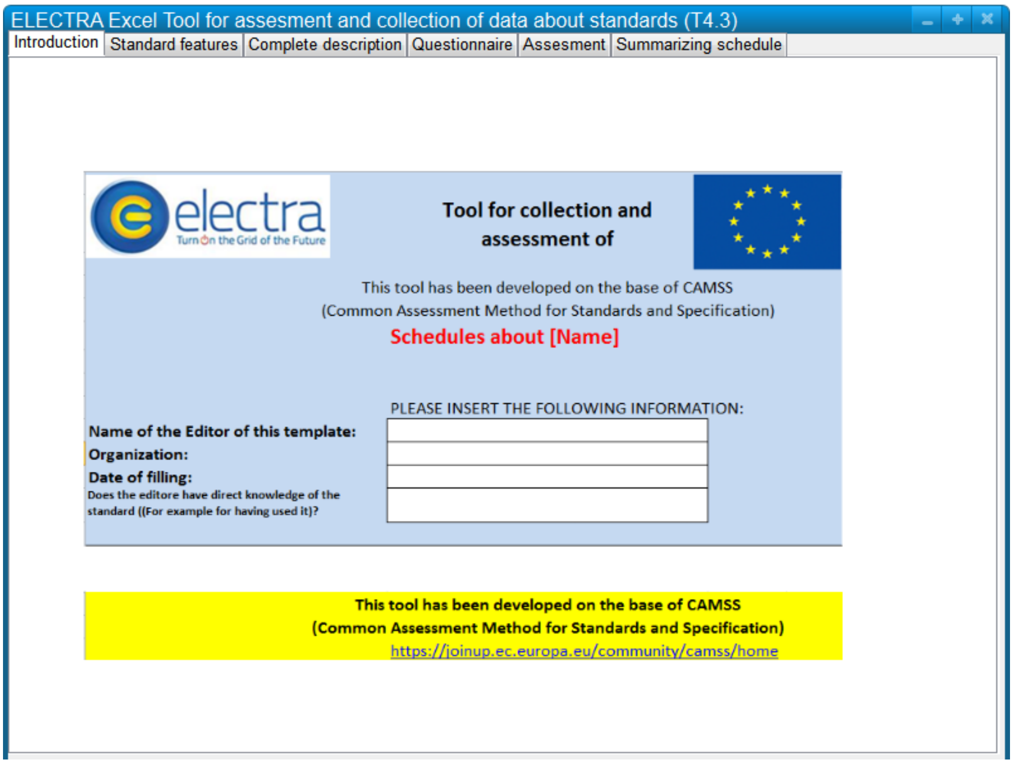


Figure 13 - Introduction to the tool

➢ <u>Sheet 2: Standard features</u>

In the second sheet (Figure 14) the main information about the standard has to be inserted. It includes the aims of the standard and a short description. Also the involved roles (possibly according to the ENTSO-E Harmonized Electricity Market role model) will be required here.

The answer about the "coordinated" on the SGAM model, covered by the standards, will be used for evaluating the coherence with SGAM category together with the questionnaire answers.

In addition to the SGAM layers, other kinds of classifications are suggested by this identity card:

- If the standard covers the SGAM "information layer":
  - It is asked "If the information layer specification provides Document specification, how does it provide them? (e.g. XML schema)";
  - What are the main kinds of messages/document/information that can be exchanged by the information standard (For example, "Energy Market Information, like Prices, Tariffs and Products" or "Demand response signals" or "Generation forecast"…).

  These two pieces of information seem to be fundamental for understanding if an information standard is suited for being used in a specific use case.

- "What are the Smart Grid Functionalities enabled by this standard?"
  The list of the functionality is the following one (coming from the US DOE document about Smart Grid Research and Development Multi-year program plan [26]:
  - Customer Participation;
  - Integration of all generation and storage options;
  - New markets and operations;
  - Power quality;
  - Asset optimization and operational efficiency;
  - Self-healing from disturbance;
  - Resiliency against attack and disaster.

- Use case clusters which are enabled by the standard. The list of the clusters came directly from the SGCG “set of standards” document.

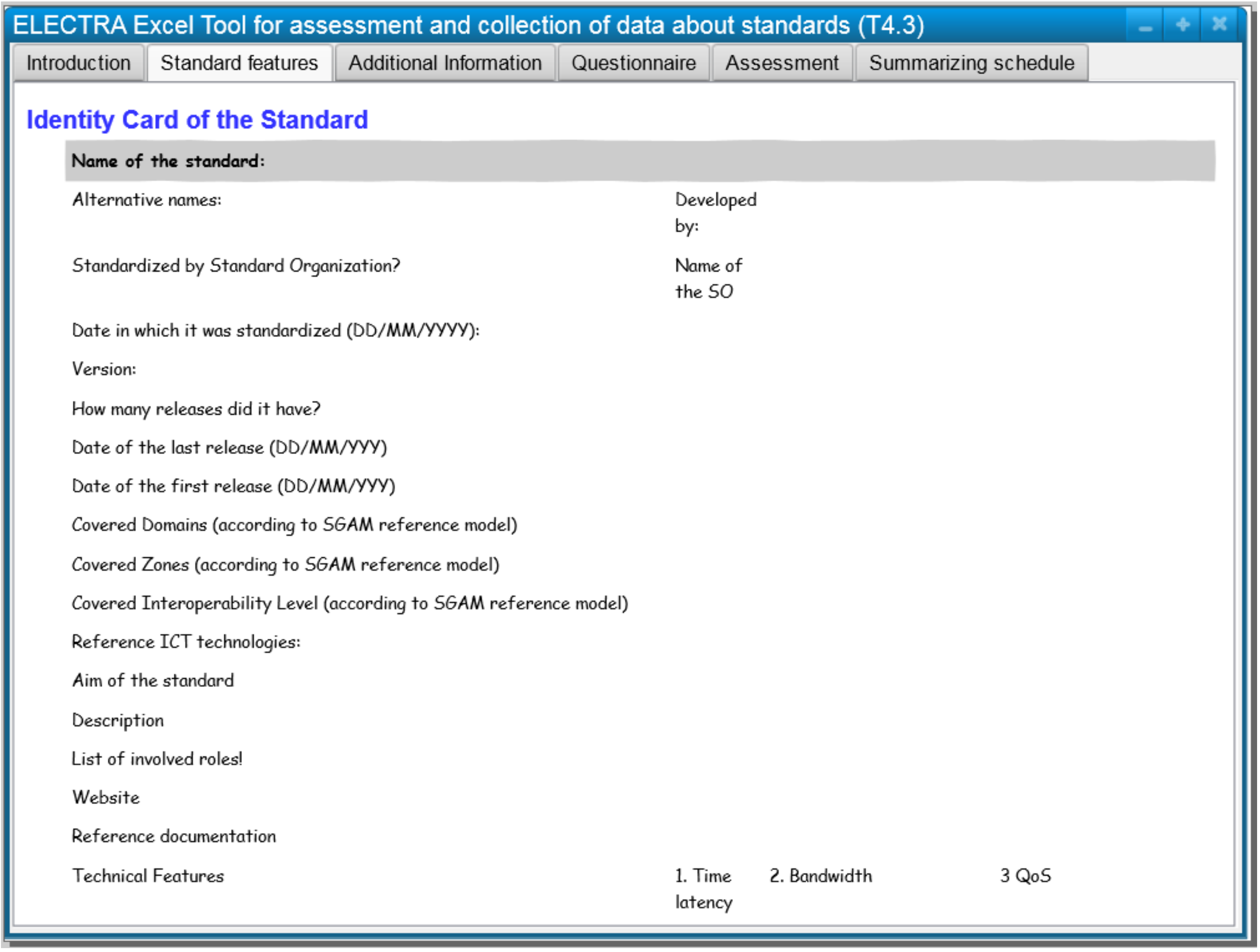


Figure 14 - The identity Card of the standard

➢ <u>Sheet 3: Additional Information</u>

In the third sheet (Figure 15), there are free pages for inserting a longer description of the standards, including, if needed, also images. A Word document would be more suited for this aim, but it seems better to have all the needed information in the same Excel file, for avoiding excessive multiplying of files.

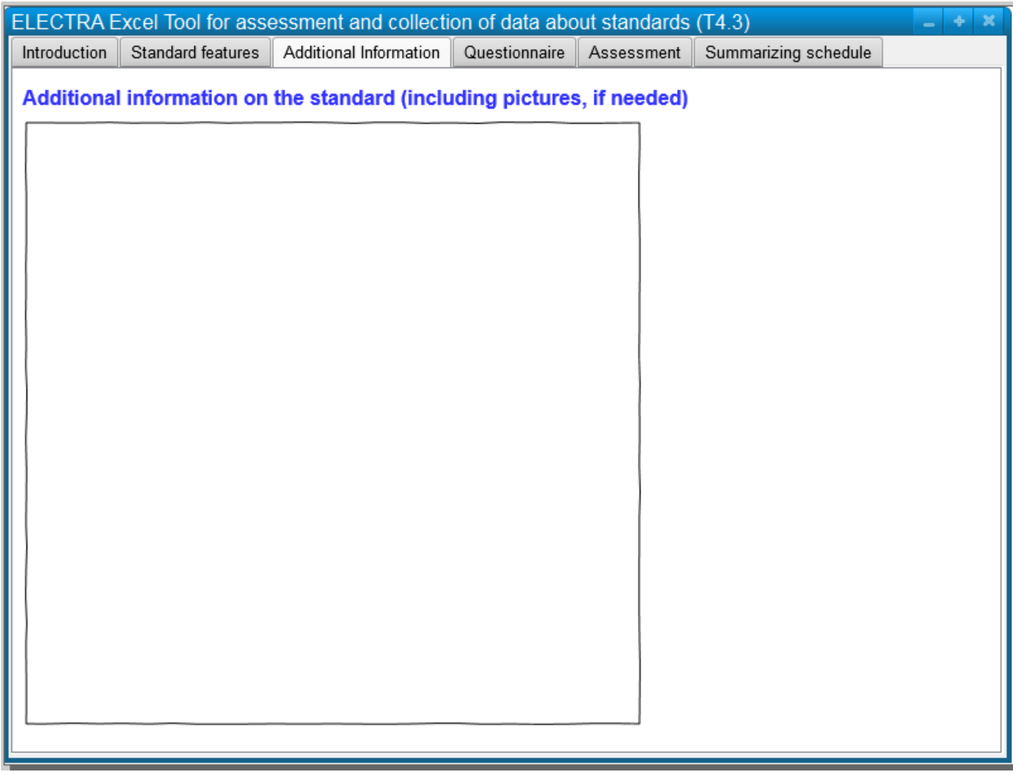


Figure 15 - Here, additional information about the Standard can be inserted

➢ <u>Sheet 4: Questionnaire</u>

In the fourth sheet (Figure 16) the questionnaire has to be filled out. The questionnaire is the one shown in Table 6.

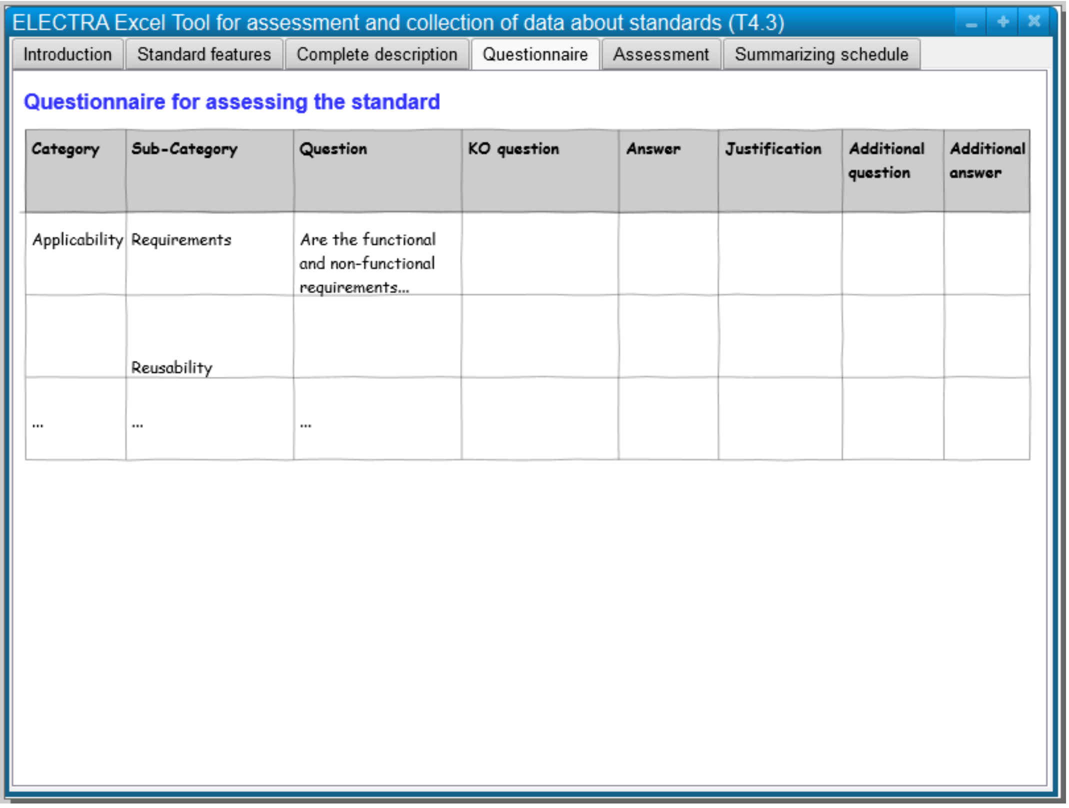
More in detail, the fields are:

- **Category**: the feature evaluated among the six in Table 6.
- **Subcategory**: the parameters contributing to the evaluation of each category (see Table 6).
- **Question**: the question for assessing the categories.
- **KO question**: is this question so important for making the standard to knock out the standard?
- Response: it can be one of the following:
  - Yes;
  - No;
  - Not Applicable;
  - Insufficient documentation.

  In the original CAMSS questionnaire the "Insufficient documentation" was not present and the Not Applicable answer was considered as a not provided answer. The adding of this further option has the aim to allow to distinguish the case in which the question is really not applicable since it has not sense (in this case a comment for justifying why it has no sense is required) and so the answer has to be considered as valid and the case in which it is not possible to answer because of lacking of documentation.
- **Justification**: a comment for justifying the answer can be inserted in this field. This comment is considered mandatory for the "Not Applicable" answer.

- **Additional question**: this field can contain for some row a request for additional information (this additional information is that present in the "comment" columns of Table 6). Always the question appears only for some values of the answer field (for example, if the answer about compatibility with other standards would be yes, a question about what are the names of these compatible standards would appear).

Answer to the additional question: In the case of additional question in the previous cell, the answer can be written here.



ELECTRA Excel Tool for assessment and collection of data about standards (T4.3)

Introduction | Standard features | Complete description | Questionnaire | Assessment | Summarizing schedule

Questionnaire for assessing the standard

Category	Sub-Category	Question	KO question	Answer	Justification	Additional question	Additional answer
Applicability	Requirements	Are the functional and non-functional requirements...					
	Reusability						
...	...	...					

Figure 16 - Questionnaire for assessment of the standard

➢ <u>Sheet 5: assessment</u>

On the base of the previous questionnaire, the evaluation of the standard is calculated and shown also in graphical way (Figure 17).

The **score** is calculated, for each category, with the following formula:

$$Score = \begin{cases} IF\ nr.of\ Yes + nr.of\ No = 0 \ \rightarrow Not\ assessed \\ IF\ nr.of\ Yes + nr.of\ No > 0 \rightarrow \frac{nr.of\ Yes}{nr.of\ Yes + nr.of\ No} \end{cases}$$

The **strength** of the evaluation is calculated as the share of answered questions (so excluding "white" fields and "insufficient documentation" answers):

$$Strength = \frac{nr.of\ Yes + nr.of\ No + nr.of\ Not\ applicable}{Nr.of\ questions\ for\ this\ category}$$

The denominator of previous formula needs to take into account that there are some questions that can disappear and so the total number could be variable (e.g. question 3 can be hidden if the answer to question 1 is different from "Yes").

The **knock-out** field is automatically reported if some knock-out criteria have been broken, according to the following table:

Table 8 - How the knock-out criteria are shown

Number of KO questions	Number of KO	Knock-Out criteria met?
=0	=0	“Knock-Out criteria are not specified.”
n>0	=0	“There are *n* Knock-Out criteria specified and they are all met.”
n>0	m>0	”There are *n* Knock-Out criteria specified and they are broken *m* time(s).”

The **evaluation** can be assigned by the editor, choosing among the following values: very low, low, moderate, high, very high.

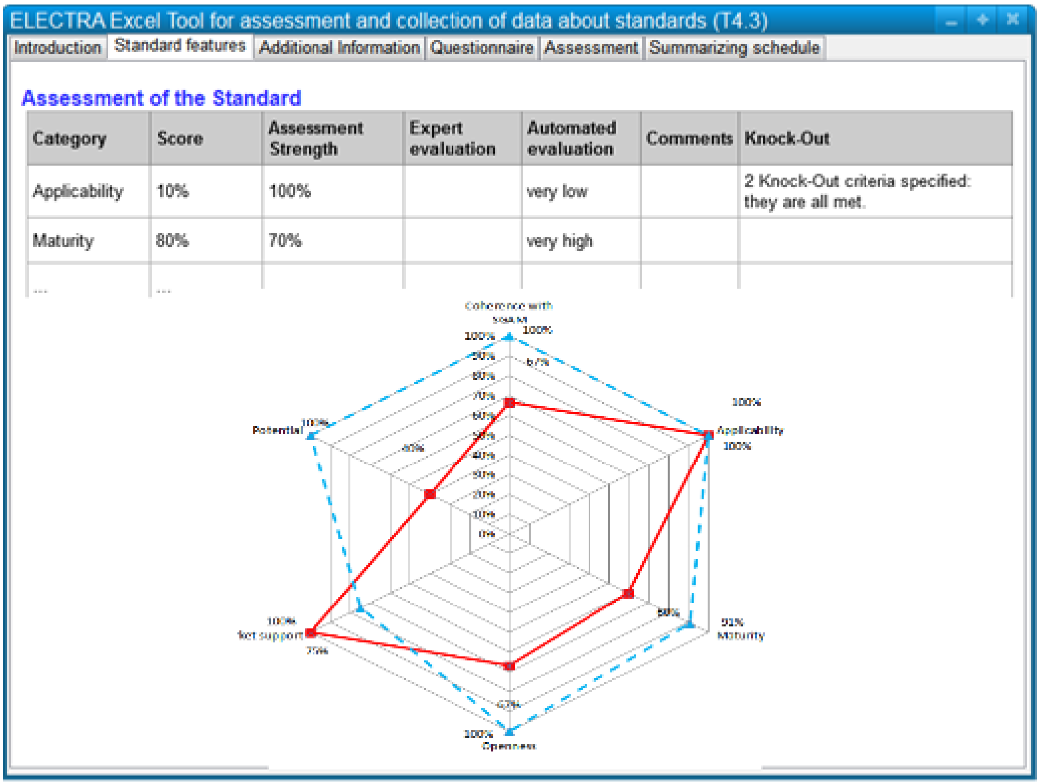
The automated evaluation is evaluated in the following way:

$$IF\ Score \cdot Strength \begin{cases} < 0{,}2 \rightarrow very\ low \\ > 0{,}2\ AND < 0{,}4 \rightarrow low \\ > 0{,}4\ AND < 0{,}6 \rightarrow moderate \\ > 0{,}6\ AND < 0{,}8 \rightarrow high \\ > 0{,}8 \rightarrow very\ high \end{cases}$$

This field is thought both as a suggestion for the editor and as a replacement for the manually assigned value if it is not assigned by the editor.

In the **comment** field the assessment can be commented by the editor.

The last row in the table of Figure 17shows the “Final assessment” containing results of the final calculations of the assessment parameters. The Final Score, the Final Strength, and the Final Automated Assessment are calculated with respect to the whole questionnaire shown in Table 6 using similar formulas as those shown earlier, but calculated on the total number of answers, instead of being split in categories.

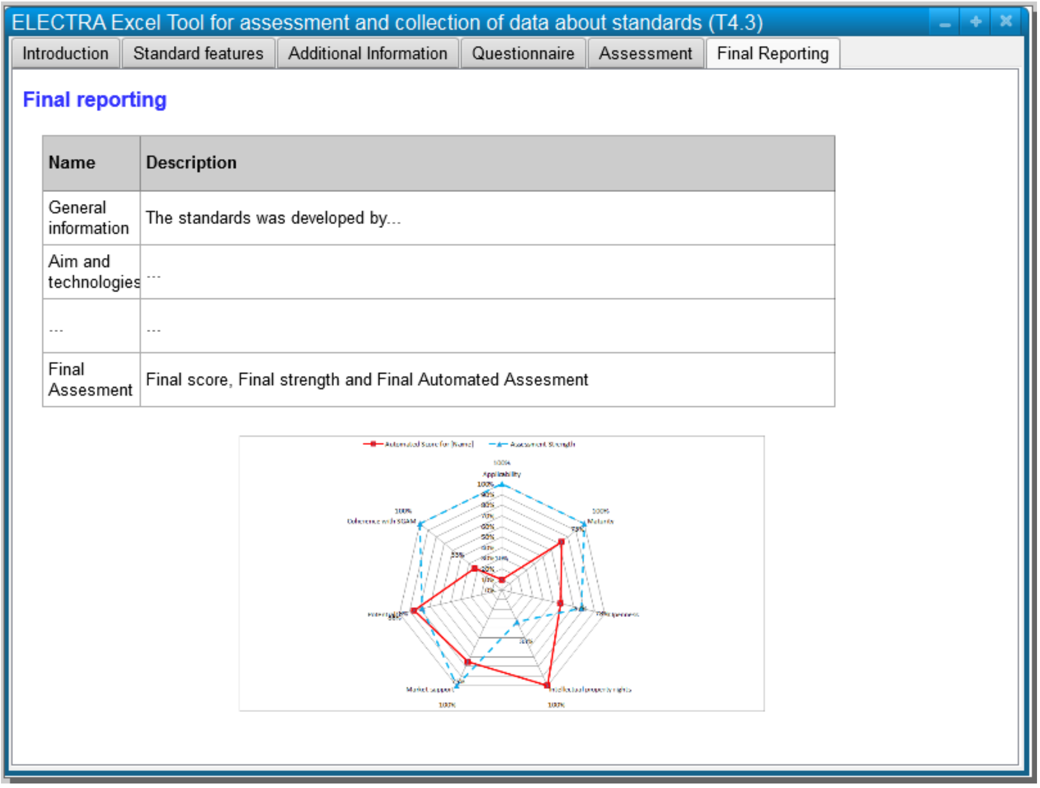


Category	Score	Assessment Strength	Expert evaluation	Automated evaluation	Comments	Knock-Out
Applicability	10%	100%		very low		2 Knock-Out criteria specified: they are all met.
Maturity	80%	70%		very high		
...	...					

Figure 17 - Assessment of the standard (red line: Score / blue line: Assessment Strength)

➢ <u>Sheet 6: Reporting</u>

The last sheet (Figure 18) will be automatically filled in order to summarize the main information in a printable screen.



Name	Description
General information	The standards was developed by...
Aim and technologies	...
...	...
Final Assesment	Final score, Final strength and Final Automated Assesment

Figure 18 - Summary of information about the standard

The fields that have to be presented are the following:

Summarizing table	
General information:	*Some General information (like name, developer organization, version and number of releases and so on) about the analysed standard has to be shown.*
Aim and technologies	*The aim, the technologies on which it is based and the "coordinated" on the SGAM Reference Model have to be shown here.* *Moreover, some important sub-criteria have to be shown: does it address (or not) Interoperability, Stability, Security and Privacy?*
Description	*The concise description will be pasted here from sheet 6*
Other Technical Information	*The kind of messages and the way in which document format are specified, for the Information Layers standards and the Time Latency and Bandwidth for Communication Layer standards*
List of enabled Smart Grid functionalities	*The list of the SG functionality (like Customer Participation, Power quality, New Market and Operation, …) enabled by this standard*
Involved actors	*The involved actors/roles are pasted here from sheet 6*
Involved use case cluster	*It shows the list of use case cluster in which this standard could be used*
Covered SGAM Domain specific systems	
Function specific and other covered system	
IPR	*Information from IPR sub-criteria will be shown here*
Diffusion	*Information about diffusion of the standard (Market support sub-criteria) will be summarized*
Relation with other standards and technologies	*Information about relation with alternative and compatible standard and about related technologies will be summarized*
Tools and documentation	*Information about available tools (including conformity and interoperability ones, if any) will be summarized*
Possible barriers	*A combination of sub-criteria will be evaluated in order to verify if the standard could incur some of following barriers to interoperability:* • *scarce maintenance/updating of the specifications* • *lacking of Critical mass* • *ambiguity of specifications* • *interoperability issues due to use of different standards for the same exchange* *Each of them will be evaluated assigning a score if a criterion is satisfied, as shown below (the Criteria, in the first column, refers to questions from the previous questionnaire).*

Scarce maintenance/updating of the specifications		
Criteria	***Score for Yes***	***Score for the other options***
Backward compatibility (Question 23)	*1*	*0*
Updates in specification, documentation or Web site in the last 3 years (25)	*1*	*0*
Existence of a defined maintenance organization (39)	*1*	*0*

The sum of the previous scores can be from 0 to 3. Splitting this range in *three parts (0; 1; from 2 to 3), this barrier can be evaluated of: high probability, moderate probability, low probability.*

Similar score tables can be defined for the other three barriers:

Lacking of Critical mass		
Criteria	***Score for Yes***	***Score for the other options***
Standard publicly available on reasonable terms (29)	*0,5*	*0*
Licensed on a royalty-free basis (30)	*0,5*	*0*
Used for different implementations by vendors/suppliers (31)	*1*	*0*
Used in different industries, business sectors of functions (32)	*1*	*0*
Significant share of adoption (33)	*1*	*0*
Interest/user groups (34)	*1*	*0*
Added value with respect to alternative standards (9)	*1*	*0*
Compatibility with related (not alternative) standards (10)	*1*	*0*
Ongoing/planned harmonization process (11)	*1*	*0*

In the previous table, there are some parameters that have been evaluated with 0,5 points. This is because they are complementary: the first two taken together give the indication about the openness of the specifications, the following two gives the indication about the public availability of the standard

The sum of the previous scores can be from 0 to 8. Splitting this range in three parts (from 0 to 2; from 2 to 5; from 6 to 8), this barrier can be evaluated of: high probability, moderate probability, low probability.

Ambiguity of specifications		
Criteria	***Score for Yes***	***Score for the other options***
Address interoperability (4)	*1*	*0*
Clear definition of functional and non-functional requirement (6)	*1*	*0*
Ambiguity of specification well addressed (8)	*1*	*0*
Technical specification sufficiently developed (15)	*1*	*0*
Existence of conformity tests (16)	*1*	*0*
Existence of interoperability tests (17)	*1*	*0*
Sufficient detail, consistency and completeness for the use and development (18)	*1*	*0*
Availability of guidelines and documentation for implementation (19)	*1*	*0*
Availability of tutorials and/or examples (20)	*1*	*0*
Availability of a reference implementation (21)	*1*	*0*
Availability of tools for facilitating implementation (22)	*1*	*0*
Strong support from interest/user groups (34)	*1*	*0*

The sum of the previous scores can be from 0 to 12. Splitting this range in three parts (from 0 to 4; from 5 to 8; from 9 to 12), this barrier can be evaluated of: high probability, moderate probability, low probability.

Interoperability issues due to use of different standards for the same exchange		
Criteria	***Score for Yes***	***Score for the other options***

Summarizing table

Added value with respect to alternative standards (9)	*1*	*0*
Compatibility with related (not alternative) standards (10)	*1*	*0*
Ongoing/planned harmonization process (11)	*1*	*0*
Part of SGCG set of Standard by SGCG (2)	*1*	*0*
Is it the only one at these SGAM coordinates? (3)	*1*	*0*

The sum of the previous scores can be from 0 to 5 (since the last two questions are alternative). Splitting this range in three parts (from 0 to 1; equals to 2; from 3 to 4), this barrier can be evaluated of: high probability, moderate probability, low probability.

Assessment for each Category	In the remaining cells the category will be listed (applicability, maturity, openness, IPR, market support, potential, coherence with SGAM. For each of them it will be reported: • the score and the strength of the evaluation • the assessment inserted by the editor (or that automatically calculated, if the editor did not insert it) • in the case some KO criteria have been broken, their number • in the case the number of insufficient documentation answers is greater than 30%, it will be shown here • the comments added by the editor in the assessment page, if any
Final Assessment	*The Final Score, Strength and Evaluation (the automated calculated one, if the editor did not insert his/her evaluation) were reported. Moreover, it is highlighted if there are broken KO Criteria and if, for some questions, available documentation has been judged insufficient*
Problems in the questionnaire	*Here, there will be shown, if any:* • *The number of questions for which important answer are lacking (for example the list of compatible standard, if it was said that they exists) or for which the explanation of not applicability is lacking* • *The number of not answered criteria*
Reference documentation	*Main documents used for studying and evaluating the standard*
Critical points for each category	If a category is under a specified threshold (80%) some critical points are put in evidence on the base of the questions which caused this “low” value. For example, if Maturity is under the threshold, and the question about Vitality had a negative answer, in this field it is written that “vitality seems low” (see Figure 19)
Additional comments for each category	If comments are present for explaining particular critical answers (for example, a comment explain the negative answer about vitality), they are reported in this field (see Figure 19).

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Openness	Specifications are not licensed on a royalty-free basis.
Critical points for Potential	There are no evidences about its impact Security is not well addressed, Privacy is not well addressed.
Comments on Maturity	Vitality of the standard: - The previous edition was finished in 2005 and issued in 2006.
Comments on Openness	Documentation: - The standard should be purchased
Comments on Potential	Security: - The standard does not address the cyber security directly. However, the cyber security issue is addressed by the IEEE Std. C37.242 - 2013: IEEE Guide for Phasor Data Concentrator Requirements for Power System Protection, Control, and Monitoring and also by IEEE std. C37.240 - 2014: IEEE Standard Cybersecurity Requirements for Substation Automation, Protection and Control Systems.

Figure 19 - Examples of Critical Points and Comment fields

The final version of the tool is provided together with this document.

3 Standards for the use cases

3.1 ICT standard selection criteria

3.1.1 General considerations

Considering that ELECTRA is related to the vision of the future European power system, in order to identify the proper ICT solutions it could be useful to consider the trend that characterize the ICT standard development both at international and European level.

The focus of the ICT standard is moving up from the lower level to a higher one, giving more importance to the semantic level (roughly the SGAM information layer), often considering the lower level as something already in place (e.g. Ethernet, TCP/IP). Of course, there are also some exceptions where new approach is coming up also at lower level (e.g. Deterministic Ethernet), but this doesn't seem to change the general trend.

This point of view seems confirmed by the IEC-TC57 reference architecture (IEC 62357-1) and the "IEC Smart Grid core standards" [27], where all the standards have a strong semantic layer (CIM based, IEC-61850, DLMS/COSEM).

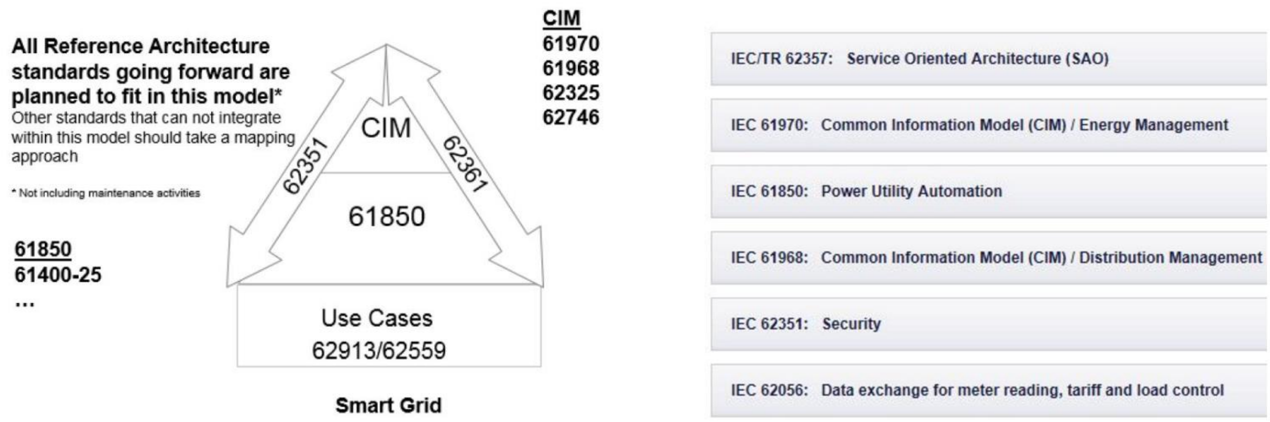


Figure 20 - IEC Smart Grid Core Standards

Also ENTSO-E, as one of the main institutional and technical stakeholder of the European power system, seems to be in line with this approach considering its very active role both in CIM and IEC-61850 standard development and interoperability test.

Considering this international and European scenarios, it could be appropriate to give priorities, where it will be possible, to these cited core ICT standards.

The CIM based IEC-61970 standards series [28] related to Network Operations objectives, usually express Measurement and State information linked to network topology elements. This approach is useful not only when the information is exchanged inside a single operator domain, but also when the exchanges involve different cooperating operators. A concrete example of this approach is reported on page 83 of the ENTSO-E "Common Grid Model Methodology Generation and Load Data Provision Methodology" document, where the "Structural" and "Variable" information that a TSO need from a DSO are specified [29].

The IEC-61850 standards series [30], which could be considered as the operating section of the ICT standards usually related to field devices, include different application scope like: Substation automation, Distribution automation, DER management, etc.

The synergy improvement, involving the two complementary CIM related and IEC-61850 standards, is one of the main SDO's objectives that could really help the Smart Grid implementation.

3.1.2 Consideration related to the ELECTRA project

The ICT standards to be selected in the ELECTRA project should be already available or on the way to be defined, possibly excluding the definition of further new standards. For this reason it's necessary to identify the relationship between some new concepts related to the ELECTRA approach and the current approach for the management of an electrical system.

Hereafter, the ICT standards related to a specific use case are identified considering the relationship between the data requirements specified in section 5 "Information exchanged" of the use case description and the available/coming standard defined in the "SG-CG - Smart Grid Set of Standards Version 3.1" and the IEC Smart Grid Standard map.

In a first step, the set of information required by the actor/function specified in the use case will drive the information layer mapping of standards, followed by the communication technology mapping.

For executing this kind of analyses we need to mix two approaches:

- The SGCG standard reference document and the related IoP tool (SGCG – Interoperability Tool) and from the IEC map
- The Domain knowledge from the experts

The first point, alone, allows having a strong theoretical reference for the analysis but risks to be dispersive, since these tools are not optimized for being used by designers. The second is more effective but it risks to restrict the field to an incomplete set of standards.

The approach followed in this analysis is:

- Identification of possible SGAM Component Layer diagram (this passage is needed since there is no reason for using standards for exchanging information between functions located within the same physical component, but also for helping in identifying the most suited Communication Layer standards).
- Identification, for each information exchange, of the coordinates on the SGAM and using the IoP tool, the "set of standards document" [9] complemented with the IEC map [27] for identifying the set of standards that could have particular relevance for it and, then, trying to identify the standards that can really satisfy the needs of that exchange. Where possible the domain knowledge will be used for refining the selection. Being this process really long, just the final results were reported in this document.

3.2 The use cases

The analysed use cases were defined and examined in details in D4.2 [31]. They are the following ones:

Name	Scope
Inertia Response Power Control (IRPC)	Coordinate flexible inertia resources within a synchronous area and its division over cells, and its division within a cell over inertial resources, through a direct monitoring technique that relies on fast communication infrastructure. The missing amount of inertia for ensuring frequency stability can be provided by either deploying extra inertia resources, or changing the inertia coefficients J of the individual inertia resources.
Frequency Containment Control (FCC)	Support cell's containment of frequency deviation (both dynamic and steady-state) by observing and responding to frequency changes. The specific variant implements control with a frequency dead-band. The dispatching of parameters to the core controllers is obtained by functions at cell level that decompose the NPFC (Network Power Frequency Characteristic of web-of-cells) requirement to CPFC (cell requirement) and consequently optimally decompose the FCC response profiles to individual units.
Balance Restoration Control (BRC)	Power balancing within the cell using a policy-based approach, restoring the cell error signals.
Balance Steering Control (BSC)	Secure cell's balance by selecting an appropriate set-point for balance (and therefore tie-line power flows) by observing the following: • Minimisation/Optimisation of balancing reserves activations while • Ensuring that the new tie-line power flows do not violate operating limits
Primary Voltage Control (PVC)	Maintain voltage locally at a connection point of a flexibility resource by automatic control process based on a given setpoint, local measurement and control algorithm. The setpoint for this control is provided by PPVC.
Post Primary Voltage Control (PPVC)	Restore the voltages in the nodes of the cells to the set-point values and keep the voltage within dead-bands (with optimum margin) while optimizing the reactive power flows in the system. The optimization method used in order to fulfil the goals of the UC variant is the Interior Point Methods.

Each of these use cases can have some variants, which are referred, in the following paragraphs, with the codes used in D4.2.

3.3 Standard analysis for Inertia Response Power Control (IRPC) use cases

3.3.1 The IRPC use cases

Before starting the mapping, all related time sequence diagrams (TSD) in IRPC2.2.2 are shown in the following figures. According the Figure 21 to Figure 25, there is a systematic approach applied while drawing the TSDs. A general flow is shown in Figure 21, while details inside the main actors (i.e. Synchronous Area Imbalance Detection) are shown in the other four figures.

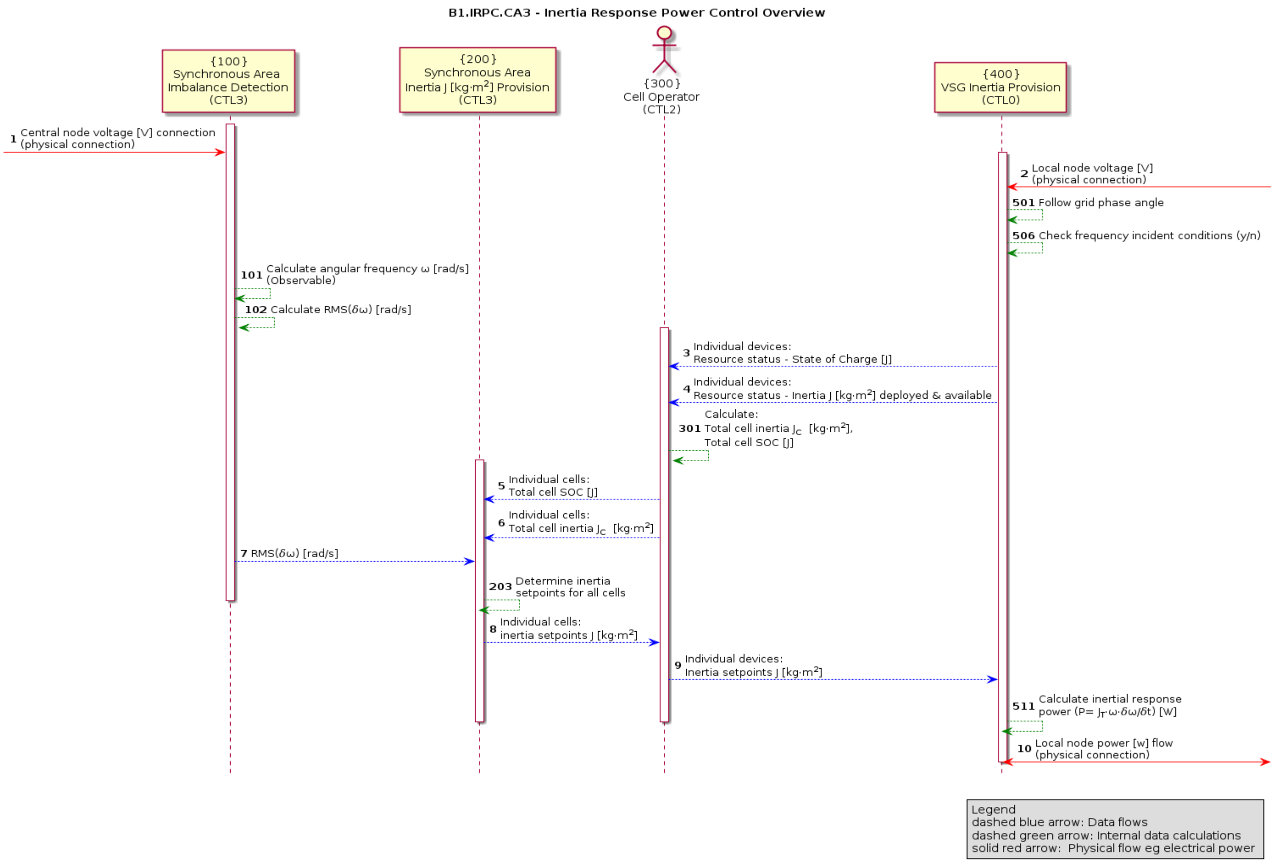


Figure 21 - The high level operation of IRPC Variant 2.2.2

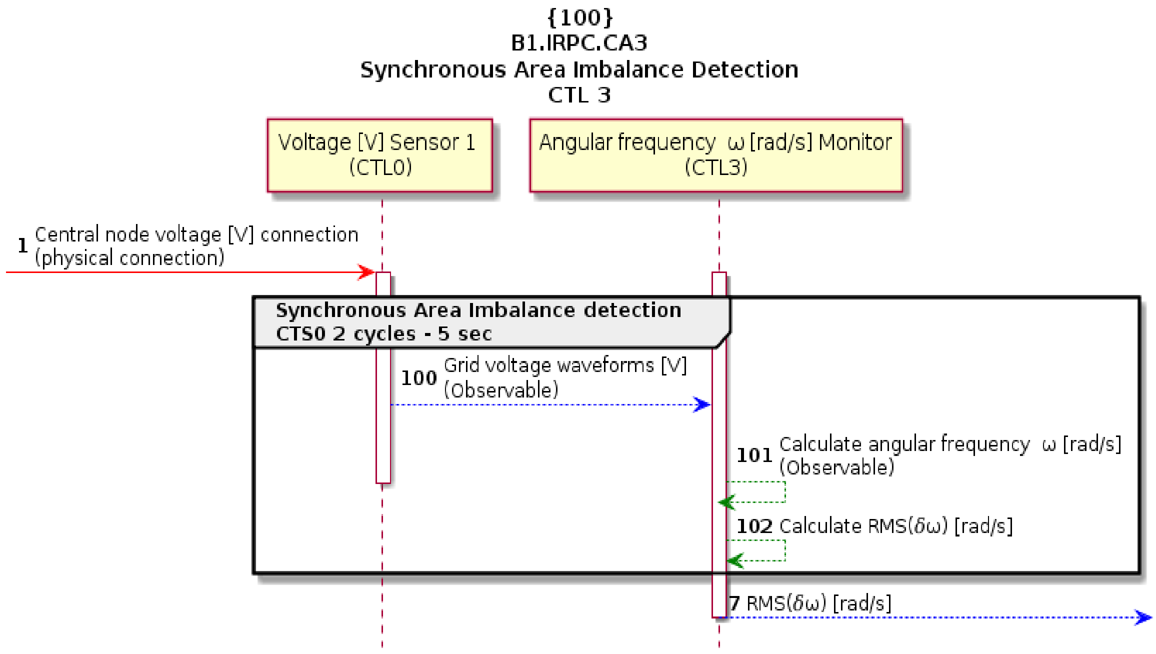


Figure 22 - Synchronous Area Imbalance Detection (SAID)

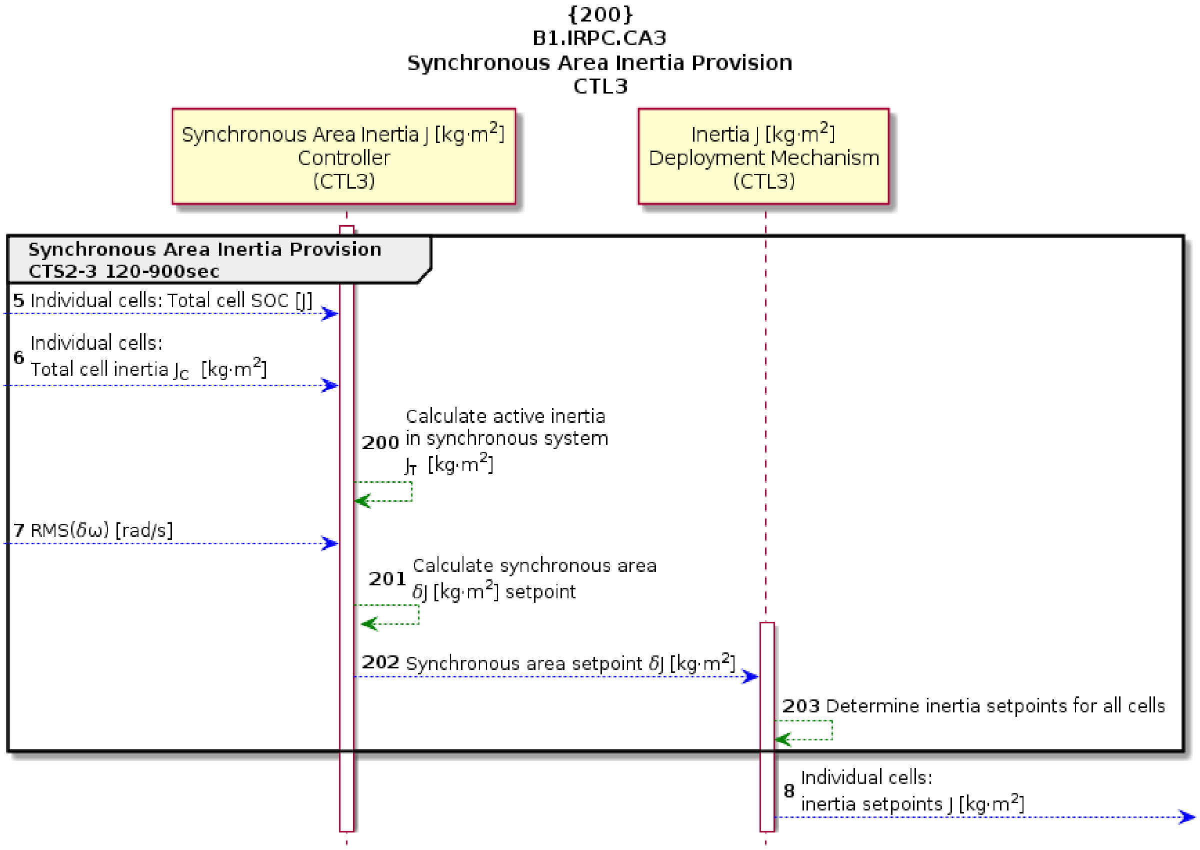


Figure 23 - Synchronous Area Inertia Provision (SAIP)

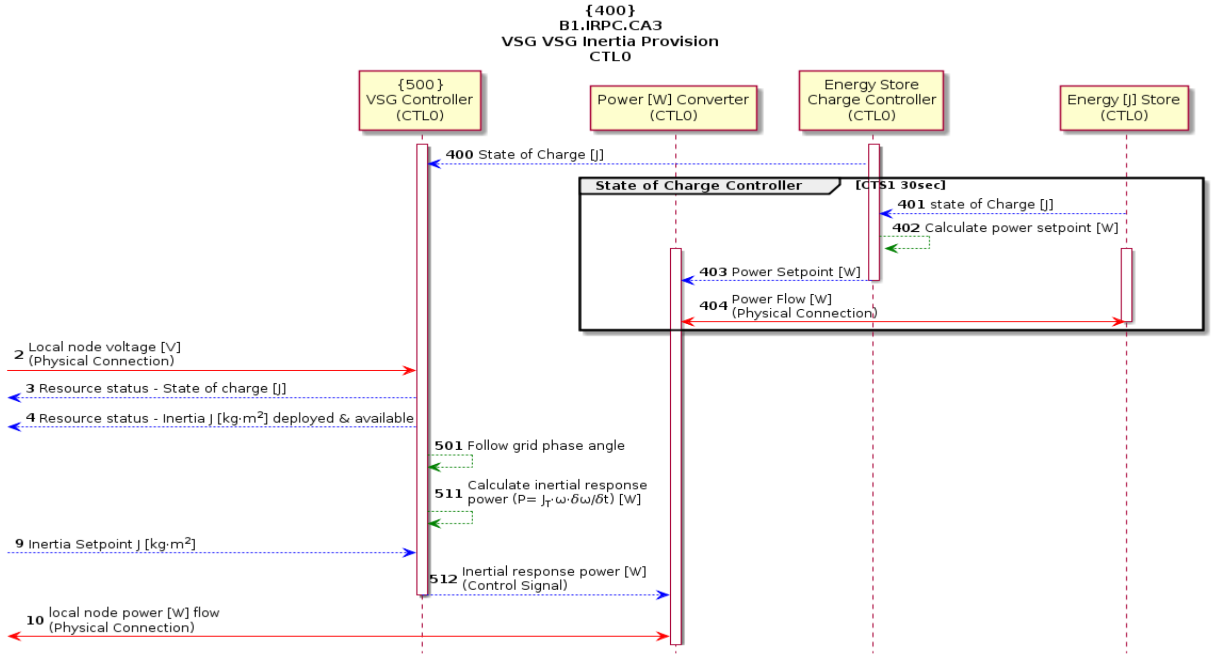


Figure 24 - VSG Inertia Provision

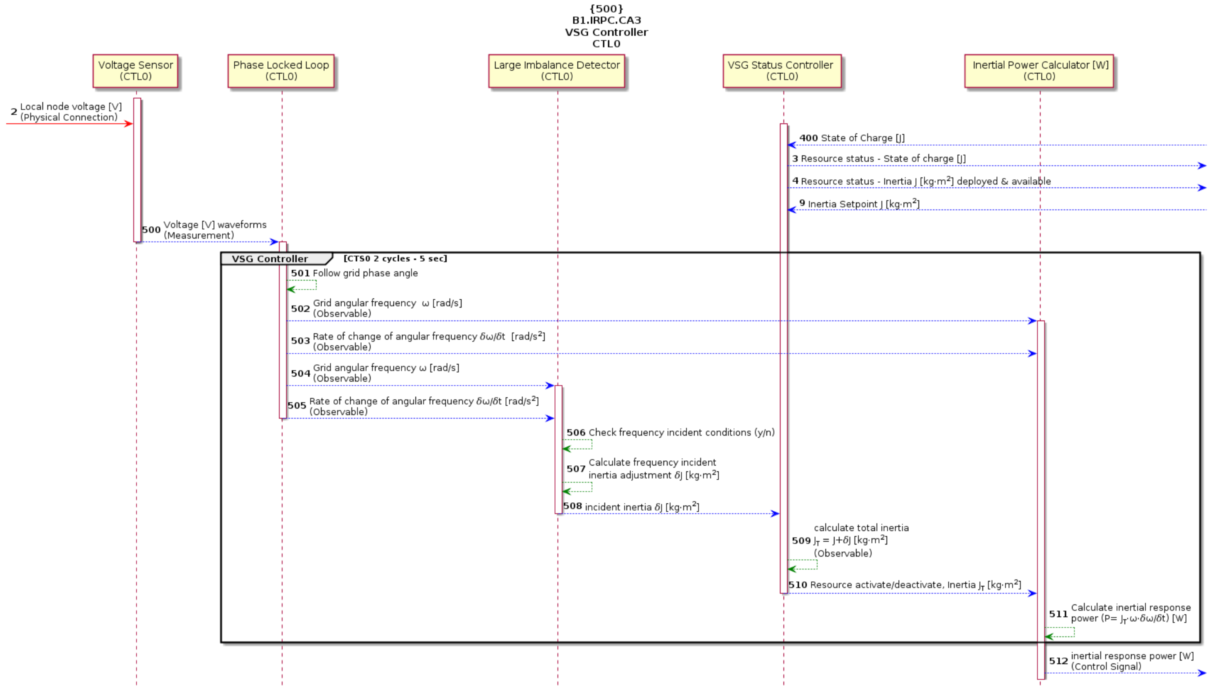


Figure 25 - VSG Controller

3.3.2 SGAM Mapping

3.3.2.1 Function layer

By using all these five TSDs, a conceptual SGAM mapping has been performed by showing all function in detail. It is important to see the overall picture of the IRPC 2.2.2 (see Figure 26). Then, similar to Figure 21, the functions are grouped together and named with a capital letter (see Figure

27). Finally, in order to assess the flow and required components, the SGAM mapping has been simplified (see Figure 28).

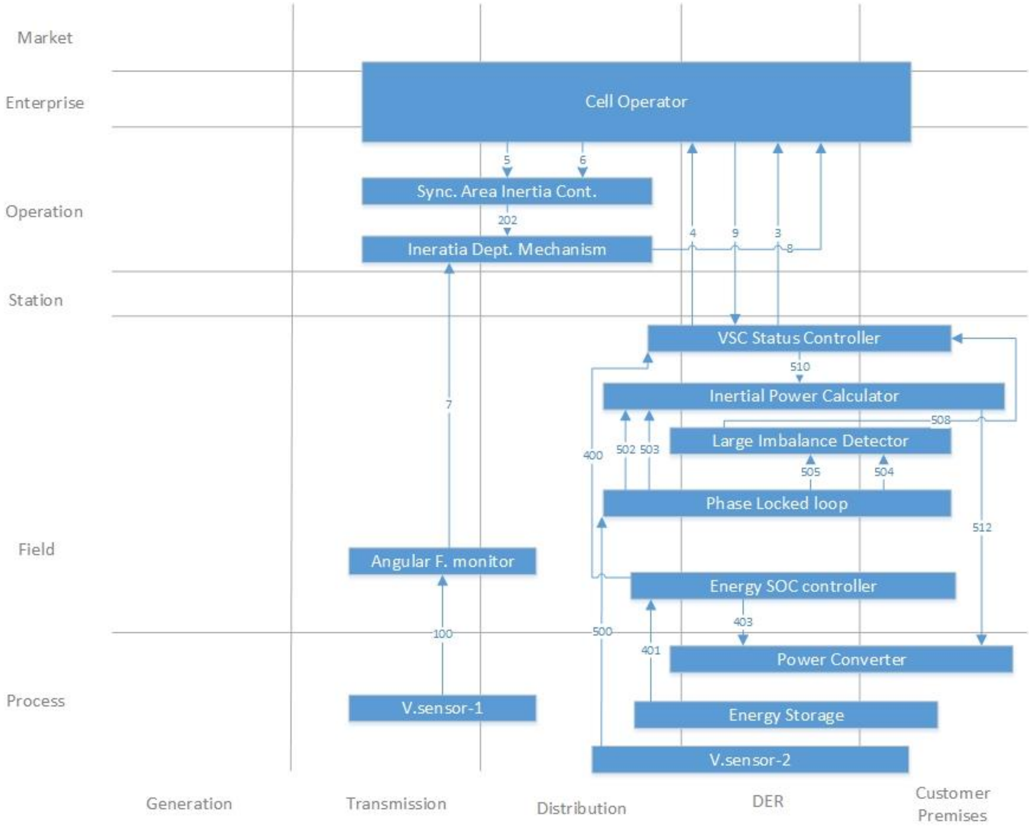


Figure 26 - SGAM Mapping (actors, functions, devices)

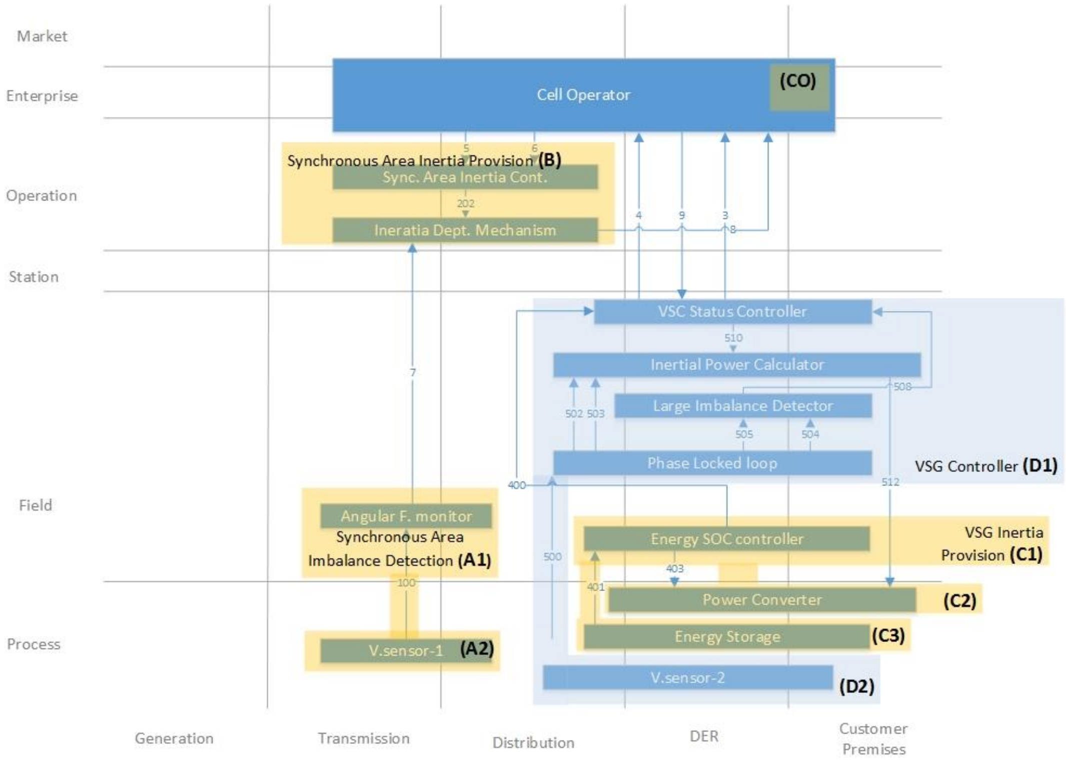


Figure 27 - SGAM Mapping with possible components and grouping

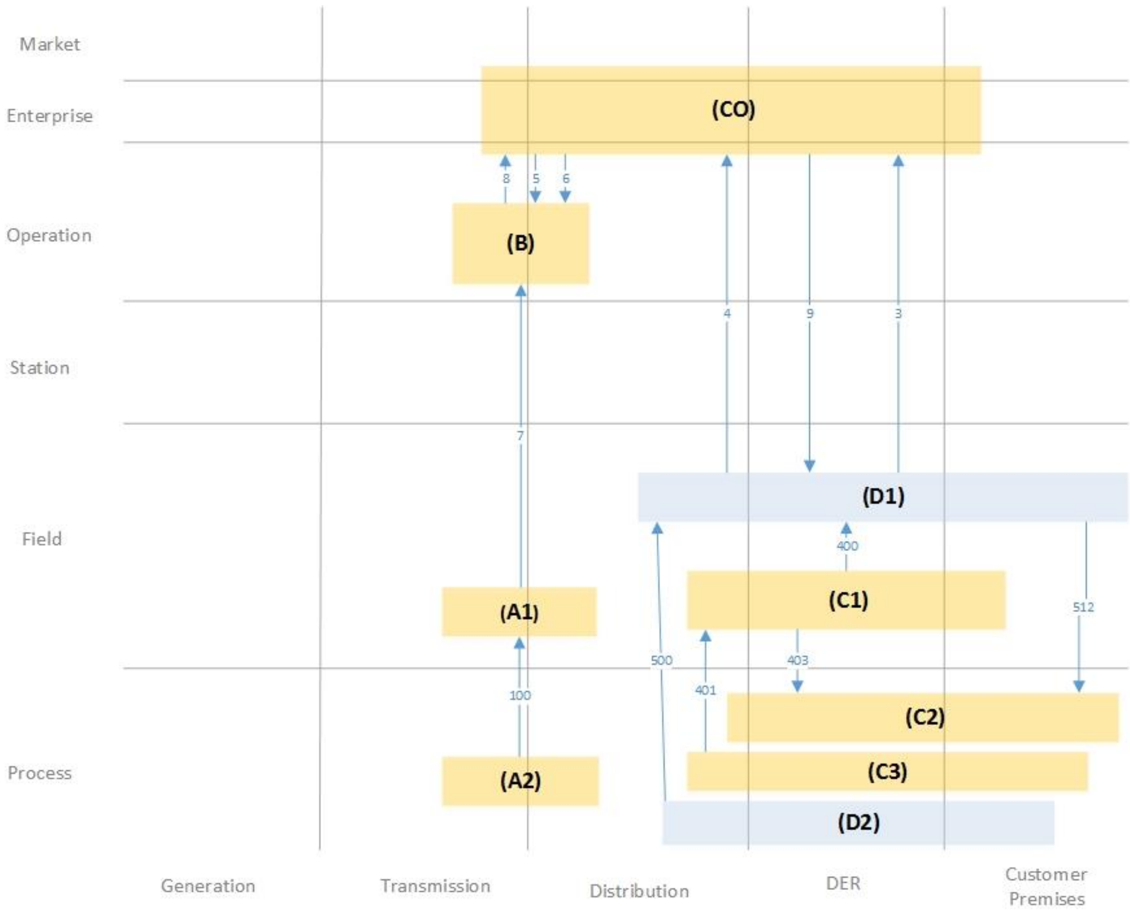


Figure 28 - Simplified mapping

In the following paragraphs, details regarding the each group are explained. The information stated is used during the mapping process and will be used in the determination of the standards. Each group are evaluated in terms of SGAM zones, SGAM domains, possible components (how is the group be represented; a device, a computer, etc.), and information exchanges.

CO: (Cell Operator)

Roles for the determination of zones:

- Managing resources within the cell in order to meet the set-points received from the actors at CTL3 and reporting back to them in aggregated form ***(Operation zone)***
- The calculation of actual cell inertia J_{cell} [kg m^2] and adjusting its value by the required change δJ [kg m^2] received
- Deployment individual inertial resources in the cell ***(Operation zone)***
- In case the cell is large enough, it may be economically feasible to use a separate market based deployment mechanism ***(Enterprise and Market Zones)***

Determination of Domains:

The CO operates at all domains except the bulk generation (***transmission, distribution, DER, and customer premises***).

Possible device:

It is a computer based actor or a controller, possibly with an operator control.

Details on information exchanges:

Number	Name	Definition	Service	Device	Information Exc.	Req.
3/periodically - CTS2-3 120-900sec	send - individual devices: state of charge [J]	The charge controller of each VSG energy storage device sends SOC status information to the cell operator	inertia monitoring & dispatching	**(D1)**	IEX_09	Digital signal [rad/s^2]
4	send - individual devices: resource status - inertia deployed and available	Each VSG sends its status data to the cell operator	inertia monitoring & dispatching	**(D1)**	IEX_10	digital signal [kg.m^2]
5/periodically CTS2-3 (120 - 900sec)	Individual cells: total cell SOC [J]	The cell operator sends aggregated cell VSG SOC status information to the inertia controller	inertia monitoring	**(B)**	IEX_03	-Digital signal [kg.m^2] -the high speed communicati on
6	individual cells: total cell inertia Jc [kg.m2]	the cell operator sends aggregated cell inertia status information to the inertia controller	inertia monitoring	**(B)**	IEX_04	Digital signal [kg.m^2]
8	send - individual cells: inertia setpoint	the deployment mechanism sends inertia setpoints to each cell operator	inertia deployment	**(B)**	IEX_06	digital signal [J]
9	individual devices: inertia setpoints	The cell operator deploys individual VSG devices to achieve the inertia setpoint	inertia deployment	**(D1)**	IEX_11	digital signal [1], [kg.m^2]

A1: (Angular Frequency Monitor)

Roles for the determination of zones:

- Calculates the angular frequency of the grid, from 3-phase voltage waveforms ***(Field zone)***
- Filtering is needed to get values that reflect the rotational speed of synchronous rotors nearby the control node.

Determination of Domains:

It must be located where the voltage sensor is located. (***Transmission and distribution domains***)

Possible component:

It is a sensor that has a communication interface.

Details on information exchanges:

Number	Name	Definition	Service	Device	Information Exc.	Req.
100/periodically - 1 cycle to 5 sec	send - grid voltage waveforms	high voltage grid waveforms are transformed into levels that can be used by the controller	Voltage Sensing	**(A2)**	IEX_01	-Digital signal [V] -sampling rate for grid sine waves > 1000 Hz
7	send - RMS($\delta\omega$) [rad/s]	RMS($\delta\omega$) data sent to inertia controller	angular frequency monitoring	**(B)**	IEX_02	Digital signal [rad/s]

A2: This is a physical device (process level), interacting only with A1. No necessary for detailed assessment.

B: (Synchronous Area Inertia Provision)

Roles for the determination of zones:

- Synchronous Area Inertia J [kg.m^2] Controller: Determine the required change in cell inertia δJ [kg.m^2] with the calculation of using the present system inertia and a reference inertia set-point. ***(Operation zone)***
- Inertia Deployment Mechanism: Deployment mechanism for the required change of inertia δJ [kg.m^2] (from CTL3 controller) within a synchronous area. This function determines the change in inertia required from each cell to meet controller demand. ***(Operation zone)***

Determination of Domains:

Transmission and distribution.

Possible component:

It is a device or a computer based controller.

Details on information exchanges:

Number	Name	Definition	Service	Device	Information Exc.	Req.
5/periodically CTS2-3 (120 - 900sec)	Individual cells: total cell SOC [J]	The cell operator sends aggregated cell VSG SOC status information to the inertia controller	inertia monitoring	**(CO)**	IEX_03	-Digital signal [kg.m^2] -the high speed communication
6	individual cells: total cell inertia Jc [kg.m^2]	the cell operator sends aggregated cell inertia status information to the inertia controller	inertia monitoring	**(CO)**	IEX_04	Digital signal [kg.m^2]
7	send - RMS($\delta\omega$) [rad/s]	RMS($\delta\omega$) data sent to inertia controller	angular frequency monitoring	**(A2)**	IEX_02	Digital signal [rad/s]
8	send - individual cells: inertia setpoint	the deployment mechanism sends inertia setpoints to each cell operator	inertia deployment	**(CO)**	IEX_06	digital signal [J]

C1: (Energy Store Charge Controller)

Roles for the determination of zones:

- A device that monitors the State Of Charge (SOC) of an energy storage device and sends control signals to charge or discharge to a power conversion device ***(Field zone)***
- This function also communicates the SOC information to the VSG status controller to be sent to the cell operator ***(Field zone)***

Determination of Domains:

Since most of converter based resources will be at the distribution level the domains will be: ***Distribution, DER, Customer premises.***

Possible component:

It is a device based controller.

Details on information exchanges:

Number	Name	Definition	Service	Device	Information Exc.	Req.
400/periodically - CTS1 30sec	*send - State of charge [J]*	*The energy store charge controller sends SOC information to the VSG status controller*	*charge control*	**(D1)**	IEX_07	- digital signal [kg.m^2], [J] -the high speed communication
401	send - State of charge [J]	The energy store sends its SOC status information to the charge controller	charge control	**(C3)**	IEX_07	- digital signal [kg.m^2], [J] -the high speed communication
403	send - power setpoint	the power set point for controlling the SOC of the energy store is sent to the power converter	charge control	**(C2)**	IEX_08	digital signal [W]

C2 and C3: They are actuator and physical device (located at process level), respectively. Necessary information is covered in other devices.

D1: (VSG Controller)

Roles for the determination of zones:

- VSG Status controller: Monitors the status of the VSG (available Inertia + energy store SOC). This information is communicated to CTL2/3 functions (inertia monitor + deployment mechanism) over high speed communication technology. receives dispatch commands from the deployment mechanism ***(Field zone)***
- Inertial Power Calculator: Calculates the required inertial power response based on the total inertia J_T [kg m^2], angular grid frequency ω [rad/s] and the ROCOF dω/dt. ***(Field zone)***
- Large Imbalance Detector: Uses the frequency and its time to detect frequency incidents and calculate an inertial adjust factor. ***(Field zone)***
- Control loop which calculates the frequency and rate of change of frequency (ROCOF) of the grid voltage waveforms using a phase angle following feedback loop. ***(Field zone)***

Determination of Domains:

They will be at the distribution level the domains will be: ***Distribution, DER, Customer premises.***

Possible component:

It is a controller.

Details on information exchanges:

Number	Name	Definition	Service	Device	Information Exc.	Req.
3/periodically - CTS2-3 120-900sec	send - individual devices: state of charge [J]	The charge controller of each VSG energy storage device sends SOC status information to the cell operator	inertia monitoring & dispatching	**(CO)**	IEX_09	Digital signal [rad/s^2]
4	send - individual devices: resource status - inertia deployed and available	Each VSG sends its status data to the cell operator	inertia monitoring & dispatching	**(CO)**	IEX_10	digital signal [kg.m^2]
400/periodically - CTS1 30sec	*send - State of charge [J]*	*The energy store charge controller sends SOC information to the VSG status controller*	*charge control*	**(C1)**	IEX_07	- digital signal [kg.m^2], [J] -the high speed communication
500	voltage waveforms	voltage sensor transforms the physical grid voltage level into a small signal that can be used by the controller	voltage sensing	**(D2)**	IEX_01	-Digital signal [V]
512	send - inertial response power	The power calculator sends the inertial power setpoint to the power converter	VSG control	**(C2)**	IEX_15	-digital signal [kg.m^2]
9	individual devices: inertia setpoints	The cell operator deploys individual VSG devices to achieve the inertia setpoint	inertia deployment	**(CO)**	IEX_11	digital signal [1], [kg.m^2]

D2: This is a physical device (process level), interacting only with D1. No necessary for detailed assessment.

3.3.2.2 Component Layer

The component layer for the IRPC 2.2.2 has been defined using the "***First Set of Standards***" report published by CEN-CENELEC-ETSI Smart Grid Coordination Group and "detailed description document of IRPC 2.2.2" by writing team. Since there are not many details about the components in the use case document, the most feasible way selected while determining the component layer (See Figure 29).

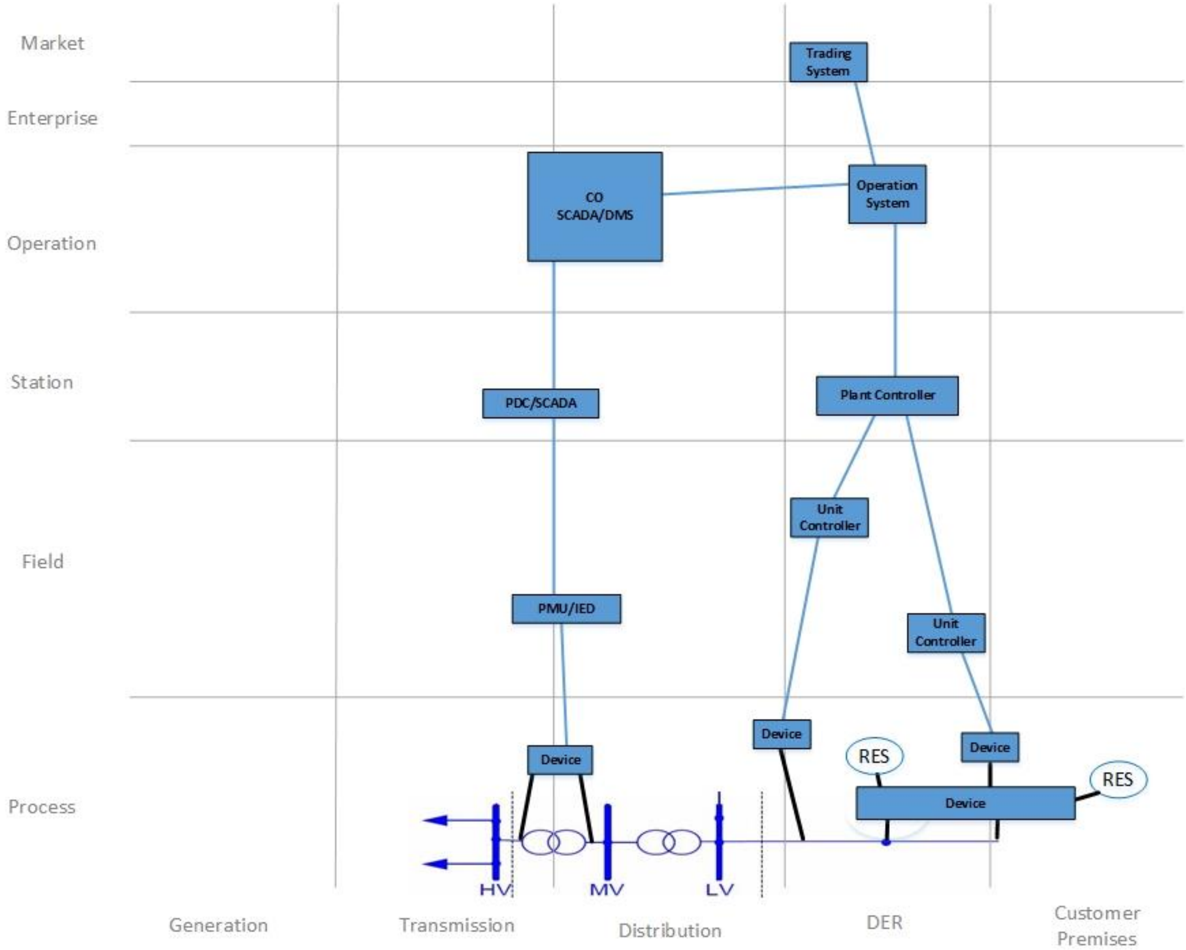


Figure 29 - Component Layer

The IRPC 2.2.2 use case comprises mainly three actions as "device inertial response power exchange", "synchronous area inertia control" and "cell inertia control". Considering the component layer, it can be grouped in two main actions: "***device inertial response power exchange***" and "***inertia control***". Therefore, two main component schemes can be drawn for each group.

The "device inertial response power exchange" can be correlated with the ***DER management systems***. The component scheme for ***DER operation*** and/or ***DER EMS and VPP system*** can be mapped into this use case. Voltage sensor-2, power converter and energy storage systems are located at the process zone as devices while Energy Store Charge Controller and VSG controller are located at the field zone as unit controllers. They are connected to a plant controller located in the substation zone (in order to fit the common scheme). Then, in the duty of the cell operator, the operation system (possibly a computer based) has performed the "device inertial response power exchange”. Considering the possibility of a market based deployment mechanism, it is also interacting with the trading system.

Since the measurement of major node may be from either transmission or distribution level (it depends on the cell structure), the “inertia control” can be correlated with the ***Substation Automation System*** (transmission and distribution). Other possibility is to use PMU systems while measuring the inertia from the major node (***Wide Area Measurement System***). Therefore, Angular Frequency Monitor can be either an IED or PMU connected to the voltage sensor-1. Here, the information flows through a PDC (PMU Data Concentrator) or Substation SCADA and reaches the Cell Operator SCADA/DMS center.

3.3.3 Relevant Standards - Communication and Information Layers

The communication and information layers for the IRPC 2.2.2 has also been defined using the “***First Set of Standards***” report. Since the component layer has recently been defined, the possible communication and information layers are generated in the direction of component layer. They are shown in Figure 30 and Figure 31 respectively.

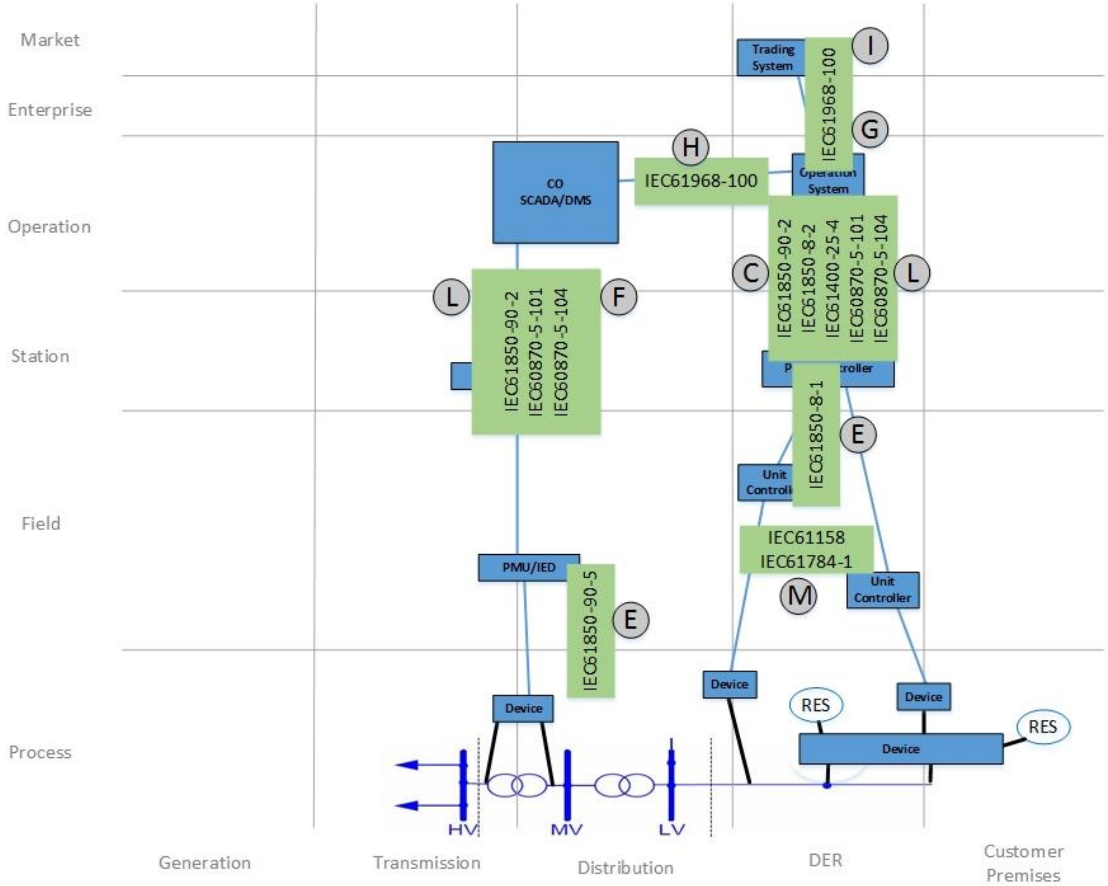


Figure 30 - Communication Layer

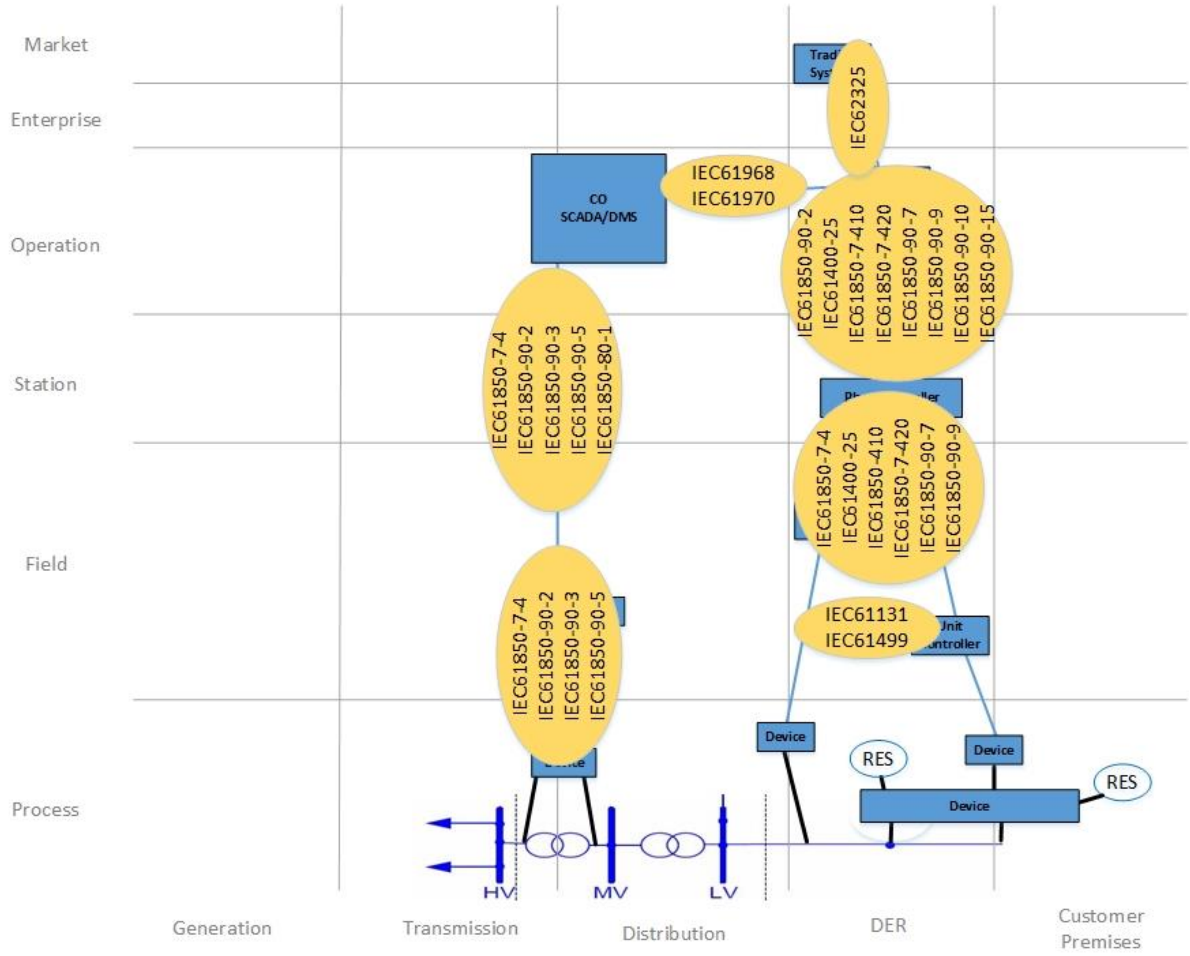


Figure 31 - Information Layer

a) All Possible Communication Networks:

M - Industrial Fieldbus Area Network: Networks that interconnect process control equipment mainly in power generation (bulk or distributed) in the scope of smart grids. ***In this Use Case, It may be suggested between unit controllers and field devices.***

E - Intra-substation network: Network inside a primary distribution substation or inside a transmission substation. It is involved in low latency critical functions such as tele-protection. Internally to the substation, the networks may comprise from one to three buses (system bus, process bus, and multi-services bus). ***In this Use Case, it can be used between IEDs and devices, and Unit Controllers and Plant Controllers.***

C - Field Area Network: Networks at the distribution level upper tier, which is a multi-services tier that integrates the various sub layer networks and provides backhaul connectivity in two ways: directly back to control centers via the WAN or directly to primary substations to facilitate substation level distributed intelligence. It also provides peer-to-peer connectivity or hub and spoke connectivity for distributed intelligence in the distribution level. ***In this Use Case, it can be suggested between plant controllers and central controller.***

L - Wide and Metropolitan Area Network: Networks that can use public or private infrastructures. They inter-connect network devices over a wide area (region or country) and are defined through SLAs (Service Level Agreement). ***In this use case, it is suggested for the synchronous inertia control operation (CTL3).***

F - Inter substation network: Networks that interconnect substations with each other and with control centers. These networks are wide area networks and the high end performance requirements for them can be stringent in terms of latency and burst response. In addition, these networks require very flexible scalability and due to geographic challenges they can require mixed physical media and multiple aggregation topologies. System control tier networks provide networking for SCADA, SIPS, event messaging, and remote asset monitoring telemetry traffic, as well as peer-to-peer connectivity for tele-protection and substation-level distributed intelligence. ***In this Use Case, it can be needed between Substation SCADA and central SCADA/controller.***

H - Enterprise Network: Enterprise or campus networks, as well as inter-control center networks. Since utilities typically have multiple control centers and multiple campuses that are widely separated geographically, ***it is suggested for connecting the SCADA and DER operation system in case they are separated.***

G - Intra-Control Centre / Intra-Data Centre network: Networks inside two different types of facilities in the utility: utility data centers and utility control centers. They are at the same logical tier level, but they are not the same networks, as control centers have very different requirements for connection to real time systems and for security, as compared to enterprise data centers, which do not connect to real time systems. Each type provides connectivity for systems inside the facility and connections to external networks, such as system control and utility tier networks. ***In this Use Case, it is possibly needed for the future DER control with the market operations.***

I - Balancing Network: Networks that interconnect generation operators and independent power producers with balancing authorities, and networks those interconnect balancing authorities with each other. In some emerging cases, balancing authorities may also dispatch retail level distributed energy resources or responsive load. ***In this Use Case, it may be needed for the possible future market based inertia deployment in Cell Operator.***

b) All Possible Communication Standards:

IEC 61158 and **IEC 61784-1 –** Field bus protocols are standardized within these two protocols.

IEC 61850-90-5 – Use of IEC/EN 61850 to transmit synchrophasor information according to IEEE. (Ed. 1.0:2012 - Communication networks and systems for power utility automation - Part 90-5: Use of IEC/EN 61850 to transmit synchrophasor information according to IEEE C37.118)

IEC 61850-8-1 – Defines the communication for any kind of data flows except sample values (Ed. 2.0 2011- Communication networks and systems for power utility automation - Part 8-1: Specific communication service mapping (SCSM) - Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3)

IEC 61850-90-2 – Guideline for using IEC/EN 61850 to control centers.

IEC 60870-5-101 – (Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks)

IEC 60870-5-104 – (Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles)

IEC 61850-8-2 – A new mapping of IEC/EN 61850 over the web services technology (IEC 61850-8-2) is under specification, in order to enlarge (in security) the scope of application of IEC/EN 61850 outside the substation, while facilitating its deployment. (Coming Standard)

IEC 61400-25-4 – Wind turbines communication

IEC 61968-100 – Communication at the operations and enterprise levels

c) All Possible Information Standards:

IEC 61131 – Programmable controllers

IEC 61499 – Distributed control and automation

IEC 61850-7-4 – Core Information model and language for the IEC/EN 61850 series

IEC 61850-90-2 – Substation to control center communication

IEC 61850-90-3 – Condition monitoring

IEC 61850-90-5 – Synchrophasors

IEC 61400-25 – Wind Farms

IEC 61850-7-410 – Hydroelectric power plants

IEC 61850-7-420 – DER

IEC 61850-90-7 – PV Inverters

IEC 61850-90-9 – Batteries

IEC 61850-80-1 – Mapping of IEC/EN 61850 data model over 60870-5-101 and 104

IEC 61850-90-10 – Scheduling functions

IEC 61850-90-15 – Multiple Use DER

IEC 61968 – Common Information Model (System Interfaces for Distribution Management)

IEC 61970 – Common Information Model (System Interfaces for Transmission Management)

IEC 62325 – Market Operation models

d) Association of standards with Information Exchange:

Grid Voltage Waveforms (IEX_01): Two types of voltage waveform measurements are carried out in IRPC2.2.2. The first one is the “High voltage grid waveforms” transformed into levels that can be used by the controller. To acquire this information exchange, we can use either substation automation system (IEDs) or wide area measurement system (PMUs) at HV transmission level (or distribution level if the web of cell area covers only the distribution side). It is assumed that PMUs might slightly have better advantage in the future so that it is selected to be used in this information exchanged. The second one is “the physical grid voltage level” transformed into a small signal by Voltage sensor that can be used by the controller. We can assume that the second information exchanged is an internal operation realized by voltage sensors for the DER unit controllers.

It is suggested that IEC61850-90-5 must be used as information and communication standard in this information exchange at the transmission side.

Grid Angular Frequency (IEX_02): This information exchanged is the “RMS ($\delta\omega$) data” sent to inertia controller located at the operation zone by PMUs.

From the SGAM architecture, it is suggested that it would be possible to apply IEC 60870-5-104 standard for this exchange. One note that there is a coming standard as IEC61850-90-2 that also be used in this IEX, but it is not taken into account for now.

Total cell SOC (IEX_03): The information exchanged is the "aggregated cell VSG SOC status information" sent by the cell operator to the inertia controller. Here, we can assume that the inertia controller will be in the cell operation center at operation level.

It is suggested that IEC61968-100 protocol can possibly apply for communication, while IEC61968 series can be used for the information interfaces. Here, Part 3 (interface for network operations) and Part 11 (CIM extensions for distribution) are two candidates for IEC61968 information standard. In this assessment, IEC61968-11 are suggested for the information layer.

Total cell inertia (IEX_04): The information exchanged is the "Deployment setpoint" sent by the cell operator to the inertia controller.

This IEX_04 has similar characteristic as IEX_03, therefore same standards can be suggested.

Individual cells: Inertia setpoints (IEX_06): It is the "Individual cells inertia setpoints" value sent by the inertia deployment to the cell operator. This information exchanged is an inter-cell value that can be sent to other cells by the cell operator.

Similar standard as IEX_3 can be applied between deployment mechanism and cell operator.

SOC (IEX_07): It is the "SOC status information" sent by the energy storage device to the charge controller.

Field protocols can be suggested for this IEX. IEC61499 protocol for information and IEC61158 protocol (or IEC671784-1) for communication layer can be implemented.

Power Setpoint (IEX_08): The "set point for controlling the SOC of the energy store" is sent by the charge controller to the power converter.

Similar to IEX_07, field protocols can be suggested for this information exchanged.

Individual devices: state of charge (IEX_09): "SOC status information" is sent by each VSG energy storage device to the cell operator.

From the SGAM architecture, it is suggested that it would be possible to apply IEC 60870-5-104 protocol for this exchange.

Individual devices: resource status - inertia deployed and available (IEX_10): Each VSG sends its "status data" to the cell operator.

Same standard in IEX_09 can be applied.

Individual devices: inertia setpoints (IEX_11): The cell operator deploys individual VSG devices to achieve "the inertia setpoint".

Same standard in IEX_09 can also be applied.

Dispatch Command, Inertia Setpoint (IEX_15): The information exchanged is the "inertia power setpoint" sent by the power calculator (unit controller) to the power converters in the fields.

The exchanged information is in DER operation between field and process. So that, it can be suggested that an industrial field protocol might be used for communication and information.

Therefore, IEC61499 protocol for information and IEC61158 protocol (or IEC671784-1) for communication layer can be implemented.

Besides these 11 information exchanges, there are 5 more internal information exchanges (5, 12, 13, 14, 16), which is not mentioned due to the fact that they are not related with the standard assessment.

3.3.4 Conclusions

As a conclusion, the summary table for the information and communication standards is given below:

Table 9 - Information and communication standards for IRPC

Information Exchanged	*Name*	*Related Information Standard*	*Related Communication Standard*
IEX_01	Grid Voltage Waveforms	IEC61850-90-5	IEC61850-90-5
IEX_02	Grid Angular Frequency	IEC 60870-5-104	IEC 60870-5-104
IEX_03	Total cell SOC	IEC61968-11	IEC61968-100
IEX_04	Total cell inertia	IEC61968-11	IEC61968-100
IEX_06	Individual cells: Inertia setpoints	IEC61968-11	IEC61968-100
IEX_07	SOC	IEC61499	IEC61158
IEX_08	Power Setpoint	IEC61499	IEC61158
IEX_09	Individual devices: state of charge	IEC 60870-5-104	IEC 60870-5-104
IEX_10	Individual devices: resource status - inertia deployed and available	IEC 60870-5-104	IEC 60870-5-104
IEX_11	Individual devices: inertia setpoints	IEC 60870-5-104	IEC 60870-5-104
IEX_15	Dispatch Command, Inertia Setpoint	IEC61499	IEC61158

3.4 Standard analysis for Frequency Containment Control (FCC) use cases

The present chapter executes an analysis of the FCC use looking at the Information Layer of the SGAM.

3.4.1 The FCC Use cases

The present sequence diagram is proposed for this use case:

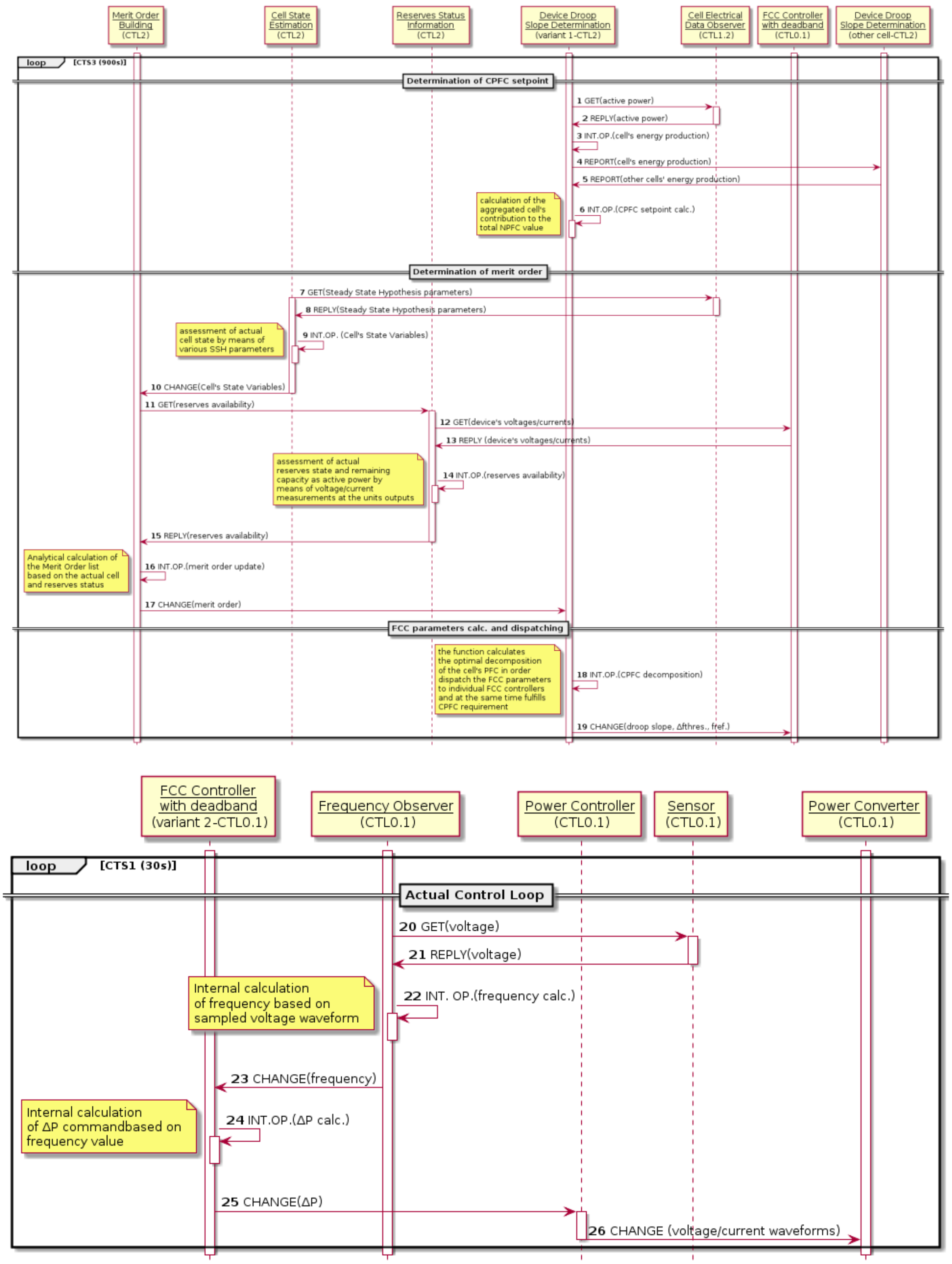


Figure 32 - Sequence diagram

3.4.2 SGAM Mapping

3.4.2.1 Function layer

Table 10 - Functions and their definitions

Function	Definition
Sensor	Device to transform large amplitude voltage waveforms down to levels that can be used by a digital controller
Power Converter	A physical device for controlling the exchange of power between the grid and an electrical device In particular devices that are not compatible with nominal grid voltage and frequency need power converters for proper operation
Power Controller	Each resource which provides reserves has a function that increases/decreases its power generation/consumption as requested. Input: power activation signal What: increases/decreases power generation/consumption as requested Output: increased/decreased power generation/consumption
Frequency Observer	Each reserves providing resource has a function that continuously samples voltage waveforms to calculate the instantaneous value of the system frequency. This can be at either the connection point of a single device or a Point of Common Coupling of the aggregated resource. Input: Voltage waveforms (continuously) What: Calculate actual frequency from the input signals (as fast as possible) Output: Actual value of frequency (as fast and often as possible)
FCC Controller	Each reserves providing resource has a function that continuously calculates the frequency error signal, taking into account the optional deadband, and based on this and its droop slope, increases or decreases active power generation/consumption in a proportional manner to counter the frequency deviation / system imbalance. Input : frequency set-point (could be constant ; otherwise at the beginning of each control time window at Ti), instantaneous value of frequency (as fast and often as possible), Droop Slope (either at beginning of each control time window at Ti – for FCCx.1-4 – or as often as possible – for FCCx.5-8) What: Increase/Decrease active power generation/consumption according to the frequency error signal (with or without deadband: two variants) and the droop slope (continuously) Output: Increased/Decreased active power generation/consumption (continuously).
Reserves Status Information	Each reserves providing resource (and the aggregator) has a function that provides up-to-date information on its reserves providing capabilities for the next time window as well as associated cost. Input: none (local information) What: Determine how much and what type of reserves can be provided Output: a description of what reserves can be provided for what cost
Cell Electrical Data Observer	This function aggregates all the measurements of interest within the cell and makes these available upon request Input: sensor data (e.g. from CTs and VTs) What: aggregate and process the data Output: processed measurements (e.g. RMS voltage and current) at the required monitoring locations within the cell, and the cell electrical topology
Cell State Estimation	This cell central function builds a forecasted estimate of the cell's grid state (bus voltages and line flows) to be used by the Merit Order Building function. Input: grid topology with connection points, bus voltages (dynamic measurement) and line flows (dynamic measurement), other TBD information

	What: forecast grid state for the next TBD time window. Output: Estimated bus voltages and line flows for the next TBD time window (a time vector with values for each bus)
Device Droop Slope Determination	This cell-central function determines the droop slope of available FCC devices by decomposing the cell's NFPC into device droop slopes in such a manner that the aggregated droop slope is equal (or larger) than the cell's decided NPFC contribution, taking into account activation cost and grid security. It will ensure that for each timestep the worst case activation will be grid secure by taking into account the cell state time vector information and the effect of a worst case activation on this. Comment: In this variant the Device Droop Slope Determination of the cell of interest interacts with its counterparts throughout the WoC in order to acquire the total energy production and thus calculate the CPFC set point as its contribution to the WoC. The process is illustrated with the use of an extra DDSD function of the other cells. The function is performed by the **cell controller**
Merit Order Building	This cell central function build a merit order based on the information received by the Cell State Estimation function and the Reserves Status Informing function. The merit order not only takes into account the cost of an activation, but as well the cell state estimation and the location of the reserves providing resource in the cell, so that (normally) all activations can be done in a grid secure manner. Input: cell state estimation, reserves information What: Determines a location and cell state aware merit order list Output: an ordered list of reserves to be activated (which one and how much and/or according to what profile) The function is performed by the **cell controller** and belongs to CTL2

The mapping on the function layer is the following:

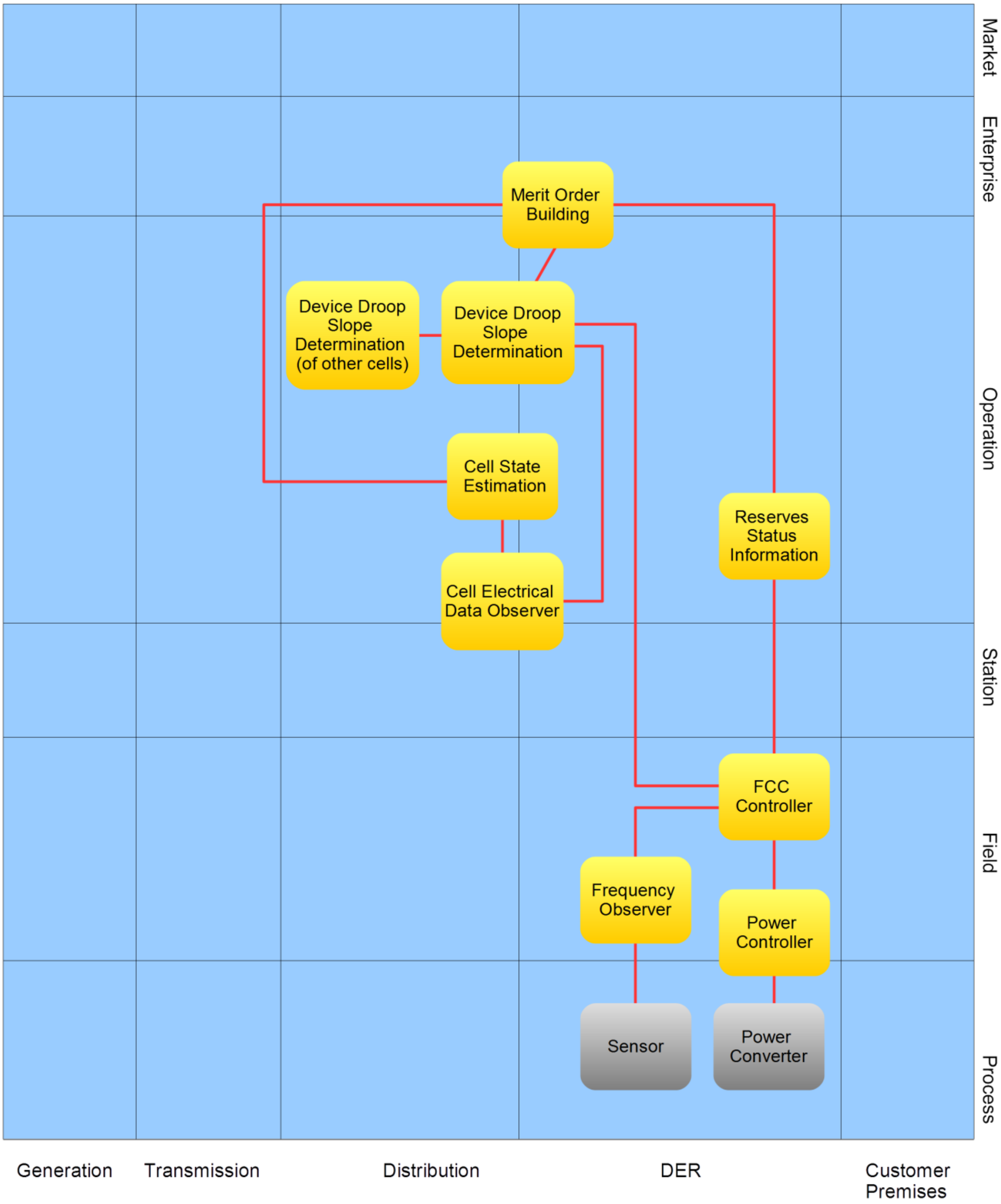


Figure 33 - FCC use case – assignment of actors to SGAM coordinates on the Function Layer

3.4.2.2 *Component layer*

The possible implementation of the variants in terms of component is generic and so different implementation options would be possible. However, the identification of standards, and particularly at communication level, presumes the mapping of the the use cases in terms of components, making some reasonable assumptions derived from the abovementioned associations with the use case clusters.

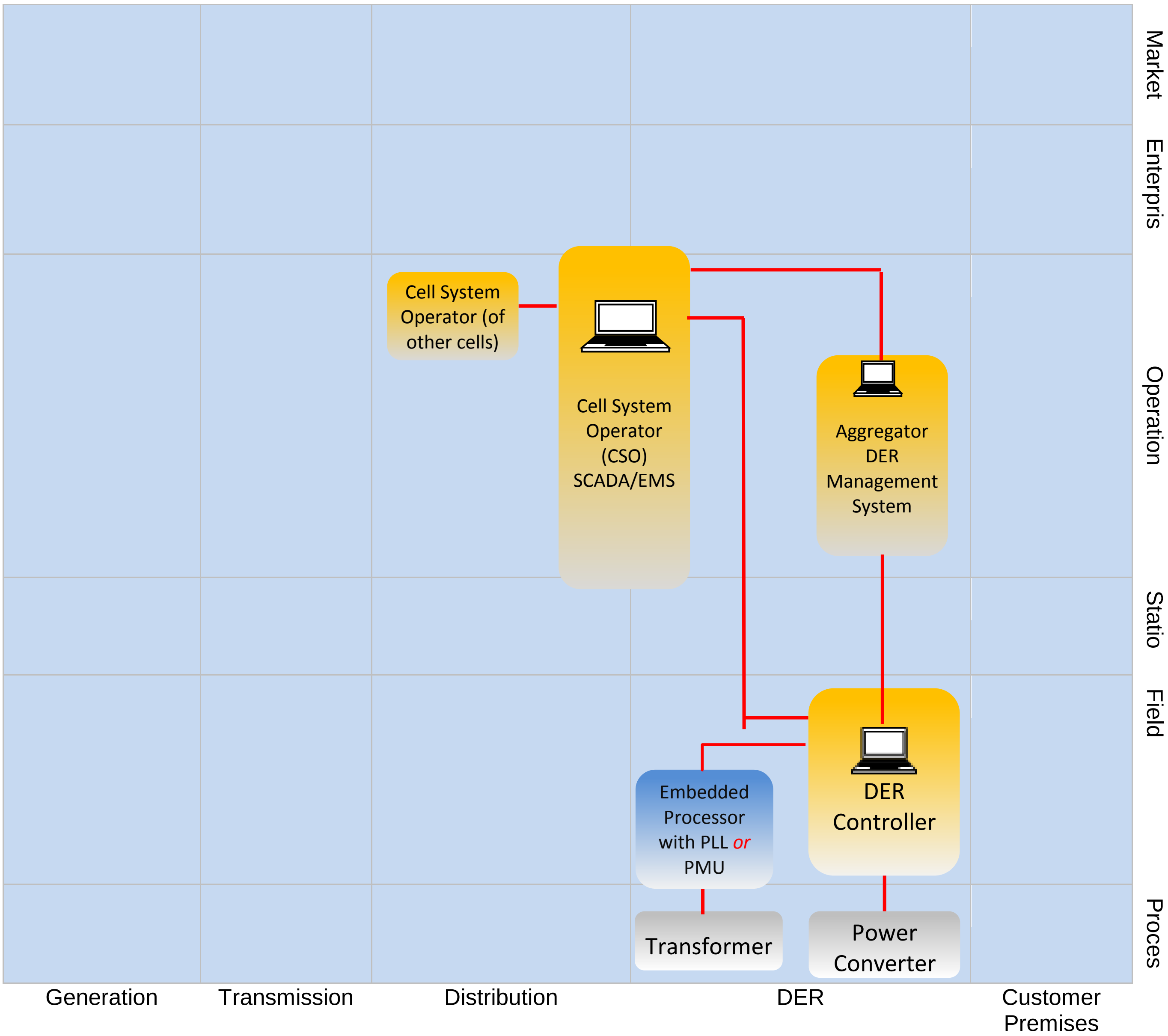


Figure 34 - FCC use case – definition of the component layer

Table 11 - Definition of the components and functions mapped on them

Component	Definition	Mapped functions
Transformer	Electric Energy converter without moving parts that changes voltages and currents associated with electric energy without change of frequency	Sensor
Power Converter	It converts an AC waveform another AC waveform, where the output voltage and frequency can be set arbitrarily	Power Converter

Component	Definition	Mapped functions
DER Control	Control of a DER that allows the adjustment of its active or reactive power output according to a received set point	Power Controller FCC Controller
Embedded processor with PLL	PLL stands for 'Phase-Locked Loop' and is basically a closed loop frequency control system, which tracks the frequency and phase of a sinusoidal signal by using an internal frequency oscillator	Frequency observer
PMU	A Phasor Measurement Unit (PMU) is a device which measures the electric waves on an electricity grid, using a common time source for synchronization. Time synchronization allows synchronized real-time measurements of multiple remote measurement points. It could be inserted in the component layer alternatively to the “Embedded processor with PLL)	Frequency observer
Aggregator DER Management System	It is a ICT system which represents the Aggregator’s underlying function	Reserve Status Information
Cell System Operator	The CSO (Cell System Operator) takes care of real-time balancing of residual imbalances by the activation of reserves that restore the system balance and has been defined in the context of Web of Cells idea, proposed by ELECTRA. It can be assumed that: • to perform his duties the Cell System Operator (CSO) is equipped with a (central) SCADA/EMS system. • both SCADA and EMS will be delivered by the same provider (manufacturer) and in this case both elements, i.e. SCADA and EMS, are integrated by the manufacturer - this is quite typical situation well known from our experience. Therefore, the following UC actors can be considered as particular CSO SCADA/EMS functions: • Cell Electrical Data Observer - SCADA, • Cell State Estimation – EMS. • Device Droop Slope Determination - EMS • Merit Order Building – EMS • Reserves Status Information That means that data flow between both mentioned actors can be considered as an "internal CSO SCADA/EMS data flow".	Cell Electrical Data Observer Cell State Estimation Device Droop Slope Determination Merit Order Building

3.4.3 Relevant Standards - Information Layer

On the base of the precedent mappings and of the set of standard document from the SGCG [9] a first sub set of standards can be identified for this use case, looking at what in the SGCG document is suggested for the "DER operation system” use case. The overview of these standards as proposed by the SGCG is shown in Table 12.

As can be seen, the pieces of information available from the document are not sufficient for understanding if they satisfy the needs of the use case, so a more reasoned process is applied in paragraph 3.4.5.

Table 12 - List of relevant information standards from the SGCG set of standards (source, figure 32 of SGCG, 2014)

IEC 61131	Programmable controllers
IEC 61499	Distributed control and automation
IEC 61850-7-4	Core Information model and language for the IEC/EN 61850 series
IEC 61400-25	Wind farms
IEC 61850-7-420	DER
IEC 61850-90-7	DER Inverters
IEC 61850-90-8	Batteries
IEC 61850-90-15	Multiple Use DER
IEC 61850-90-11	Methodologies for modelling of logics for IEC/EN 61850 based applications
IEC 61850-90-2	Substation to control center communication
IEC 61850-410	Hydroelectric power plants - Communication for monitoring and control
IEC 61968	Distribution CIM
IEC 61970	Transmission CIM

3.4.4 Relevant Standards - Communication Layer

Table 13 - List of relevant communication standards from the SGCG set of standards (source, figure 31 of SGCG, 2014)

IEC 61158	Field bus
IEC 61784-1	Field bus
IEC 61850-8-1	IEC/EN 61850 communication except Sample values
IEC 61850-90-2	Substation to control center communication
IEC 61850-8-2	Web-services mapping
IEC 61400-25-4	Wind turbines communication
IEC 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
IEC 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
IEC 61968-100	Defines profiles for the communication of CIM messages using Web Services or Java Messaging System.

3.4.5 Association of standards with Information Exchange

The previous diagrams (function and information layers and relevant standards) together with the tables about information exchange presented by the use case are the base for this analysis. Now each information exchange in the sequence diagram is examined.

It is important to note that the central CSO SCADA/EMS incorporates the following functions:

- Cell Electrical Data Observer;
- Reserves Status Information;
- Cell State Estimation;
- Merit Order building;
- Device Droop Slope Determination

This assumption is important for the rest of this chapter.

3.4.5.1 Request command (IEX_01)

According to the FCC use case definition, active power is a request command containing the requested parameters values:

- Get active power - The *Device Droop Slope Determination function* requests active power values from the *Cell Electrical Data Observer* in order to calculate the energy production yield (this information object is sent from *Device Droop Slope Determination* to *Cell Electrical Data Observer*: considering the component layer, this is an internal exchange);
- Get reserves availability - The *Merit Order Building function* acquires information of available reserves for preliminary merit order building. The data are retrieved from *Reserves Status Information function* (this information object is sent from Cell State Estimation to Cell Electrical Data Observer: considering the component layer, this is an internal exchange);
- Get device's voltages/currents - The *Reserves Status Information* requests voltages and currents of the *devices* in order to calculate the available power capacity for the service provision (this information object is sent from *Merit Order Building* to *Reserves Status Information*: considering the component layer, this is an internal exchange);
- Get voltage measurement - The *Frequency Observer* function requests the actual voltage waveform from the *Sensor*;

3.4.5.2 Active Power (IEX_02)

According to the FCC use case definition, active power is:

- Array containing the active power profiles of generation/consumption over time
- These arrays are sent from a *Cell Electrical Data Observer* to *Device Droop Slope Determination*
- These data are requested (IEX 01) in order to calculate the energy production yield

It can be expected that the Cell State Estimation will be included in the CSO SCADA/EMS system. At the moment it has not yet established how the Device Droop Slope Determination will be realized. In the component layer, it is supposed that it can be part of the CSO SCADA/EMS system and so it is an internal **exchange** and no standards are needed.

NOTE: If it were a central device and different from the CSO SCADA/EMS then it could be assumed that IEC 60870-5-104 standard would be used to transmit active power values.

3.4.5.3 Energy (IEX_03)

According to the use case definition, the IEX-03 exchange

- contains the energy yield of the cells and it is a scalar value containing energy
- is executed between *Device Droop Slope Determination* actors of different cells (and so between CSO SCADA/EMS systems of different cells)
- the *Device Droop Slope Determination* receives information with regard to the energy yield of the web of cells so that all cells can use the information to calculate the CPFC set-point in a distributed manner

The standard suggested for the IEX-03 is the IEC 60870-5-104. Indeed, this standard enable communication between CSO SCADA/EMS systems of different (e.g. neighboring) cells via a standard TCP/IP network and support the exchange of scalar values and related time information.

3.4.5.4 Buses' voltages and currents (IEX_05)

According to the use case definition, these buses' voltages and currents are:

- Steady-State Hypothesis parameters and, specifically, are vectors containing the following grid parameters applicable to this variant: Switches status, control settings (active power/voltage RMS), operating limits (active power/voltage RMS), energy injection of reserves providing devices
- exchanged between *Cell Electrical Data Observer* and *Cell State Estimation*

According to the Component layer, Cell Electrical Data Observer and Cell State Estimation are included within the same component (CSO) so this is an internal exchange and no standards are needed.

3.4.5.5 Cell State (IEX_06)

According to the use case definition, these cell states are:

- Vectors containing the following state variables associated with the grid parts where FCC reserves are connected: energized state (line, device), bus voltages (amplitude/phase), bus injections (amplitude/phase), violations of operating limits
- These vectors are sent by Cell State Estimator to Merit Order Building

According to the Component layer, Cell Electrical Data Observer and Cell State Estimation are included within the same component (CSO) so this is an internal exchange and no standards are needed.

3.4.5.6 Reserve Availability (IEX_08)

According to the FCC use case definition, this reserve availability (where DER, storage, flexible loads constitute the reserves with respect to FCC) brings information of available reserves for preliminary merit order building.

- In detail it is an array containing the availability (power capacity) versus time.
  - These schedules are sent from a *Reserves Status Information* to *Merit Order Building*
- Then The Merit Order function acquires information of available reserves for preliminary merit order building. The data are retrieved from Reserves Status Information function

So the CSO SCADA/EMS component receives the information of available reserves either directly from the DER Controller component or from Aggregator DER Management System component as is shown in Figure 34.

For the purpose of data exchange within Reserves Status Information function (i.e. between CSO SCADA/EMS and DER Controller) the following communication relations (interfaces) shown in Figure 34 of the FCC SGAM Component layer should be considered:

1. For indirect CSO SCADA/EMS communication with DER Controller (via Aggregator DER Management System):
   (a) local DER Controller ←→ Aggregator DER Management System
   (b) Aggregator DER Management System ←→CSO SCADA/EMS
2. For direct CSO SCADA/EMS communication with DER Controller:
   (c) local DER Controller ←→ CSO SCADA/EMS

If it is assumed that the IEC 61850 standard is applied then the IEC 61850-8-1 standard has to be used on SGAM Communication layer and the IEC 61850-7-420 standard has to be used together with IEC 61850-7-4, IEC 61850-7-3, and IEC 61850-7-2 standards on the SGAM Information layer.

Moreover, instead of IEC 61850, also the standard IEC 60870-5-104 could be used in (a), (b), and (c) interfaces.

3.4.5.7 Voltages and currents (IEX_07)

According to the use case definition, these production/consumption schedules are:

- Array containing voltages and currents of the associated reserves
    - These schedules are get by the *Reserve Status Information* from the *FCC Controller*
- the Reserve Status Information acquires voltages/currents of the devices in order to calculate the available power for the service provision

So, the Reserves Status Information element of the CSO SCADA/EMS component receives the information of voltages and currents of the associated DER reserve either directly from the DER Controller component or from Aggregator DER Management System component what is shown in Figure 34.

As stated in the previous paragraph, the interested interfaces are (b) or (c) and, in particular, either IEC 61850-7-420 or IEC 60870-5-104 solutions are the most suited to be applied.

3.4.5.8 Merit order list (IEX_09)

According to the use case definition, merit order is:

- Array containing priority activation of reserves
- They are sent from *Merit Order Building* to *Device Droop Slope Determinations*.

According to the Component layer these two functions are implemented within the same component (the CSO EMS/SCADA). So it is an internal exchange end no standards are needed for it.

3.4.5.9 FCC parameters dispatching (IEX_10)

According to the use case definition, the “FCC parameters” is:

- a vector containing droop slope, Δfthres. and fref. values
- sent from “Device Droop Slope Determination” to “FCC Controller”

The exchanged information are frequency value and slope value.

These are scalar values. In this case the CSO SCADA/EMS component has to send data to the DER Controller component. Similarly as in section 3.4.5.6 either direct or indirect (via Aggregator DER Management System) communication is possible. Therefore, two solutions are possible: either the IEC 61850 standard (i.e. IEC61850-7-420, IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2, IEC 61850-8-1) or the IEC 60870-5-104 standard can be used.

3.4.5.10 Voltage Waveform (IEX_11)

According to the use case definition, the voltage waveform (report voltage measurement):

- is electrical signal but also the option of digital sampling of voltage can be considered
- is sent by the Sensor to the Frequency Observer

Due to the assumed FCC SGAM Component layer definition, voltage waveform is needed to either for the PMU device, locally connected with DER Controller, or for the Embedded Processor with PLL which is also locally used with DER Controller component and in this case it is probable that this Embedded Processor is the internal element of this component. In both cases they are electrical connections.

3.4.5.11 Frequency Value (IEX_12)

According to the use case definition, the Frequency Value:

- is a Scalar value of frequency
- is sent by a Frequency Observer to the FCC Controller

The frequency is measured either by PMU device, locally connected with DER Controller, or by the Embedded Processor with PLL which is also locally used with DER Controller component and in this case it is probable that this Embedded Processor is the internal element of this component. Summarizing:

1. If PMU is used then the IEEE C37.118.2 standard (or IEC/TR 61850-90-5 technical report) has to be used in the interface between the PMU and the DER Controller. This standard has to be used both on SGAM Information and Communication layer.
2. If, instead of the PMU, the Embedded Processor with PLL is used then it can be expected that this module would be integrated within the DER Controller and it is not necessary to indicate standards in this case.

NOTE: At present the PMUs offered on the market are consistent with the standard: either IEEE Standard C37.118.2-2011 or its earlier version IEEE Standard C37.118-2005. Unfortunately recently it has not been possible for us to find the PMU consistent with IEC 61850-90-5.

3.4.5.12 Power deviation (IEX_13)

According to the use case definition, the power deviation:

- is a control signal and is the power deviation value with reference to the frequency error
- is sent by the *FCC Controller* (Domain: Distribution; Zones: Process-Field) to the Power Controller (that should be the CPFC. Domain: Distribution; Zones: Field-Station)

Both these functions are implemented within the same component (DER Controller) and so this is an <u>internal exchange</u> and no standard are needed.

3.4.5.13 Voltage/current change (IEX_14)

According to the use case definition, the voltage/current change signals:

- are Waveform references used by the power converter to produce the requested power deviation
- are sent by the *Power Controller* (Domain: DER; Zones: Field) to the *Power Converter* (Domain: DER; Zone: Process)
- to modify the active power of the device

This connection is not relevant from the standards point of view because it takes place within the power converter itself, namely, the latter is equipped with a function that allows for power control.

3.4.6 Conclusions

The following table summarizes the previous results.

Information exchanged ID	Name of information exchanged	Description of information exchanged	Related Information Standards	Related Communication Standards
IEX_03	Energy	the energy yield of the cells and it is a scalar value containing energy	IEC 60870-5-104	IEC 60870-5-104
IEX_08	Reserve Availability	An array containing the availability (power capacity) versus time	Either IEC 61850-7-420IEC 61850-7-4 IEC 61850-7-3 IEC 61850-7-2 Or IEC 60870-5-104	Either IEC 61850-8-1 Or IEC 60870-5-104
IEX-07	Voltages and currents	Array containing voltages and currents of the associated reserves	Either IEC 61850-7-420 IEC 61850-7-4 IEC 61850-7-3 IEC 61850-7-2 Or IEC 60870-5-104	Either IEC 61850-8-1 Or IEC 60870-5-104
IEX-10	FCC parameters dispatching	A vector containing droop slope, Δfthres. and fref. values	Either IEC 61850-7-420 IEC 61850-7-4 IEC 61850-7-3 IEC 61850-7-2 Or IEC 60870-5-104	Either IEC 61850-8-1 Or IEC 60870-5-104
IEX-11	Voltage Waveform	Digitalized waveform of instantaneous voltage, e.g. array structured with time stamp	Electrical signal	Electrical signal
IEX-12	Frequency Value	Scalar value of frequency	Either IEC 61850-90-5 Or IEEE C37.118.2	Either IEC 61850-90-5 Or IEEE C37.118.2
IEX-14	Voltage current change	Waveform references used by the power converter to produce the requested power deviation		

The previous results can be shown by the resulting SGAM Information (Figure 35) and Communication (Figure 36) layers:

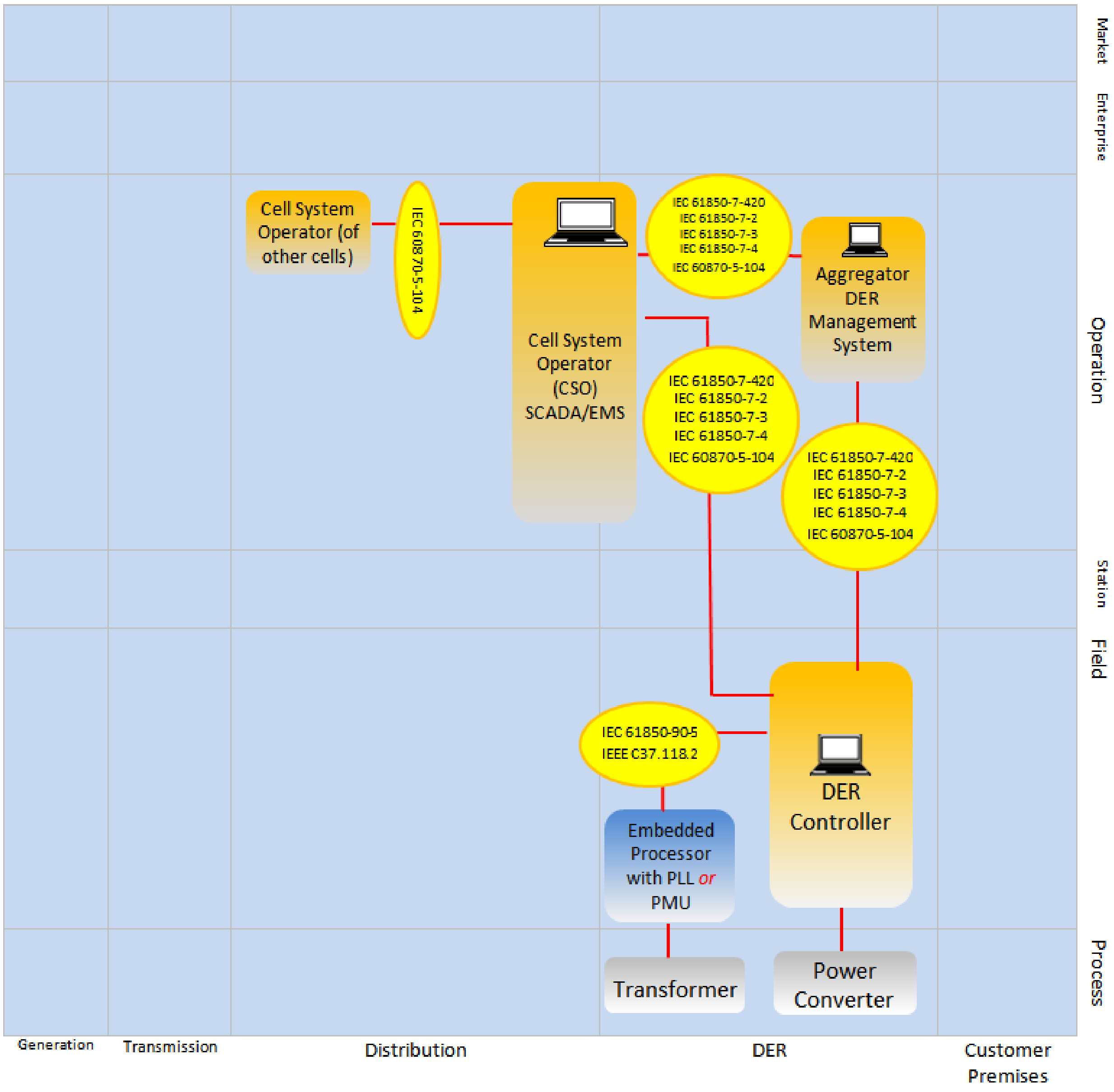


Figure 35 - Information Layer for the FCC use case

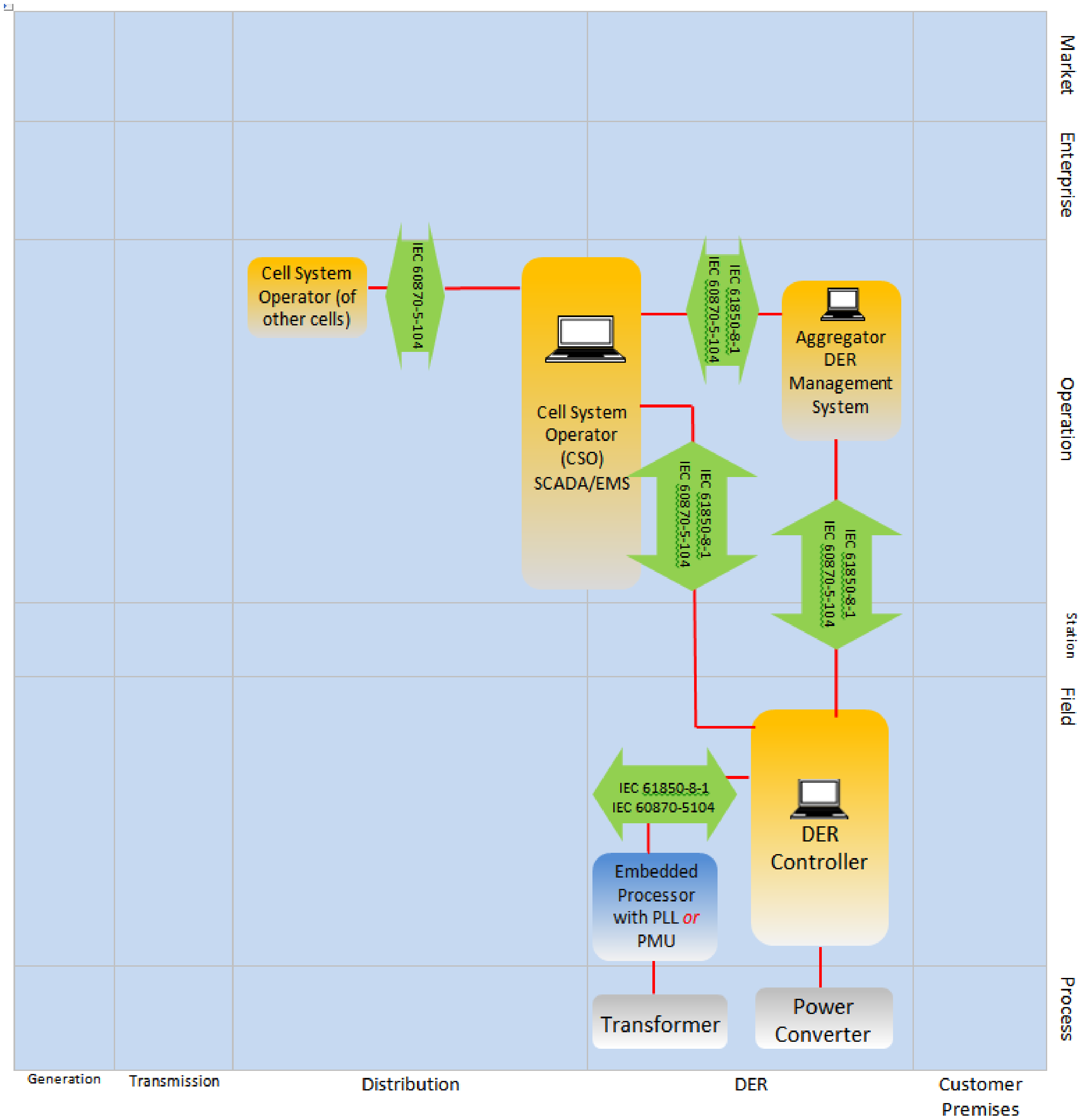


Figure 36 - Communication Layer for the FCC use case

3.5 Standard analysis for Balance restoration control (BRC) use cases

3.5.1 The BRC Use cases

All three variants of Balance Restoration Control, namely 1.1, 1.2 and 1.5 have the two-fold scope of dispatching reserves and activating them whenever an imbalance incident occurs. These variants present similarities in terms of used functions and sequence of interactions. Especially BRC1.1 and 1.2 are identical in terms of information exchanges and involved functions. Therefore, in this analysis they presented in parallel making distinct, whenever necessary, special characteristics of each one. As it can be seen in Figure 37, Figure 38 and Figure 39, the variants are divided into two phases. The first stage, depicted in Figure 37 (BRC1.1 and 1.2) and Figure 38 (BRC1.5) is concerned with the planning of reserves in order to ensure that enough flexibility will be available when, based on an imbalance incident, the Cell Imbalance Observer function will invoke the reserves in order to restore the initial balance. This latter set of actions (phase 2) is illustrated in the lower part of Figure 37 (BRC1.1 and 1.2) and in Figure 39 (BRC1.5) respectively. The implementation of the variant presumes a number of function blocks that interact in order to produce the expected result. These functions cover mainly Control Topology Levels, such as CTL1 and 2. Particularly, it is worth noting for BRC1.5 that among the functions there are two actors, namely the Cell Operator and the Aggregator. Although, these two actors can have a wide and more generic use in a process, in the specific variant they represent a subset of functionalities making so possible to assume that these actors can be illustrated as function of the SGAM Function Layer. This subset of functionalities is further specified in BRC1.1 and1.2, which involves a more concrete set of functions playing the role of Aggregator and Cell Operator. In the case of the aggregator, the functions which cover its aspect are: Aggregator Reserve Controller (as the physical aggregator of electrical signals), Aggregator Reserve Bid Calculator (as a market role) and BRC controller (as the block that activates reserves). Similarly, the Merit Order Building function of BRC1.1 and1.2 performs similar to the Cell Operator (BRC1.5) actions.

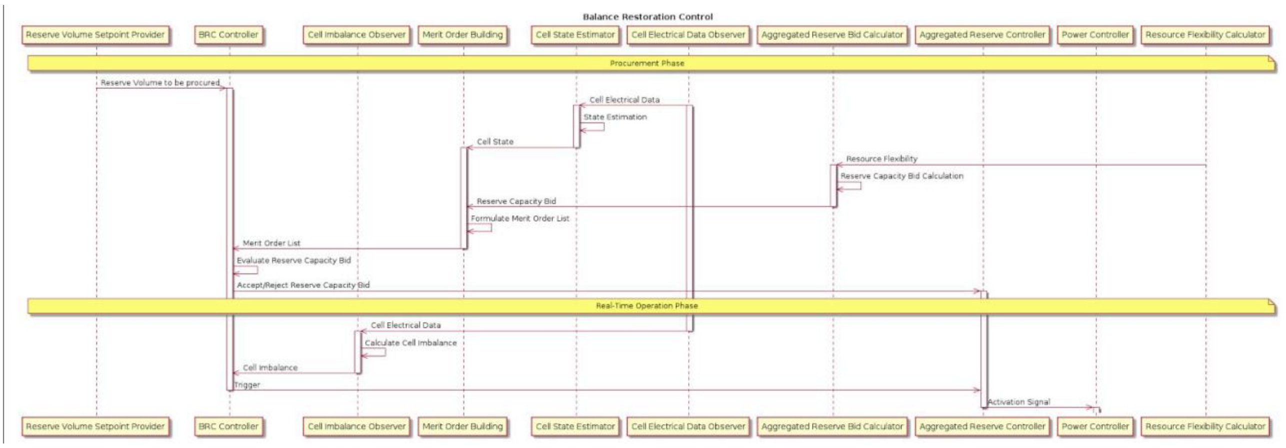


Figure 37 - Interactions between actors taking place during procurement and real-time control of BRC1.1 and 1.2

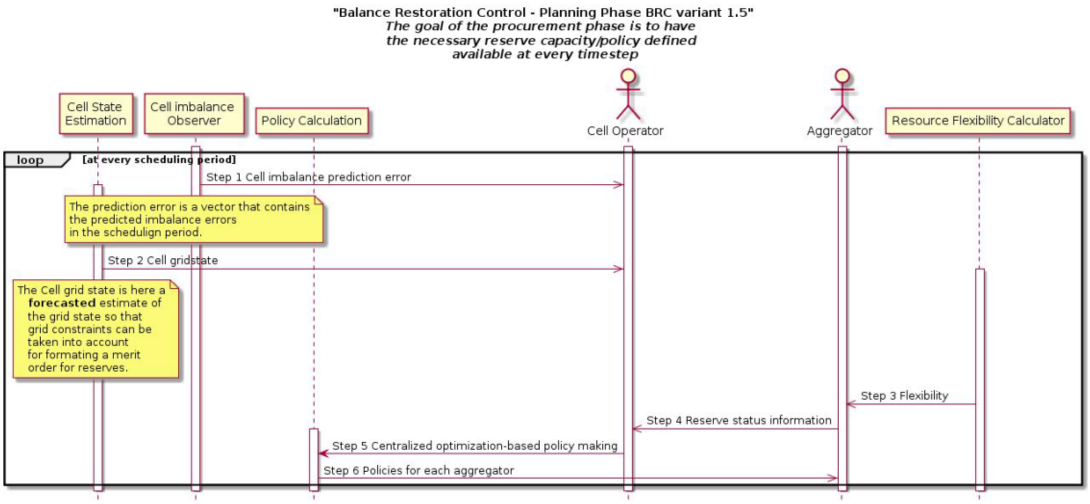


Figure 38 - Interactions between actors taking place during the procurement phase of BRC1.5

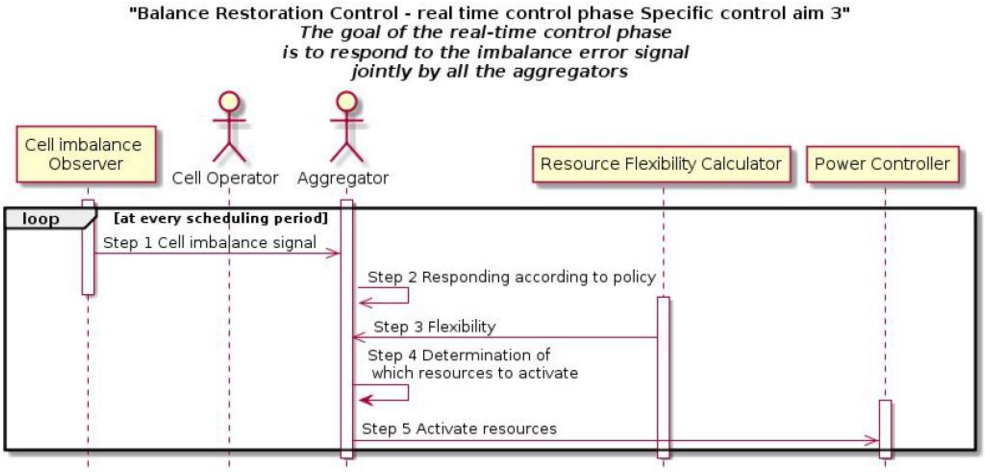


Figure 39 - Interactions between actors taking place during the real-time control phase of BRC1.5

3.5.2 SGAM Mapping

For the identification of standards in these variants, it is essential that a reasonable mapping for the functions and components should be made. To this end the background work from the Smart Grid Coordination Group with regard to the relevant set of standards is used. The scope of using this methodology is to identify use cases and components that best describe the various parts of the selected variants. It is noteworthy that despite the holistic applicability that the ELECTRA solutions present, namely implementation of the variants at any level (transmission or distribution), the analysis here in combination with the diagrams emphasize mainly the distributed aspect because, first and foremost, in the ELECTRA view this will be the norm in the future (2030+) power systems' operation and, also because the analysis of this use case variants is based on the assumption of distributed implementation, with several interactions involving aggregators of resources.

In terms of timescale implementation the variants fall into short-term Operational Planning (phase 1) and intra-term Network Operation (for phase 2). Also, in order for the placement of functions and assumed components to be consistent with the approach, the various high-level use cases of

SGCG Standards Report are considered. The objective is for our analysis to identify similarities and implementation schemes that best fit our use case variants. There are three main areas or clusters of use cases relevant to the specific variants summarized below:

Advanced Distribution Management Systems (ADMS):

The main subset of functions for the implementation the two variants, namely Cell Operator, Policy Calculation, Cell State Estimation and Cell Imbalance Observer for BRC1.5 as well as Merit Order Building, BRC Controller, Reserve Volume Setpoint Provider, Cell Imbalance Observer and Cell State Estimation for BRC1.1 and 1.2 would most probably (but not exclusively) be located on the Advanced Distribution Management System without excluding the possible applicability to Energy Management Systems as well. Based on the SGCG Standards Report, the main features of an ADMS involve, among others, the following two functionalities that are highly relevant to the specific variant:

- SCADA real-time monitoring and control
- Advanced network applications including network modelling

In general, the system supports all kind of processes, from planning and design to the day-to-day operation and maintenance activities. It provides the operator and planner with the asset location and other relevant asset specifications and dimensions. The location is a particularly important aspect used explicitly in variant 1.5 as a piece of information exchanged between the Aggregator and the Cell Operator so that the latter, in cooperation with the Policy Calculation, can optimally dispatch reserves. The same aspect is also applicable although not explicitly described in the case of BRC1.1 and 1.2 for the Merit Order Building since location of reserves is crucial for maintaining a secure system state after reserves activation, which would otherwise lead to operating constraints’ violations. The overall ADMS concept is assumed quite similar (though less advanced) to Transmission EMS, which is important due to the potential applicability of this and perhaps any other variant to transmission level as well.

Distributed Energy Resource Operation System (DER-OS):

BRC1.5 implementation involves the second important subset of functions that includes the Aggregator, the Resource Flexibility Calculator, and the Power Controller. Similarly, the use case variants BRC1.1 and BRC1.2 make use of a similar subset consisting of the Resource Flexibility Calculator, the Aggregator Reserves Controller, the Aggregator Reserve Bid Calculator and the Power Controller. By definition these functions involve power resources, power plants and Virtual Power Plants. Thus their deployment and the use case cluster of DER OS are alike. In general, this system is responsible for operation and enterprise level management of the DER assets. It performs supervision of the components, provides information to the operators and controls of actual generation. It can act as a technical VPP (tVPP) as well as commercial VPP (cVPP) interacting directly with the DSO and the Market, aspects both highly relevant to the specific variants. The system may control one or more DERs which can be geographically distributed. These DERs could be single generation plants or could be combined to VPPs.

Feeder Automation System:

In the specific use cases there is a third important subsystem is related to the Cell Imbalance Observer function. From the three variants, BRC1.1 and 1.2 make specific use of the function Cell Electrical Data Observer which is highly related to the Feeder Automation System. The same interrelation is implied, yet not explicitly described in the analysis of BRC1.5. In particular, in BRC1.5 (as in 1.1 and 1.2) the Cell Imbalance Observer is the function that measures deviation from the scheduled tie-lines set-points. In this respect the applicability of this functionality ought to involve measurements of the power system flows at specific branches, from which the imbalance can be deduced. From the relevant clusters of use cases described in the SGCG Standards Report, the most representative one is the Feeder Automation System. In principle, this is mostly made of 3 zones, the process zone which, among others, includes measuring elements such as voltage and current transformers/sensors, the field zone including IEDs for monitoring, and last but not least, the station zone which involves aggregation of monitoring via Remote Terminal Units. The chain of the above described components is, in principle the Cell Electrical Data Observer of BRC1.1 and 1.2, the information feeder to the Cell Imbalance Observer (in both variants), which in turn, calculates the actual imbalance. However, in terms of mapping on the function layer, based on the variant description the Cell Imbalance Observer function is specifically located in the Operation zone and somewhere in between distribution and transmission, although, the association with the FAS implies that only MV is regarded.

3.5.2.1 Function Layer

Based on the above mentioned assumptions and the association of the variants' functions and interactions with the use case clusters of SGCG, the following two mappings of functions on the function layer are derived (Figure 40 and Figure 41).

In these mappings, with the assumption that the procedure is focused on the distribution level implementation, the Cell State Estimation is located in the Operation zone, covering both distribution and DER domains, the Cell Imbalance Observer is also located in the Operation zone covering both distribution and transmission domains as it is possible for a (distribution level) cell to be interconnected to a transmission system (other cell). The Resource Flexibility Calculator and the Power Controller are both field-level functions with the latter much more close to the process zone. From the functions that are not common in the variants the Cell Operator and Policy Calculation functions for BRC1.5 are mainly located in the Operation Zone, covering also Enterprise aspects due to the use of geographical data (i.e. process of location of resources). The latter feature makes the use of a GIS component highly relevant. Last but not least, the Aggregator in the case of BRC1.5 is a function that addresses mainly Operation zone but involving also aspects of substation, thereby mapped to cover both zones. In principle, this actor may as well be considered as a Market-zone actor, due also to the fact that it participates in the procurement phase.

However, due to the fact that it incorporates real-time activation of reserves and because the real-time aspect is more important in the ELECTRA view, the mapping of the function in the Operation zone is more representative. This ambiguity is properly dealt with in BRC1.1 and1.2. In this variant, there are two distinct functions, namely the Aggregator Reserves Controller and the Aggregator Reserve Bid Calculator. The first one is clearly associated with the Operation zone, whereas the second represents the actions of the VPP in the Market/Enterprise zones. In addition, the functions Merit Order Building and Reserves Volume Setpoint Provider are associated with the Operation/Enterprise zones. Last but not least, the function Cell Electrical Data Observer is located in between the Operation and Substation zones, while it is concerned only with the distribution domain (if we assume that our cell is a MV/LV grid).

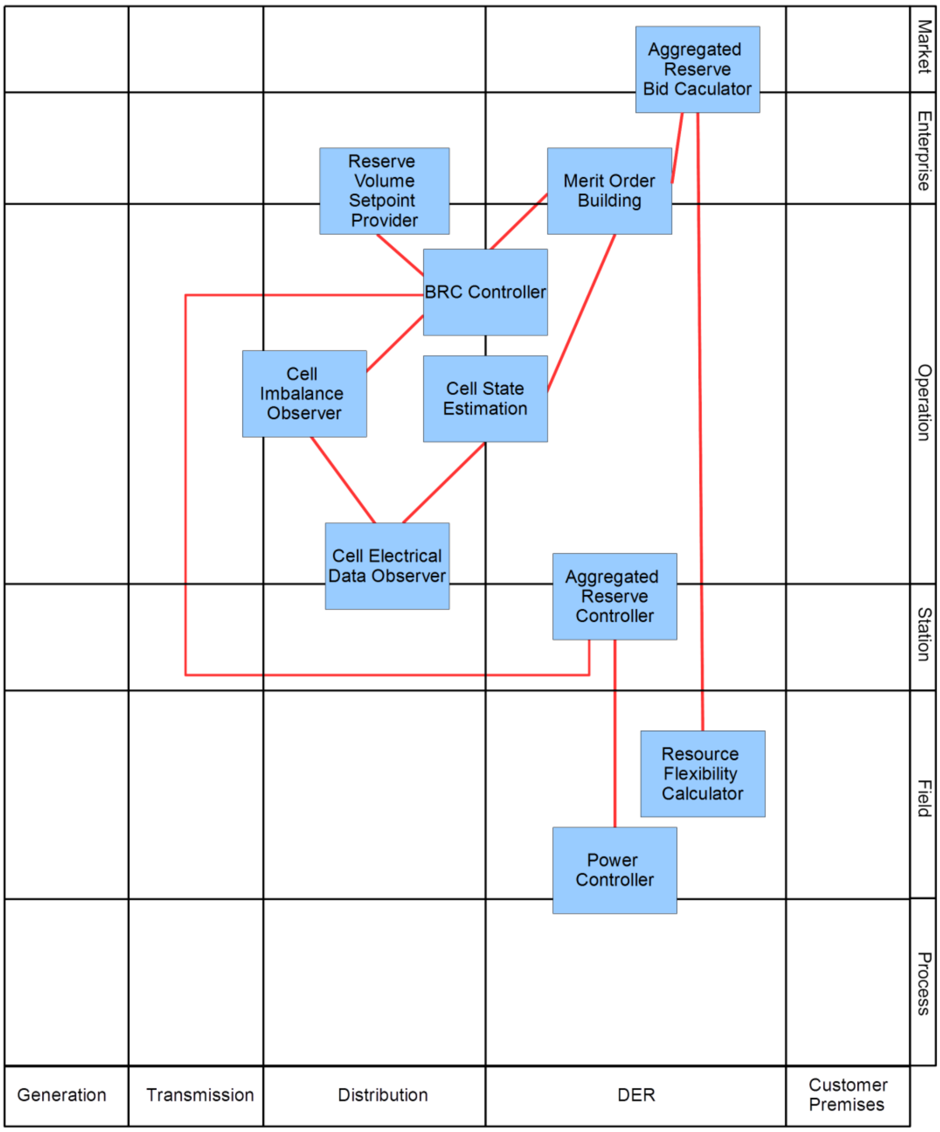


Figure 40 - Mapping of the BRC1.1 and 1.2 functions on the SGAM Function Layer

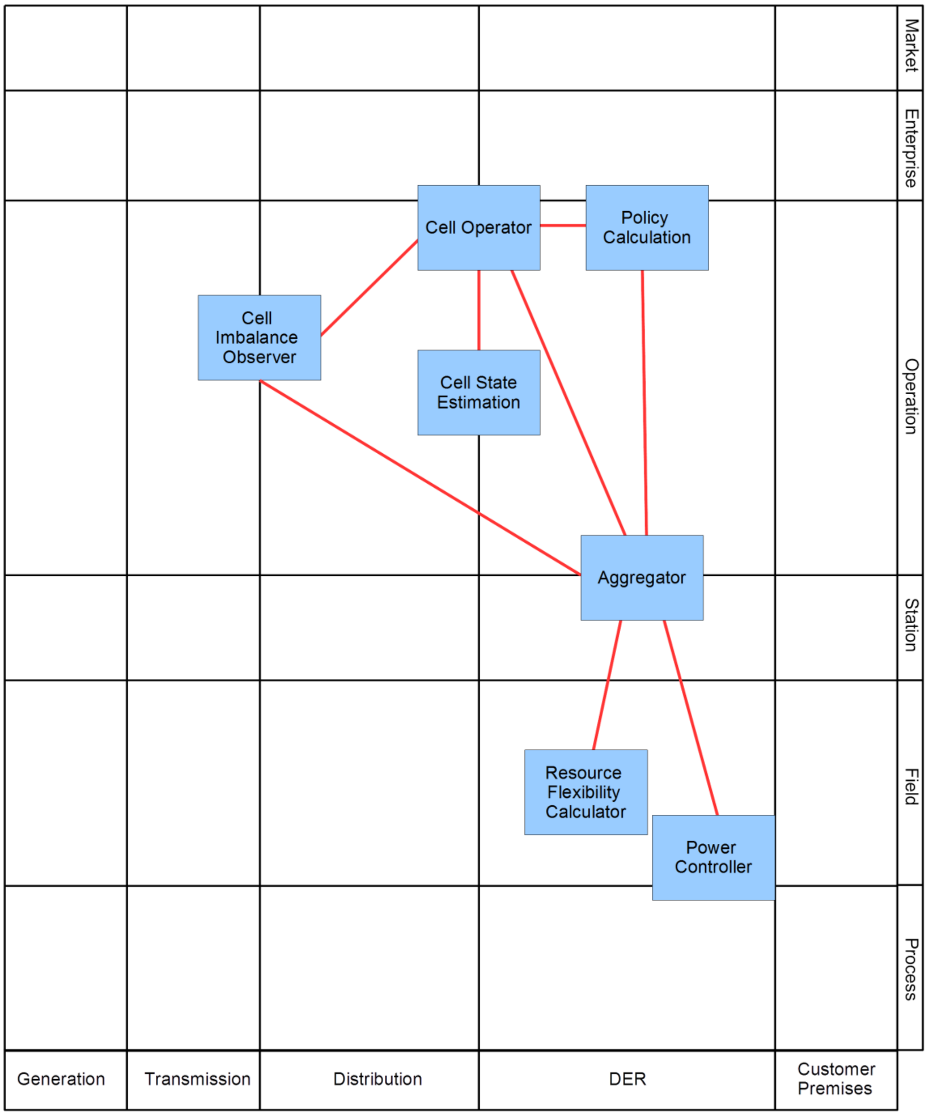


Figure 41 - Mapping of the BRC1.5 functions on the SGAM Function Layer

3.5.2.2 Component Layer

In terms of components, the possible implementation of the variants is generic allowing for different implementation options. However, the identification of standards, particularly at communication level, presumes the mapping of the use cases in terms of components, making some reasonable assumptions derived from the abovementioned associations with the use case clusters. Thus, in principle, the functions of the ADMS can be located on a SCADA system, which communicates with a GIS, the DER EMS (which represents the Aggregator's underlying function), the Application Server used as the cVPP application (BRC1.2) and the distributed infrastructure such as RTUs and IEDs used for monitoring cell power flows. With regard to the aggregation and resource functions, the exemplary component set involves power plant and DER controllers. The components' layer mapping for BRC1.1 and 1.2 in Figure 42 and for BRC1.5 is shown in Figure 43.

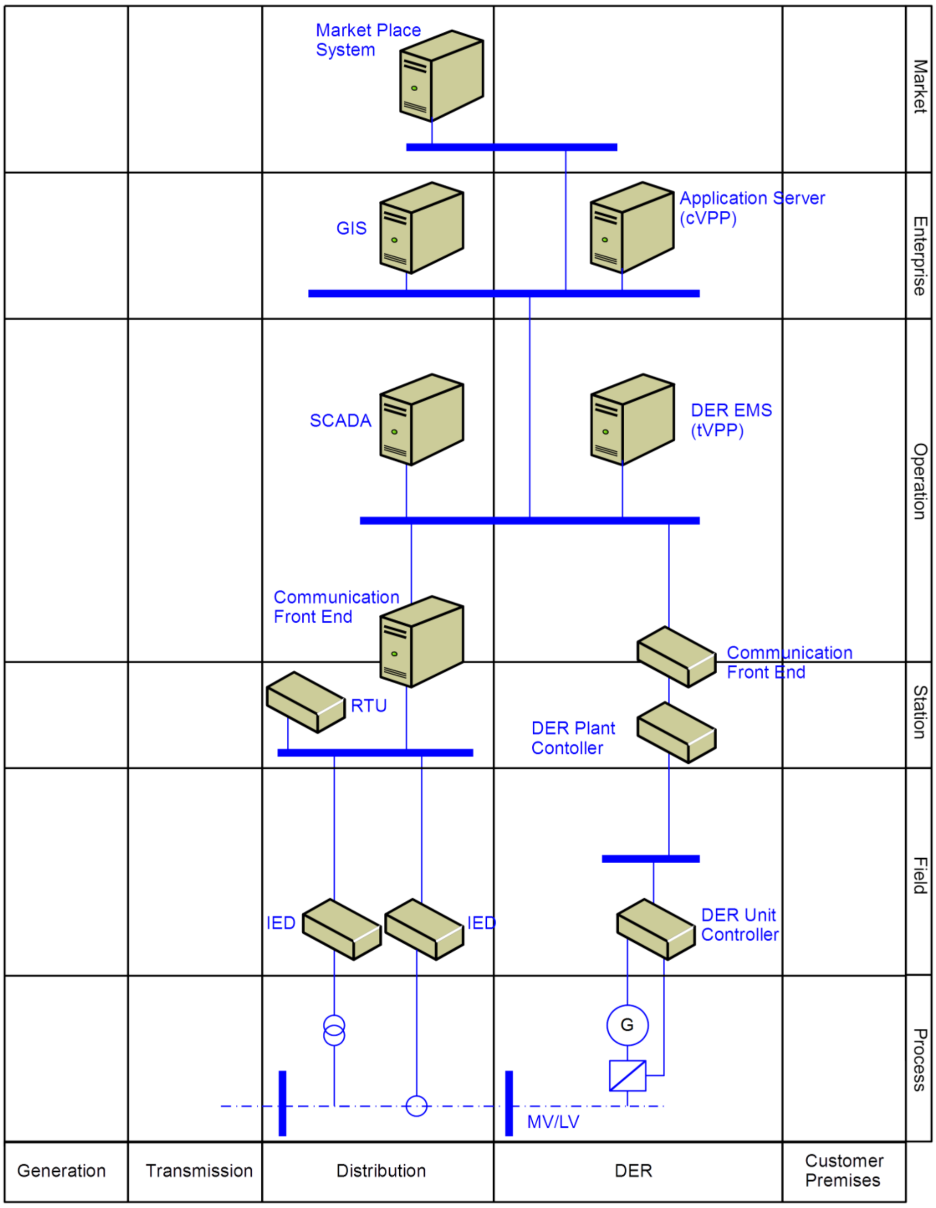


Figure 42 - Mapping of the BRC1.1 and 2 exemplary set of components on the SGAM Components Layer

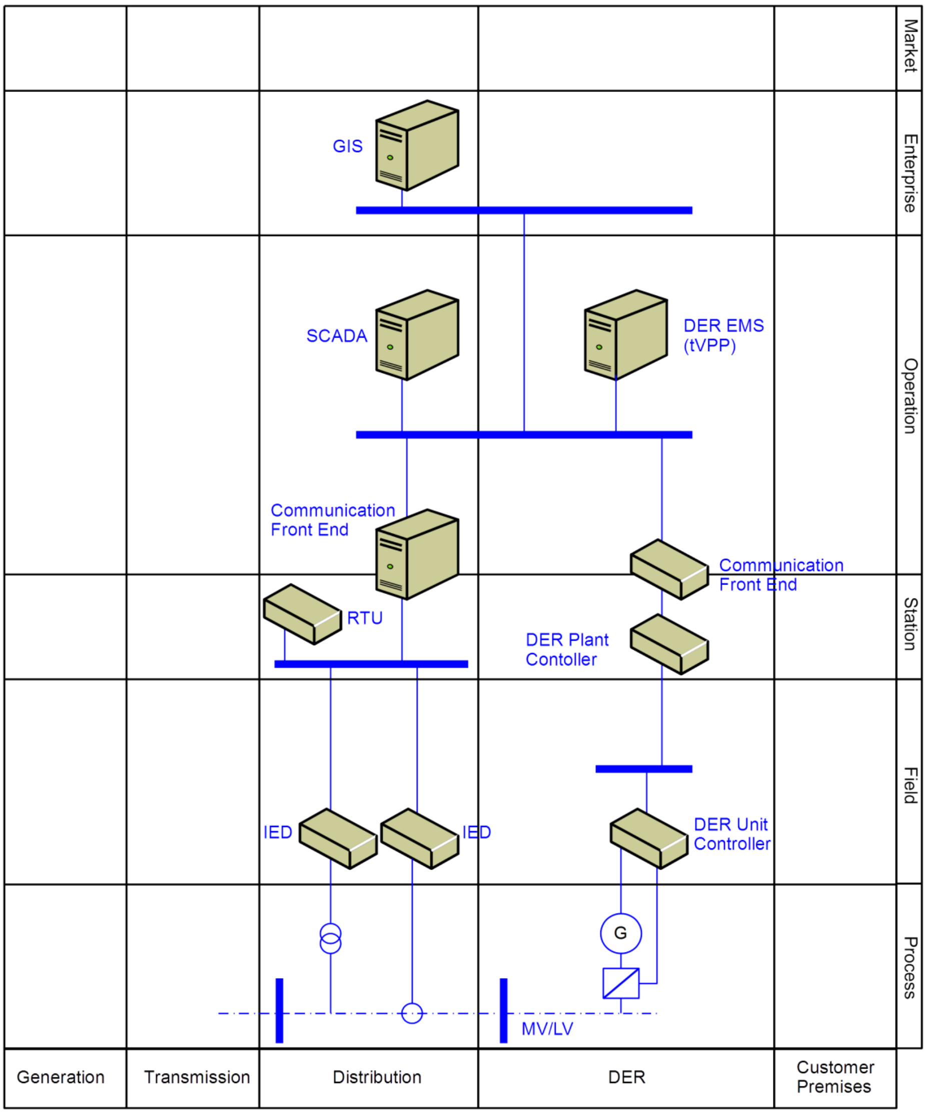


Figure 43 - Mapping of the BRC1.5 exemplary set of components on the SGAM Components Layer

Table 1 below summarizes the indicative set of components that are necessary for the deployment of both variants.

Table 14 - Overview of components used in the BRC variants

Geographic Information System (application server) (abbr. GIS)	Geographic Information System application server is a server which hosts an application designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology.	BRC1.1, BRC1.2, BRC1.5
Supervisory Control And Data Acquisition (abbr. SCADA)	Supervisory Control And Data Acquisition system provides the basic functionality for implementing EMS or DMS, especially provides the communication with the substations to monitor and control the grid	BRC1.1, BRC1.2, BRC1.5
Remote Terminal Unit (abbr. RTU)	A remote terminal unit is a microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA by transmitting telemetry data to the system, and by using messages from the supervisory control	BRC1.1, BRC1.2, BRC1.5

DER Control	Control of a DER that allows the adjustment of its active or reactive power output according to a received set point	BRC1.1, BRC1.2, BRC1.5
Communication Front End	Application or system providing communication with the substations to monitor and control the grid	BRC1.1, BRC1.2, BRC1.5
cVPP Application Server	Application Server used for the purpose of the cVPP management	BRC1.1, BRC1.2

3.5.3 Relevant Standards - Information Layer

Based on the functions and components mapping described above, some subsets of information related standards can be specified. The overview of these standards is given in Table 15 and the mapping for BRC1.1 and 1.2 on the information layer is illustrated in Figure 44 and for BRC1.5 in Figure 45 respectively. It is evident that in terms of information exchange at the higher CTLs which regard the zones of operation and enterprise, the CIM family standards, in particular IEC 61968 and 61970, applies. A more extensive set of information standards applies to the functions that relate to aggregation and resources, due to the possible use of different types of resources, each one implementing different type of standards. For instance, IEC 61850-7-410 and 420 are both valid information standards since they cover different types of resources (Hydroelectric Power Plants and DER) both of which are valid resources in the specific variant. Also, it is worth noting that apart from the standards already existing, a subset of them includes coming ones, thus extending the relevant list. Last but not least, the participation of aggregation functions in the procurement phase, particularly specified in BRC1.1. and 1.2 and implicitly in BRC1.5, necessitate the involvement of information standards in the Market and Enterprise zones, which include, as shown in Figure 45, IEC 62325, ENTSO-E Role Model, IEC 62351 and, as usual, IEC 61968 and 61970.

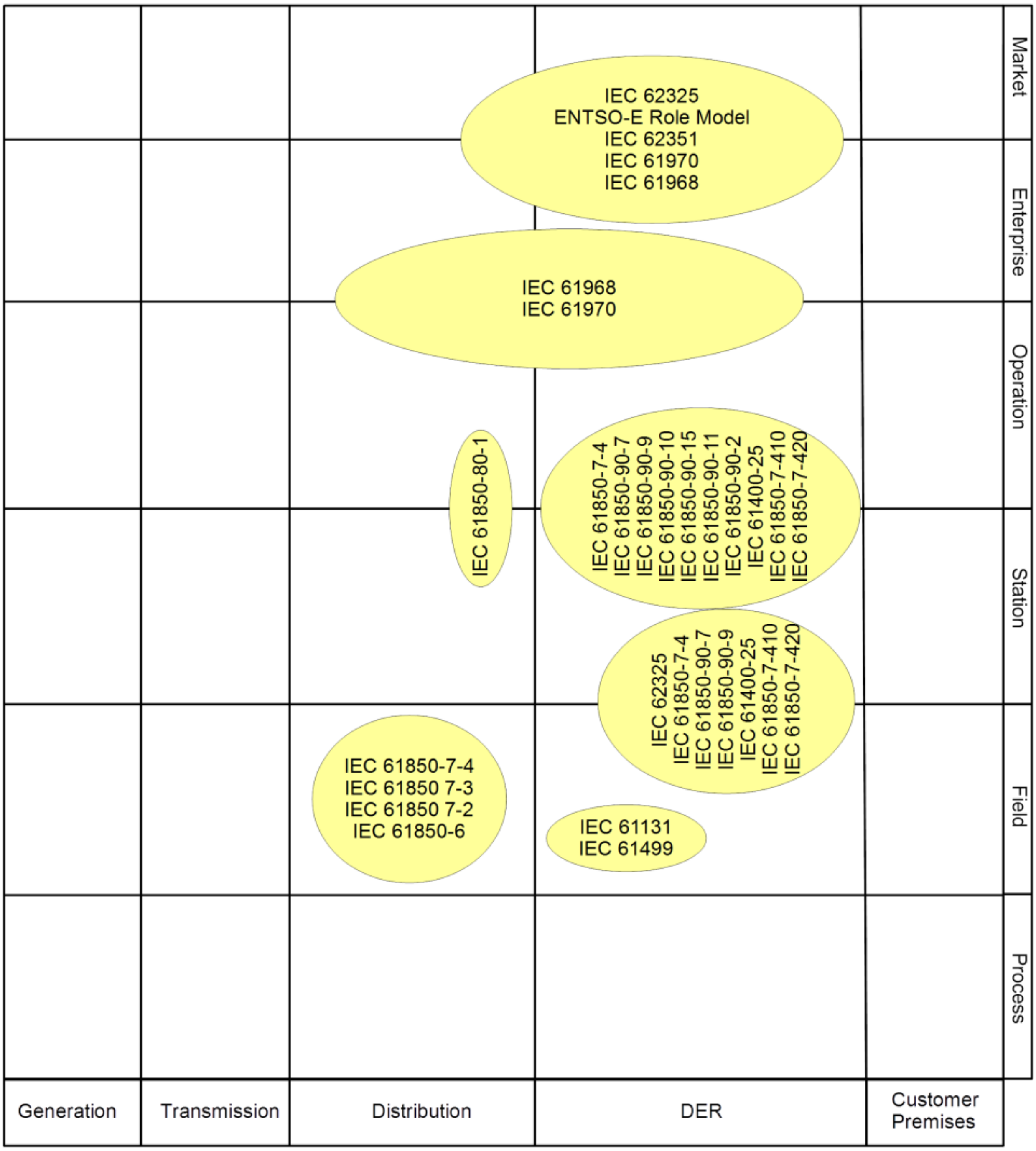


Figure 44 - Information layer and relevant standards for BRC1.1 and 1.2

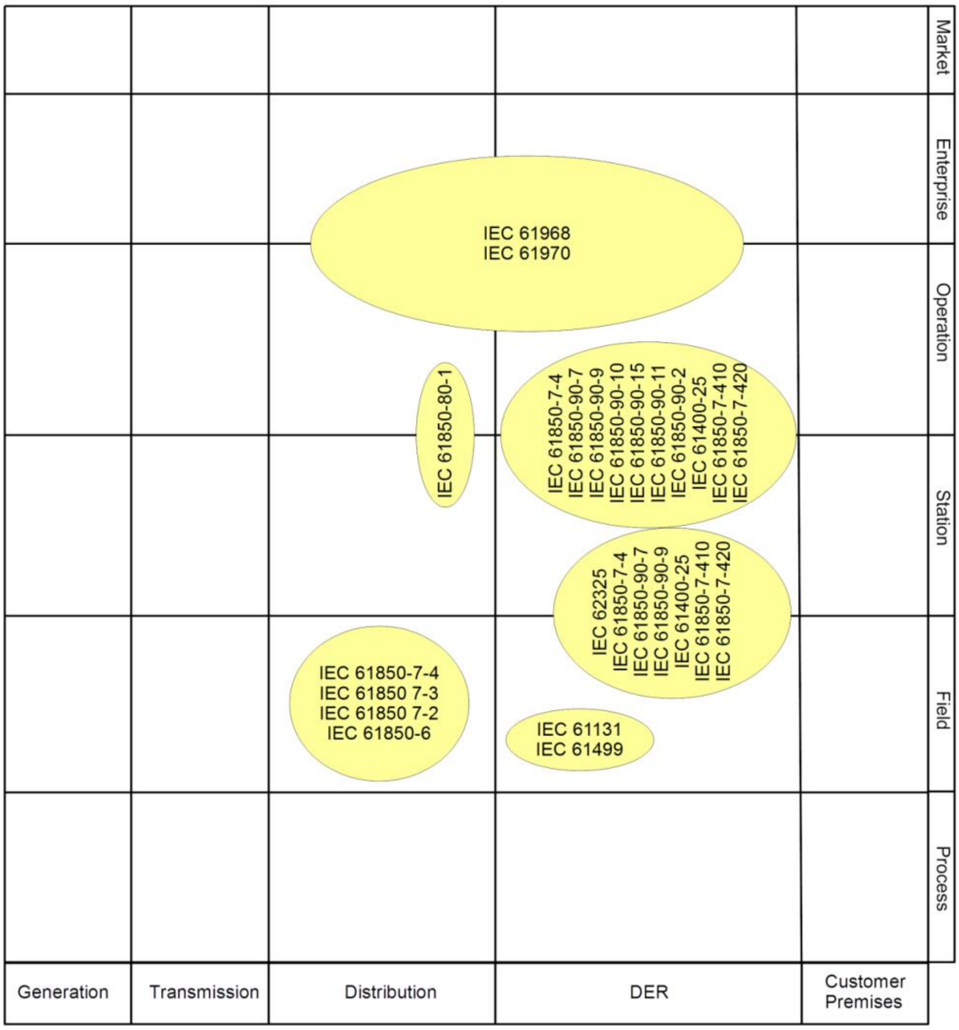


Figure 45 - Information layer and relevant standards for BRC1.5

Table 15 - Relevant Information Standards-overview

IEC 61850-7-4 **IEC 61850-7-3** **IEC 61850-7-2** **IEC 61850-6**	Core Information model and language for the IEC/EN 61850 series
EN 61400-25-1 **EN 61400-25-2** **EN 61400-25-3** **EN 61400-25-4**	Wind farms
IEC 61850-7-410	Hydroelectric power plants
IEC 61850-7-420	DER
IEC 61850-90-7	DER Inverters
IEC 61850-90-9**	Batteries
IEC 61850-90-10 **	Scheduling Functions
IEC 61850-90-11**	Methodologies for modelling of logics for IEC/EN 61850 based applications
IEC 61850-90-15**	Multiple Use of DER
IEC 61850-90-2**	Guidelines for communication to control centers

EN 61131	Programmable controllers
IEC 61499	Distributed control and automation
IEC 61850-80-1	Mapping of IEC/EN 61850 data model
IEC 61968 (all parts)	Common Information Model (System Interfaces For Distribution Management)
IEC 61970 (all parts)	Common Information Model (System Interfaces For Energy Management)
IEC 62325-450 **IEC 62325-301 **** **IEC 62325-351 **** **IEC 62325-451-1**** **IEC 62325-451-2**** **IEC 62325-451-3**** **IEC 62325-451-4**** **IEC 62325-451-5****	CIM information model (Market profiles)
IEC 62351**	Cyber-security aspects
ENTSO-E Role Model	Joint ENTSO-E, ebIX ®, EFET
****Coming standards**	

In relation to the specific pieces of information exchanged in the variant, Table 16 provides an association with the relevant list of standards shown above.

Table 16 - Association of Information Standards with Information Exchanges is BRC1.1 and 1.2

Information exchanged ID	Name of information exchanged	Description of information exchanged	Related Standards
IEX_01	Reserve Volume	Required cell reserve volume in MW	IEC 61968, IEC 61970
IEX_02	Cell Electrical Data	Individual tie-line power flows, network switch states	IEC 61968 IEC 61970 IEC 61850-7-4 IEC 61850-7-3 IEC 61850-7-2 IEC 61850-6, IEC 61850-80-1
IEX_03	Cell State	*The present* cell *network configuration*, i.e. all power flows within the cell	IEC 61968, IEC 61970
IEX_04	Device Flexibility	Flexibility vs. price curve of the device	IEC 61850-7-4, IEC 61850-90-7, IEC 61850-90-9, IEC 61400-25, IEC 61850-7-410, IEC 61850-7-420, IEC 62325 series
IEX_05	Reserve Status	Aggregated flexibility vs. price curve	IEC 61968, IEC 61970, IEC 62325 series

IEX_06	Merit Order List	A prioritised ordered list of reserves	IEC 61968, IEC 61970
IEX_07	Accept/Reject Capacity Bid	Boolean signal: 1 for “Accept”, 0 for “Reject”	IEC 61850-7-4, IEC 61850-90-7, IEC 61850-90-9, IEC 61400-25, IEC 61850-7-410, IEC 61850-7-420,
IEX_08	Cell Electrical Data	Individual tie-line power flow	IEC 61968 IEC 61970 IEC 61850-7-4 IEC 61850-7-3 IEC 61850-7-2 IEC 61850-6, IEC 61850-80-1
IEX_09	Cell Imbalance Error	Cell Imbalance	IEC 61968, IEC 61970
IEX_10	Trigger	Trigger signal (i.e. a Boolean value)	IEC 61968, IEC 61970
IEX_11	Activation Signal	Price	IEC 62325 series

Table 17 - Association of Information Standards with Information Exchanges is BRC1.5

Information exchanged ID	Name of information exchanged	Description of information exchanged	Related Standards
IE_P_01	Covariance matrix of the cell imbalance error signal	Covariance matrix is calculated from the historical imbalance signals, and this matrix will be used in the optimization.	IEC 61968 IEC 61970 (also complemented by IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2, IEC 61850-6)
IE_P_02	Grid state	Thermal capacity of lines of the cell grid.	IEC 61968, IEC 61970
IE_P_03	Flexibility information of the aggregator	Flexibility curve of the aggregator.	IEC 61850-7-4, IEC 61850-90-7, IEC 61850-90-9, IEC 61400-25, IEC 61850-7-410, IEC 61850-7-420
IE_P_04	Reserve bid information	The bid information contains the flexibility, if needed, may also contain other information, such as the location of the aggregators.	IEC 61968, IEC 61970, IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2, IEC 61850-6, IEC 62325 series
IE_P_05	IE_P_01, IE_P_04, IE_P_02	The information of IE_P_01, IE_P_02, IE_P_04 received by the cell operator will be used in the merit order building function	IEC 61968, IEC 61970,
IE_P_06	policies	Individual policy will be defined for each aggregator.	IEC 61968, IEC 61970, IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2, IEC 61850-6
IE_RT_01	Real time cell imbalance error signals	The processed cell imbalance error signal	IEC 61968, IEC 61970, IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2, IEC 61850-6, IEC 61850-80-1,
IE_RT_03	Flexibility bids	The flexibilities of flexible resources	IEC 61850-7-4, IEC 61850-90-7, IEC 61850-90-9, IEC 61400-25, IEC 61850-7-410, IEC 61850-7-420,
IE_RT_04	Bids information of all flexible resources	Bids information of all flexible resources, which will be used by the aggregator merit order building function.	IEC 62325 series, IEC 61968, IEC 61970, IEC 61850-7-4,

			IEC 61850-7-3, IEC 61850-7-2, IEC 61850-6,
IE_RT_05	Prices	Prices will be sent to all the flexible resources, thus the output power of the flexible resources can be identified.	IEC 62325 series

3.5.4 Relevant Standards-Communication Layer

Based on the components layer description the set of relevant standards for the specific variants are summarized in Table 18 and in Figure 46 and Figure 47.

Table 18 - Relevant Communication Standards-Overview

IEC 61850-8-1	IEC/EN 61850 communication except Sample values
IEC 61850-9-2	IEC/EN 61850 Sample values communication
IEC 61850-90-2 **	Guidelines for communication to control centers
IEC 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
IEC 60870-5-103	Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment
IEC 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
EN 61158, IEC 61784-1	Field bus
IEC 61850-8-2**	Web-services mapping
EN 61400-25-4	Wind farms
IEC 61968-100	Defines profiles for the communication of CIM messages using Web Services or Java Messaging System
ECAN	ENTSO-E Capacity Allocation and Nomination
ESS	ENTSO-E Scheduling System
ERRP	ENTSO-E Reserve Resource Planning
ESP	ENTSO-E Settlement Process
IEC 62325-451-1** IEC 62325-451-2** IEC 62325-451-3** IEC 62325-451-4** IEC 62325-451-5**	Acknowledgement business process and contextual model for CIM European market
**Coming standards	

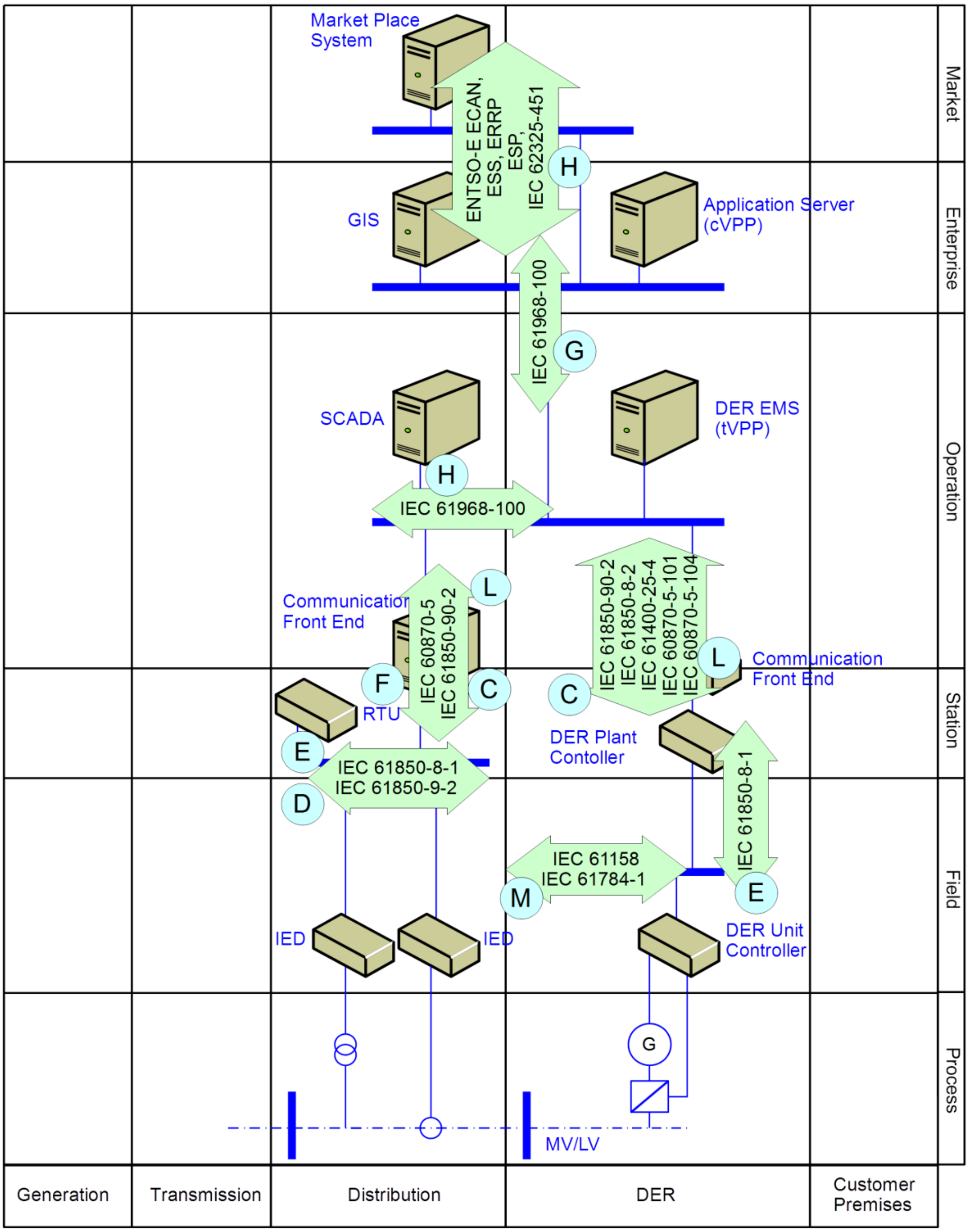


Figure 46 - Communication layer and relevant standards for BRC1.1 and 1.2

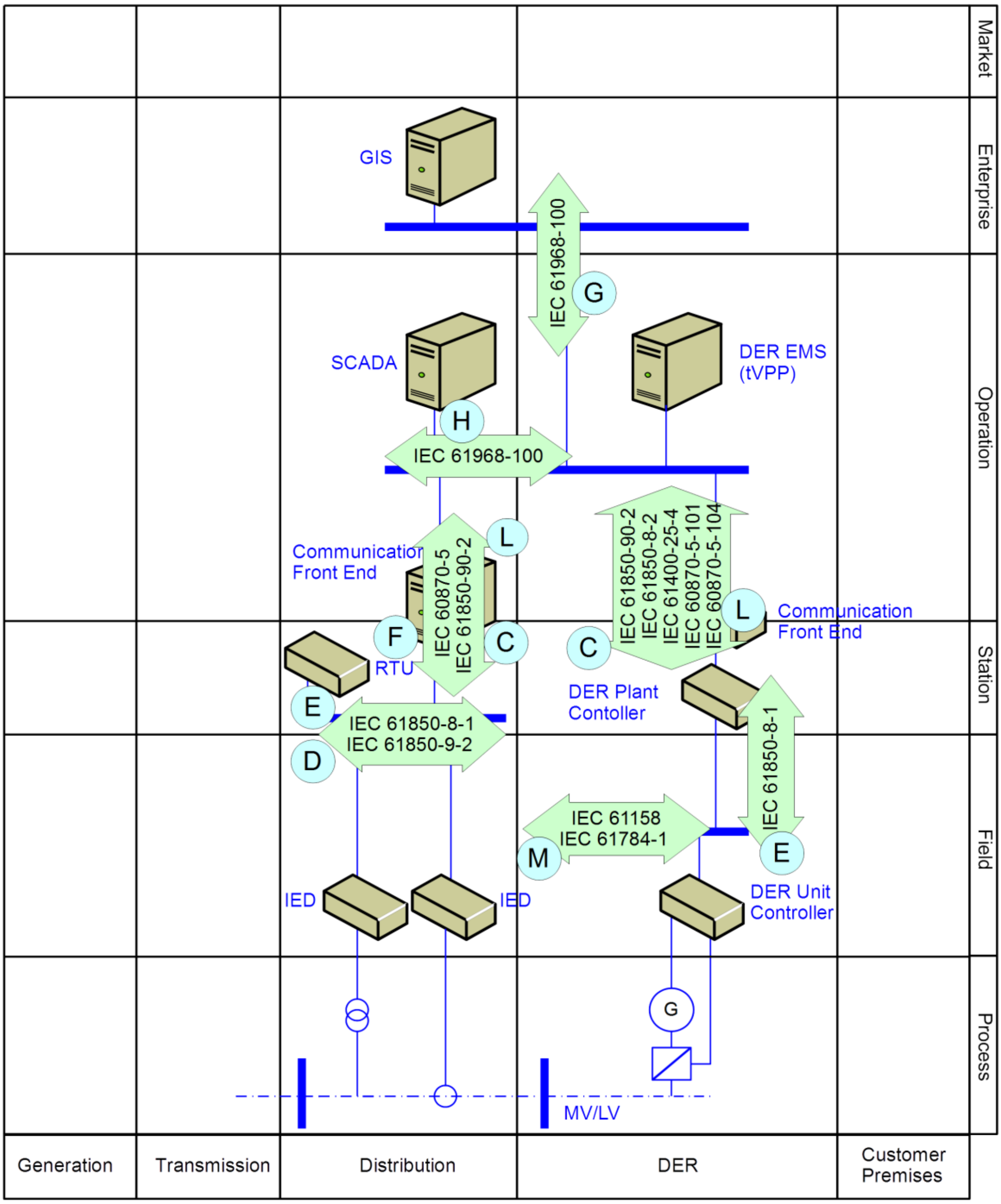


Figure 47 - Communication layer and relevant standards for BRC1.5

3.6 Standard analysis for Balance Steering Control (BSC) use cases

3.6.1 The BSC use cases

Both B4.BSC.1.3.1 and B4.BSC.1.1.1 use cases consider the “Balance Steering Control” functions in charge of a “Cell Controller” role that seem close to the classic EMS/DMS functions.

Assuming that these functions are mainly located in the SGAM “Operations” zone, even if some specific aspect (e.g. Power scheduling, Energy Market management) could also interest the “Enterprise” and “Market” zone too, it could be useful to consider the standard solution proposed for this area both by IEC [32] and SG-CG [9].

The suggested IEC system integration solution in the “Operation” zone is the CIM based IEC-61968 standard series, while the specific EMS/DMS related functions could be mapped both on IEC-61970 and IEC-61968 standard series.

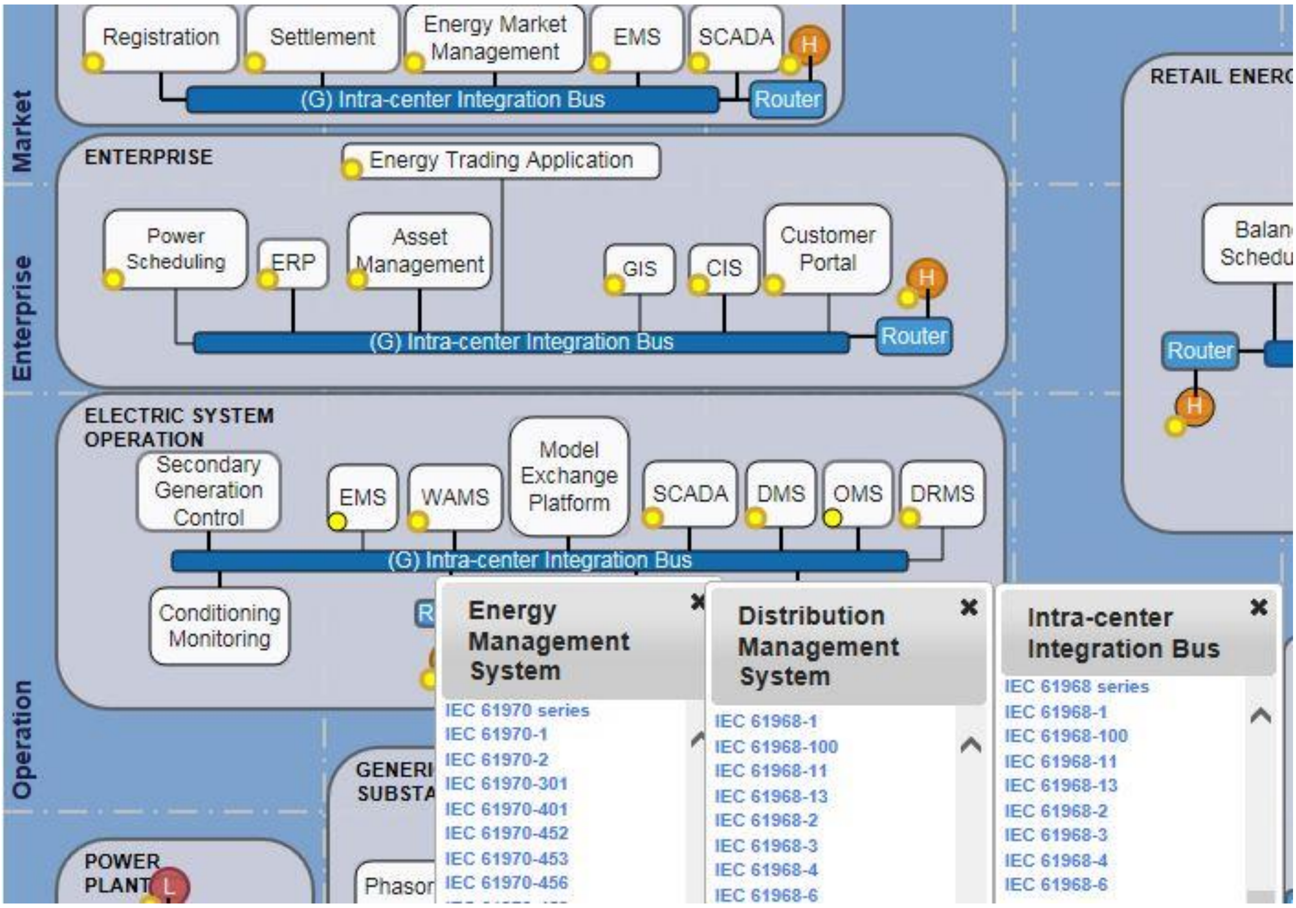


Figure 48 - Related standards in the IEC mapping

The SG-CG analysis confirms this vision identifying the IEC-61968 and IEC-61970 standard as applicable for EMS/DMS related functionalities.

3.6.2 SGAM Mapping

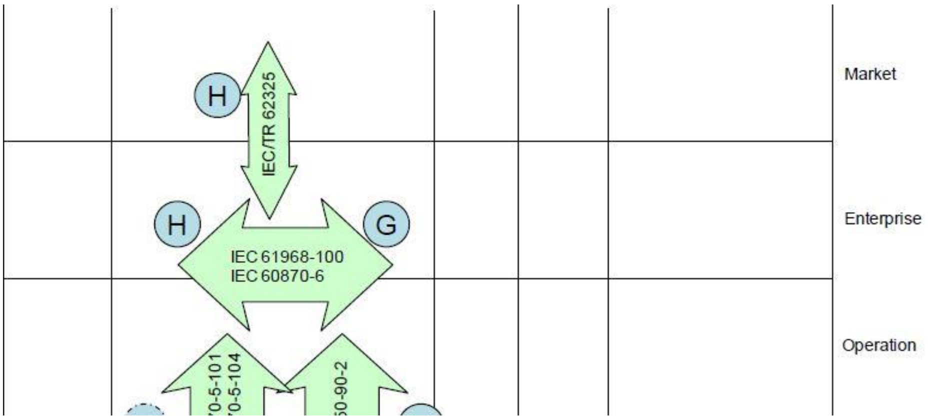


Figure 49 - SGCG EMS Communication standards

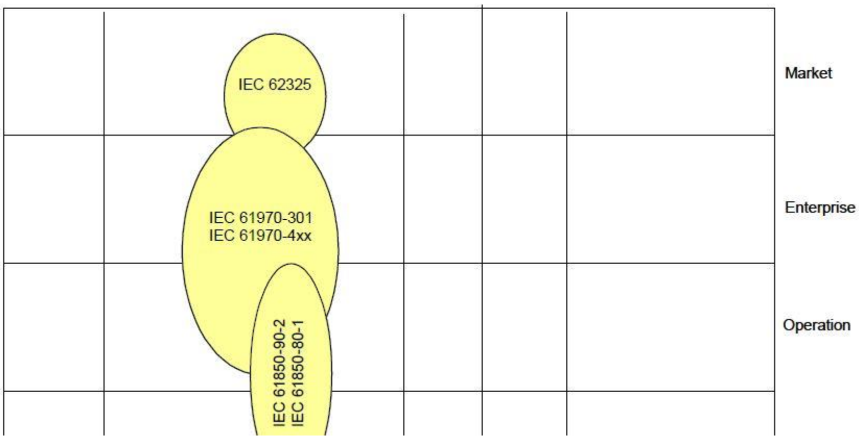


Figure 50 - SGCG EMS information layer standards

3.6.3 The standard related to Network Analysis functions

As a preamble, it could be useful to consider that in the current approach the management of an electrical system is often based on “Network Operations” and “Operational Planning” activity. The definitions of these concepts could help in order to better identify the ICT standards framework related to the generic “Network Analysis” functions and more specifically to the “State Estimation” function.

The “Operational Planning” is considered as a forecast activity that aims at anticipating and resolving constraints situations in the network that would be difficult or impossible to resolve by “Network operation” in real time situation. The timescale covered by “Operational Planning” is typically a few hours, days or even weeks.

The “Network Operations” are the functions required in order to manage the network in real time.

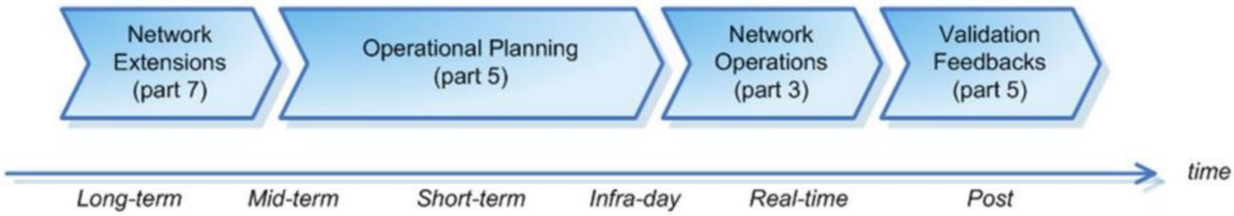


Figure 51 - The time scale covered by operational planning is, typically, a few hours, a few days or even a few weeks

In order to analyse the standards related to the “State Estimation” function used in ELECTRA use cases, it could be useful to consider how the more generic “Network Analysis” functionality are managed by the IEC 61970 standard series.

More specifically the IEC 61970-456 part reports in its introduction: “This document describes an interface standard in which XML payloads are used to transfer initial conditions and results created during typical steady-state network analysis processes (e.g. state estimation or power flow solutions)”.

This approach is synthesized in the picture below Figure 52 where the input/output interfaces of a generic “Network Analysis Function” [33], including “State Estimation”, are defined by four type of dataset (profiles):

- Equipment *(EQ)*
  - Power System Model, usually expressed as node-breaker network
- Steady State Hypothesis (SSH)
  - Define a steady state condition for the network
  - This condition could be related to the current time (for Network Operation objectives) or to a future time (for “Operational planning” purpose) (See “Other External Sources” box in the picture below)
- Topology (TP)
  - Based on switch position, it defines the bus branch model of the network model and the related islands
- State Variables (SV)
  - Contains the output of the Network Analysis (e.g. Bus voltage module and angle, P&Q of any branch (Terminal flows))

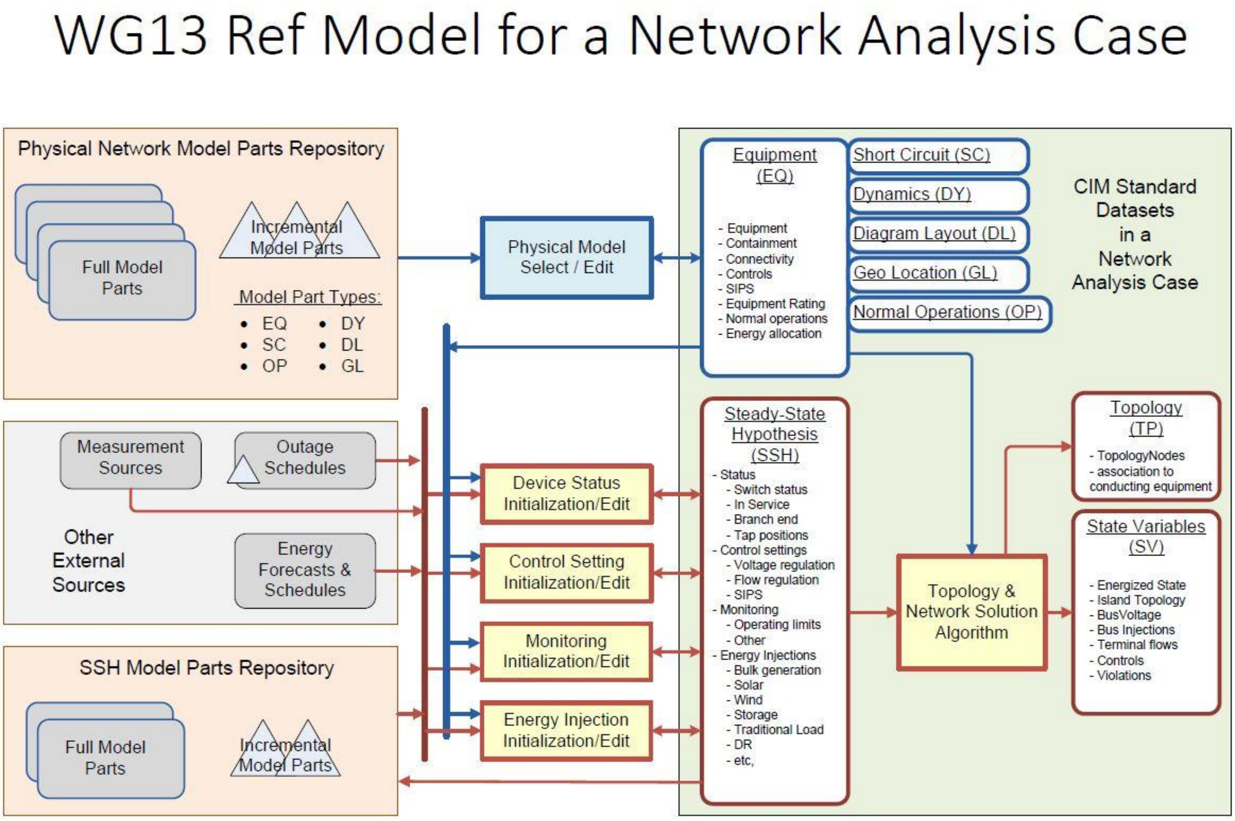


Figure 52 - Network analysis functions

The relationships between the different profiles are represented in the following figure.

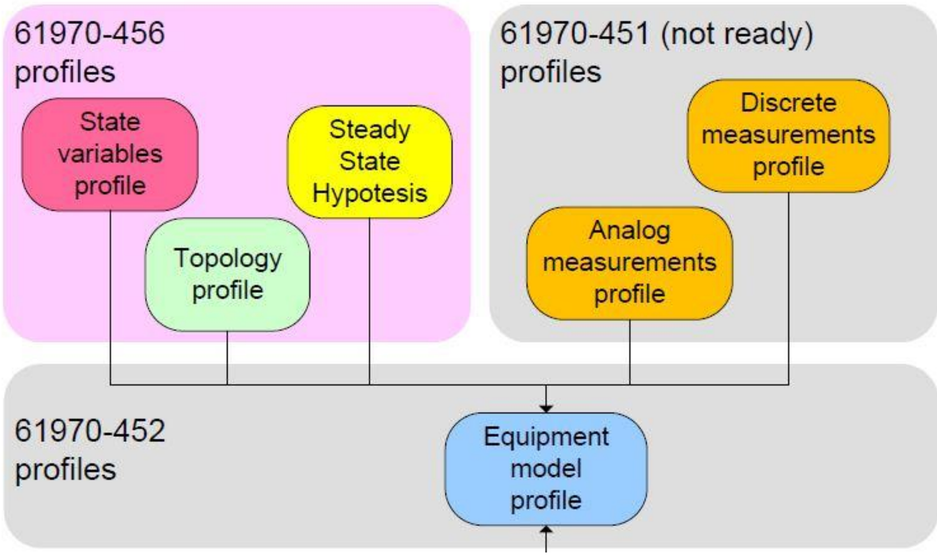


Figure 53 - Relationships among profiles

This approach is also used in order to implement the ENTSO-E “Common Grid Model” [29] that is a European network model obtained by merging TSOs Individual Grid Model (IGM). These models and related states are defined in conformity with CGMES (“Common Grid Model Exchange Standard“) that is a European standard derived from the above IEC 61970 profiles. The boundary points, representing the electrical equipment point (e.g. Terminal of a tie line) where two grids are connecting to each other, have some analogies with the connection point between two ELECTRA Cells.

Also the data requirements related to the TSO-DSO information exchange described in “Generation and Load Data Provision Methodology” (from [29] pag.83) for both “Structural” and “Variable” information and the data requirements for “transmission system operation” objective (article 4 from [34]), seems suitable to be represented by the type of information defined in IEC 61970 series standards.

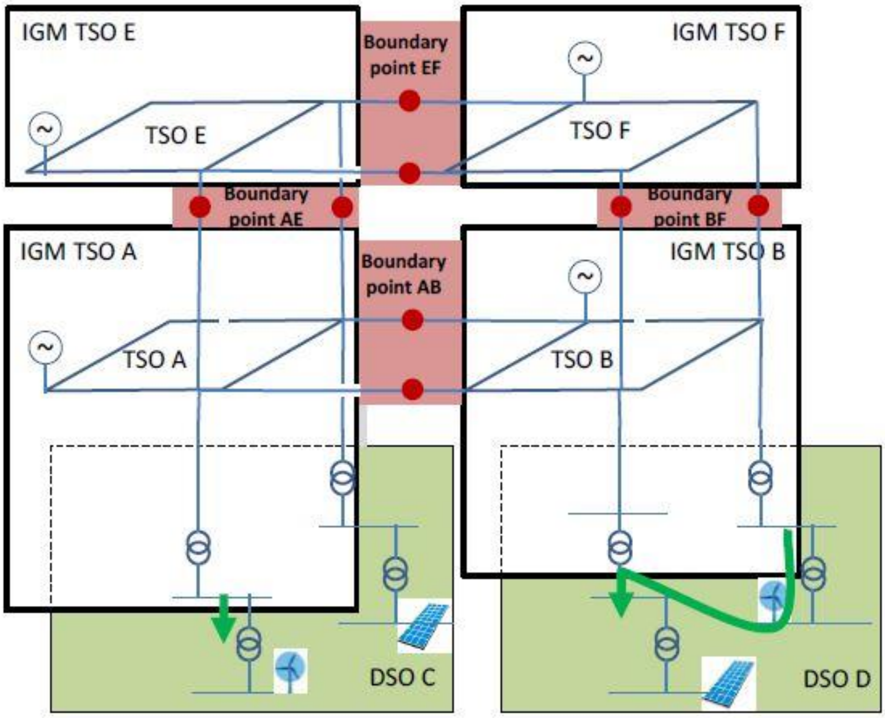


Figure 54 - The Common Grid Model (CGM) is the merging of all Individual Grid Models (IGMs) together (Stufkens, 2016)

The above described IEC 61970-456 standard part specifies the CIM information required in order to implement the payload that need to be serialized in accordance with IEC 61970-552.

The serialized XML payload could be then transported by an IEC 61968-100 standard compliant solution for systems integration, based on Web Services[9].

Considering the future proof perspective of Electra, it could also be useful to consider some newer system integration technology, like AMQP protocol[10], as alternative to Web Services solutions.

3.6.4 Relevant Standards - Information Layer

In the table below is reported a standards selection related to the information exchange of the B4.BSC.1.3.1 use case, considering the “State Estimation” standards previously described.

[9] This solution is currently used by ENTSO-E members in order to exchange information related to “Electricity Market Transparency”. See “140909 Data provider workshop - TOP 4 ECP-WS DP Presentation.pdf” extracted from https://www.entsoe.eu/Documents/MC%20documents/Transparency%20Platform/Information_for_Data_Providers/140909_ENTSOE_Second_Transparency_Workshop_for_Data_Providers_Presentations.zip and https://transparency.entsoe.eu/

[10] This system integration option is currently under consideration by ENTSO-E for future OPDE (“Operational Planning Data Environment”)

Considering that the B4.BSC.1.1.1 use case contains a subset of the information exchanges related to B4.BSC.1.3.1 use case, the below standard mapping is also valid for the B4.BSC.1.1.1 use case.

The use case description doesn't include the information exchange between any of the actors considered in the use case and field devices in order to collect measurements/state or to send Setpoints.

Consequently the analysis is based on the hypothesis that the actors/functions will exchange State/Measurements information linked to network topology element (e.g. Active Power related to a tie line terminal, Voltage on a Busbar, ...) that are already in their disposal.

Table 19 - Information exchanged extracted from B4.BSC.1.3.1

Information Exchanged			
Information exchanged ID	**Name of information exchanged**	**Description of information exchanged**	**STANDARDS**
IEX_01	Request command	Request command containing the requested parameters values	
IEX_02	Steady-State Hypothesis parameters	Vector containing the following tie line parameters applicable to this variant: Switch status, control settings (active power/voltage RMS), operating limits (active power/voltage RMS), energy injection (imported/exported average active power within the time window).	(Input of Cell State Estimation) IEC 61970-456 - SSH Profile
IEX_03	Cell State variables	Vector containing the following state variables associated with the tie lines: Energized state (of tie line), bus (to which tie lines are connected) voltages (amplitude/phase), bus (to which tie lines are connected) injections (amplitude/phase), violations of operating limits.	(Output of Cell State Estimation) IEC 61970-456 - Topology + State Variable Profile
IEX_04	Active power	Vector containing separately aggregated active powers of production and consumption	(Input of forecasted Cell State Estimation) Considering what reported above "*Power flow solution algorithms and outputs are virtually the same whether run* ***in operations or planning contexts",*** the "Cell Imbalance Observer" function seems similar to State Estimation with the variant that the input doesn't come only from field measurement, but are integrated with forecasting function related to operational planning purpose. If this is the case, this information could be a subset (e.g. only Active Power linked to a specific

			network topology point, ...) of IEC 61970-456 - SSH Profile.
IEX_05	Imbalance value	Vector containing the expected imbalance as well as production/consumption within the next time window in the form of active power	(Output of forecasted Cell State Estimation) Considering what reported in the previous row, these information could be mapped on IEC 61970-456 TP + SV
IEX_06	Tie-lines set-point	Vector containing the new tie-lines set-points in the form of active power	If the setpoints are to be communicate to a function that will do calculation linking them to a network topology, the information could be exchanged by IEC 61970-456 State Variable (SV) If this information have more “operative” objective, it could also be evaluated the IEC 60870-6 TASE.2, also known as Inter-Control Centre Communications Protocol (ICCP)
IEX_07	Tie-lines/balance constraints	Vector containing the assessment of constraints based on the new tie-lines set-points	IEC 61970-456 State Variable
IEX_08	Tie-lines set-point adjustment	Vector containing the final tie-lines set-points as active power	See IEX_06

In order to use IEC 61970-456 part, it’s also necessary to use IEC 61970-452 in order to specify the grid model by the “Equipment” profile.

All the information exchanges should be transported by IEC 61968-100 compliant solution.

3.7 Standard analysis for Primary Voltage Control (PVC) and Post Primary Voltage Control (PPVC) use cases

3.7.1 The PVC and PPVC use cases

Basing on the use case (UC) descriptions introduced in the deliverable D4.2 [31], it is necessary to determine the most possible component (engineering) arrangement in order to proceed to the SGAM Component Layer diagram and in the next steps to the SGGAM Function and Communication Layers diagrams [7].

Detailed use case descriptions of the Primary Voltage Control (PVC) and the Post-Primary Voltage Control (PPVC) are included in the D4.2 deliverable. Considering the SGAM Function Layer one can see that both voltage control schemes proposed by ELECTRA Project for the WoC concept are described by two sequence diagrams – see Figure 55 for PVC and Figure 56 for PPVC.

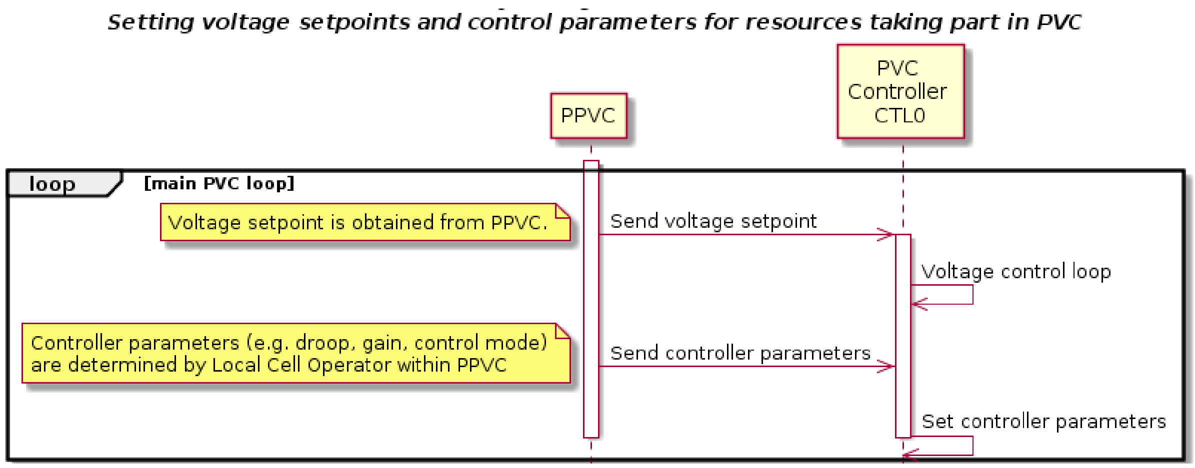


Figure 55 - The sequence diagram of the PVC (see D4.2 (ELECTRA IRP, 2016))

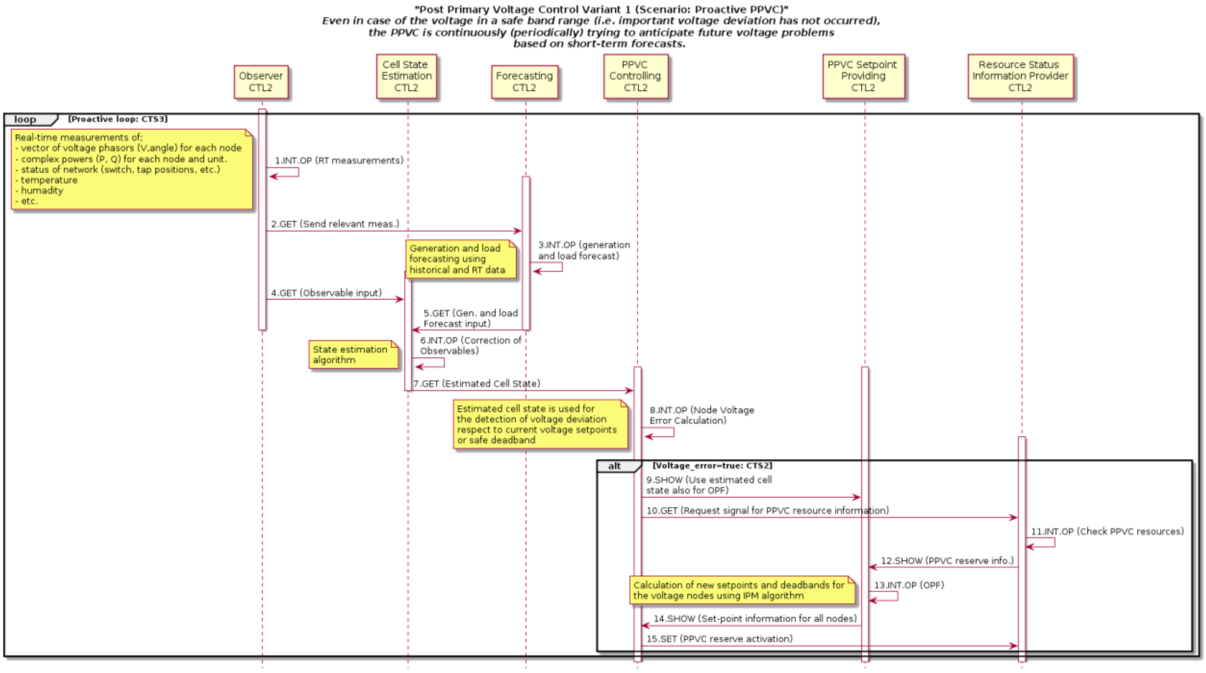


Figure 56 - The sequence diagram of the PPVC (see D4.2 [31])

3.7.2 SGAM Mapping

3.7.2.1 Function layer

Basing on these two sequence diagrams one can locate PVC and PPVC actors on the SGAM Function Layer as it is shown in Figure 57.

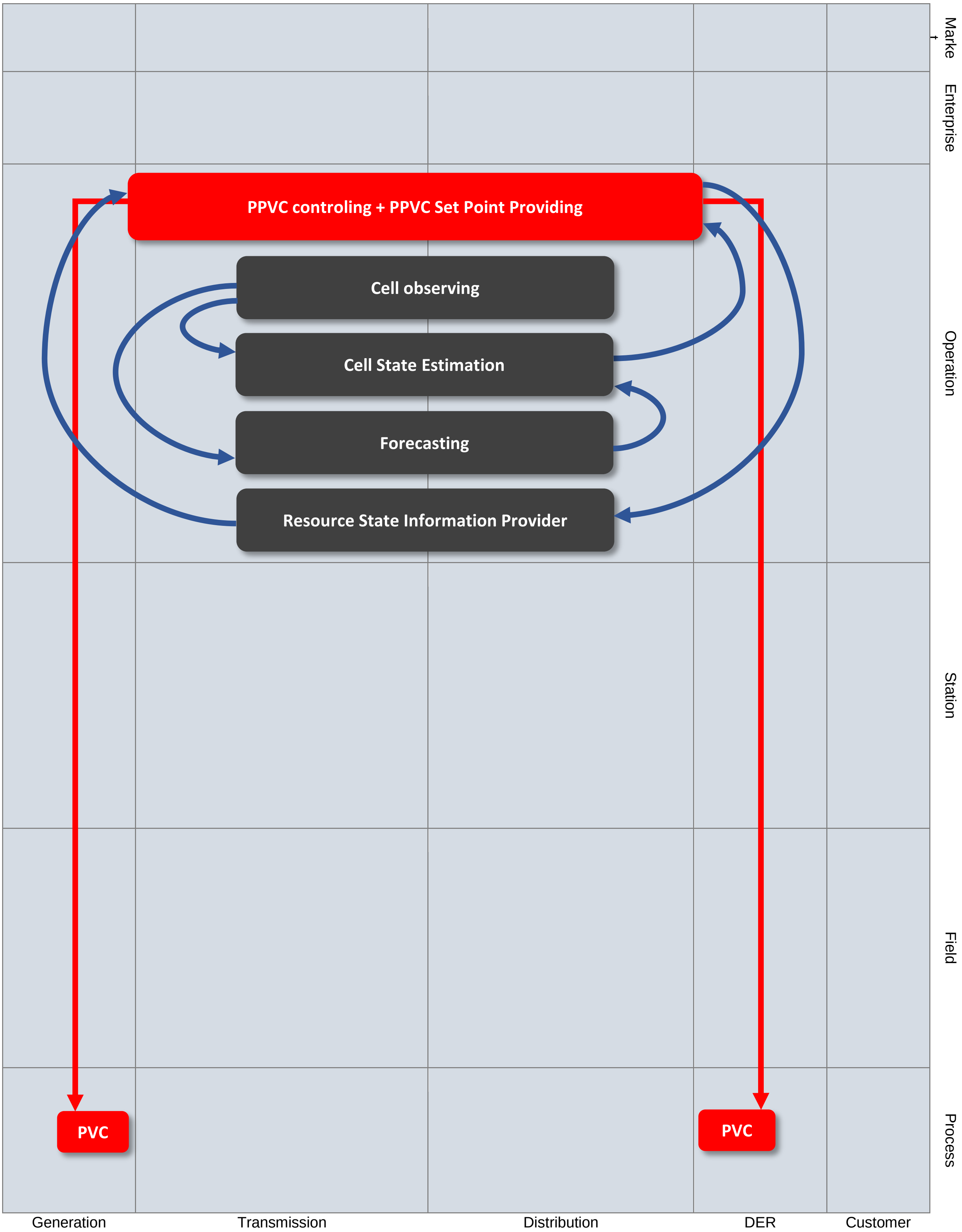


Figure 57 - PVC and proactive PPVC use cases - assignment of actors to SGAM coordinates on the Function Layer

All lines shown in Figure 57 represent streams of information (data) objects which are defined by both sequence diagrams (see Figure 55 and Figure 56).

The blue arcs represent data streams which are necessary to determine the cell state estimator – this is the Operation zone and the Transmission and Distribution domains (the definition of the cell is so general that both transmission distribution networks fragments can be potentially simultaneously covered by the hypothetical cell area).

The red arcs represent streams of data objects sent between the centrally located PPVC (Operation zone) and the PVCs which are located directly with generation sources (Process zone).

3.7.2.2 Component layer

Now, looking at Figure 57, one can imagine the possible and perhaps the most probable solution of the SGAM Component Layer for both PVC and PPVC. The result of this consideration can be shown also on the SGAM plane using the same coordinates – see Figure 58.

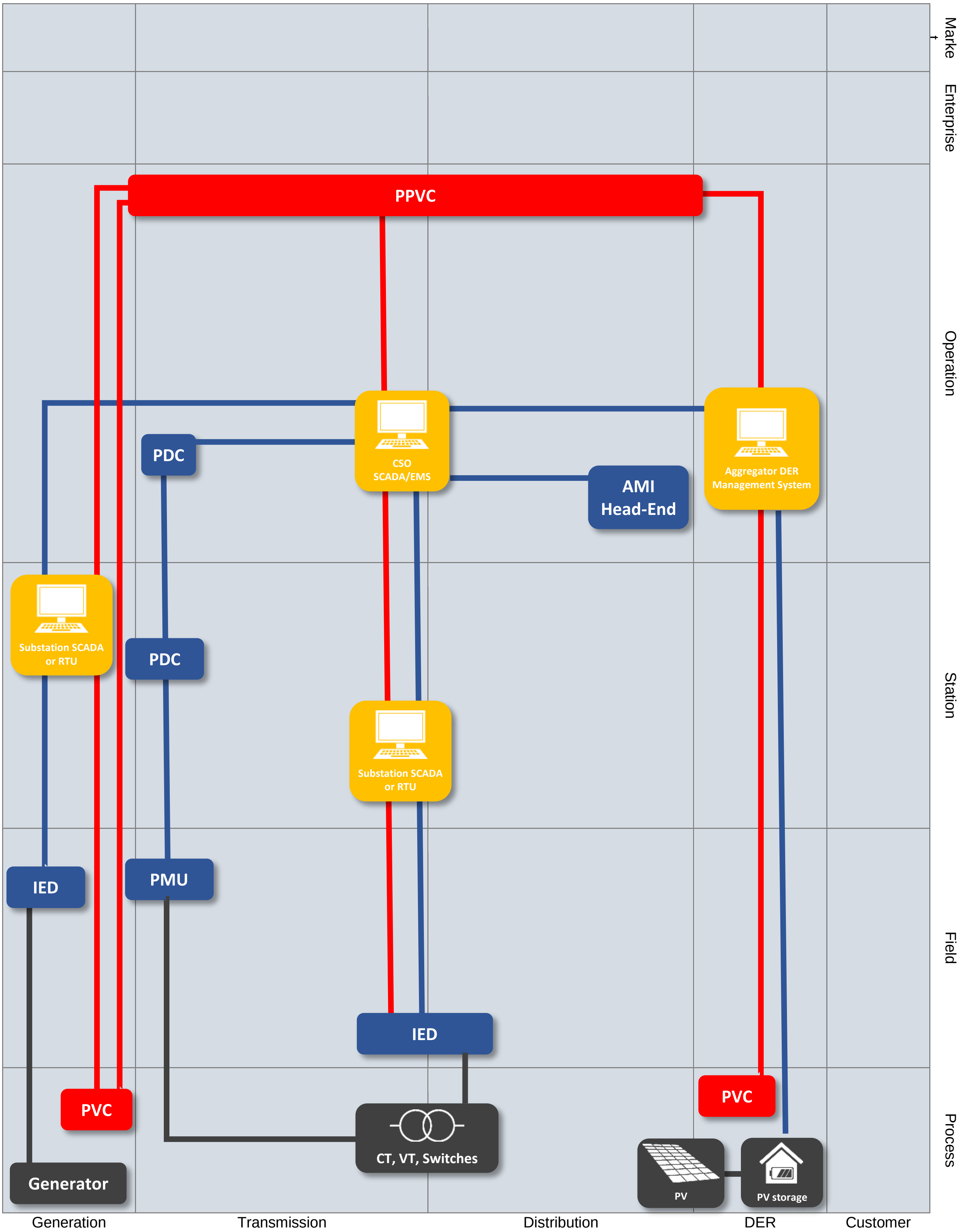


Figure 58 - SGAM Component Layer for PVC and proactive PPVC use cases - assignment of components to SGAM coordinates at the possible SGAM Component Layer

The black lines in Figure 58 represent electrical connections, the red lines (as in Figure 57) represent streams of data objects sent to perform voltage control by PPVC (Operation zone), by PVCs (Process zone) and by reactive power control devices located within the cell (e.g. substation SCADAs can perform this task). Finally, blue lines represent data streams which are necessary to determine the cell state estimator and the resources status.

We assume that:

1. To perform his duties the Cell System Operator (CSO) is equipped with a SCADA/EMS system. The following UC actors (shown in Figure 57) can be considered as particular CSO SCADA/EMS functions:
    - Observer (Cell Observing) – SCADA,
    - Forecasting (relevant only for proactive PPVC) – SCADA,
    - Resource State Information Provider – SCADA,
    - Cell State Estimation – EMS.

   The CSO SCADA/EMS system is located in the area defined by Transmission/Distribution domains and Operation zone since in general the CSO has to control both transmission and distribution network covered by a given cell.
2. DERs are supervised by Aggregator DER Management System (DER EMS) that is located in the area of DER domain and Operation zone.
3. Big (bulk) generation objects (i.e. power plants) including big wind farms with their substations connecting them to the grid are located in the area of Generation domain.
4. The CSO SCADA/EMS has to work on data (i.e. on information objects) received in real-time form all remote cell components like:
    - Substation SCADAs (which receive data from IEDs located in the area of substation busbars of Field zone) or substation RTUs both located in the area of Generation/Transmission/Distribution domains and Station zone.
    - Aggregator DER Management System (DER EMS) gathering data from DERs – it is located in the area of DER domain and Operation zone.
    - WAMS (Wide Area Measurement Systems) based on PMUs (Phasor Measurement Unit) and PDCs (Phasor Data Concentrators) - PMUs and substation PDCs are located in the area of Generation/Transmission domains and Field/Station zones. The central PDC is located close to the CSO SCADA/EMS.
    - AMI (Advanced Metering Infrastructure) that is a source of LV network data (e.g. quasi-real-time voltages within the LV distribution network). The AMI data can be obtained directly from AMI Head-End system located in the area of Distribution domain and Operation zone.
5. PVC equipment is integrated with generation equipment so it is located in the area of Generation or DER domains and Process zone.
6. PPVC is a central controller located similarly as the CSO SCADA/EMS in the area of Operation zone and additionally covering Generation and DER zones. The PPVC sends data to PVCs either directly or through substation SCADA (as in the case of wind farms) or through DER Aggregator. It is also a controller for reactive power control devices located within the cell, in particular in substations.

To recapitulate Table 20 contains definitions of the components and functions mapped on them.

Table 20 - Definitions of the components and functions mapped on them

Component	Definition	Mapped functions
CSO SCADA/EMSr	The SCADA/EMS system that belongs to the Cell System Operator (CSO) of a given cell.	- Observer (Cell Observing) – SCADA, - Forecasting (relevant only for proactive PPVC) – SCADA, - Resource State Information Provider – SCADA, - Cell State Estimation – EMS.
PPVC	Post-Primary Voltage Controller	- PPVC Controlling - PPVC Setpoint Providing
PVC	Primary Voltage Controller	PVC
Substation SCADA	The SCADA system installed at a substation	- A source of data for the Observer function. - Resends signals from PPVC Controlling to PVCs - Resends control signals from CSO SCADA/EMS to reactive power control devices located at substations
RTU	Remote Terminal Unit plays the role of the remote terminal unit of a substation	A source of data for the Observer function
IED	Intelligent Electronic Device is a digital controller controllers of power system equipment, such as circuit breakers, transformers, capacitor banks at substations	A source of data for the Observer function
AMI Head-End	The system that receives the stream of meter data brought back to the utility through the remote electric meters which belong to the Advanced Metering Infrastructure.	A source of data for the Observer function
Aggregator DER Management System (DER EMS)	The system that performs monitoring and control of a given group of Distributed Energy Resources (DERs). Usually it is located between the control center and a group of DERs.	- A source of data for the Observer function - Resends signals from PPVC Controlling to PVCs
PMU	Phasor Measurement Unit is a digital device that transforms voltage and current waveforms into voltage and current phasors. It also measures the frequency and the rate of change of frequency.	A source of data for the Observer function
PDC	Phasor Data Concentrator concentrates flows of phasor data frames received from PMUs or other PDCs.	A source of data for the Observer function
Generator	The source of bulk generation in the electric power system (e.g. at power plants, big wind farms, etc.)	Electric power generation
CT, VT, Switches	Electric power equipment like current transformers, voltage transformers, switching devices like circuit breakers	Electric power equipment
PV and Storage	The equipment that represents elements of typical DER installation - the energy converter (e.g. PV, wind generator), energy storage and AC/AC converter	DER equipment

Comparing Figure 57 and Figure 58 one can notice that the relevant problem of gathering and collecting remote real-time data to be used by the CSO SCADA/EMS needs some additional components (with blue interfaces) shown in Figure 58. The respective actors are not present in Figure 57 since it is assumed that all necessary real-time data are available for Observer (Cell Observing), Forecasting, Resource State Information Provider and Cell State Estimation actors. But in practice for all “blue interfaces” shown in Figure 58 standards are needed both for transmitted data models (SGAM Information Layer) and for communication protocols (SGAM Communication Layer).

3.7.3 Relevant Standards - Information and Communication Layer

Basing on the use case (UC) descriptions introduced in the deliverable D4.2 [31], it is necessary to determine the most possible component (engineering) arrangement in order to proceed to the SGAM Component Layer diagram and in the next steps to the SGAM Function and Communication Layers diagrams [7].

One can assume that there are *n* PVC controllers in a given cell. They are distributed in the cell with respect to the location of the central Post Primary Voltage Controller of the cell. In general each PVC is distant with respect to the central PPVC. Thus, a data communication solution has to be employed in each particular case.

Looking at the PVC sequence diagram (Figure 55) one can see that each PVC receives from PPVC the following signals:

- The voltage setpoint (IEX_01);
- The set of PVC parameters (IEX_02) which are not precisely defined in the deliverable D4.2 since there is a broad range of possible PVCs coupled with different sources of generation (bulk synchronous generation, wind farms, PV DERs etc.).

Considering the defined set of information objects (i.e. IEX_01 and IEX_02) it seems that to solve the data communication problem it would be possible to apply IEC 60870-5-104 standard ("Telecontrol equipment and systems. Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles"). To implement IEC 60870-5-104 standard the TCP/IP protocol stack is recommended. Therefore, this standard can be applied for both wired and wireless communications media. The standard covers both Information and Communication SGAM Layers since it defines both information objects and application OSI layer protocol for the transmission of these objects.

Looking at the assumed SGAM Component Layer diagram shown in Figure 57, one can assume that PPVC central controller can be located at the CSO premises together with the CSO SCADA/EMS. On the other hand, the Aggregator DER Management System (DER EMS) can be located not necessarily at the CSO premises – in general the SCADA system that represents the Aggregator can be located somewhere within the considered cell, say in one of substations which belong to the cell.

Both components the CSO SCADA/EMS and the Aggregator have to work on data (i.e. on information objects) received in real-time form all remote cell objects like substation busbars, DER controllers, etc. Thus, the real-time data sources will be substation SCADAs or RTU systems, substation IED devices, substation PMU (Phasor Measurement Units) or PDC (Phasor Data Concentrators) devices, DER remote controllers, AMI Head-End systems.

Therefore, the whole set of information objects which are incoming to the CSO SCADA/EMS component are represented by the following information objects represented in the considered PPVC sequence diagram (see Figure 56) by:

- The **1. INT.OP (IEX_01)** coupled with the Observer actor – real time electrical (V, I, P, Q, f, df/dt, tap changer positions, switching element positions) and non-electrical (temperature, humidity, etc.) measurements from subst. SCADA/RTUs, IEDs, PMU/PDCs, AMI Head-End systems, DER controllers, neighboring CSO SCADA/EMS, including both analog and digital data,

- The **3. INT.OP (IEX_03)** information objects coupled with Forecasting actor will contain real time measurements (that are included in IEX_01) and also historical data stored in the local CSO SCADA/EMS system,
- the **11. INT.OP (IEX_09)** information objects coupled with Resource Status Information Provider actor (PPVC reserves – Q, their availability and location of the resource).

Moreover, the real time measurements from distributed DERs gathered by the Aggregator component have to be delivered form the Aggregator to the CSO SCADA/EMS (see Figure 58).

Therefore, one can notice that the data communication solutions are needed to get all required real-time data by the CSO SCADA/EMS cell component from different remote locations (where other components are present):

- Substation SCADA/RTUs,
- Substation IEDs,
- Substation PMU/PDCs,
- AMI Head-End system concentrating data from AMI meters and AMI data concentrators (LV and MV distribution network area),
- Aggregator DER Management System (s),

To perform the required information object transmission the following standards could be used:

A1. **IEC 60870-5-104 "**Telecontrol equipment and systems. Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles" [35] (the standard is suitable for both Information and Communication SGAM Layers) to get real-time data from:

- Substation SCADA/RTUs,
- Aggregator DER Management System (DER EMS),
- DERs;

A2. **IEC TR 61850-90-2 Ed1**. "Communication Networks and systems for power utility automation – Part 90-2: Using IEC 61850 for communication between substations and control centres" [36] – this technical report can be used to determine the substitute IEC 61850 solution (with respect to IEC 60870-5-104) suitable for both Information and Communication SGAM Layers) to get real-time data from:

- Substation SCADA/RTUs,
- Aggregator DER Management System (DER EMS).

B1. **IEC 61850-7-2 Ed2.** "Communication Networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract Communication service interface (ACSI)" [37] (the standard is suitable for Information SGAM Layer);

B2. **IEC 61850-7-3 Ed2.** "Communication Networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes" [38] (the standard is suitable for Information SGAM Layer);

B3. **IEC 61850-7-4 Ed2.** "Communication Networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes" [39] (the standard is suitable for Information SGAM Layer);

B4. **IEC 61850-8-1 Ed2.** "Communication Networks and systems for power utility automation – Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3" [40] (the standard is suitable for Communication SGAM Layer);

to get real-time data from IED devices in substations and also to get data from substation SCADA/RTUs and Aggregator DER Management System (DER EMS) in the case when IEC 61850 solution will be used according to IEC TR 61850-90-2 rules instead of using IEC 60870-5-104;

C1. **IEEE Std C37.118.2™-2011:** IEEE Standard for Synchrophasor Data Transfer for Power Systems (Revision of IEEE Std C37.118™-2005). IEEE Power & Energy Society. Sponsored by the Power System Relaying Committee [41] (the standard is suitable for both Information and Communication SGAM Layers) to get real-time data from:

- the central PDC,
- substation PDCs,
- substation PMUs;

C2. **IEC TR 61850-90-5 Ed1**. "Communication Networks and systems for power utility automation – Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118", 2012 [42] – this technical report can be used to determine the substitute IEC 61850 solution (with respect to IEEE Std C37.118.2) suitable for both Information and Communication SGAM Layers) to get real-time data from:

- the central PDC,
- substation PDCs,
- substation PMUs;

D1. **IEC 61968-100:** "Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles" [43] (the standard is suitable for the SGAM Communication Layer) and

D2. **IEC 61968-9:** "Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control" [44] (the standard is suitable for the SGAM Information Layer) to get real-time or near-real-time data from:

- AMI Head-End systems;

Going further on and still looking at the proactive PPVC sequence diagram (Figure 57) one can notice that the PPVC controller component is represented by two actors:

- PPVC Controlling,
- PPVC Setpoint Providing.

The information objects which are needed by PPVC to perform its functions are represented by:

- The **4. GET Estimated Cell State (IEX_07)** - the information objects which represent estimated cell state that is offered by Cell State Estimation actor to PPVC Controlling actor;
- The **12. GET Request signal for PPVC resource information (IEX_08)** – the trigger signal to get PPVC reserve activation from Resource Status Information Provider System.
- The **9. SHOW PPVC reserves info. (IEX_09)** - the information objects which represent reserves available for PPVC offered by Resource Status Information Provider actor to PPVC Setpoint Providing actor.

The output of the PPVC is transmitted by:

- The **12. SET PPVC reserve activation** (**IEX_11**) **–** the information objects which represent voltage setting points offered by PPVC Controlling actor to Resource Status Information Provider actor.

Considering the defined set of information objects (i.e. IEX_07, IEX_09, IEX_08, IEX_11) it seems that to solve the data communication problem it would be possible to apply:

A1. **IEC 60870-5-104 “Telecontrol equipment and systems. Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles”** [35] (the standard is suitable for both Information and Communication SGAM Layers) to send between:

- CSO SCADA/EMS and PPVC controller - this data is represented by data flows from:
    - Cell State Estimation actor to PPVC Controlling actor (IEX_07);
    - PPVC Controlling actor to Resource Status Information Provider actor (IEX_08);
    - Resource Status Information Provider actor to PPVC Setpoint Providing actor (IEX_09);
    - PPVC Controlling actor to Resource Status Information Provider actor and also to all PVCs and reactive power control devices (IEX_11).

Taking into account the selected standards suitable for the SGAM Information Layer it is possible to design the SGAM Information Layer diagram on the basis of the SGAM Component Layer shown in Figure 58. The SGAM Information Layer diagram is presented in Figure 59.

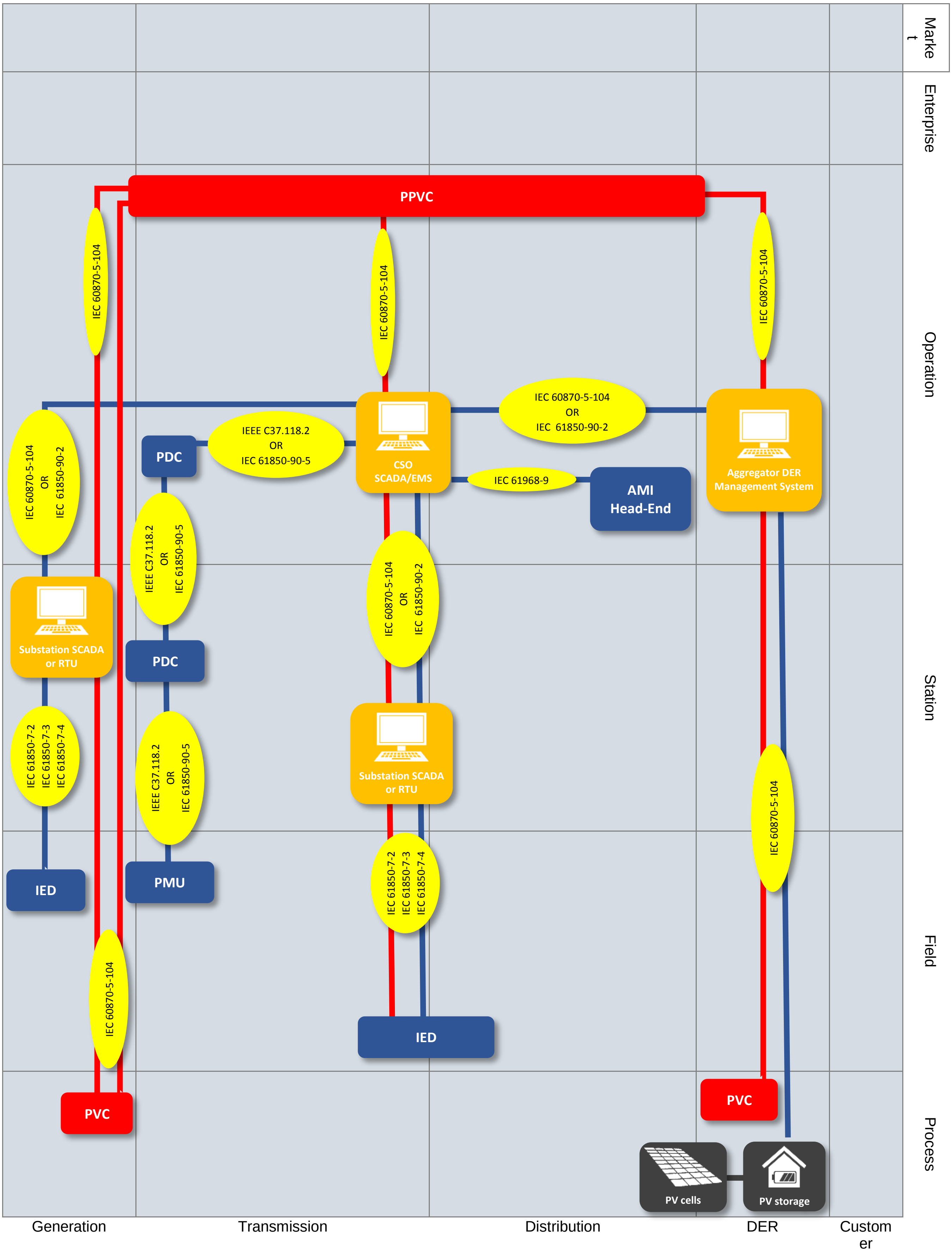


Figure 59 - SGAM Information Layer for PVC and proactive PPVC use cases - assignment of possible standards for information objects transmitted between components

Similarly, taking into account the selected standards suitable for the SGAM Communication Layer it is possible to design the SGAM Communication Layer diagram on the basis of the SGAM Component Layer shown in Figure 58. The SGAM Communication Layer diagram is presented in Figure 60.

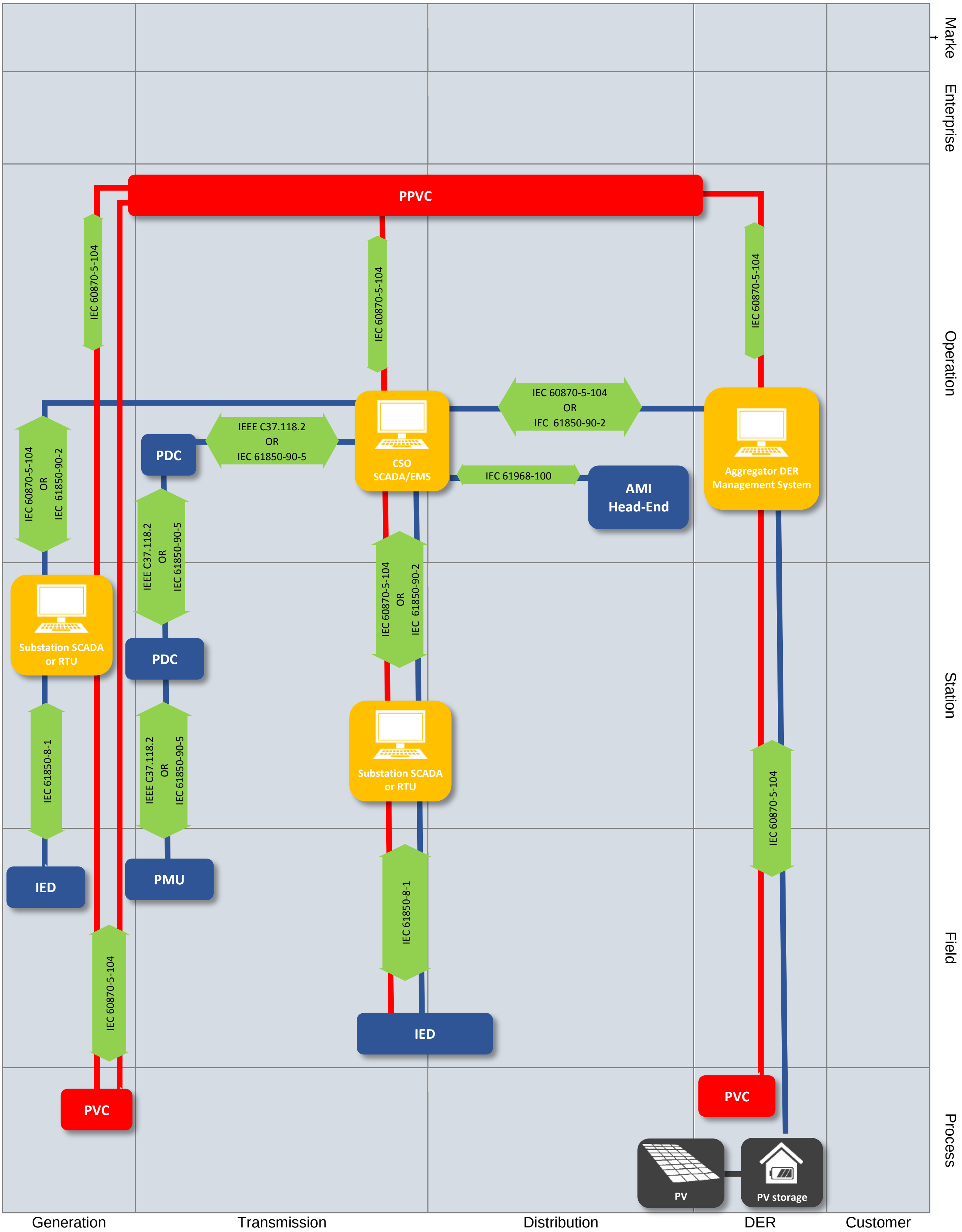


Figure 60 - SGAM Communication Layer for PVC and proactive PPVC use cases - assignment of possible standards for communication solutions between components

Taking into account the presented considerations it is possible now to supplement the "Information exchanged" tables introduced in the deliverable D4.2 by adding suggested standards for both SGAM Information and Communication Layers.

In case of PVC the "Information exchanged" table is shown as Table 21.

Table 21 - PVC - Information exchanged

Information exchanged ID	Name of information exchanged	Description of information exchanged	Suggested standards for SGAM Information Layer	Suggested standards for SGAM Communication Layer
IEX_01	Voltage setpoint	A reference voltage value for a particular primary voltage controller	IEC 60870-5-104 std. (A1)	IEC 60870-5-104 std. (A1)
IEX_02	Controller parameters	A vector containing basic parameters used in the control algorithm, e.g. droop, max and min limits, etc.	IEC 60870-5-104 std. (A1)	IEC 60870-5-104 std. (A1)

In case of PPVC the supplemented "Information exchanged" table is shown as Table 22.

Table 22 - PPVC - Information exchanged

Information exchanged ID	Name of information exchanged	Description of information exchanged	Suggested standards for SGAM Information Layer	Suggested standards for SGAM Communication Layer
IEX_01	Real-time measurements	- Vector of voltage phasors (V, angle) of each node - Complex powers (P, Q) of each node (generators and loads) - Status of network *Switch/breaker positions (on/off) *Transformer tap positions (step info) *Tie-lines power flow (P, Q) -Temperature -Humidity	1. IEC 61870-5-104 (A1) and/or IEC 61850-90-2 (A2) for data transmitted between substations and CSO SCADA/EMS 2. IEC 61870-5-104 (A1) and/or IEC 61850-7/2,3,4 (B1 – B3) for typical SCADA/EMS data 3. IEEE C37.118.2 (C1) and/or IEC61850-90-5 (C2) for synchrophasor data (WAMS) 4. IEC 61968-9 (D2) for AMI data.	1. IEC 61870-5-104 (A1) and/or IEC 61850-90-2 (A2) for data transmitted between substations and CSO SCADA/EMS 2. IEC 61870-5-104 (A1) and/or IEC 61850-8-1 (B4) for typical SCADA/EMS data 3. IEEE C37.118.2 (C1) and/or IEC61850-90-5 (C2) for synchrophasor data (WAMS) 4. IEC61968-100 (D1) for AMI data.
IEX_02	Real-time measurements for Forecasting System	- Complex powers (P, Q) of each node (generators and loads) - Temperature - Humidity	Internal CSO SCADA/EMS data flow.	Internal CSO SCADA/EMS data flow.

Information exchanged ID	Name of information exchanged	Description of information exchanged	Suggested standards for SGAM Information Layer	Suggested standards for SGAM Communication Layer
IEX_03	Forecasting data	Forecasting short-term (15min) generation and load data using RT measurements (IEX_02) and historical data (It is assumed that there is enough historical data for generation and loads).	Internal CSO SCADA/EMS data flow (RT and historical data).	Internal CSO SCADA/EMS data flow (RT and historical data).
IEX_04	Real-time measurements for Cell State Estimation System	- Vector of voltage phasors (V, angle) of each node - Complex powers (P, Q) of each node (generators and loads) - Status of network: • Switch/breaker positions (on/off) • Transformer tap positions (step info) • Tie-lines power flow (P, Q)	Internal CSO SCADA/EMS data flow.	Internal CSO SCADA/EMS data flow.
IEX_05	Forecasted data	Forecasted generation and load values (P, Q)	Internal CSO SCADA/EMS data flow.	Internal CSO SCADA/EMS data flow.
IEX_06	State estimation	With the input data (IEX_04 and IEX_05), the cell state algorithm calculates bus voltages and line flows for each node and units discarding incorrect measurements and completing the missing ones.	Internal CSO SCADA/EMS data flow.	Internal CSO SCADA/EMS data flow.
IEX_07	Estimated cell state	Estimated node voltages and line flows of the complete cell system	IEC 60870-5-104 (A1)	IEC 60870-5-104 (A1)
IEX_08	Request PPVC signal	Trigger signal to get the PPVC reserve activation from Resource Status Information Provider System	IEC 60870-5-104 (A1)	IEC 60870-5-104 (A1)
IEX_09	PPVC reserve information	PPVC reserves (Q), availability (1 or 0), and location of the resource are provided by Resource Status Information Provider System and sent to PPVC Set-point Providing System	IEC 60870-5-104 (A1)	IEC 60870-5-104 (A1)

Information exchanged ID	Name of information exchanged	Description of information exchanged	Suggested standards for SGAM Information Layer	Suggested standards for SGAM Communication Layer
IEX_10	OPF calculation	Besides the information of estimated cell (IEX_07) and PPVC resources (IEX_09), power flow limits of lines, power generation limits of generators, and voltage limits of busbars/terminals (it is determined by regulatory will be the constraints of the IPM algorithm. The output is the optimal set-point values (IEX_11)	Internal PPVC data flow	Internal PPVC data flow
IEX_11	Voltage set-points	With the determination of new-voltage set-points and dead-bands; - The field current of excitation system (for synchronous machines' AVRs), - PWM signals (for converter-coupled sources, ESS), - Signals to thyristor drivers (FACTS), - Curtailment/shedding commands (controllable loads), and - Voltage level of activation command (OLCT)	IEC 60870-5-104 std. (A1)	IEC 60870-5-104 std. (A1)

3.7.4 Conclusions

The performed analysis of PVC and PPVC use cases shows that the following standards and reports should be recommended for further assessment using EAT-SGIS tool:

1. IEC 60870-5-104: "Telecontrol equipment and systems. Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles", 2006;
2. IEC 61850-7-2 Ed2.: "Communication Networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract Communication service interface (ACSI)", 2010;
3. IEC 61850-7-3 Ed2.: "Communication Networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes", 2010;
4. IEC 61850-7-4 Ed2.: "Communication Networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes", 2010;

5. IEC 61850-8-1 Ed2.: "Communication Networks and systems for power utility automation – Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and . ISO 9506-2) and to ISO/IEC 8802-3", 2011;
6. IEEE Std C37.118.2™-2011: "IEEE Standard for Synchrophasor Data Transfer for Power Systems (Revision of IEEE Std C37.118™-2005)". IEEE Power & Energy Society. Sponsored by the Power System Relaying Committee, 2011;
7. IEC 61968-100: "Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles", 2013;
8. IEC 61968-9: "Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control", 2013;
9. IEC TR 61850-90-2 Ed1. "Communication Networks and systems for power utility automation – Part 90-2: Using IEC 61850 for communication between substations and control centres", 2016;
10. IEC TR 61850-90-5 Ed1. "Communication Networks and systems for power utility automation – Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118", 2012.

3.8 Gap analysis

The previous analysis gave very good results putting in evidence that the information exchange needed by the ELECTRA use cases are completely covered by the existing standards.

What can be collected in the gap analysis are just some possible (end not necessarily critical) issues in the selected standards. The resulting list of gaps comes from three sources:

- Some issues highlighted by the mapping phase documented in the previous paragraphs
- Some gaps in the selected standards highlighted by the "Standardisation Gaps Prioritisation for the Smart Grid" document by the SGCG [45]
- Some issues resulting by the standard assessment phase (that is the application of the assessment tool, documented in the attached appendix).

Table 23 - List of possible gaps

Gap	Description	Source	Influenced use case
IEC 61850-90-9	The standard has not been yet published	Mapping Phase	BRC
IEC 61850 IEC61968 IEC 61970	Need to align glossaries as much as possible with electronic data models (TC57/SC 3D)	[45]	BRC, PPVC, IRPC, BSC
IEC 61850 IEC61968 IEC 61970	Need to provide a standard way to manage in security the different steps of an smart grid System	[45]	BRC, PPVC, IRPC, BSC
IEC 61968 IEC 62325	Handling DER integration in distribution networks	[45]	BRC, PPVC, IRPC
IEC 60870-5-104	The standard IEC 60870-5-104 does not address the cyber security directly. However, the cyber security issue is addressed by the companion standard IEC/TS 60870-5-7	Standard Assessment	IRPC, FCC, PPVC
IEC 60870-5-104	Migration form IEC 60870-5-104 to IEC 61850-90-2 is expected	Standard Assessment	IRPC, FCC, PPVC

4 Future perspectives related to ICT solution applicable to the Smart Grid domain

Considering that the selected ICT standards necessarily refer to existing technological solution, it's useful to provide some perspective related to future ICT solution for the Smart Grid.

It's presumable that the future implementation of the Internet of Thing (IoT) will also affect the energy domain.

The IoT implementation will require new approach for the communication architecture that by 5G technology[11] will focalize on the infrastructure edge, enabling different solutions like Fog Computing (FC), Software Defined Networking (SDN), Network Functions Virtualization (NFV), Mobile Edge Computing (MEC).

An example of IoT approach applied to Smart Grid domain is represented by the OpenFMB™ initiative[12] that offers a framework for distributed intelligent nodes interacting with each other at the grid edge, through loosely coupled peer to peer messaging.

Open Field Message Bus™ is based on a single unified information model compatible with the IEC 61850/61968/61970 data models and IoT communication protocols (e.g. DDS, AMQP, MQTT) that could fit well with 5G technology. The clear distinction between the Information and Communication layer, in line with the SGAM and IEC approach, will facilitate the adoption of new emerging communication technology.

A further ICT topic that could represent a key able to boost new business models[13] is the blockchain technology that provides a way to register any transaction without the need of a central authority.

The blockchain is an immutable public record of data secured by a network of peer to peer participants where, once an entry is made, it cannot be removed or edited by anyone.

Traditionally, exchanges require an intermediary such as broker/clearing housing to match buyers and sellers. With the blockchain orders to buy and sell are matched and executed without the need for any third party arbiter because the network acts as a validator.

This technology could facilitate business model where every smart device in the "Internet of Thing" become an autonomous actor in a global data market.

An energy domain application example could be represented by a recently developed smartplug that leverages blockchain technology to seek the lowest tariffs available, thereby saving money by lowering electricity costs wherever possible[14].

[11] https://ec.europa.eu/digital-single-market/en/towards-5g
[12] http://www.sgip.org/openfmb/
[13] http://www.huffingtonpost.com/don-tapscott/what-you-need-to-know-abo_b_10264706.html , https://www.abe-eba.eu/downloads/knowledge-and-research/EBA_20150511_EBA_Cryptotechnologies_a_major_IT_innovation_v1_0.pdf
[14] http://www.bbc.com/news/technology-35604674

5 References

[1] ISO/IEC, "ISO/IEC 42010 Systems Engineering – Architecture description," ISO/IEC, 2011.

[2] IEEE, IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries, Inst of Elect & Electronic, 1991.

[3] CEN-CENELEC-ETSI, "Methodologies to facilitate Smart Grid System Interoperability through standardizationm system, design and testing," CEN-CENELEC-ETSI Smart Grid Coordination Group, 2014.

[4] P. D. S. A. F. C. N. N. G. Arianna Brutti, "Standard for eBusiness in SMEs networks: the increasing role of customization rules and conformance testing tools to achieve interoperability," Stockholm, 2011.

[5] ISO, "Standards," [Online]. Available: http://www.iso.org/iso/home/standards.htm. [Accessed 17 12 2015].

[6] EC - Directorate-General for Energy, "Smart Grid Mandate," European Commission, Brussels, 2011.

[7] SGCG, "Smart Grid Reference Architecture," CEN-CENELEC-ETSI Smart Grid Coordination Group, 2012.

[8] SGCG, "First Set of Standards," CEN-CENELEC-ETSI Smart Grid Coordination Group, 2012.

[9] SGCG, "SGCG/M490/G_Smart Grid Set of Standards," CEN-CENELEC-ETSI Smart Grid Coordination Group , 2014.

[10] C. Neureiter, "Flexible Loads - SGAM Toolbox Reference Example," Josef Ressel Center for User-Centric Privacy, Security and Control, Salzburg (AU), 2013.

[11] C. Brunner, "IEC 61850 & Smart Grids," 2013. [Online]. Available: http://www.pacw.org/issue/september_2013_issue/iec_61850_update/the_semantic_data_model/complete_article/1.html. [Accessed 15 12 2015].

[12] H. E. H. Dawidczak, "Integration of DER systems into the Electrical Power System with a generic IEC 61850 interface," Berlin, Germany, 2013.

[13] A. K. Srinath Balaraman, "An overview of ZigBee's Smart Energy Profile 2.0 standard," 2013. [Online]. Available: http://www.eetimes.com/document.asp?doc_id=1280846&page_number=2. [Accessed 15 12 2015].

[14] ZigBee Alliance, "Smart Energy Profile 2," 2014. [Online]. Available: http://old.zigbee.org/Standards/ZigBeeSmartEnergy/SmartEnergyProfile2.aspx. [Accessed 15 12 2015].

[15] OpenADR Alliance, "IEC Approves OpenADR Specification," 2014. [Online]. Available: http://www.openadr.org/index.php?option=com_content&view=article&id=92:iec-approves-

openadr-specification&catid=21:press-releases&Itemid=121. [Accessed 15 12 2015].

[16] OASIS, "Energy Market Information Exchange (EMIX) Version 1.0," 2012. [Online]. Available: http://docs.oasis-open.org/emix/emix/v1.0/cs02/emix-v1.0-cs02.html. [Accessed 15 12 2015].

[17] G. A. McNaughton, "How MultiSpeak® Supports Interoperability of Diverse Grid Automation Systems," MultiSpeak Initiativ, 2007. [Online]. Available: http://www.multispeak.org/about/Presentations/Documents/McNaughton_Grid_Interop110807.pdf. [Accessed 07 07 2014].

[18] SGCG, "Methodologies to achieve Smart Grid system interoperability through 9 standardization, system design and testing - Intermediate report," SGCG, 2013.

[19] D. C. B. V. Nicolas Daclin, "Enterprise interoperability measurement - Basic concepts," Conference: EMOI - INTEROP'06, Luxembourg, 2006.

[20] The GridWise Architecture Council, "Smart Grid Interoperability Maturity Model," GridWise Architecture Council, 2011.

[21] European Commission, "CAMSS: Common Assessment Method for Standards and Specifications," January 2010. [Online]. Available: http://ec.europa.eu/idabc/en/document/7407.html.

[22] The European Parliament and the Council, "DECISION No 922/2009/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 September 2009 on interoperability solutions for European public administrations (ISA)," Official Journal of the European Union , 2009.

[23] European Commission , "Action 23," June 2013. [Online]. Available: https://ec.europa.eu/digital-agenda/en/pillar-ii-interoperability-standards/action-23-provide-guidance-ict-standardisation-and-public.

[24] CEN-CENELEC-ETSI Smart Grid Coordination Group, "Smart Grid Reference Architecture," SGCG, 2012.

[25] CEN-CENELEC-ETSI Smart Grid Coordination Group, "First Set of Standards," 2012.

[26] U.S. Department of Energy, "Smart Grid Research & Development - Multi-Year Program Plan 2010-2014," U.S. DoE, 2010.

[27] IEC, "Core IEC Smart Grid Standards," 2016. [Online]. Available: http://www.iec.ch/smartgrid/standards/.

[28] ENTSOE, "Common Information Model (CIM)," 2015. [Online]. Available: https://www.entsoe.eu/major-projects/common-information-model-cim/Pages/default.aspx.

[29] D. Stufkens, "Common Grid Model Methodology Generation and Load Data Provision Methodology," 18 02 2016. [Online]. Available: https://consultations.entsoe.eu/system-operations/common-grid-model/supporting_documents/CGMMGLDPMM%2020160218%20%20External%20Workshop%20final.pdf.

[30] ENTSOE, "Substation Automation – The IEC61850 Standard," 2016. [Online]. Available:

https://www.entsoe.eu/about-entso-e/research-and-development/standardisation/IEC61850/Pages/default.aspx.

[31] ELECTRA IRP project no. 609687, "D4.2 Description of the detailed functional architecture of the frequency and voltage control solution (functional and information layer)," FP7-ENERGU-3013-IRP, 2016.

[32] IEC, "Architecture View," 2016. [Online]. Available: http://smartgridstandardsmap.com/.

[33] EPRI, "Using the Common Information Model for Network Analysis Data Management: A CIM Primer Series Guide," 2014.

[34] European Commission, "COMMISSION REGULATION (EU) establishing a guideline on transmission system operation - Draft version," 2015.

[35] IEC, "IEC 60870-5-104:2006 Telecontrol equipment and systems - Part 5-104: Transmission protocols - Network access for IEC 60870-5-101 using standard transport profiles," IEC, 2006.

[36] IEC, "IEC TR 61850-90-2 Ed1. “Communication Networks and systems for power utility automation – Part 90-2: Using IEC 61850 for communication between substations and control centres"," IEC, 2016.

[37] IEC, "IEC 61850-7-2 Ed2. “Communication Networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract Communication service interface (ACSI)”," IEC, 2010.

[38] IEC Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes, "IEC 61850-7-3," 2010.

[39] IEC, "IEC 61850-7-4 Ed2. “Communication Networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes”," IEC, 2010.

[40] IEC, ". IEC 61850-8-1 Ed2. “Communication Networks and systems for power utility automation – Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3”," IEC, 2011.

[41] IEEE, "C37.118.2-2011: IEEE Standard for Synchrophasor Data Transfer for Power Systems," IEEE Power & Energy Society, 2011.

[42] IEC, "IEC TR 61850-90-5 Ed1. “Communication Networks and systems for power utility automation – Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118," IEC, 2012.

[43] IEC, "IEC 61968-100: “Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles”," IEC, 2013.

[44] IEC, "IEC 61968-9: “Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control”," IEC, 2013.

[45] SGCG, "Standardisation Gaps Prioritisation for the Smart Grid," SGCG, 2013.

[46] Wikipedia, "IEC 61968," 2015. [Online]. Available: https://en.wikipedia.org/wiki/IEC_61968.

[Accessed 15 12 2015].

[47] European Commission, "The IDABC programme," [Online]. Available: http://ec.europa.eu/idabc/en/chapter/3.html. [Accessed 2014].

[48] A. Layne-Farrar, A. J. Padilla and R. Schmalensee, " "Pricing Patents for Licensing in Standard-Setting Organizations: Making Sense of FRAND Commitments"," Antitrust Law Journal 74: 671., 2007.

6 Disclaimer

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7 Annex: list of standards evaluated with the EAT-SGIS tool

The complete Annex with all the evaluation of standards is provided in a separated document for space reasons. In any case the complete list of evaluated standards is the following:

Table 24 - list of evaluated standards

Standard	Layer	Related use cases
IEC 60870-5-104	Information and Communication	IRPC - FCC - PPVC
IEC 61850-7-2	Information	BRC
IEC 61850-7-3	Information	BRC
IEC 61850-7-4	Information	BRC
IEC 61850-7-410	Information	BRC
IEC 61850-7-420	Information	FCC, BRC
IEC 61850-8	Communication	PPVC
IEC 61850-80-1	Information	BRC
IEC 61850-90-2	Information and Communication	PPVC
IEC61850-90-5	Information and Communication	IRPC - PPVC
IEC 61850-90-7	Information	BRC
IEC 60870-5-104	Information and Communication	PPVC - PVC
IEC 61968-9	Information and Communication	PPVC
IEC 61968-11	Information	IRPC
IEC 61968-100	Communication	IRPC - PPVC
IEC 61970-452	Information	BSC
IEC 61970-456	Information	BSC
IEEE Standard C37.118.2-2011	Communication	FCC - PPVC
IEC 61968-13	Information	*No one*
OASIS EMIX	Information	*No one*
OASIS MADES	Information	*No one*

Project No. 609687

FP7-ENERGY-2013-IRP

ELECTRA

European Liaison on Electricity Committed Towards long-term Research Activities for Smart Grids

WP 4

Fully Interoperable Systems

Annex to Deliverable D4.3

Evaluated standards

20/01/2017

ID&Title	**D4.3** Existing standards and Gap analysis for the proposed frequency and voltage control solutions	Number of pages:	121

Short description (Max. 50 words):
This is the Annex of D4.3 providing Standard Assessments

Version	Date	Modification's nature
V0.01	12/05/2016	First Draft
V0.9	30/08/2016	Final version
V01	11/01/2017	Inserting of list of interaction Section, with the mapping of the interaction identified by the Task 4.2 and the Standards

Accessibility	
☒ PU, Public	
☐ PP, Restricted to other program participants (including the Commission Services)	
☐ RE, Restricted to other a group specified by the consortium (including the Commission Services)	
☐ CO, Confidential, only for members of the consortium (including the Commission Services)	
If restricted, please specify here the group:	

Owner / Main responsible:		
Task 4.3 Leader:	Angelo Frascella (ENEA)	11/01/2017
Reviewed by:		
WP 4 Leader	Chris Caerts (VITO)	13/01/2017
Final Approval by:		
ELECTRA Technical Committee TOQA appointed Reviewers:	Mihai Calin (DERlab) Carlo Tornelli (RSE)	20/01/2017

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Executive summary

This D4.3 Annex provides the evaluation of standards got by the application of the ELECTRA Assessment Tool for Smart Grid Interface Standards (EAT-SGIS) to the information and communication layer standards identified in the D4.3 Analysis.

The list of the evaluated standards, chosen mainly on the base of the result of mapping between ELECTRA use case and the Smart Grid standards, is the following:

Standard	**Layer**	**Related use cases**
IEC 60870-5-104	Information and Communication	IRPC - FCC - PPVC
IEC 61850-7-2	Information	BRC
IEC 61850-7-3	Information	BRC
IEC 61850-7-4	Information	BRC
IEC 61850-7-410	Information	BRC
IEC 61850-7-420	Information	FCC, BRC
IEC 61850-8-1	Communication	PPVC
IEC 61850-90-2	Information and Communication	PPVC
IEC61850-90-5	Information and Communication	IRPC - PPVC
IEC 61850-90-7	Information	BRC
IEC 60870-5-104	Information and Communication	PPVC - PVC
IEC 61968-9	Information and Communication	PPVC
IEC 61968-11	Information	IRPC
IEC 61968-13	Information	*No one*
IEC 61968-100	Communication	IRPC - PPVC
IEC 61970-452	Information	BSC
IEC 61970-456	Information	BSC
IEEE Standard C37.118.2-2011	Communication	FCC - PPVC
OASIS EMIX	Information	*No one*
OASIS MADES	Information	*No one*

Abbreviations

CAMSS	Common Assessment Method for Standards and Specification
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
DER	Distributed Energy Resources
DMS	Distribution Management System
EAT-SGIS	ELECTRA Assessment Tool for Smart Grid Interface Standards
EC	European Commission
EMS	Energy Management System
ESO	European Standardisation Organisation
ETSI	European Telecommunications Standards Institute
FRAND	Fair, Reasonable And Non-Discriminatory
ICT	Information and Communication Technologies
IOP	Interoperability
ISO	International Organization for Standardization
SDO	Standard Development Organization
SGAM	Smart Grid Architecture Model
SGIMM	Smart Grid Interoperability Maturity Model
SGCG	Smart Grid Coordination Group

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List of figures and tables

Introduction

This is the Annex to the D4.3 of the ELECTRA project.

It contains the assessments of the standards identified in the D4.3 as potentially useful for the ELECTRA use cases. These assessments have been produced using the ELECTRA Assessment Tool for Smart Grid Interface Standards (EAT-SGIS), designed and implemented within this task. Please, for all the details look at the D4.3 Deliverable.

IEC 60870-5-104: Transmission Protocols - Network access for IEC 60870-5-101 using standard transport profiles

NAME	DESCRIPTION
General information:	IEC 60870-5-104 was developed by IEC TC 57 and standardized by IEC – International Electrotechnical Commission. It is at its 2nd version (Edition 2), released on the June 2006. Its first release was released on the December 2000. More information at: https://webstore.iec.ch/publication/3746
Aim and technologies	IEC 60870-5-104 was developed with the following aim: The aim of the standard IEC 60870-5-104 is to define the use of an open TCP/IP-interface to a network, containing for example a LAN for telecontrol equipment, which transports IEC 60870-5-101 ASDUs (Application Service Data Unit). It is based on the following technologies: TCP/IP, Ethernet technology. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution, DER - Zones: Process, Field , Station, Operation - Interoperability Levels: Information, Communication
Description	The standard IEC 60870-5-104 applies to telecontrol equipment and systems with coded bit serial data transmission for monitoring and controlling geographically widespread processes. It defines a telecontrol companion standard that enables interoperability among compatible telecontrol equipment. The specifications of the defined telecontrol companion standard present a combination of the application layer of IEC 60870-5-101 and the transport functions provided by a TCP/IP (Transmission Control Protocol/Internet Protocol). Within TCP/IP, various network types can be utilized, including X.25, FR (Frame Relay), ATM (Asynchronous Transfer Mode) and ISDN (Integrated Service Data Network).

NAME	DESCRIPTION
Other Technical Information	**INFORMATION STANDARD FEATURES:** Document specifications provided by Table format specification is used. Main kind of provided messages/document/information: The main information objects of IEC 60870-5-104 are as follows: Process information in monitor direction: single-point information, double-point information, step position information, bit string of 32 bits, measured value (normalized value), measured value (scaled value), measured value (short floating point number), integrated totals, packed single-point information with status change detection, measured value (normalized value without quality descriptor), single-point information with time tag, double-point information with time tag, step position information with time tag, bitstring of 32 bit with time tag, measured value (normalized value) with time tag, measured value (scaled value) with time tag, measured value (short floating point number) with time tag, integrated totals with time tag, event of protection equipment with time tag, packed start events of protection equipment with time tag, packed output circuit information of protection equipment with time tag, Process information in control direction: single command, double command, regulating step command, set point command (normalized value), set point command (scaled value), set point command (short floating point number), bitstring of 32 bits, reserved for further compatible definitions, single command with time tag, double command with time tag, regulating step command with time tag, set point command (normalized value) with time tag, set point command (scaled value) with time tag, set point command (short floating-point number) with time tag, bitstring of 32 bits with time tag, System information in control direction: interrogation command, counter interrogation command, read command, clock synchronization command, reset process command, test command with time tag. **COMMUNICATION STANDARD FEATURES**: Time latency: single seconds Bandwidth: 100 kb/s - 2 Mb/s
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring system control --- Ensuring quality of supply
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator; Energy Market Place: Aggregator;
Use case clusters	- Blackout management - Connect an active actor to the grid - Controlling the grid (locally/ remotely) manually or automatically - Grid stability - Managing power quality - Monitoring the grid flows - Operate DER(s) - Reconfiguring the network in case of fault

NAME	DESCRIPTION
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems - EMS Scada system - WAMPACs - FACTS Distribution: - Substation automation systems - Feeder Automation System - ADMS - FACTS - DMS SCADA and GIS system DER: - DER operation systems
Function specific and other covered system	Micro-grid: - Micro-grid systems Administration: - Assets and maintenance management system - Clock reference system Cross-cutting: - Telecommunication
IPR	The standard is publicly available with fee.
Diffusion	- The standard has been implemented by vendors/suppliers Known implementations: The main suppliers: ABB, Siemens, Alstom, GE - The standard has been used in different electric power industry applications. Known implementations: Data communications within substations and between substations and control centers.
Relation with other standards and technologies	- The following standards are possible alternative to IEC 60870-5-104: 1. IEC 60870-5-101 Telecontrol equipment and systems - Part 5-101: Transmission protocols - Companion standard for basic telecontrol tasks, 2015 2. IEEE 1815 IEEE Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3), 2012 - IEC 60870-5-104 results to be largely compatible with the following standards: 1. TCP/IP/Ethernet 2. TCP/IP/PPP (serial links) - A process of harmonization with other standards is involving IEC 60870-5-104: Harmonization with IEC 61850 (IEC TS 61550-80-1 Communication networks and systems for power utility automation - Part 80-1: Guideline to exchanging information from a CDC-based data model using IEC 60870-5-101 or IEC 60870-5-104, 2008)

NAME	DESCRIPTION
Tools and documentation	IEC 60870-5-104 has interoperability tests. The reference to these tests are the following: • IEC TS 60870-5-601: Telecontrol equipment and systems - Part 5-601: Transmission protocols - Conformance test cases for the IEC 60870-5-101 companion standard, 2015, https://webstore.iec.ch/publication/23486 - IEC 60870-5-104 provides tools for facilitating implementation. The reference to them are the following: 1. INFO TECH - ProTester ultimate MASTER and SLAVE station simulators - DNP3.0, IEC101, IEC103, IEC104, (https://www.infotech.pl/en/products/2015-09-04-07-55-44/protester), 2. SystemCORP Embedded Technology Pty Ltd. - IEC 60870-5-104 DLL for Windows and libraries for Ubuntu Linux operating system (for both server and client functionality, http://www.systemcorp.com.au/products/softwarelibraries/ - Evidence about positive impact of the standard provided by the following case studies: On one hand the huge number of applications of the IEC 60870-5-104 standard. On the other hand It is difficult to find a document that provides the required data.
Possible barriers	- There is some probability that IEC 60870-5-104 can be affected by lacking of real interoperability due to ambiguity of specifications
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 64%. The strength of this evaluation is 100%. This parameter seems to be high. Knock-Out criteria are not specified.
Openness	Openness equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 67%. The strength of this evaluation is 75%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Potential	Potential equals to 40%. The strength of this evaluation is 100%. This parameter seems to be low. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 71,79% Final Strength = 97,5% Final Automated Evaluation = high NOTE: For the 2,5% of the questions, available documentation has been judged insufficient

Reference	[IEC 60870-5-104:2006 Telecontrol equipment and systems - Part 5-104:

NAME	DESCRIPTION
documentation	Transmission protocols - Network access for IEC 60870-5-101 using standard transport profiles.] + https://webstore.iec.ch/publication/3746 [SGCG/M490/G Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf

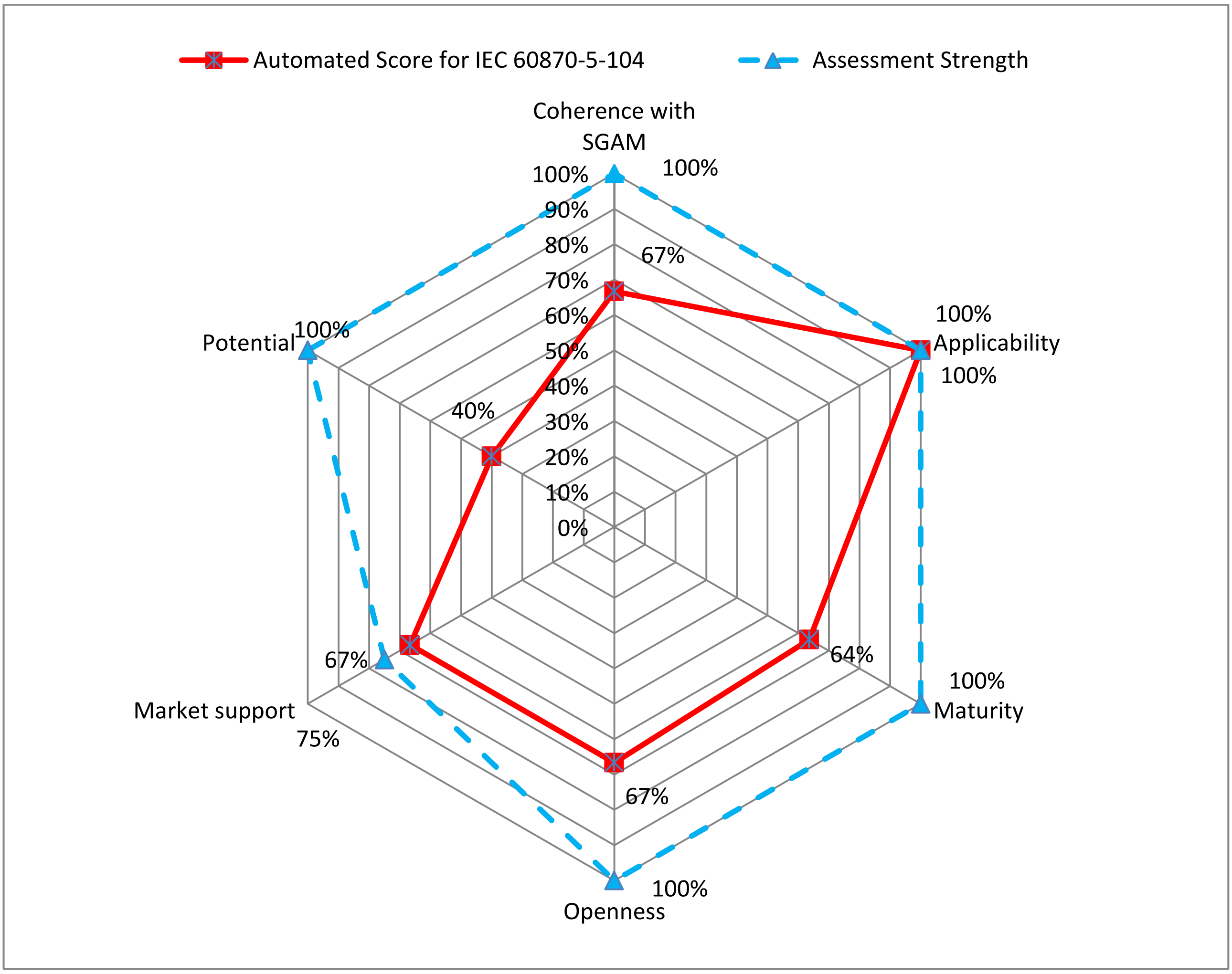

Figure 1 - Summary of IEC 60870-5-104 Evaluation

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient.
Critical points for Openness	Specifications are not licensed on a royalty-free basis.
Critical points for Market support	There is no support from user groups.
Critical points for Potential	There are no evidences about its impact Security is not well addressed. Privacy is not well addressed.

Comments on Maturity	Quality: - The testing tools are available but have to be purchased. The interoperability list is defined in IEC 60870-5-104 which is necessary for protocol implementation.
Comments on Openness	Documentation: - The standard must be purchased.
Comments on Potential	Security: - The standard IEC 60870-5-104 does not address the cyber security directly. However, the cyber security issue is addressed by the companion standard IEC/TS 60870-5-7 "Telecontrol equipment and systems - Part 5-7: Transmission protocols - Security extensions to IEC 60870-5-101 and IEC 60870-5-104 protocols (applying IEC 62351), 2013.

Additional information about the standard IEC 60870-5-104 from IEC TC 57

The standard IEC 60870-5-104 defines the use of an open TCP/IP-interface to a network, containing for example a LAN for telecontrol equipment, which transports IEC 60870-5-101 ASDUs (Application Service Data Units). This means that application layer of IEC 60870-5-104 is preserved same as that of IEC 60870-5-101 with some of the data types and facilities not used. The basic application protocol functions are as follows:

- -station initialization,
- -data acquisition by polling,
- -cyclic data transmission,
- -acquisition of events,
- -general interrogation,
- -clock synchronization.

The standard defines the process and system information objects which can be transmitted in the monitor direction and in the control direction. The main information objects of IEC 60870-5-104 are as follows:

1. **Process information in monitor direction**: single-point information, double-point information, step position information, bitstring of 32 bits, measured value (normalized value), measured value (scaled value), measured value (short floating point number), integrated totals, packed single-point information with status change detection, measured value (normalized value without quality descriptor), single-point information with time tag, double-point information with time tag, step position information with time tag, bitstring of 32 bit with time tag, measured value (normalized value) with time tag, measured value (scaled value) with time tag, measured value (short floating point number) with time tag, integrated totals with time tag, event of protection equipment with time tag, packed start events of protection equipment with time tag, packed output circuit information of protection equipment with time tag,
2. **Process information in control direction**: single command, double command, regulating step command, set point command (normalized value), set point command (scaled value), set point command (short floating point number), bitstring of 32 bits, reserved for further compatible definitions, single command with time tag, double command with time tag, regulating step command with time tag, set point command (normalized value) with time tag, set point command (scaled value) with time tag, set point command (short floating-point number) with time tag, bitstring of 32 bits with time tag,
3. **System information in monitor direction**: end of initialization,
4. **System information in control direction**: interrogation command, counter interrogation command, read command, clock synchronization command, reset process command, test command with time tag.

Additional information about the standard IEC 60870-5-104 from IEC TC 57
Moreover the protocol enables to send **parameters in control direction**: parameter of measured value (normalized value), parameter of measured value (scaled value), parameter of measured value (short floating-point number), and parameter activation. File transfer is also possible. The standard considers multiple redundant connections established between the two communicating stations. The last clause describes the interoperability issues that arise when standby connections are used as redundant connections.

IEC 61850-7-2: Abstract communication service interface (ACSI) - Ed.2

NAME	DESCRIPTION
General information:	IEC 61850-7-2 was developed by IEC TC 57 and standardized by IEC - International Electrotechnical Commission. It is at its 2nd (two editions) version (Edition 2), released on the 08/2010. Its first release was released on the 05/2003. More information at: https://webstore.iec.ch/publication/6015
Aim and technologies	The standard IEC 61850-7-2 is part of a set of definitions which details a layered utility communication architecture. This architecture has been chosen to provide abstract definitions of classes and services such that the definitions are independent of specific protocol stacks, implementations, and operating systems. The IEC 61850 series is intended to provide interoperability between a variety of devices. Communication between these devices is achieved by the definition of a hierarchical class. model (for example, logical device, logical node, data, data set, report control, or log) and services provided by these classes (for example, get, set, report, define, delete) in IEC 61850-7-x. It is based on the following technologies: IEC 61850 family of standards, Ethernet technology. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution - Zones: Process, Field , Station, Operation - Interoperability Levels: Information
Description	The standard IEC 61850-7-2 defines the abstract communication service interface (ACSI) for use in the utility application domain that requires real-time cooperation of intelligent electronic devices. The ACSI has been defined so as to be independent of the underlying communication systems. Specific communication service mappings (SCSM) are specified in IEC 61850-8-x and IEC 61850-9-x. This part (7-2) of IEC 61850 defines the abstract communication service interface in terms of: - a hierarchical class model of all information that can be accessed via a communication network, - services that operate on these classes, and - parameters associated with each service. The ACSI description technique abstracts away from all the different approaches to implement the cooperation of the various devices.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by the text document including both tables and Substation Configuration Language -SCL - (XML) description of CDC classes. Main kind of provided messages/document/information: Data of the substation automation system. SECURITY AND PRIVACY: - Security: In the standard one can find the remark "security issues are solved by the IEC 62351 series". Also: The security requirements for the restriction of access to the data in a server are defined in IEC 61850-5.

NAME	DESCRIPTION
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring system control
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator;
Use case clusters	- Blackout management - Connect an active actor to the grid - Controlling the grid (locally/ remotely) manually or automatically - Generation Maintenance - Maintaining grid assets - Managing power quality - Monitoring the grid flows - Protecting the grid assets - Reconfiguring the network in case of fault - System and security management
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems - EMS Scada system - WAMPACs - FACTS Distribution: - Substation automation systems - Feeder Automation System - ADMS - DMS SCADA and GIS system
Function specific and other covered system	Cross-cutting: - Data modelling
IPR	The standard is publicly available with fee.
Diffusion	- The standard has been implemented by vendors/suppliers. The main suppliers: ABB, Siemens, Alstom - The standard has been used in different electric power industry applications. Known implementations: Electric substations, power plants - There is support from one Interest/users group. It is: UCA International User Group
Relation with other standards and technologies	- IEC 61850-7-2 results to be largely compatible with the following standards: IEC 61850-7-2, IEC 61850-7-3, IEC 61850-7-4, MMS/ACSE, TCP/IP, Ethernet - A process of harmonization with other standards is involving IEC 61850-7-2: IEC carries out harmonization process for IEC 61850, CIM and COSEM interfaces (e.g. IEC 61850-80-4: COSEM over IEC 61850, IEC62056-6-9: Mapping between CIM and DLMS/COSEM data models). There is also IEC 61850-80-1 that contains guidelines to exchange the information from CDC (IEC 61850) based data model using IEC 60870-5-101/104 standards.

<table>
<tr><th>NAME</th><th>DESCRIPTION</th></tr>
<tr><td>Tools and documentation</td><td>- IEC 61850-7-2 has interoperability tests. The reference to these tests are the following: IEC 61850-10 Ed.2.: "Communication networks and systems for power utility automation - Part 10:Conformance testing". https://webstore.iec.ch
- IEC 61850-7-2 provides guidelines and/or documentation. The reference to them are the following:
1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010;
2. IEC 61850-7-1 Ed.2: "Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models"; https://webstore.iec.ch/publication/6014;
3. IEC 61850-90-11: "Communication networks and systems for power utility automation – Part 90-11: Methodologies for modelling of logics for IEC 61850 based applications" - this technical report has not been published yet
4. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010 : http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf
- IEC 61850-7-2 provides tutorials and/or examples. The reference to them are the following:
1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010;
2. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010 : http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf
- IEC 61850-7-2 provides tools for facilitating implementation. The reference to them are the following:
• SISCO (USA) tools: http://www.sisconet.com/our-products/
• INFO TECH (Poland) tools: http://infotech.gdansk.pl
• KalkiTech (India) tools: http://www.kalkitech.com/
- Evidence about positive impact of the standard provided by the following case studies: "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010</td></tr>
<tr><td colspan="2">Possible barriers</td></tr>
<tr><th>Assessment</th><th>The standard has been evaluated in following way, according to the following parameters:</th></tr>
<tr><td>Applicability</td><td>Applicability equals to 100%. The strength of this evaluation is 100%.
This parameter seems to be very high.
There are 1 Knock-Out criteria specified and they are all met.</td></tr>
<tr><td>Maturity</td><td>Maturity equals to 73%. The strength of this evaluation is 100%.
This parameter seems to be high.
Knock-Out criteria are not specified.</td></tr>
</table>

NAME	DESCRIPTION
Openness	Openness equals to 83%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 60%. The strength of this evaluation is 100%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 84,21% Final Strength = 97,44% Final Automated Evaluation = very high NOTE: For the 2,56% of the questions, available documentation has been judged insufficient

Reference documentation	[Communication networks and systems for power utility automation. Part 7-2: Ed.2: Communication networks and systems for power utility automation – Part 7-2: Basic communication structure – Abstract communication service interface (ACSI)] + https://webstore.iec.ch/publication/6015 [SGCG/M490/G_Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf [Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard. Group of Spanish Electricity Companies for studies on IEC 61850] + http://www.cired.net/publications/cired2011/part1/papers/CIRED2011 0422final.pdf

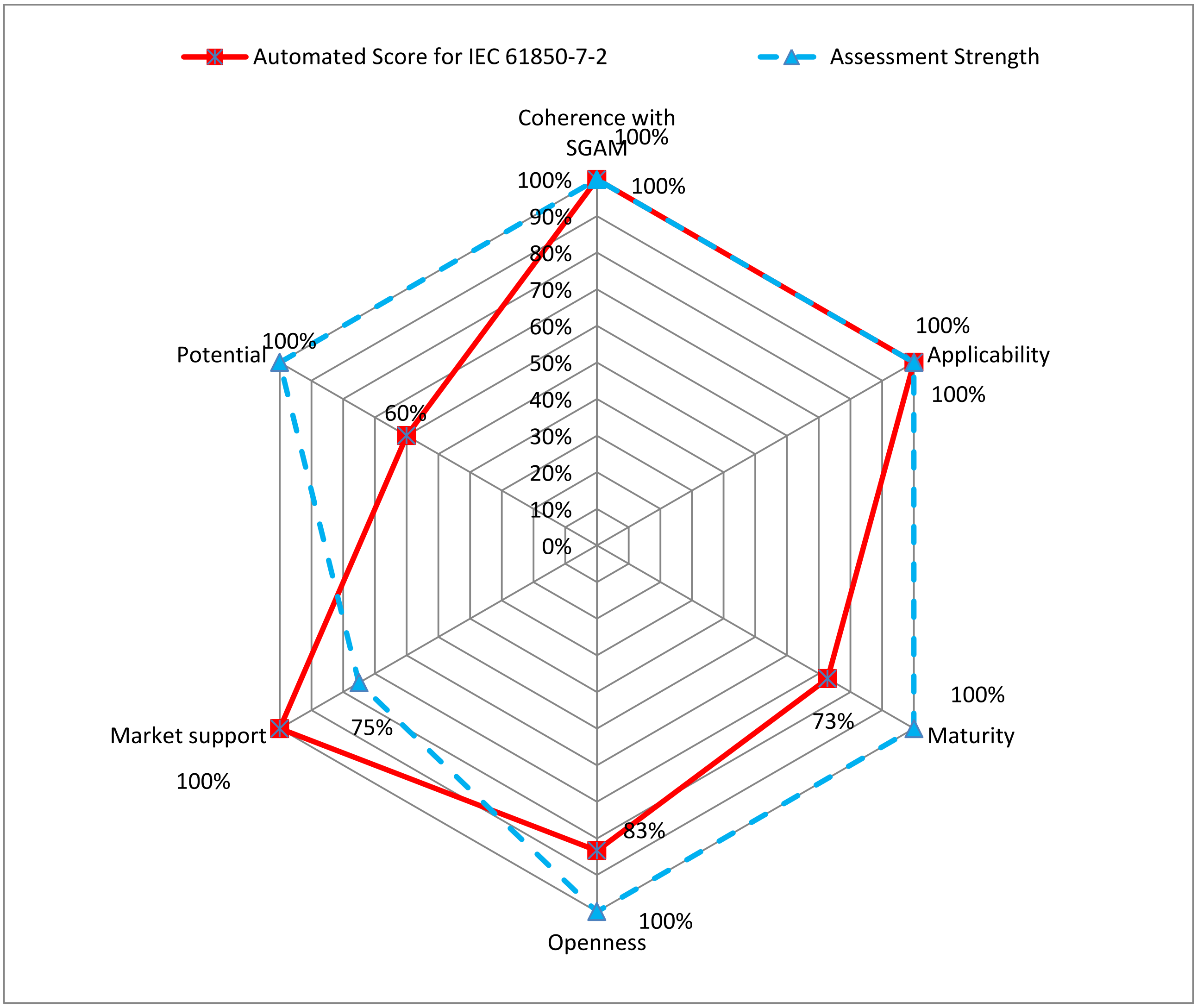

Figure 2 - Summary of IEC 61850-7-2 Evaluation

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Potential	There are no evidences about its impact Privacy is not well addressed.

Comments on Coherence with SGAM	Alternative standards: - The standard is an integral part of IEC 61850-7-x standards, where x=3,4, and also an integral part of extensions of CDC defined by other standards that belong to IEC 61850 group. From this point of view IEC 61850-7-2 is the only possible standard.

Comments on Applicability	Focus on interoperability for Smart Grid: - The IEC 61850 series is intended to provide interoperability between a variety of devices. Communication between these devices is achieved among other things, by the definition so called Logical Nodes. They represent precisely defined virtual "bricks" which correspond to well-known functions in real devices. - There is no direct reference to Smart Grid concept within IEC 61850-7-2 standard. However the implementation of the standard IEC 61850 in SGAM information and communication layers is evident. Requirements: - IEC 61850-8-1 standard specifies the functional requirements of the IEC61850-7-x, x=2,3,4. Reusability: - The IEC 61850-7-2 standard is suitable only for SGAM information layer. However, it is suitable for different SGAM domains and zones.
Comments on Openness	Documentation: - The standard should be purchased.
Comments on Potential	Impact: - Revolution rather than evolution is required

Additional information about the standard IEC 61850-7-2 from IEC TC 57

This part (7-2) of IEC 61850 applies to the Abstract Communication Service Interface (ACSI) communication for utility automation. The ACSI provides the following abstract communication service interfaces.

a) Abstract interface describing communications between a client and a remote server for

– real-time data access and retrieval,

– device control,

– event reporting and logging,

– setting group control,

– self-description of devices (device data dictionary),

– data typing and discovery of data types, and

– file transfer.

b) Abstract interface for fast and reliable system-wide event distribution between an application in one device and many remote applications in different devices (publisher/sub-scriber) and for transmission of sampled measured values (publisher/subscriber).This part of IEC 61850 applies to the ACSI communication for utility automation. The ACSI provides the following abstract communication service interfaces.

Part 7-2 of IEC 61850 defines mainly the meta model for the whole IEC 61850 standard series. The meta model comprises classes for the description of a device with regard to data models and information exchange. The following overall classes are defined:

a) Server – represents the external visible behaviour of a device. All other ACSI models are

part of the server.

NOTE A server has two roles: to communicate with a client (most service models in IEC 61850 provide communication with client devices) and to send information to peer devices (for example, for sampled values).

b) Logical device (LD) – represents the information produced and consumed by a group of domain-specific

Additional information about the standard IEC 61850-7-2 from IEC TC 57
application functions. c) Logical node (LN) – contains the information produced and consumed by a single domain-specific application function, for example, overvoltage protection or circuitbreaker. d) Data objects – provide means to define typed information, for example, position of a switch with quality information and timestamp, contained in logical nodes. Each of these models is defined as a class. The classes comprise attributes and services. In addition to the models listed above, the ACSI comprises the following models that provide services operating on data objects, data attributes, and data sets. a) Data Set – permits the grouping of data objects and data attributes. Used for direct access, for reporting, logging, GOOSE messaging and sampled value exchange. b) Substitution – supports replacement of a process value by another value. c) Setting group control – defines how to switch from one set of setting values to another one and how to edit setting groups. d) Report control and logging – describe the conditions for generating reports and logs based on parameters set by configuration or by a client. Reports may be triggered by changes of process data values (for example, state change or dead band) or by quality changes. Logs can be queried for later retrieval. Reports may be sent immediately or deferred. Reports provide change-of-state and sequence-of-events information exchange. e) Control blocks for generic substation event (GSE) – supports a fast and reliable system-wide distribution of input and output data values; peer-to-peer exchange of IED binary status information, for example, a trip signal. f) Control blocks for transmission of sampled values – fast and cyclic transfer of samples, for example, of instrument transformers. g) Control – describes the services to control, for example, devices. h) Time and time synchronization – provides the time base for the device and system. i) File system – defines the exchange of large data blocks such as programs. j) Tracking – provides a diagnosis interface to track services (control, configuration, exchange).

IEC 61850-7-3: Common Data Classes

NAME	DESCRIPTION
General information:	IEC 61850-7-3 was developed by IEC TC 57 and standardized by IEC - International Electrotechnical Commission. It is at its 2nd (two editions) version (Edition 2), released on the 12/2010. Its first release was released on the 05/2003. More information at: https://webstore.iec.ch/publication/6016
Aim and technologies	This standard (IEC 61850-7-3) is part of a set of specifications, which details layered substation communication architecture. This architecture has been chosen to provide abstract definitions of classes and services such that the specifications are independent of specific protocol stacks and objects. The mapping of these abstract classes and services to communication stacks is outside the scope of IEC 61850-7-x and may be found in IEC 61850-8-x (station bus) and IEC 61850-9-x (process bus). It is based on the following technologies: IEC 61850 family of standards, Ethernet technology. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution - Zones: Process, Field , Station, Operation - Interoperability Levels: Information
Description	The IEC 61850-7-3 defines constructed attributed classes and common data classes related to applications in the power system using IEC 61850 modelling concepts like substations, hydro power or distributed energy resources. These common data classes are used in IEC 61850-7-4 to define compatible dataObject classes. The SubDataObjects, DataAttributes or SubAttributes of the instances of dataObject are accessed using services defined in IEC 61850-7-2. The IEC 61850-7-3 is used to specify the abstract common data class and constructed attribute class definitions. These abstract definitions are mapped into concrete object definitions that are to be used for a particular protocol (for example MMS, ISO 9506 series). Common data classes used for service tracking are defined in IEC 61850-7-2.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by the text document including both tables and Substation Configuration Language -SCL - (XML) description of CDC classes. Main kind of provided messages/document/information: Data of the substation automation system SECURITY AND PRIVACY: - Security addressed by In the standard one can find the remark “security issues are solved by the IEC 62351 series”. Also: The security requirements for the restriction of access to the data in a server are defined in IEC 61850-5.
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring system control
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator;

NAME	DESCRIPTION
Use case clusters	- Blackout management - Connect an active actor to the grid - Controlling the grid (locally/ remotely) manually or automatically - Generation Maintenance - Maintaining grid assets - Managing power quality - Monitoring the grid flows - Protecting the grid assets - Reconfiguring the network in case of fault - System and security management
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems - EMS Scada system - WAMPACs - FACTS Distribution: - Substation automation systems - Feeder Automation System - ADMS - DMS SCADA and GIS system
Function specific and other covered system	Cross-cutting: - Data modelling
IPR	The standard is publicly available with fee.
Diffusion	- The standard has been implemented by vendors/suppliers. The main suppliers: ABB, Siemens, Alstom - The standard has been used in different electric power industry applications. Known implementations: Electric substations, power plants - There is support from one interest/users group. This is: UCA International User Group
Relation with other standards and technologies	- IEC 61850-7-3 results to be largely compatible with the following standards: IEC 61850-7-2, IEC 61850-7-3, IEC 61850-7-4, MMS/ACSE, TCP/IP, Ethernet - A process of harmonization with other standards is involving IEC 61850-7-3: IEC carries out harmonization process for IEC 61850, CIM and COSEM interfaces (e.g. IEC 61850-80-4 : COSEM over IEC 61850, IEC62056-6-9: Mapping between CIM and DLMS/COSEM data models). There is also IEC 61850-80-1 that contains guidelines to exchange the information from CDC (IEC 61850) based data model using IEC 60870-5-101/104 standards.

NAME	DESCRIPTION
Tools and documentation	- IEC 61850-7-3 has interoperability tests. The reference to these tests are the following: IEC 61850-10 Ed.2.: "Communication networks and systems for power utility automation - Part 10:Conformance testing". https://webstore.iec.ch - IEC 61850-7-3 provides guidelines and/or documentation. The reference to them are the following: 1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010; 2. IEC 61850-7-1 Ed.2: "Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models"; https://webstore.iec.ch/publication/6014; 3. IEC 61850-90-11: "Communication networks and systems for power utility automation – Part 90-11: Methodologies for modelling of logics for IEC 61850 based applications" - this technical report has not been published yet, 4. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010: http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf - IEC 61850-7-3 provides tutorials and/or examples. The reference to them are the following: 1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010; 2. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010: http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf - IEC 61850-7-3 provides tools for facilitating implementation. The reference to them are the following: • SISCO (USA) tools: http://www.sisconet.com/our-products/ • INFO TECH (Poland) tools: http://infotech.gdansk.pl • Kalki (India) tools: http://www.kalkitech.com/ - Evidence about positive impact of the standard provided by the following case studies: "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010
Possible barriers	
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.

NAME	DESCRIPTION
Maturity	Maturity equals to 73%. The strength of this evaluation is 100%. This parameter seems to be high. Knock-Out criteria are not specified.
Openness	Openness equals to 83%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 60%. The strength of this evaluation is 100%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 84,21% Final Strength = 97,44% Final Automated Evaluation = very high NOTE: For the 2,56% of the questions, available documentation has been judged insufficient

Reference documentation	[Communication networks and systems for power utility automation. Part 7-3: Ed.2: Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes] + https://webstore.iec.ch/publication/6016 [SGCG/M490/G_Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf [Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard. Group of Spanish Electricity Companies for studies on IEC 61850] + http://www.cired.net/publications/cired2011/part1/papers/CIRED2011_0422_final.pdf

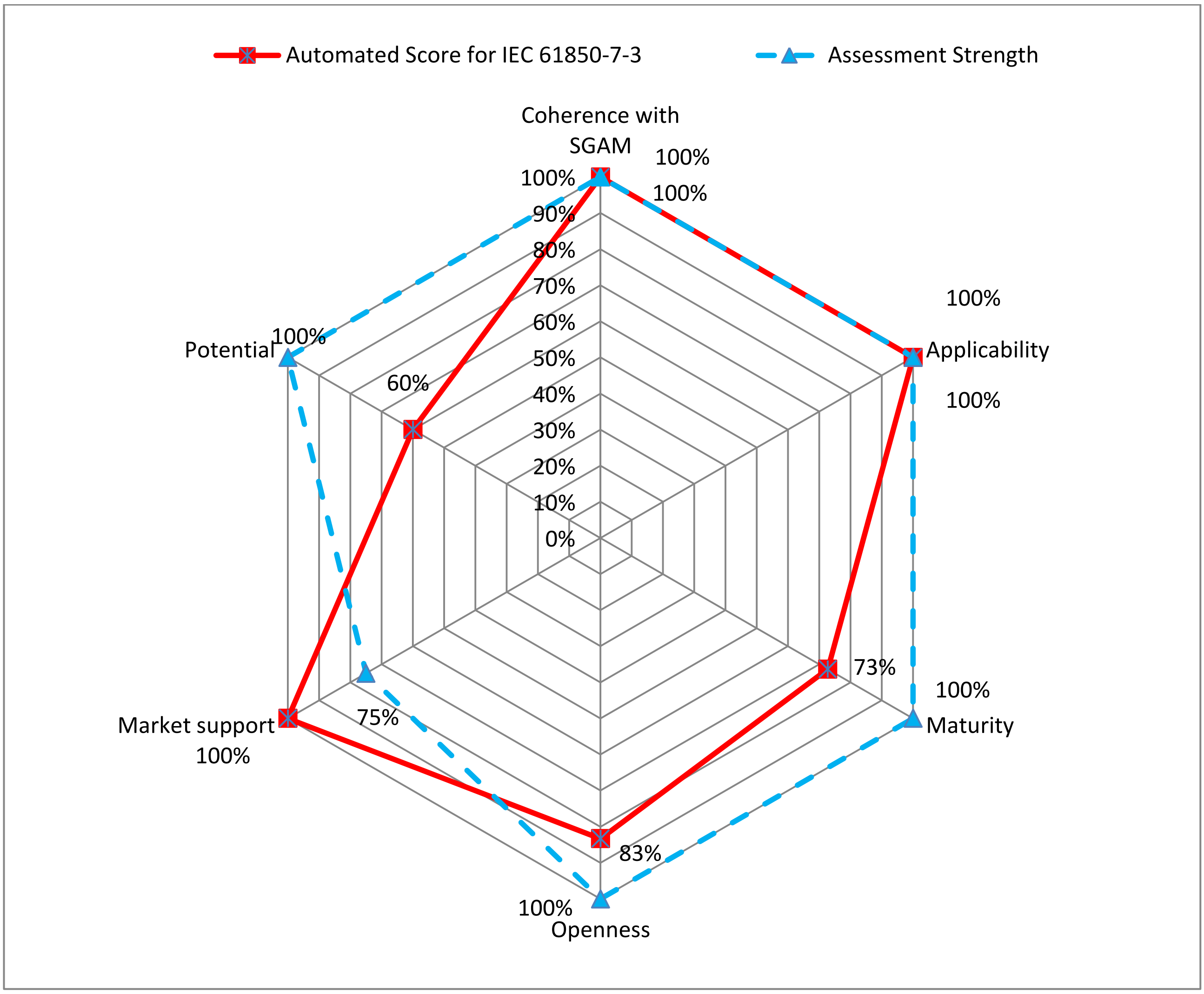

Figure 3 - Summary of IEC 61850-7-3 Evaluation

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Potential	There are no evidences about its impact Privacy is not well addressed.

Comments on Coherence with SGAM	Alternative standards: - The standard is an integral part of IEC 61850-7-x standards, where x=2,4 and also an integral part of extensions of CDC defined by other standards that belong to IEC 61850 group. From this point of view IEC 61850-7-3 is the only possible standard.

Comments on Applicability	Focus on interoperability for Smart Grid: - The IEC 61850 series is intended to provide interoperability between a variety of devices. Communication between these devices is achieved among other things, by the definition of so called Common Data Classes. They represent precisely defined types of data objects with their attributes useful for broad range of power utility automation applications. - There is no direct reference to Smart Grid concept within IEC 61850-7-3 standard. However the implementation of the standard IEC 61850 in SGAM information and communication layers is evident. Requirements: - IEC 61850-8-1 standard specifies the functional requirements of the IEC61850-7-x, x=2,3,4. Reusability: - The IEC 61850-7-3 standard is suitable only for SGAM information layer. However, it is suitable for different SGAM domains and zones.
Comments on Openness	Documentation: - The standard should be purchased.
Comments on Potential	Impact: - Revolution rather than evolution is required

Additional information about the standard IEC 61850-7-3 from IEC TC 57

The part 7-3 of the standard IEC 61850 specifies constructed attribute classes and common data classes (CDC) related to substation applications:

- common data classes for status information,
- common data classes for measured information,
- common data classes for control,
- common data classes for status settings,
- common data classes for analogue settings and
- attribute types used in these common data classes.

This part of the standard IEC 61850 also defines semantic for data attributes, controllable parameters and in some cases for data used in Clause 7 where the CDC is defined. Data attribute semantic is defined in a table form.

The IEC 61850-7-3 is applicable to the description of device models and functions of substations and feeder equipment. This standard may also be applied, for example, to describe device models and functions for:

- substation to substation information exchange,
- substation to control centre information exchange,
- power plant to control centre information exchange,
- information exchange for distributed generation, or
- information exchange for metering.

IEC 61850-7-4: Compatible logical node classes and data classes

NAME	DESCRIPTION
General information:	IEC 61850-7-4 was developed by IEC TC 57 and standardized by IEC - International Electrotechnical Commission. It is at its 2nd (two editions) version (Edition 2), released on the 03/2010. Its first release was released on the 05/2003. More information at: https://webstore.iec.ch/publication/6017
Aim and technologies	This standard is part of a set of specifications, which details layered substation communication architecture. This architecture has been chosen to provide abstract definitions of classes and services such that the specifications are independent of specific protocol stacks and objects. The mapping of these abstract classes and services to communication stacks is outside the scope of IEC 61850-7-4 and may be found in IEC 61850-8-x (station bus) and IEC 61850-9-x (process bus). It is based on the following technologies: IEC 61850 family of standards, Ethernet technology. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution - Zones: Process, Field , Station, Operation - Interoperability Levels: Information
Description	The IEC 61850-7-4 specifies the information model of devices and functions generally related to common use regarding applications in systems for power utility automation. It also contains the information model of devices and function-related applications in substations. In particular, it specifies the compatible logical node names and data object names for communication between intelligent electronic devices (IED). This includes the relationship between logical nodes and data objects. The logical node names and data object names defined in IEC 61850-7-4 are part of the class model introduced in IEC 61850-7-1 and defined in IEC 61850-7-2. The names defined in IEC 61850-7-4 are used to build the hierarchical object references applied for communicating with IEDs in systems for power utility automation and, especially, with IEDs in substations and on distribution feeders. The naming conventions of IEC 61850-7-2 are applied in IEC 61850-7-4.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by The text document including both tables and Substation Configuration Language -SCL - (XML) description of CDC classes Main kind of provided messages/document/information: Data of the substation automation system SECURITY AND PRIVACY: - Security addressed by In the standard one can find the remark: security issues are solved by the IEC 62351 series. Also: The security requirements for the restriction of access to the data in a server are defined in IEC 61850-5.
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring system control

NAME	DESCRIPTION
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator;
Use case clusters	- Blackout management - Connect an active actor to the grid - Controlling the grid (locally/ remotely) manually or automatically - Generation Maintenance - Maintaining grid assets - Managing power quality - Monitoring the grid flows - Protecting the grid assets - Reconfiguring the network in case of fault - System and security management
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems - EMS Scada system - WAMPACs - FACTS Distribution: - Substation automation systems - Feeder Automation System - ADMS - DMS SCADA and GIS system
Function specific and other covered system	Cross-cutting: - Data modelling
IPR	The standard is publicly available with fee.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: The main suppliers: ABB, Siemens, Alstom- - The standard has been used in different electric power industry applications. Known implementations: Electric substations, power plants - There is support from one interest/users group. This is: UCA International User Group
Relation with other standards and technologies	- IEC 61850-7-4 results to be largely compatible with the following standards: IEC 61850-7-2, IEC 61850-7-3, IEC 61850-7-4, MMS/ACSE, TCP/IP, Ethernet - A process of harmonization with other standards is involving IEC 61850-7-4: IEC carries out harmonization process for IEC 61850, CIM and COSEM interfaces (e.g. IEC 61850-80-4: COSEM over IEC 61850, IEC62056-6-9: Mapping between CIM and DLMS/COSEM data models). There is also IEC 61850-80-1 that contains guidelines to exchange the information from CDC (IEC 61850) based data model using IEC 60870-5-101/104 standards.

NAME	DESCRIPTION
Tools and documentation	- IEC 61850-7-4 has interoperability tests. The reference to these tests are the following: IEC 61850-10 Ed.2.: "Communication networks and systems for power utility automation - Part 10:Conformance testing". https://webstore.iec.ch - IEC 61850-7-4 provides guidelines and/or documentation. The reference to them are the following: 1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010; 2. IEC 61850-7-1 Ed.2: "Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models"; https://webstore.iec.ch/publication/6014; 3. IEC 61850-90-11: "Communication networks and systems for power utility automation – Part 90-11: Methodologies for modelling of logics for IEC 61850 based applications" - this technical report has not been published yet, 4. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010: http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf - IEC 61850-7-4 provides tutorials and/or examples. The reference to them are the following: 1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010; 2. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010: http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf - IEC 61850-7-4 provides tools for facilitating implementation. The reference to them are the following: • SISCO (USA) tools: http://www.sisconet.com/our-products/ • INFO TECH (Poland) tools: http://infotech.gdansk.pl • KalkiTech (India) tools: http://www.kalkitech.com/ - Evidence about positive impact of the standard provided by the following case studies: "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010
Possible barriers	
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 73%. The strength of this evaluation is 100%. This parameter seems to be high. Knock-Out criteria are not specified.
Openness	Openness equals to 83%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.

NAME	DESCRIPTION
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 60%. The strength of this evaluation is 100%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 84,21% Final Strength = 97,44% Final Automated Evaluation = very high NOTE: For the 2,56% of the questions, available documentation has been judged insufficient

Reference documentation	[Communication networks and systems for power utility automation. Part 7-4: Ed.2: Communication networks and systems for power utility automation – Part 7-4: Basic communication structure – Compatible logical node classes and data object classes] + https://webstore.iec.ch/publication/6017 [SGCG/M490/G Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf [Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard. Group of Spanish Electricity Companies for studies on IEC 61850] + http://www.cired.net/publications/cired2011/part1/papers/CIRED2011_0422_final.pdf

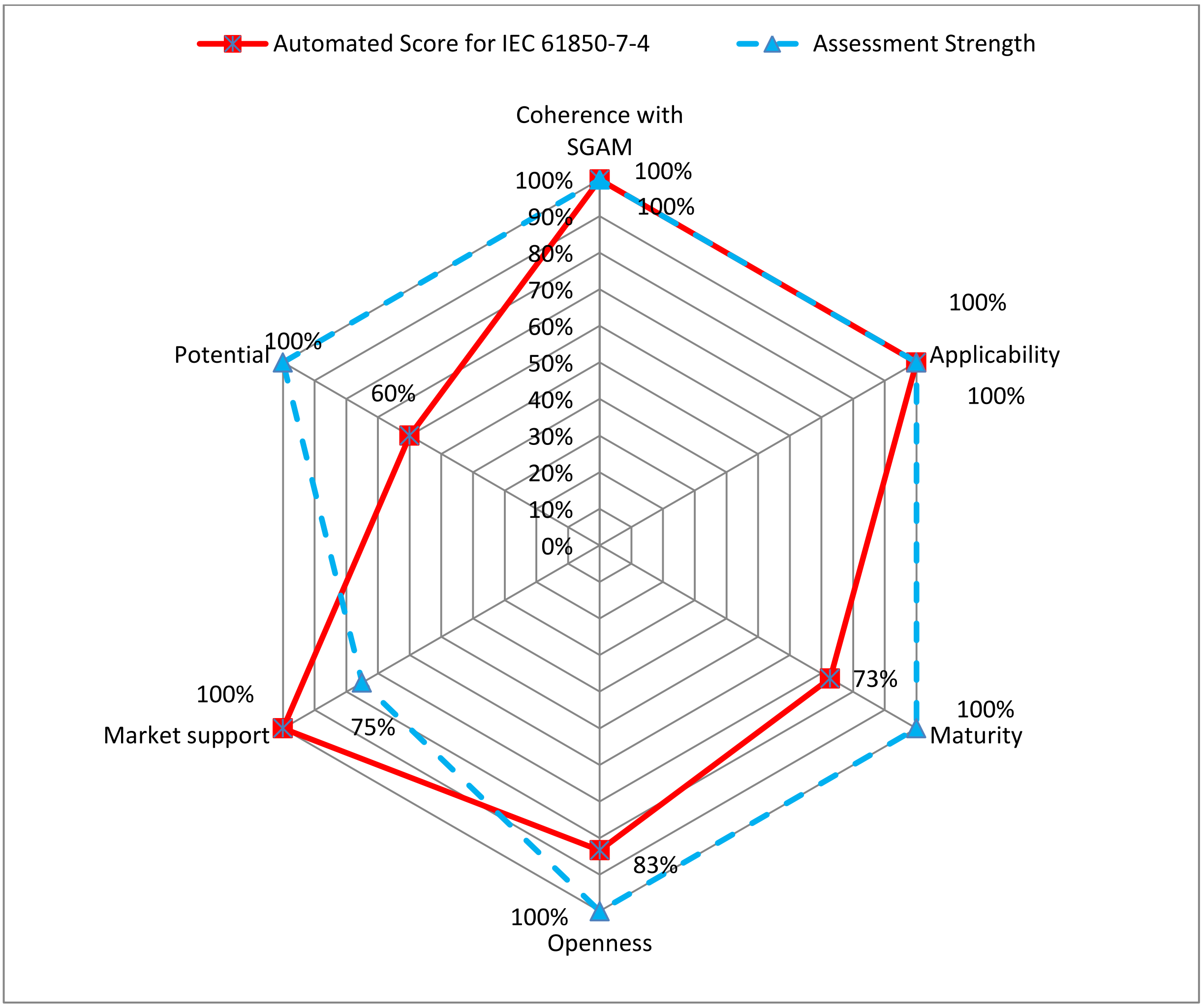

Figure 4 - Summary of IEC 61850-7-4 Evaluation

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Potential	There are no evidences about its impact Privacy is not well addressed.

Comments on Coherence with SGAM	Alternative standards: - The standard is an integral part of IEC 61850-7-x standards, where x=2,3, and also an integral part of extensions of logical nodes defined by other standards that belong to IEC 61850 group. From this point of view IEC 61850-7-4 is the only possible standard.

Comments on Applicability	Focus on interoperability for Smart Grid: - The IEC 61850 series is intended to provide interoperability between a variety of devices. Communication between these devices is achieved among other things, by the definition so called Logical Nodes. They represent precisely defined virtual "bricks" which correspond to well-known functions in real devices. - There is no direct reference to Smart Grid concept within IEC 61850-7-4 standard. However the implementation of the standard IEC 61850 in SGAM information and communication layers is evident. Requirements: - IEC 61850-8-1 standard specifies the functional requirements of the IEC61850-7-x, x=2,3,4. Reusability: - The IEC 61850-7-4 standard is suitable only for SGAM information layer. However, it is suitable for different SGAM domains and zones.
Comments on Openness	Documentation: - The standard should be purchased.
Comments on Potential	Impact: - Revolution rather than evolution is required

Additional information about the standard IEC 61850-7-4 from IEC TC 57

The part 7-4 of the standard IEC 61850 specifies the information model of devices and functions generally related to common use regarding applications in systems for power utility automation. It also contains the information model of devices and function-related applications in substations. In particular, it specifies the compatible logical node (LN) names and data object names for communication between intelligent electronic devices (IED). This includes the relationship between logical nodes and data objects.

The logical node names and data object names defined in IEC 61850-7-4 are part of the class model introduced in IEC 61850-7-1 and defined in IEC 61850-7-2. The names defined in this document are used to build the hierarchical object references applied for communicating with IEDs in systems for power utility automation and, especially, with IEDs in substations and on distribution feeders. The naming conventions of IEC 61850-7-2 are applied in this part. To avoid private, incompatible extensions, this part specifies normative naming rules for multiple instances and private, compatible extensions of logical node (LN) classes and data object names. Any definition is based on IEC 61850 or on referenced well identified public documents.

IEC 61850-7-4 is applicable to describe device models and functions of substation and feeder equipment. The concepts defined in this standard are also applied to describe device models and functions for:

- substation-to-substation information exchange,
- substation-to-control centre information exchange,
- power plant-to-control centre information exchange,
- information exchange for distributed generation,
- information exchange for distributed automation, or
- information exchange for metering.

The groups of logical nodes defined in IEC 61850-7-4 are ordered according to some semantic meaning (for convenience, the logical nodes are defined in this standard in alphabetical order): systems LNs - L, interface LNs - I, unit/bay level LNs - C, P, R, process/equipment level LNs - K, S, X, T, Y, Z, general use LNs - G, F.

IEC 61850-7-410: Hydroelectric Power Plants - Communication for monitoring and control

NAME	DESCRIPTION
General information:	IEC 61850-7-410 was developed by IEC TC 57 and standardized by IEC - International Electrotechnical Commission. It is at its 2nd version (Edition 2), released on the 2012. Its first release was released on the 2007. More information at: https://webstore.iec.ch
Aim and technologies	This part (IEC 61850-7-410) of the standard IEC 61850 specifies the additional (with respect to IEC 61850-7-4 and IEC 61850-7-3) logical nodes, common data classes and semantics of data object attributes required for the use of IEC 61850 in a hydroelectric power plant. It is based on the following technologies: IEC 61850 family of standards, Ethernet technology. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution, DER - Zones: Process, Field , Station, Operation - Interoperability Levels: Information
Description	This standard is part of the set of specifications which belong to IEC 61850 standard family, which details layered communication architecture for electric power utility automation. This architecture has been chosen to provide abstract definitions of data classes and services such that the specifications are independent of specific protocol stacks and objects. The mapping of these abstract data classes and services to communication stacks is outside the scope of IEC 61850-7-410 and may be found in IEC 61850-8-x (station bus) and IEC 61850-9-x (process bus). The IEC 61850-7-410 extends IEC 61850-7-4 and IEC 61850-7-3 standards and specifies the information model of devices and functions generally related to common use in hydroelectric power plans.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by The text document including tables which define Logical Nodes (LN), Common Data Classes (CDC) and data attribute semantics. Main kind of provided messages/document/information: Data of the hydroelectric power plant automation system.
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring system control
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator;

NAME	DESCRIPTION
Use case clusters	- Blackout management - Connect an active actor to the grid - Controlling the grid (locally/ remotely) manually or automatically - Generation Maintenance - Generation Transverse - Maintaining grid assets - Managing power quality - Monitoring the grid flows - Operate DER(s) - Protecting the grid assets - Reconfiguring the network in case of fault
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems Distribution: - Substation automation systems - Feeder Automation System DER: - DER operation systems
Function specific and other covered system	Cross-cutting: - Data modelling
IPR	The standard is publicly available with fee.
Diffusion	- The standard has been implemented by vendors/suppliers. The main suppliers: ABB, Siemens, Alstom - The standard has been used in different electric power industry applications. Known implementations: Electric substations, power plants - There is support from one interest/users groups. This is: UCA International User Group
Relation with other standards and technologies	- IEC 61850-7-410 results to be largely compatible with the following standards: IEC 61850-7-410, IEC 61850-7-4, IEC 61850-7-3, IEC 61850-7-2, MMS/ACSE, TCP/IP, Ethernet - A process of harmonization with other standards is involving IEC 61850-7-410: IEC carries out harmonization process for IEC 61850, CIM and COSEM interfaces (e.g. IEC 61850-80-4: COSEM over IEC 61850, IEC62056-6-9: Mapping between CIM and DLMS/COSEM data models). There is also IEC 61850-80-1 that contains guidelines to exchange the information from CDC (IEC 61850) based data model using IEC 60870-5-101/104 standards.

NAME	DESCRIPTION
Tools and documentation	- IEC 61850-7-410 has interoperability tests. The reference to these tests are the following: IEC 61850-10 Ed.2.: "Communication networks and systems for power utility automation - Part 10:Conformance testing". https://webstore.iec.ch - IEC 61850-7-410 provides guidelines and/or documentation. The reference to them are the following: 1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010; 2. IEC 61850-7-1 Ed.2: "Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models"; https://webstore.iec.ch/publication/6014; 3. IEC 61850-90-11: "Communication networks and systems for power utility automation – Part 90-11: Methodologies for modelling of logics for IEC 61850 based applications" - this technical report has not been published yet, 4. IEC TR 61850-7-510. "Communication networks and systems for power utility automation - Part 7-510: Basic communication structure - Hydroelectric power plants - Modelling concepts and guidelines"; https://webstore.iec.ch/publication/6020; 5. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010: http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf - IEC 61850-7-410 provides tutorials and/or examples. The reference to them are the following: 1. IEC 61850-7-1 Ed.2: "Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models"; https://webstore.iec.ch/publication/6014; 2. IEC TR 61850-7-510 Ed.1. "Communication networks and systems for power utility automation - Part 7-510: Basic communication structure - Hydroelectric power plants - Modelling concepts and guidelines"; https://webstore.iec.ch/publication/6020; 3. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010; http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf - IEC 61850-7-410 provides tools for facilitating implementation. The reference to them are the following: SISCO (USA) tools: http://www.sisconet.com/our-products/ INFO TECH (Poland) tools: http://infotech.gdansk.pl KalkiTech (India) tools: http://www.kalkitech.com/ - Evidence about positive impact of the standard provided by the following case studies: "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010
Possible barriers	
Assessment	**The standard has been evaluated in following way, according to the following parameters:**

NAME	DESCRIPTION
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 82%. The strength of this evaluation is 100%. This parameter seems to be very high. Knock-Out criteria are not specified.
Openness	Openness equals to 83%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 40%. The strength of this evaluation is 100%. This parameter seems to be low. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 84,21% Final Strength = 97,44% Final Automated Evaluation = very high NOTE: For the 2,56% of the questions, available documentation has been judged insufficient

Reference documentation	[Communication networks and systems for power utility automation - Part 7-410: Basic communication structure - Hydroelectric power plants - Communication for monitoring and control.] + https://webstore.iec.ch [SGCG/M490/G_Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf [Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard. Group of Spanish Electricity Companies for studies on IEC 61850] + http://www.cired.net/publications/cired2011/part1/papers/CIRED2011_0422_final.pdf

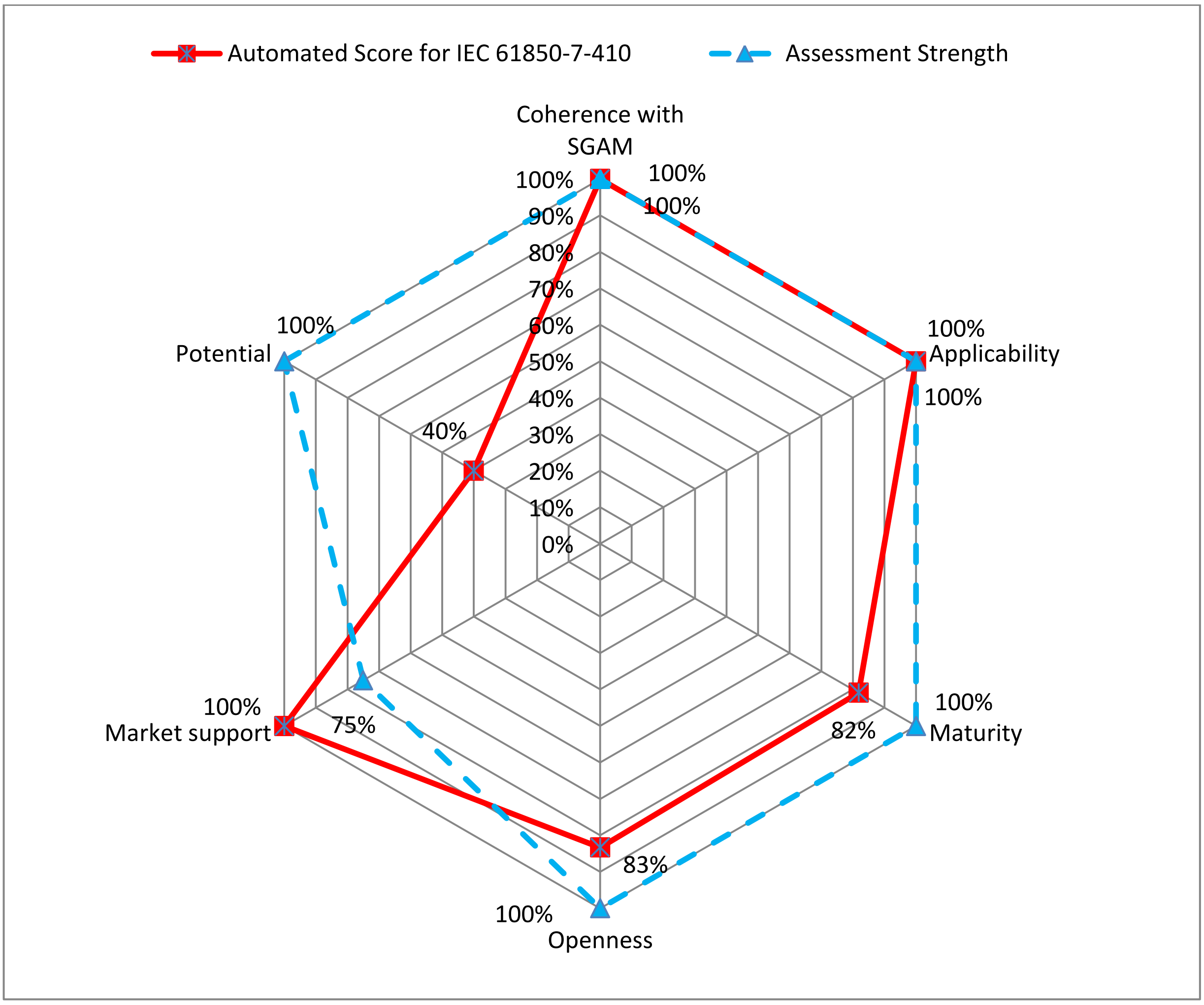

Figure 5 - Summary of IEC 61850-7-410 Assessment

Critical points for Potential	There are no evidences about its impact Security is not well addressed, Privacy is not well addressed.

Comments on Coherence with SGAM	Alternative standards: - The standard has to be considered as the integral part of the IEC 61850-7-x standard group, where x=2,3,4. The standard is destined for modelling data communication in hydroelectric power plants and from this point of view IEC 61850-7-410 is the only possible standard.

Comments on Applicability	Focus on interoperability for Smart Grid: - The IEC 61850 series is intended to provide interoperability between a variety of devices. Communication between these devices is achieved among other things, by the definition so called Logical Nodes. They represent precisely defined virtual "bricks" which correspond to well-known functions in real devices. - There is no direct reference to Smart Grid concept within IEC 61850-7-410 standard. However, the implementation of the standard IEC 61850 in SGAM information and communication layers is evident. Requirements: - IEC 61850-8-1 standard specifies the functional requirements for the use and implementation of the IEC 61850-7-410 (as in the case of IEC 61850-7-x, x=2,3,4). Reusability: - The IEC 61850-7-410 standard is suitable only for SGAM information layer. However, it is suitable for different SGAM domains and zones.
Comments on Openness	Documentation: - The standard should be purchased.
Comments on Potential	Impact: - Revolution rather than evolution is required

Additional information about the standard IEC 61850-7-410 from IEC TC 57

The part 7-410 of the standard IEC 61850 specifies the information model of devices and functions generally related to common use regarding applications in systems for power utility automation. In particular, it specifies the logical nods (LN) and data objects of these LNs (belonging to the so called Common Data Classes - CDC) which are dedicated for data communication modelling between devices in hydroelectric power plants. It also specifies semantics of the data object attributes .

The logical node and data object names defined in IEC 61850-7-410 are part of the class model introduced in IEC 61850-7-1 and defined in IEC 61850-7-2. The names defined in this document are used to build the hierarchical object references applied for communicating with devices in hydroelectric power plants.

The standard IEC 61850-7-410 contains:

1. Definitions of Logical Nodes classes which are not included in IEC 61850-7-4. These definitions are divided into the following groups:

- Group A – Automatic functions;
- Group F – Functional blocks;
- Group H – Hydropower specific logical nodes;
- Group I – Interface and archiving;
- Group K – Mechanical and non-electrical primary equipment;
- Group P – Protection functions;
- Group R – Protection related functions;
- Group S – Supervision and monitoring;
- Group X – Switchgear.

2. Definitions of Common Data Classes which are not included in IEC 61850-7-3.

3. Descriptions of data attribute semantics (for the attributes which are not described in IEC 61850-7-3 and IEC 61850-7-2).

IEC 61850-7-420: Communications systems for Distributed Energy Resources (DER) - Logical nodes

NAME	DESCRIPTION
General information:	IEC 61850-7-420 Edition 1.0 2009-03 was developed by The International Electrotechnical Commission IEC and standardized by IEC. It is at its 1st version (Edition 1.0 2009-03), released on the 10/03/2009. Its first release was released on the 10/03/2009. More information at: https://webstore.iec.ch/publication/6019
Aim and technologies	IEC 61850-7-420 Edition 1.0 2009-03 was developed with the following aim: Provision of DER owners with communication standards and protocols for monitoring and control of DER devices interconnected with the utility power system It address: Interoperability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Transmission, Distribution, DER, Customer Premises - Zones: Field , Station, Operation - Interoperability Levels: Information
Description	Increasing number of DER poses operational challenges which can be tackled with standards unifying and harmonising communication among DER devices. In this context, the present standard provides a conceptual data architecture for DER. This architecture is based on Logical Nodes. In particular, this information model provides standardised names and structures of data, facilitating so the exchange of information among the devices. The hierarchy of the model is divided into layers, such as: Standard Data Types, Common Attributes, Common Data Classes, Data Objects, Logical Nodes and Logical Devices. Types of DER devices that can be serviced by the model include reciprocating engines, fuel cells, microturbines, photovoltaic plants, CHPs and energy storage. The standard can also be applicable to central-station generation installations comprised of groupings of multiple units of the same type.
Other Technical Information	
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring electricity network security --- Ensuring system control --- Ensuring quality of supply
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator; Electricity Installer / Contractor; Supplier ; Retailer; Customers: Industrial customer; Buildings; Home customer; Energy Market Place: Power Exchange; Balance Responsible Party; Supplier; Aggregator;
Use case clusters	- Access Control (Substation Remote Access Example) - (AMI) Collect events and status information - (AMI) Configure events, statuses and actions - Controlling the grid (locally/ remotely) manually or automatically - Demand and production (generation) flexibility - Operate DER(s) - System and security management

NAME	DESCRIPTION
Covered SGAM Domain specific systems	Transmission: - Substation automation systems Distribution: - Substation automation systems - Feeder Automation System DER: - DER operation systems Customer Premises: - e-Mobility
Function specific and other covered system	Micro-grid: - Micro-grid systems
IPR	The standard is publicly available with fee.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: ABB, SIEMENS etc. - The standard has been used in different electric power industry applications. Number of known implementations: http://www09.abb.com/global/scot/scot313.nsf/veritydisplay/37cc3658aa6c2cb3c12576ff0070719d/$file/3BUS095133_en_Process_and_Substation_Integration_White_Paper.pdf http://www.openmuc.org/fileadmin/user_upload/papers/20120726_isgt-europe2012_feuerhahn_iec61850-chp-profile_final.pdf http://www.cired.net/publications/cired2011/part1/papers/CIRED2011_0790_final.pdf http://www.microgrids.eu/documents/657.pdf - There is support from one ore more interest/users groups. These are:DSOs: http://www.edsoforsmartgrids.eu/wp-content/uploads/public/DSO-Priorities-Smart-Gird-Standardisation.pdf TSOs:https://www.entsoe.eu/fileadmin/user_upload/_library/position_papers/120409_RDC-Statement_IEC61850_final_.pdf
Relation with other standards and technologies	- IEC 61850-7-420 Edition 1.0 2009-03 results to be largely compatible with the following standards: MMS(ISO9506), Sampled Values (SV), GOOSE, TimeSync(SNTP), GSSE - A process of harmonization with other standards is involving IEC 61850-7-420 Edition 1.0 2009-03: The second version of IEC 61850-7-420 is due in September 2015 and it will be fully harmonised with IEC 61850-90-7

NAME	DESCRIPTION
Tools and documentation	- IEC 61850-7-420 Edition 1.0 2009-03 has interoperability tests. The reference to these tests are the following: https://www.entsoe.eu/Documents/RDC%20documents/Standardisation/IEC61850/ISTool_IEC61850_Poster.pdf - IEC 61850-7-420 Edition 1.0 2009-03 has interoperability tests. The reference to these tests are the following: https://www.entsoe.eu/Documents/RDC%20documents/Standardisation/IEC61850/ISTool_IEC61850_Poster.pdf - IEC 61850-7-420 Edition 1.0 2009-03 provides guidelines and/or documentation. The reference to them are the following: https://webstore.iec.ch/publication/6019, http://ieeexplore.ieee.org/Xplore/defdeny.jsp?url=http%3A%2F%2Fieeexplore.ieee.org%2Fstamp%2Fstamp.jsp%3Ftp%3D%26arnumber%3D1709546%26userType%3Dinst&denyReason=-134&arnumber=1709546&productsMatched=null&userType=inst - IEC 61850-7-420 Edition 1.0 2009-03 provides tutorials and/or examples. The reference to them are the following: https://webstore.iec.ch/publication/6019, http://ieeexplore.ieee.org/Xplore/defdeny.jsp?url=http%3A%2F%2Fieeexplore.ieee.org%2Fstamp%2Fstamp.jsp%3Ftp%3D%26arnumber%3D1709546%26userType%3Dinst&denyReason=-134&arnumber=1709546&productsMatched=null&userType=inst - IEC 61850-7-420 Edition 1.0 2009-03 provides tools for facilitating implementation. The reference to them are the following: https://www.omicron.at/en/products/all/secondary-testing-calibration/iedscout/#Download - Evidence about positive impact of the standard provided by the following case studies: MoreMicrogrids, "DE4: Report on applied data structures and mapping to communication means", December 2009 http://www.microgrids.eu/documents/657.pdf - Evidence about positive migration of current system provided by the following case studies: MoreMicrogrids, "DE4: Report on applied data structures and mapping to communication means", December 2009 http://www.microgrids.eu/documents/657.pdf
Possible barriers	- There is some probability that IEC 61850-7-420 Edition 1.0 2009-03 can be affected by scarce maintenance/updating of the specifications
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 90%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 80%. The strength of this evaluation is 100%. This parameter seems to be very high. Knock-Out criteria are not specified.
Openness	Openness equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.

NAME	DESCRIPTION
Potential	Potential equals to 60%. The strength of this evaluation is 100%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There is 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 78,38% Final Strength = 97,44% Final Automated Evaluation = high NOTE: For the 2,56% of the questions, available documentation has been judged insufficient

Reference documentation	IEC 61850-7-420 Ed. 1.0 2009-03, "Communication networks and systems for power utility automation"-Part 7-420: "Basic communication structure-Distributed energy resources logical nodes" https://webstore.iec.ch/publication/6019 CEN-CENELEC-ETSI Smart Grid Coordination Group, "Set of standards, ver. 3.1", October 31st, 2014 R. E. Mackienwicz, "Overview of IEC 61850 and benefits", IEEE Power Engineering Society General Meeting, 2006, Montreal, Canada http://ieeexplore.ieee.org/Xplore/defdeny.jsp?url=http%3A%2F%2Fieeexplore.ieee.org%2Fstamp%2Fstamp.jsp%3Ftp%3D%26arnumber%3D1709546%26userType%3Dinst&denyReason=-134&arnumber=1709546&productsMatched=null&userType=inst

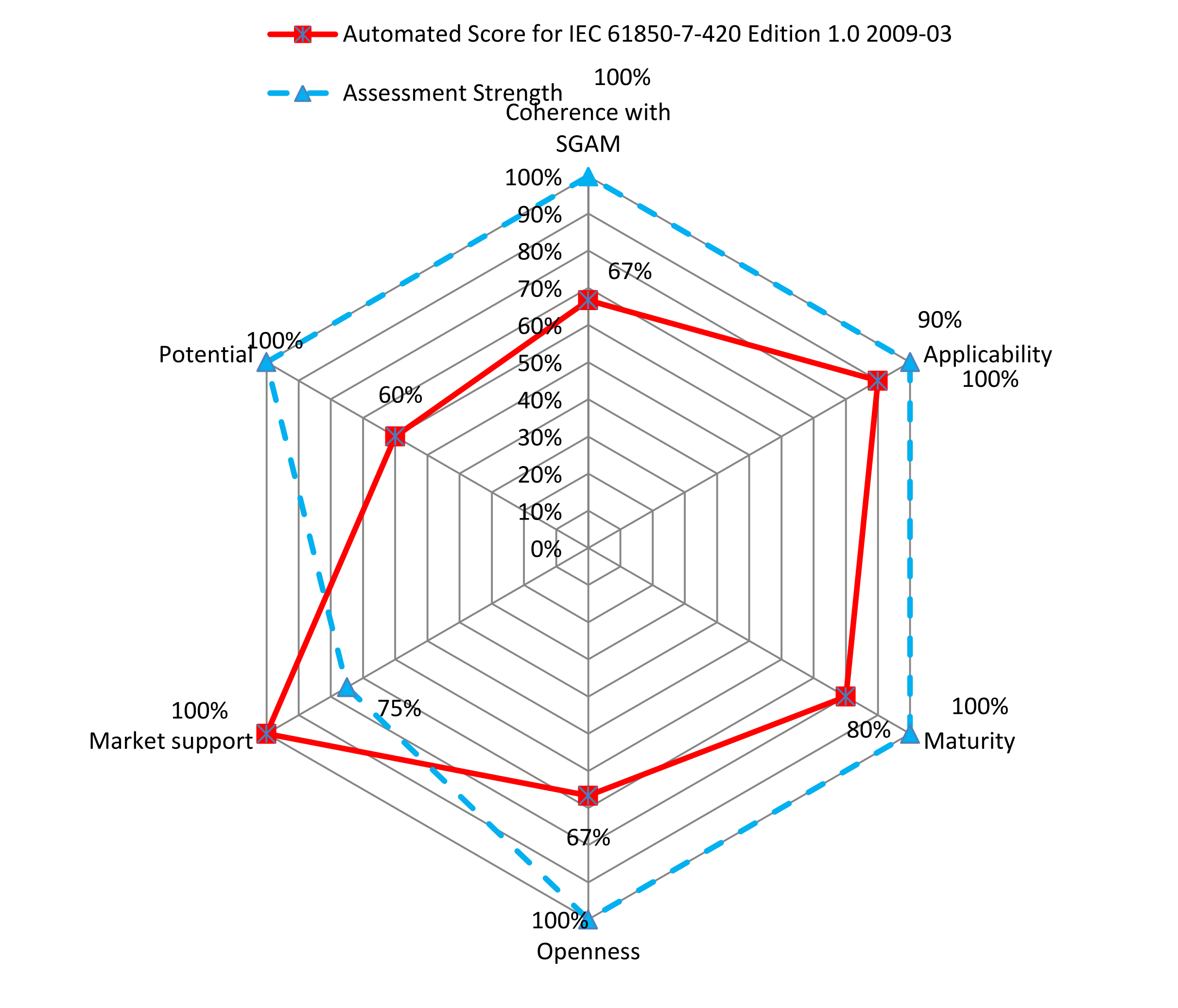

Figure 6 - Summary of IEC 61850-8 Assessment

Critical points for Openness	Some important information/documentation about the process or the standard is not publicly available. Specifications are not licensed on a royalty-free basis.
Critical points for Potential	Security is not well addressed, Privacy is not well addressed.

Comments on Coherence with SGAM	Coordinates on the SGAM Reference Model: - The standard is explicitly positioned in SGAM. Particularly on the Information Layer - It is explicitly associated with the use cases (where applicable) as these are defined by the SGCG Alternative standards: - Part of the IEC 61850-7-420 regarding power inverters is further addressed in IEC 61850-90-7

Comments on Applicability	Focus on interoperability for Smart Grid: - The aim of the standard in not only to establish communication between devices (locally) but also with operators who manage the DER plant as a virtual source for energy and/or ancillary services Requirements: - The standard addresses the data format but it should be used as part of the 61850 series which also covers services, communication protocols and telecommunication media required Reusability: - For instance although dedicated to DER management, the standard is also placed in SGAM Use Cases regarding Transmission and Distribution Management Systems Ambiguity: - Ambiguities are neatly tackled with the categorisation and organisation of logical nodes which does not allow for misinterpretations and misuse of these elements Dependencies: - The main scope of this standard and the relevant series was the disconnection of data exchange from proprietary vendor-based platforms - For the same reason as above Geographical basis: - The specifications of the whole series have global applicability, independent of geographical criteria
Comments on Maturity	Development status: - The first version was published in March 2009, after reaching a maturity level following 6 years of processing. In the near future (September 2015) the second version is expected to come out Stability: - This is the first version of the standard
Comments on Openness	Process: - The process and decisions of the TC are announced yet the discussion results/documents are not freely available Documentation: - The process and decisions of the TC are regularly announced yet the discussion results/documents are not freely available - There is a substantial number of published work which presents an overview and implementation examples of the specific series Licences: - Each user has to pay a fee for buying a copy of the standard

Additional information about the standard IEC 61850-7-420 Edition 1.0 2009-03 from The International Electrotechnical Commission IEC
The specific standard addresses the IEC 61850 modelling for DER. One of the main features of the standard is that it is fully compatible with the Common Information Model (CIM) concepts. Also, it is complementary to a wider set of standards covering substation automation (IEC 61850-7-4) and large hydroelectric plants (IEC 61850-7-410). As a matter of fact IEC 61850-7-420 makes use of existing logical nodes from IEC 61850-7-4 where applicable and defines new logical nodes which are DER-specific. The hierarchical structure of the data in this standard includes Logical Nodes organised under specific Logical Devices. Since different applications require different combinations of LNs, LDs cannot be directly defined. However, LNs can be defined as groupings of Data Objects. The latter consist of Common Data Classes made up from Common Attributes. Exact definitions of all the above mentioned elements are provided by the accompanying standards IEC 61850-7-3 and 4. The LNs for DER contain some items that are either mandatory, optional or conditional and follow a specific naming structure (based on IEC 61850-7-2 Ed. 2).

Additional information about the standard IEC 61850-7-420 Edition 1.0 2009-03 from The International Electrotechnical Commission IEC
The LNs in the standard are organised in groups according to their purpose of use, thus including System Logical Nodes (e.g. physical device information LNs) and DER Management LNs. Of note logical nodes with high relevance to the ELECTRA UCs are the LN for DER energy and/or ancillary services schedule (DSCH).

IEC 61850-8-1: Mappings to MMS (ISO/IEC9506-1 and ISO/IEC 9506-2)

NAME	DESCRIPTION
General information:	IEC 61850-8-1 was developed by The International Electrotechnical Commission (IEC) and standardized by IEC. It is at its 2nd version (2.0), released on the 17/06/2011. Its first release was released on the 25/05/2004. More information at: https://webstore.iec.ch/publication/20082
Aim and technologies	IEC 61850-8-1 was developed with the following aim: The purpose of IEC 61850-8-1 is to provide detailed instructions/specification as to the mechanisms and rules required to implement the services, objects, and algorithms specified in IEC 61850-7-2, IEC 61850-7-3, and IEC 61850-7-4 while making use of ISO 9506 (all parts) (Manufacturing Message Specification), SNTP, and other application protocols. It address: Interoperability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution, DER - Zones: Field , Station - Interoperability Levels: Communication
Description	Specifies a method of exchanging time-critical and non-time-critical data through local-area networks by mapping ACSI to MMS and ISO/IEC 8802-3 frames. MMS services and protocol are specified to operate over full OSI and TCP compliant communications profiles. The use of MMS allows provisions for supporting both centralized and distributed architectures. This standard includes the exchange of real-time data indications, control operations, report notification.
Other Technical Information	COMMUNICATION STANDARD FEATURES: Time latency: Fast, medium speed, low speed messages
List of enabled Smart Grid functionalities	- Ensuring network security, system control and quality of supply -> In particular: --- Ensuring electricity network security --- Ensuring system control --- Ensuring quality of supply
Involved actors	Grid Operators: TSO; DSO;
Use case clusters	- Controlling the grid (locally/ remotely) manually or automatically - Grid stability - Managing power quality - Secure adequacy of supply - System and security management

NAME	DESCRIPTION
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems - WAMPACs Distribution: - Substation automation systems - Feeder Automation System - ADMS DER: - DER operation systems
Function specific and other covered system	Administration: - Assets and maintenance management system
IPR	The standard is publicly available with fee.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: Siemens, ABB, Kalkitech, etc. Uses this standard in their products. - The standard has a significant market share of adoption. Markets share: Two sources below: http://www.bloomberg.com/apps/news?pid=newsarchive&sid=a440bfedUDaE http://www.researchandmarkets.com/research/c76c9c/iec_61850_routers
Relation with other standards and technologies	- IEC 61850-8-1 results to be largely compatible with the following standards: MMS (ISO 9506), SNTP, … - A process of harmonization with other standards is involving IEC 61850-8-1: IEC 61850-90-2 for future vertical communication
Tools and documentation	- IEC 61850-8-1 has interoperability tests. The reference to these tests are the following: http://www.dnvkema.com/Images/COM118%20Conformance%20test%20Register%2061850.pdf - IEC 61850-8-1 provides guidelines and/or documentation. The reference to them are the following: International standard document of IEC61850-8-1 - IEC 61850-8-1 provides tutorials and/or examples. The reference to them are the following: International standard document of IEC61850-8-1 - IEC 61850-8-1 provides tools for facilitating implementation. The reference to them are the following: https://www.trianglemicroworks.com/ - Evidence about positive impact of the standard provided by the following case studies: http://www09.abb.com/global/scot/scot296.nsf/veritydisplay/a56430e1e7c06fdfc12577a00043ab8b/$file/3BSE063756_en_ABB_Review_Special_Report_IEC_61850.pdf - Evidence about positive migration of current system provided by the following case studies: http://www09.abb.com/global/scot/scot296.nsf/veritydisplay/a56430e1e7c06fdfc12577a00043ab8b/$file/3BSE063756_en_ABB_Review_Special_Report_IEC_61850.pdf

NAME	DESCRIPTION
Possible barriers	- There is strong probability that IEC 61850-8-1is affected by scarce maintenance/updating of the specifications - There is some probability that IEC 61850-8-1 can be affected by lacking of Critical mass
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 90%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 78%. The strength of this evaluation is 74%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Openness	Openness equals to 50%. The strength of this evaluation is 90%. This parameter seems to be low. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 45%. This parameter seems to be moderate. The evaluation of this parameter is partial, since, for the 50% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Potential	Potential equals to 100%. The strength of this evaluation is 36%. This parameter seems to be low. The evaluation of this parameter is partial, since, for the 60% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 81,25% Final Strength = 73,85% Final Automated Evaluation = high NOTE: For the 17,95% of the questions, available documentation has been judged insufficient

Reference documentation	

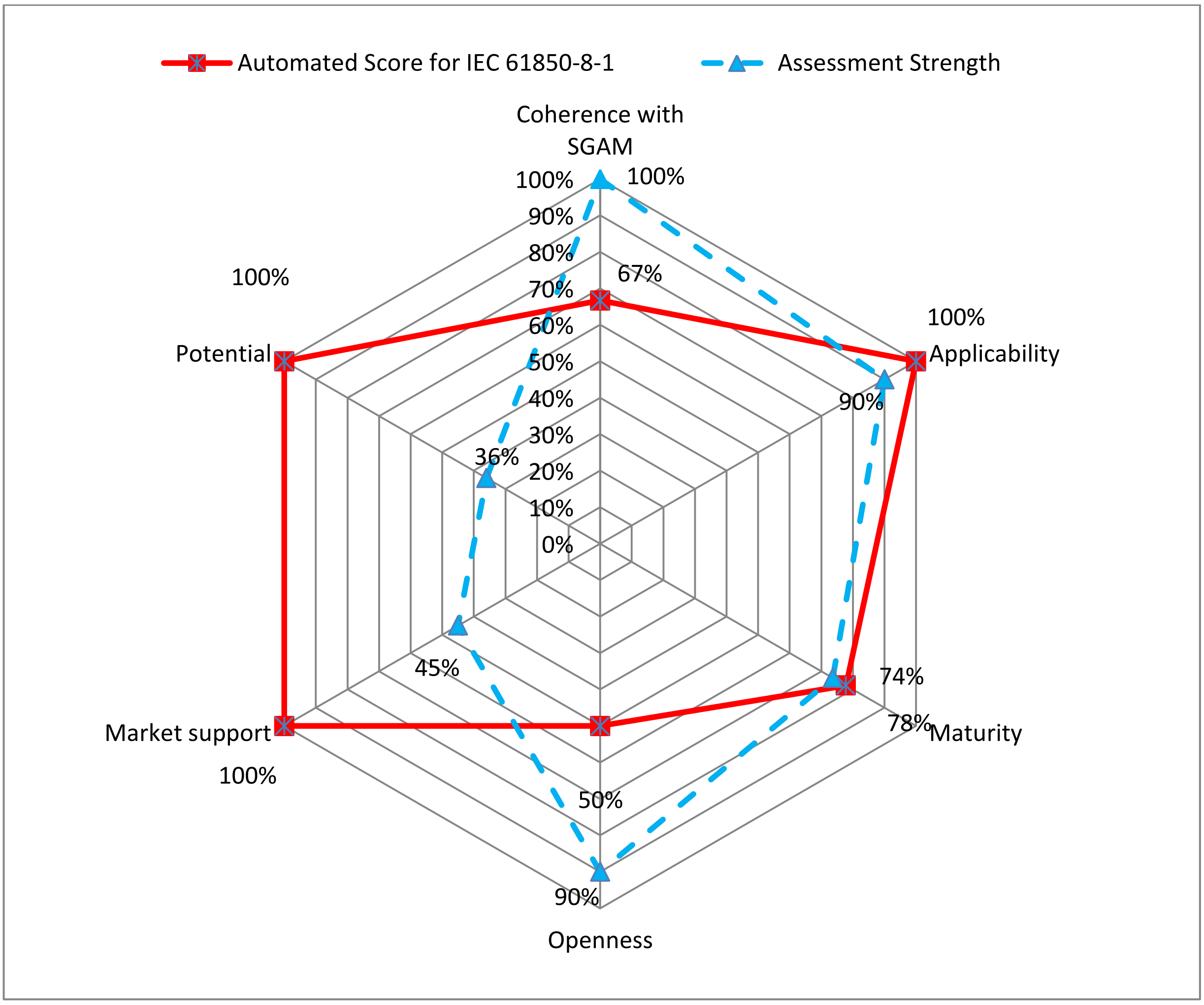

Figure 7 - Summary of IEC 61850-8-1 Assessment

Critical points for Maturity	Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Openness	Some important information/documentation about the process or the standard is not publicly available. Specifications are not licensed on a royalty-free basis.

IEC 61850-90-2: Use of IEC 61850 for the communication between control centres and substations

NAME	DESCRIPTION
General information:	IEC 61850-90-2 was developed by IEC TC 57 and standardized by IEC - International Electrotechnical Commission. It is at its 1st version (Edition 1.0), released on the 02/2016. Its first release was released on the 02/2016. More information at: https://webstore.iec.ch/publication/24249
Aim and technologies	The part 90-2 of IEC 61850, which is a technical report, provides a comprehensive overview of the different aspects that need to be considered while using IEC 61850 for information exchange between substations and control or maintenance centres or other system level applications. It is based on the following technologies: TCP/IP, Ethernet technology, SCL syntax: XML schema definition. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution, DER - Zones: Station, Operation - Interoperability Levels: Information, Communication
Description	The technical report IEC TR 61850-90-2 provides a comprehensive overview of the matters that need to be considered in order to use IEC 61850 for information exchange between substations and control or maintenance systems. Areas that require extension of specific parts of the existing IEC 61850 standards will be incorporated in future editions of the affected part of IEC 61850.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by Table format , state machine , implementation comments. Main kind of provided messages/document/information: control: direct control with normal security, SBO control with normal security, direct control with enhanced security, SBO with enhanced security, settings: Setting Group Control Block SGCB, reports: Report Control Block RCB, logs: Log Control Block LCB, file transfer COMMUNICATION STANDARD FEATURES: Time latency: single seconds Bandwidth: 0,5 - 10 Mb/s SECURITY AND PRIVACY: - Security addressed by The security requirements should be solved by using the IEC 62351 standard.
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring system control --- Ensuring quality of supply
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator;

NAME	DESCRIPTION
Use case clusters	- Blackout management - Connect an active actor to the grid - Controlling the grid (locally/ remotely) manually or automatically - Grid stability - Managing power quality - Monitoring the grid flows - Reconfiguring the network in case of fault
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems - EMS Scada system - WAMPACs - FACTS Distribution: - Substation automation systems - Feeder Automation System - ADMS - FACTS - DMS SCADA and GIS system DER: - DER operation systems
Function specific and other covered system	Administration: - Assets and maintenance management system - AAA system
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- There is support from one interest/users group. This is: UCA International User Group
Relation with other standards and technologies	- The following standards are possible alternative to IEC 61850-90-2: 1. IEC 60870-5-104 (Telecontrol equipment and systems - Part 5-104: Transmission protocols - Network access for IEC 60870-5-101 using standard transport profiles), 2. DNP 3.0 (IEEE 1815-2012 - IEEE Standard for Electric Power Systems Communications-Distributed Network Protocol (DNP3)) - IEC 61850-90-2 results to be largely compatible with the following standards: TCP/IP/Ethernet - A process of harmonization with other standards is involving IEC 61850-90-2: IEC carries out harmonization process for IEC 61850, CIM and COSEM interfaces (e.g. IEC 61850-80-4 : COSEM over IEC 61850, IEC62056-6-9: Mapping between CIM and DLMS/COSEM data models). There is also IEC 61850-80-1 that contains guidelines to exchange the information from CDC (IEC 61850) based data model using IEC 60870-5-101/104 standards.

NAME	DESCRIPTION
Tools and documentation	- IEC 61850-90-2 has interoperability tests. The reference to these tests are the following: IEC 61850-10 Ed.2.: "Communication networks and systems for power utility automation - Part 10: Conformance testing". https://webstore.iec.ch - IEC 61850-90-2 provides guidelines and/or documentation. The reference to them are the following: 1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010; 2. IEC 61850-7-1 Ed.2: "Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models"; https://webstore.iec.ch/publication/6014; 3. IEC 61850-90-11: "Communication networks and systems for power utility automation – Part 90-11: Methodologies for modelling of logics for IEC 61850 based applications" - this technical report has not been published yet, 4. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010: http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf - IEC 61850-90-2 provides tools for facilitating implementation. The reference to them are the following: 1. SISCO (USA) tools: http://www.sisconet.com/our-products 2. INFO TECH (Poland) tools: http://infotech.gdansk.pl 3. KalkiTech (India) tools: http://www.kalkitech.com/ - Evidence about positive impact of the standard provided by the following case studies: "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010
Possible barriers	- There is some probability that IEC 61850-90-2 can be affected by lacking of Critical mass
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 91%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 64%. The strength of this evaluation is 100%. This parameter seems to be high. Knock-Out criteria are not specified.
Openness	Openness equals to 83%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 25%. This parameter seems to be low. The evaluation of this parameter is partial, since, for the 75% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Potential	Potential equals to 60%. The strength of this evaluation is 100%. This parameter seems to be moderate. Knock-Out criteria are not specified.

NAME	DESCRIPTION
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 75,68% Final Strength = 92,5% Final Automated Evaluation = high NOTE: For the 7,5% of the questions, available documentation has been judged insufficient

Reference documentation	[IEC TR 61850-90-2:2016 Communication networks and systems for power utility automation - Part 90-2: Using IEC 61850 for communication between substations and control centres] + https://webstore.iec.ch/publication/24249 [SGCG/M490/G_Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf [Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard. Group of Spanish Electricity Companies for studies on IEC 61850] + http://www.cired.net/publications/cired2011/part1/papers/CIRED2011_0422_final.pdf

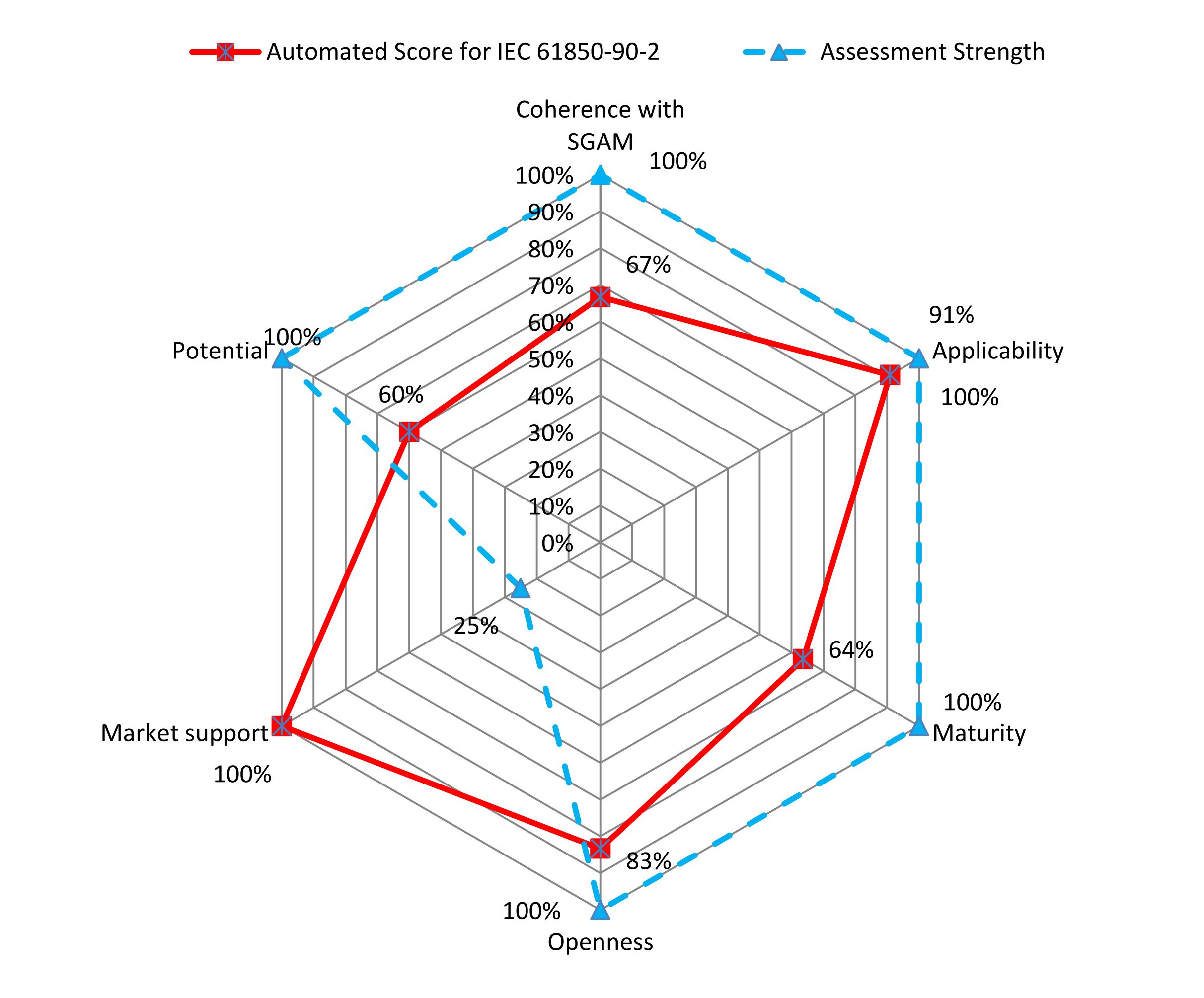

Figure 8 - Summary of IEC 61850-90-2 Assessment

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Potential	There are no evidences about its impact Privacy is not well addressed.

Comments on Applicability	Reusability: - The technical report is suitable for interfaces between substations and control and maintenance centers. i.e. between SGAM Station and Operation zones.
Comments on Maturity	Development status: - The IEC 61850 is a mature standard. Stability: - Compatibility with Edition 2 of IEC 61850 standard Vitality of the standard: - This is the first edition.
Comments on Openness	Documentation: - The technical report should be purchased.

Comments on Market support	Implementations: - This is the new technical report showing the possibility to use IEC 61850 standard for data exchange between substations and control centers. - This the new technical report showing the possibility to use IEC 61850 standard for data exchange between substations and control centers. Market demand: - This the new technical report showing the possibility to use IEC 61850 standard for data exchange between substations and control centers.
Comments on Potential	Impact: - Migration form IEC 60870-5-104 to IEC 61850-90-2 is expected.

Additional information about the standard IEC 61850-90-2 from IEC TC 57

The technical report IEC 61850-90-2 provides a comprehensive overview of the matters that need to be considered in order to use IEC 61850 for information exchange between substations and control or maintenance systems. It provides a comprehensive overview of the different aspects that need to be considered while using IEC 61850 for information exchange between substations and control or maintenance centres or other system level applications. In particular, this technical report:

- defines use cases and communication requirements that require an information exchange between substations and control or maintenance centres
- describes the usage of the configuration language of IEC 61850-6
- gives guidelines for the selection of communication services and architectures compatible with IEC 61850
- describes the engineering workflow
- introduces the use of a Proxy/Gateway concept
- describes the links regarding the Specific Communication Service Mapping (SCSM).

The scope of this technical report is limited to two interfaces. The first interface represents as telecontrol interface the communication of the substation automation system to the remote control centre(s). The second Interface represents as telemonitoring interface the communication to remote engineering, monitoring and maintenance places.

The report does not define constraints or limitations for specific device implementations. There is no specific chapter for cyber security which is tackled when it is necessary. The model, for IEC TR 61850-90-2, provides security functions based upon the security threats and security functions found in IEC TS 62351.

Beneath information authentication and integrity, information availability is an important aspect for telecontrol. The technical report IEC 61850-90-2 provides redundancy architectures to enhance the availability of information in control and maintenance centres.

IEC 61850-90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118

NAME	DESCRIPTION
General information:	IEC TR 61850-90-5 was developed by IEC TC 57 and standardized by IEC - International Electrotechnical Commission. It is at its 1st version (Ed. 1.0, 2012), released on the 05/2012. More information at: https://webstore.iec.ch/publication/6026
Aim and technologies	IEC TR 61850-90-5 was developed with the following aim: The technical report IEC TR 61850-90-5 introduces communication mechanism for synchrophasors that is compliant to the concept of IEC 61850. This mechanism can be considered an alternative to the communication mechanism introduced in IEEE C37.118.2 standard. It is based on the following technologies: Ethernet, TCP/IP technology. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution - Zones: Process, Field , Station, Operation - Interoperability Levels: Information, Communication
Description	Synchrophasor data is measured and calculated by phasor measurement units (PMUs). This data is considered to be useful information to assess the condition of the electrical power network. The synchrophasors and related message formats to transmit synchrophasor data over long distances are defined in IEEE C37.118 standard. Even though the communication according to IEEE C37.118 has proven to be usable and work well, there is a desire to have a communication mechanism that is compliant to the concept of IEC 61850. The technical report IEC TR 61850-90-5 lays out how this shall be done. The technical report describes exchanging synchrophasor data between PMUs, PDC (Phasor Data Concentrators), and between control center applications.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by Description of the data formats is presented using tables together with extensive comments. Main kind of provided messages/document/information: Streams of synchrophasors are transmitted as Sampled Values and event driven information is sent as GOOSE - both defined in IEC 61850-7-2 standard. Modified control bloks are introduced which extend definitions of control blocks given in IEC 61850-7-2 standard: 1. Routable Multicast Sample Value Control Block for synchrophasors: R-MSVCB, 2. Routable GOOSE Control block for synchrophasors: R-GoCB. COMMUNICATION STANDARD FEATURES: Time latency: 20 - 100 ms Bandwidth: 10 - 1000 Mb/s SECURITY AND PRIVACY: - Security addressed by Security functions based on IEC 62351-6 standard.
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring electricity network security --- Ensuring system control

NAME	DESCRIPTION
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator;
Use case clusters	- Blackout management - Controlling the grid (locally/ remotely) manually or automatically - Grid stability - Monitoring the grid flows
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems - EMS Scada system - WAMPACs Distribution: - Substation automation systems - Feeder Automation System
Function specific and other covered system	Cross-cutting: - Telecommunication - Security - Connecting DER
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- There is support from interest/users groups. These are: 1. UCA International User Group, 2. North American SynchroPhasor Initiative (NASPI)
Relation with other standards and technologies	- The following standards are possible alternative to IEC TR 61850-90-5: IEEE C37.118, 2005 IEEE C37.118.2, 2011 - IEC TR 61850-90-5 results to be largely compatible with the following standards: IEC 61850-8-1 (GOOSE) / IEC 61860 -90-5 session / ITU X.234 / RFC 1240 / UDP / IP / Ethernet - A process of harmonization with other standards is involving IEC TR 61850-90-5: IEC carries out harmonization process for IEC 61850, CIM and COSEM interfaces (e.g. IEC 61850-80-4 : COSEM over IEC 61850, IEC62056-6-9: Mapping between CIM and DLMS/COSEM data models). There is also IEC 61850-80-1 that contains guidelines to exchange the information from CDC (IEC 61850) based data model using IEC 60870-5-101/104 standards.

NAME	DESCRIPTION
Tools and documentation	- IEC TR 61850-90-5 has interoperability tests. The reference to these tests are the following: IEC 61850-10 Ed.2.: "Communication networks and systems for power utility automation - Part 10:Conformance testing". https://webstore.iec.ch - IEC TR 61850-90-5 provides guidelines and/or documentation. The reference to them are the following: 1. IEC 61850-3 Ed.2: "Communication networks and systems for power utility automation - Part 3: General requirements"; https://webstore.iec.ch/publication/6010; 2. IEC 61850-7-1 Ed.2: "Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models"; https://webstore.iec.ch/publication/6014; 3. IEC 61850-90-11: "Communication networks and systems for power utility automation – Part 90-11: Methodologies for modelling of logics for IEC 61850 based applications" - this technical report has not been published yet, 4. "Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard", Group of Spanish electricity companies for studies on IEC 61850, ed. 3 9.06.2010 : http://www.nettedautomation.com/download/std/61850/e3_iec61850_specification_document_20100609.pdf - IEC TR 61850-90-5 provides tools for facilitating implementation. The reference to them are the following: 1. SISCO (USA) tools: http://www.sisconet.com/our-products/ 2. INFO TECH (Poland) tools: http://infotech.gdansk.pl 3. KalkiTech (India) tools: http://www.kalkitech.com/
Possible barriers	- There is some probability that IEC TR 61850-90-5 can be affected by lacking of Critical mass
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 64%. The strength of this evaluation is 100%. This parameter seems to be high. Knock-Out criteria are not specified.
Openness	Openness equals to 83%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 3 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 25%. This parameter seems to be low. The evaluation of this parameter is partial, since, for the 75% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Potential	Potential equals to 40%. The strength of this evaluation is 100%. This parameter seems to be low. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.

NAME	DESCRIPTION
Final Assessment	Final Score = 75,68% Final Strength = 92,5% Final Automated Evaluation = high NOTE: For the 7,5% of the questions, available documentation has been judged insufficient

Reference documentation	[IEC TR 61850-90-2: Communication networks and systems for power utility automation - Part 90-5: Use of IEC 61850 to transmit synchrophasor information according to IEEE C37.118] + https://webstore.iec.ch/publication/6026 [SGCG/M490/G_Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf [Minimum common specification for substation protection and control equipment in accordance with the IEC 61850 standard. Group of Spanish Electricity Companies for studies on IEC 61850] + http://www.cired.net/publications/cired2011/part1/papers/CIRED2011_0422_final.pdf

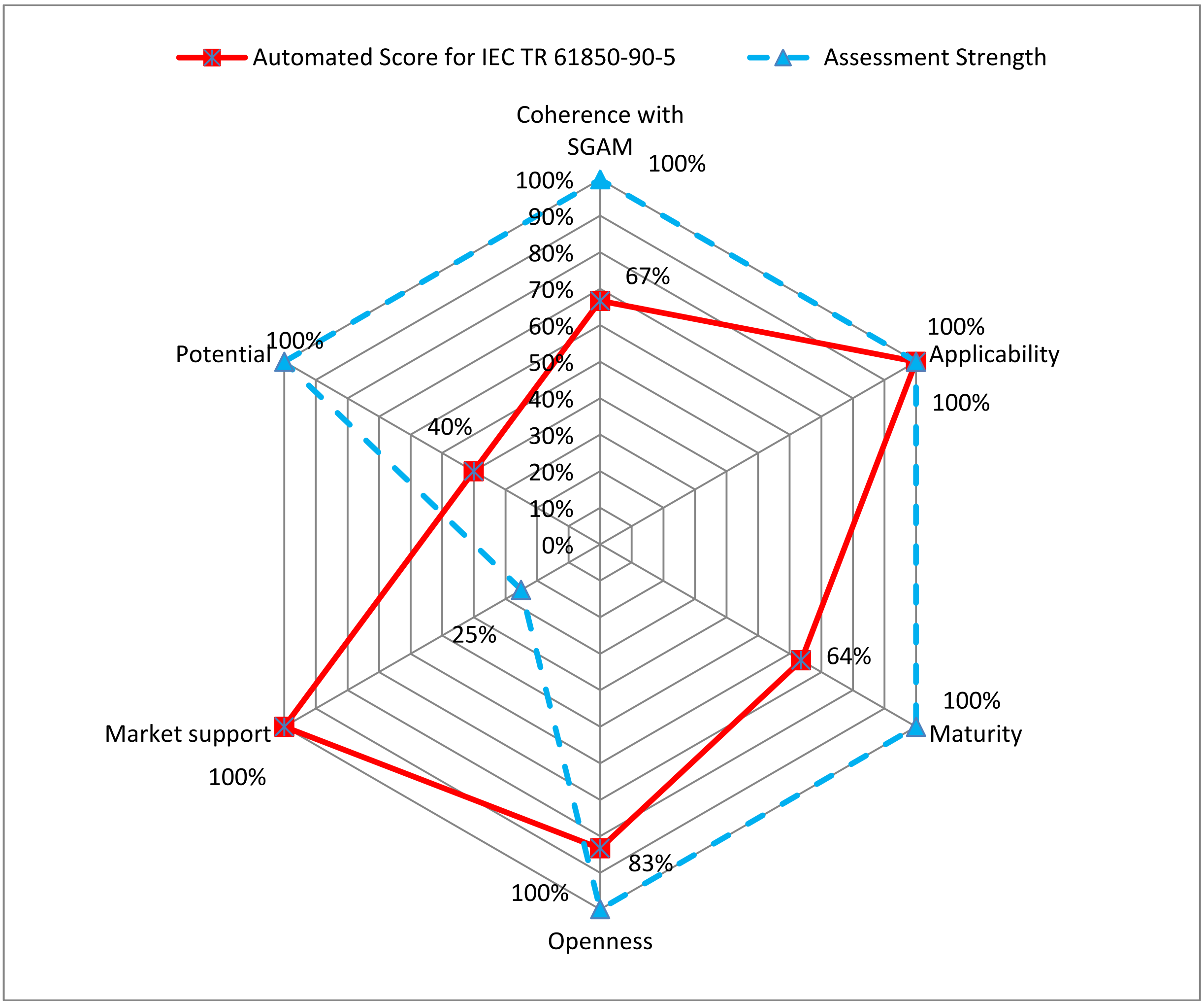

Figure 9 - Summary of IEC 61850-90-5 Assessment

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Potential	There are no evidences about its impact Privacy is not well addressed.

Comments on Maturity	Stability: - Compatibility with Edition 2 of IEC 61850 standard Vitality of the standard: - This is the first edition.

Additional information about the standard IEC 61850-90-5 from IEC TC 57

The technical report IEC TR 61850-90-5 describes exchanging synchrophasor data between PMUs (Phasor Measurement Units), PDCs (Phasor Data Concentrators), and between control center applications. Synchrophasor data is measured and calculated by PMUs and transmitted to control centers via PDCs. The synchrophasor measurement and communication can also be used within a substation such as for synchrocheck or substation level state estimation.

The synchrophasors and related message formats to transmit synchrophasor data over long distances are defined in IEEE C37.118 standard. Even though the communication according to IEEE C37.118 has proven to be usable and work well, there is a desire to have a communication mechanism that is compliant to the concept of IEC 61850. The technical report IEC TR 61850-90-5 lays out how this shall be done.

The report IEC TR 61850-90-5 describes the possible application of the synchrophasor technology solutions by the usage of use cases (wide area applications utilizing synchrophasors, synchro-check, adaptive relaying, out-of-step protection, situational awareness, state estimation and on-line security assessment, wide area controls like special protection schemes, predictive dynamic stability maintaining system, under voltage load shedding).

The report also introduces the gateway approach for synchrophasor transmission between different locations. It also contains a comprehensive security model. Several aspects of security are addressed within the report with the following basic assumptions:

- Information authentication and integrity (e.g. the ability to provide tamper detection) is needed.
- Confidentiality is optional.

The available command services are described according to services defined in IEEE C37.118 standard.

The report defines also communication profiles (the Application profile and the Transport profile) including the IEC TR 61850-90-5 Session Protocol. To support defined profiles some extensions to the IEC 61850 standard are needed. They are described by using the SCL (XML) format.

IEC 61850-90-7: Object models for power converters in distributed energy resources (DER) systems

NAME	DESCRIPTION
General information:	IEC TR 61850-90-7:2013 was developed by IEC (International Electrotechnical Commission) and standardized by IEC. It is at its 1st version (1.0), released on the 21/03/2013 More information at: https://webstore.iec.ch/publication/6027
Aim and technologies	IEC TR 61850-90-7:2013 was developed with the following aim: IEC/TR 61850-90-7:2013(E) mainly describes the functions for DER systems including IEC61850 information models to be used in the exchange of information between power converter-based DER systems and the utilities. It is based on the following technologies: Power converters, DERs (PV, battery, EV, etc.). It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Transmission, Distribution, DER - Zones: Field , Station, Operation - Interoperability Levels: Information
Description	IEC/TR 61850-90-7:2013(E) describes the functions for power converter-based distributed energy resources (DER) systems, focused on DC-to-AC and AC-to-AC conversions and including photovoltaic systems (PV), battery storage systems, electric vehicle (EV) charging systems, and any other DER systems with a controllable power converter. It defines the IEC 61850 information models to be used in the exchange of information between these power converter-based DER systems and the utilities, energy service providers (ESPs), or other entities which are tasked with managing the volt, var, and watt capabilities of these power converter-based systems. These power converter-based DER systems can range from very small grid-connected systems at residential customer sites, to medium-sized systems configured as microgrids on campuses or communities, to very large systems in utility-operated power plants, and to many other configurations and ownership models.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by Description of the data formats/models (IEC61850 information models) for power-converter based functions are presented using tables. Main kind of provided messages/document/information: The information exchanged mainly related with the DER systems. -Power converter (AC to DC, DC to AC, DC to DC, and AC to AC) functions -DER (photovoltaic systems (PV), battery storage systems, electric vehicle (EV) charging systems and any other DER systems) management functions SECURITY AND PRIVACY: - Security addressed by Security functions based on IEC 62351-6 standard.

NAME	DESCRIPTION
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring system control - Improving market functioning and customer service -> In particular: --- Improving customer service - Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management
Involved actors	Grid Operators: TSO; DSO; Grid Users: Retailer; Customers: Industrial customer; Transportation Customer; Buildings; Home customer;
Use case clusters	- Customer - (AMI) Customer information provision - Demand and production (generation) flexibility - Operate DER(s)
Covered SGAM Domain specific systems	Distribution: - ADMS - DMS SCADA and GIS system DER: - DER operation systems
Function specific and other covered system	Micro-grid: - Micro-grid systems Administration: - Device remote management system Cross-cutting: - Data modelling - Connecting DER
IPR	The standard is publicly available with fee.
Diffusion	- There is support from one interest/users group. This is: US National Institute of Standards and Technology (NIST) Smart Grid Interoperability Panel (SGIP)
Relation with other standards and technologies	- The following standards are possible alternative to IEC TR 61850-90-7:2013: IEC 61850-7-4 - IEC TR 61850-90-7:2013 results to be largely compatible with the following standards: Data object model: - IEC 61850-7-420 Application protocols: - IEC61850-8-1 - IEC60870-5 - Modbus and DNP3 Transport protocols: - IEC60870-5-101 - A process of harmonization with other standards is involving IEC TR 61850-90-7:2013: IEC carries out harmonisation process for IEC 61850, CIM and COSEM interfaces.

NAME	DESCRIPTION
Tools and documentation	- IEC TR 61850-90-7:2013 has interoperability tests. The reference to these tests are the following: SANDIA REPORT - Test Protocols for Advanced Inverter Interoperability Functions (look at the references) - IEC TR 61850-90-7:2013 has interoperability tests. The reference to these tests are the following: SANDIA REPORT - Test Protocols for Advanced Inverter Interoperability Functions (look at the references) - IEC TR 61850-90-7:2013 provides guidelines and/or documentation. The references to them are the following: IEC/TR 61850-90-7:2013 main document includes details about the implementation. - IEC TR 61850-90-7:2013 provides tutorials and/or examples. The references to them are the following: IEC/TR 61850-90-7:2013 main document includes some examples to be used in application.
Possible barriers	- There is some probability that IEC TR 61850-90-7:2013 can be affected by scarce maintenance/updating of the specifications - There is some probability that IEC TR 61850-90-7:2013 can be affected by lacking of Critical mass
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 90%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 73%. The strength of this evaluation is 90%. This parameter seems to be high. Knock-Out criteria are not specified.
Openness	Openness equals to 83%. The strength of this evaluation is 90%. This parameter seems to be high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 23%. This parameter seems to be low. The evaluation of this parameter is partial, since, for the 75% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Potential	Potential equals to 33%. The strength of this evaluation is 54%. This parameter seems to be very low. The evaluation of this parameter is partial, since, for the 40% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 80% Final Strength = 79% Final Automated Evaluation = high NOTE: For the 13% of the questions, available documentation has been judged insufficient

NAME	DESCRIPTION
Reference documentation	[IEC/TR 61850-90-7:2013 - Communication networks and systems for power utility automation - Part 90-7: Object models for power converters in distributed energy resources (DER) systems] + https://webstore.iec.ch/publication/6027 [SGCG/M490/G_Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf [SANDIA REPORT - Test Protocols for Advanced Inverter Interoperability Functions] + http://energy.sandia.gov/wp-content/gallery/uploads/SAND2013-9880.pdf

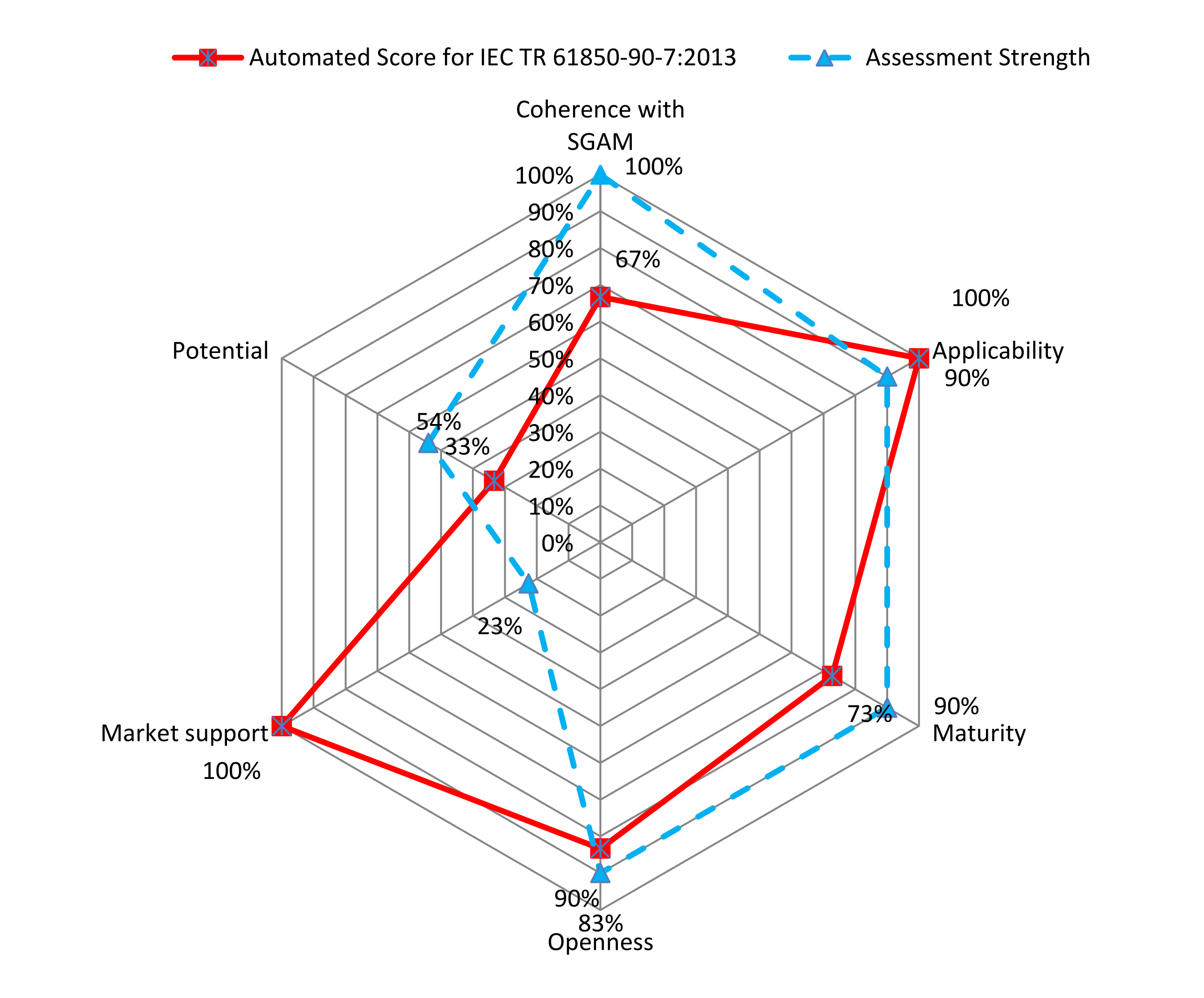

Figure 10 - Summary of IEC 61850-90-7 Assessment

Critical points for Maturity	Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Potential	Privacy is not well addressed. Maintenance could be problematic.

Comments on Coherence with SGAM	Coordinates on the SGAM Reference Model: - Position in Information layer Alternative standards: - IEC 61850-7-420 covers DER information models, which may covers information models for PV inverters
Comments on Maturity	Development status: - Up to now, only 1 version has been released. Vitality of the standard: - This is the first edition.

IEC 61968-9: Interface Standard for Meter Reading & Control

NAME	DESCRIPTION
General information:	IEC 61968-9 was developed by IEC TC57 WG 14 and standardized by IEC - International Electrotechnical Commission. It is at its 2nd version (Ed. 2), released on the 16/10/2013. Its first release was released on the 16/09/2009. More information at: https://webstore.iec.ch/publication/6204
Aim and technologies	The purpose of this part of IEC 61968 is to define a standard for the integration of metering systems (MS), which includes traditional manual systems, and (one or two-way) automated meter reading (AMR) systems, and meter data management (MDM) systems with other enterprise systems and business functions within the scope of IEC 61968. The scope of this part of IEC 61968is the exchange of information between metering systems, MDM systems and other systems within the utility enterprise. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Distribution, Customer Premises - Zones: Operation, Enterprise - Interoperability Levels: Information
Description	This part of IEC 61968 specifies the information content of a set of message types that can be used to support many of the business functions related to meter reading and control. Typical uses of the message types include meter reading, controls, events, customer data synchronization and customer switching. Although intended primarily for electrical distribution networks, IEC 61968-9 can be used for other metering applications, including non-electrical metered quantities necessary to support gas and water networks.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by XML schema Main kind of provided messages/document/information: Meter reading and control message, like End device event, meter reading, End device control, Meter service requests, Metering system events, Customer switching, Payment metring service, Premise area networks, Master data management. SECURITY AND PRIVACY: - Security addressed by https://www.oasis-open.org/standards https://www.oasis-open.org/standards#wssv1.1.1 - Privacy addressed by https://www.oasis-open.org/standards https://www.oasis-open.org/standards#wssv1.1.1
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring quality of supply- Improving market functioning and customer service -> In particular: --- Improving customer service - Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management
Involved actors	Grid Operators: DSO; Grid Users: Generator; Customers: Industrial customer; Home customer;

NAME	DESCRIPTION
Use case clusters	- (AMI) Billing - Billing - (AMI) Collect events and status information - (AMI) Configure events, statuses and actions - Controlling the grid (locally/ remotely) manually or automatically - (AMI) Customer information provision - Demand and production (generation) flexibility - (AMI) Installation & configuration - Monitor AMI event - Provide and collect contractual measurements
Covered SGAM Domain specific systems	Generation: - Generation management system Distribution: - ADMS Customer Premises: - AMI System - Metering-related Back Office system - Aggregated prosumers management system
Function specific and other covered system	
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: http://cimug.ucaiug.org/Meetings/London2012/CIMug%20Presentations%20%20London%202012/Day%204%20-%20Friday,%20May%2018/AM2_CIM%20for%20Distribution%20and%20AMI%20Interoperability%20Testing_Goodrich_SISCO.pdf - The standard has a significant market share of adoption. Markets share: http://w3.usa.siemens.com/smartgrid/us/en/distributech/Documents/SG%20EM%20Gartner%20Magic%20Quadrant%2012%202013.pdf - There is support from one interest/users group. This is: http://cimug.ucaiug.org/default.aspx
Relation with other standards and technologies	- The following standards are possible alternative to IEC 61968-9: IEC 62056 - IEC 61968-9 results to be largely compatible with the following standards: SOAP

NAME	DESCRIPTION
Tools and documentation	- IEC 61968-9 has interoperability tests. The reference to these tests are the following: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001024448 - IEC 61968-9 provides guidelines and/or documentation. The reference to them are the following: https://webstore.iec.ch/publication/6198 - IEC 61968-9 provides tutorials and/or examples. The reference to them are the following: http://cimug.ucaiug.org/Meetings/Charlotte2009/Presentations/CIM%20University/Using%20CIMTool.ppt - IEC 61968-9 provides tools for facilitating implementation. The reference to them are the following: http://www.sparxsystems.com/products/ea/ http://www.cimea.org/ http://wiki.cimtool.org/index.html - Evidence about positive impact of the standard provided by the following case studies: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001024448
Possible barriers	
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 82%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 82%. The strength of this evaluation is 100%. This parameter seems to be very high. Knock-Out criteria are not specified.
Openness	Openness equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 75%. The strength of this evaluation is 100%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 80%. The strength of this evaluation is 100%. This parameter seems to be very high. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 82,5% Final Strength = 100,% Final Automated Evaluation = very high
Reference documentation	[IEC 61968-9:2013 Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control] + https://webstore.iec.ch/publication/6204 [SGCG/M490/G_Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf

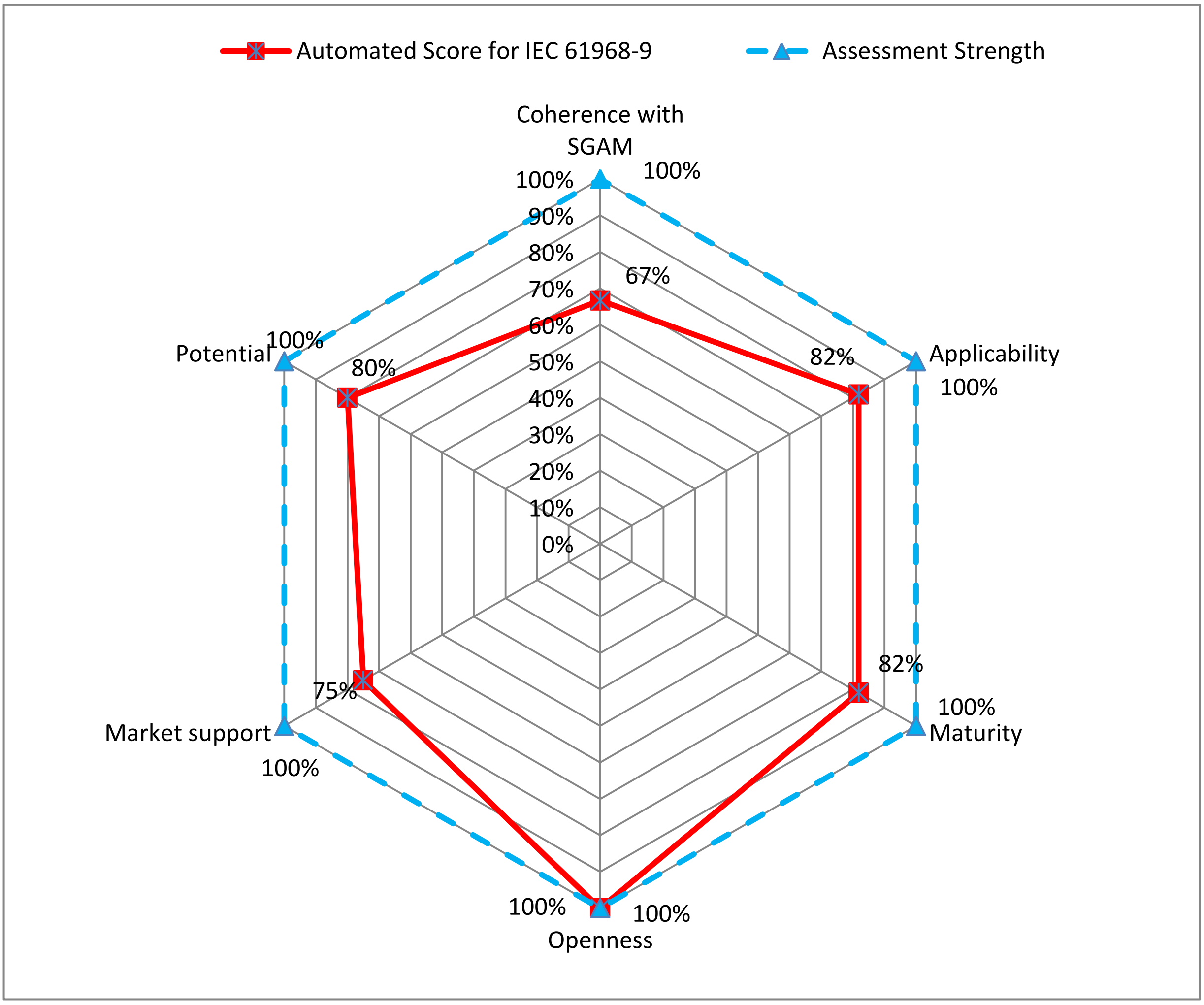

Figure 11 - Summary of IEC 61968-9 Assessment

Comments on Maturity	Guidelines: - IEC 61968-100 Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles - The normative XML schemas for messages defined in IEC 61968-9 are provided in Annex H, providing more detailed, annotated descriptions of the message structures. These XML schemas were defined using profile definitions within CIMTool. This Annex H is supplemented by the informative XML schemas provided in Annex I. In addition to a link the tutorial "Using CIMTool" - Enterprise Architect is used to store and develop the model, CIMEA used to build a profile, CIMTool used to build xsd. Stability: - IEC 61968-100 defines a set of implementation profiles for IEC 61968 using technologies commonly used for enterprise integration. More specifically, this document describes how message payloads defined by parts 3-9 of IEC 61968 are conveyed using web services and the Java Messaging System (JMS). Guidance is also provided with respect to the use of Enterprise service Bus (ESB) technologies. The goal is to provide details that would be sufficient to enable implementations of IEC 61968 to be interoperable. In addition, this document is intended to describe integration patterns and methodologies that can be leverages using current and future integration technologies.

Comments on Openness	Organisation: - IEC Documentation: - Preliminary results are available to registered users on the website http://cimug.ucaiug.org/default.aspx
Comments on Market support	Implementations: - EIServer® meter data management (MDM) system (Elster) (http://www.elster.com/en/press-releases/2012/1699694); EnergyICT MDM (Elster); Zonos MDM (Cuculus); Market demand: - Page number 3 shows the market share of the product (MDM) different suppliers. Interest/User groups: - CIMug - CIM user group
Comments on Potential	Impact: - Organizational processes are standardized through message templates. Case studies are Interoperability tests. Security: - For example WS-Security linked to Web Services. Privacy: - For example WS-Security linked to Web Services.

IEC 61968-11: Common Information Model (CIM) Extensions for Distribution

NAME	DESCRIPTION
General information:	IEC 61968-11 was developed and standardized by IEC - TC 57, Power systems management and associated information exchange It is at its 2nd version (2.0), released on the 03/2013. Its first release was released on the 07/2010. More information at: https://webstore.iec.ch/publication/6199
Aim and technologies	IEC 61968-11 was developed with the following aim: The scope of this standard is the information model that extends the base CIM for the needs of distribution networks, as well as for integration with enterprise-wide information systems typically used within electrical utilities It is based on the following technologies: - UML: Unified Model Language - XML: Xtensible Markup Language - XSD: XML Schema Definition - RDF: Resource Description Framework - OWL: Web Ontology Language - CIM: Common Information Model - DCIM: Common Information Model with Distribution Extensions - EA: Enterprise Architecture. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Distribution - Zones: Operation, Enterprise - Interoperability Levels: Information
Description	IEC 61968-11 specifies the distribution extensions of the common information model (CIM) specified in IEC 61970-301. It defines a standard set of extensions of common information model (CIM), which support message definitions in IEC 61968-3 to IEC 61968-9, IEC 61968-13 and IEC 61968-14. The IEC 61968 series is intended to facilitate inter-application integration of the various distributed software application systems supporting the management of utility electrical distribution networks within a utility's enterprise systems environment
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by The CIM model is defined and maintained using UML. The source and point of maintenance for the CIM model is currently an Enterprise Architect (EA) file. From the EA file, XML file is also generated that can be used within various tools that support generation of context specific message payloads in XSD, RDF or OWL. Main kind of provided messages/document/information: Two major data exchange among enterprise systems: - Bulk data exchanges for the purpose of configuration of systems. - Operational (dynamic) data exchanges among running systems.
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply- Improving market functioning and customer service
Involved actors	Grid Operators: DSO;

NAME	DESCRIPTION
Use case clusters	- (AMI) Billing - (AMI) Collect events and status information - Controlling the grid (locally/ remotely) manually or automatically - Exchange of metered data - Grid stability - Maintaining grid assets - Provide and collect contractual measurements
Covered SGAM Domain specific systems	Generation: - Generation management system Distribution: - DMS SCADA and GIS system
Function specific and other covered system	
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: http://cimug.ucaiug.org/default.aspx - The standard has been used in different electric power industry applications. Number of known implementations: Main users: utilities, supplier companies, manufacturers - There is support from one interest/users group. This is: http://cimug.ucaiug.org/default.asp x
Relation with other standards and technologies	- IEC 61968-11 results to be largely compatible with the following standards: xml protocol
Tools and documentation	- IEC 61968-11 has interoperability tests. The reference to these tests are the following: https://www.entsoe.eu/major-projects/common-information-model-cim/interoperability-tests/Pages/default.aspx http://cimug.ucaiug.org/Groups/Validation%20and%20Complliance%20Testing/Forms/AllItems.aspx?RootFolder=http%3a%2f%2fcimug%2eucaiug%2eorg%2fGroups%2fValidation%20and%20Complliance%20Testing%2fInteroperability%20Test%20Reports&FolderCTID=0x0120006FB95C9A266F9244BED7BDFBA51EE2D0
Possible barriers	- There is some probability that IEC 61968-11 can be affected by lacking of real interoperability due to ambiguity of specifications
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 91%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 55%. The strength of this evaluation is 100%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Openness	Openness equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 2 Knock-Out criteria specified and they are all met.

NAME	DESCRIPTION
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 33%. The strength of this evaluation is 60%. This parameter seems to be low. The evaluation of this parameter is partial, since, for the 40% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 72% Final Strength = 90% Final Automated Evaluation = high NOTE: For the 10% of the questions, available documentation has been judged insufficient

Reference documentation	Smart Grid Coordination Group - Interoperability tool SGCG/M490/G_Smart Grid Set of Standards_ Version 3.1_ 2014 IEC Smart Grid Standardization Roadmap_ Edition 1.0_ June 2010

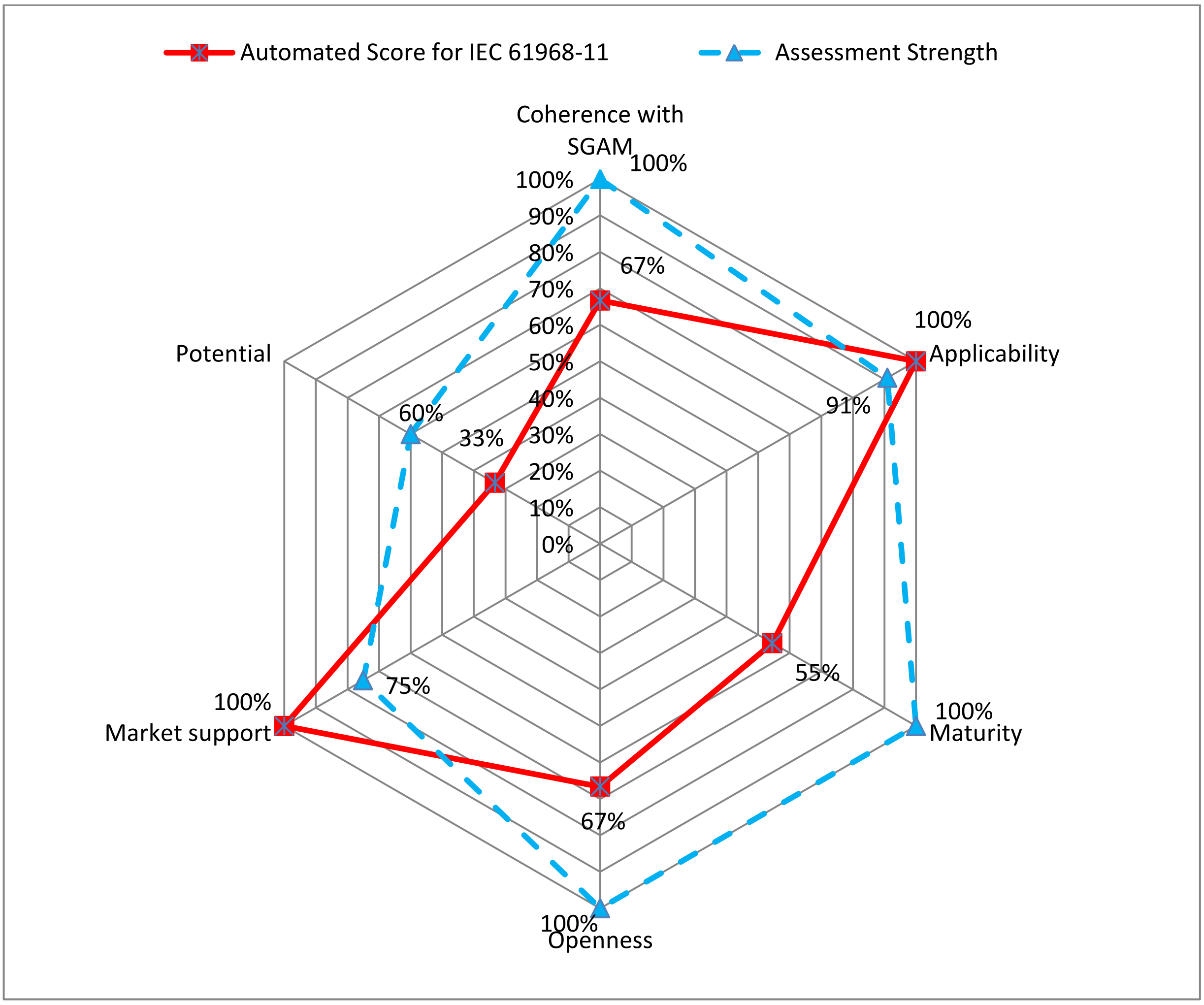

Figure 12 - Summary if IEC 61968-11 Assessment

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient.
Critical points for Openness	Some important information/documentation about the process or the standard is not publicly available.
Critical points for Potential	Security is not well addressed, Privacy is not well addressed.

Comments on Coherence with SGAM	Coordinates on the SGAM Reference Model: - IEC 61968 is considered to be core standard for any implementation of Smart Grid now and in the future. Core standards are standards that have an enormous effect on any Smart Grid application and solution.
Comments on Applicability	Focus on interoperability for Smart Grid: - IEC 61968 is considered to be core standard for any implementation of Smart Grid now and in the future. Reusability: - According to "IEC smart grid standardization roadmap" prepared by Strategic Group SG3, the vision for the next generation of CIM embraces some new concepts in a four layer architecture not currently incorporated into the CIM architecture: - Information layer: This layer includes the CIM but provides for the reality that there are other sources of information as well as the CIM that need to be taken into consideration when creating CIM based information exchanges or repositories. - Contextual layer: This layer formally recognizes that only a subset of the models in the Information Layer is needed for any particular interface or message definition - Message Assembly layer: this layer defines the structure of a Message that carries the Profile Information and what kind of operation should be performed with message payload - Implementation Layer or Message Syntax layer: For specific implementations of the Profiles defined in the Contextual Layer. Geographical basis: - EN 61968-11 standard = IEC 61968-11:2013

Comments on Maturity	Quality: - ENTSO-E_Interoperability tests ENTSO-E plays a leading role in organizing CIM interoperability tests related to both grid model and market exchanges. There are at least two types of interoperability tests: i) Tests to validate a CIM standard as a part of the standard's development process. ii) Tests to validate the conformance of available software solutions with an approved standard. The ENTSO-E CIM interoperability tests facilitate the development of CIM standards for both ENTSO-E and IEC. These IOP tests are tailored to ensure adequate representation of important business requirements for TSOs. The tests are also designed to allow vendors to verify the correctness of the interpretation of the CIM standards. UCA User Group CIM Interoperability Test The UCA CIM Interop Working Group evaluates the interoperability of EMS and third-party vendor products through the administration of formal test procedures. Interoperability testing proves that products from different participant vendors can exchange information based on the use of the IEC standards. These standards include various parts of the IEC 61970, IEC 61968 and IEC 62325 family of standards. Guidelines: - There are some third party open source implementations
Comments on Market support	Implementations: - The CIM Users Group is dedicated to managing and communicating issues concerning the TC57 IEC 61970 and 61968 standards and to serving as the primary means for developing consensus and consistency across the industry http://cimug.ucaiug.org/default.aspx The CIM user group draws its membership from utility user, supplier companies, manufacturers; ABB, Areva, CISCO, IBM, EDF, Siemens, etc. Interest/User groups: - The CIM Users Group (CIMug) was formed in 2005, as a subgroup of the UCA International Users Group, to provide a forum in which users, consultants, and suppliers could cooperate and leverage the IEC CIM international standards to advance interoperability across the utility enterprise. The primary purpose is to share technology basics, best practices and technical resources while Advancing Interoperability for the Utility Enterprise.
Comments on Potential	Impact: - Due to the high degree of maturity of the standard, it is expected that publications and other documentation may exist. But no extensive documentation search has been done for this study. - Due to the high degree of maturity of the standard, it is expected that publications and other documentation may exist. But no extensive documentation search has been done for this study.

IEC 61968-13: Common Information Model (CIM) RDF Model exchange format for distribution

NAME	DESCRIPTION
General information:	IEC 61968-13 Ed.1 was developed by IEC and standardized by IEC. It is at its 1st version (Ed.1.0), released on the 24/06/2008. Its first release was released on the 24/06/2008. More information at: http://webstore.iec.ch/webstore/webstore.nsf/Artnum_PK/41598
Aim and technologies	IEC 61968-13 Ed.1 was developed with the following aim: Exchange of distribution network data model information based upon the IEC Common Information Model It is based on the following technologies: Resource Description Framework (RDF). It address: Interoperability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Distribution - Zones: Operation - Interoperability Levels: Information
Description	IEC 61968-13 specifies the format and rules for exchanging modelling information based upon the Common Information Model ("CIM") and related to distribution network data. Allows the exchange of instance data in bulk. Thus, the imported network model data should be sufficient to allow performing network connectivity analysis, including network tracing, outage analysis, load flow calculations, etc. This standard could be used for synchronizing geographical information system databases with remote control system databases.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by RDF Schema Main kind of provided messages/document/information: Electrical equipment and connectivity model
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring electricity network security --- Ensuring system control - Enabling better planning of future network investment
Involved actors	Grid Operators: DSO;
Use case clusters	- Controlling the grid (locally/ remotely) manually or automatically - Monitoring the grid flows - Reconfiguring the network in case of fault
Covered SGAM Domain specific systems	Distribution: - ADMS - DMS SCADA and GIS system
Function specific and other covered system	
IPR	The standard is publicly available with fee.
Diffusion	- There is support from one or more interest/users groups. These are: IEEE, RSE

NAME	DESCRIPTION
Relation with other standards and technologies	- A process of harmonization with other standards is involving IEC 61968-13 Ed.1: It's planned to harmonize this standard with ENTSO-E CGMES and IEC-61970 series
Tools and documentation	- IEC 61968-13 Ed.1 has interoperability tests. The reference to these tests is the following: Commercial tools are available in order to verify the conformity - IEC 61968-13 Ed.1 has interoperability tests. The reference to these tests is the following: IOP test were performed in 2009 and 2011. http://testing.ucaiug.org/IOP_Registration/2011%20CIM-61850%20IOP/IOP%20Reports/CDPSM%202011%20IOP%20Final%20Report.pdf - IEC 61968-13 Ed.1 provides tutorials and/or examples. The reference to them is the following: http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5772541&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5772541 http://wiki.powerdistributionresearch.com/index.php?title=CIM_Packages#CDPSM_Profile - Evidence about positive impact of the standard provided by the following case studies: EPRI Report Network Model Manager Technical Market_ 000000003002003053.pdf - Evidence about positive migration of current system provided by the following case studies: EPRI Report Network Model Manager Technical Market_ 000000003002003053.pdf
Possible barriers	- There is some probability that IEC 61968-13 Ed.1 can be affected by scarce maintenance/updating of the specifications - There is some probability that IEC 61968-13 Ed.1 can be affected by lacking of Critical mass - There is some probability that IEC 61968-13 Ed.1 can be affected by lacking of real interoperability due to ambiguity of specifications - There is strong probability that IEC 61968-13 Ed.1 is affected by interoperability issues due to use of different standards for the same exchange
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 50%. The strength of this evaluation is 100%. This parameter seems to be low. Knock-Out criteria are not specified.
Openness	Openness equals to 83%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 25%. This parameter seems to be low. The evaluation of this parameter is partial, since, for the 75% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Potential	Potential equals to 60%. The strength of this evaluation is 100%. This parameter seems to be high. Knock-Out criteria are not specified.

NAME	DESCRIPTION
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 76,47% Final Strength = 92,5% Final Automated Evaluation = high NOTE: For the 7,5% of the questions, available documentation has been judged insufficient

Reference documentation	IEC 61968-13:200X (57/930/FDIS) (EQV)

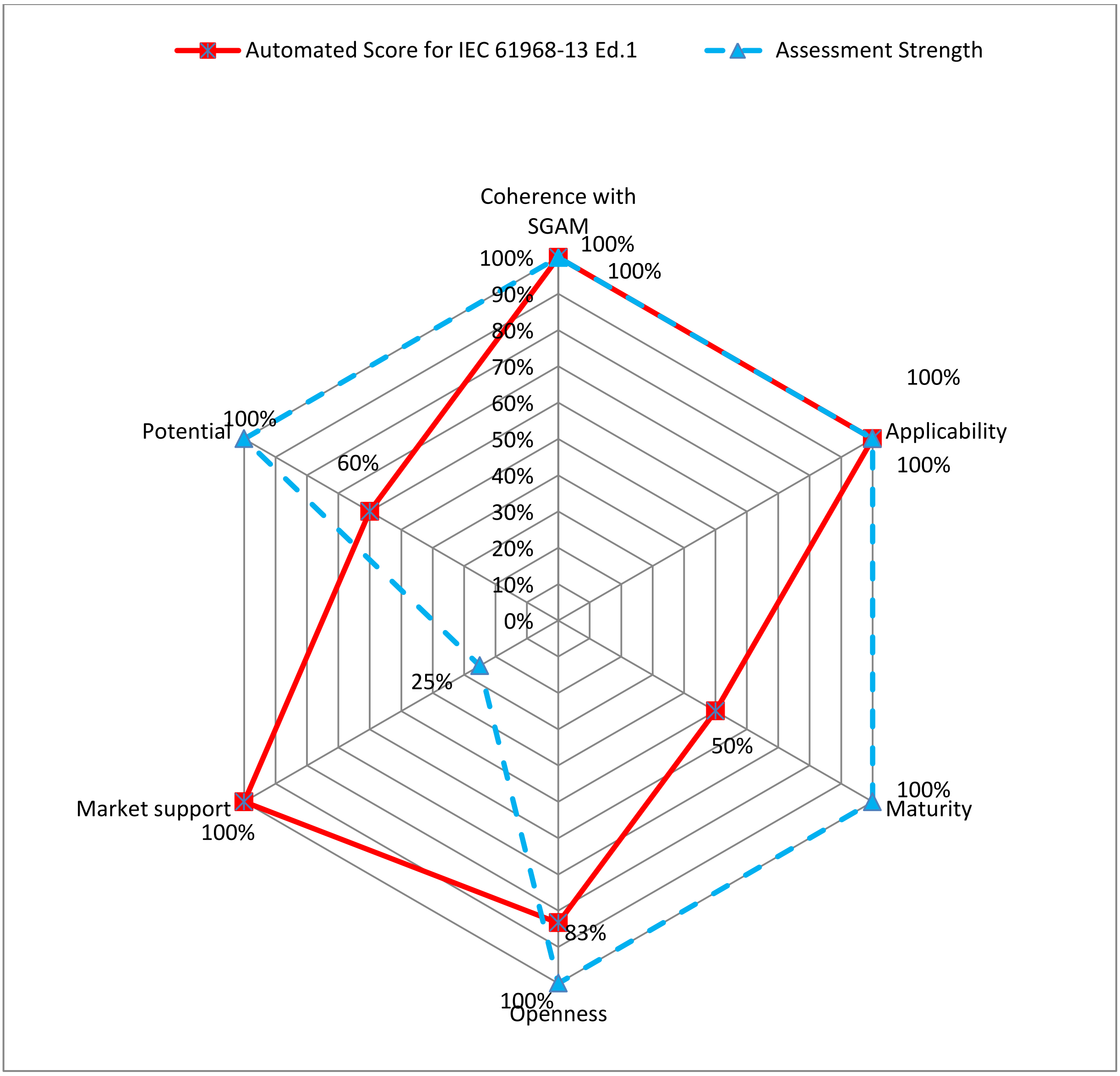

Figure 13 - Summary of IEC 61968-13 Assessment

Critical points for Maturity	Development status seems insufficient. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Potential	Security is not well addressed, Privacy is not well addressed.

Comments on Coherence with SGAM	Coordinates on the SGAM Reference Model: - Operation/Distribution
Comments on Applicability	Requirements: - The CDPSM profile defines the information and the serialization (RDF) needed for information exchange between systems included in a DMS. It could also be used for information exchange involving actors external to DSO (i.e. TSO, other DSOs, third parties). Reusability: - It could also be used at Station Zone (i.e. Primary Substation) Alternatives: - An alternative to this standard isn't available Compatibility: - The standard produce an RDF instance file, that could be exchanged between systems in several ways
Comments on Maturity	Development status: - A first not official update was performed in 2011 and the next official update is an ongoing activity that should be finalized in 2017 Stability: - This is the first version
Comments on Openness	Organisation: - IEC Process: - IEC Documentation: - IEC - IEC Licences: - Price: 250 CHF (more or less 238 EURO)

Additional information about the standard IEC 61968-13 Ed.1 from IEC
The current activity related to IEC 61968-13 update process, is considering the following use cases: - DSO provides its power system models to TSO - A customer provides its DER plant power models to DSO - DSO 1 and 2 mutual exchange their power system models - TSO and DSO provides their power system models to a third party - DSO/DNO internal information exchange - DNOs provide their power system models to DSO

IEC 61968-100: Implementation profiles

NAME	DESCRIPTION
General information:	IEC 61968-100 was developed by IEC TC57 WG 14 and standardized by IEC - International Electrotechnical Commission. It is at its 1st version (Ed. 1), released on the 26/07/2013. Its first release was released on the 26/07/2013. More information at: https://webstore.iec.ch/publication/6198
Aim and technologies	The purpose of this standard is to define a set of implementation profiles for IEC 61968 using technologies commonly used for enterprise integration. More specifically, this standard describes how message payloads defined by parts 3-9 of IEC 61968 are conveyed using web services and the Java Messaging System. Guidance is also provided with respect to the use of Enterprise service Bus (ESB) technologies. The goal is to provide details that would be sufficient to enable implementations of IEC 61968 to be interoperable. In addition, this document is intended to describe integration patterns and methodologies that can be leverages using current and future integration technologies. It is based on the following technologies: XML, XML Schema (XSD), Web Services, WSDL, SOAP, Enterprise Service Bus (ESB), Java Messaging System (JMS). It address: Interoperability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution, DER, Customer Premises - Zones: Operation, Enterprise, Market - Interoperability Levels: Communication
Description	IEC 61968-100 specifies an implementation profile for the application of the other parts of IEC 61968 using common integration technologies, including JMS and web services. This International Standard also provides guidance with respect to the use of Enterprise Service Bus (ESB) technologies. This provides a means to derive interoperable implementations of IEC 61968-3 to IEC 61968-9. At the same time, this International Standard can be leveraged beyond information exchanges defined by IEC 61968, such as for the integration of market systems or general enterprise integration.
Other Technical Information	COMMUNICATION STANDARD FEATURES: Time latency: N/A Bandwidth: N/A SECURITY AND PRIVACY: - Security addressed by https://www.oasis-open.org/standards https://www.oasis-open.org/standards#wssv1.1.1 - Privacy addressed by https://www.oasis-open.org/standards https://www.oasis-open.org/standards#wssv1.1.1

NAME	DESCRIPTION
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring ICT network security --- Ensuring quality of supply
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator; Customers: Industrial customer;
Use case clusters	- (AMI) Billing - Billing - (AMI) Collect events and status information - (AMI) Configure events, statuses and actions - Controlling the grid (locally/ remotely) manually or automatically - (AMI) Customer information provision - Demand and production (generation) flexibility - (AMI) Installation & configuration - Maintaining grid assets - Monitor AMI event - Provide and collect contractual measurements
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - EMS Scada system Distribution: - ADMS - DMS SCADA and GIS system DER: - DER operation systems Customer Premises: - AMI System - Metering-related Back Office system
Function specific and other covered system	Administration: - Assets and maintenance management system
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: http://cimug.ucaiug.org/Meetings/London2012/CIMug%20Presentations%20%20London%202012/Day%204%20-%20Friday,%20May%2018/AM2_CIM%20for%20Distribution%20and%20AMI%20Interoperability%20Testing_Goodrich_SISCO.pdf - The standard has a significant market share of adoption. Markets share: http://cimug.ucaiug.org/Meetings/Melbourne2014/Presentations/Day%202%20-%20Wednesday,%2026%20February/2013%20Gartner-EPRI%20CIM%20Survey%20Results.pdf - There is support from one interest/users group. This is: http://cimug.ucaiug.org/default.aspx
Relation with other standards and technologies	- IEC 61968-100 results to be largely compatible with the following standards: SOAP

NAME	DESCRIPTION
Tools and documentation	- IEC 61968-100 provides guidelines and/or documentation. The reference to them are the following: https://webstore.iec.ch/publication/6198 - IEC 61968-100 provides tutorials and/or examples. The reference to them are the following: https://webstore.iec.ch/publication/6198 - IEC 61968-100 provides tools for facilitating implementation. The reference to them are the following: http://wiki.cimtool.org/index.html http://www.oracle.com/technetwork/developer-tools/jdev/overview/index.html https://msdn.microsoft.com/en-us/vstudio/cc136611.aspx - Evidence about positive impact of the standard provided by the following case studies: not available
Possible barriers	- There is some probability that IEC 61968-100 can be affected by scarce maintenance/updating of the specifications - There is some probability that IEC 61968-100 can be affected by lacking of Critical mass - There is strong probability that IEC 61968-100 is affected by interoperability issues due to use of different standards for the same exchange
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 90%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 60%. The strength of this evaluation is 100%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Openness	Openness equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 75%. The strength of this evaluation is 100%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 80%. The strength of this evaluation is 100%. This parameter seems to be very high. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 81,58% Final Strength = 100,% Final Automated Evaluation = very high
Reference documentation	[IEC 61968-100:2013 Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation Profiles] + https://webstore.iec.ch/publication/6198 [SGCG/M490/G_Smart Grid set of standards, ver 3.1, CEN-CENELEC-ETSI Smart Grid Coordination Group, Oct. 31th, 2014] + https://www.dke.de/de/std/informationssicherheit/documents/sgcg_standards_report.pdf

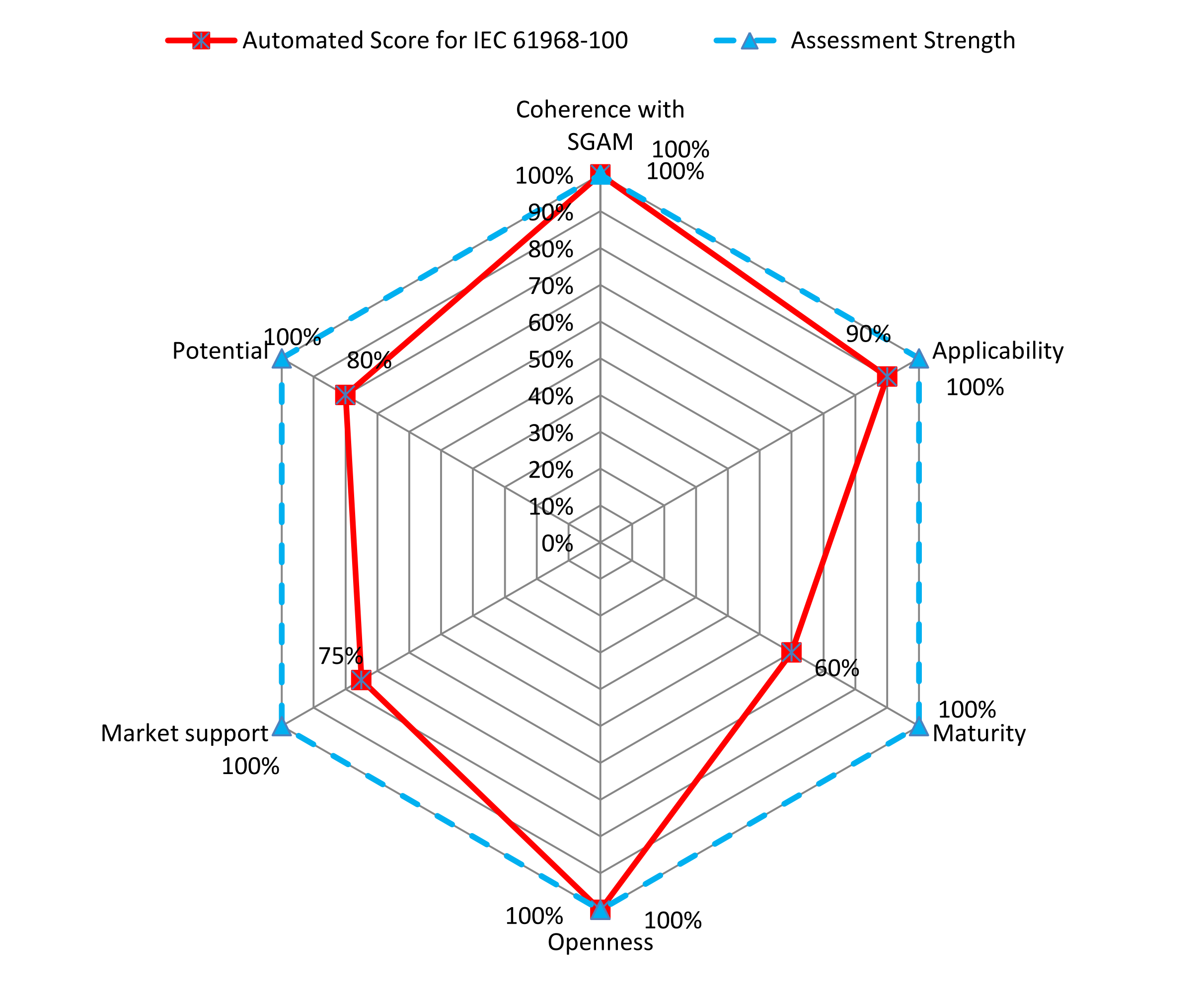

Figure 14 - Summary of IEC 61968-100 Assessment

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.

Comments on Maturity	Guidelines: - IEC 61968-100 defines a set of implementation profiles for IEC 61968 using technologies commonly used for enterprise integration. - Examples for the implementation of products are provided in Annex A, C, D, F (IEC 61968-100). Annex A (Normative): XML Schema for Common Message Envelope, Annex C (Normative): Procedure for Strongly Typed WSDL Generation, Annex D (Normative): Generic WSDL, Annex F (Informative): Payload Compression Example - CIMTool used to build xsd and wsdl. Oracle JDeveloper, Java WSDP, Microsoft Visual Studio used to build a Web Services. Stability: - This is the first edition. Vitality of the standard: - An update is planned for 2016.

Comments on Openness	Organisation: - IEC Documentation: - Preliminary results are available to registered users on the website http://cimug.ucaiug.org/default.aspx
Comments on Market support	Implementations: - ElServer® meter data management (MDM) system (Elster) (http://www.elster.com/en/press-releases/2012/1699694); EnergyICT MDM (Elster); Zonos MDM (Cuculus); Market demand: - Page number 24 and 25 show the types of interfaces that are most commonly used to support the framework. Interest/User groups: - CIMug - CIM user group
Comments on Potential	Security: - For example WS-Security linked to Web Services. Privacy: - For example WS-Security linked to Web Services.

Additional information about the standard IEC 61968-100 from IEC TC57 WG 14
International Standard IEC 61968-100 has been prepared by IEC technical committee 57: Power systems management and associated information exchange. This part of the IEC 61968 standard and specifies an implementation profile for the application of the other parts of 61968 using common integration technologies, including JMS and web services. Guidance is also provided with respect to the use of Enterprise Service Bus (ESB) technologies. This provides a means to derive interoperable implementations of IEC 61968 parts 3 through 9. At the same time, this standard can be leveraged beyond information exchanges defined by IEC 61968. The scope of the IEC 61968-100 specifically includes the following: • Integration patterns that support IEC 61968 information exchanges • Design of interfaces for use of strongly typed web services • Design of interfaces for use of generically typed web services • Design of interfaces using JMS • Definition of standard design artefacts and related templates • Recognition that technologies other than JMS and web services may be used for integration leveraging this standard (with some specific examples and associated recommendations described in appendices)

IEC 61970-452: CIM model exchange specification

NAME	DESCRIPTION
General information:	IEC 61970-452 was developed and standardized by IEC It is at its 2nd version (IEC 61970-452:2015 Edition 2), released on the 09/04/2015. Its first release was released on the 12/08/2013. More information at: https://webstore.iec.ch/publication/22090
Aim and technologies	IEC 61970-452 was developed with the following aim: This standard specifies the specific profiles (or subsets) of the CIM for exchange of static power system data between utilities, security coordinators and other entities participating in an interconnected power system. It is based on the following technologies: Ontologies, Data Model, Profile. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Transmission - Zones: Operation - Interoperability Levels: Information
Description	This standard, IEC 61970-452, is a member of the IEC 61970-450 to 499 series that, taken as a whole, defines at an abstract level the content and exchange mechanisms used for data. transmitted between control centers and/or control center components. The purpose of this document is to rigorously define the subset of classes, class attributes, and roles from the CIM necessary to execute state estimation and power flow applications. A companion standard, 61970-552, defines the CIM XML Model Exchange Format based on the Resource Description Framework (RDF) Schema specification language which is recommended to be used to transfer power system model data for the 61970-452 profile.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by The "Equipment profile" is specified in tables. Main kind of provided messages/document/information: static power system model description.
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring electricity network security --- Ensuring system control - Improving market functioning and customer service -> In particular: --- Improving market functioning - Enabling better planning of future network investment
Involved actors	Grid Operators: TSO;
Use case clusters	- Grid reliability using market-based mechanisms - Grid stability - Monitoring the grid flows
Covered SGAM Domain specific systems	Transmission: - EMS Scada system

NAME	DESCRIPTION
Function specific and other covered system	
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: See IOP result in Appendix A-Tools description at https://www.entsoe.eu/major-projects/common-information-model-cim/cim-for-grid-models-exchange/iop-cgmes-archive/Pages/default.aspx - The standard has been used in different electric power industry applications. Number of known implementations: ENTSO-E, EU member state TSOs - There is support from on or more interest/users groups. These are:CIM User Group http://cimug.ucaiug.org/default.aspx
Relation with other standards and technologies	- IEC 61970-452 results to be largely compatible with the following standards: JMS, Web Services - A process of harmonization with other standards is involving IEC 61970-452: This standard have to be used with IEC 61970-456, the harmonization of these standards is implicit in the development of the CIM Data Model
Tools and documentation	- IEC 61970-452 has interoperability tests. The reference to these tests are the following: CIMTool (http://wiki.cimtool.org/index.html) - IEC 61970-452 has interoperability tests. The reference to these tests are the following: ENTSO-E organize annual interoperability tests - IEC 61970-452 provides tutorials and/or examples. The reference to them are the following: EPRI published "Common Information Model Primer: Third Edition" http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002006001 - IEC 61970-452 provides tools for facilitating implementation. The reference to them are the following: CIMTool
Possible barriers	- There is some probability that IEC 61970-452 can be affected by interoperability issues due to use of different standards for the same exchange
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 82%. The strength of this evaluation is 100%. This parameter seems to be very high. Knock-Out criteria are not specified.
Openness	Openness equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.

NAME	DESCRIPTION
Potential	Potential equals to 100%. The strength of this evaluation is 60%. This parameter seems to be high. The evaluation of this parameter is partial, since, for the 40% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 94,12% Final Strength = 92,31% Final Automated Evaluation = very high NOTE: For the 7,69% of the questions, available documentation has been judged insufficient

Reference documentation	IEC 61970-452:2015 https://webstore.iec.ch/publication/22090 Common Information Model (CIM) for Grid Models Exchange https://www.entsoe.eu/major-projects/common-information-model-cim/cim-for-grid-models-exchange/Pages/default.aspx SGCG/M490/G_Smart Grid Set of Standards Version 3.1 ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Standards_Report.pdf

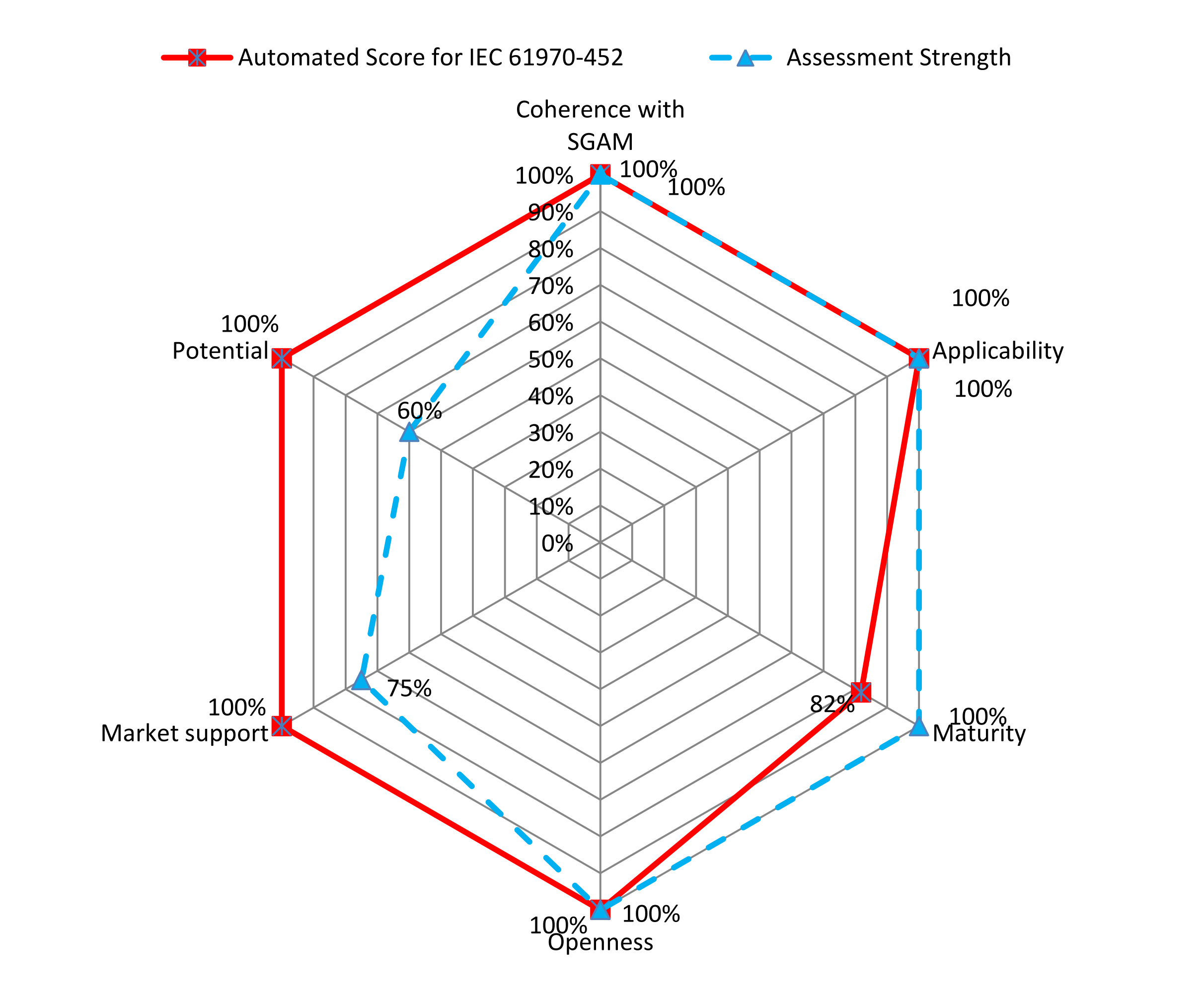

Figure 15 - Summary of IEC 61970-452 Assessment

Comments on Applicability	Reusability: - In perspective it's also applicable to Distribution and Microgrid domain Compatibility: - Standard IEC 61968-100
Comments on Potential	Security: - The standard only refers to abstract information level Privacy: - The standard only refers to abstract information level

Additional information about the standard IEC 61970-452 from IEC
This standard is one of the IEC 61970 series that define an application program interface (API) for an energy management system (EMS). The IEC 61970-3x series of documents specify a Common Information Model (CIM). The CIM is an abstract model that represents all of the major objects in an electric utility enterprise typically needed to model the operational aspects of a utility. It provides the semantics for the IEC 61970 APIs specified in the IEC 61970-4x series of Component Interface Standards (CIS). The IEC 61970-3x series includes IEC 61970-301: Common Information Model (CIM) base and draft standard IEC 61970-302: Common Information Model

Additional information about the standard IEC 61970-452 from IEC
(CIM) Financial, EnergyScheduling, and Reservation. This standard is one of the IEC 61970-4x series of Compoment Interface Standards that specify the functional requirements for interfaces that a component (or application) shall implement to exchange information with other components (or applications) and/or to access publicly available data in a standard way. The component interfaces describe the specific message contents and services that can be used by applications for this purpose. The implementation of these messages in a particular technology is described in 61970-5. This standard specifies the specific profiles (or subsets) of the CIM for exchange of static power system data between utilities, security coordinators and other entities participating in a interconnected power system, such that all parties have access to the modelling of their neighbour's systems that is necessary to execute state estimation or power flow applications. Currently only one profile, the Equipment Profile, has been defined. A companion standard, 61970-552, defines the CIM XML Model Exchange Format based on the Resource Description Framework (RDF) Schema specification language which is recommended to be used to transfer power system model data for the 61970-452 profile

IEC 61970-456: CIM model exchange specification

NAME	DESCRIPTION
General information:	IEC 61970-456 was developed and standardized by IEC It is at its 2nd version (IEC 61970-456:2013+AMD1:2015 CSV Edition 1.1), released on the 29/09/2015. Its first release was released on the 07/05/2013. More information at: https://webstore.iec.ch/publication/6214
Aim and technologies	IEC 61970-456 was developed with the following aim: IEC 61970-456 specifies the profiles (or subsets) of the Common Information Model required to describe a steady state solution of a power system case, such as is produced by power flow or state estimation applications. It is based on the following technologies: Ontologies, Data Model, Profile. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Transmission - Zones: Operation - Interoperability Levels: Information
Description	The standard describes the solution with reference to a power system model that conforms to IEC 61970-452 in this series of related standards. (Thus solution data does not repeat the power system model information.) IEC 61970-456 is made up of several component profiles that describe: topology derived from switch positions, measurement input (in the case of state estimation), and the solution itself.
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by The Data Model profiles are specified in tables Main kind of provided messages/document/information: steady state solution of a power system case
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring electricity network security --- Ensuring system control - Improving market functioning and customer service -> In particular: --- Improving market functioning - Enabling better planning of future network investment
Involved actors	Grid Operators: TSO;
Use case clusters	- Grid reliability using market-based mechanisms - Grid stability - Monitoring the grid flows
Covered SGAM Domain specific systems	Transmission: - EMS Scada system
Function specific and other covered system	

NAME	DESCRIPTION
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: See IOP result in Appendix A-Tools description at https://www.entsoe.eu/major-projects/common-information-model-cim/cim-for-grid-models-exchange/iop-cgmes-archive/Pages/default.aspx - The standard has been used in different electric power industry applications. Number of known implementations: ENTSO-E, EU member state TSOs - There is support from one or more interest/users groups. These are: CIM User Group http://cimug.ucaiug.org/default.aspx
Relation with other standards and technologies	- IEC 61970-456 results to be largely compatible with the following standards: JMS, Web Services - A process of harmonization with other standards is involving IEC 61970-456: This standard have to be used with IEC 61970-452, the harmonization of these standards is implicit in the development of the CIM Data Model
Tools and documentation	- IEC 61970-456 has interoperability tests. The reference to these tests are the following: CIMTool (http://wiki.cimtool.org/index.html) - IEC 61970-456 has interoperability tests. The reference to these tests are the following: ENTSO-E organize annual interoperability tests - IEC 61970-456 provides tutorials and/or examples. The reference to them are the following: EPRI published "Common Information Model Primer: Third Edition" http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002006001 - IEC 61970-456 provides tools for facilitating implementation. The reference to them are the following: CIMTool
Possible barriers	- There is some probability that IEC 61970-456 can be affected by interoperability issues due to use of different standards for the same exchange
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 82%. The strength of this evaluation is 100%. This parameter seems to be very high. Knock-Out criteria are not specified.
Openness	Openness equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 100%. The strength of this evaluation is 60%. This parameter seems to be high. The evaluation of this parameter is partial, since, for the 40% of questions, available documentation resulted inadequate Knock-Out criteria are not specified.

NAME	DESCRIPTION
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 94,12% Final Strength = 92,31% Final Automated Evaluation = very high NOTE: For the 7,69% of the questions, available documentation has been judged insufficient

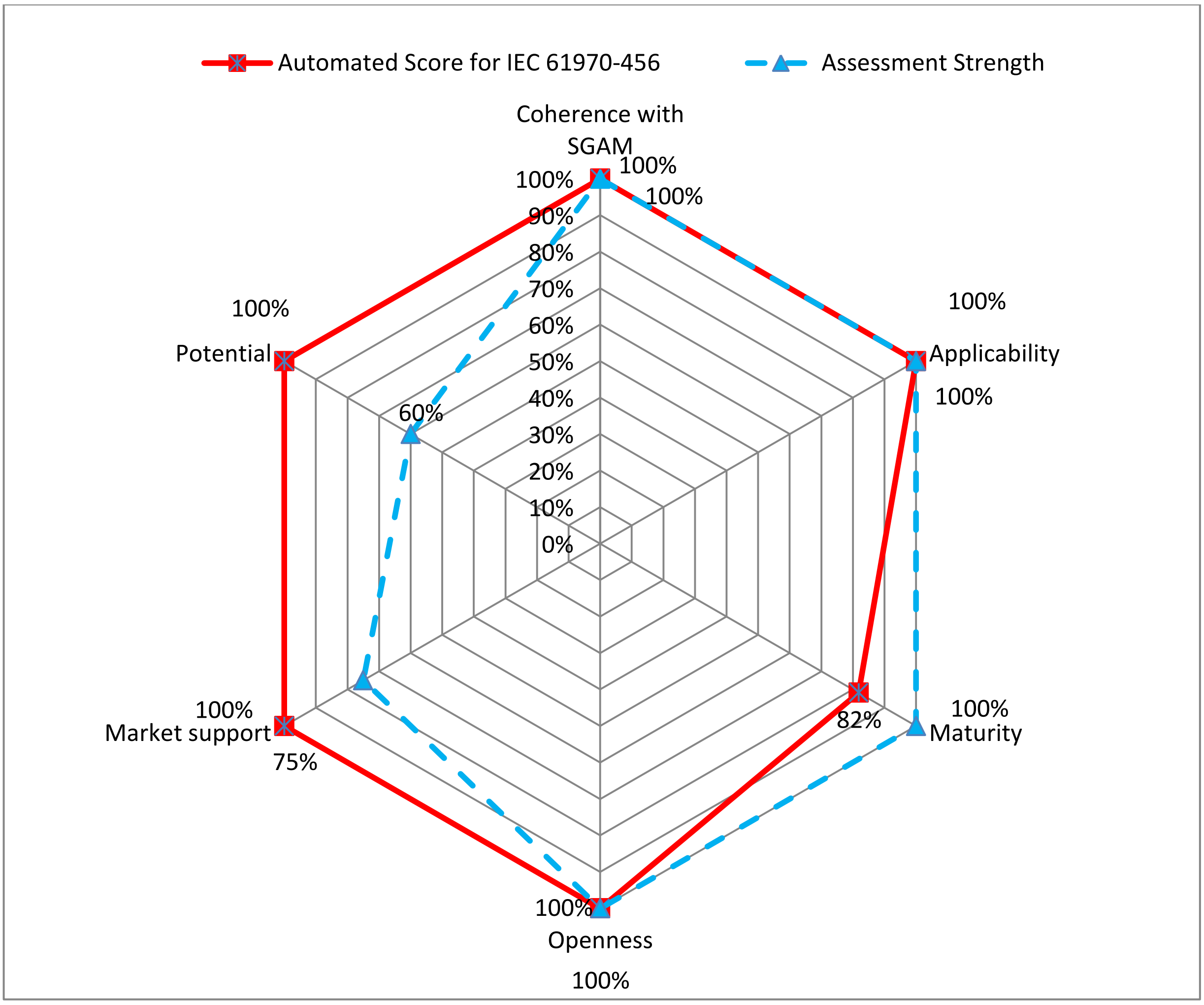

Figure 16 - Summary of IEC 61970-456

Comments on Applicability	Reusability: - In perspective it's also applicable to Distribution and Microgrid domain Compatibility: - Standard IEC 61968-100
Comments on Potential	Security: - The standard only refers to abstract information level Privacy: - The standard only refers to abstract information level

Additional information about the standard IEC 61970-456 from IEC
This standard is one of several parts of the IEC 61970 series that defines common information model (CIM) datasets exchanged between application programs in energy management systems (EMS). The IEC 61970-3xx series of documents specify the common information model (CIM). The CIM is an abstract model that represents the objects in an electric utility enterprise typically needed to model the operational aspects of a utility. This standard is one of the IEC 61970-4xx series of component interface standards that specify the semantic structure of data exchanged between components (or applications) and/or made publicly available data by a component. This standard describes the payload that would be carried if applications are communicating via a messaging system, but the standard does not include the method of exchange, and therefore is applicable to a variety of exchange implementations. This standard assumes and recommends that the exchanged data is formatted in XML based on the resource description framework (RDF) schema as specified in 61970-552 CIM XML model exchange standard. IEC 61970-456 specifies the profiles (or subsets) of the CIM required to describe a steady state solution of a power system case, such as is produced by power flow or state estimation applications. It describes the solution with reference to a power system model that conforms to IEC 61970-452 in this series of related standards. (Thus solution data does not repeat the power system model information.) IEC 61970-456 is made up of several component profiles that describe: topology derived from switch positions, measurement input (in the case of state estimation), and the solution itself. As CIM evolves the base model described in IEC 61970-301 and the profiles (e.g. IEC 61970-452 and 61970-456) are updated. The relation between the documents and IEC 61970 CIM versions is shown below • CIM14, IEC 61970-301 Ed. 4, IEC 61970-452 Ed. 1, IEC 61970-456 Ed. 1 • CIM15, IEC 61970-301 Ed. 5, IEC 61970-452 Ed. 2, IEC 61970-456 Ed. 1 Amendment 1 • CIM16, IEC 61970-301 Ed. 6, IEC 61970-452 Ed. 3, IEC 61970-456 Ed. 2

IEEE Standard C37.118.2-2011: Synchrophasor Data Transfer for Power Systems

NAME	DESCRIPTION
General information:	IEEE Std. C37.118.2-2011 was developed by IEEE Power and Energy Society and standardized by IEEE - Institute of Electrical and Electronics Engineers. It is at its 2nd version (C37.118.2-2011), released on the 28/12/2011. Its first release was released on the 03/04/2006.
Aim and technologies	IEEE Std. C37.118.2-2011 was developed with the following aim: The purpose for the standard IEEE C37.118.2-2011 is to facilitate data exchange among measurement, data collection, and application equipment. It provides a defined, open access method for all vendors to use to facilitate development and use of synchrophasors. It is a simple and direct method of data transmission and accretion within a phasor measurement system, which may be used directly or with other communication protocols. It is based on the following technologies: Ethernet, TCP/IP technology. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution - Zones: Process, Field , Station, Operation - Interoperability Levels: Information, Communication
Description	The standard IEEE C37.118.2-2011 defines data transmission formats for real-time data reporting for synchronized phasor measurements used in electric power systems. In particular the standard contains: - background for synchrophasor measurement. - description of the synchrophasor measurement system. - definition of the real-time communication protocol and message formats. Additionally six informative annexes are provided to clarify the standard and give supporting information: - Annex A is a bibliography. - Annex B gives information about cyclic redundancy codes and the cyclic redundancy check (CRC) required by this standard. - Annex C provides background in communication bandwidth. - Annex D illustrates the message formats defined in Clause 6 with complete message examples. - Annex E defines message mapping into standard communication protocols. - Annex F discusses synchrophasor communications methods for Internet Protocol (IP).
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by Description of the data formats is presented using tables together with extensive comments. Main kind of provided messages/document/information: Data frames, configuration frames, header frames. COMMUNICATION STANDARD FEATURES: Time latency: 20 - 100 ms Bandwidth: 10 - 500 kb/s
List of enabled Smart Grid functionalities	- Enhancing efficiency in day-to-day grid operation - Ensuring network security, system control and quality of supply -> In particular: --- Ensuring electricity network security

NAME	DESCRIPTION
	--- Ensuring system control
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator;
Use case clusters	- Blackout management - Controlling the grid (locally/ remotely) manually or automatically - Grid stability - Monitoring the grid flows
Covered SGAM Domain specific systems	Generation: - Generation management system Transmission: - Substation automation systems - EMS Scada system - WAMPACs Distribution: - Substation automation systems - Feeder Automation System
Function specific and other covered system	Cross-cutting: - Telecommunication
IPR	The standard is publicly available with fee.
Diffusion	- The standard has been implemented by vendors/suppliers. The main suppliers: ABB, SEL, GE, VISIMAX - The standard has been used in different electric power industry applications. Number of known implementations: WAMS installations all over the world (USA, Canada, Mexico, Europe, India, China, Russia) - There is support from one or more interest/users groups. These are: North American SynchroPhasor Initiative (NASPI), https://www.naspi.org/
Relation with other standards and technologies	- The following standards are possible alternative to IEEE Std. C37.118.2-2011: 1. IEEE Std. C37.118 - 2005, IEEE Standard for Synchrophasor Data Transfer for Power Systems 2. IEC TR 61850-90-5 Ed.1: Communication networks and systems for power utility automation - Part 90-5. Use of IEC 61850 to transmit synchrophasors information according to IEEE C.37.118 - IEEE Std. C37.118.2-2011 results to be largely compatible with the following standards: TCP/IP, UDP/IP - A process of harmonization with other standards is involving IEEE Std. C37.118.2-2011: The data covered by IEEE Std. C37.118.2 -2011 is transported in a way that is compliant to the concepts of IEC 61850 that is described in IEC TR 61850-90-5.

NAME	DESCRIPTION
Tools and documentation	- IEEE Std. C37.118.2-2011 has interoperability tests. The reference to these tests are the following: 1. IEEE Std. C37.242 - 2013: IEEE Guide for Phasor Data Concentrator Requirements for Power System Protection, Control, and Monitoring 2. IEEE Std. C37.242-2013: IEEE Guide for Synchronization, Calibrating, Testing, and Installation of Phasor Measurement Units (PMUs) for Power System Protection and Control - IEEE Std. C37.118.2-2011 provides guidelines and/or documentation. The reference to them are the following: 1. IEEE Std. C37.244 - 2013: IEEE Guide for Phasor Data Concentrator Requirements for Power System Protection, Control, and Monitoring 2. IEEE Std. C37.242-2013: IEEE Guide for Synchronization, Calibrating, Testing, and Installation of Phasor Measurement Units (PMUs) for Power System Protection and Control - Evidence about positive impact of the standard provided by the following case studies: 1. Wide Area Monitoring – Current Continental Europe TSOs Applications Overview, Version 4, ENTSOE, System Protection & Dynamics Working Group, 7 August 2015. 2. IEEE Power & Energy Magazine, September/October 2015. 3. Aminifar F. et al. Synchrophasor Measurement Technology in Power Systems: Panorama and State-of-the-Art, IEEE Access, vol. 2, 2014.
Possible barriers	- There is some probability that IEEE Std. C37.118.2-2011 can be affected by lacking of real interoperability due to ambiguity of specifications
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 60%. The strength of this evaluation is 91%. This parameter seems to be moderate. Knock-Out criteria are not specified.
Openness	Openness equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 2 Knock-Out criteria specified and they are all met.
Market support	Market support equals to 100%. The strength of this evaluation is 75%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 40%. The strength of this evaluation is 100%. This parameter seems to be low. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 67%. The strength of this evaluation is 100%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 73,68% Final Strength = 95,% Final Automated Evaluation = high NOTE: For the 5,% of the questions, available documentation has been judged insufficient

NAME	DESCRIPTION
Reference documentation	[IEEE Std. C37.118.2 - 2011, IEEE Standard for Synchrophasor Data Transfer for Power Systems] + https://standards.ieee.org/findstds/standard/C37.118.2-2011.html [IEEE Std. C37.118.1 - 2011, IEEE Standard for Synchrophasor Measurements for Power Systems] + https://standards.ieee.org/findstds/standard/C37.118.1-2011.html [IEEE Std. C37.244 - 2013: IEEE Guide for Phasor Data Concentrator Requirements for Power System Protection, Control, and Monitoring] + https://standards.ieee.org/findstds/standard/C37.244-2013.html

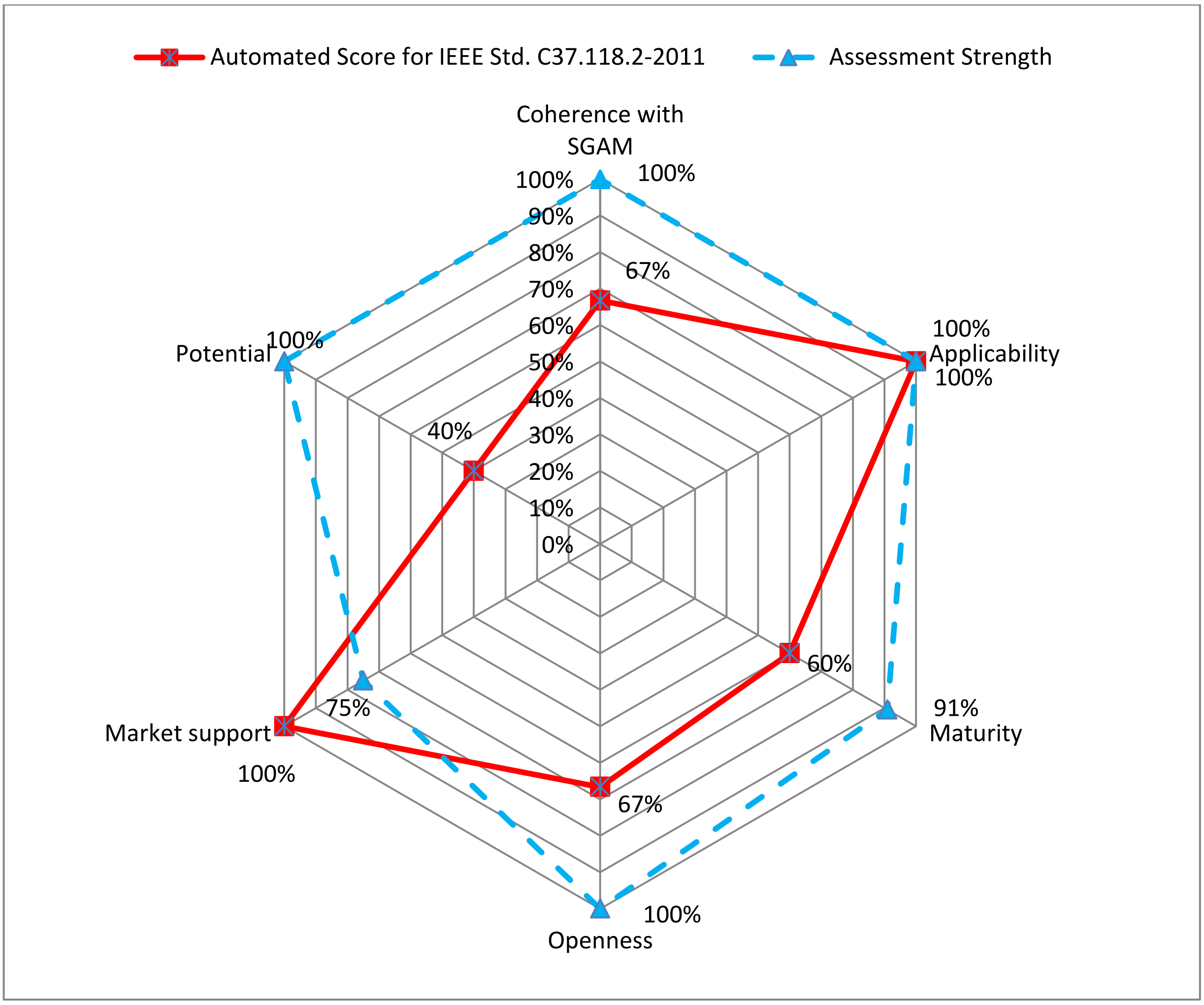

Figure 17 - Summary of IEEE C37.118.2-2011 Assessment

Critical points for Maturity	There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Openness	Specifications are not licensed on a royalty-free basis.
Critical points for Potential	There are no evidences about its impact Security is not well addressed, Privacy is not well addressed.

Comments on Maturity	Vitality of the standard: - The previous edition was finished in 2005 and issued in 2006.
Comments on Openness	Documentation: - The standard should be purchased
Comments on Potential	Security: - The standard does not address the cyber security directly. However, the cyber security issue is addressed by the IEEE Std. C37.242 - 2013: IEEE Guide for Phasor Data Concentrator Requirements for Power System Protection, Control, and Monitoring and also by IEEE std. C37.240 - 2014: IEEE Standard Cybersecurity Requirements for Substation Automation, Protection and Control Systems.

Additional information about the standard IEEE Std. C37.118.2-2011 from IEEE Power and Energy Society

The standard IEEE C37.118.2-2011 defines data transmission formats for real-time data reporting for synchronized phasor measurements used in electric power systems.

In particular the standard contains:

- background for synchrophasor measurement.
- description of the synchrophasor measurement system.
- definition of the real-time communication protocol and message formats.

Additionally six informative annexes are provided to clarify the standard and give supporting information:

- Annex A is a bibliography.
- Annex B gives information about cyclic redundancy codes and the cyclic redundancy check (CRC) required by this standard.
- Annex C provides background in communication bandwidth.
- Annex D illustrates the message formats defined in Clause 6 with complete message examples.
- Annex E defines message mapping into standard communication protocols.
- Annex F discusses synchrophasor communications methods for Internet Protocol (IP).

A simple structure of a synchrophasor network consists of the PMUs (Phasor Measurement Units) and PDCs (Phasor Data Concentrators).

A PMU is a function or logical device that provides synchrophasor and system frequency estimates, as well as other optional information such as calculated megawatts (MW) and megavars (MVAR), sampled measurements, and Boolean status words. The PMU may provide synchrophasor estimates from one or more voltage or current waveforms. The PMU can be realized as a stand-alone physical device or as a part of a multifunction device such as a protective relay, DFR, or meter.

A PDC works as a node in a communication network where synchrophasor data from a number of PMUs or PDCs is correlated and fed out as a single stream to the higher level PDCs and/or applications. The PDC correlates synchrophasor data by time tag to create a system wide measurement set.

If multiple intelligent electronic devices (IEDs) in a substation provide synchrophasor measurements, a local PDC may be deployed in the substation. Typically, many PMUs located at various key substations gather data and send it in real time to a PDC at the utility location where the data is aggregated. The data collected by PDCs may be used to support many applications, ranging from visualization of information and alarms for situational awareness, to ones that provide sophisticated analytical, control, or protection functionality. Applications, such as dynamics monitoring, use full-resolution real-time data along with grid models to support both operating and planning functions. The application displays locally measured frequency, primary voltages, currents, real and reactive power flows, and other quantities for system operators.

OASIS EMIX: Energy Market Information Exchange

NAME	DESCRIPTION
General information:	EMIX was developed by OASIS. It has still not been standardized by official SDO. It is at its 1st version (1.0), released on the 11/01/2012. Its first release was released on the 11/01/2012. More information at: http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.html
Aim and technologies	This standard has not been considered by SGCG final report. EMIX was developed with the following aim: to define an information model and XML vocabulary for the interoperable and standard exchange of prices and product definitions in transactive energy markets. It is based on the following technologies: XML, XML schema, WS-Calendar 1.0. It address: Interoperability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Generation, Transmission, Distribution, DER, Customer Premises - Zones: Market - Interoperability Levels: Information
Description	EMIX enable communication of both intrinsic properties (those that can be measured and/or verified at the point of delivery, such as electric power and price) and extrinsic properties (those that can only be known with prior knowledge, such as the carbon cost, the energy source...). To get this result it use an information structure similar to an "envelope containing Warrants": the intrinsic properties are on the face of the envelope and the extrinsic one are in its content. The focus of EMIX is on a Price and Product information model for communication in support of commercial transactions. The messaging and interaction patterns for commercial transactions are out of scope for EMIX. The EMIX 1.0 Specification consists of four schemas: - the EMIX Schema (made of 3 files: emix.xsd, emix-terms.xsd, and emix-warrants.xsd), It defines the framework, the extensibility and agreement types common to many markets - the SI Scale schema, which defines code list fo measurement defined by the System International - the Power Schema (3 files: power.xsd, power-product.xsd, and power-quality.xsd), which define specific information exchanges - the Resource schema, which defines specific capabilities of devices and systems
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by XML Schema (available at: http://docs.oasis-open.org/emix/emix/v1.0/cs02/xsd/) Main kind of provided messages/document/information: Price information, Bid information, Time for use or availability, Units and quantity to be traded, Characteristics of what is traded SECURITY AND PRIVACY: - Security addressed by The industry-standard OASIS security standards can be composed with EMIX, WS-Calendar, and Energy Interoperation, tailoring security to the requirements for an interaction or a piece of information
List of enabled Smart Grid functionalities	- Improving market functioning and customer service -> In particular: --- Improving market functioning --- Improving customer service

NAME	DESCRIPTION
Involved actors	Grid Operators: TSO; DSO; Grid Users: Generator; Supplier ; Retailer; Customers: Industrial customer; Transportation Customer; Buildings; Home customer; Energy Market Place: Power Exchange; Trader; Supplier; Aggregator;
Use case clusters	- Demand and production (generation) flexibility - (AMI) Energy market events - Flexibility markets - Grid reliability using market-based mechanisms - Manage commercial relationship for electricity supply - Market Settlements - Operate wholesale electricity market - Trading front office operation
Covered SGAM Domain specific systems	Generation: - Generation management system DER: - DER operation systems Customer Premises: - Metering-related Back Office system - Aggregated prosumers management system
Function specific and other covered system	Market: - Market place system - Trading system Cross-cutting: - Data modelling
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: Implementation work is in progress, including by members of the OpenADR Alliance and TeMIX Inc. In addition, two open source projects implementing Energy Interoperation 1.0 and/or profiles that use the EMIX information model are starting up. - There is support from one or more interest/users groups. These are:TeMIX and OpenADRAlliance
Relation with other standards and technologies	- EMIX results to be largely compatible with the following standards: Information and communication model is described by OASI Energy interoperation, which defines web services consistent with OASIS SOA reference model - A process of harmonization with other standards is involving EMIX: EMIX is part of a suite of OASIS Standards with OASIS WS-Calendar and OASIS Energy Interop. Other coordinated OASIS Standards are: OASIS Emergency Management Standards, OASIS Security Standards, OASIS Message Reliability Standards. Moreover, harmonization process is forecast with OpenADR (see http://www.gridwiseac.org/pdfs/forum_papers11/ghatikar_paper_gi11.pdf) and is addressed by the Priority Action Plans (PAPs), which are SGIP (Smart Grid Interoperability Panel) projects that produce, harmonize, or modify Smart Grid Standards - Unfortunately EMIX results largely dependent from a geographical basis different from Europe (USA)
Tools and documentation	- EMIX provides guidelines and/or documentation. The reference to them are the following: http://docs.oasis-open.org/emix/emix/v1.0/emix-v1.0.html

NAME	DESCRIPTION
Possible barriers	- There is some probability that EMIX can be affected by scarce maintenance/updating of the specifications - There is some probability that EMIX can be affected by lacking of Critical mass - There is strong probability that EMIX is affected by lacking of real interoperability due to ambiguity of specifications - There is some probability that EMIX can be affected by interoperability issues due to use of different standards for the same exchange
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 80%. The strength of this evaluation is 90%. This parameter seems to be high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 20%. The strength of this evaluation is 90%. This parameter seems to be very low. Knock-Out criteria are not specified.
Openness	Openness equals to 67%. The strength of this evaluation is 90%. This parameter seems to be moderate. There are 2 Knock-Out criteria specified and they are **broken** 1 time(s)
Market support	Market support equals to 50%. The strength of this evaluation is 90%. This parameter seems to be low. Knock-Out criteria are not specified.
Potential	Potential equals to 40%. The strength of this evaluation is 90%. This parameter seems to be low. Knock-Out criteria are not specified.
Coherence with SGAM	Coherence with SGAM equals to 33%. The strength of this evaluation is 100%. This parameter seems to be low. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 50,% Final Strength = 90,% Final Automated Evaluation = low BUT this is NOT a recognized standard! BUT at least one KO criteria has been broken!

Reference documentation	EMIX Specifications: http://docs.oasis-open.org/emix/emix/v1.0/cs02/emix-v1.0-cs02.pdf EMIX XML Schema: http://docs.oasis-open.org/emix/emix/v1.0/cs02/xsd/

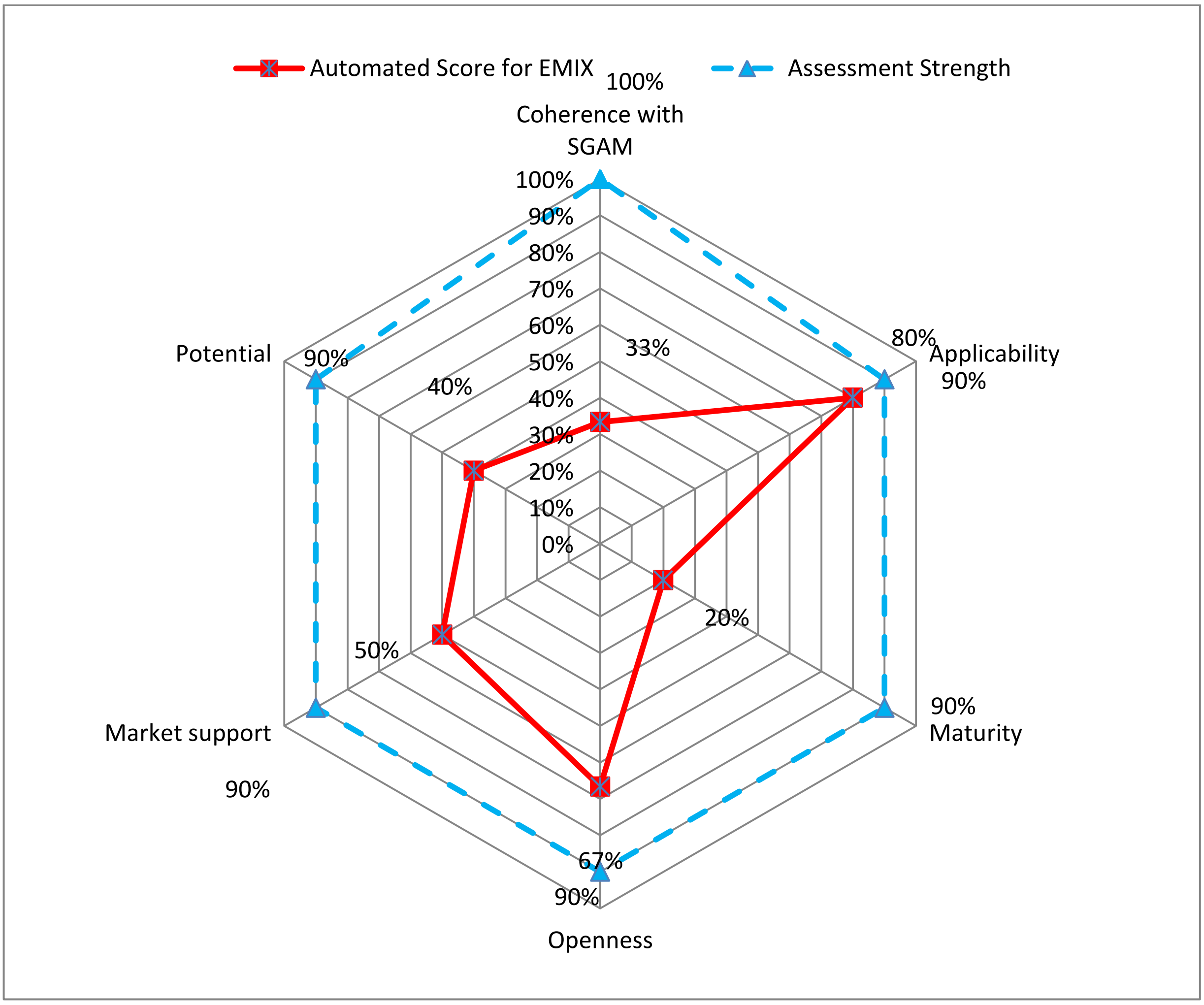

Figure 18 - Summary of EMIX Assessment

Critical points for Coherence with SGAM	The standard is out of the set provided by the SGCG (report and Excel List).
Critical points for Maturity	Development status seems insufficient. There are some problems in assessing its quality. Guidelines seem insufficient. The vitality of the standard seems low.
Critical points for Openness	The standardizing organization is not a recognized SDO.
Critical points for Market support	Adoption of the standard in real world seems scarce.
Critical points for Potential	There are no evidences about its impact Privacy is not well addressed.

Comments on Coherence with SGAM	Coordinates on the SGAM Reference Model: - It is quoted in the document, about DER operations, but not inserted in the list of standards

Comments on Applicability	Reusability: - A first extension allowing to define the base production to define terms for Real Power, Apparent Power, and Reactive Power is already available Geographical basis: - Application in Europe is not excluded, but this specification was born in USA and there could be differences with European market that have been not take in consideration
Comments on Maturity	Stability: - This is the first version.

Additional information about the standard EMIX from OASIS

FROM:
https://www.qualitylogic.com/tuneup/uploads/docfiles/TC_OpenADR_Roles_and_Relationshipsv107.pdf

EMIX is intended for commercial transactions in all types of energy markets. Transactions start with a tender, which is an offer to buy or sell between two parties. Once agreement is reached, parties agree to a transaction, which is a contract or award. The parties to the transaction then perform by arranging for supply, transport, consumption, settlement, and payment. The EMIX standard provides a generalized information model for the tenders and transactions. EMIX also supports energy options, which is an instrument that gives the buyer the right, but not the obligation, to buy or sell a product at a set price during a given time window.

It is best to think of EMIX as a tool box that can be utilized to construct energy products for a given market and need. The tools include inheritance methods to efficiently communicate the same product being delivered in different time frames (gluons, sequences), methods to describe standard terms and market expectations (market context), and methods to express the source of energy or its environmental characteristics (warrants).

The EMIX standard defines a set of extensions specific to representing power products with support for characteristics such as real, apparent, or reactive power, as well as ways to describe levels and tiers. These extensions are used in the standard to define the following detailed EMIX product descriptions:

- Power products that are bought under terms that specify the energy and its rate of delivery over a duration, or made available for up to the maximum deliverable by the in-place infrastructure

- Resource offers that include characteristics of generators, storage resources, and loads that produce power through curtailment, as well as the prices and quantities of products/services offered

- Transport products provide for the transport of a product using transmission and distribution facilities from one location to another. Transport pricing includes factors such as energy loses and congestion prices.

Each of these products supports a wide variety of transaction types such as Full

Requirements Power, Transport Services, and Demand Charges.

ENTSO-E MADES: Market Data Exchange Standard

NAME	DESCRIPTION
General information:	MADES was developed by ENTSO-E It has still not been standardized by official SDO. It is at its 2nd version (1.1), released on the 20/06/2014. Its first release was released on the 18/01/2012. More information at: https://www.entsoe.eu/publications/electronic-data-interchange-edi-library/work%20products/mades/Pages/default.aspx
Aim and technologies	MADES was developed with the following aim: to provide TSOs with a standardized communication access point to securely exchange documents with others parties involved in the European electricity market and to create a data exchange standard comprised of standard protocols and utilizing IT best practices to create a mechanism for exchanging data over any TCP/IP communication network, in order to facilitate business-to-business information exchanges. It is based on the following technologies: Web Services, HTTPS, X.509 digital certificates. It address: Interoperability, Stability. In the SGAM Reference Model, it covers the following coordinates: - Domains: Transmission - Zones: Market - Interoperability Levels: Information
Description	MADES specifies a framework for asynchronous communication; therefore the architecture contains hubs (namely Nodes) that offer a service to temporary store messages. So, MADES is not intended for real time messaging. MADES specifies a message delivery platform with the following features: Message delivery, Transparency in the sense that each message can be tracked, Security, Reliability, Integration with wide variety of technologies, Integrity of the transported message. The document transported between sender and recipient can be any text or binary data. Security is assured by encryption of the messages, use of secure communication protocols (HTTP/SSL) and unique identification and authentication of the message. MADES describes two logical communication components (Node and Endpoint) and their interface and a MADES network (which has a distributed architecture) may consist of multiple interconnected nodes. For the defined interfaces and services, there are provided the WSDL for defining the needed Web Services
Other Technical Information	INFORMATION STANDARD FEATURES: Document specifications provided by WSDL Main kind of provided messages/document/information: It provide interfaces like "Send Message", "Upload Message", "Connectivity test" SECURITY AND PRIVACY: - Security addressed by HTTS, encryption, use of X451 certificates - Privacy addressed by HTTS, encryption, use of X451 certificates
List of enabled Smart Grid functionalities	- Improving market functioning and customer service -> In particular: --- Improving market functioning
Involved actors	Grid Operators: TSO; DSO; Energy Market Place: Trader;

NAME	DESCRIPTION
Use case clusters	- Manage commercial relationship for electricity supply - Market Settlements
Covered SGAM Domain specific systems	
Function specific and other covered system	Market: - Market place system - Trading system
IPR	The standard is publicly available on royalty-free basis.
Diffusion	- The standard has been implemented by vendors/suppliers. Number of known implementations: One: http://www.unicornsystems.eu/en/industry-solutions/solutions/ecp-energy-communication-platform_en.html - The standard has been used in different electric power industry applications. Number of known implementations: It is widely used among TSOs to communicate transactional data (source: https://ec.europa.eu/energy/sites/ener/files/documents/20121207_wholesale_energy_markets_remit_report.pdf) - The standard has a significant market share of adoption. Markets share: Widely used among TSOs
Relation with other standards and technologies	- MADES results to be largely compatible with the following standards: It could be use over any TCP/IP communication network
Tools and documentation	- MADES provides guidelines and/or documentation. The reference to them are the following: https://www.entsoe.eu/fileadmin/user_upload/edi/library/mades/mades-v1r1.pdf
Possible barriers	- There is some probability that MADES can be affected by lacking of real interoperability due to ambiguity of specifications - There is some probability that MADES can be affected by interoperability issues due to use of different standards for the same exchange
Assessment	**The standard has been evaluated in following way, according to the following parameters:**
Applicability	Applicability equals to 91%. The strength of this evaluation is 90%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Maturity	Maturity equals to 45%. The strength of this evaluation is 90%. This parameter seems to be low. Knock-Out criteria are not specified.
Openness	Openness equals to 33%. The strength of this evaluation is 90%. This parameter seems to be low. There are 2 Knock-Out criteria specified and they are broken 1 time(s)
Market support	Market support equals to 75%. The strength of this evaluation is 90%. This parameter seems to be high. Knock-Out criteria are not specified.
Potential	Potential equals to 60%. The strength of this evaluation is 90%. This parameter seems to be moderate. Knock-Out criteria are not specified.

NAME	DESCRIPTION
Coherence with SGAM	Coherence with SGAM equals to 100%. The strength of this evaluation is 100%. This parameter seems to be very high. There are 1 Knock-Out criteria specified and they are all met.
Final Assessment	Final Score = 65,% Final Strength = 90,% Final Automated Evaluation = moderate BUT this is NOT a recognized standard! BUT at least one KO criteria has been broken!

Reference documentation	https://www.entsoe.eu/fileadmin/user_upload/edi/library/mades/mades-v1r1.pdf

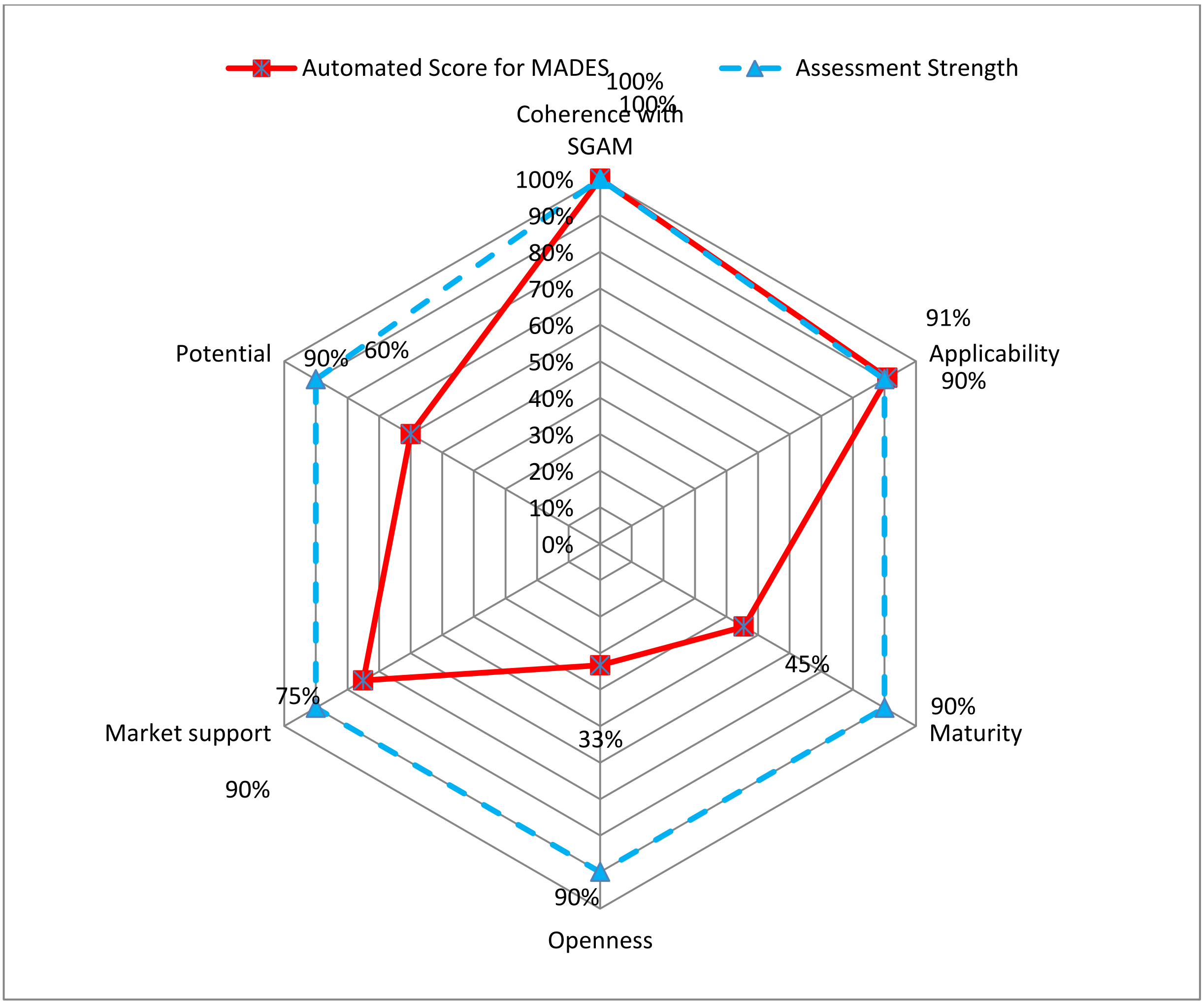

Figure 19 - Summary of MADES Assessment

Critical points for Maturity	Development status seems insufficient. There are some problems in assessing its quality. Guidelines seem insufficient.

Critical points for Openness	The standardizing organization is not a recognized SDO. Some important information/documentation about the process or the standard is not publicly available.
Critical points for Market support	There is no support from user groups.
Critical points for Potential	There are no evidences about its impact

Comments on Openness	Organisation: - Even it is not a standard approved by an official SDO (KO parameter), this specification was officially listed by the SGCG so it has to be taken into consideration

List of interactions

On the base of the work made by the Task 4.2 on use cases the following mapping by interaction and standards can be suggested:

New Unique ID	Name	Spec	From	To	UC	Suggested standard for SGAM Information Layer	Suggested standard for SGAM Communication Layer
IEX_01	Cell CPFC setpoint	Value of requested cell freq. droop contribution in Watts/Hz with resolution 1 Watt/Hz ; CTS3 timescale (e.g. every 15-min)	Cell CPFC setpoint provider	Frequency Droop Slope Determination	FCC	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
IEX_01	Cell CPFC setpoint	Value of requested cell freq. droop contribution in Watts/Hz with resolution 1 Watt/Hz ; CTS3 timescale (e.g. every 15-min)	Cell CPFC setpoint provider	Cell Setpoint Adjuster	BSC 1.3.1	engineering of SCADA -> e.g. Cim LimitSet - IEC 61970-301	IEC 60870-5-104
IEX_02	Tie-line Active Powerflow setpoints	Vector of individual tie-lines active powerflow schedules (Pi; flat numbers) in Watt with resolution 1 Watt in conjunction with EANi (location); CTS3 timescale (e.g. every 15min).	Tie-line Active Powerflow setpoint provider	Imbalance Observation	BRC 1.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
IEX_03	Tie-line Reactive Powerflow setpoints	Vector of individual tie-lines reactive powerflow schedules (Qi; flat numbers) in VAr with 1 VAr resolution in conjunction with EANi (location); CTS3 timescale (e.g. every 15min).	Tie-line Reactive Powerflow setpoint provider	PPVC setpoint providing	PPVC	IEC 60870-5-104	IEC 60870-5-104
IEX_04	Cell Inertia setpoint	Value of requested cell (virtual) inertia (J; flat number) in kgm2 with resolution 1 kgm2; CTS3 timescale (e.g. every 15min).	Cell Inertia setpoint provider	df/dt Droop Slope Determination	IRPC 1.2.1	IEC61968-11	IEC61968-100

IEX_05	Balance Reserves information	Vector of active power values (forecasted Pmax, Pmin, Pbaseline ; flat numbers) in Watt with resolution 1 Watt, and Cost (euros/Watt) ; CTS3 timescale (e.g. every 15min) (EANi optionally depending on communication approach)	Balance Reserves Information provider	Merit Order Collection	FCC	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Balance Reserves Information provider	Merit Order Collection	BRC 1.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
IEX_06	Inertia Reserves information	Vector of (virtual) inertia (J) in kgm2 with resolution 1 kgm2 and cost (euros/kgm2) ; CTS3 timescale (e.g. every 15min). (EANi optionally depending on communication approach)	Inertia Reserves Information provider	Merit Order Collection	IRPC 1.2.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
IEX_07	Voltage Reserves information	For AVR nodes : Vector of three reactive power values (forecasted Qmax, Qmin, Qbaseline ; flat numbers) in VAr with 1 VAr resolution ; CTS3 timescale (e.g. every 15min) (EANi optionally depending on communication approach) For controllable Q nodes : Vector of three reactive power values (forecasted Qmax, Qmin, Qbaseline ; flat numbers) in VAr with 1 VAr resolution ; CTS3 timescale (e.g. every 15min) (EANi optionally depending on communication approach) For capacitor banks : none : it is assumed that the PPVC setpoint providing knows/remembers the current state and the possible alternative states. For OLTC nodes : it is assumed that the PPVC setpoint providing knows/remembers the current position and the possible alternative positions.	Voltage Reserves Information provider	PPVC Setpoint Providing	PPVC	IEC 60870-5-104	IEC 60870-5-104

IEX_08	Forecasted Load and Generation	Vector of active and reactive power values (P, Q ; flat numbers) in Watt with resolution 1 Watt and VAr with resolution 1 VAr respectively ; CTS3 timescale (e.g. every 15min) (EANi optionally depending on communication approach)	Load & Generation forecast provider	Merit Order Decision	FCC	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Load & Generation forecast provider	Merit Order Decision	BRC 1.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Load & Generation forecast provider	Tie Line Limits calculation	BSC 1.3.1	Same information format with FCC/BRC(IEX_09) only for the tie lines.	Same information format with FCC/BRC(IEX_09) only for the tie lines.
			Load & Generation forecast provider	Tie Line Limits calculation	BSC 1.1.1	Same information format with FCC/BRC(IEX_09) only for the tie lines.	Same information format with FCC/BRC(IEX_09) only for the tie lines.
			Load & Generation forecast provider	Merit Order Decision	IRPC 1.2.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Load & Generation forecast provider	PPVC Setpoint Providing	PPVC	IEC 60870-5-104	IEC 60870-5-104

IEX_09	Measured Frequency	Value in mHz with resolution 10 mHz ; CTS2 timescale (e.g. every 10 periods - 200msec)	Frequency Observation	Adaptive CPFC Determination	FCC	IEEE C37.118.2	IEEE C37.118.2
			Frequency Observation	Cell Setpoint Adjusting	BSC 1.3.1	IEEE C37.118.2	IEEE C37.118.2
			Frequency Observation	Imbalance Observation	BRC1.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Frequency Observation	DER (freq droop device)	FCC	IEEE C37.118.2	IEEE C37.118.2

IEX_10	Measured Tie-line Active Powerflow	Value of tie-lines power flow (P) in Watt with resolution 1 Watt ; CTS1 timescale (as fast as possible). (EANi optionally depending on communication approach)	Tieline Active Powerflow observation	Imbalance Observation	BRC 1.1	IEC 60870-5-104	IEC 60870-5-104

IEX_11	Measured Voltage	Value of voltage set-point (V) in mV with resolution 10mV; CTS3 timescale (e.g. every 15min) in proactive mode	Voltage Observation	DER - AVR device	PVC	IEC 60870-5-104	IEC 60870-5-104
		Value of voltage set-point (V) in mV with resolution 10mV; CTS3 timescale (e.g. every 15min) in proactive mode (EANi optionally depending on communication approach)	Voltage Observation	PPVC Controlling	PPVC	IEC 60870-5-104	IEC 60870-5-104

IEX_12	Balance Initial Merit Order list	Matrix of active power values (forecasted Pmax, Pmin, Pbaseline ; flat numbers) in Watt with resolution 1 Watt in conjunction with EANi (location) ; CTS3 timescale (e.g. every 15min) (ordered in increasing cost; cost information could be added optionally)	Merit Order Collection	Merit Order Decision	FCC	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Merit Order Collection	Merit Order Decision	BRC 1.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required

IEX_13	Inertia Initial Merit Order list	Matrix of (virtual) inertia (J) in kgm2 with resolution 1 kgm2 in conjunction with EANi (location) ; CTS3 timescale (e.g. every 15min). (ordered in increasing cost ; cost information could be added optionally).	Merit Order Collection	Merit Order Decision	IRPC 1.2.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required

IEX_14	Balance Final Merit Order list	Matrix of active power values (forecasted Pmax, Pmin, Pbaseline ; flat numbers) in Watt with resolution 1 Watt in conjunction with EANi (location) ; CTS3 timescale (e.g. every 15min) (only those that can be activated securely ; ordered in increasing cost ; cost information could be added optionally)	Merit Order Decision	Frequency Droop Slope Determination	FCC	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Merit Order Decision	Imbalance Correction	BRC 1.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
IEX_15	Inertia Validated Merit Order list	Matrix of (virtual) inertia (J) in kgm2 with resolution 1 kgm2 in conjunction with EANi (location); CTS3 timescale (e.g. every 15min). (only those that can be activated securely ; ordered in increasing cost ; cost information could be added optionally).	Merit Order Decision	df/dt Droop Slope Determination	IRPC 1.2.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
IEX_16	Instantaneous Imbalance	Value of active power (P) in Watt with resolution 1 Watt ; CTS2 timescale (sampling time 1 sec or less)	Imbalance Correction	Cell Setpoint Adjusting	BSC 1.1.1	CIM: Base Unit Active Power object from 61970-301	IEC 61968-100, IEC 60870-6
IEX_17	Cell Imbalance error	Value of active power (P) in Watt with resolution 1 Watt ; CTS1 timescale (as fast as possible) or CTS2 timescale (10 periods-200msec) (aggregated error signal)	Imbalance Observation	Adaptive CPFC Determination	BRC 1.1	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Imbalance Observation	Adaptive CPFC Determination	FCC	Internal Exchange - no information standard is required	Internal Exchange - no Communication standard is required
			Imbalance Observation	Imbalance Correction	BRC 1.1	setPoint Object from IEC 61850 compliant device	setPoint Object from IEC 61850 compliant device
			Cell Setpoint Adjusting Imbalance Observation	Imbalance Observation Cell Setpoint Adjusting	BSC 1.3.1	setPoint Object from IEC 61850 compliant device	setPoint Object from IEC 61850 compliant device

IEX_18	Setpoint Change	Value of active power (P) in Watt with resolution 1 Watt ; CTS2 timescale (sampling time 1 sec or less)	Cell Setpoint Adjusting	Imbalance Observation	BSC 1.1.1	setPoint Object from IEC 61850 compliant device	setPoint Object from IEC 61850 compliant device
			Cell Setpoint Adjusting Imbalance Observation	Imbalance Observation Cell Setpoint Adjusting	BSC 1.3.1	setPoint Object from IEC 61850 compliant device	setPoint Object from IEC 61850 compliant device
IEX_19	P Activation Signal	Value of active power (P) in Watt with resolution 1 Watt or (Broadcast mode) Matrix of Values of active Power (P) in Watt with resolution 1 Watt in conjunction with EANi (location)	Imbalance Correction	DER (controllable P device)	BRC 1.1	IEC 60870-5-104	IEC 60870-5-104
IEX_20	Freq Droop Parameters	Vector of droop slope and frequency threshold in Watts/Hz with resolution 1 Watt/Hz and in mHz with resolution 10 mHz respectively ; CTS3 timescale (e.g. every 15min) or (Broadcast mode) Matrix of droop slope and frequency threshold in Watts/Hz with resolution 1 Watt/Hz and in mHz with resolution 10 mHz respectively in conjunction with EANi (location) ; CTS3 timescale (e.g. every 15min)	Frequency Droop Slope Determination	DER (freq droop device)	FCC	IEC 60870-5-104	IEC 60870-5-104
IEX_21	CPFC Scaling factor	Value between 0.00 and 1.00 with resolution 0.01 ; CTS1 timescale (as fast as possible) or (Broadcast mode) matrix of values between 0.00 and 0.01 with resolution 0.01 in conjunction with EANi (location) ; CTS1 timescale (as fast as possible)	Adaptive CPFC Determination	DER (freq droop device)	FCC	IEC 60870-5-104	IEC 60870-5-104

IEX_22	Allowed tie-line deviations	Vector of active power values (P ; flat number) in Watt with resolution 1 Watt in conjunction with EANi ; CTS3 timescale (e.g. every 15min)	Tie-line Limits calculation	Cell Setpoint Adjusting	BSC 1.3.1	IEC 61970-456	IEC 61970-552
			Tie-line Limits calculation	Cell Setpoint Adjusting	BSC 1.1.1	IEC 61970-456	IEC 61970-552
IEX_23	Proposed balance setpoint adjustment	Value of active power (P ; flat number) in Watt resolution 1 Watt ; CTS3 timescale (e.g. every 15min)	Cell Setpoint Adjusting Cell Setpoint Adjusting (adjacent cell)	Cell Setpoint Adjusting (adjacent cell) Cell Setpoint Adjusting	BSC 1.3.1	engineering of SCADA -> e.g. Cim LimitSet - IEC 61970-301	IEC 60870-5-104
			Cell Setpoint Adjusting Cell Setpoint Adjusting (adjacent cell)	Cell Setpoint Adjusting (adjacent cell) Cell Setpoint Adjusting	BSC 1.1.1	engineering of SCADA -> e.g. Cim LimitSet - IEC 61970-301	IEC 60870-5-104
IEX_24	Accepted balance setpoint adjustment	Value of active power (P ; flat number) in Watt resolution 1 Watt ; CTS3 timescale (e.g. every 15min)	Cell Setpoint Adjusting Cell Setpoint Adjusting (adjacent cell)	Cell Setpoint Adjusting (adjacent cell) Cell Setpoint Adjusting	BSC 1.3.1	engineering of SCADA -> e.g. Cim LimitSet - IEC 61970-301	IEC 60870-5-104
			Cell Setpoint Adjusting Cell Setpoint Adjusteing(adjacent cell)	Cell Setpoint Adjusting (adjacent cell) Cell Setpoint Adjusting	BSC 1.1.1	engineering of SCADA -> e.g. Cim LimitSet - IEC 61970-301	IEC 60870-5-104
IEX_25	Device Inertia Setpoints	Value of (virtual) inertia (J ; flat number) in kgm2 with resolution 1 kgm2 ; CTS3 timescale (e.g. every 15min). or (Broadcast mode) Matrix of (virtual) inertia (J ; flat number) in kgm2 with resolution 1 kgm2 in conjunction with EANi (location) ; CTS3 (e.g. every 15min)	df/dt Droop Slope Determination	DER (ROCOF droop device) = device inertia setpoints	IRPC 1.2.1	IEC61968-11	IEC61968-100

IEX_26	PVC setpoint	Value of voltage set-point (V) in mV with resolution 10mV ; CTS3 timescale (e.g. every 15min) in proactive mode	PPVC Controlling	DER - AVR device	PVC	IEC 60870-5-104	IEC 60870-5-104
			PPVC Controlling	DER - AVR device	PPVC	IEC 60870-5-104	IEC 60870-5-104
IEX_27	OPF trigger	On/Off Trigger ; CTS3 timescale (e.g. every 15min) in proactive mode	PPVC Controlling	PPVC Setpoint providing	PPVC	Internal PPVC data flow	Internal PPVC data flow

IEX_28	Capacitor Bank setting	On/Off Trigger ; CTS3 timescale (e.g. every 15min) in proactive mode or (Broadcast mode) Matrix of On/Off Triggers in conjunction with EANi (location) ; CTS3 timescale (e.g. every 15min) in proactive mode	PPVC Controlling	Capacitor Bank	PPVC	IEC 60870-5-104	IEC 60870-5-104

IEX_29	Q Activation signal	Value of reactive power (Q) in VAr with resolution 1 VAr ; CTS3 timescale (e.g. every 15min) in proactive mode or (Broadcast mode) Matrix of values of reactive power (Q) in VAr with resolution 1 VAr in conjunction with EANi (location) ; CTS3 timescale (e.g. every 15min) in proactive mode	PPVC Controlling	DER (Controllable Q device)	PPVC	IEC 60870-5-104	IEC 60870-5-104

IEX_30	OLTC setting	Value of tap position change (-a, +a) ; CTS3 timescale (e.g. every 15min) in proactive mode or (Broadacst mode) Matrix of tap position changes (-a, +a) in conjunction with EANi (location) ; CTS3 timescale (e.g. every 15min) in proactive mode	PPVC Controlling	OLTC	PPVC	IEC 60870-5-104	IEC 60870-5-104

IEX_31	Calculated voltage setpoints	(set-point matrix): 1. Switching positions for capacitor banks (on/off (1/0)) [NC-1istati] 2. Curtailment/shedding for controllable reactive loads (Qseti in VAr) 3. Voltage level (tap position -a / +a where a is positive real value) of activation command (OLCT) 4. Voltage set-points for AVRs and other PVC controllers (|V| in V) Matrix form = [NC-1i stati; NC-2i Qseti; NC-3i vali; PVCi Vi]	PPVC Setpoint Providing	PPVC Controlling	PPVC	Internal PPVC data flow	Internal PPVC data flow

Legend: In-Scope

In-scope, from other UC

Observables/Actuators

Emulated

Disclaimer

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