ADVANCED STANDARDIZATION IN DISTRIBUTION SYSTEM MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE

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ABSTRACT

Standardization in the context of smart grids is predominantly characterized by focusing on interface specifications enabling the interoperability of systems, devices and equipment. Developing standards for the syntactic and semantic understanding between the information and communication technology (ICT) systems and devices in the field of power system management makes IEC Technical Committee 57 one of the key smart grid committees.
After an overall presentation of TC57 the paper gives:

- *An overview of TC57 production, with a focus on the field of Power Distribution, with a description of its objectives, and how it fits in the existing series.*
- *A description of the projects undertaken for the revision of the reference architecture for power system information exchange.*

The later will provide guidance for future developments not limited to TC57 only, but also for the whole smart grid domain. It will cover explanation of the underlying methodology (Smart Grid Architecture Model), how Use Cases developed in several IEC Technical Committees are key in order to coordinate, harmonize and facilitate interoperability, and how other existing smart grid related principles are used in TC57.

TC57 CONTRIBUTION TO SMART GRIDS

Information exchange plays the key role in smart grid architectures because it is crucial for systems interoperability and data consistency. This topic with its related challenges is addressed by the International Electrotechnical Commission (IEC) standardization, and more specifically by its Technical Committee 57 (Power System Management and Associated Information Exchange). This committee was launched more than 50 years ago to address the urgent need to produce international standards in the field of communications between pieces of equipment and systems for the electric power industry, which was a first contribution to smart grids.
The scope of TC57 has evolved several times in order to stick to the market needs, comprising communication interfaces, information security and data model specifications covering power utility automation (protection, substation automation, distribution automation), DER management, SCADA, EMS, DMS, market communication as well as information exchange between power system and home-, building- and industry automation. TC57 production is not a juxtaposition of publications. It relies on core semantics standards which are the Common Information Model (CIM) and IEC 61850 series, that have been recognized as pillars of the smart grids architectures.

Besides the production of dedicated standards to cover specific needs and their evolutions (ex telecontrol), the challenges of TC57 are manifolds: to keep a consistent, open and up-to-date reference architecture taking into account the evolving requirements in generation, transmission, market, distribution, including customer support. Thus, the 600 experts of TC57 work in collaboration with other standardization committees (renewables, storage, EV, metering, demand-response ...) and large organizations or associations dealing with smart grids (NIST, EU, ENTSO-E, CIGRE, CIRED…). Internally to IEC, strong co-operations were established with Strategic Group 3 (dealing with smart grids) and with the Advisory Committee for Transmission and Distribution (ACTAD).
TC57 is responding to the market needs by extending and developing its standards portfolio through various projects. These projects are initiated by new work item proposals requested by national committees, in many cases fed through the gap analyses of smart grid standardization initiatives e.g. NIST, EU M490 or Strong and Smart Grid China.

STRATEGY

In order to provide future-proof and consistent standards in reasonable time for an immediate reaction on market needs TC 57 applies the following strategy:

- Apply use case and requirements oriented approach for standards development
- Open proprietary structures by standardization of data exchange interfaces among IT systems and software applications, avoid to standardize applications them selves
- Use of state of the art standard information and communication technology platforms wherever available and applicable

- Ensure quality, consistency and compatibility of TC57 standards portfolio

TC57 STANDARDS IN THE FIELD OF DISTRIBUTION: A SHORT OVERVIEW

TC57 Structure

TC57 is today organized in the following active working groups [1]:

- WG 03 Telecontrol protocols
- WG 09 Distribution automation using distribution line carrier systems
- WG 10 Power system IED communication and associated data models
- WG 13 Energy management system application program interface (EMS - API)
- WG 14 System interfaces for distribution management (SIDM)
- WG 15 Data and communication security
- WG 16 Deregulated energy market communications
- WG 17 Power system intelligent electronic device communication and associated data models for distributed energy resources and distribution automation
- WG 18 Hydroelectric power plants – Communication for monitoring and control
- WG 19 Interoperability within TC 57 on long term
- WG 20 Planning of (single-sideband) power line carrier systems
- WG 21 Interfaces and protocol profiles relevant to systems connected to the electrical grid

Add to that joint WGs with other committees, mainly for data model development for dedicated domains. Here are examples for metering (with TC13), wind farm plants (with TC88), fault locators (with TC38), or Ad Hoc working groups to address specific question (ex. AHG8 on the relevance of IPv6 technology across TC57, which was just disbanded).
Broadly speaking, having both product and system aspects under consideration, TC57 has intensive cooperation with other technical committees and organizations through joint working groups and liaisons.

All these working groups cover the domain of power systems as a whole. Since, it is clearly impossible to give in a few lines a detailed description of TC57 production dealing with distribution only, the present chapter ends with a short overview of the achievements on distribution management (SIDM) and on 61850 foreseen extensions only.

Core Semantic Standards

The Common Information Model (CIM) (IEC 61968, IEC 61970 and IEC 62325 series) and the IEC 61850 series, have been recognized as pillars for realization of the Smart Grid objectives of interoperability and device management. These series define the semantic domains of power system management [3]. Figure 1 depicts the application coverage of CIM and IEC 61850 in the Smart Grid Architecture Model (SGAM).

The concept of decoupling data models from communication protocols and technologies is the key to achieve long-term interoperability. By introducing an adaptation layer between data model and communication services (e.g. Abstract Communication Service Interface (ACSI) in IEC 61850), this allows the flexible use of different communication technologies. This technology independence guarantees long-term stability for the data model and opens up the possibility to cope and benefit with the evolution of communication technologies.

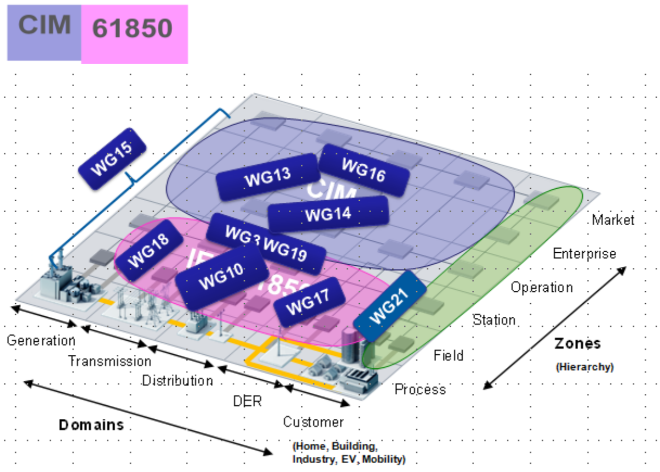

Figure 1: Semantic Domains in Smart Grid Architecture Model

Current and future projects, a focus on distribution

TC57 is responding to the market needs by extending and developing its standards portfolio through various projects.
In the following paragraphs, we illustrate TC57 end production in distribution through examples: services interfaces for distribution management and some extension of 61850.

Initially, WG 14 was formed to address the need for standards for System Interfaces for Distribution Management Systems (SIDMS). 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. These standards define requirements, integration architecture, and interfaces for the major elements of a utility's Distribution Management System (DMS) and other associated external IT systems. Examples of DMS include Asset

Management Systems, Work Order Management Systems, Customer Information Systems. The message-based technology used to mesh these applications together into one consistent framework is commonly referred to as Enterprise Application Integration (EAI); IEC 61968 guides the utility's use of EAI. Figure 2 clarifies the scope of IEC 61968-1 graphically in terms of business functions.

Standard interfaces are being defined for each class of applications identified in the IEC 61968-1 Interface Reference Model (IRM). A series of normative CIM-based XML message payloads have been defined for each ones.

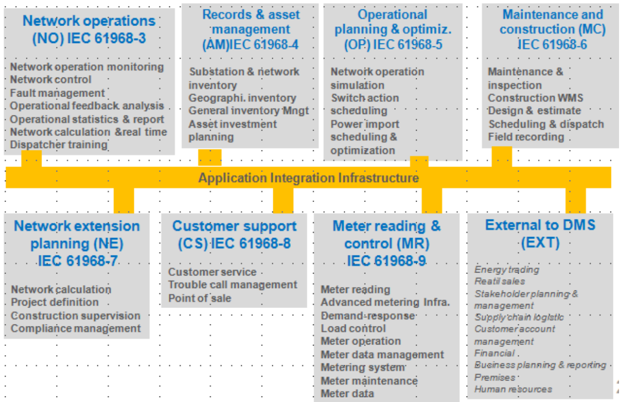

Figure 2 : Interfaces for Distribution Management

WG14 is using the Unified Modeling Language (UML) to define additional Real World Objects classes in the CIM that are relevant to inter-application information exchange in the distribution domain. The resulting CIM classes govern the semantics used in message types being defined for the Information Exchange Model.

XML is a data format for structured document interchange particularly on the Internet. One of its primary uses is information exchange between different and potentially incompatible computer systems. XML is thus well-suited to the domain of System Interfaces for Distribution Management. Therefore, where applicable, IEC 61968 Parts 3 to 9 define document structures in XML.

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WG10 is developing standards related to communication and data models for Power Systems IEDs (Intelligent Electronic devices). It is responsible for the generic aspects of IEC 61850 and coordinates with other working groups that are developing domain specific data models.

The following figure shows some developments based on the 61850 series that are carried out by other WGs or committees.

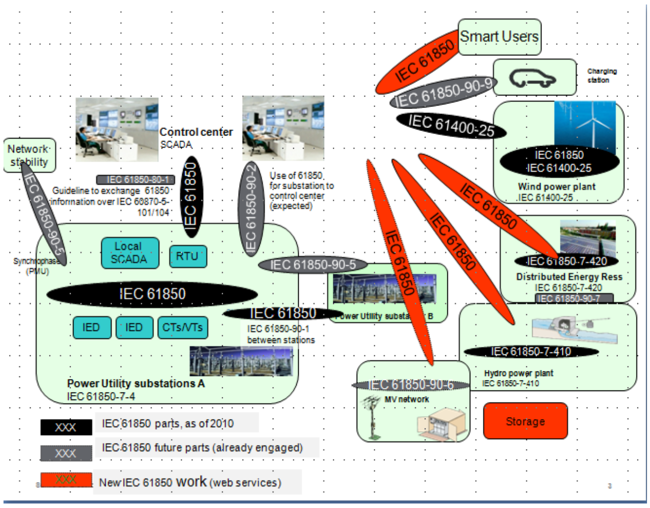

Figure 3 : IEC 61850 & extensions

For instance, WG17 extends the IEC 61850 object models and services required for information exchanges, covering

- Distributed energy resources (DER), comprising generation, load and storage;
- Distribution feeder and network equipment, to support automation of power distribution systems
- Management systems required for their operation and integration with electric power systems.

Here are some developments in progress for WG17: mapping to web services (61850 parts 8-2 and 80-3), use of 61850 in distribution automation for advanced application (part 90-6), object model for electric mobility (part 90-8), use of 61850 for electrical storage systems (part 90-9), object models for scheduling (part 90-10)…WG17 will also provide a guidance for a hierarchical DER system model which comprises a DER management system with various types of DER (part 90-15).

ARCHITECTURE FRAMEWORK

The objectives of the TC57 reference architecture framework (IEC/TR 62357-1 [2]) to be progressively reach under the different standardisation activities are :

➔ Anticipate the new usage of electricity and support the new business models attached to these new usages. Electricity paradigms are changing due to the introduction of intermittent distributed resources, as well as higher and higher presence of active users, modifying their behavior to take the best of energy. It is the role of IEC TC57 to enable the emergence of these new ways to using electricity. It shall enable meaningful data flowing freely across the system as the energy flows in various directions and ensure any information available anywhere it is needed

➔ Provide sustained foundations to existing and future systems. The expectations of standard users is to get the longer lasting assets, it is an expected top priority of the reference architecture to guarantee the most stable technical principles and resilience to future changes. This relies on two main principles :

- Breakdown the reference architecture in a way the dependencies between different layers are minimized. Then changing one layer won't affect the others.
- Then the second principle is for standardization to provide all needed means to define and manage in a sustained way the data models, which are considered as the most stable part of the reference architecture.

➔ Support flexibility and assets agility while preserving the existing one. Architecture flexibility refers to its ability to adapt to dynamic changes mostly through incremental changes. Agility means the ability to support new user's objectives driven by internal (new user's company objectives) or external pressures (technological change, regulatory changes). Both may lead the architecture to adding/ removing/ updating function/ services/ components at different level of depths. Market is requiring more and more flexibility and agility from their assets and standardization should help the users managing these needed evolutions. Increasing flexibility and assets agility through international standard will increase the value and the duration of concerned assets. Backward compatibility with an easy migration from the existing appears among the main properties to consider to reach such an objective

➔ Support interoperability by design and offer multi-vendor system capabilities. It is one of the main properties of the Reference architecture to support interoperable architecture enabling mixing components, sub-systems and systems coming from different vendors. This includes also properties of the reference architecture to allow any market players to have equal chance to participate to this architecture. The needed property of such a reference architecture to meet this objective relies of the availability of common data model across a maximum number of levels of the architecture. The reference architecture shall support the "customization" of standard usage – also known as "profiling", if it helps reaching a better level of interoperability in a specific context.

➔ Reduce integration efforts while anticipating an increased complexity of the systems.
Integration effort is really one of the main challenges in making system smarter. It is the role of TC57 reference architecture to offer to the market the most efficient way to integrate such system, and then consider the processes and services needed to support the full system cycle from its specification down to its de-construction. One way to reach this objective is relying on the ability of systems, sub-systems and components to support pre-defined meaningful data models (meaningful, means with a defined standard semantic)

➔ Maximise the re-use of on the shelves technologies, especially the technologies coming from the IT and communication domain. Offering capabilities to exchange data between components, sub-system and systems means the use of Information and communication technologies. Considering that the use of this technology is not specific to the electricity domain, it is the challenge of the reference architecture to maximize the re-use of opened transverse technologies which are used in other domains. However it is also the challenge to pick from these, the most opened, sustained and used one, and in any case to make the reference architecture resilient to changes in this domain which is known as a fast moving one.

➔ Make as easy as possible the use of the proposed set of standards. For most of the stakeholders, moving to smarter systems raises the need for this market player to get the needed knowledge the quickest and at lowest efforts, and to adapt its processes and tools to manage the new set of technologies. It is the role of the reference architecture to provide the easiest access to the standard technologies and to foreseen the better ways to support the needed process and tools to make the life of the user the easiest. Among one of the main challenge of expected properties is to focus on the most limited number of semantic domains.

IEC/TR 62357-1 leverages the SGAM (Smart Grid Architecture Model), presented in the following figure, as a mean to facilitate a common understanding between stakeholders.

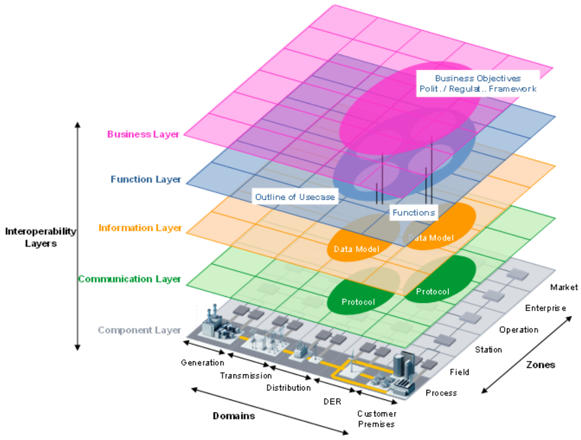

Figure 4 : The Smart Grid Architecture Model (SGAM)

It describes all the existing object models, services, and protocols within TC 57 and how they relate to each other.

As other IEC TCs like TC13 for Metering or TC69 for Electric Transportation are defining other semantic models, the following figure illustrates a more "complete" key smartgrid standard framework:

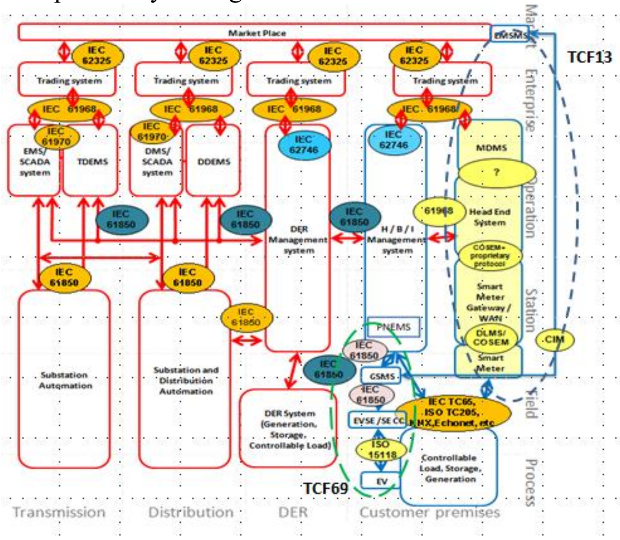

Figure 5 : Mapping of main Smartgrid stds on SGAM

Furthermore it helps to direct longer term goals and activities, specifically to ensure compatibility of all new standards developed in TC57, and other related TCs . This architecture provides the user of standards a framework as basis to develop implementation strategies and architectures for specific project realizations.

IEC TC8 / WG6 (in charge of smart-grid requirements) is using a business-driven, top-down approach to describe business processes impacted by smart grid technologies, detailing the Smart Grid functions called by these processes to provide new requirements for the development of data models and protocols, which are defined in TC57 for CIM and 61850.
The figure 6 describes the overall process.

Security and telecommunication are also considered by the Reference Architecture and allow to define additional architecture requirements.

IEC/TR 62357-1 with other key IEC standards must play a key role in Entreprise Architecture management. Business use cases (BUC) developed at the business layer, supported by System use cases (SUC) at the functional layer, and standardized information models and related profiles can then be referenced by Utilities which are adapting and transforming their existing architecture in order to comply with a set of new requirements.

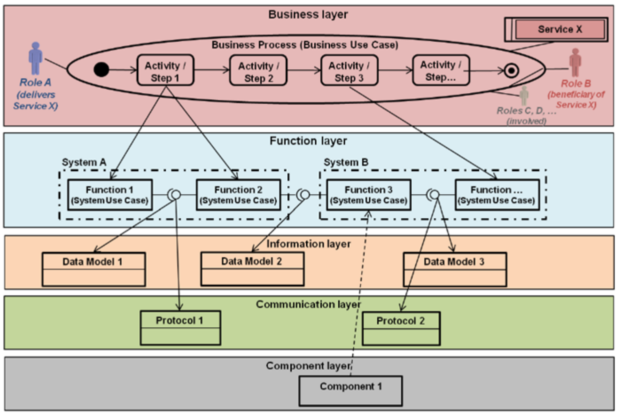

Figure 6 : the overall method, from Use cases to data models and protocols

CONCLUSION

IEC being an open, transparent and consensus oriented standardization organization provides the basis for future-proof and internationally accepted standards. Based on this platform TC57 offers a smart grid standards portfolio which is being today highly adopted by industry.
TC57 publications is not a simple collection of standards. They rely on a consistent and collaborating approach for their development & updating.
Active participation and contribution of experts of different skill (technical, utility operators…) around the world is a crucial requirement to ensure that TC57 will deliver standards which fulfill the market needs today and in the future.

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E. Lambert is in charge of the revision of the edition 2 of the Reference Architecture.
H. Englert is the TC57 secretary
T.Lefebvre has been the TC57 chairman since 2001

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