CEN-CENELEC-ETSI Coordination Group on Smart Energy Grids (CG-SEG)

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Change tracking

Note :

- Versions noted in italic are internal to the “Set of Standards” team
- Versions noted in italic are intermediate internal one to the editorial team
- The comment resolution process is an incremental one, which means that to each comment resolution treatment is attached the version of the draft report when it was included. This information is captured and exposed in the comment resolution file.

Version	**When**	**Who**	**Main changes**
v4.1 draft v0	Jan 6th 2017	L. Guise	Comments resolution integration
v4.0 final	Oct 24nd 2016	L. Guise	Final consolidation
v4.0 draft v3	Oct 22nd 2016	L.Anderson	Editing, final checks, updating references
v4.0 draft v2	Oct 24th 2016	L. Guise	*Inclusion of the latest update on smart metering* *Update of section 10 (summary tables)*
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v4.0 draft v0	Aug 31st 2016	L. Guise	*Inclusion of the latest update section 8.1,8.2 (partly), 8.3, 8.4* *Inclusion of the latest update from SGIS* *Inclusion of the latest update from Methodology (interoperability)* *Inclusion of the latest update on Micro-grids, EMC & Power Quality section 8.9, 9.5 et 9.6* *Inclusion of the latest update for all cross-cutting technologies (section 9, other than security and communication)* *Inclusion of the latest update for all administration systems (section 8.10, except communicatin management and weather forecast)*
v3.1 draft v2	Oct 31th 2014	L. Guise	Released version to SG-CG stakeholders
v3.1 draft v1	Oct 28th 2014	L. Guise	*Internal release for inclusion of the latest resolutions of the comments before Oct 28th meeting*
v3.1 draft v0	Oct 17th 2014	L. Guise	*Internal release for inclusion of the resolutions of the comments resulting from the review by SG-CG stakeholders from Sept 1st to October 7th 2014*
v3.0	August 28th 2014	L. Guise	Released version to SG-CG stakeholders for review
v3.0 draft v3.0	*August 25th 2014*	*L. Guise*	*Inclusion resolution of comments received from circulation of “final draft v2.1” to WG members*
v3.0 draft v2.1	*July 17th 2014*	*L. Guise*	*Inclusion of the latest update from EMC & Power Quality* *Inclusion of the latest update from SGIS* *Inclusion of the latest update from Methodology (communication, modeling)* *Inclusion of the latest update from ITU* *Tables at the end of this report come from the IOP tool from SGCG-WGI (updated consequently)*
v3.0 draft v1.1	*june 17th 2014*	*L. Guise*	*Inclusion of AMI and other contributions, and comments from April 23d Face to face meeting of the Set of Standards Group.* *Inclusion of the updated section on Smart Metering, Interoperability and on other sections.* *Update on many drawings and tables.* *Achieved alignment with the IOP tool elaborated together with the WGI Group*
V3.0 draft v0	*April 23d 2014*	*L. Guise*	*Starting update to meet mandate iteration request by end 2014*
2.0	Nov 16th 2012	L. Guise	Released at mandated deliverables
1.0	Oct 2d 2012	L. Guise	First official draft release for circulation to SG-CG stakeholders

Contents

List of figures

List of tables

1 Scope

On March 1st 2011, The European Commission issued a Mandate [1] for Smart Grids standards to the European Standardization Organizations.
Through this mandate, the EC requested CEN, CENELEC, and ETSI to develop or update a set of consistent standards within a common European framework of communication and electrical architectures and associated processes, that will enable or facilitate the implementation in Europe of the different high level Smart Grid services[1] and functionalities as defined by the Smart Grid Task Force that will be flexible enough to accommodate future developments.
Building, Industry, Appliances and Home automation are out of the scope of this mandate; however, their interfaces with the Smart Grid and related services have to be treated under this mandate.

The mandate stated that "a set of consistent standards", which will support the information exchange (communication protocols and data models) and the integration of all users into the electric system operation shall be provided.
The current report fulfills this mandated work, as part of the framework delivered in [2]. It is the new release of the original "first set of standards" and proposes an updated framework of standards which can support Smart Grids deployment in Europe.

It provides a selection guide setting out, for the most common Smart Grid systems the relevant set of existing and upcoming standards to be considered, from CEN, CENELEC, ETSI and further from IEC, ISO, ITU or even coming from other bodies when needed.
It also explains how these are able to be used, where, and for which purpose.

It should be noted that this set of existing and upcoming standards may not fully support all systems and use cases. Standardization gaps have been identified [7] and the related standardization work program has been defined [8]. The results of these activities will be included in future releases of this report.

2 References

Reference documents :

[1] M/490 EN - Smart Grid Mandate - Standardization Mandate to European Standardization Organizations (ESOs) to support European Smart Grid deployment;

[2] CEN-CENELEC-ETSI Smart Grid Coordination Group, 'Framework for Smart Grid Standardization', Brussels, 2012

[3] M/441 EN - Standardisation mandate to CEN, CENELEC and ETSI in the field of measuring instruments for the development of an open architecture for utility meters involving communication protocols enabling interoperability.

[4] CEN/CENELEC/ETSI TR 50572 - Functional reference architecture for communications in smart metering systems - prepared by CEN/CENELEC/ETSI Smart Meters Coordination Group (SM-CG) and published in December 2011 & Introduction and Guide to the work undertaken under the M/441 mandate (report published December 2012)

[5] CEN-CENELEC-ETSI Smart Metering Coordination Group - M/441 – Work Program (SMCG_Sec0074_DC_M441WP-1 (V0.6))

[6] CEN-CENELEC-ETSI Smart Grid Coordination Group, 'Rules for establishing the "first set of standards" report' (SGCG_0040_DC), Brussels, 2012

[7] CEN-CENELEC-ETSI Smart Grid Coordination Group, 'Standardization Gaps Prioritization for the Smart Grid', (SGCG_Sec0060_DC v0.1 2014-06-30), Brussels, 2014.

[8] CEN-CENELEC-ETSI Smart Grid Coordination Group, ' Programme of standardisation work for the Smart Grid' (SGCG_Sec0032_05_DC (version 2.01)), Brussels, 2014

[9] CEN-CENELEC-ETSI Smart Grid Working Group Reference Architecture, 'Reference Architecture for the Smart Grid' (SGCG/M490/C_Smart Grid Reference Architecture), Brussels, 2012

[1] The 6 high level services the Smart Grids Task Force defined are:
- Enabling the network to integrate users with new requirements
- Enhancing efficiency in day-to-day grid operation
- Ensuring network security, system control and quality of supply
- Enabling better planning of future network investment
- Improving market functioning and customer service
- Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management

[10] CEN-CENELEC-ETSI Smart Grid Working Group Sustainable Processes 'Use Case Collection, Management, Repository, Analysis and Harmonization' (SGCG/M490/E_Smart Grid Use Cases Management Process), Brussels, 2012
[11] CEN-CENELEC-ETSI Smart Grid Working Group Smart Grid Information Security, 'Smart Grid Information Security' (SGCG/M490/D_Smart Grid Information Security), Brussels, 2012– completed by the SG-CG/M490/H_Smart Grid Information Security published end 2014
[12] Regulation (Eu) No 1025/2012 of the European Parliament and of The Council of 25 October 2012 on European standardisation, amending Council Directives 89/686/EEC and 93/15/EEC and Directives 94/9/EC, 94/25/EC, 95/16/EC, 97/23/EC, 98/34/EC, 2004/22/EC, 2007/23/EC, 2009/23/EC and 2009/105/EC of the European Parliament and of the Council and repealing Council Decision 87/95/EEC and Decision No 1673/2006/EC of the European Parliament and of the Council
[13] Regulation on EU standardization – adopted Oct 4th 2012 - PE-CONS 32/12 and 13876/12 ADD1.
[14] SG-CG/M490/J_Conceptual model - market models published end 2014
[15] SG-CG/M490/I_Smart Grid Interoperability published end 2014
[16] European Smart Grids Task Force EG1 Standards and Interoperability, ‘Interoperability of interfaces for the large scale roll out of smart metering systems in EU Member States’, August 2016

Other documents :

[a1] Final Report of the CEN/CENELEC/ETSI Joint Working Group on standards for smart grids V1.12 approved by the CEN/CENELEC/ETSI Joint Presidents Group (JPG) on 4 May 2011, and by the individual ESOs by 2011-06-05.
[a2] GridWise Interoperability Context-Setting Framework (March 2008), GridWise Architecture Council, online: www.gridwiseac.org/pdfs/
[a3] IEC Smart Grid Standardization Roadmap - Prepared by IEC SMB Smart Grid Strategic Group (SG3) - June 2010; Edition 1.0 – a new release prepared by the newly created IEC System Committee Smart Energy should be available by beginning of 2017. A draft document (v3.0e) already circulated to IEC National Committees in March 2016.
[a4] IEV : International Electrotechnical Vocabulary – published as IEC 60050
[a5] IEC 62357 : Reference Architecture – Power System management.
[a6] The Harmonized Electricity Market Role Model (January 2015), ENTSO-E/EFET/ebIX, online: https://www.entsoe.eu/publications/electronic-data-interchange-edi-library/work%20products/harmonised_electricity_role_model/Pages/default.aspx

3 Terms and definitions

Note : Definitions of Smart grid components (shown in the Smart Grid system mappings) are given in 7.7.2.

3.1.
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 [ISO/IEC 42010].

3.2.
AVAILABLE
a standard is identified as “AVAILABLE” when it has reached its final stage (IS, TS or TR, …) by Dec 31st 2015

3.3.
architecture framework
Conventions, principles and practices for the description of architectures established within a specific domain of application and/or community of stakeholders [ISO/IEC 42010].

3.4.
COMING
a standard is identified as “COMING” when it has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015

3.5.
conceptual domain
A conceptual domain highlights the key areas of the conceptual model from the point of view of responsibility. It groups (market) roles and their associated responsibilities present in the European electricity markets and the electricity system as a whole.

3.6.
conceptual model
The Smart Grid is a complex system of systems for which a common understanding of its major building blocks and how they interrelate must be broadly shared. SG-CG has developed a conceptual architectural reference model to facilitate this shared view. The European conceptual model of Smart Grids clusters (European harmonized) roles and system actors, in line with the European electricity market and electricity system as whole. This model provides a means to analyze use cases, identify interfaces for which interoperability standards are needed, and to facilitate development of a cyber security strategy. Adopted from [NIST 2009]

3.7.
Customer Energy Manager (CEM)
The internal automation function of the *customer* role for optimizations according to the preferences of the customer, based on signals from outside and internal flexibilities. Refer also to 7.7.2
EXAMPLE A demand response approach uses variable tariffs to motivate the customer to shift consumption in a different time horizon (i.e. load shifting). On customer side the signals are automatically evaluated according to the preset customer preferences like cost optimization or CO2 savings and appropriate functions of one or more connected devices are initiated.

3.8.
Demand Response (DR),
A concept describing an incentivizing of customers by costs, ecological information or others in order to initiate a change in their consumption or feed-in pattern (“bottom-up approach” = Customer decides).
Alternative.as defined in [IEV 617-04-15] as: action resulting from management of the electricity demand in response to supply conditions.

3.9.
Demand Side Management (DSM)
The measures taken by market roles (e.g. utilities, aggregator) controlling electricity demand as measure for operating the grid (“Top-down approach”).
Alternative as defined in [IEV 617-04-15] as: process that is intended to influence the quantity or patterns of use of electric energy consumed by end-use customers.

3.10.
domain
In the rest of the document (and its annexes), this term may refer to two different concepts. In order to avoid ambiguity, the full names 'conceptual domain' or 'SGAM domain' (as defined below) will be used systematically.

3.11.
energy services (conceptual domain)
(according to [14] - §6.3) -The Energy Services conceptual domain is defined by roles and actors involved in providing energy services to the Grid Users conceptual domain. These services include trading in the electricity generated, used or stored by the Grid Users conceptual domain, and ensuring that the activities in the Grid Users conceptual domain are coordinated in e.g. the system balancing mechanisms and Customer Information Systems. More details are available in 7.1.2.3.

3.12.
flexibility
The general concept of elasticity of resource deployment (demand, storage, generation) providing ancillary services for the grid stability and / or market optimization (change of power consumption, reduction of power feed-in, reactive power supply, etc.).

3.13.
flexibility offer (short: Flex-offer)
An offer issued by roles connected to the grid and providing flexibility profiles in a fine-grained manner dynamically scheduled in near real-time, e.g. in case when the energy production from renewable energy sources deviates from the forecasted production of the energy system.
NOTE Flexibility offer starts a negotiation process.

3.14.
flexibility operator
A generic role which links the role *customer* and its possibility to provide flexibilities to the roles *market* and *grid*; generic role that could be taken by many stakeholders, such as a DSO company, an Energy Service Company (ESCO) or an energy supplier.

3.15.
grid users (conceptual domain)
(according to [14] - §6.3) -The Grid Users conceptual domain is defined by roles and actors involved in the generation, usage and possibly storage of electricity; from bulk generation and commercial and industrial loads down to distributed energy resources, domestic loads, etc. The roles and actors in this domain use the grid to transmit and distribute power from generation to the loads. Apart from roles related to the generation, load and storage assets, the Grid Users conceptual domain includes system actors such as (customer) energy management and process control systems. More details are available in 7.1.2.2.

3.16.
intelligent load shedding
A modified Load Shedding process where the selection of loads, which have to be disconnected, can be selected in a finer granularity using advanced control possibilities of the connected loads based on communication infrastructures.

3.17.
interoperability
The ability of two or more networks, systems, devices, applications, or components to interwork, to exchange and use information in order to perform required functions..

3.18.
IOP tool - interoperability
Spreadsheet, built originaly by the SG-CG/WGI and SG-SS groups and which contains the same list of standards than in this report, however, which provides further information related to interoperability on a per standard basis. Refer to section 10 of [15]

3.19.
load management
See Demand Side Management.

3.20.
load shedding
The process of deliberately disconnecting preselected loads from a power system in response to an abnormal condition in order to maintain the integrity of the remainder of the system [SOURCE: IEC IEV Electropedia: reference 603-04-32].

3.21.
market
An open platform operated by a market operator trading energy and power on requests of market participants placing orders and offers, where accepted offers are decided in a clearing process, usually by the market operator.
EXAMPLES Trading platform.

3.22.
markets (conceptual domain)
(according to [14] - §6.3) -The *Market* conceptual domain is defined by roles and actors that support the trade in electricity (e.g. on day-ahead power exchanges) and other electricity products (e.g. grid capacity, ancillary services). Sub domains which are identified in this domain are: *Energy Market, Grid Capacity Market*, and *Flexibility Market*. Activities in the *Market* conceptual domain are coordinated by the *Operations* conceptual domain to ensure the stable and safe operation of the power system. More details are available in 7.1.2.4.

3.23.
microgrid
A low-voltage and/or medium-voltage grid equipped with additional installations aggregating and managing largely autonomously its own supply- and demand-side resources, optionally also in case of islanding.

3.24.
operations (conceptual domain)
(according to [14] - §6.3) - The Operations conceptual domain is defined by market roles and actors related to the stable and safe operations of the power system. The domain ensures the usage of the grid is within its operational constraints and facilitates the activities in the market. More details are available in 7.1.2.1.

3.25.
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. A Reference Architecture defines restrictions for an instantiation (concrete architecture). Through abstraction from individual details, a Reference Architecture is universally valid within a specific domain. Further architectures with the same functional requirements can be constructed based on the reference architecture. Along with *reference* architectures comes a *recommendation*, based on experiences from existing developments as well as from a wide acceptance and recognition by its users or per definition. [ISO/IEC 42010]

3.26.
SGAM domain
One dimension of the *Smart Grid Plane* covers the complete electrical energy conversion chain, partitioned into 5 domains: Bulk Generation, Transmission, Distribution, DER and Customers Premises.

3.27.
SGAM interoperability layer
In order to allow a clear presentation and simple handling of the architecture model, the interoperability categories described in the GridWise Architecture model are aggregated in SGAM into five abstract interoperability layers: Business, Function, Information, Communication and Component.

3.28.
SGAM smart grid plane
The Smart Grid Plane is defined from the application to the Smart Grid Conceptual Model of the principle of separating the Electrical Process viewpoint (partitioning into the physical domains of the

electrical energy conversion chain) and the Information Management viewpoint (partitioning into the hierarchical zones (or levels) for the management of the electrical process. [IEC62357-2011, IEC 62264-2003]

3.29.
SGAM zone
One dimension of the *Smart Grid Plane* represents the hierarchical levels of power system management, partitioned into 6 zones: Process, Field, Station, Operation, Enterprise and Market [IEC 62357 2011].

3.30.
Smart Grid Connection Point (SGCP)
The borderline between the area of grid and markets towards the *customer* role (e.g. households, building, industry).

3.31.
smart grids
Refer to [1]. an electricity network that can cost efficiently integrate the behavior and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety

3.32.
standard
a standard is a technical specification approved by a recognized standardization body, with which compliance is not compulsory (According to [12] – Article 2). Please refer to 6.2 for further details

3.33.
system
Set of interrelated objects considered in a defined context as a whole and separated from their environment performing tasks under behave of a service.
However, in the context of this report, it has been considered in addition as a typical industry arrangement of components and systems, based on a single architecture, serving a specific set of use cases.

3.34.
traffic light concept
On the one hand, a concept which describes the relationship between the use of flexibilities on the grid side (red phase) and the market side (green phase) and the interrelation between both (yellow phase).
On the other hand, a use case which evaluate the grid status (red, yellow, green) and provides the information towards the relevant market roles.

3.35.
use case - generic
A use case that is broadly accepted for standardization, usually collecting and harmonizing different real use cases without being based on a project or technological specific solution.

3.36.
use case - high level
A use case that describes a general requirement, idea or concept independently from a specific technical realization like an architectural solution.

3.37.
use case - individual
A use case that is used specific for a project or within a company / organization.

3.38.
use cases - involved tc
A Technical Committee within a standardization organization with an interest in a generic use case.

3.39.

use case - primary

A use case that describes in details the functionality of (a part of) a business process.

NOTE Primary use cases can be related to a primary goal or function, which can be mapped to one architectural solution.

3.40.

use cases repository

A place where information like use cases can be stored (see Use Case Management Repository).

3.41.

use case scenario

A possible sequence of interactions.

NOTE Scenario is used in the use case template defining one of several possible routes in the detailed description of sequences

3.42.

use case - secondary

An elementary use case that may be used by several other primary use cases.

EXAMPLE Communication functions

3.43.

use case - specialized

A use case that is using specific technological solutions / implementations.

EXAMPLE Use case with a specific interface protocol

3.44.

use case

Class specification of a sequence of actions, including variants, that a system (or other entity) can perform interacting with actors of the system [SOURCE: IEC 62559, ed.1 2008-01 - IEC 62390, ed 1.0:2005-01].

Alternative. Description of the possible sequences of interactions between the system under discussion and its external actors, related to a particular goal [Cockburn].

4 Abbreviations

The list provided below is just a list of the most common abbreviations used in this document.
A full list is provided in addition in Annex A**.**

In addition definitions of Smart Grid components (used within the Smart Grid system mappings) are given in 7.7.2.

Table 1 – Network typology abbreviations

Abbreviation	Meaning
A	Subscriber access network
B	Neighborhood network
C	Multi-services backhaul Network
D	Low-end intra-substation network
E	Intra-substation network
F	Inter substation network
G	Intra-control centre / intra-data centre network
H	Backbone Network
L	Operation Backhaul Network
M	Industrial Fieldbus Area Network
N	Home and Building integration bus Network

Note ; this list is needed to better understand the graphics related to communication standards in the system sections. It is extracted from section 9.3.2.

Table 2 – Abbreviations list extract

Abbreviation	Meaning
ADMS	Advanced Distribution Management System
AMI	Advanced Metering Infrastructure
AS	Application Server
BAP	Basic Application Profile
BAIOP	Basic Application Interoperability Profile
CEM	Customer Energy Management (refer 7.7.2 for details)
CEN	European Committee for Standardization (Comité Européen de Normalisation)
CENELEC	European Committee for Electrotechnical Standardization (Comité Européen de Normalisation Electrotechnique)
CIM	Common Information Model (EN 61970 & EN 61968 series as well as IEC 62325 series)
CIS	Customer Information System
COSEM	Companion Specification for Energy Metering
cVPP	Commercial Virtual Power Plant (see VPP)
DA	Distribution Automation
DCS	Distributed Control System (usually associated with generation plant control systems)
DER	Distributed Energy Resources (refer 7.7.2 for details)
DMS	Distribution Management System (refer 7.7.2 for details)
DR	Demand Response
DSO	Distribution System Operator
EC	European Commission
EDM	Energy Data Management
EMC	Electro Magnetic Compatibility
EMG	Energy Management Gateway (refer 7.7.2 for details)
EMS	Energy Management System (refer 7.7.2 for details)
ENTSO-E	European Network of Transmission System Operators for Electricity

Abbreviation	Meaning
ESO	European Standardization Organization
ETSI	European Telecommunications Standards Institute
DIN	Deutsches Institut für Normung
FACTS	Flexible Alternating Current Transmission Systems (refer 7.7.2 for details)
FEP	Front End Processor (refer 7.7.2 for details)
GIS	Geographic Information System (refer 7.7.2 for details)
GSM	Global System for Mobile [communications]
HAN	Home Area Network
HBES	Home and Building Electronic System
HES	Head End system (refer 7.7.2 for details)
HV	High Voltage
HVDC	High Voltage Direct Current
ICT	Information & Communication Technology
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IOP	Inter-operability
IS	International Standard
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-T	ITU's Telecommunication standardization sector (ITU-T)
LAN	Local Area Network
LNAP	Local Network Access Point (refer 7.7.2 for details)
NNAP	Neighborhood Network Access Point (refer 7.7.2 for details)
LV	Low Voltage
M/490	Mandate issued by the European Commission to European Standardization Organizations (ESOs) to support European Smart Grid deployment [1]
MDM	Meter data management (refer 7.7.2 for details)
MID	(European) Measuring Instruments Directive (2004/22/CE) currently being reviewed in the context of the adoption of the European New Legislative Framework 765/2008/EC
MV	Medium Voltage
NAN	Neighborhood Area Network
NIC	Network Interface Controller (refer 7.7.2 for details)
NWIP	New Work Item Proposal
OASIS	Organization for the Advancement of Structured Information Standards
OMS	Outage Management System (refer 7.7.2 for details)
PEV	Plug-in Electric Vehicles (refer 7.7.2 for details)
PLC	Power Line Carrier communication
PV	Photo-Voltaic – may also refer to plants using photo-voltaic electricity generation
SAS	Substation Automation System
SCADA	Supervisory Control and Data Acquisition (refer 7.7.2 for details)
SDO	Standards Developing Organization
SEG-CG	Smart Energy Grid Co-ordination Group, reporting to CEN-CENELEC-ETSI continuing the mission of the former SG-CG, since beginning of 2015.

Abbreviation	**Meaning**
SG	Smart Grid as defined in the M/490 mandate [1] as well as in the JWG report [a1]
SGAM	Smart Grid Architecture Model – delivered by the SG-CG-RA team as part of the mandated deliveries of M/490, which proposes 3 different axes to map a Smart Grid feature (Domains, Zones and Layers) – details available in [9]
SG-CG	(continued by SEG-CG) Smart Grid Co-ordination Group, which reported to CEN-CENELEC-ETSI and was in charge of answering the M/490 mandate
SG-CG/FSS	Team of experts acting on behalf of the CEN-CENELEC-ETSI SG-CG to manage part of the mandated tasks as defined by SG-CG in the “First Set of Standards” package.
SG-CG/RA	Team of experts acting on behalf of the CEN-CENELEC-ETSI SG-CG to manage part of the mandated tasks as defined by SG-CG in the “Reference Architecture” package
SG-CG/SGIS	Team of experts acting on behalf of the CEN-CENELEC-ETSI SG-CG to manage part of the mandated tasks as defined by SG-CG in the “smart grid information security” package
SG-CG/SP	Team of experts acting on behalf of the CEN-CENELEC-ETSI SG-CG to manage part of the mandated tasks as defined by SG-CG in the “Sustainable Processes” package
SLA	Service Level Agreement
SM-CG	Smart Metering Co-ordination Group, reporting to CEN-CENELEC-ETSI and in charge of answering the M/441 mandate [3]
TC	Technical Committee
TMS	Transmission Management System
TR	Technical Report
TS	Technical Specification
TSO	Transmission System Operator
tVPP	Technical Virtual Power Plant (see VPP)
UC	Use Case
VAR	Volt Ampere Reactive – unit attached to reactive power measurement
VPP	Virtual Power Plant Note : cVPP designates Commercial Virtual Power Plant tVPP designates Technical Virtual Power Plant
WAMPAC	Wide Area Measurement System (refer 7.7.2 for details)
WAN	Wide Area Network
W3C	World Wide Web Consortium
WG	Working Group

5 Executive Summary

5.1 Report summary

As the result of the mandated work requested through the M/490 mandate [1], this report intends to build a list of standards, enabling or supporting the deployment of Smart Grid systems in Europe.
It is based on CEN-CENELEC-ETSI experts' assessment. It is intended to depict the portfolio of European and/or International standards and to **facilitate interoperable solutions based on standards**[2].
More than just a flat list, this reports aims to provide to any kind of Smart Grid users a **selection guide which, depending on the targeted system and the targeted layer (component, communication or information layers), will set out the most appropriate standards to consider.**
The proposed framework will assist Member States, Smart Grid system owners and others to specify their smart grid solutions corresponding to their own requirements and taking into account specific national legislations and local situations.

This report fully relies on the work performed by the 3 other main parts of Smart Energy Grid Co-ordination Group (originaly SG-CG, now continued as Smart Energy Grid Coordination Group SEG-CG) committed to fulfill the M/490 [1] expected deliverables (Methodology & New Applications, Interoperability, Smart Grid Security), as well as on the outcome of the Smart Metering Co-ordination Group in charge of answering the M/441 mandate [3].

Because Smart Grids may appear of very wide scope and too complex, the writers of these reports have chosen to present their selection in the easiest way, mostly using graphics, re-using the Smart Grid Architecture Model.

The objective is not to be comprehensive, but more to provide guidance within the galaxy of standards which may apply. Preference is given to consistency wherever possible. Therefore possibly all available standards may not be reflected in this report.

At the end this guide includes about 23 types of Smart Grid systems, more than 500 standard references, coming from more than 50 different bodies.
In addition, it also indicates the standardization work which may have started, stating in the most accurate manner, on a per system approach, the user impact (use case) this standardization work may have in a near future, in order to fill the identified gaps.

That is why this report is called "Set of standards" : a regular re-assessment, based on new market requirements but also new standardization achievements, will provide periodic updates of the relevant list of standards to consider for the most efficient deployment of Smart Grids in Europe.

5.2 Core Standards

The IEC can already look back at an impressive collection of standards in the field of Smart Grid. The IEC Smart Grid Standardization Roadmap [a3] provides an overview on these standards. Some of these standards are considered to be core standards 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. They are seen as a backbone of a future Smart Grid.

These core standards are forming the "backbone" of the IEC standards portfolio.

Table 3 - Smart Grids – Core standards

Core Standard or series	Topic
IEC 61970/61968	CIM (Common Information Model) Applying mainly to : Generation management systems, EMS (Energy Management System); DMS (Distribution Management System); DA; SA; DER; AMI; DR; E-Storage
IEC 62325	CIM (Common Information Model) based, Energy market information exchange

[2] According to [12] - Article 2, "a standard is a technical specification approved by a recognised standardisation body, with which compliance is not compulsory"

	Applying mainly to : Generation management systems, EMS (Energy Management System); DMS (Distribution Management System); DER; AMI; DR; meter-related back-office systems; E-Storage
IEC 61850	Power Utility Automation, Hydro Energy Communication, Distributed Energy Resources Communication Applying mainly to : Generation management systems, EMS; DMS; DA; SA; DER E-Storage; E-mobility
IEC 62056	COSEM Applying mainly to : DMS; DER; AMI; DR; Smart Home; E-Storage; E-mobility Data exchange for meter reading, tariff and load control
IEC 62351	Applying mainly to : Security for all systems
IEC 61508	Applying mainly to : Functional safety of electrical/electronic/programmable electronic safety-related systems

5.3 Other highly important standards

Besides the core standards, IEC also offers a number of highly important standards for Smart Grid.

Table 4 - Smart Grids – Other highly important standards

Standard or series	Topic
IEC 62357	Power utilities Reference Architecture – SOA Applying mainly to : Energy Management Systems; Distribution Management Systems; DER operation systems, market & trading systems, DR systems, meter-related back-office systems
IEC 60870-5	Telecontrol Applying mainly to : EMS; DMS; DA; SA
IEC 60870-6	TASE2 Inter Control Center Communication Applying mainly to : EMS; DMS
IEC/TR 61334	"DLMS" Distribution Line Message Specification Applying mainly to : AMI
IEC 61400-25	Wind Power Communication Applying mainly to : DER operation systems (Wind farms); EMS; DMS;
IEC 61851	EV-Communication Applying mainly to : E-mobility; Home&Building management systems;
IEC 62051-54/58-59	Metering Standards Applying mainly to : DMS; DER; AMI; DR; Smart Home; E-Storage; E-mobility

6 Objectives, rules and expected usage of this report

Note : Sub sections 6.1 and 6.2 are mostly replicating the content of [6], previously validated in July 2012 by SG-CG stakeholders.

6.1 Limits of scope and usage

Here are some limits the reader of this report should be aware of:

- The list of Generic Use Cases (UCs) per sub-system cannot be exhaustive.
- The standards listed in this report represent a selection according to the rules set in section 6.2.1 and 6.2.2. The list is not comprehensive.
- Detailed "application notes" for the standards are not in the scope of this document.
- The generic Ucs are limited to "typical" applications. Customer specific applications are not considered.
- Proprietary or non-standardized solutions covering the generic UCs are not considered in this report.
- This report represents the current status of the available standards (considering their "maturity" level indicated in 6.2.2). Standards gaps are identified [7], and standardization activities to fix the gaps are listed, ranked and monitored in [8].
- Standardization projects which do not fulfill the maturity-time constraints defined in section 6.2.2 are not part of this report.

6.2 How to select standards?

All standards identified in this report have been selected applying the rules defined in this section, and presented below.

These rules are also compliant with the Regulation on EU standardization [12][3].

6.2.1 Standardization body ranking

In order to identify a standard fulfilling a defined set of requirements, the following procedure has been adopted:

1. Standards from the European Organizations, CEN, CENELEC or ETSI, are identified and available,
2. where no standards were available from 1, then ISO, IEC or ITU standards are considered
3. If no standards from either 1 or 2 were available to support a particular set of requirements, then “open specification“(see criteria below) can be considered.

“Open specifications” that are considered applicable from a CEN CENELEC ETSI point of view, are complying with the following criteria, in compliance with the EU regulation [12] as defined for ICT technical specifications[4]:

1. the specification is developed and/or approved, and maintained by a collaborative consensus-based process;
2. such process is transparent;
3. materially affected and interested parties are not excluded from such process;
4. the specification is subject to RAND/FRAND Intellectual Property Right (IPR) policies in accordance with the “EU Competition rules”,
5. the specification is published and made available to the general public under reasonable terms (including for reasonable fee or for free).

Note : considering the purpose of this report, i.e a selection guide, technical reports are also considered in the list of applicable smart grid standards, as soon as they followed a neutral review and voting process, by the bodies listed above.

6.2.2 Maturity level

Two maturity levels of the standards are considered:

- A standard that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015, is identified as “AVAILABLE”
- A standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) before Dec 31st 2015, is identified as “COMING”

Further sets of standards (including newly developed ones) should be available in due course.

Note:

- "COMING" standards listed are presented with a brief summary of their scope.
- The same standard reference may appear in both AVAILABLE and COMING tables, when a release of this standard is available as such (fitting the rules defined above for AVAILABLE standards), but a new revision is in preparation (fitting the rules defined above for COMING standards).

6.2.3 Release management

Should several releases of a standard exist then – if not explicitly stated differently – the latest release is considered in this report.

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3 Chapter IV of Regulation [12] on “ICT technical specifications”,article13 says that:

“Either on proposal from a Member State or on its own initiative the Commission may decide to identify ICT technical specifications that are not nationals, European or international standards, but meet the requirements set out in Annex II, which may be referred, primary to enable interoperability, in public procurement.

Either on proposal from a Member State or on its own initiative, when an ICT technical specified in accordance with paragraph 1 is modified, withdrawn, or no longer meet the requirements set out in Annex II, the Commission may decide to identify the modified ICT technical specification or to withdraw the identification.

The decisions provide for in paragraphs 1 and 2 shall be adopted after consultation of the European multi-stakeholder platform on ICT standardization, which includes ESOs, Member States and relevant stakeholders, and after the consultation of the committee set up by the corresponding Union legislation, if it exists, or after other forms of consultation of sector experts, if such a committee does not exist”.

The ICT technical specifications referred to in article 13 of this Regulation shall constitute common technical specifications referred to in Directives 2004/17/EC, 2004/18/EC, 2009/81/EC and Regulation 2342/2002”.

4 Article 14 of the Regulation [12] says:

“Annex II prescribes the criteria required in article 13.1: market acceptance; not conflict with European Standards; developed by a non-profit organization; openness; consensus based; transparency; meeting FRAND criteria on licensing; relevance; neutrality, stability and quality.

6.2.4 Standards naming convention

It appears that standard naming conventions may differ from one body to another. For the sake of harmony within this report we propose the here-under rules :

CEN-CENELEC standards, specifications and reports will be named :

- EN xxxxx for CEN-CENELEC European Standards number xxxxx
- TS xxxxx for CEN-CENELEC European technical specification number xxxxx
- TR xxxxx for CEN-CENELEC European technical report number xxxxx
- prEN xxxxx for draft CEN-CENELEC European Standards number xxxxx
- prTS xxxxx for draft CEN-CENELEC European technical specification number xxxxx
- prTR xxxxx for draft CEN-CENELEC European technical report number xxxxx

For all other bodies, and to avoid possible conflicts with the above, the rule will be to name standard this way:

- the name of the concerned body (typically ETSI, IEC, ITU, …)
- a unique identifier within this body

6.3 Process for "List of Standards" update

The mandate [1] originally requested the ESOs to anticipate the expected long term duration of Smart Grid deployment. This therefore suggests the ESOs should set up a framework that is:

- Comprehensive and integrated enough to embrace the whole variety of Smart Grid actors and ensure communications between them.
- In-depth enough to guarantee interoperability of Smart Grids from basic connectivity to complex distributed business applications, including a unified set of definitions so that all Member States have a common understanding of the various components of the Smart Grid.
- Flexible and fast enough to take advantage of the existing telecommunications infrastructure and services as well as the emergence of new technologies while enhancing competitiveness of the markets.
- Flexible enough to accommodate some differences between EU Member State approaches to Smart Grids deployment.

Then the current document is the new release of the original “first set of standards” and proposes an updated framework of standards which can support Smart Grids deployment in Europe.
This update tries also to state in the clearest way what is available and what is coming (based on the known standardization work and the triggers defined above).

The current report may be further updated.

6.4 Mapping chart (use of)

6.4.1 Motivation

The IEC currently provides the large majority of all standards needed to build the smart grid, with new standards being brought into the portfolio on an ongoing basis. The IEC is bringing relevant national or regional standards via a fast track system into the international consensus process. The increased dynamic in the field of standardization creates the demand for a better transparency in the work of IEC to give a better overview which standards are already available and suitable for smart grid and how they can be applied. This will speed up the implementation of smart grid and avoid waste of resources due to double work. “The smart grid represents a technical challenge beyond building infrastructure, and can’t reach its potential if every country and company is building it based on different standards,” said Jacques Régis, the former IEC President. “Our international set of standards ensures the smart grid industry can grow and function as one coordinated entity, relying on optimal compatibility and the ability of one system or device to communicate with others.”

To satisfy this demand for better transparency IEC Strategic Group 3 on Smart Grid (now transferred to IEC System Committee Smart Energy SYC1) creates the idea of the so called “Mapping Tool”. This multidimensional interactive tool creates a map of the smart grid and enable smart grid managers around the world to quickly identify IEC and other international smart grid standards, positions them in relation to technical components and systems in the smart grid, and verifies the feasibility of workflows and use cases (see also chapter 1.4.2.1.2). The Mapping Tool is an open resource and helps reducing the complexity of building smart grids by simplifying the identification and application of smart grid standards.

This mapping chart is freely available following the here-under link:

http://smartgridstandardsmap.com/

The IEC Smart Grid Standard Mapping Chart will help smart grid project managers to easily identify the standards they need in their smart grid. Currently, this process must be done manually, often by reading through thousands of pages of standard documents , leading to non-reproducible results with the danger of creating more problems than are solved The chart will be constantly updated, new use cases and standards will be continuously fed into the open source database. It will allow users to search by pointing to areas or links between elements of the electric system.

6.4.2 Chart content

The mapping chart gives a visualization of the generic Smart Grid landscape covering all areas from generation to consumption (horizontal axis) and from the process equipment up to market applications (vertical axis). Its presentation structure is aligned with the SGAM plane.

The typical components (devices, applications, etc.) of the Smart Grid are visualized as boxes which are clustered according to their organizational or topological togetherness. E.g. the components of a substation can be found in the Generic substation cluster or the components typically used for grid operation are clustered und “Electric System Operation”.

Components within one cluster typically have a direct data connection, utilizing some kind of Local Area Network marked as “Integration Bus” in the chart. The external communication links of clusters are symbolized by a small cloud icon, while the color of this icon shows the type of external communication network. For the network connections it is distinguished between for types, the backbone network, the backhaul network, the access network and the home automation network. Typically the components are not directly connected to a network but utilize a router or network interface controller (NIC) to bridge from the local network segment to a wide area connection.

Moving the mouse cursor over a component it will open a pop up showing all Standards identified as relevant for the component. All components involved in at least one use case have a small yellow bubble in their lower left corner. Moving the mouse cursor over this bubble will open a pop up showing all use cases which are affiliated with the component.
A filtering function permits components or standards to be shown according to defined groups or SDOs.

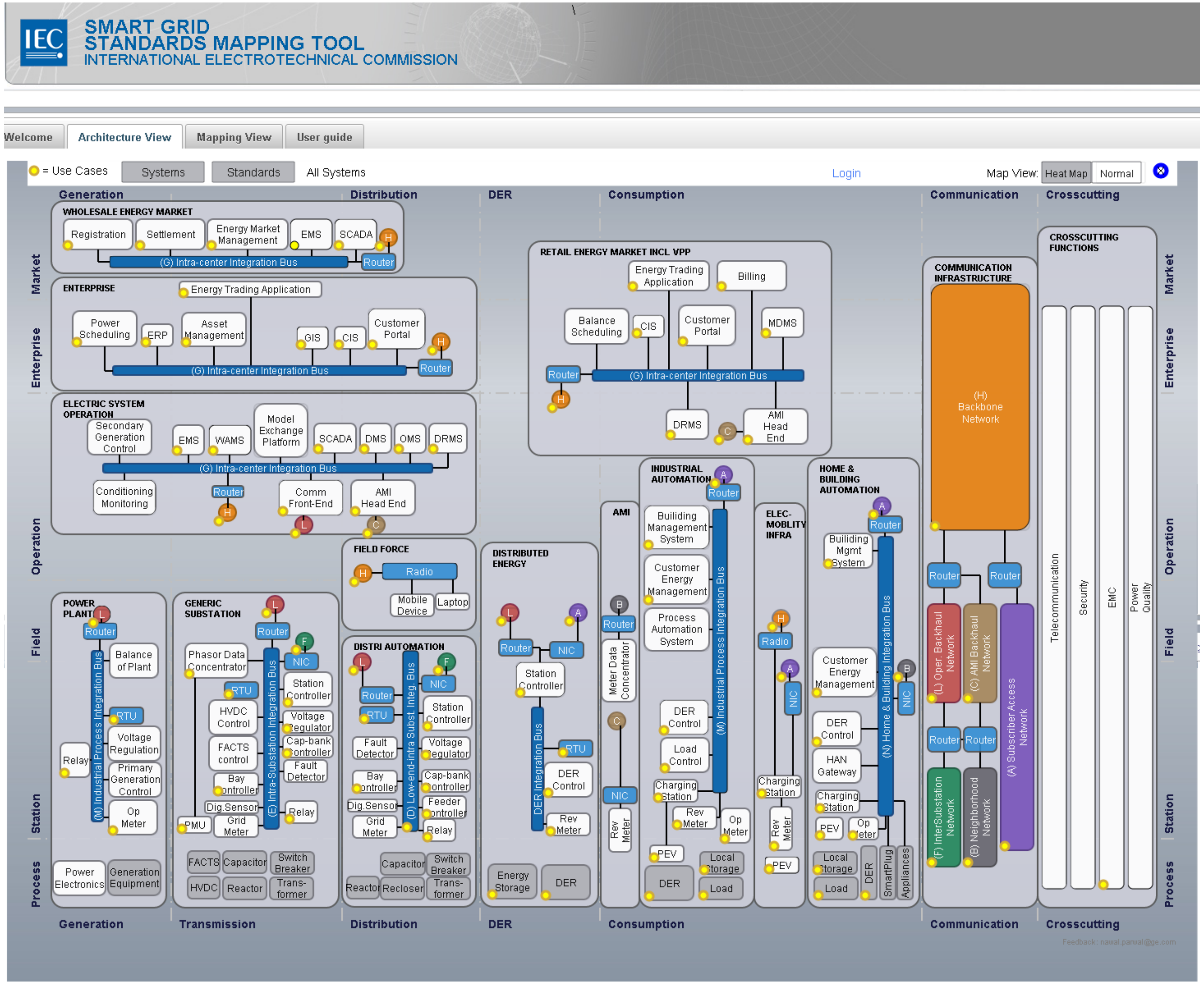


Figure 1 - Smart Grid mapping chart

6.5 Towards seamless interoperability

6.5.1 What does interoperability mean?

A smart grid consists of numerous components provided by different actors, working together to provide a smart power system. For such a system to operate and the desired services and functionalities to be provided in a sustainable way, interoperability of components, systems and attached processes to demonstrate such interoperability become of major importance. Interoperability shall be envisaged between two or more components of the same system, or between systems.
It means (derived from GridWise Architecture Council (GWAC) work [a2]):

- exchange of meaningful information
- a shared understanding of the exchanged information,
- a consistent behavior complying with system rules, and
- a requisite quality of service: reliability, time performance, privacy, and security.

Many levels of interoperability can be considered, but in all cases smart grids require interoperability at the highest level, i.e. at information semantic level.
The "Set of standards" is a path towards seamless interoperability.

However, further standardization steps shall be considered to reach the ultimate goal, such as

- ensure an accurate definition of the semantic of any exchanged information, with no risk of ambiguity,
- define the behavior of the object which implements the standard (state machine), consistently with the system behavior,
- define profiles which would restrict the options offered by the standards, in order to ensure a minimum set of functionalities, to support a predefined set of Use cases
- include a conformance statement, to check the implementation of the standard against the standard specification and
- offer profile testing means and procedures.

The absence of answers to the above expectations mostly means additional complexity for setting up and maintaining Smart Grids systems.

The Smart Grid as a system cannot be engineered from the ground up. Instead, Smart Grid development is most likely to follow a transformation process. This means that business models and market roles on the one hand, and technical components and architectural structures on the other hand, are to be transformed from the current "legacy" state into the "Smart Grid". Due to the scale of the system and its economic importance, failures in operation and especially architectural and functional planning of the system, potentially induce high costs. In order to enable a well-structured migration process, the requirements for the Smart Grid and the current system have to be decomposed using an appropriate model. Although the majority of Smart Grid equipment is based on (inter)national standards, this has not resulted in an interoperable Smart Grid infrastructure yet. This is partly due to misunderstanding of what interoperability means, what can be expected from it and what should be done to realize it.

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. Key to reaching Smart Grid system interoperability is through detailed specification of use cases, selection of applicable standards and technical specifications, profiling and testing. Nevertheless, it is also important that interoperability will be maintained over the complete system life cycle.

6.5.2 Summary of the IOP Methodology of SEG-CG WG Interoperability

Developing an understanding of and paving the way for progress in this area has been the focus of the Working Group Interoperability (WGI). In essence, their report [15], which is summarised in this section, provides methodologies related to these aspects, in order to reach the desired level of interoperability. The methodology introduced essentially describes how these aspects will contribute towards achieving interoperability, with a focus on Smart Grids (incl. smart metering) and is generic in that it can be applied to all kind of Smart Grid standards. It seeks to achieve this by focusing on five different aspects and therefore associated tasks as described below in Figure 2:

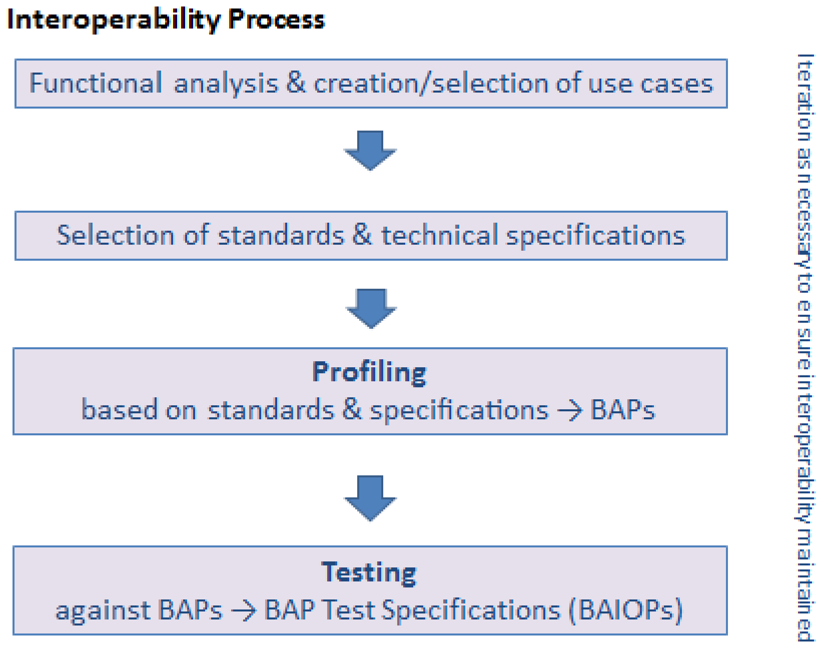


Figure 2 Interoperability process

- **Functional analysis and creation/selection of use case**

Interoperability normally starts with defining the functionality of information exchange - in other words: what data will be exchanged and how. Use cases describe the information exchange in terms of the interactions between actors and components of the smart grid system.

The interfaces between different components in the smart grid infrastructure can therefore be identified and the layer(s) on which interoperability is required (functional, information, communication and component).

With respect to system design, the IT Software/System Development Life Cycle provides a widely used methodology for system development, which ensures to deliver high quality software or system effectively and efficiently. Use cases provide a basis for the specification of functional requirements, non-functional requirements, test cases and test profiles. As a starting point, the system interoperability must be considered and well specified in the use cases in order to develop interoperable Smart Grid system by design. It is for this reason that the WGI selected the V-model to describe the different kind of specifications and related tests possible to perform in order to reach and demonstrate interoperability.

- **Selection of standards and specifications**

Once the relevant use cases are defined, appropriate standards and technical specifications for the considered interoperability layers can be selected.

The selection of appropriate standards for any layers and individual interfaces is supported by this report and the “IOP Tool” of the WGI [15].

- **Profiling**

A profile describes how standards or specifications are deployed to support the requirements of a particular application or function. This means that on top of the selection of e.g. communication standards such as IEC 61850, an additional specification has to be developed which describes the way a standard will be used, and fixes the options. These additional definitions are called BAPs (Basic Application Profiles). BAPs shall identify relevant parts of the applicable standards and specifications and are intended to be used as building blocks for interoperable specifications, e.g. by specifying the requirements according to the different layers.

The definition of a BAP is an important step in achieving interoperability as it reduces the number of options and complexity of the full standard(s) referring to. Interoperability in the Smart Grid domain is further facilitated by usage of the SGAM model for Smart Grid systems. The WGI report sets out to define the various terms related to interoperability, such as conformity, compatibility and interchangeability. It then defines the various types of standards that exist.

- **Testing**

In order to prove interoperability a BAP has to be extended to describe a testing process. Testing is one of the most important phases in reaching interoperability. A BAP Test Specification named BAIOP (Basic Application Interoperability Profile) specifies the detailed setup to test the individual technical requirements of a BAP.

Although many types of tests exist, the two main types of testing to demonstrate interoperability are conformance testing and interoperability testing.

Conformance testing verifies the correct implementation of the standards and technical specifications: the system/component concerned is tested against a test tool or reference implementation of the standard. The test also verifies what part of the standard is implemented if it is not a full scope implementation. Conformance testing is a prerequisite for interoperability testing, which means after the conformance test, the system/component will be interconnected with other systems in the Smart Grid and interoperability test will be performed to ensure that functionalities over the system boundaries are working correctly.

Interoperability testing is performed to verify that components within a system are interoperable, i.e. they are able to exchange information according to the final defined functionalities (use cases). During interoperability testing, components are tested in their final configuration together with other components of the total architecture known to be correct (according to a BAIOP). This is necessary because it is possible for two components that individually comply with a standard (resulting is a positive conformance test) to be still unable to interoperate, for example when components have implemented different or conflicting options or cover a different part of the standard(s). The interoperability test is therefore based on the BAP that describes the way the standards are used.

Therefore, the task of developing a “Conformance testing map” undertaken by WGI represented a more detailed exploration of the item ‘Conformance testing’ and ‘interoperability testing’ in the Interoperability methodology.

- **Maintaining interoperability**

It should be recognised that use cases, components, systems and standards will evolve over time, and that a management process for companion documents and profiles should be put in place to ensure that the required levels of interoperability are maintained.

Therefore the general WGI recommendation is that user groups should take ownership of creating and managing profiles, which includes the responsibility of maintaining interoperability over the lifetime of associated components and systems.

6.5.3 Linkages to the work undertaken by SEG-CG WG Methodology and SGTF EG1

It is important to recognise that how and where the methodologies described in this document are applied, depends on the business needs. Therefore, in essence, the WGI report is describing the methodology how to improve interoperability and how to deploy these methodologies under leadership of user groups for specific smart grid applications.

However, it is important to pin-point to key relationship between the output of the WG Methodology and WG Interoperability, particularly in the area of use case development and usage. In essence the degree and precision to which the methodology discussed in this particular report is executed has a direct bearing on the quality, accuracy and usefulness of the output of the WGI methodology. Put simply, in order for IOP methodology to be fully utilised a clearly articulated use case, following IEC 62559 template, is required coupled with the graphical representation on the SGAM as illustrated by the WG-SS. Conversely, if no use case is currently defined, but interoperability is required by a key stakeholder community, then the use case needs to be established using the methodology and tool kit described in section 7 of this report. Once this has been achieved, the IOP Methodology can then be followed.

Another practical implementation of the WGI methodology supporting the rollout of smart metering systems in Europe has been promoted mid 2016 by the Smart Grid Task Force (SGTF) EG1 in their repor t[16], focusing on the interfaces in and with the metering infrastructure from the Head End System to the Smart Meter and on the provision of interoperability profiles for the interfaces H1 and H2 according to CLC TR 50572, required for the provision of energy services and Demand Side Flexibility (DSF). These interfaces incl. applicable standards are also described in this report in section 8.5.

6.5.4 From Standards to Interoperability and Test Profiles

As is explained in their report [15], WGI observes that in general, profiling within a standard and between standards and specification helps to both improve interoperability and meet expectations of different projects where these will be implemented. To reach the goal of interoperability a common understanding and interpretation of the related standard and the identical use of functional elements and data representation for a given domain specific application function has to be achieved by defining profiles.

As defined in the glossary an IOP profile is a document that describes how standards or specifications are deployed to support the requirements of a particular application, function, community, or context, a profile defines a subset of an entity (e.g. standard, model, rules). It may contain a selection of Data models and Services. Furthermore a profile may define Instances (e.g. specific device types) and Procedures (e.g. programmable logics, message sequences).

The objective of profiles is to reduce complexity, clarify vague or ambiguous specifications and so aims to improve interoperability. These do generally apply for both sides of the V-Model in terms of Basic Application Profiles (BAP) for the design phase and as extended BAP test specifications (BAIOP) in the testing phase.

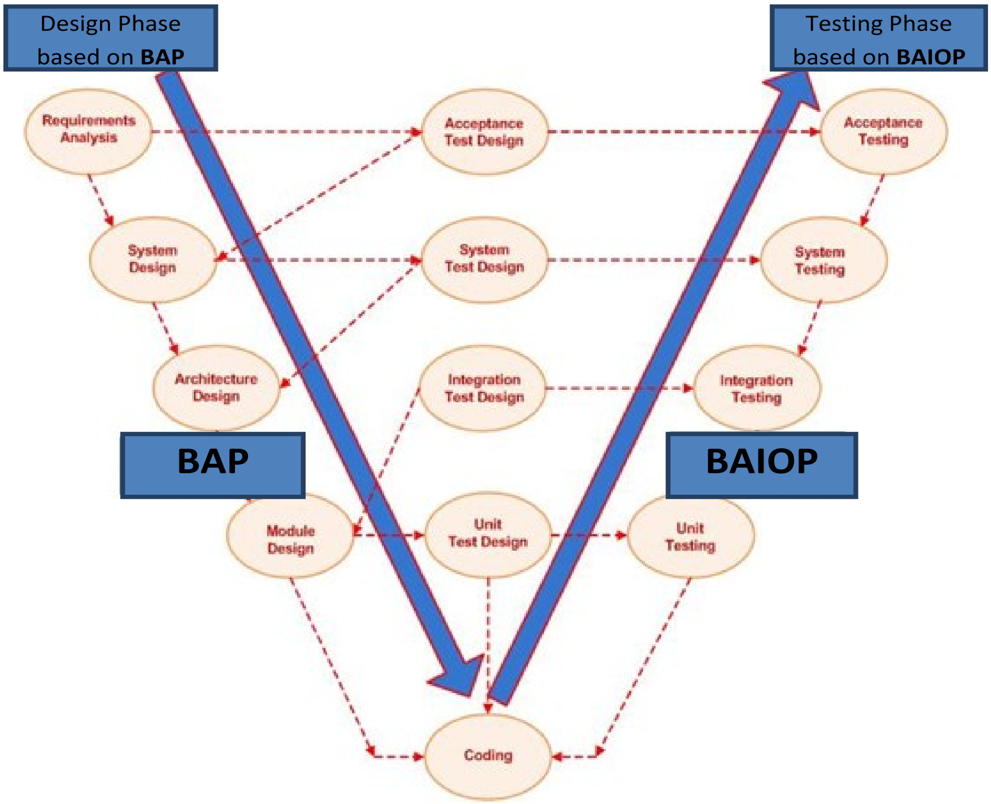


Figure 3: V-Model including BAP and BAIOP

Figure 4 illustrates the process from a Use Case to Interoperability on SGAM function layer by using BAPs and BAIOPs.

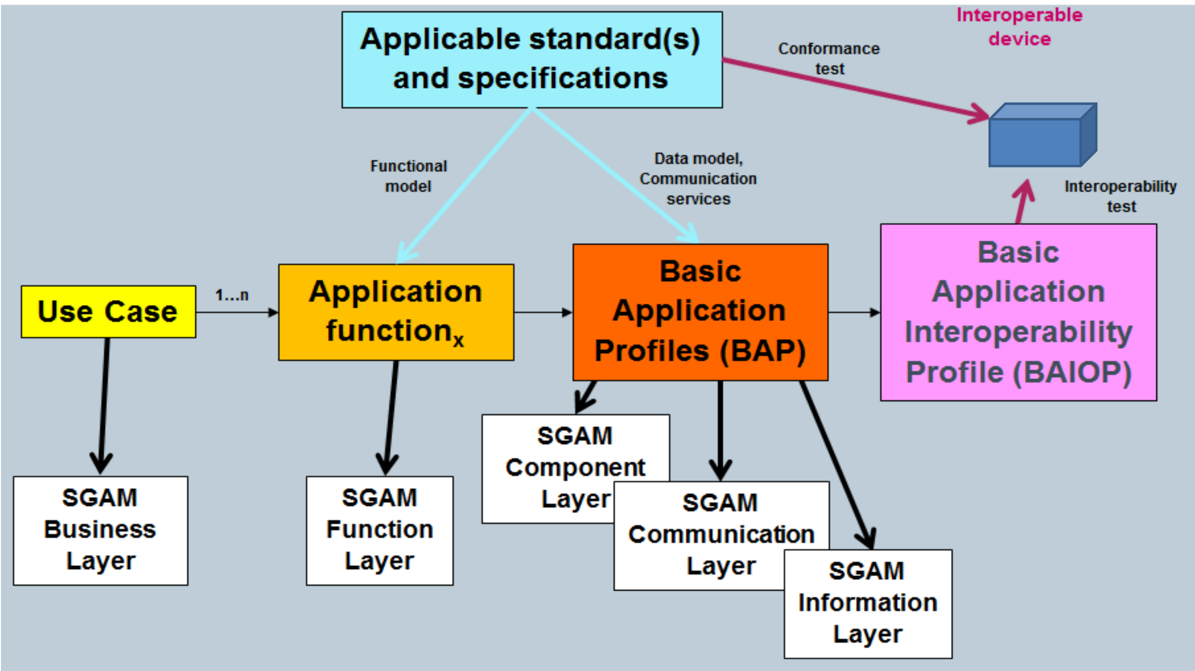


Figure 4: Process from Use Case to Interoperability on SGAM function layer

6.5.4.1 Basic Application Profiles (BAP)

A BAP basically applies to the design phase of the V-Model and is based on system/subsystem specific basic application functions descriptions. It is an agreed-upon selection and interpretation of relevant parts of the applicable standards and specifications and is intended to be used as building blocks for interoperable user/project specifications.

The key ideas of BAPs are:

- BAPs are elements in a modular framework for specific application systems/subsystems
- Combinations of different BAPs are used in real projects as building blocks
- Project specific refinement is required to implement the real projects
- Extensions or changes of the standard might be necessary to meet specific requirements

BAPs are valid for specific application systems/subsystems (e.g. Substation automation, DER operation, hydro power). They are intended to represent a user agreed common denominator of a recommended implementation or a proven best practice implementation of an application function in a specific smart Grid system/subsystem, but is not aimed to cover all possible implementation options.

BAPs must not have options, all selected criteria are mandatory to achieve interoperability. If variants of BAPs for an application function are needed, different BAPs for the same application function have to be defined.

BAPs are built on the basis of international standards and will have an influence in the further development of standards. Figure 5 shows BAPs in the workflow of a standardization process.

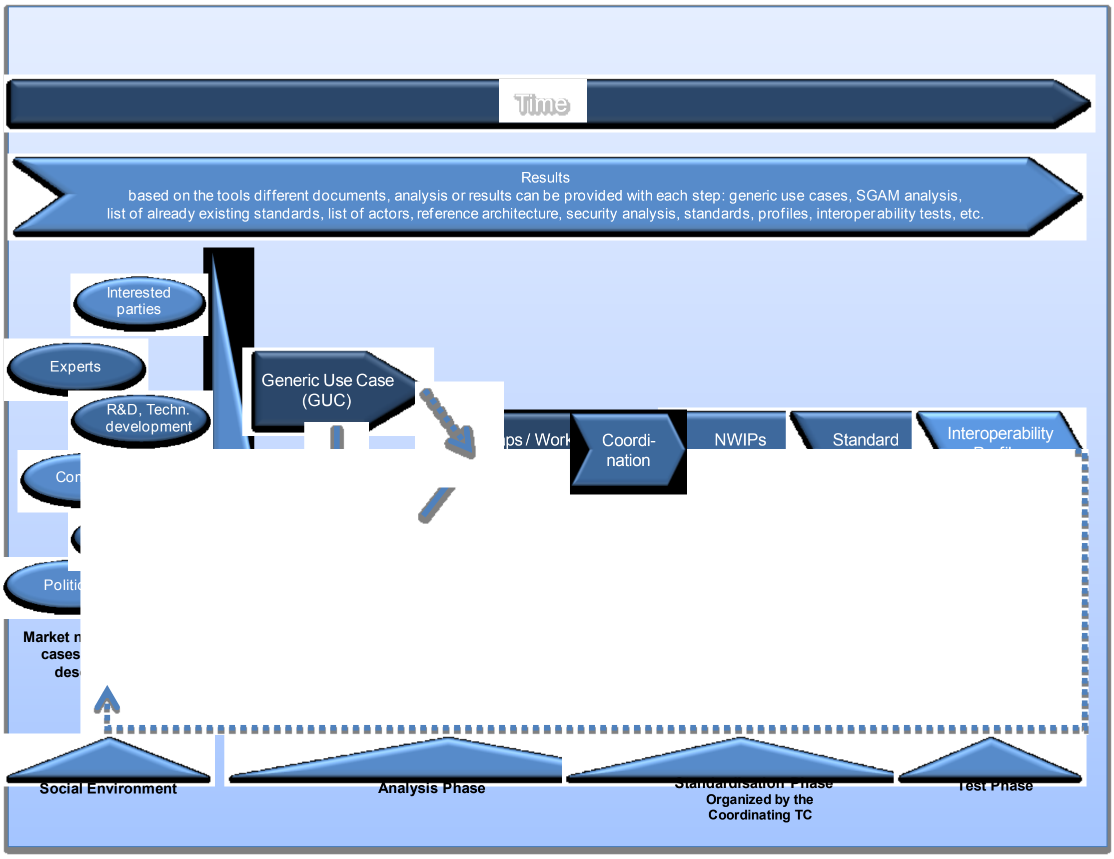


Figure 5 - Workflow of standardization process

A typical BAP may comprise:

- An introduction incl. purpose of the BAP
- Scope

- Terms, definitions & abbreviations
- Referenced documents, e.g. to other companion documents
- System architecture
- Use case definitions for different interoperability layers, starting with the functional layer, including standards and implementation details i.e.
    - functional layer incl.
        - use cases to be covered, which should be described in such detail that the test cases can be derived from it.
        - a list of standards used to support the use cases
    - information layer
    - communication layer
    - component layer
- Security

BAPs should furthermore be created under consideration of the following general rules:

- Only existing standards shall be referenced
- A BAP should not contain any conflict to the referenced standards (i.e. a device passing the BAP testing shall also pass the conformance test of the referenced standard)
- A BAP should only contain statements which are testable at the accessible interfaces
- Specifications should be precise enough that its implementation can be tested with a unique verdict: “passed” or “not passed”
- Options should be avoided (the options chosen in theses sections must be identified and specified in detail, but the standard should not be modified). All selected criteria are mandatory to achieve interoperability
- Where available, formal language should be used for the specifications
  The sections of the standard used have to be identified - no new options should be introduced into the standard.

The definition and common use of BAPs should lead to a win-win situation for all stakeholders involved in a smart Grid project in general, e.g.:

- The benefit for utilities and User Associations is the chance to harmonize the various company specific application function variants to a common denominator / best practice implementation for each basic application function. This reduces the risk of interoperability problems caused by products/systems as these may be selected from standardized BAP frameworks and tested according to BAIOPs.
- The benefit for vendors which will use standardized BAP‘s in their products is the reduction of project specific or utility specific implementation variants of application functions and therefore reduce product complexity, development costs and parameterization efforts. BAIOPs can be used for internal tests before the product will be placed on the market.
- The benefit for Certification Bodies / Test Labs is the ability to perform interoperability tests based on BAIOPs and create a new business case.
- The benefit for system integrators is that they can specifically select products conformant with BAP’s and tested according to BAIOPs. This significantly reduces the efforts for integration of subsystems or devices.

6.5.4.2 Basic Application Interoperability Profile (BAIOP)

To reach interoperability a BAP has to be extended for interoperability testing. The extended BAP is referred to as BAIOP. For interoperability testing a BAP has to be extended by e.g.

- Device configuration
- Test configuration with communication infrastructure (topology)

- BAP related test cases
- specific capability descriptions (e.g. PICS, PIXIT, MICS in case of IEC 61850)
- Engineering framework for data modeling (instances) and communication infrastructure (topology, communication service mapping)

A typical BAIOP may comprise:

- An introduction incl. purpose of the BAIOP
- Scope
- Terms, definitions & abbreviations
- Referenced documents e.g. to the related BAP and any other companion documents
- Description of the test procedure and test architecture (incl. requirements for conformance testing)
- List of test cases
    - for Test case N
        - identify section in BAP which is tested
        - specify purpose of the test
        - specify pre-conditions for the test
        - describe the test
        - specify expected results and requirements for passing the test
- Security
- Documentation of testing

BAIOPs should be created under consideration of the following general rules:

- The verdict of the test must be “passed” or “failed” (i.e. not “passed but …”)
- The tests must be reproducible in time (the same device tested several times must result in the same verdict)
- It must be possible to perform the tests without the support of the manufacturer of the device under test
- for Conformance testing
    - the test cases should follow the applicable standards/specification (what is specified is tested; what is not specified is not tested)
    - the tests should be as far as possible automated with minimal human interference.
- for Interoperability testing:
    - the test cases should follow the use cases defined in the BAP
    - the tests should be as far as possible automated with minimal human interference
- the test cases should be described to such detail that a programmer can write a program performing these tests.

Further explanation can be found in section 8.5 of the WGI report [15].

7 Main guidelines

7.1 Smart Grid Conceptual Model

(according to [14] - §6.3. More details can be found in [14])

7.1.1 Smart Grid Conceptual Model principles

During the coming years the power system will undergo fundamental changes. In order to define standards that support, in a consistent way, this transition, applicable in all European markets, a generic European conceptual model is required. This European conceptual model is to be regarded as the starting point for all modeling activities, and for all other models, frameworks and architectures, which are used to arrive at standards required for smart grids and smart markets.

The conceptual model aims to highlight the key areas of attention – conceptual domains and subdomains – from the point of view of responsibility. The model consists of four main conceptual domains: *Operations*, *Grid Users, Markets, and Energy Services*. Each of these conceptual domains contains one or more subdomains which group market roles from the European electricity market.

Its main underpinning is the analysis of market roles and responsibilities from [a6]. While this model is based on the electricity market structures of the EU member states, their roles and responsibilities are defined in a clear manner and provide a solid basis; new parties may enter certain markets, responsibilities may be redistributed, but the fundamental market roles and responsibilities are expected to remain constant.

Operations and *Grid Users* are conceptual domains that are directly involved in the physical processes of the power system: electricity generation, transport/distribution and electricity usage. Also, these domains include (embedded) ICT enabled system actors. The *Markets* and *Energy Services* conceptual domains are defined by market roles and (business and system) actors and their activities in trade of electricity products and services (markets), and the participation in the processes of trade and system operations representing grid users (energy services).

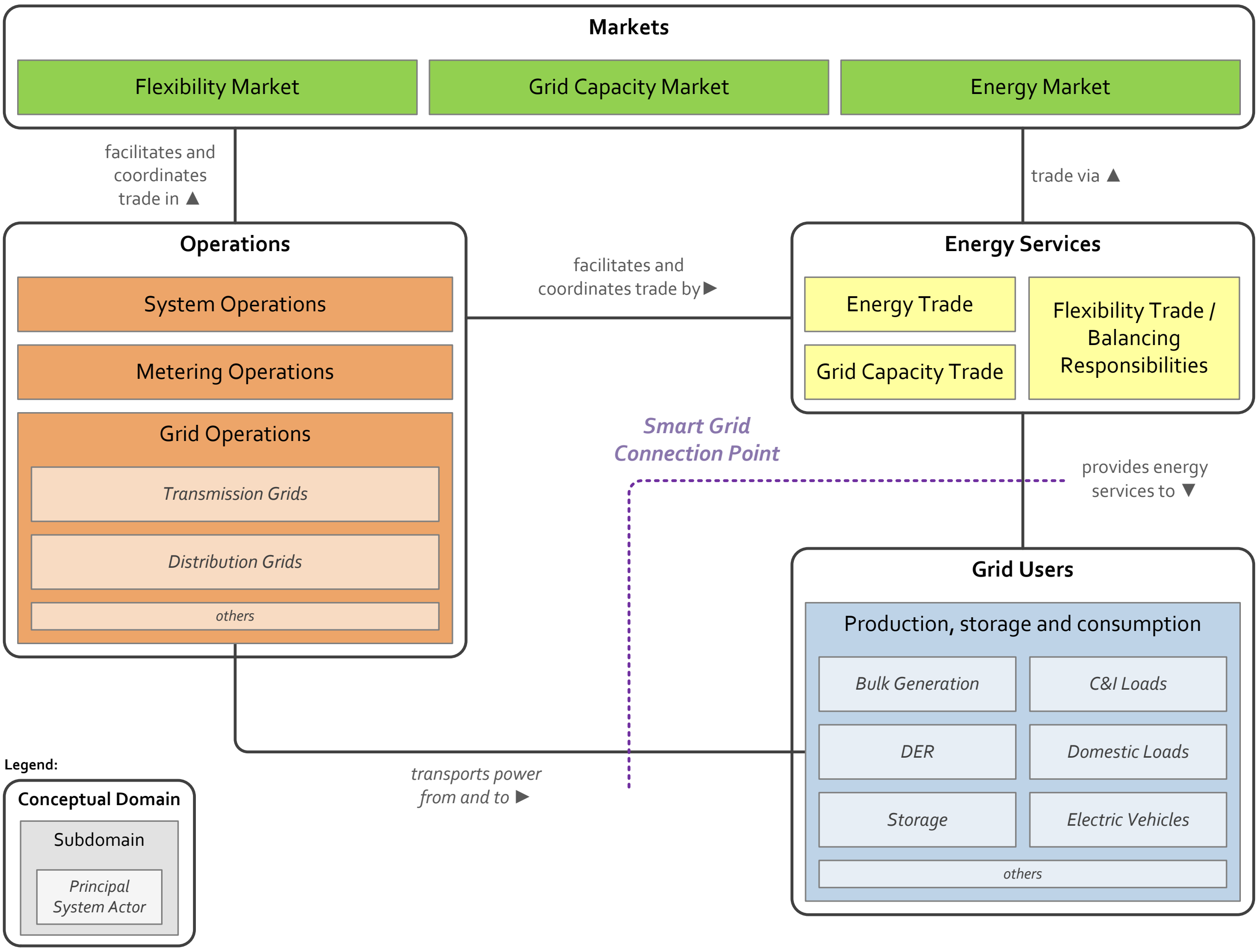


Figure 6: European Conceptual Model for the Smart Grid

In the creation of this conceptual model, input is used from the EU-flexibility concept, the SG-CG/SP on Sustainable processes, NIST, SGIP, SGAC, the Harmonized Electricity Market Role Model and EU market model developments (e.g. EG3). For more detail how this information is used and which starting principles are the bases for this model, please refer to Annex A.9 of [14] on the Conceptual model.

Furthermore, the Annex A.8 of [14] describes a more detailed mapping of all the roles from the Harmonized Electricity Market Role Model and the domains in this conceptual model and a description of each of these roles.

7.1.2 Conceptual Model Domains

The sections below provide descriptions for the domains in the conceptual model introduced above.

7.1.2.1 Operations

The *Operations* conceptual domain is defined by market roles and actors related to the stable and safe operation of the power system. The domain ensures the usage of the grid is within its operational constraints and facilitates the activities in the market. Actors in this domain may use services from the market to fulfill these responsibilities. *Grid Operations*, *System Operations* and *Metering Operations* are identified as sub-domains in the *Operations* conceptual domain. The principal system actors in this domain include *Transmission and Distribution Grids.* Other system actors could include grid assets such as transformers, switchgear, distribution management systems (DMS), energy management systems (EMS), microgrid management systems, metering systems, control center systems, etc.

Typical roles in the *Operations* conceptual domain are:

Subdomain	Harmonized role
System Operations	System Operator, Control Area Operator, Control Block Operator, Coordination Center Operator, Imbalance Settlement Responsible, Reconciliation Responsible
Metering Operations	Meter Administrator, Meter Operator, Metering Point Administrator, Metered Data Aggregator, Metered Data Collector, Metered Data Responsible
Grid Operations	Grid Operator, Grid Access Provider

7.1.2.2 Grid Users

The *Grid Users* conceptual domain is defined by market roles and actors involved in the generation, usage and possibly storage of electricity; from bulk generation and commercial and industrial loads down to distributed energy resources, domestic loads, etc. The market roles and actors in this domain use the grid to transmit and distribute power from generation to the loads. Apart from market roles related to the generation, load and storage assets, the *Grid Users* conceptual domain includes system actors such as (customer) energy management and process control systems. Grid users also provide flexibility, as they become an active participant of the energy system.

Roles in the *Grid Users* conceptual domain are:

Subdomain	Harmonized role
Production, storage and consumption	Party Connected to the Grid, Consumer, Producer

7.1.2.3 Energy Services

The *Energy Services* conceptual domain is defined by market roles and actors involved in providing energy services to the *Grid Users* conceptual domain. These services include balancing & trading in the electricity generated, used or stored by the *Grid Users* domain, and ensuring that the activities in the Grid Users domain are coordinated in e.g. the system balancing mechanisms and customer information services (CIS) systems.

Through the *Energy Services* conceptual domain the *Grid Users* conceptual domain is connected to activities such as trade and system balancing. From the *Grid Users* domain, flexibility in power supply and demand is provided. This flexibility is used for system balancing (through e.g. ancillary services, demand response, etc.) and trading on the market. Also roles are included which are related to trade in grid capacity (as currently is traded on the transmission level).

The roles and actors from the *Energy Services* conceptual domain facilitate participation in the electricity system, by representing the *Grid Users* conceptual domain in operations (e.g. balance responsibility) and markets (trading).

Roles in the *Energy Services* conceptual domain are:

Subdomain	Harmonized role
Energy Trade	Balance Supplier, Block Energy Trader, Reconciliation Accountable
Grid Capacity Trade	Capacity Trader, Interconnection Trade Responsible
Flexibility Trade / Balancing Responsibilities	Balance Responsible Party, Consumption Responsible Party, Production Responsible Party, Trade Responsible Party, Scheduling Coordinator, Resource Provider

7.1.2.4 Markets

The *Markets* conceptual domain is defined by the market roles and actors that support the trade in electricity (e.g. on day ahead power exchanges) and other electricity products (e.g. grid capacity, ancillary services). It is reflecting the market operations possible along the energy conversion chain, e.g. energy trading, wholesale market, retail market. Sub domains which are identified in this domain are: *Energy Market* (e.g. commodity market), *Grid Capacity Market* (e.g. Transmission capacity market), and *Flexibility Market* (e.g. Imbalance market). Activities in the *Market* domain are coordinated by the *Operations* domain to ensure the stable and safe operation of the power system. Examples of (system) actors in this domain are trading platforms.

Roles in the *Markets* conceptual domain are:

Subdomain	Harmonized role
Flexibility Market	Reserve Allocator, Merit Order List Responsible
Grid Capacity Market	Capacity Coordinator, Transmission Capacity Allocator, Nomination Validator
Energy Market	Market Information Aggregator, Market Operator

7.2 General method used for presenting Smart Grids standards

Considering the main expectation of readers of this report, i.e. to get a standards selection guide, the entry points considered for presenting the "Set of standards" are **the Smart Grid systems** as introduced in the report "Reference Architecture for the Smart Grid" – functional architecture [9].

The list of considered systems is provided in section 7.4.

Note :

This list represents today's optimum, based on today's requirement, regulation and technologies, then this may change in the future for future reasons - technology evolution, new regulation, new market needs.

These systems are just to be considered as typical example.

This list is considered as complete enough as soon as all major standards are exposed in a meaningful and appropriate context.

Then systems are mapped on the SGAM reference model (see section 7.5.2). This mapping shows which standards are to be considered and where to use them.

Standards are selected from Standardization bodies, following the ranking method proposed in section 6.2. For each of the listed standards "maturity information" according to section 6.2.2 and 6.2.3 is provided. This approach will be used as a template for any system-related section of this report.

Some cross-cutting domains (such as EMC, power quality, functional safety, security or communication) are treated separately in section 9 to avoid too many repetitions and/or provide a global, higher level picture.

This means that cross-cutting standards may also apply to dedicated systems. Please refer to each system details for more details. More specifically, section 7.5.4 indicates how the upper OSI layers of communication, presented in each system, are bound to the lower OSI layers of communication (present in the cross-cutting section 9.3 dealing with communication).

At the end of the document, in section 10, tables sorted by standardization bodies, containing all currently proposed standards, their maturity levels and the systems where the standards may be used, are provided.

7.3 SGAM introduction

Note: the SGAM is a main outcome of the SG-CG/RA working group and is extensively described in [9] and in [14].

The SGAM framework and its methodology are intended to present the design of smart grid use cases in an architectural but solution and technology-neutral manner. In accordance with the scope of the M/490 program, the SGAM framework allows the validation of smart grid use cases and their support by standards.

The SGAM framework consists of five layers representing business objectives and processes, functions, information exchange and models, communication protocols and components. These five layers represent an abstract and condensed version of the GWAC interoperability categories. Each layer covers the smart grid plane, which is spanned by electrical domains and information management zones. The intention of this model is to represent on which zones of information management interactions between domains take place. It allows the presentation of the current state of implementations in the electrical grid, but furthermore to depict the evolution to future smart grid scenarios by supporting the principles' universality, localization, consistency, flexibility and interoperability.

7.3.1 SGAM Smart Grid Plane

In general power system management distinguishes between the electrical process and information management viewpoints. These viewpoints can be partitioned into the physical domains of the electrical energy conversion chain and the hierarchical zones (or levels) for the management of the electrical process (refer to [a5]). This smart grid plane enables the representation on the levels (hierarchical zones) of which power system management interactions between domains or inside a single domain take place.

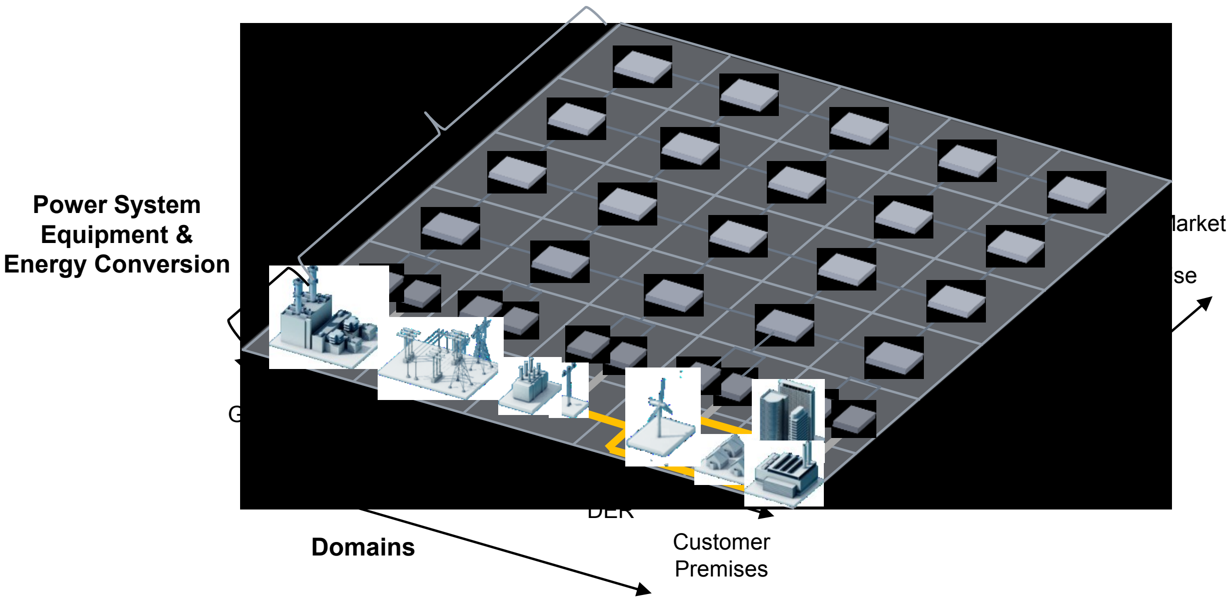


Figure 7: Smart Grid plane - domains and hierarchical zones

7.3.2 SGAM Interoperability Layers

As already introduced above in the introduction to 7.3, the interoperability categories described in [a2] are aggregated into five abstract interoperability layers (refer to Figure 8).

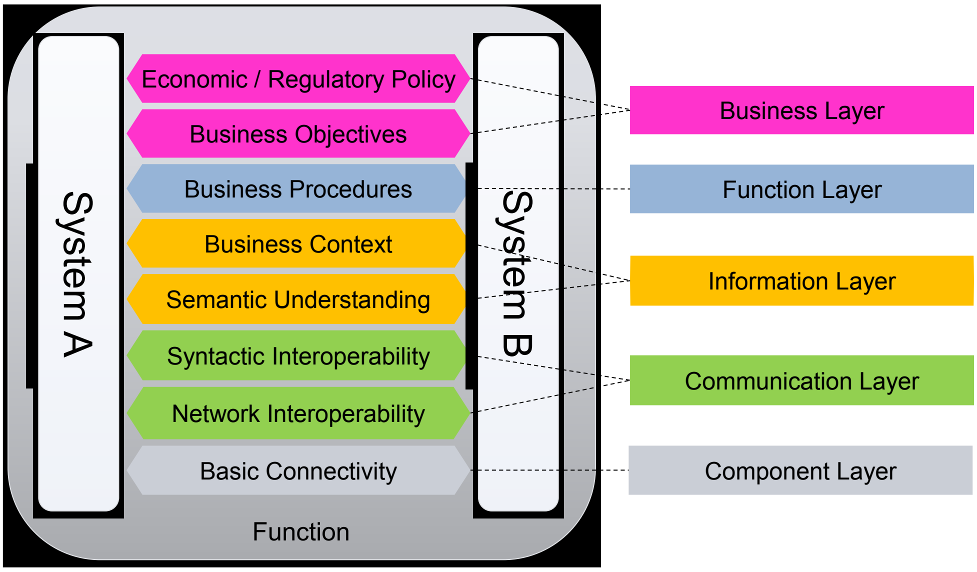


Figure 8: Grouping into interoperability layers

7.3.3 SGAM Framework

The SGAM framework is established by merging the concept of the interoperability layers defined in section 7.3.2 with the previously introduced smart grid plane. This merge results in a model (see Figure 9) which spans three dimensions:

- X: Domain
- Y: Interoperability (Layer)
- Z: Zone

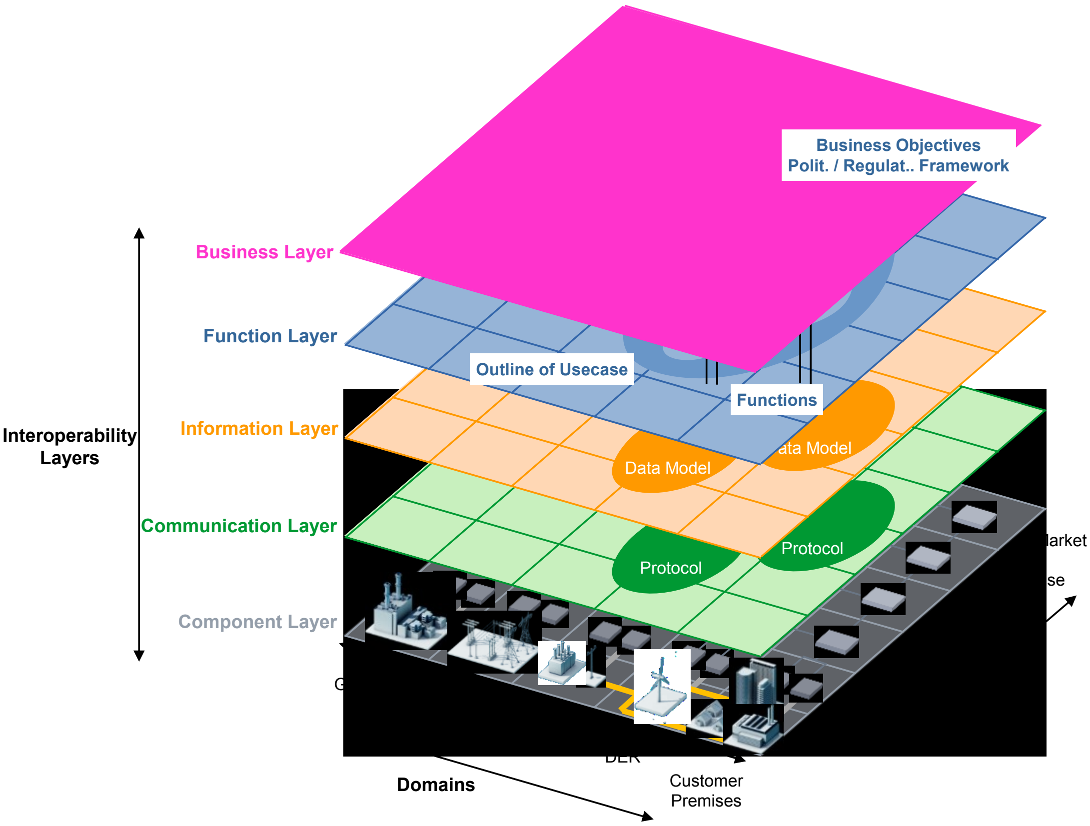


Figure 9: the SGAM framework

7.4 List of systems

Here are the systems which have been considered in this document, and which de facto form the set of the Smart Grid systems.
The guidelines mentioned in 7.1 indicate the purpose and limits associated to system definition and completeness of the considered list.

This list is actually made of three types of systems:

- Domain specific systems (Generation, Transmission, Distribution, DER, Customer Premises).
- Function specific systems (usually crossing domain borders) (Marketplace systems, Demand flexibility systems, Smart metering systems, Weather observation and forecast systems).
- Other systems usually focusing on administration features (asset management, clock reference, communication management, device management, etc).
  These so-called “Administration systems” are usually present in all the above ones, but are generally implemented to co-habit with the domain or function specific domains. Depending on the implementation such cohabitation may lead to really separated systems and roles, or completely integrated systems and roles.

Table 5 - Smart Grids - list of the main systems

Domain or Function	**Systems**
Generation	Generation management system
Transmission management system	Substation automation system
	Blackout Prevention System - Wide Area Measurement Protection and Control System (WAMPAC)
	EMS SCADA system
	Flexible AC Transmission Systems FACTS
Distribution management systems	Substation automation system
	Feeder automation system
	Advanced Distribution Management System (ADMS)
	FACTS system
DER operation systems	DER operation system
Smart Metering systems	AMI system
	Metering-related back office system
Demand and production (generation) flexibility systems	Aggregated prosumers management system
Micro-grid	Micro-grid systems
Marketplace system	Marketplace system
	Trading system
E-mobility (connection to grid)	E-mobility systems
Administration systems	Asset and Maintenance Management system
	Communication network management system
	Clock reference system
	Authentication, Authorization, Accounting system
	Device remote Management system
	Weather forecast and observation system

Note 1: So called “Administration systems” can/may be implemented in superposition of previous “operational systems”. There are in most of the cases re-using communication capabilities already present in the “operational system”.

Note 2: HVDC systems will be considered in further revisions of the present document.

Note 3: Specificities of offshore systems will be considered in further revisions of the present document.

7.5 Mapping of systems on SGAM Smart Grid Plane

7.5.1 Overview

An overall view of all these domain or function specific systems onto the SGAM plane allows positioning each system in the domains and zones as shown in Figure 10. Note that not all administrative systems and cross-cutting technologies are shown in order to keep the figure readable.

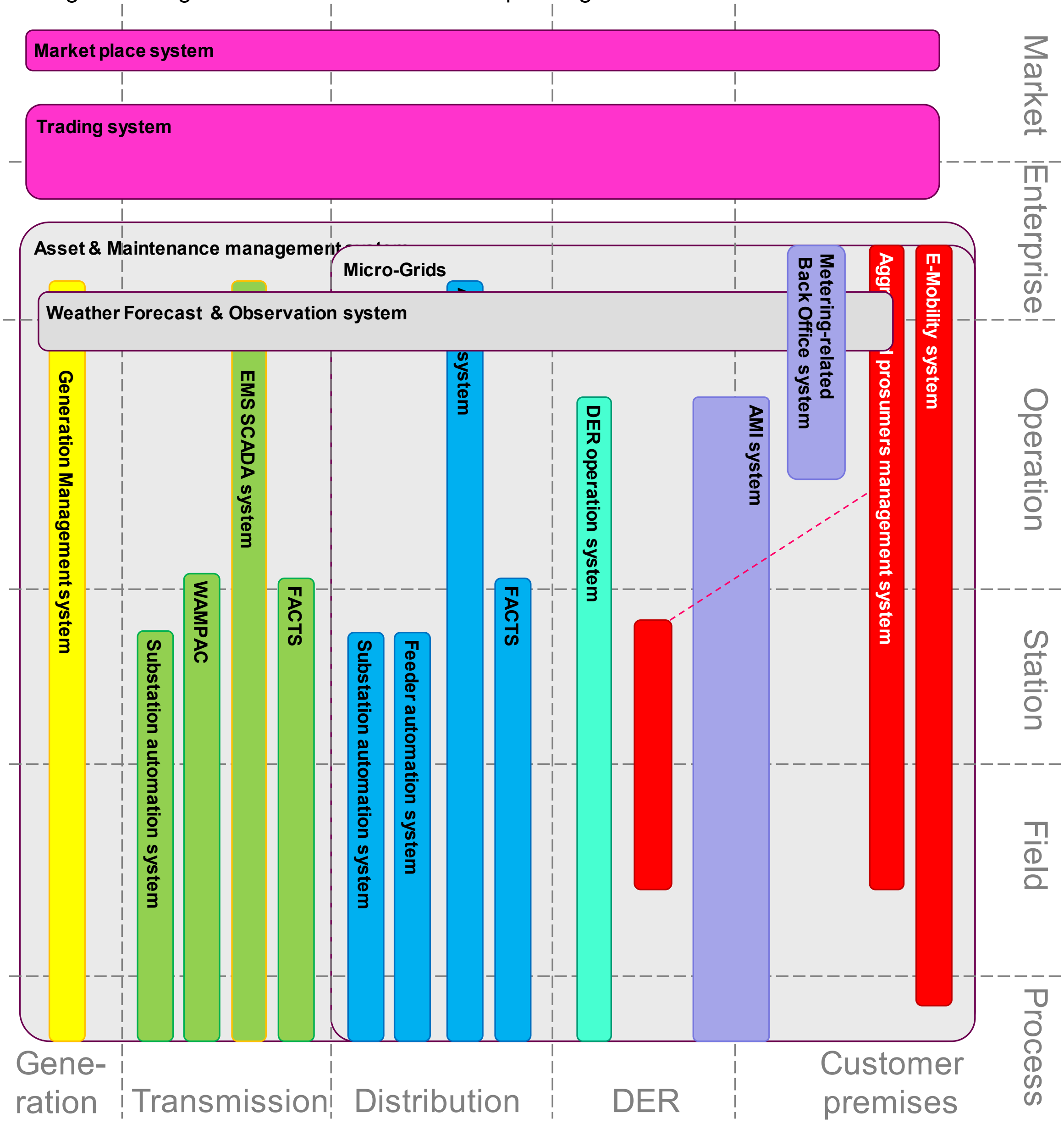


Figure 10 - Mapping of Smart Grids systems to the SGAM model

7.5.2 Specific usage of the SGAM in the current document

For a structured system description, each system will be mapped to the SGAM model described above in section 7.3.3. Each system mapping is following the same path:

- Definition of the set of “Generic use cases” (ref glossary) the considered system can/may support
    - This “function layer” is described as a flat list
- Drawing of the typical architecture and components used by this system (component layer)
- List of standards to be considered for interfacing each components within this system
    - at “**component**” layer
    - at “**communication**” layer
    - at “**information**” layer

7.5.3 Conventions used to draw the component layer of a system mapping

As a reminder (extracted from section 3), a system is a typical industry arrangement of components and systems, based on a single architecture, serving a specific set of use cases.

This means that there are multiple ways to implement a system.
The challenge for mapping such a system on the SGAM to represent associated standards is then:

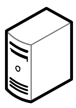
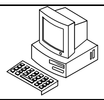
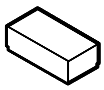
- To be accurate enough to show the typical usage of standards
- To be generic enough not to “dictate” any preferences regarding such system arrangement.

So the main rules which have been considered in the system-related section below to draw the component layers of a system on the SGAM tool are:

- The drawing represents a functional view of the system

- The components and arrangement are represented in very generic ways as shown in the table below :

Table 6 - Typical components used for system mapping on SGAM

Graphical representation	Description	Comment
	A software base application	Usually met at higher level of the architecture May be grouped with others components
	An operator interface	May be grouped with others components
	A generic “field” component	Usually hosting field level interface/treatment function. May be grouped with others components

- The links are representing a requirement of information (data) exchange between the selected components

Table 7 - Typical links used for system mapping on SGAM

Graphical representation	Description	Comment
	Electrical connection between process level component	Showing the presence of an electrical network
	Communication path between two (or more) components	Showing the presence of a communication network
	Communication between a component and another system	Expressing the potentiality for one system to contribute to UCs hosted by another one. Showing the presence of a communication network, when noted in a level different than the "process" zone level

7.5.4 Conventions used to draw the communication layer of a system mapping

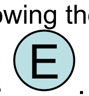
When a communication path appears between two (or more) components, then it has to be represented on the communication layer.

The following rules for drawing the communication layer of a system are:

- System-related section (listed in chapter 8) and associated standards mostly focuses on application layers (layer 5 to 7 of the OSI model)
- Upper layers of communication are represented on the mapping using a large green arrow. Typically this will appear as follows:

  where NN indicates the standardisation body[5], and XXXX indicates the standard reference
- Communication technologies corresponding more to OSI layers 1 to 4 are described in section 9.3 11 types of networks have been identified, which are noted by letters from "A" to "N".
  More specifically the communication standards categories able to fulfill the requirement of the considered type(s) of network are listed in the Table 80 (on a 'per type of network' basis). The detailed list of communication standards, related to each standard categories, are given in Table 81 and Table 82.
- The two parts mentioned above are bound graphically by adding to the communication network representation (a green arrow which appears on each SGAM mapping of the communication layer of the corresponding system) a blue disk showing the type of network to consider.

  The tag used to express this connection is 

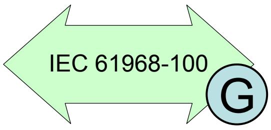
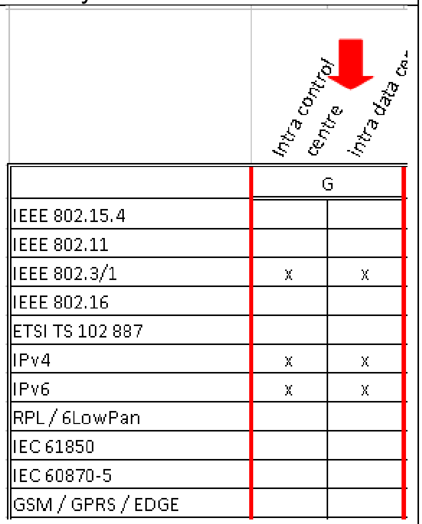
  .

Then, when a **communication dataflow** is mapped on the SGAM, for a selected system, it will be shown with a **green large arrow**, but **close to this arrow a blue disk** is placed, **including a letter (from A to M) indicating which type(s) of network is this dataflow relying on.**

An example is provided below.

[5] For some of the EN standards, the IEC body is mentioned on the graphics. The numbering of the standard remains the same. The standards tables define precisely which body to consider

Table 8 – Example in binding system standards and low OSI layer communication standards

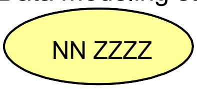
Representation of a communication flow	Meaning	Relationship with lower OSI layers of communication
	Such a drawing means that for this communication dataflow: • **IEC 61968-100** may be considered for the OSI layers 5 to 7, • and that the network said of **type "G"** may be considered as the lower OSI layers 1 to 4, i.e. "Intra-control centre / intra-data centre network" as explained in section 9.3.2. Then the **Table 80 in section 9.3.3 indicates which standard(s) category may support the lower OSI layers of a communication network of type "G".** In that example, Table 80 indicates that the categories IEEE 802.3/1, IPv4 … standards may fit (the screenshot on the right shows how to understand the usage of Table 80).	 The figure above shows how Table 80 may contribute to select the appropriate lower OSI layer communication standards category for a given type of network

7.5.5 Conventions used to draw the information layer of a system mapping

When a communication path appears between two (or more) components, then it has to be represented on the information layer, in order to express which standard data model is considered for this data exchange.

The following rules for drawing the information layer of a system are:

- Data modeling standards mostly focus on OSI layers greater than 7
- Data modeling primitives (like, "Binary", "Analog", "String", …) are not considered as such. Only semantic level modeling is considered
- Data modeling standards are shown on the drawing using a yellow ellipse such as

  where NN indicates the standard body[6], and ZZZZ indicates the standard reference.

7.6 Smart Grid Generic use cases

7.6.1 List of Generic Use cases

De facto, many Smart Grid systems host or contribute to implementing one or more Smart Grid Use cases.

The way Smart Grid Generic use cases (UCs) are broken down and sorted is described in [10].
A summary list of the considered Smart Grid use cases is provided in Table 9.
This list is non exhaustive and will be progressively completed.
Then further in the document, for each system (refer to the list above in Table 5), a specific section will describe the detailed list of supported UCs.

[6] For some of the EN standards, the IEC body is mentioned on the graphics. The numbering of the standard remains the same. The standards tables define precisely which body to consider

1475 **Table 9 – Summary list of Smart Grid Generic use cases**

Use cases cluster	High level use cases
Access Control (Substation Remote Access Example)	Local access to devices residing in a substation, with higher level support (e.g. control center) for authentication and authorization
	Local access to devices residing in a substation, with substation local authentication and authorization
	Remote access to devices residing in a substation, with higher level support (e.g. control center) for authentication and authorization using a separate VPN
	Remote access to devices residing in a substation, with higher level support (e.g. control center) for authentication and authorization using a communication protocol inherent security mean.
	Remote access to devices residing in a substation, with substation local authentication and authorization using a separate VPN
	Remote access to devices residing in a substation, with substation local authentication and authorization using a communication protocol inherent security mean.
(AMI) Billing	Obtain scheduled meter reading
	Set billing parameters
	Add credit
	Execute supply control
Billing	Obtain meter reading data
	Support prepayment functionality
	Manage tariff settings on the metering system
	Consumer move-in/move-out
	Supplier change
Blackout management	Black-out prevention through WAMPAC
	Provision of black start facilities for grid restoration
	Restore power after black-out
	Shedding loads based on emergency signals
	Under frequency shedding
(AMI) Collect events and status information	Manage supply quality
(AMI) Configure events, statuses and actions	Configure meter events and actions
	Manage events
	Retrieve AMI component information
	Check device availability
Connect an active actor to the grid	Managing generation connection to the grid
	Managing microgrid transitions
Controlling the grid (locally/ remotely) manually or automatically	Enable multiple concurrent levels of control (local-remote)
	Feeder load balancing
	Switch/breaker control
Customer	Change of transport capacity responsible
	Change of balance responsible party
	Change of metered responsible
	Change of supplier
	End of metered data responsible
	End of supply
	Notify meter point characteristics
	Query metering point characteristics
	Request metering point characteristics
(AMI) Customer information provision	Provide information to consumer
Demand and production (generation) flexibility	Generation forecast
	Load forecast
	Load forecast of a bunch of prosumers in a DR program (from remote)

Use cases cluster	High level use cases
	Managing energy consumption or generation of DERs via local DER energy management system bundled in a DR program
	Managing energy consumption or generation of DERs and EVSE via local DER energy management system to increase local self-consumption
	Participating to the electricity market
	Receiving metrological or price information for further action by consumer or CEM
	Registration/deregistration of customers in DR program
	Registration/deregistration of DER in DR program
(AMI) Energy market events	Manage consumer moving in
	Manage customer gained
	Manage customer lost
	Manage customer moving out
Exchange of metered data	Measure collected data
	Measure for imbalance settlement
	Measure for labeling
	Measure for reconciliation
	Measure, determine meter read
	Measure, determine meter read for switch
Flexibility markets	Operate flexibility markets
Generation Maintenance	Commissioning and Maintenance strategy (CMMS) definition
	Collection of additional maintenance counters for Boiler & Steam Turbine stress
	Collection of switching cycles and operating hours (maintenance counters)
	Condenser maintenance optimization
	Condition based operational advisories
	Field alarms collection for maintenance
	Field data collection for corrective and reactive maintenance
	Field data collection for predictive or condition based maintenance
	Field data collection for preventive maintenance
	Risk assessment
Generation Operation Scheduling	Ancillary services and reserve products control
	Day-ahead fleet scheduling
	Day-ahead hydro plant valley scheduling
	Fuel and other resources allocation, cogeneration and other by-products production
	Intra-day fleet scheduling
	Plant scheduling
Generation Transverse	Emissions compliance assessment
	Emissions reporting
	Equipment actual availability monitoring
	Performance monitoring
	Permit to work management
	Plant capability estimation
	Production reporting
Grid reliability using market-based mechanisms	Manage (auction/resale/curtailment) transmission capacity rights on interconnectors
	Consolidate and verify energy schedules
	Operate (register/bidding/clearing/publishing) Ancillary Services Markets
	Solve balancing issues through Balancing Market (out of the real-time window)
	Solve grid congestion issues through Balancing Market (out of the real-time window)

Use cases cluster	High level use cases
Grid stability	Monitoring and reduce harmonic mitigation
	Monitoring and reduce power oscillation damping
	Monitoring and reduce voltage flicker
	Stabilizing network by reducing sub-synchronous resonance (Sub synchronous damping)
	Stabilizing network after fault condition (Post-fault handling)
(AMI) Installation & configuration	AMI component discovery & communication setup
	Clock synchronization
	Configure AMI device
	Security (Configuration) Management
Maintaining grid assets	Archive maintenance information
	Monitoring assets conditions
	Optimize field crew operation
	Supporting periodic maintenance (and planning)
Manage commercial relationship for electricity supply	Further from ESMIG
	Further suggestions to market
	Invoicing customers
	Registration/deregistration of customers
Managing power quality	Frequency support
	Voltage regulation
	VAR regulation
Market Settlements	Perform measurement and validation (M&V)
	Perform settlements
Monitor AMI event	Install, configure and maintain the metering system
	Manage power quality data
	Manage outage data
	Manage the network using metering system data
	Manage interference to metering system
	Enable and disable the metering system
	Display messages
	Facilitate der for network operation
	Facilitate demand response actions
	Interact with devices at the premises
	Manage efficiency measures at the premise using metering system data
	Demand side management
Monitoring the grid flows	Archive operation information
	Capture, expose and analyze disturbance events
	Monitoring electrical flows
	Monitoring power quality for operation (locally)
	Producing, exposing and logging time-stamped events
	Supporting time-stamped alarms management at all levels
Operate DER(s)	Aggregate DER as commercial VPP
	Aggregate DER as technical VPP
	DER performance management
	DER process management
	DER process management with reduced power output
	DER remote control (dispatch)
	Registration/deregistration of DER in VPP
	Store energy from the grid
Operate wholesale electricity market	Receive energy offers and bids
	Clear day-ahead market
	Clear intraday market
	Clear real-time market
	Publish market results
Protecting the grid assets	Perform networked protection logic (Intertripping, logic selectivity...)

Use cases cluster	High level use cases
	Perform networked security logic (Interlocking, local/remote)
	Protect a single equipment (Incomer/feeder, Transformer, Generator)
	Protect a zone outside of the substation boundary
	Set/change protection parameters
Provide and collect contractual measurements	Collect metered data (for revenue purpose)
	Cross border transmission systems
	Measuring and exposing energy flows for revenue purpose (smart meter)
	Measuring and exposing power quality parameters for revenue purpose (smart meter)
	Transmission system/ distribution borders
Reconfiguring the network in case of fault	Supporting automatic FLISR
	Supporting reclosing sequence
	Supporting source switching
Secure adequacy of supply	Operate capacity markets
System and security management	User management
	Role management
	Rights/privileges management
	Key management
	Events management
	Configure newly discovered device automatically to act within the system
	Discover a new component in the system
	Distributing and synchronizing clocks
Trading front office operation	Bid into energy markets
	Compute optimized assets schedules to match commercial contracts
	Send assets schedules to operation systems
	Bid into ancillary services markets
	Purchase transmission capacity rights
	Nominate schedules to system operator
	Send market schedules to operation systems
	Publish market results
	Perform M&V
	Perform shadow settlements
Weather condition forecasting & observation	Wind forecasting
	Solar forecasting
	Temperature forecasting
	Providing weather observations
	Situational alerting

7.6.2 Coverage of use cases by standards (C, I, CI, X)

While attaching use cases to each system, the current report aims also to provide additional information to better evaluate the real coverage of standards in their ability to fulfill use cases.

Within each system-specific section, describing the detailed list of supported UCs, three columns were added as shown below in Table 10.
4 possibilities of support are considered:

- **C**: “C”, as “communication”, means that at least one of the communication standards (standards represented in the communication layer, and mostly covering the OSI layer from 3 to 7) which fits the AVAILABLE or COMING triggers can/will host the data exchange flow
- **I**: “I”, as “information”, means that at least one of the information model standards (standards represented in the information layer, and mostly above the OSI layer 7) which fits the AVAILABLE or COMING triggers can/will host the specific data exchange flow

- **CI**: means that both above conditions are/will be met
- **X**: If in “AVAILABLE” or “COMING” Column:
  this means that at least one of the available/coming communication standards (will) supports this use case but the exact level of support (could be C or I or CI) needs further investigation.
  If in the “Not yet” column, this means that no standard supports the UC yet,
- **Blank** : means that further information/knowledge is needed to answer it.

Table 10 - Use case coverage example

Possible combination of “use-case support” tags			
AVAILABLE	**COMING**	**Not yet**	**Explanation**
CI			Example 1 : **CI** in “AVAILABLE” means that available standards for Communication and Information layers cover market requirement for the considered UC
C	I		Example 2 : **C** in “AVAILABLE” with **I** in “COMING” means that available standards for communication cover market requirement for the considered UC but standards covering the information layer for the same UC are still in the pipe of standardization
CI	C		Example 3 : **CI** in “AVAILABLE” with **C** in “COMING” means that available standards for communication and information layers cover market requirement for the considered UC but standard improvements covering the communication layer for the same UC are in the pipe of standardization
C		I	Example 4 : **C** in “AVAILABLE” with **I** in “Not Yet” means that available standards for communication cover market requirements for the considered UC but no specific standardization activity covering the information layer is fitting the triggers yet (ref 6.2) i.e. too early stage or not started at all.
		X	Example 5: **X** in “Not yet” neither Communication nor Information layer standards are in “AVAILABLE” or “COMING” state i.e. too early standardization stage or not started at all.
			Example 6 : **blank/empty line** means that further information/knowledge is needed to answer the coverage of the considered UC

7.7 Inputs from the IEC Smart Grid Standardization Roadmap – The Smart Grid Component plane

These inputs are based on the current working IEC Smart Grid Standardization Roadmap version available on March 2016 [a3]. The future final IEC release of [a3] may be further refined, compared to the extraction provided below.

7.7.1 Cluster descriptions

Table 11 - Smart Grids – Mapping Chart clusters description

Cluster name	Description
Wholesale Energy Market	contains major components which are typically implemented to establish market operation
Retail Energy Market	contains major components which are typically implemented to act as energy service provider and/or to market distributed energy resources

Cluster name	Description
Enterprise	contains major components (applications) which are used in a utility to manage it assets, resources and customers
Electric System Operation	contains major components which are typically used in the control room environment of a grid operator
Power plant	contains major components which are typically used to operate a power plant
Generic substation	contains major components which can be implemented in a substation. Major high voltage substation might be equipped with all shown components while medium voltage substation uses only a subset.
Field force	contains major components which are used by mobile field forces to achieve supporting information or to receive orders from the control center.
Distribution automation device	contains major components which are used in the more decentralized distribution automation, aka feeder automation.
Distributed Energy	contains major components which are used to integrate distributed generation, e.g. small wind turbines, solar production, combined heat and power, biomass, etc., into the grid.
Industrial Automation	contains major components which are connected to the grid within larger industrial plants
E-mobility charging infrastructure	contains major components which are used to build up a charging infrastructure for e-cars.
Automated Metering infrastructure	(abbr. AMI) contains major components which are used to implement an automated metering infrastructure
Home & Building automation	contains major components which are used in the area of home or building automation. These components are typically implemented to achieve energy efficiency and comfort for the inhabitants/users.
Communication Infrastructure	contains the various communication network types used for information exchange between the clusters. Small bubbles with corresponding letters in the cluster shows the interconnections
Crosscutting	Acts as placeholder for crosscutting topics

1508 ### 7.7.2 List of components

1509 This list of Smart Grid components provided in Table 12, provided by IEC SYC1, will be used further in the
1510 document to complete the SGAM mapping of each system at the component layer:
1511 This list not only depicts each component, but also introduces where relevant the possible interaction of this
1512 component with other components and/or systems.

1513 **Table 12 - Smart Grid Component list (extracted from [a3])**

Component	Description
AMI Head End	A system which acts as back-end for the metering communication and controls and monitors the communication to the meter devices. The collected meter information is provided for other system like meter data management
Appliances	Appliances within buildings which are providing an interface to influence their consumption behavior
Asset Management	Application which optimizes the utilization of assets regarding loading, maintenance and lifetime
Balance of Plant	Synonym for all automation which is required to maintain a safe, secure, efficient and economical operation of a power plant.

Component	Description
Balance Scheduling	Application which plants the energy procurement of a balance responsible energy retailer to satisfy the energy demand its customer
Bay Controller	A device or application which communicates with the substation to provide status information of the field equipment and to receive switching commands an control their execution
Billing	Application which creates the energy bill information based on received metering information
Building Management System	A system consisting of several decentralized controllers and a centralized management system to monitor and control the heating, ventilation, air conditioning, light and other facilities within a building.
Cap Bank Controller	Device or application which controls the reactive power generation of a controllable capacitor bank, typically to maintain the voltage at a certain node in the grid
Capacitor	Two-terminal device characterized essentially by its capacitance (ref IEV [a4])
Charging Control	Controls the charging of one car at a residential customer side according to set points received from the customer's energy management
Charging Station	Single or multiple power outlets specially designed to charge the battery of cars. Typically including also facilities meter the energy consumption and to authenticate the owner of the car to be charged for settlement reasons.
Communication Front End	Application or system providing communication with the substations to monitor and control the grid
Conditioning Monitoring	Application or system which monitors the 'health' of grid equipment to detect upcoming failure in advance to extend the lifetime of the equipment
Customer Energy Management System	Energy management system for energy customers to optimize the utilization of energy according to supply contracts or other economic targets
Customer Information System (CIS)	System or application which maintains all needed information for energy customers. Typically associated with call center software to provide customer services like hot-line etc.
Customer Portal	Web-server application which allows utility customers to register and login to retrieve information about their tariffs, consumption and other information
Demand Response Management System	(abbr. DRMS) Demand Response Management System; a system or an application which maintains the control of many load devices to curtail their energy consumption in response to energy shortages or high energy prices. A DMS may have interfaces to other DMS.
DER Control	Control of a DER the allows the adjustment of its active or reactive power output according to a received set point
Digital Sensors	Sensors for voltage, current, etc. with a digital interface that allows connecting the sensor directly to the substation integration bus
Distributed Energy Resource	(abbr. DER) Distributed Energy Resource; a small unit which generates energy and which is connected to the distribution grid. Loads which could modify their consumption according to external set points are often also considered as DER
Distribution Management System (application server)	(abbr. DMS) Application server of a Distribution Management System which hosts applications to monitor and control a distribution grid from a centralized location, typically the control center. A DMS typically has interfaces to other systems, like an GIS or an OMS
Energy Management Gateway	(Functional) Gateway used to interface the private area with remote service provider and also with smart metering system.
Energy Management System (application server)	(abbr. EMS) Application server of an Energy Management System which hosts applications to monitor and control a transmission grid and the output of the connected power plants from a centralized location, typically the control center. An EMS may have interfaces to other EMS.

Component	Description
Energy Market Management	Application of system which manages all transactions and workflows necessary to implement an energy market
Energy Storage	An electrical energy storage which is installed within the distribution grid or DER site and operated either by a utility or energy producer
Energy Trading Application	Application(s) which are used to trade energy in corresponding markets, supports the dispatcher in the decision to buy, sell or to self-produce energy and also provides facilities to exchange the necessary information with the energy market IT systems.
Enterprise Resource Planning	(abbr. ERP) “Enterprise resource planning systems integrate internal and external management information across an entire organization, embracing finance/accounting, manufacturing, sales and service, customer relationship management, etc.” (source: Wikipedia)
FACTS	“Flexible Alternating Current Transmission System is a system composed of static equipment used for the AC transmission of electrical energy. It is meant to enhance controllability and increase power transfer capability of the network. It is generally a power electronics-based system.” (source Wikipedia). Despite their name, FACTS are also possibly used in Distribution.
FACTS controller	Control for FACTS in a way that the active or reactive power flow is adjusted according to received set points
Fault Detector	Special devices typically mounted on distribution lines to detect whether a high current caused by a network failure has passed the supervised distribution line.
Feeder controller	Distributed Automation within a distribution feeder controlling typically voltage profile and providing fault restoration logic
Front End Processor	(abbr. FEP) System component in charge of interfacing widely spread remote sub/systems or component usually communicating over WAN, to a central database,
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.
Grid Meter	Device which meters the energy exchange between neighboring grid operators or between grid operator and large energy producer/consumer
HAN Gateway	A specialized gateway device or application which establishes the communication between external systems and the Home Automation Network (HAN) devices
Head End System	(abbr. HES) Central data system exchanging data via the AMI of various meters in its service area
High Speed Bus	Communication bus within a control center system providing sufficient bandwidth and short latency to fulfill energy automation requirements
HVDC controller	Control for HVDC lines in a way that the active or reactive power flow is adjusted according to received set points
Integration Bus	Middleware supporting the information exchange between the various applications within a control center.
Laptop	Synonym for a mobile PC with keyboard, monitor and sufficient CPU power to run similar user interface clients as typically used in control rooms. Used by mobile workforces to work more independent from control room dispatcher.
Load	Energy consuming devices at customer site which might become subject for energy management
Load controller	Control the energy consumption of a load according to an received set point without jeopardizing the desired process of the load
Local Network Access Point	(abbr. LNAP) (Functional) Specialized Network Interface controller between the Local Network (within the private area) and the AMI system

Component	Description
Local Storage	An electrical energy storage which is installed behind the meter point an operated by the energy consumer/produce and not by the utility
Meter Data Concentrator	Device or application typically in a substation which establishes the communication to smart meters to collect the metered information and send it in concentrated form to an AMI head end
Meter Data Management System	(abbr. MDMS) Meter Data Management System is a system or an application which maintains all information to be able to calculate the energy bill for a customer based on the meter data retrieved from AMI head end(s). The energy bill information is typically forwarded to consumer relationship and billing systems
MID meter	Revenue Meter compliant with the European MID directive (2004/22/CE) currently being reviewed in the context of the adoption of the European New Legislative Framework 765/2008/EC
Mobile Device	Synonym for a mobile hand held device with limited CPU power to run specialized user interface clients. Used by mobile workforces to work more independent from control room dispatcher
Model Exchange Platform	Data warehouse system or application which enables the interchange of information described using the operation data model.
Neighborhood Network Access Point	(abbr. NNAP) (Functional) Specialized Network Interface Controller between the Neighborhood Network and Wide Area Network (WAN) connecting the Head End Systems
Network Interface Controller	(abbr. NIC) “A network interface controller (also known as a network interface card, network adapter, LAN adapter and by similar terms) is a computer hardware component that connects a computer to a computer network.” (source: Wikipedia)
Operation Meter	Device which monitors the energy consumption for operational and control reasons. The meter values are not used for commercial purposes
Outage Management System	(abbr. OMS) System or application which intends to help a network operator to handle outage in optimizing the fix depending on many criteria (number of customer minutes lost, number of affected customer, capability of the network, …)
Phasor Data Concentrator	Specialized data concentrator collecting the information from Phasor measurement units (PMU) within a substation and forwarding this information in concentrated form to a system on higher level.
Phasor Measurement Units	(abbr. PMU) A Phasor measurement unit is a device which measures the electrical waves on an electricity grid, using a common time source for synchronization. Time synchronization allows synchronized real-time measurements of multiple remote measurement points
Plug-In Electric Vehicles	(abbr. PEV) A vehicle with an electric drive (as only drive or in combination with a fuel engine) and a battery which can be charged at a charging station.
Power Electronics	Generation which uses power electronics to inject electrical energy, typically resulting from renewable resources, into the grid
Power Scheduling	Application deriving the optimal schedule to run the power plants to minimize costs
Primary Generation Control	Device or application within a power plant monitoring actual frequency and adjust generation if frequency deviates from desired value
Process Automation System	Automation system to monitor and control industrial production plants.
Protection Relay	Devices or application which monitors voltage and current at the terminals of grid devices to detect failures of this equipment and than issuing tripping commands to circuit breaker to avoid further damages.
Radio	Synonym for wireless communication

Component	Description
Reactor	(also named inductor) Two-terminal device characterized essentially by its inductance (ref IEV [a4])
Recloser	Special switch for distribution feeder typically combined with some automation logic to execute automated restoration after a failure in the corresponding feeder.
Registration	Application within an energy market system which handles the user registration for the market and monitors its transaction at the market.
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 system to control connected objects
Revenue Meter	Device which measures the energy consumption within predefined cycles. The metered energy consumption is used to determine the energy bill
Router	TCP/IP communication device which typically interconnects an internal network with the public network infrastructure.
Secondary Generation Control	Application which monitors the frequency and the energy exchange over tie-line and generates set points for a controlled generating unit to maintain the desired values.
Settlement	Application within an energy market system which maintains the commercial information from the executed energy transactions
Smart Plug	Synonym for a load switch which can be controlled by the customer energy management via the home automation network
Station controller	Automation system monitoring and controlling the devices in a substation. Provides interface to network control center.
Substation Integration Bus	Intercommunication system for all intelligent electronic devices (IED) within a substation
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
Switchgear	A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for use in connection with generation, transmission, distribution and conversion of electric energy (ref IEV [a4]). Switches and breaker may vary reading their switching automation and breaking capability.
Transformer	Electric energy converter without moving parts that changes voltages and currents associated with electric energy without change of frequency (ref IEV [a4])
Voltage Regulator	(abbr. VR) Device or application within the substation automation or a power plant to control the voltage at busbar(s) within the substation
Wide Area Monitoring System (application server)	(abbr. WAMPAC) application server which host the management of Wide Area Monitoring System i.e. which evaluates incoming information from PMUs to derive information about the dynamic stability of the grid

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8 Per systems standards mapping

8.1 Generation

8.1.1 Generation management system

8.1.1.1 System Description

Generation management system refers to the real-time information system and all the elements needed to support all the relevant operational activities and functions used in day to day operation of the Generation system, including the control of generation assets under normal and abnormal operating conditions. It enables implementing generating programs that are prepared for a certain period, improves the information made available to operators at the control room, field and crew personnel, customer service representatives and management. It may thus support or help in making operational decisions.
Such a system is usually made of one or many interconnected IT systems, connected to field generation operation systems, through the use of LAN/WAN communication systems. It may also include the components needed to enable field crew to operate the generation system from the field.
A generation management system usually provides following major functions:

- EMS/SCADA, real time monitoring and control of the (geographically localized) generation system at the Transmission Operator level
- DCS, real time monitoring and control of the generation assets at the station/field level
- Scheduling, monitoring and control of the (scattered) generation fleet at the generation company level for the production of energy, ancillary services and by-products in close relation to the Asset Management System
- Advanced generation management applications
- Work management
- Support of trading functions
- Black start facilities

8.1.1.2 Set of high level use cases

Here is a set of high level use cases which may be supported by a generation management system. The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the "C", "I", "CI", "X" conventions are given in section 7.6.2.

Table 13 - Generation Management systems - use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Maintaining grid assets	Monitoring assets conditions	CI		
	Supporting periodic maintenance (and planning)	CI		
	Optimize field crew operation	X		
	Archive maintenance information	CI		
Managing power quality	VAR regulation	CI		
	Frequency support	CI		
Provide and collect contractual measurements	Collect metered data (for revenue purpose)			
Connect an active actor to the grid	Managing generation connection to the grid	CI		
Blackout management	Restore power after black-out	CI		
	Under frequency shedding			

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Demand and production (generation) flexibility	Receiving metrological or price information for further action by consumer or CEM			X
	Load forecast (from local)	CI		
	Generation forecast (from remote)	CI		
	Generation forecast (from local)	CI		
	Participating to the electricity market			
	Registration/deregistration of customers in DR program			X
Grid stability	Stabilizing the network after fault condition (Post-fault handling)			
	Monitoring and reduce power oscillation damping			
	Stabilizing network by reducing sub-synchronous resonance (Sub synchronous damping)			
	Monitoring and reduce harmonic mitigation	I		
	Monitoring and reduce voltage flicker	I		
Generation Operation Scheduling	Day-ahead fleet scheduling			X
	Intra-day fleet scheduling			X
	Plant scheduling			X
	Ancillary services and reserve products control			X
	Fuel and other resources allocation, cogeneration and other by-products production			X
	Day-ahead hydro plant valley scheduling			X
Generation Maintenance	Commissioning and maintenance strategy definition			X
	Field data collection for corrective and reactive maintenance			X
	Field data collection for preventive maintenance			X
	Field alarms collection for maintenance	CI		
	Collection of switching cycles and operating hours (maintenance counters)			X
	Field data collection for predictive or condition based maintenance	CI		
	Collection of additional maintenance counters for boiler & steam turbine stress			X
	Risk assessment	I		
	Condition based operational advisories			X
	Condenser maintenance optimization			X
Generation Transverse	Permit To Work management			X
	Plant capability estimation			X
	Equipment actual availability monitoring	CI		
	Performance monitoring	CI		
	Production reporting			X
	Emissions reporting			X
	Emissions compliance assessment			X

8.1.1.3 Mapping on SGAM

8.1.1.3.1 Preamble

The European Commission's Energy Roadmap 2050 has pointed out that the EU will see a growing share of renewable energy sources connected to the power grid and a steady transition towards a complex combination of a few large centralized power plants and a great number of small and decentralized power generating facilities. Integrating these facilities into a reliable and affordable power system will require an unprecedented level of co-operative action within the electric industry and between the industry and states. The power grid has existing flexibility in the system to cost-effectively integrate wind and solar resources but, as operated today, that flexibility is largely unused. The Generation management system will address such challenges as:

- expand sub-hourly dispatch and intra-hour scheduling
- improve reserves management
- access greater flexibility in the dispatch of existing generating plants
- focus on flexibility for new generating plants

Addressing these challenges requires process-level and Asset management system constraints to be more closely integrated within the higher levels of the Generation management system.

8.1.1.3.2 Component layer

The Generation operation component architecture involves all Zones from Process to Enterprise levels, which may be interconnected through wires or communication.
The lower level components are easily identified as Generation related or not. The higher level components are more tightly integrated with Market, Asset Management & Transmission related components.

The Process level is populated with:

- electrical equipment, sensors and actuators (such as current and voltage transformers, breakers or switches)
- electro-mechanical machines with associated sensors and actuators (turbines and generators)
- industrial equipment with general purpose sensors and actuators (typically hydro or thermal plant)

The Field level is in charge of protection, monitoring and control. It is mostly based on PLCs, which can be replaced by IEDs for electrical equipment.

Above the DCS HMI, higher level components are to be integrated with Market, Asset Management & Transmission related components.
The Transmission EMS/SCADA system communicates with the Generation Management System RTU to implement the Secondary Generation Control.

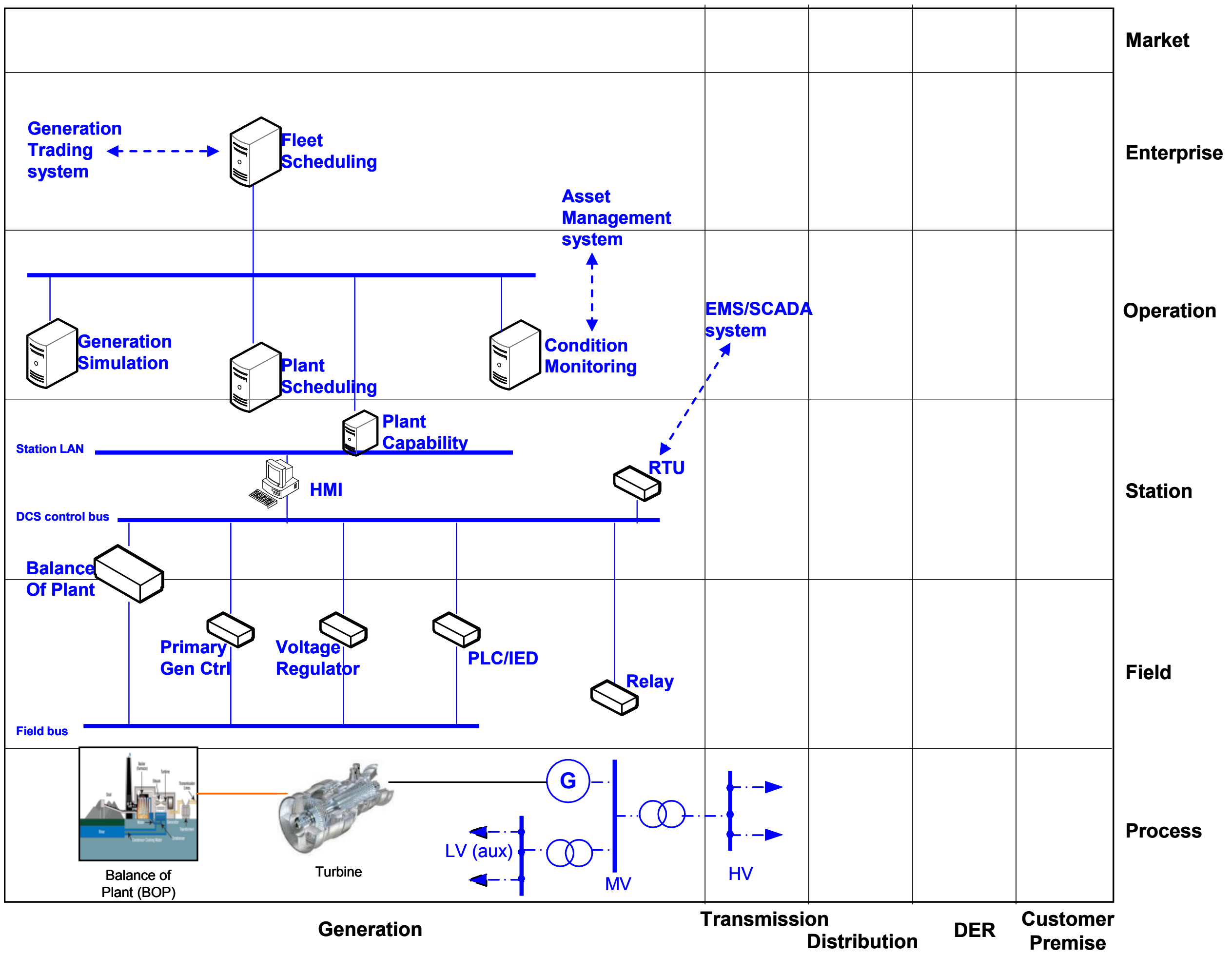


Figure 11 - Generation management system - Component layer

8.1.1.3.3 Communication layer

Within the Generation management system, the significant communication protocols are:

- Field bus protocols are standardized within EN 61158 and IEC 61784-1
- Mission-critical networks hosted in Station level rely on IEC/EN 62439
- The communication standards of the EN 60870-5 family (profiles 101 and 104 to connect to the Plant, profile 103 to connect to protection Relays)
- The messaging standard EN 61968-100 for Enterprise and Operation level messages
- The communication standards of the IEC/EN 61850 family for IED components
- The communication standards of the IEC/EN 62541 family for OPC UA servers and clients

This set of standards can be positioned this way on the communication layer of SGAM. Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

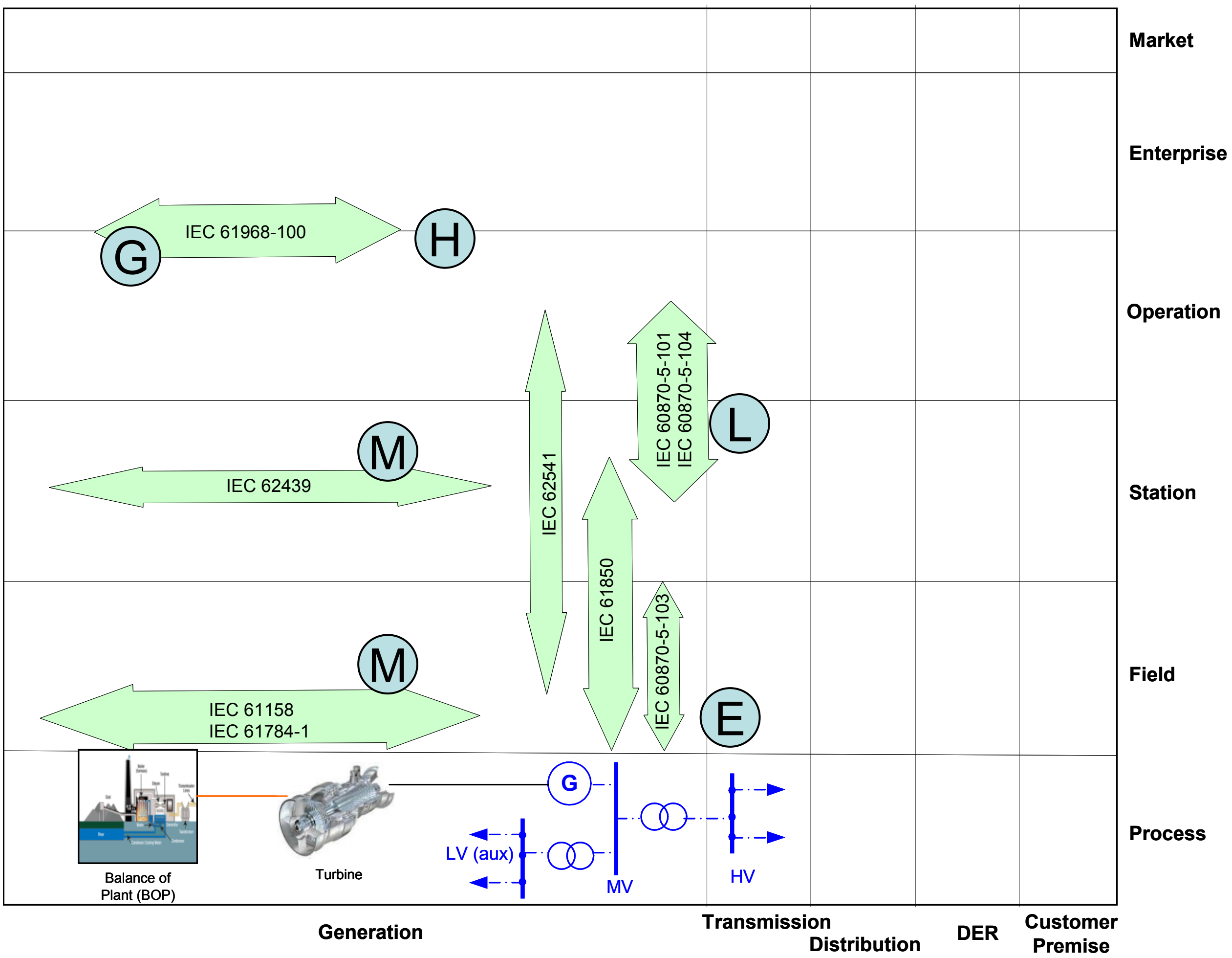


Figure 12 - Generation management system - Communication layer

8.1.1.3.4 Information (Data) layer

The information layer of Generation management is based on the following families of information models:

- Field devices are standardized within EN 61131, with associated work in progress IEC 61499 and IEC 61804
- Plant electrical devices are standardized within the IEC/EN 61850 family, with standards for specific generation types: EN 61400-25 series for Wind turbines, EN 61850-7-410 for Hydro power plants, IEC 61850-90-13 for steam and gas turbines
- Industrial plants information models are standardized in the following family: IEC 62264 (ISA 95), IEC 61512 (ISA 88), IEC 61987 and EN 61360. Their relevance to the Generation management system is at the Station level

Operation and Enterprise level information models are standardized in the CIM family: EN 61968, EN 61970, IEC 62325 and IEC 62361. EN 61968 parts relevance to Generation has not been formally assessed yet. Few parts are fully appropriate for Generation domain, but most parts can be extended to become relevant to Generation domain.

Mappings between most of these information models and the IEC/EN 62541 address space are defined or in progress.

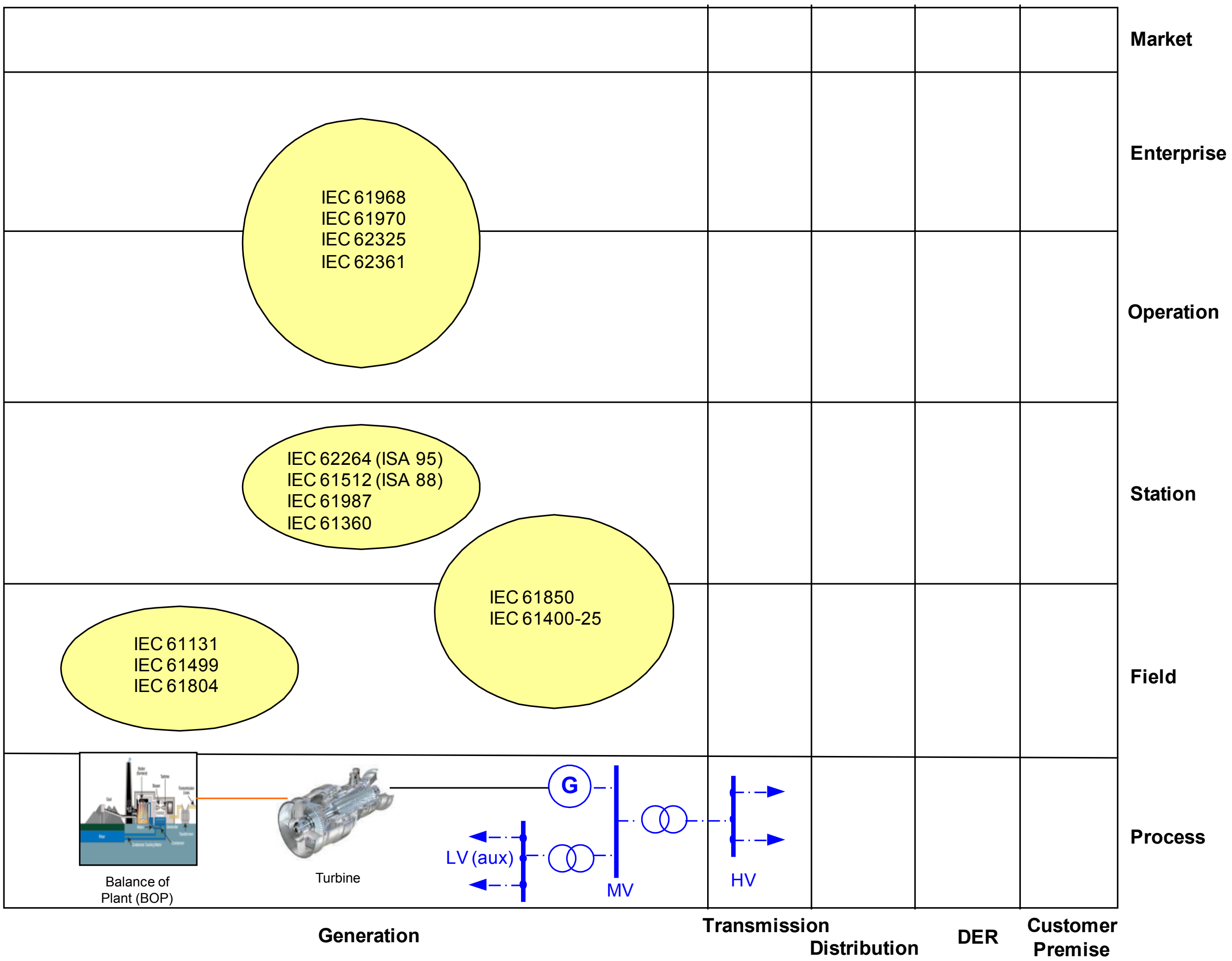


Figure 13 - Generation management system - Information layer

8.1.1.4 List of Standards

Here is the summary of the standards which appear relevant to support Generation management system. According to 7.1, standards for cross-cutting domains such as EMC or security are treated separately (IEC 62351, ISO/IEC 27001, EN 61000 etc…).

8.1.1.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by Dec 31st 2015 is considered as “available”.

Table 14 - Generation management system - Available standards

Layer	Standard	Comments
Information	EN 61131	Programmable controllers
Information	EN 61499	Function Blocks
Information	IEC 61804	Function Blocks for process control
Information	IEC 62264	Enterprise-control system integration (ISA 95)
Information	IEC 61512	ISA 88
Information	IEC 61987	Industrial-process measurement and control - Data structures
Information	EN 61360	CDD - Component Data Dictionary
Information	EN 61968-1 EN 61968-2	Application integration at electric utilities - System interfaces for distribution management

Layer	Standard	Comments
	EN 61968-3 EN 61968-4 EN 61968-6 EN 61968-9 EN 61968-11	
Information	EN 61970-1 EN 61970-2 EN 61970-301 EN 61970-401 EN 61970-452 EN 61970-453 EN 61970-456 EN 61970-501 EN 61970-552	Energy management system Application Program Interface
Information	EN 61850-6 EN 61850-7-4 EN 61850-7-3 EN 61850-7-2	Core Information model for the IEC/EN 61850 series
Information	EN 61850-7-410	Hydro power plants
Information	EN 61400-25-1 EN 61400-25-2 EN 61400-25-3 EN 61400-25-4	Wind farms
Information	EN 62541-1 EN 62541-2 EN 62541-3 EN 62541-5 EN 62541-8 EN 62541-9 EN 62541-10 OPC UA part 11 OPC UA part PLCopen	IEC/EN standards for OPC UA OPC foundation open specifications for OPC UA parts 11 and PLCopen are not yet announced in the IEC SC65E work program
Information	EN 62325-301 EN 62325-351 EN 62325-450 EN 62325-451-1 EN 62325-451-2 EN 62325-451-3 EN 62325-451-4 EN 62325-451-5 EN 62325-503 EN 62325-504	CIM information model (Market profiles)
Information	IEC 62361-100	CIM information model (profiling rules)
General	IEC 62746-3	Systems interface between customer energy management system and the power management system - Part 3: Architecture
Communication	EN 61158 (all parts) IEC 61784-1	Industrial communication networks - Fieldbus specifications – Profiles
Communication	EN 62439	Industrial communication networks - High availability automation networks
Communication	EN 62541-4 EN 62541-6 EN 62541-7	IEC standards for OPC UA
Communication	EN 61850-8-1	IEC/EN 61850 communication except sample values
Communication	IEC 61850-90-1	Use of IEC/EN 61850 for the communication between substations

Layer	Standard	Comments
Communication, Information	IEC 61850-90-2	Guidelines for communication to control centers
Communication	IEC 61850-90-4	Guidelines for communication within substation
Communication	EN 60870-5-104	to connect to the Plant (standard transport protocol)
Communication	EN 60870-5-103	to connect to protection Relays
Communication	EN 60870-5-101	to connect to the Plant (serial link)
Communication	IEC 61850-80-1	Guidelines for mapping IEC 61850 data model over IEC 60870-5-101 or 104, at CDC level
Communication	EN 61850-9-2	IEC/EN 61850 Sample values communication
Component	IEC 60255	Measuring relays and protection equipment
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)
Communication	EN 61968-100	Application integration at electric utilities - System interfaces for distribution management Implementation profiles
Component	EN 61400-1	Wind turbines - Part 1: Design requirements
Component	EN 61400-2	Wind turbines - Part 2: Design requirements for small wind turbines
Component	EN 61400-3	Wind turbines - Part 3: Design requirements for offshore wind turbines

8.1.1.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 15 - Generation management system - Coming standards

Layer	Standard	Comments
Information	*EN 61968-1* *EN 61968-3* *EN 61968-11*	Application integration at electric utilities - System interfaces for distribution management
Information	*EN 61970-301* *EN 61970-302* *EN 61970-452* *EN 61970-453* *EN 61970-458* *EN 61970-502-8* *EN 61970-552*	Energy management system Application Program Interface for 61970
Information	*EN 62325-301* *EN 62325-451-1* *EN 62325-451-6*	CIM information model (Market profiles) – Refer to 8.7 for more details
Information	*IEC 62361-101*	CIM information model (profiling rules)
Information	*IEC 61850-90-13*	Steam and gas turbines
Information	*IEC 61850-90-11*	Methodologies for modeling of logics for IEC/EN 61850 based applications
Information	IEC 61850-90-17	Using IEC 61850 to transmit power quality data
Information	*EN61400-25-1* *EN 61400-25-4* *EN 61400-25-5* *EN 61400-25-6* *EN 61400-25-41*	Wind farms
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services
Communication	*IEC 61850-80-5*	Guideline for mapping information between IEC 61850 and IEC 61158-6 (Modbus)

Layer	Standard	Comments
Communication	*IEC 61850-10-210*	IEC 61850 Interoperability tests - Hydro profile
Communication	*IEC 62351-4* *IEC 62651-6* *IEC 62351-7* *IEC 62351-9* *IEC 62351-11* *IEC 62351-12* *IEC 62351-90-1*	Cyber-security aspects (refer to section 9.4)
Information	*IEC 62361-102*	Power systems management and associated information exchange - Interoperability in the long term - Part 102: CIM - IEC 61850 harmonization

8.2 Transmission management domain

The transmission domain of a power grid consists of 4 main systems in order to transmit electrical energy from generation to consumption over longer distances.

- **Substation Automation System –** elements needed to perform automated operation remotely or local of a substation, and of connected assets (grid lines, loads...).
- **Blackout Prevention System (WAMPAC)** – protect power systems from instability and collapse, whilst accommodating continuous load growth and with reduced operational margins within stability limits.
- **EMS SCADA System** – real-time information system and all the elements needed to support all the relevant operational activities and functions used in transmission automation at dispatch centers and control rooms.
- **Flexible AC Transmission System (FACTS)** – covers several power electronics based systems utilized in AC power transmission and distribution. FACTS solutions are particularly justifiable in applications requiring rapid dynamic response, ability for frequent variations in output, and/or smoothly adjustable output

8.2.1 Substation automation system (Transmission & Distribution)

8.2.1.1 System description

The Substation Automation System refers to the system and all the elements needed to perform protection, monitoring and control of a substation, and of connected assets (inside the substation such as transformers, busbar, etc or outside the substation such as grid lines, loads, etc).
Substation automation system may also act as remote terminal for upper levels of grid monitoring and control for operation and/or maintenance.
Some of the capabilities are fully automatic, i.e. are providing a spontaneous response of the system triggered by external events. Some others are in support of remote and/or manual operation.

Substation automation systems are often implemented in the Distribution, Transmission and Generation domains. They can also be implemented on large industrial sites or infrastructure.
As a particular simplified case, Substation Automation System may be used for Automated MV/LV transformer Substation System, where the automated operations may include also LV feeders placed on the MV/LV transformer substation and typically (but not limited to) MV-switching elements connected to the MV/LV transformer, (controllable) MV/LV transformers and automated low-voltage boards.

8.2.1.2 Set of use cases

Here is a set of high level use cases which may be supported by a substation automation system.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 16 - Substation automation system - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Protecting the grid assets	Protect a single equipment (incomer/feeder, transformer, generator)	CI		
	Protect a zone outside of the substation boundary	CI		
	Perform networked protection logic (intertripping, logic selectivity...)	CI		
	Perform networked security logic (interlocking, local/remote)	CI		
	Set/change protection parameters	CI		
	Monitoring electrical flows	CI		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Monitoring the grid flows	Monitoring power quality for operation (locally)	CI		
	Producing, exposing and logging time-stamped events	CI		
	Supporting time-stamped alarms management at all levels	CI		
	Capture, expose and analyze disturbance events	CI		
	Archive operation information	CI		
Maintaining grid assets	Monitoring asset conditions	C	I	
	Supporting periodic maintenance (and planning)	C	I	
	Archive maintenance information	CI		
Controlling the grid (locally/ remotely) manually or automatically	Switch/breaker control	CI		
	Feeder load balancing	CI		
	Enable multiple concurrent levels of control (local-remote)	CI		
Managing power quality	Voltage regulation	CI		
	VAR regulation	CI		
Reconfiguring the network in case of fault	Supporting reclosing sequence	CI		
	Supporting source switching	CI		
	Supporting automatic FLISR	CI		
Provide and collect contractual measurements	Measuring and exposing energy flows for revenue purpose (smart meter)	C	I	
	Measuring and exposing power quality parameters for revenue purpose (smart meter)	C	I	
Connect an active actor to the grid	Managing generation connection to the grid	CI		
Blackout management	Black-out prevention through WAMS	CI		
	Shedding loads based on emergency signals	CI		
	Restore power after black-out	CI		
System and security management	discover a new component in the system	C		I
	Configure newly discovered device automatically to act within the system	C		I
	Distributing and synchronizing clocks	CI		

8.2.1.3 Mapping on SGAM

8.2.1.3.1 Preamble

It is important to consider that, from a standard point of view, there are a lot of similarities between Distribution substation automation system, and transmission and generation one.
For an easy reading of the document only the distribution substation automation is mapped, but this schema can be transposed on Transmission and generation domains.
This is expressed by adding a circle indicating that the same principles can apply on these domains.

Considering that this system is not interacting with the "Enterprise" and "Market" zones of the SGAM, only the "Process", "Field", "Station" and "Operation" zones are shown in the here-under drawings.

Note : In the particular simplified case of Automated MV/LV transformer Substation System, we may observe a smaller number of IEDs, a lower level of complexity of operations to perform and possibly a simpler local area network (LAN) relying on standard technologies like the one used for home area networks (HAN) or industrial networks.

8.2.1.3.2 Component layer

The substation automation component architecture is mostly made of 3 zones of components, which may be interconnected through wires or communication.

- The **Process zone** includes the primary equipment of the substation mainly switching (i.e. circuit-breakers, switches and disconnectors), power transformer regulator and measuring elements (i.e. current and voltage sensors/transformers).
  Referring to the component list shown in 7.7.2, here are the most common “smart” components used at that level:
    - Digital sensors
- The **Field zone** includes equipment to protect, control and monitor the process of the substation, mainly through IEDs, and controllers.
    - IED is a generic representation covering components such as (but not limited to):
        - Protection relays
        - Operation, Revenue and Grid meters
        - Fault detectors
        - Reclosers
        - Bay controller
        - Generic I/O interface
        - Switch controller
    - Field Controller is a generic representation covering components such as (but not limited to):
        - Feeder controller (connecting/disconnecting/reclosing sequences)
        - Voltage Regulator controller
        - Network Interface Controller (NIC)
        - Router (remote connection interface sometimes integrated in NIC)
- The **Station zone** supports the aggregation level which interface with other elements and systems of the electrical network. It is mostly supporting 4 main technical functions, which can be grouped or separated in different components, which are:
    - RTU which serves as terminal for remote activities, the Station controller, which is in charge of performing automatic functions,
    - Possibly HMI/archiving which offers the local operators capabilities of visualizing and archive local data.
    - Controller such as (but not limited to):
        - Station controller
        - Feeder controller
        - Capacitor bank controller
        - Load tap changer controller
    - Communication which can be
        - a Network Interface Controller (NIC)
        - and/or just a Router function

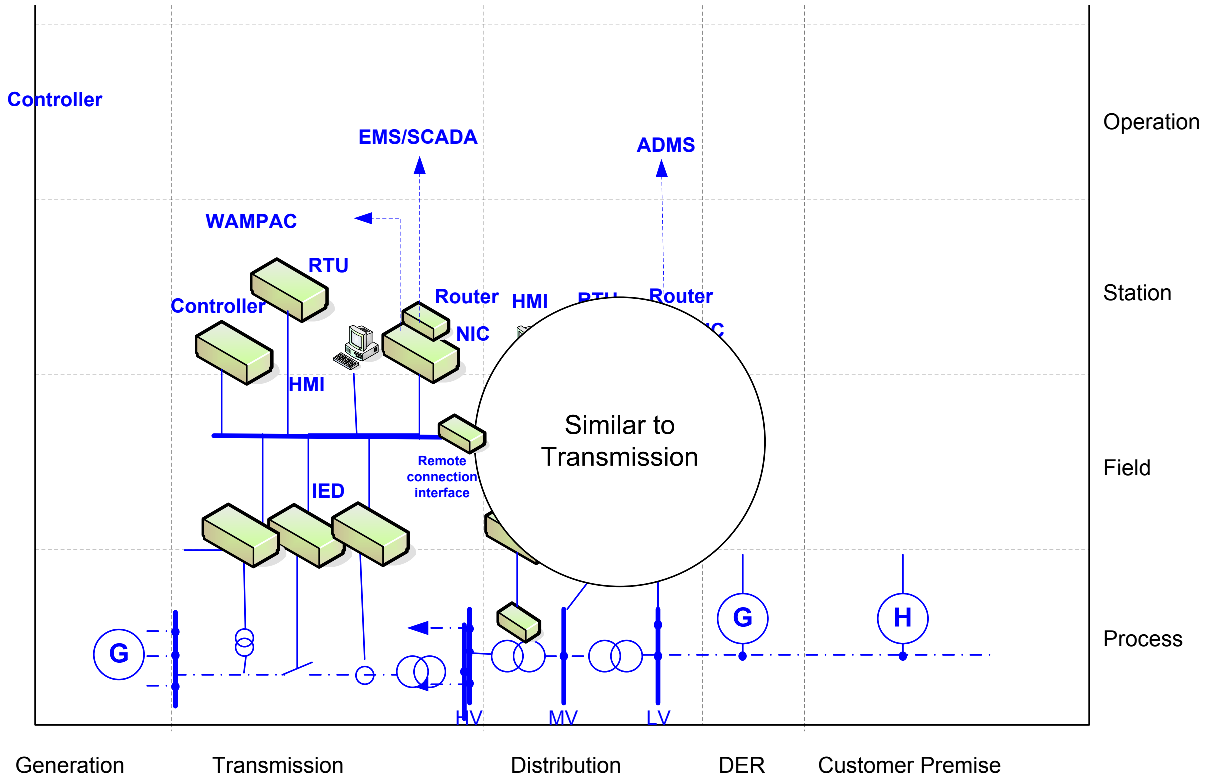


Figure 14 - Substation automation system - Component layer

8.2.1.3.3 Communication layer

Communication protocols can be used either:

- Within the substation, EN 61850-8-1 (for any kind of data flows except sample values) and EN 61850-9-2 (for sample values) are used to support the selected set of High level use cases.
  IEC 61850-90-4 provides network engineering guidelines for communication inside a substation (automated MV/LV substations are not really covered yet).
  IEC/EN 61850 mostly replaces the former EN 60870-5-103, used for connecting protection relays.
  In the specific case of automated MV/LV substations, communications are more commonly based on industrial networks.
- Outside the substation, “vertical communications” can rely EN 60870-5-101 or 104, while horizontal communications can rely on IEC 61850-90-5 (full mapping over UDP) or IEC 61850-90-1 (tunneling).
  Future vertical communication may rely on IEC 61850-90-2 (guideline for using IEC/EN 61850 to control centers) to provide a seamless architecture, based on IEC 61850.
  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.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

This set of standards can be positioned this way on the communication layer of SGAM.
Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

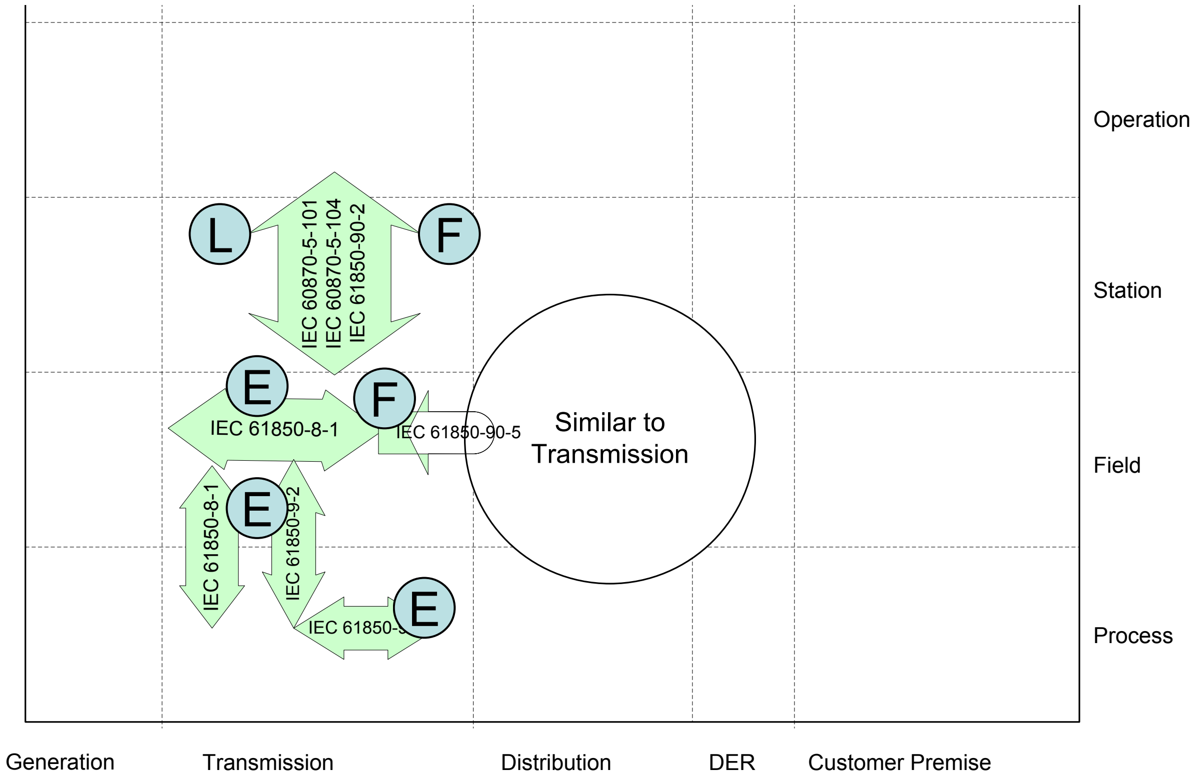


Figure 15 - Substation automation system - Communication layer

8.2.1.3.4 Information (Data) layer

The information layer of substation automation is mostly based on the IEC/EN 61850 information model. We have indicated that the EN 61850-7-4 is the core part depicting this model, however other “namespaces” of the IEC/EN 61850 series can be used such as:

- EN 61850-7-410: Hydro power plants
- EN 61850-7-420: DER
- EN 61400-25: Wind farms
- IEC 61850-90-2: Communication to control centers
- IEC 61850-90-3: Condition monitoring
- IEC 61850-90-4: Network management
- IEC 61850-90-5: Synchrophasors
- IEC 61850-90-7: PV inverters

For automated MV/LV substation IEC 61850-90-6 should also be considered, which is expected to be a guide for the implementation of IEC/EN 61850 on distribution automation.

For protocols which are not IEC/EN 61850 native such as the EN 60870-5-101 or 104, a mapping of IEC/EN 61850 information model is possible using the IEC 61850-80-1, enabling users of these technologies to use the power of data model driven engineering (and then more seamless integration) without changing of communication technologies.

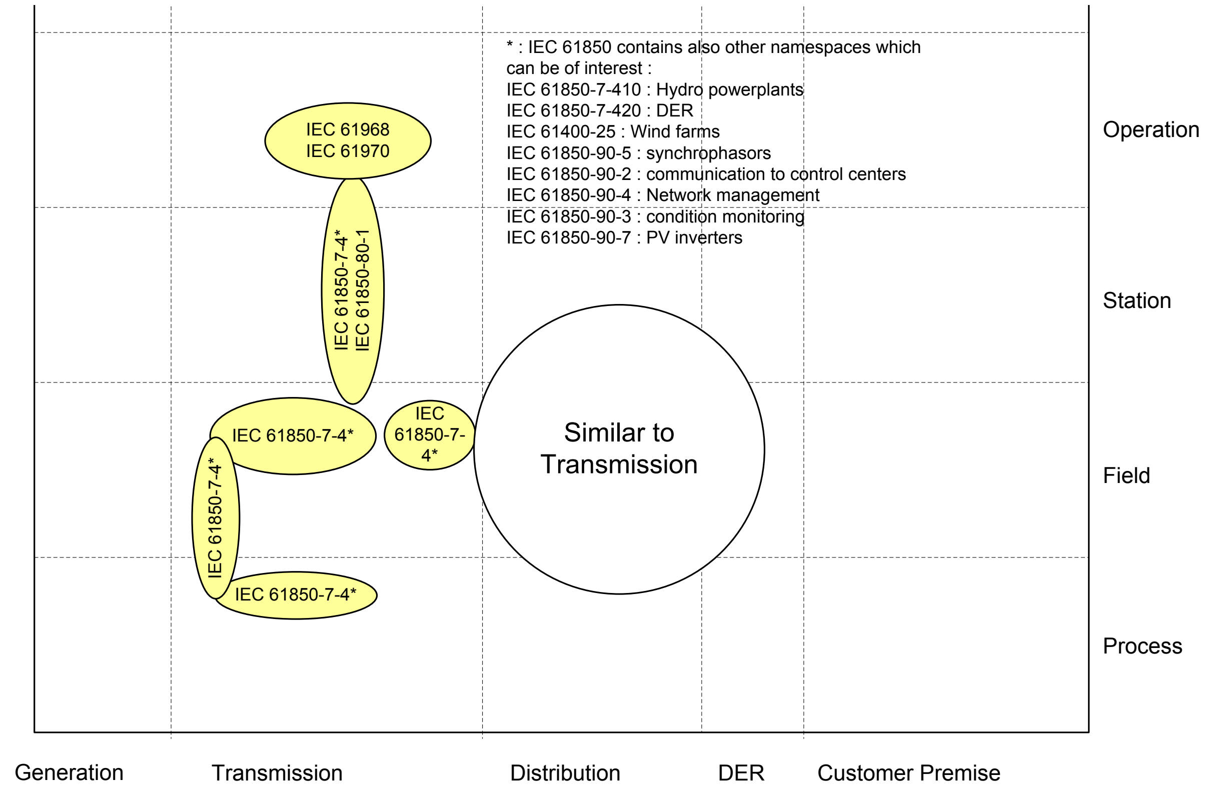


Figure 16 - Substation automation system - Information layer

8.2.1.4 List of Standards

Here is the summary of the standards which appear relevant to support substation automation system:

8.2.1.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by Dec 31st 2015 is considered as “available”.

Table 17 - Substation automation system (Transmission & Distribution) - Available standards

Layer	Standard	Comments
Information	EN 61850-7-4 EN 61850-7-3 EN 61850-7-2 EN 61850-6	Core Information model and language for the IEC/EN 61850 series
Information	EN 61850-7-410	Hydro power plants
Information	EN 61850-7-420	DER
Information	IEC 61850-80-1	Mapping of IEC/EN 61850 data model over 60870-5-101 and 104
Information	IEC 61850-80-4	Mapping between the DLMS/COSEM (IEC 62056) data models and the IEC 61850 data models
Information	IEC 61850-90-3	Condition monitoring
Information	IEC 61850-90-7	inverter-based DER interface
Information	EN 61400-25	Wind farms
Information	EN 61968 (all parts)	Common Information Model (System Interfaces For Distribution Management)
Information	EN 61970 (all parts)	Common Information Model (System Interfaces For Energy Management)

Layer	Standard	Comments
Communication	EN 61850-8-1	IEC/EN 61850 communication except Sample values
Communication	EN 61850-9-2	IEC/EN 61850 Sample values communication
Communication	IEC 61850-90-1	Use of IEC/EN 61850 for the communication between substations
Information, Communication	IEC 61850-90-2	Guidelines for communication to control centers
Information, Communication	IEC 61850-90-4	Guidelines for communication within substation
Communication	IEC 61850-90-5	Use of IEC/EN 61850 to transmit synchrophasor information according to IEEE C37.118. May also be relevant for use between substations
Communication	IEC 61850-90-12	Use of IEC 61850 over WAN
Communication	EN 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
Communication	EN 60870-5-103	Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment
Communication	EN 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
Communication	IEC 60255-24	Electrical relays - Part 24: Common format for transient data exchange (COMTRADE) for power systems
Communication	EN 62439	High availability automation Networks (PRP y HSR)
Component	IEC 62271-3	High-voltage switchgear and controlgear; Part 3:Digital interfaces based on IEC 61850
Component	EN 61850-3	General requirements for Power utility automation systems
Component	EN 61869	Instrument transformers
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)
Communication	IEC 61158 (all parts)	This standards series includes many industrial communication protocols which may partly answer substation automation systems requirements

1806 ##### *8.2.1.4.2 Coming standards*

1807 In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal
1808 equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

1809 **Table 18 - Substation automation system (Transmission & Distribution) - Coming standards**

Layer	Standard	Comments
Information	*EN 61850-7-4* *EN 61850-7-3* *EN 61850-7-2* *EN 61850-6*	Core Information model and language for the IEC/EN 61850 series
Information, Communication	*IEC 61850-90-6*	Guideline for use of IEC/EN 61850 on Distribution automation
Information	*IEC 61850-90-11*	Methodologies for modeling of logics for IEC/EN 61850 based applications
Information	*EN 61968-1* *EN61689-3*	Common Information Model (System Interfaces For Distribution Management)

Layer	Standard	Comments
	EN 61968-11 *EN61689-13*	
Information	*EN 61970-301*	Common Information Model (System Interfaces For Energy Management)
Information	*IEC 61850-90-17*	Using IEC 61850 to transmit power quality data
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services
Communication	*EN 61850-9-2*	IEC/EN 61850 Sample values communication
Communication	*IEC 61850-80-5*	Guideline for mapping information between IEC 61850 and IEC 61158-6 (Modbus)
Component	*IEC 62271-3*	High-voltage switchgear and controlgear; Part 3:Digital interfaces based on IEC 61850
Component	*IEC 62689-1* *IEC 62689-2*	Current and Voltage sensors or detectors, to be used for fault passage indication purposes
Component	*IEC 62689-3* *IEC 62689-4* *IEC 62689-100*	Current and Voltage sensors or detectors, to be used for fault passage indication purposes
Component	*IEC 62689-3* *IEC 62689-4* *IEC 62689-100*	Instrument transformers Part 6 – Additional general requirements for Low power IT Part 9 – Digital interface
Communication	*IEC 62351-4* *IEC 62651-6* *IEC 62351-7* *IEC 62351-9* *IEC 62351-11* *IEC 62351-12* *IEC 62351-90-1*	Cyber-security aspects (refer to section 9.4)
Information	*IEC 62361-102*	Power systems management and associated information exchange - Interoperability in the long term - Part 102: CIM - IEC 61850 harmonization

8.2.2 Blackout Prevention System - Wide Area Measurement Protection and Control System (WAMPAC)

8.2.2.1 Context description

The challenge posed by Smart Grid implementation and the increased unpredictable intermittency of generation; the more sophisticated and automated adaptation of consumption based on market and/or local conditions; combined with the use of grids closer to their limits, leads to a change from the quasi-static state of the grid to a more complex and highly dynamic behaviour. Therefore the current available supervision, management and control functions will need to be adapted, in addition to the implementation of some specific systems put in place to prevent black-out or at least to reduce the size of the impact of blackouts.

State estimation, for example, will have to include the transient behaviour of the grid. In addition, the traditional power, voltage and current measurements must be extended to phasor measurement provided by PMUs (Phasor Measurement Units).

An optimal representation and visualization as well as decision-supporting tools must be developed in order to support the operator of such complex systems. Massive amounts of data must be transmitted, synchronized and represented in a way to safeguard the system integrity of the overall transmission grid.

Although it is not possible to avoid multiple contingency blackouts, the probability, size, and impact of widespread outages could be reduced. Investment strategies in strengthening the electrical grid infrastructure, such as rebuilding the T&D grid, installing new generation and control systems (e.g. reactive power devices, Flexible AC Transmission Systems (FACTSs) and High-Voltage DC (HVDC)) should be emphasized. The use of Wide-Area Monitoring, Protection And Control (WAMPAC) schemes should be viewed as a cost-effective solution to further improve grid reliability and should be considered as a complement to other vital grid enhancement investment strategies.

8.2.2.2 System description

The objectives of a WAMPAC system are to protect power systems from instabilities and collapses with continuous load growth and with reduced operational margins within stability limits. In contrast to conventional protection devices which provide local protection of individual equipment (transformer, generator, line, etc…), the WAMPAC provides comprehensive protection covering the whole power system. The system utilizes phasors, which are measured with high time accuracy along with PMU units installed in the power system. WAMPAC can be seen as a complement to SCADA, FACTS and Substation Automation systems for a region/country power network.

8.2.2.3 Set of use cases

Here is a set of high level use cases which may be supported by a WAMPAC.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 19 - WAMPAC - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Blackout management	Black-out prevention through WAMPAC	C		
System and security management	Distributing and synchronizing clocks	C		

8.2.2.4 Mapping on SGAM

8.2.2.4.1 Preamble

Considering that this system is not interacting with the “Enterprise” and “Market” zones of the SGAM, only the “Process”, “Field”, “Station” and “Operation” zones are shown in the following drawings.

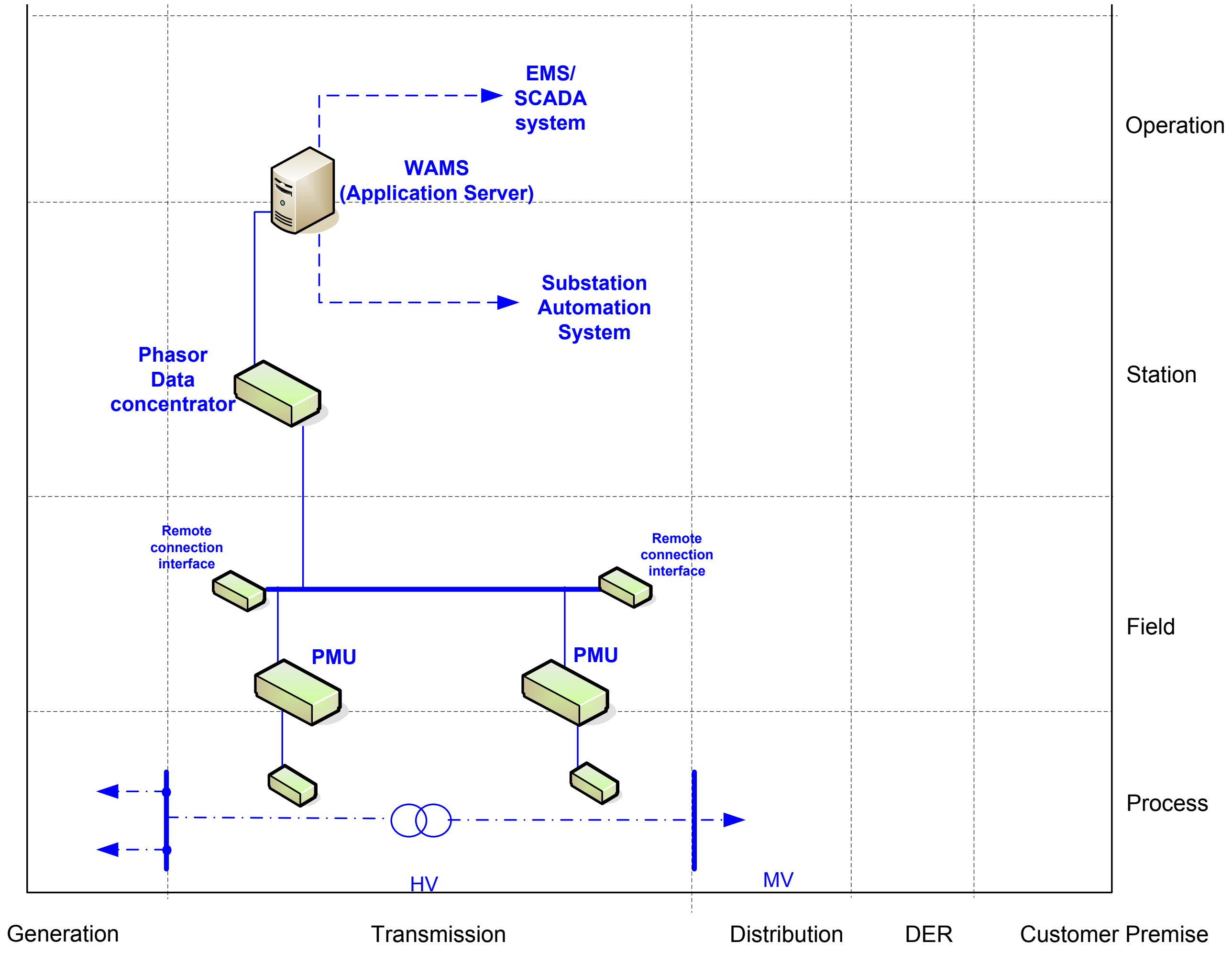
8.2.2.4.2 Component layer

The WAMPAC component architecture is mostly present on 3 zones, which may be interconnected through wired connection and digital communication link.

- **The Process** zone is mostly (but not only) made of sensors (such as current and voltage transformers) and of actuators (such as breakers or switches)

- **The Field** zone is made of PMUs/IEDs, which mostly handle equipment protection, monitoring and control features, and for data streaming of the measurements from the power system

- **The Station/Operation** zone is mostly supporting three main technical functions, which can be grouped separated in different components: WAMPAC application (e.g. SIPS) based on phasor measurements collected from the PMUs/IEDs in the power system, SCADA application based on phasor measurements and substation automation systems for monitoring and control.



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1871 **Figure 17 - WAMPAC - Component layer**

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8.2.2.4.3 Communication layer

Communication protocols can be used either:

- Within the WAMPAC, EN 61850-8-1 (for any kind of data flows except sample values) is used to support the selected set of generic Use cases.
  IEC 61850-90-4 provides detailed guidelines for communication inside a substation.
  IEC/EN 61850 mostly replaces the former EN 60870-5-103, used for connecting PMUs/IEDs.
- Vertical communications can rely EN 60870-5-101 or 104, while horizontal communications can rely on IEC 61850-90-5 (full mapping over UDP) or IEC 61850-90-1 (tunneling).
  Future vertical communication may rely on IEC 61850-90-2 (guideline for using IEC/EN 61850 to control centers) to provide a seamless architecture, based on IEC 61850.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

The set of standards can be positioned as follows on the communication layer of SGAM.
Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

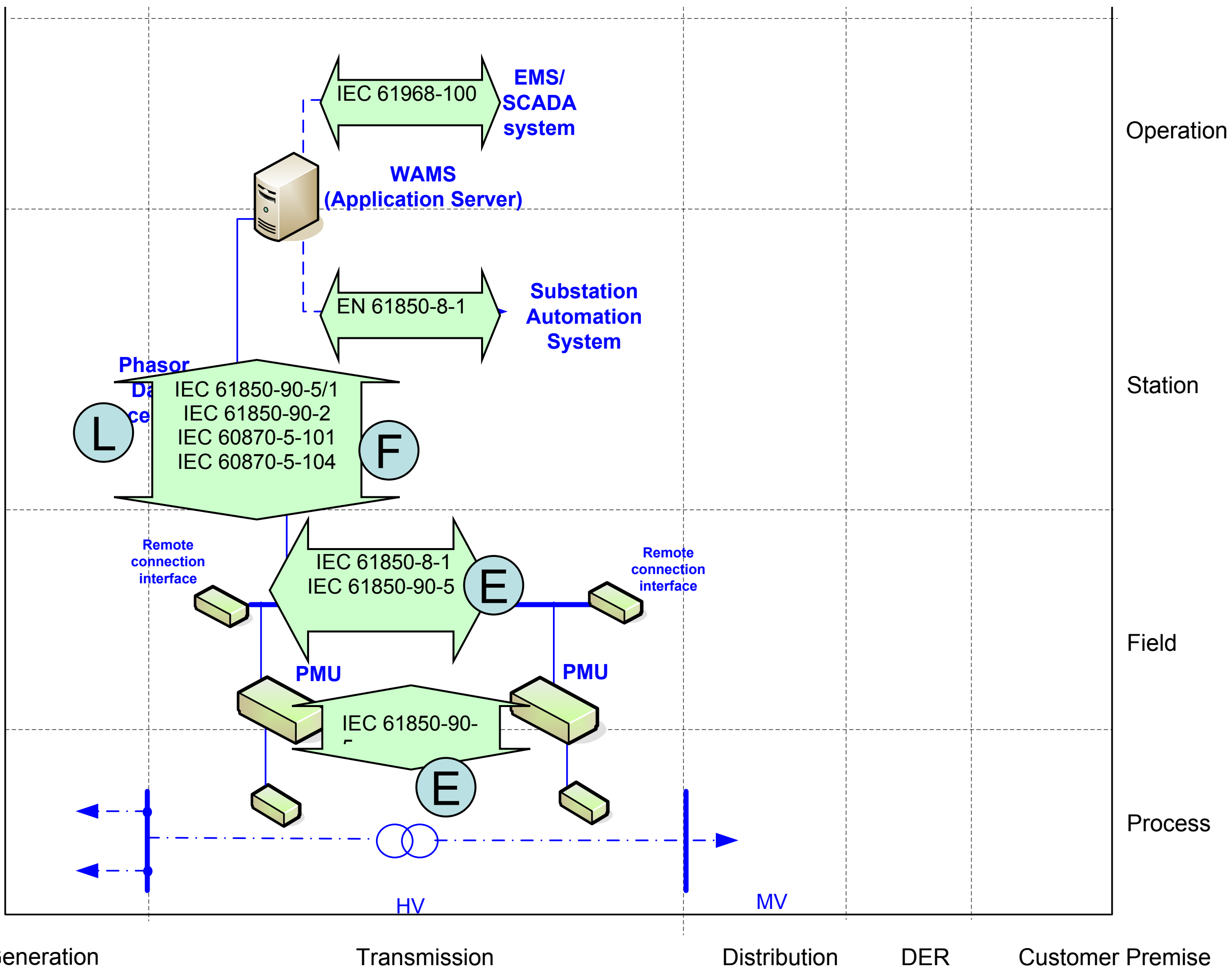


Figure 18 - WAMPAC - Communication layer

8.2.2.4.4 Information (Data) layer

The information layer is mostly based on the IEC/EN 61850 information model:

- IEC 61850-90-2: Communication to control centers
- IEC 61850-90-3: Condition monitoring
- IEC 61850-90-5: Synchrophasors

For protocols which are not IEC/EN 61850 native such as the EN 60870-5-101 or 104, a mapping of IEC/EN 61850 information model is possible using the IEC 61850-80-1, enabling users of these technologies to use the power of data modeling (and then more seamless integration) without changing communication technologies.

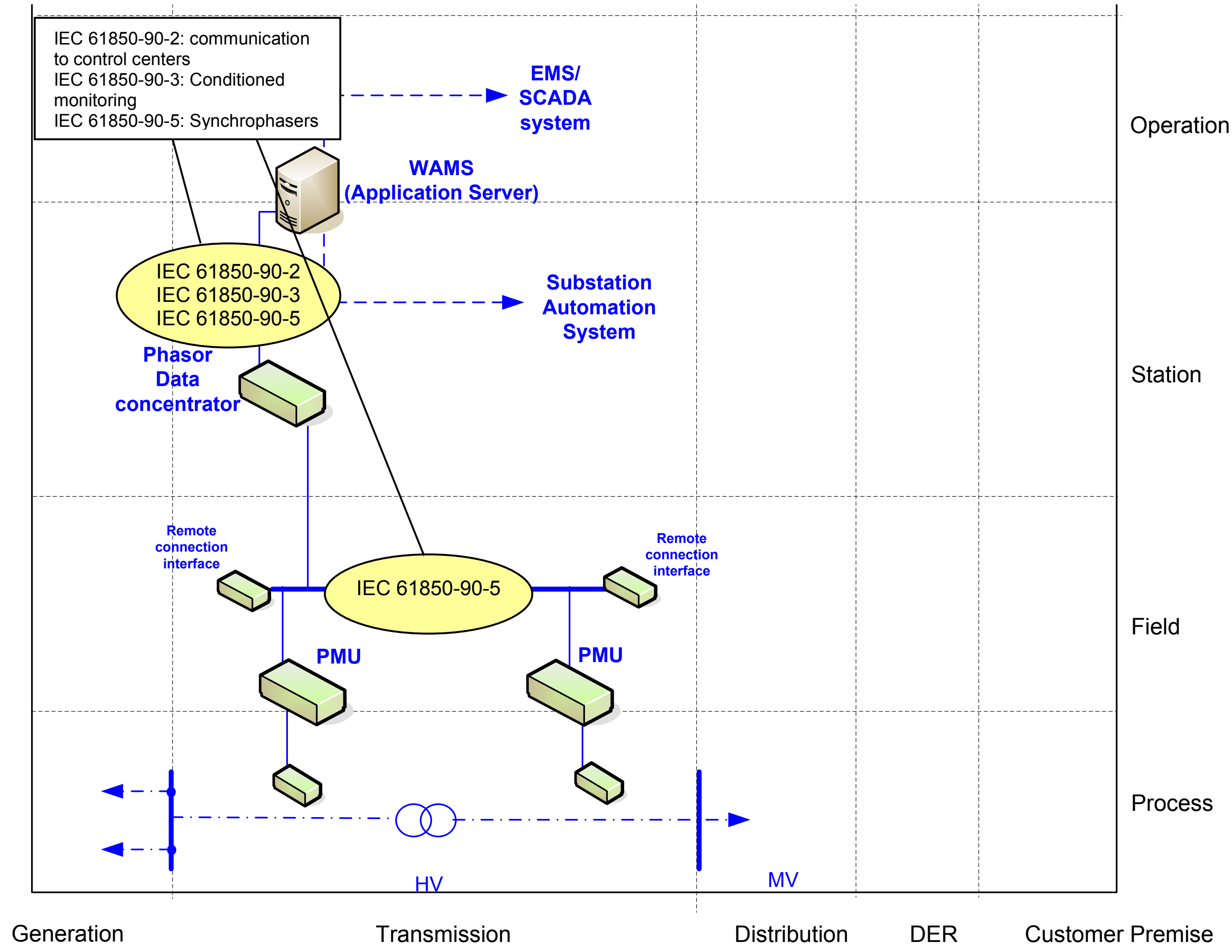


Figure 19 - WAMPAC - Information layer

8.2.2.5 List of Standards

Here is the summary of the standards which appear relevant to WAMPAC:

8.2.2.5.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by Dec 31st 2015 is considered as “available”.

Table 20 - WAMPAC - Available standards

Layer	Standard	Comments
Information	EN 61850-7-4 EN 61850-7-3 EN 61850-7-2 EN 61850-6	Core Information model and language for the IEC/EN 61850 series
Information	IEC 61850-80-1	Mapping of IEC/EN 61850 data model over 60870-5-101 and 104
Information	IEC 61850-90-4	Network Engineering Guidelines for IEC/EN 61850 based system (including clock synchronization guidelines)
Communication	EN 61850-8-1	IEC/EN 61850 communication except Sample values
Communication	IEC 61850-90-1	Use of IEC/EN 61850 for the communication between substations
Communication	EN 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
Communication	EN 60870-5-103	Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment
Communication	EN 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
Communication	EN 61850-9-2	IEC/EN 61850 Sample values communication
Communication	IEC 61850-90-5	Use of IEC/EN 61850 to transmit synchrophasor information according to IEEE C37.118.
Communication	IEEE C37.118	Synchrophasors for power systems
Communication	IEEE 1344	IRIG-B extension
Communication	IEC 61588 (IEEE 1588)	PTP (Precision Time protocol)
Information	ISO 8601 (IEC 28601)	Data elements and interchange format – Representation of dates and times Coordinated Universal Time (UTC)
Component	EN 61869	Instrument transformers
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)

8.2.2.5.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 21 - WAMPAC - Coming standards

Layer	Standard	Comments
Communication, Information	*IEC 61850-90-2*	Communication to control centers
Information	*IEC 61850-90-3*	Condition monitoring
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services
Component	*EN 61869*	Instrument transformers Part 6 – Additional general requirements for Low power IT Part 9 – Digital interface
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.4)

8.2.3 EMS SCADA system

8.2.3.1 System description

The nature of transmission networks will change and grow in importance due to Smart Grid. The increased distance of bulk power generation and load centres will result in a tendency to interconnect systems that used to be independent. Furthermore the exchange and trade of power over long distances will grow in the future.

Information exchange may be necessary across large geographical areas and across traditional systems operation boundaries.

Transmission networks are equipped for obtaining a large number of measurement values; they are able to determine the current load flow situation by means of estimation algorithms. In an estimate, the algorithm uses a numerical network model to try to find a load flow solution in which the root mean square value of the difference between the load flow solution and measurement values is minimal. The estimation of the network state supplies the operator with a complete load flow solution for supervising the network, including those sections of the network for which no measurement values are transmitted to the control system.

The network state estimation is generally followed by a limit value monitoring process that compares the result of the estimation with the operating limits of the individual operational equipment, in order to inform the operator about overloads or other limit value infringements in a timely fashion.

The load flow solution of the network state estimation is then used for ongoing functions such as outage analysis, short-circuit analysis or optimizing load flow as a basic solution for further calculations.

The outage analysis carries out “What if?” studies in which the failure of one or more items of operational equipment is simulated. The results of these load flow calculations are then compared with the operational equipment limits in order to be able to detect secondary faults resulting from an operational equipment failure. If such violations of the so-called (n-1) security are detected, an attempt can be made by, for example, using a bottleneck management application to define measures with which (n-1) security can be reestablished.

The short-circuit analysis simulates short-circuit situations for all kinds of different network nodes on the basis of numerical model calculations. It checks whether the ensuing short-circuit currents are within the operational equipment limits. The quantities to be checked are the breaking power of the circuit breakers and the peak short-circuit current strength of the systems. Here again, the operator is informed about any limit violations so that suitable remedial action can be taken in a timely fashion.

The optimizing load flow attempts to determine an optimum network state by varying the controlled variables in the power supply system. The following target functions for “optimum” are possible:

The voltage/reactive power optimization attempts to minimize the reactive power flow in the network in order to reduce transmission losses. In particular, the reactive power generation of the generators or compensation equipment and the setting levels of the in-phase regulator act as controlled variables.

The active power optimization system tries to minimize the transmission losses by re-dispatching the incoming supplies from the generator. Any available quadrature or phase-angle regulators can also be used for optimization.

If system reliability has been selected as the target function of the optimization, the optimizing load flow tries to find a system state in which the capacity of all operational equipment is utilized as evenly as possible. The purpose of this is to avoid further secondary failures in the event of failure of heavily utilized resources.

The challenge posed by Smart Grid implementation and the increased use of bulk power transmission will be a change from the quasi-static state of the transmission grid to a more complex and dynamic behaviour. Therefore the current available supervision, management and control functions will need to be adapted. State estimation, for example, will have to include the transient behaviour of the net. In addition, the traditional power, voltage and current measurements must be extended to phasor measurement provided by PMUs (Phasor Measurement Units).

An optimal representation and visualization as well as decision-supporting tools must be developed in order to support the operator of such complex systems. The massive amount of data must be transmitted, synchronized and represented in a way to safeguard the system integrity of the overall transmission net.

EMS SCADA System refers to the real-time information system and all the elements needed to support all the relevant operational activities and functions used in transmission automation at dispatch centers and control rooms. It improves the information made available to operators at control room, field and crew personnel, management and in certain cases to parties connected to the transmission system, i.e. distribution network operators, power producers, etc.

Such system is usually made of one or many interconnected IT systems, connected to field communicating devices or sub-systems, through the use of WAN communication systems. It may also include the components needed to enable field crew to operate the network from the field.

EMS SCADA provides following major functions:

- SCADA, real time monitoring and control of the generation system
- advanced network applications including network modeling
- outage management including crew & resource management
- work management
- geographical information system (GIS)

8.2.3.2 Set of high level use cases

Here is the set of high level use cases which may be supported by a EMS SCADA System.:
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 22 - EMS SCADA system - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Monitoring the grid flows	Monitoring electrical flows	CI		
	Monitoring power quality for operation (locally)	CI		
	Producing, exposing and logging time-stamped events			
	Supporting time-stamped alarms management at all levels			
	Capture, expose and analyze disturbance events			
	Archive operation information	CI		
Maintaining grid assets	Monitoring assets conditions	CI		X
	Supporting periodic maintenance (and planning)			X
	Optimize field crew operation			X
	Archive maintenance information	CI		
Controlling the grid (locally/ remotely) manually or automatically	Switch/breaker control	CI		
	Enable multiple concurrent levels of control (local-remote)			
Managing power quality	VAR regulation	CI		
Operate DER(s)	DER remote control (dispatch)			X
Connect an active actor to the grid	Managing microgrid transitions			X
	Managing generation connection to the grid	CI		
Blackout management	Black-out prevention through WAMPAC			
	Shedding loads based on emergency signals			
Demand and production (generation) flexibility	Receiving metrological or price information for further action by consumer or CEM			
	Load forecast (from remote based on revenue metering)	CI		
	Generation forecast (from remote)	CI		
System and security management	Distributing and synchronizing clocks			

8.2.3.3 Mapping on SGAM

8.2.3.3.1 Preamble:

The EMS SCADA interacts with the GIS, the field force management system as well as the asset management system. The EMS SCADA is managing the on-line operation of the transmission assets and the transmission system as a whole. Regarding the network stability and balancing between production and demand there is the necessary interaction with distribution and power plants connected to the transmission system.

8.2.3.3.2 Component layer

The EMS SCADA component architecture is given in the diagram below. Data and information of the actual status of the transmission system is available on-line through the RTUs of all substations and transformer stations in the network. The transmission network is operated and controlled from the dispatch centers by remote controlled circuit breakers in all relevant fields of the network. These circuit breakers are controlled by the operators in the network dispatch centers. The operators are supported (coached and controlled) by the EMS SCADA system regarding energy flows in the network, during normal, maintenance and emergency operation of (parts) of the network.

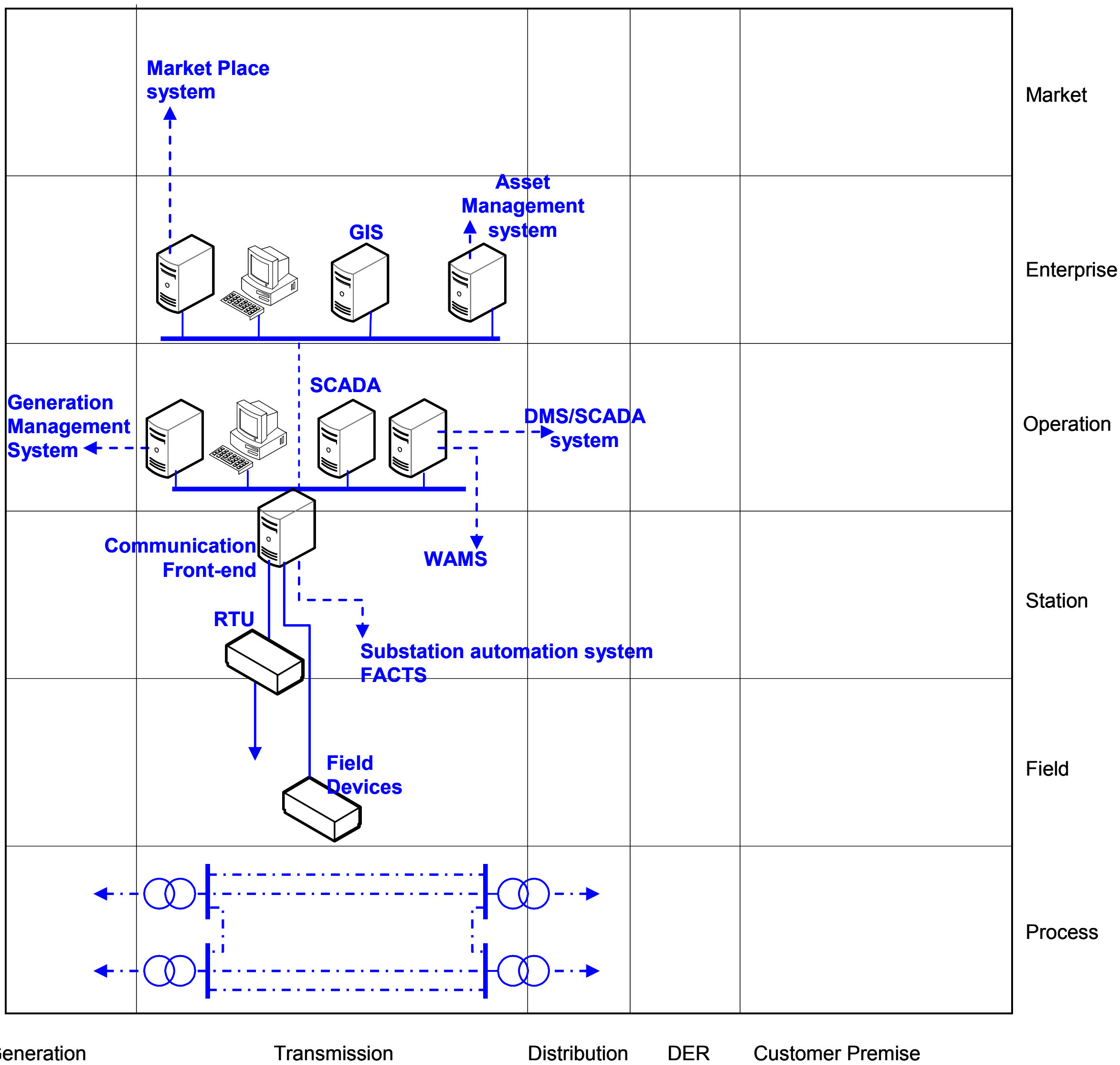


Figure 20 - EMS SCADA system - Component layer

8.2.3.3.3 Communication layer

Communication protocols can be used according to the ones mentioned in the Substation automation part of this report, because the EMS SCADA system interacts with the protection, monitoring and control systems in the substations. Furthermore the EMS SCADA will have direct interaction with power plants connected to the transmission system and Transmission System Operators (TSOs) are responsible for balancing power generation and demand. Finally TSOs have a responsibility in supporting the energy market interactions with bulk generation connected to the substations in their EHV and HV transmission networks.

The set of standards representing the related protocols regarding EMS SCADA can be positioned as shown in diagram below. This diagram shows the communication layer of Smart Grid Architecture Model. The significant standards regarding communication are EN 60870-5 (101-104) to connect power plants to the grid.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

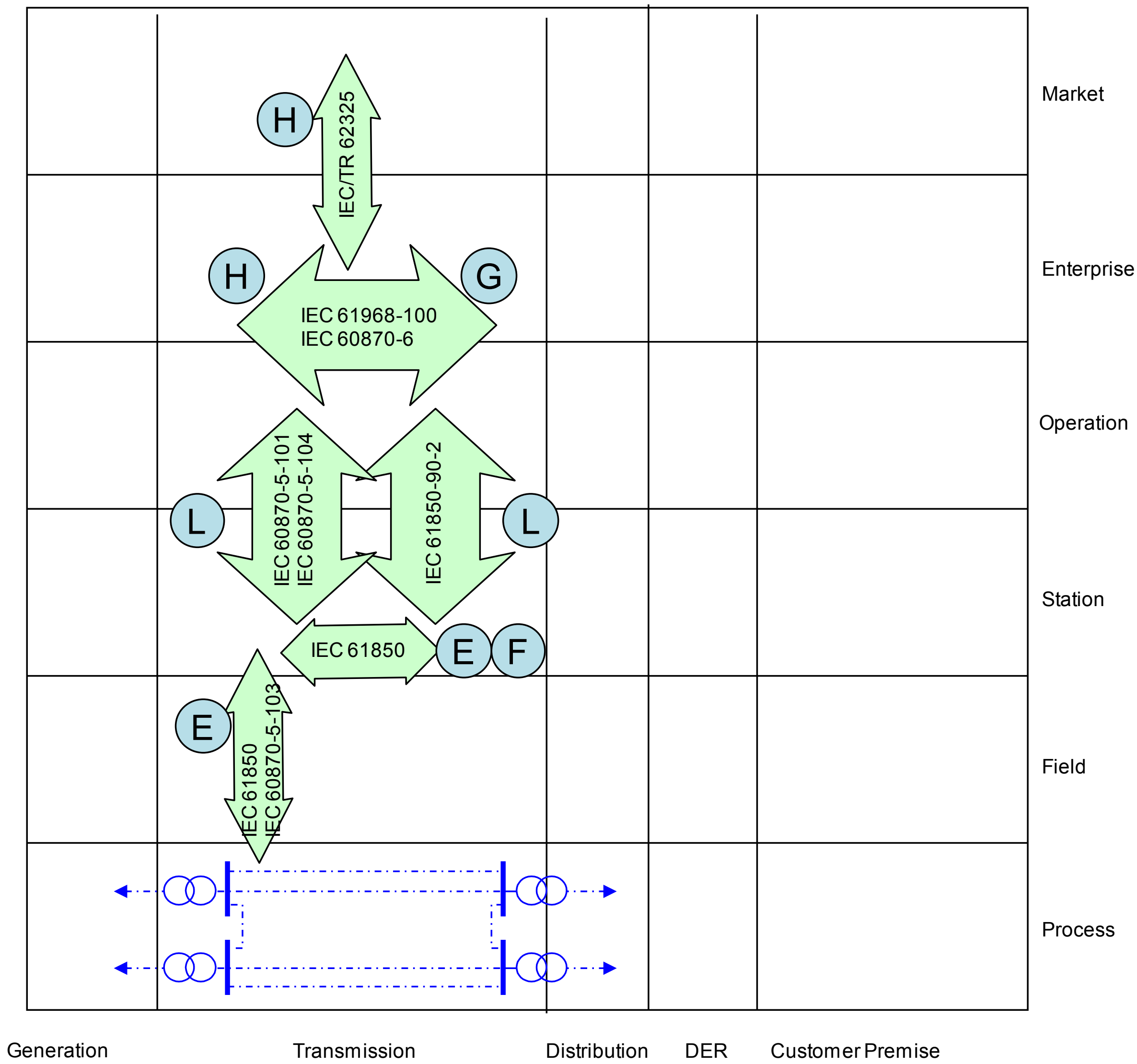


Figure 21 - EMS SCADA system - Communication layer

8.2.3.3.4 Information (Data) layer

The information layer of EMS SCADA is based on standards and guidelines that cover the Information Models relevant for EMS SCADA Systems used for operating the EHV and HV networks of TSOs.

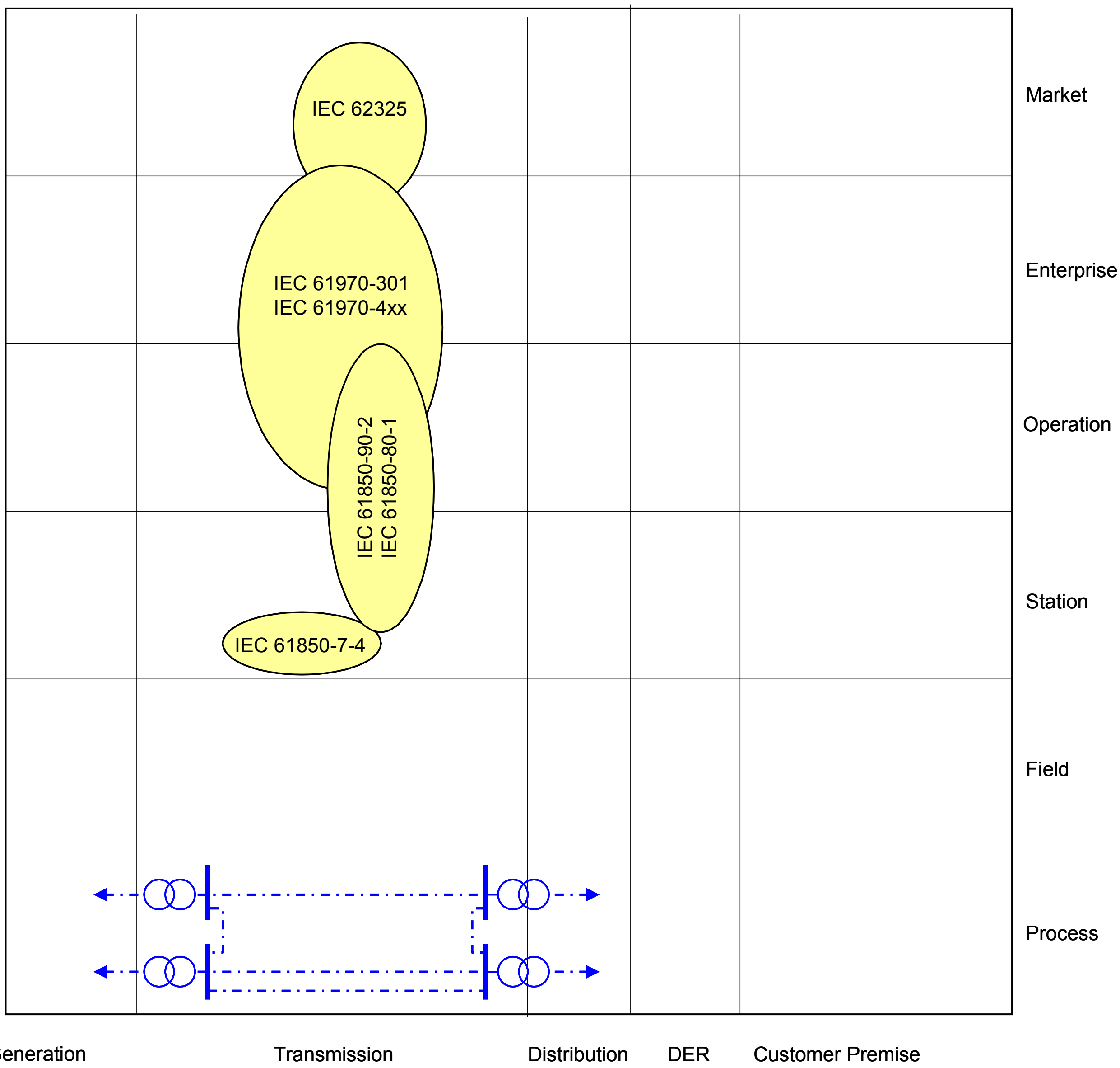


Figure 22 - EMS SCADA system - Information layer

Note:

- CIM is covered in EN 61970 focusing on transmission
- IEC 61850-80-1 presents a way to map IEC/EN 61850 over EN 60870-5-(101/104)

8.2.3.4 List of Standards

Here is the summary of the standards which appear relevant to support EMS SCADA System. According to section 6.2.2, standards for cross-cutting issues such as EMC, security are treated separately (IEC 62351, ISO/IEC 27001, EN 61000 etc.)

8.2.3.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by Dec 31st 2015 is considered as “available”.

Table 23 - EMS SCADA system - Available standards

Layer	Standard	Comments
Information	EN 61970-1 EN 61970-2 EN 61970-301 EN 61970-401 EN 61970-453 EN 61970-501 EN 61970-552	Energy management system Application Program Interface
Information	IEC 61970-452	*Energy management system Application Program Interface (EMS-API) - Part 452: CIM Static Transmission Network Model Profiles*
Information	IEC 61970-456	*Energy management system application program interface (EMS-API) - Part 456: Solved power system state profiles*
Communication, Information	IEC 62325	Framework market communication
Communication	EN 60870-5-101 EN 60870-5-104 EN 60870-6 series EN 60870-6-2 EN 60870-6-501 EN 60870-6-502 EN 60870-6-503 EN 60870-6-601 EN 60870-6-701 EN 60870-6-702 EN 60870-6-802	Telecontrol equipment and systems - Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations
Information	IEC/EN 61850 (all parts)	See substation automation system in 8.3.1
Information	IEC 62361-100	Harmonization of quality codes
General	IEC 62357	Reference architecture power system information exchange
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)

8.2.3.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

The list below is closely related with the substation automation system paragraph (ref 8.3.1) for the communication and information exchange within substations and from substation to the dispatch centers.

Table 24 - EMS SCADA system - Coming standards

Layer	Standard	Comments
Information & Communication	IEC/EN 61850	See Substation automation paragraph

Layer	Standard	Comments
Information	*EN 61970-301* *EN 61970-302*	Energy management system Application Program Interface
Information	*EN 61970-458*	Energy management system application program interface (EMS-API) - Part 458: Common Information Model (CIM) extension to generation
Communication	*EN 61970-502-8*	Energy management system Application Program Interface (EMS-API) - Part 502-8: Web Services Profile for 61970-4 Abstract Services
Communication, Information	*IEC 62325*	Framework market communication
Communication	*IEC 62351-4* *IEC 62651-6* *IEC 62351-7* *IEC 62351-9* *IEC 62351-11* *IEC 62351-12* *IEC 62351-90-1*	Cyber-security aspects (refer to section 9.4)
Information	*IEC 62361-101*	Common Information Model Profiles
Information	*IEC 62361-102*	Power systems management and associated information exchange - Interoperability in the long term - Part 102: CIM - IEC 61850 harmonization
General	*IEC 62357*	Reference architecture power system information exchange

8.2.4 Flexible AC Transmission Systems (FACTS)

8.2.4.1 Context description

Today's power transmission systems have the task of transmitting power from point A to point B reliably, safely and efficiently. It is also necessary to transmit power in a manner that is not harmful to the environment.
Typical transmission applications are FACTS (Flexible AC Transmission Systems) and HVDC (High Voltage Direct Current).
The use cases for FACTS include fast voltage control, increased transmission capacity over long lines, power flow control in meshed systems and power oscillation damping. With FACTS, more power can be transmitted within the power system. When the technical or economical feasibility of the conventional three phase technology reaches its limit, HVDC will be a solution. Its main application areas are economical transmission of bulk power over long distances and interconnection of asynchronous power grids.
The new system of voltage-sourced converters (VSC) includes a compact layout of the converter stations and advanced control features such as independent active and reactive power control and black start capability.
The main types of HVDC converters are distinguished by their DC circuit arrangements, as follows:

Back-to-back:
Indicates that the rectifier and inverter are located in the same station. These converters are mainly used:

- To connect asynchronous high-voltage power systems or systems with different frequencies
- To stabilize weak AC links or to supply even more active power where the AC system reaches the limit of short circuit capability
- Grid power flow control within synchronous AC systems

Cable transmission:
The most feasible solution for transmitting power across the sea with cables to supply islands/offshore platforms from the mainland and vice versa.

Long-distance transmission:
For transmission of bulk power over long distances (beyond approximately 600 km, considered as the break-even distance). This includes voltage levels of 800kV and higher.

Flexible AC Transmission Systems (FACTS) have been evolving into a mature technology with high power ratings. This technology, proven in various applications requiring rapid dynamic response, ability for frequent variations in output, and/or smoothly adjustable output, has become a first-rate, highly reliable one. FACTS, based on power electronics, have been developed to improve the performance of weak AC systems and to make long distance AC transmission feasible. FACTS can also help solve technical problems in the interconnected power systems.
FACTS are available in parallel connection:

- Static Var Compensator (SVC)
- Static Synchronous Compensator (STATCOM)

or in series connection:

- Fixed Series Compensation (FSC)
- Thyristor Controlled/Protected Series Compensation (TCSC/TPSC)

8.2.4.2 System description

"FACTS" (Flexible AC Transmission Systems) covers several power electronics based systems utilized in AC power transmission and distribution. FACTS solutions are particularly justifiable in applications requiring rapid dynamic response, ability for frequent variations in output, and/or smoothly adjustable output. Under such conditions, FACTS is a highly useful option for enabling or increasing the utilization of transmission and distribution grids. With FACTS, a number of benefits can be attained in power systems, such as dynamic voltage control, increased power transmission capability and stability, facilitating grid integration of renewable power, and maintaining power quality in grids dominated by heavy and complex industrial loads.

FACTS devices can be sub-divided into two groups:

- Shunt devices such as SVC and STATCOM
- Series Capacitors

With FACTS, a number of benefits can be attained in power systems, such as dynamic voltage control, increased power transmission capability and stability, facilitating grid integration of renewable power, and maintaining power quality in grids dominated by heavy and complex industrial loads.

- **Damping of power oscillations** (POD)
- **Load-flow control**
- **Mitigation of SSR** (sub synchronous resonances)
- **Increase in system capability and stability of power corridors**, without any need to build new lines. This is a highly attractive option, costing less than new lines, with less time expenditure as well as impact on the environment.
- **Dynamic voltage control**, to limit over-voltages over lightly loaded lines and cable systems, as well as, on the other side, prevent voltage depressions or even collapses in heavily loaded or faulty systems. In the latter case, systems with dominant air conditioner loads are getting increasingly important as examples of what can be achieved with FACTS when it comes to dynamic voltage support in power grids in countries or regions with a hot climate.
- **Facilitating connection of renewable generation** by maintaining grid stability while fulfilling grid codes.
- **Facilitating the building of high speed rail** by supporting the feeding grid and maintaining power quality in the point of connection.
- **Maintaining power quality in grids** dominated by heavy and complex industrial loads such as steel plants and large mining complexes.
- **Support of fast restoration** by stabilizing the network after fault conditions

8.2.4.3 Set of use cases

Here is a set of high level use cases which may be supported by FACTS systems.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 25 - FACTS - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Controlling the grid (locally/ remotely) manually or automatically	Feeder load balancing	CI		
Managing power quality	(dynamic) Voltage optimization at source level as grid support (VAR control)			
	Local voltage regulation by use of FACTS			
System and security management	Discover a new component in the system	C		I
	Configure newly discovered device automatically to act within the system	C		I
	Distributing and synchronizing clocks	I	C	
Grid stability	Stabilizing network after fault condition (Post-fault handling)			
	Monitoring and reduce power oscillation damping			
	Stabilizing network by reducing sub-synchronous resonance (Sub synchronous damping)			
	Monitoring and reduce harmonic mitigation	I		
	Monitoring and reduce voltage flicker	I		
Connect an active actor to the grid	Managing generation connection to the grid	CI		

8.2.4.4 Mapping on SGAM

8.2.4.4.1 Preamble

Considering that this system is not interacting with the “Enterprise”, “Market”, “Operation” and “Station” zones of the SGAM, only the “Process” and “Field” zones are shown in the here-under drawings.

8.2.4.4.2 Component layer

The FACTS component architecture is mostly made of two layers of components, which may be interconnected through wires or communication:

- The **Process zone** is mostly made of sensors for measurements for the FACTS equipment (SVC/STATCOM, Series Capacitor) with applications and communication to SCADA system through RTU.
- The **Station/Operation zone** is mostly supporting SCADA application for remote monitoring and control of FACTS components.

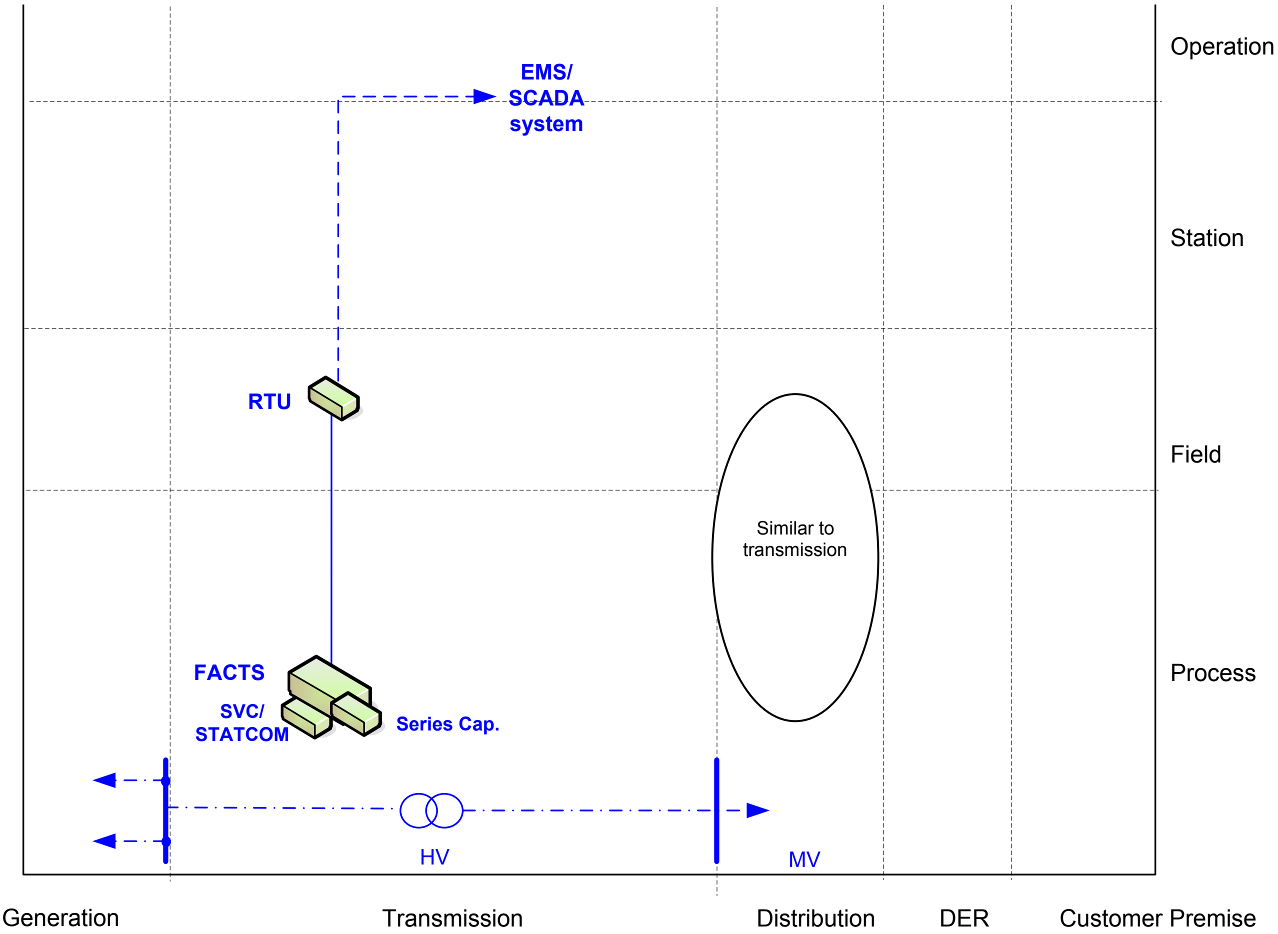


Figure 23 - FACTS - Component layer

8.2.4.4.3 Communication layer

Vertical communication protocols can be EN 60870-5-101 or 104 from FACTS equipment (FACTS controller) via RTU to SCADA.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

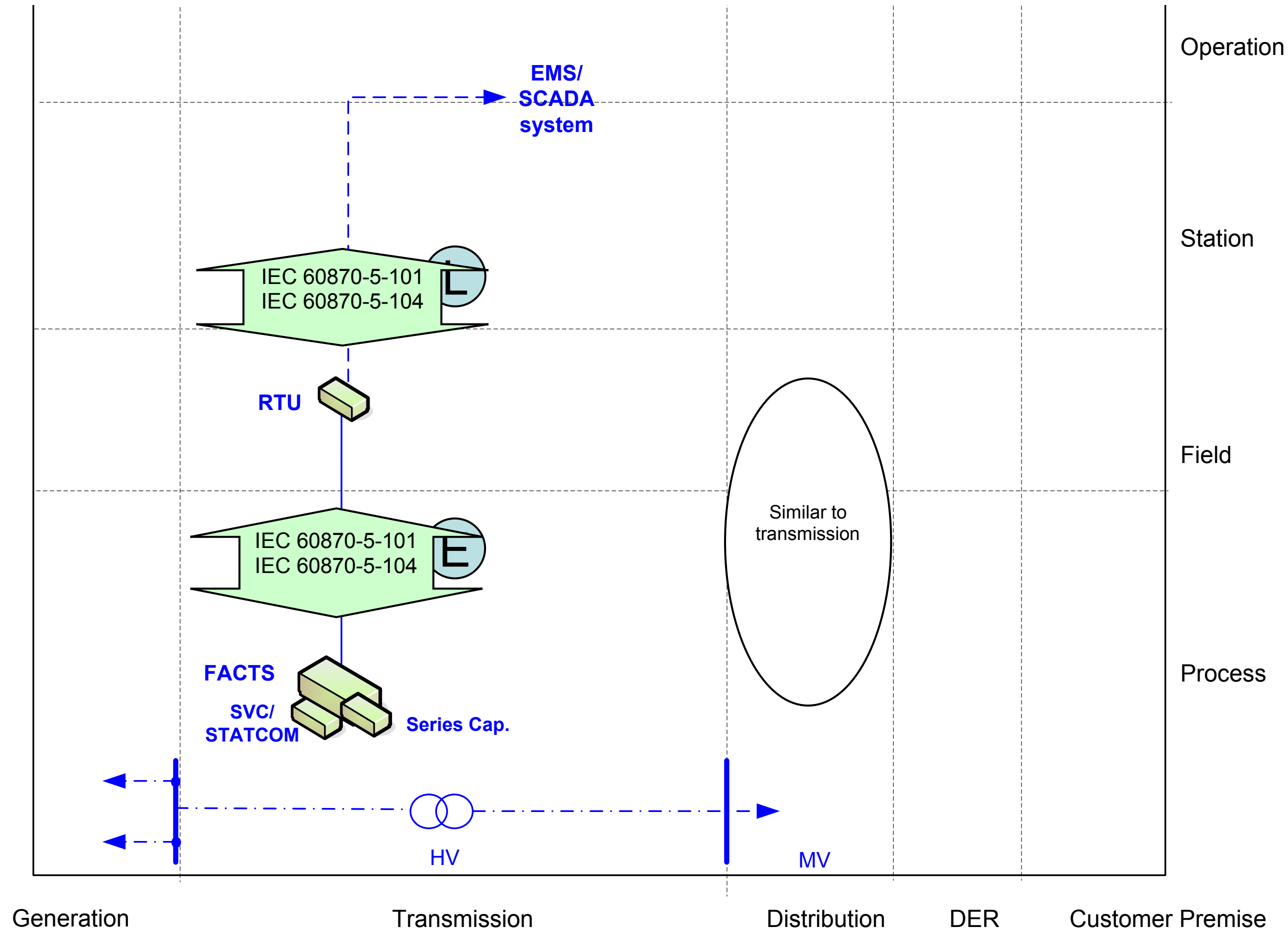
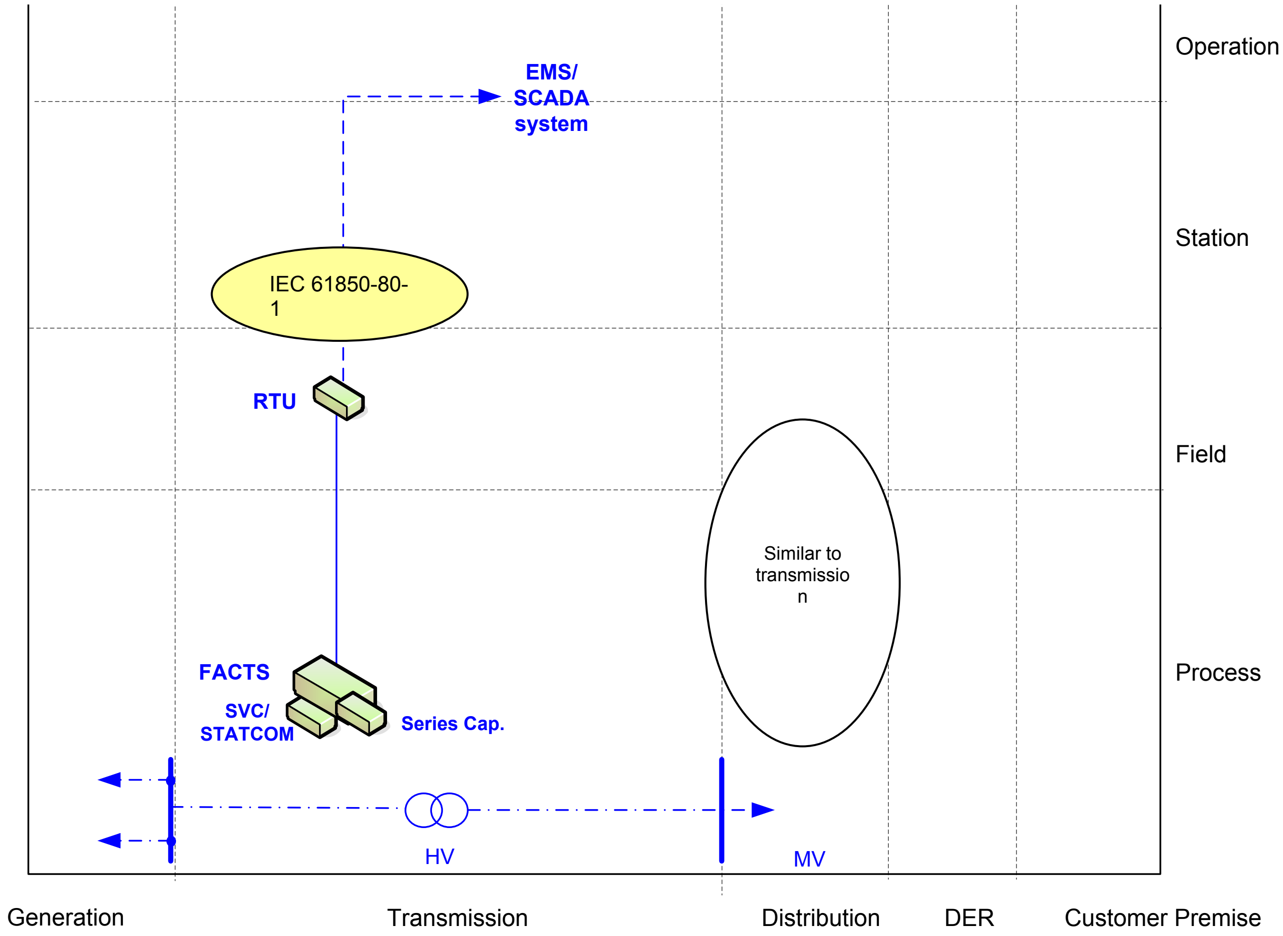


Figure 24 - FACTS - Communication layer

2184 ### *8.2.4.4.4 Information (Data) layer*

2185



2186

2187 **Figure 25- FACTS - Information layer**

2188

8.2.4.5 List of Standards

8.2.4.5.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by Dec 31st 2015 is considered as “available”.

Table 26- FACTS - Available standards

Layer	Standard	Comments
Information	IEC 61850-80-1	Mapping of IEC/EN 61850 data model over 60870-5-101 and 104
Information	EN 61850-7-4 EN 61850-7-3 EN 61850-7-2 EN 61850-6	Core Information model and language for the IEC/EN 61850 series
Information	IEC 61850-90-3	Using IEC/EN 61850 for condition monitoring
Communication, information	IEC 61850-90-2	Substation to control center communication
Communication	EN 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
Communication	EN 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
General	IEC 60633	Ed. 2.0, Terminology for high-voltage direct current (HVDC) transmission
Component	IEC 60919	Performance of high-voltage direct current (HVDC) systems with line-commutated converters
Component	IEC 60700-1	Ed.1.2, Thyristor valves for high voltage direct current (HVDC) power transmission - Part 1: Electrical testing
Component	IEC 61954	Ed.1.1, Power electronics for electrical transmission and distribution systems - Testing of thyristor valves for static VAR compensators
Component	IEC 61803	Ed.1, Determination of power losses in high-voltage direct current (HVDC) converter stations
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)

8.2.4.5.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 27 - FACTS - Coming standards

Layer	Standard	Comments
Information	*IEC 61850-90-14*	Using IEC 61850 for FACTS modelling
Communication	*IEC 62351-4* *IEC 62651-6* *IEC 62351-7* *IEC 62351-9* *IEC 62351-11* *IEC 62351-12* *IEC 62351-90-1*	Cyber-security aspects (refer to section 9.4)

8.3 Distribution management systems

8.3.1 Substation Automation System

Refer to section 8.2.1.

8.3.2 Feeder automation system (including smart field switching device and distributed Power Quality system)

8.3.2.1 System description

A Feeder automation system refers to the system and all the elements needed to perform automated operation of components placed along the MV network itself (feeders), including (but not limited to) fault detectors, pole or ground mounted MV-switches, MV-disconnectors and MV-circuit-breakers - without or with reclosing functionality (also called reclosers) between the HV/MV substation (MV side included) and the MV/LV substations.
The typical considered operations are protection functionalities (from upwards and/or distributed), service restoration (after fault conditions), feeder reconfiguration, monitoring of quality control parameters (i.e. V, I, f, THD, dips, surges,…) as well as automated distributed Power Quality regulation (Volt/VAR and frequency/W) through active control, on the MV side and/or on the LV side.

Note: Feeder automation functionalities that are usually included in a MV/LV substation are included on this sub-clause but not in "MV/LV automated substation system".

8.3.2.2 Set of use cases

Here is a set of use cases which may be supported by Feeder automation system and smart reclosers system.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the "C", "I", "CI", "X" conventions are given in section 7.6.2.

Table 28 - Feeder Automation System - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING** (CI[7])	**Not yet**
Protecting the grid assets	Protect a zone outside of the substation boundary	CI		
	Perform networked protection logic (Intertripping, logic selectivity...)	CI		
	Perform networked security logic (Interlocking, local/remote)	CI		
	Set/change protection parameters	CI		
Monitoring the grid flows	Monitoring electrical flows	CI		
	Producing, exposing and logging time-stamped events	CI		
	Supporting time-stamped alarms management at all levels	CI		
	Archive operation information	CI		
Maintaining grid assets	Archive maintenance information	CI		
Controlling the grid (locally/ remotely) manually or automatically	Switch/breaker control	CI		
	Enable multiple concurrent levels of control (local-remote)	CI		
	Supporting reclosing sequence	CI		

[7] IEC 61850-90-6, IEC 61850-8-2 as well as EN 61869 may provide some enhancement of the current set of standards to better fit Feeder automation scope, both at communication and information levels

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING** (CI[7])	**Not yet**
Reconfiguring the network in case of fault	Supporting source switching	CI		
	Supporting automatic FLISR	CI		
Managing power quality	Monitoring Power Quality criteria	CI		
	Voltage regulation	CI		
	VAR regulation	CI		

8.3.2.3 Mapping on SGAM

8.3.2.3.1 Preamble

Most parts of the functions (High level use cases) represented are covered by the same standards than for other systems being part of distribution networks; the differences being mainly in the customization of the applications and the specific functionalities used.

Considering that this system is not interacting with the “Enterprise” and “Market” zones of the SGAM, only the “Process”, “Field”, “Station” and “Operation” zones are shown in the here-under drawings.

8.3.2.3.2 Component layer

On the SGAM representation of the component layer, the current transformer, the switching element and the voltage transformer are supposed to be placed along the feeder normally at switching places, and/or in the derivation to the MV/LV transformer, and possibly in the LV lines.

The feeder automation and smart reclosers component architecture is mostly made of 3 zones of components, which may be interconnected through wires or communication.

- The **Process zone** includes the primary equipment of the electrical network such as switching (i.e. circuit-breakers, switches and disconnectors), VAR regulator, MV/LV transformer regulator and measuring elements (i.e. current and voltage sensors/transformers). The representation on the SGAM is generic and doesn't correspond necessarily to any specific example. Note that volt/VAR and frequency control of DERs (represented as G in Figure 26) would be done by the DER operation system, mostly via the DMS and DER EMS/VPP (technical VPP) systems.
- The **Field zone** includes equipment to protect, control and monitor the process of the electrical network, mainly IEDs (which mostly handle protection, monitoring and control features like reclosing sequences), NIC (the controller of the LAN or HAN) and Router (the remote connection interface).
- The **Station zone** includes the aggregation level which interface with other elements and systems of the distribution network. It is mostly supporting 3 main technical functions, which can be grouped or separated in different components, which are: the RTU which serves as terminal for remote activities, the local controller, which is in charge of performing automatic functions, and possibly an HMI/archiving component which offers the local operators capabilities of visualizing and archive local data.

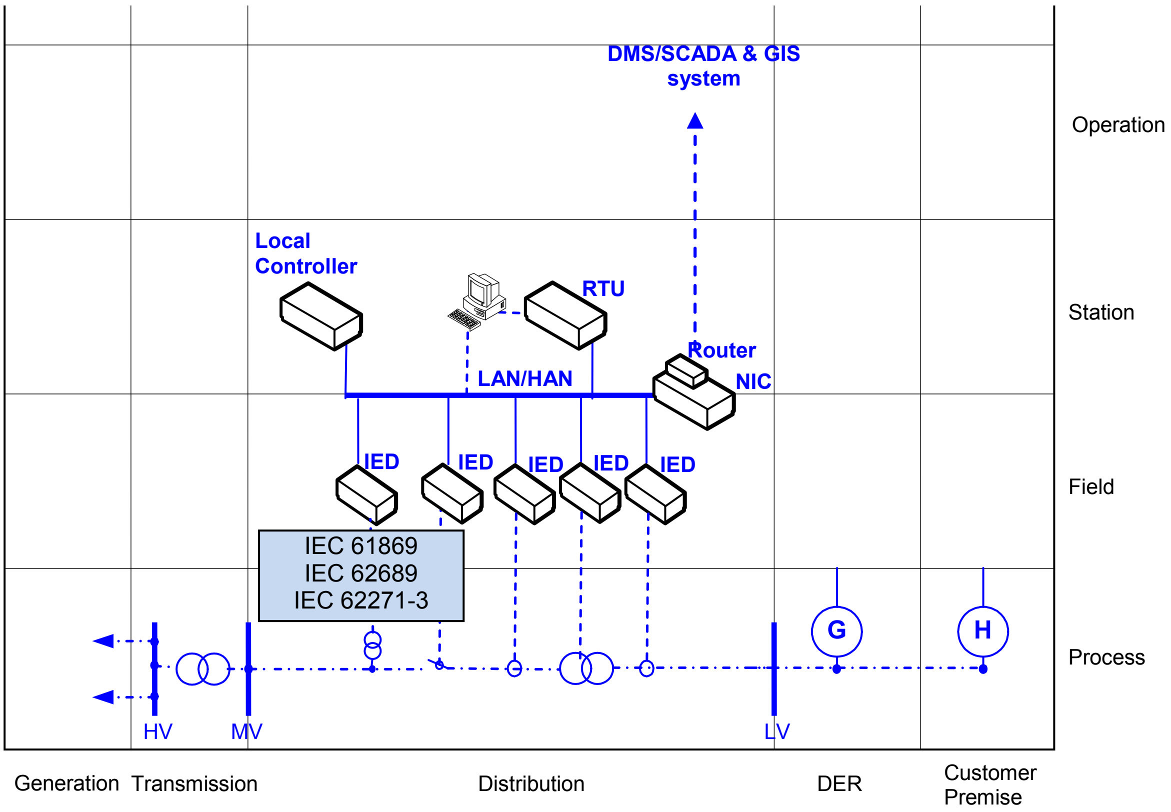


Figure 26 - Feeder automation system - Component layer

8.3.2.3.3 Communication layer

Communication protocols can be used either:

- Within each switching location along the feeder or within the feeders inside the substation, EN 61850-8-1 (for any kind of data flows except sample values) and EN 61850-9-2 (for sample values) are used to support the selected set of High level use cases .
  Considering that such a feeder may be seen as a distributed substation, many detailed guidelines provided by IEC 61850-90-4 can be applied.
  IEC/EN 61850 mostly replaces the former EN 60870-5-103, used for connecting protection relays.
- Outside each switching location, “vertical communications” can rely on EN 60870-5-101, or 104,
  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, and more specifically address feeder automation needs.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

The set of standards can be positioned as follows on the communication layer of SGAM.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

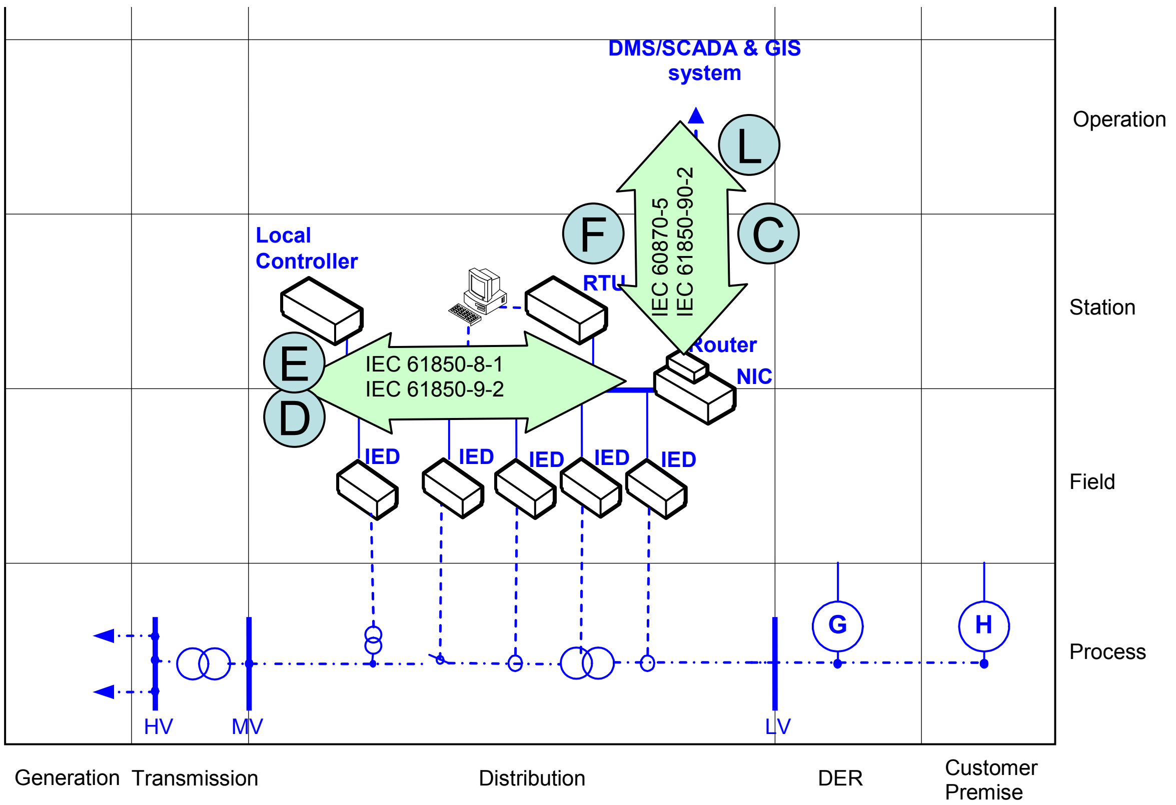


Figure 27 - Feeder automation system - Communication layer

8.3.2.3.4 Information (Data) layer

The information layer of feeder automation or smart reclosers (including distributed Power Quality capabilities) is mostly based on the IEC/EN 61850 information model.
We have indicated that the EN 61850-7-4 is the core part depicting this model for each location along each feeder, and IEC 61850-90-2 for the communication to the control center; however other parts of the IEC/EN 61850 series can be also be used.
IEC 61850-90-6 is also indicated on the SGAM, which is expected to be a guide for the implementation of IEC/EN 61850 on feeder automation.

For protocols which are not IEC/EN 61850 native such as the EN 60870-5-101 or 104, a mapping of IEC/EN 61850 information model is possible using the IEC 61850-80-1, enabling users of these technologies to use the power of data modeling (and then more seamless integration) without changing of communication technologies.

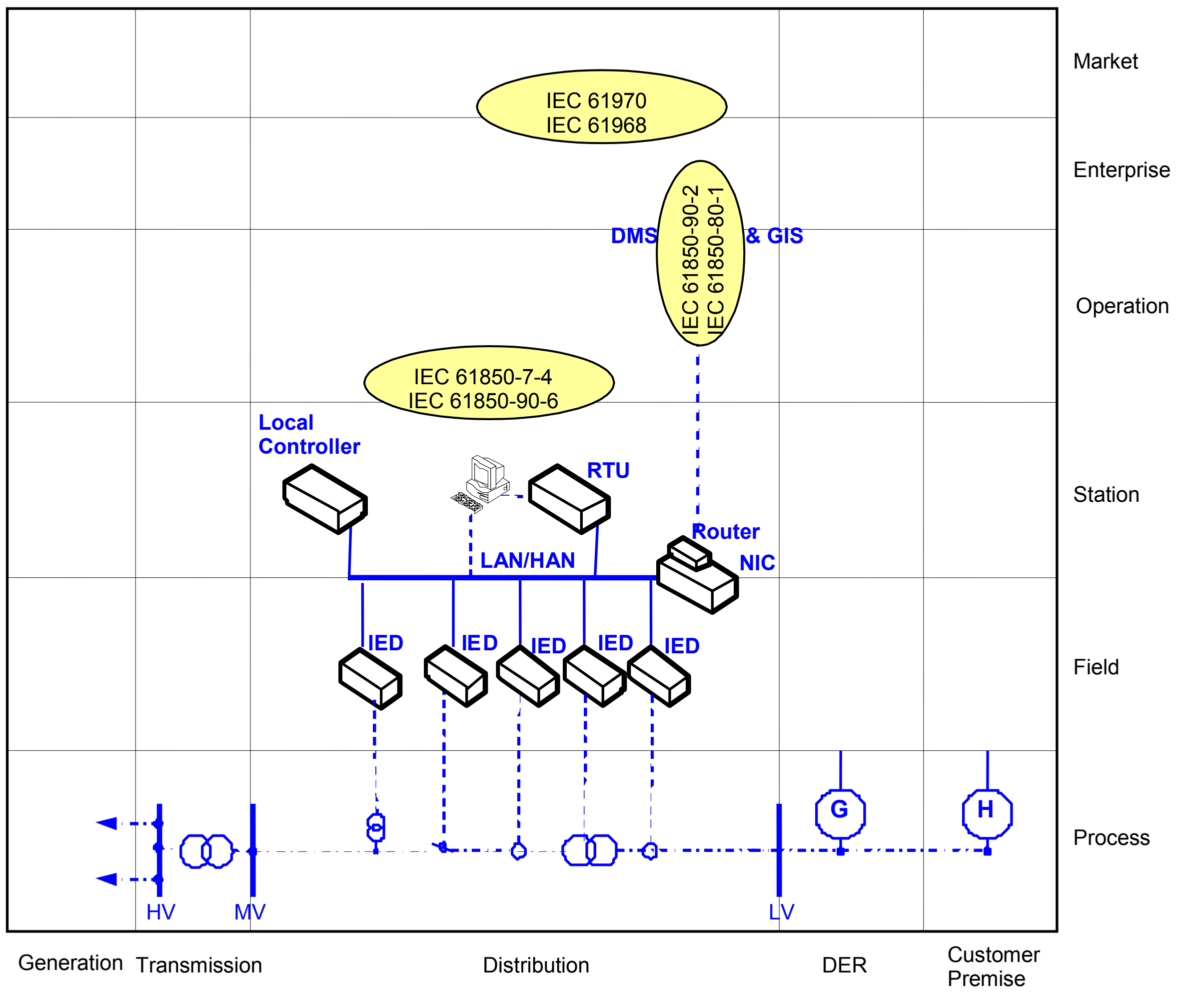


Figure 28 - Feeder automation system - Information layer

8.3.2.4 List of Standards

8.3.2.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by Dec 31st 2015 is considered as “available”.

Table 29 - Feeder automation system - Available standards

Layer	Standard	Comments
Information	EN 61850-7-4 EN 61850-7-3 EN 61850-7-2 EN 61850-6	Core Information model and language for the IEC/EN 61850 series
Information	EN 61850-7-410	Hydro power plants
Information	EN 61850-7-420	DER
Information	IEC 61850-80-1	Mapping of IEC/EN 61850 data model over 60870-5-101 and 104
Information	IEC 61850-80-4	Mapping between the DLMS/COSEM (IEC 62056) data models and the IEC 61850 data models
Information	EN 61400-25 (all parts)	Wind farms
Information	EN 61968 (all parts)	Common Information Model (System Interfaces For Distribution Management)
Information	EN 61970 (all parts)	Common Information Model (System Interfaces For Energy Management)
Information, Communication	IEC 61850-90-2	Guidelines for communication to control centers
Information	IEC 61850-90-3	Condition monitoring
Information	IEC 61850-90-7	PV inverters
Information, Communication	IEC 61850-90-4	Network engineering guidelines for communication within substation - Network management
Communication	EN 61850-8-1	IEC/EN 61850 communication except Sample values
Communication	EN 61850-9-2	IEC/EN 61850 Sample values communication
Communication	IEC 61850-90-1	Use of IEC/EN 61850 for the communication between substations
Communication	IEC 61850-90-12	Use of IEC 61850 over WAN
Communication	EN 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
Communication	EN 60870-5-103	Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment
Communication	EN 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
Communication	IEC 61850-90-5	Use of IEC/EN 61850 to transmit synchrophasor information according to IEEE C37.118. May also be relevant for use between substations
Communication	IEC 60255-24	Electrical relays - Part 24: Common format for transient data exchange (COMTRADE) for power systems
Communication	EN 62439	High availability automation Networks (PRP y HSR)
Component	EN 61869	Instrument transformers
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)
Component	IEC 62271-3	High-voltage switchgear and controlgear; Part 3:Digital interfaces based on IEC 61850
Component	CLC TS 50549-1	Requirements for the connection of generators above 16 A per phase to the LV distribution system - New Project (CLC TC 8X)

Layer	Standard	Comments
Component	CLC TS 50549-2	Requirements for the connection of generators to the MV distribution system - New Project (CLC TC 8X)

8.3.2.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 30 - Feeder automation system - Coming standards

Layer	Standard	Comments
Information	*EN 61850-7-4* *EN 61850-7-3* *EN 61850-7-2* *EN 61850-6*	Core Information model and language for the IEC/EN 61850 series
Information	*EN 61850-7-420*	IEC 61850 modelling for DER – New edition
Information, Communication	*IEC 61850-90-6*	Guideline for use of IEC/EN 61850 on Distribution automation
Information	*EN 61968-1* *EN61689-3* *EN 61968-11* *EN 61689-13*	Common Information Model (System Interfaces For Distribution Management)
Information	*EN 61970-301*	Common Information Model (System Interfaces For Energy Management)
Information	*IEC 61850-90-11*	Methodologies for modeling of logics for IEC/EN 61850 based applications
Information	*IEC 61850-90-17*	Using IEC 61850 to transmit power quality data
Communication	*EN 61850-9-2*	IEC/EN 61850 Sample values communication
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services
Communication	*IEC 61850-80-5*	Guideline for mapping information between IEC 61850 and IEC 61158-6 (Modbus)
Information	*EN 61400-25* (all parts)	Wind farms
Component	*IEC 62689-1* *IEC 62689-2* *IEC 62689-3* *IEC 62689-4* *IEC 62689-100*	Current and Voltage sensors or detectors, to be used for fault passage indication purposes
Communication	*IEC 62351-4* *IEC 62651-6* *IEC 62351-7* *IEC 62351-9* *IEC 62351-11* *IEC 62351-12* *IEC 62351-90-1*	Cyber-security aspects (refer to section 9.4)
Information	*IEC 62361-102*	Power systems management and associated information exchange - Interoperability in the long term - Part 102: CIM - IEC 61850 harmonization
Component	*prEN 50549-1-1*	Requirements for generating plants to be connected in parallel with distribution networks - Part 1-1: Connection to a LV distribution network – Generating plants up to and including Type A

Layer	Standard	Comments
Component	*prEN 50549-1-2*	Requirements for generating plants to be connected in parallel with distribution networks - Part 1-2: Connection to a LV distribution network – Generating plants of Type B
Component	prEN 50549-1-2	Requirements for generating plants to be connected in parallel with distribution networks - Part 2: Connection to a MV distribution network
Component	prEN 50549-10	Requirements for generating plants to be connected in parallel with distribution networks - Part 10 Tests demonstrating compliance of units

8.3.3 Advanced Distribution Management System (ADMS)

8.3.3.1 System Description

Advanced Distribution Management System refers to the real-time information system and all the elements needed to support all the relevant operational activities and functions used in distribution automation at dispatch centers and control rooms. It improves the information made available to operators, field and crew personnel, customer service representatives, management and, ultimately, to the end customers.
Such system is usually made of one or many interconnected IT systems, connected to field communicating devices or sub-systems, through the use of WAN communication systems. It may also include the needed components to enable the field crew to operate the network from the field.
An Advanced Distribution Management System provides following major functions:

- SCADA, real time monitoring and control
- Advanced network applications including network modeling
- Outage management including crew & resource management
- Work management

Geographical information system refers to the information system and all the elements needed to capture, store, manipulate, analyze, manage and present all types of geographical data and information to support the network operator / asset manager regarding decision making in the operation of the energy infrastructure. 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.

8.3.3.2 Set of high level use cases

The set of high level use cases which may be supported by an Advanced Distribution Management System are given in the table below. The GIS system doesn’t host a specific use case, but contributes to several use cases as a supplier for the network model as listed below.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 31 - Advanced Distribution Management System (ADMS) – Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Monitoring the grid flows	Monitoring electrical flows	CI		
	Monitoring power quality for operation (locally)	CI		
	Producing, exposing and logging time-stamped events	X		
	Supporting time-stamped alarms management at all levels	X		
	Capture, expose and analyze disturbance events	X		
	Archive operation information	CI		
Maintaining grid assets	Monitoring assets conditions	CX		
	Supporting periodic maintenance and planning	X		
	Optimize field crew operation	X		
Manage Commercial relationship for electricity supply	Registration/deregistration of customers		C	I
Operate DER(s)	Registration/deregistration of DER in VPP		CI	
	Aggregate DER as technical VPP		CI	
	Aggregate DER as commercial VPP		CI	
	Switch/breaker control	CI		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Controlling the grid (locally/ remotely) manually or automatically	Feeder load balancing	X		
	Enable multiple concurrent levels of control (local-remote)	X		
Managing power quality	Voltage regulation	CI		
	VAR regulation	CI		
Reconfiguring the network in case of fault	Supporting reclosing sequence	X		
	Supporting source switching	X		
	Supporting automatic FLISR			
Connect an active actor to the grid	Managing microgrid transitions			X
	Managing generation connection to the grid	X		
Demand and production (generation) flexibility	Receiving metrological or price information for further action by consumer or CEM			X
	Load forecast (from remote based on revenue metering)	X		
	Generation forecast (from remote)	X		
	Participating to electricity market	X		
System and security management	Distributing and synchronizing clocks	X		

8.3.3.3 Mapping on SGAM

8.3.3.3.1 Preamble:

The Advanced Distribution Management System is supported by substation automation, protection and control. It is less advanced than the EMS SCADA used in Transmission. But the amount of automation is growing in distribution systems certainly with the increasing role of distributed generation and distributed storage. Furthermore focus is on further decrease of outage minutes by support of remote sensing and switching in the network. Remote control and operation of distribution networks will have a positive influence on network management during normal and emergency situations, dependency of fieldworkers will be less. With the growing amount of distributed generation, distribution networks have to support balancing generation and demand at regional level. Hierarchically this system is covering the station and operational zones within the Distribution System operation.
The GIS system interacts with the Advanced Distribution Management System, Asset and Maintenance management system (GMAO), the CIS and EMS/VPP system.

8.3.3.3.2 Component layer

The Advanced Distribution Management System covers the online operation of the distribution network and part of the interaction with distributed generation and storage in Medium and Low voltage networks (DER). Focus is on remote sensing and switching of main feeders and distributed generators. Interconnection points to the feeding HV transmission networks are the upper boundary points of the Advanced Distribution Management System. In the near future the interaction and information from AMI will be an issue, because load and generation profiles will be available through measuring load and distributed generation with a certain time interval. Management of self-healing functionalities in the network will be done by the Advanced Distribution Management System.

The GIS component architecture focuses also on the Enterprise and Operation zone.

- At the Enterprise zone the GIS system itself is usually located.
- Various systems at the Operation zone (Advanced Distribution Management System, OMS) use the GIS data (e.g. network models and diagrams including coordinates of the assets at the process zone) for their purpose.

Here is below an example of architecture of a Advanced Distribution Management System, and associated components:

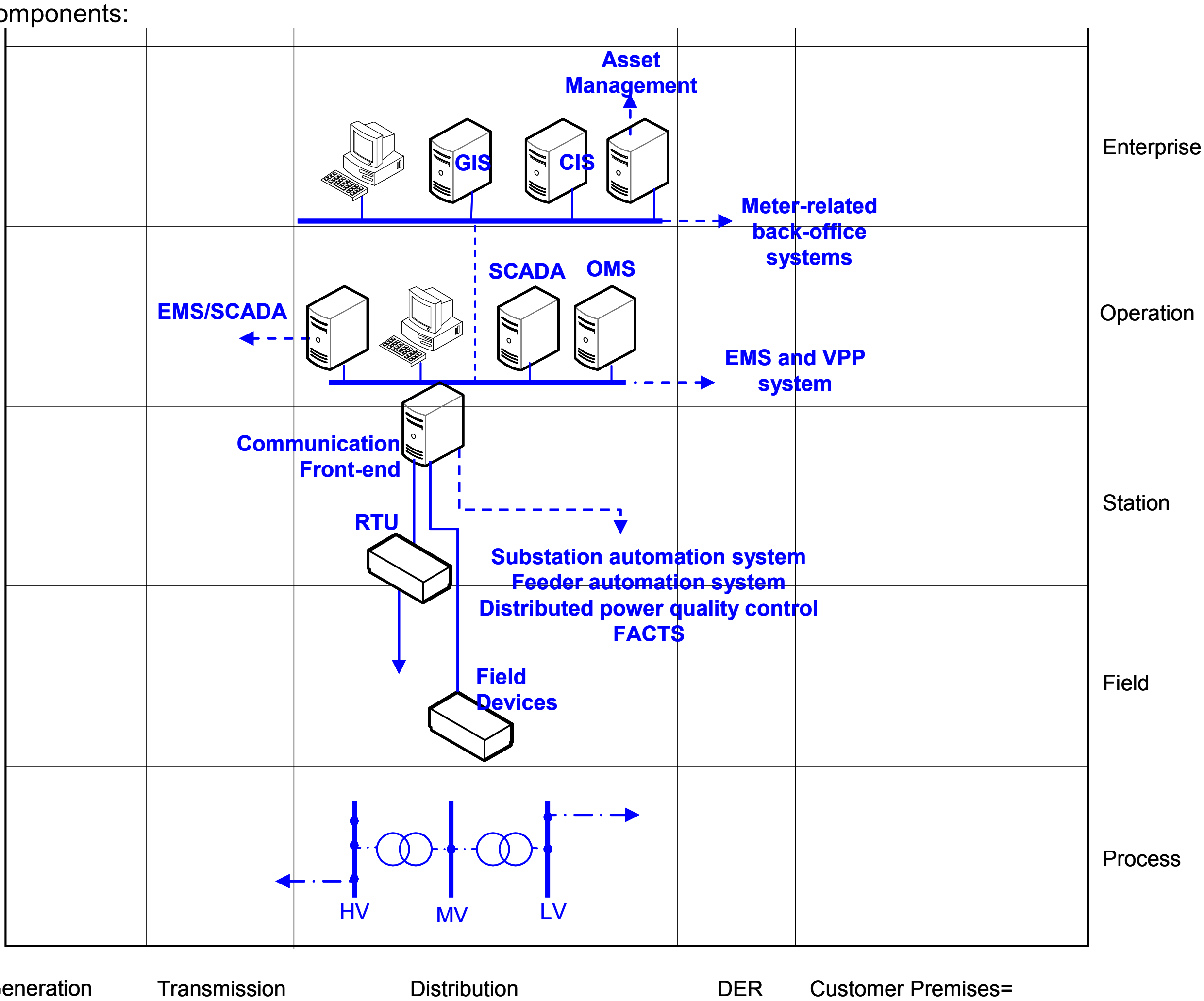


Figure 29 - Advanced Distribution Management System (ADMS) - Component layer

8.3.3.3.3 Communication layer

Communication protocols mentioned under Substation Automation will be applied for retrieving necessary information and control of the network.

This set of standards regarding Advanced Distribution Management System can be positioned as is shown in the diagram below representing the communication layer of SGAM.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

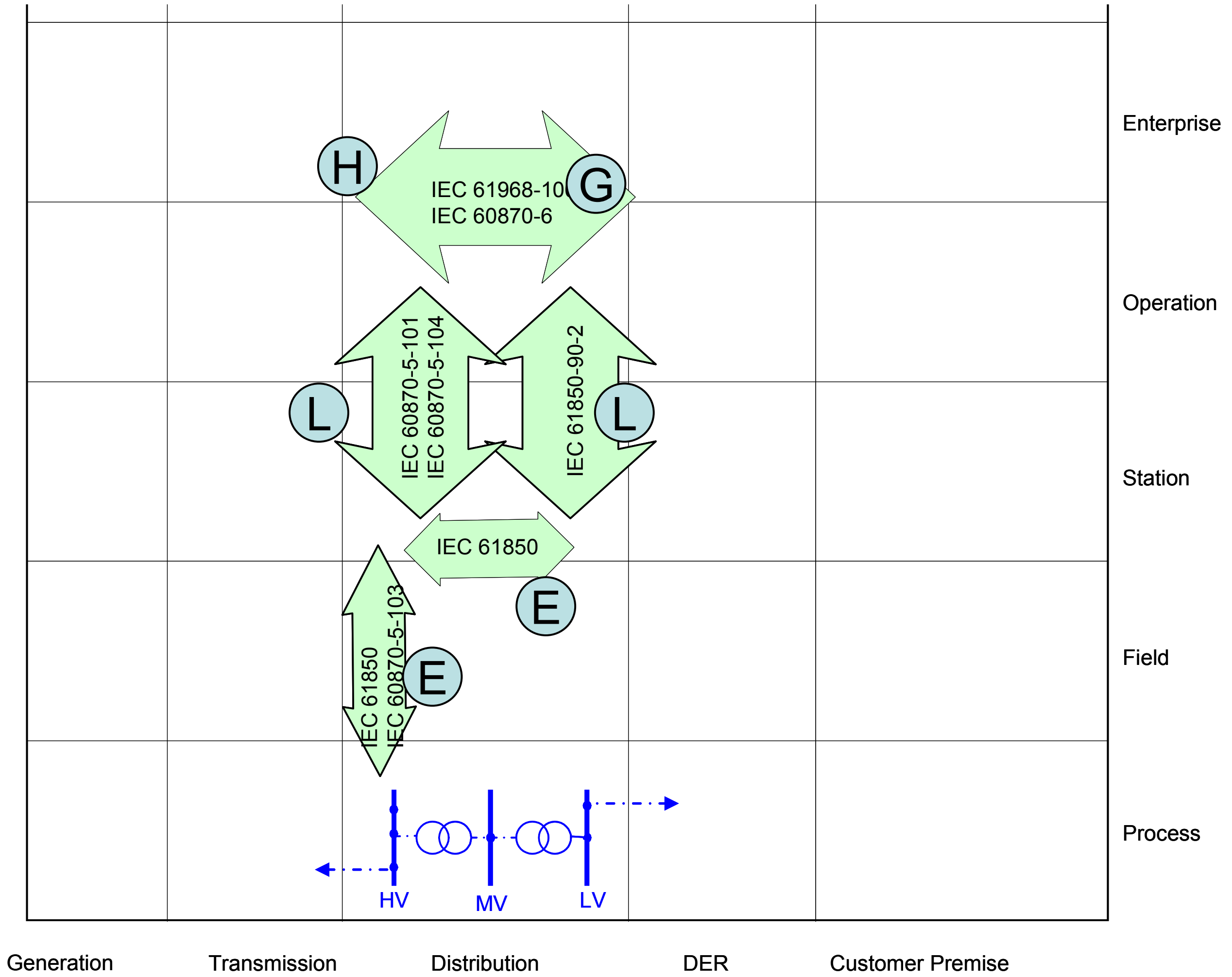


Figure 30 - Advanced Distribution Management System (ADMS) - Communication layer

8.3.3.3.4 Information (Data) layer

Advanced Distribution Management System makes use of the information models at station and operation level of course. For Advanced Distribution Management System most of the parts of EN 61968 (and EN 61970) are applicable. It describes the Common Information Model CIM for distribution management and it covers most of the interfaces between the different applications and the head-end level of the utility. GIS related information is defined in IEC 61698-4 and IEC 61968-13.

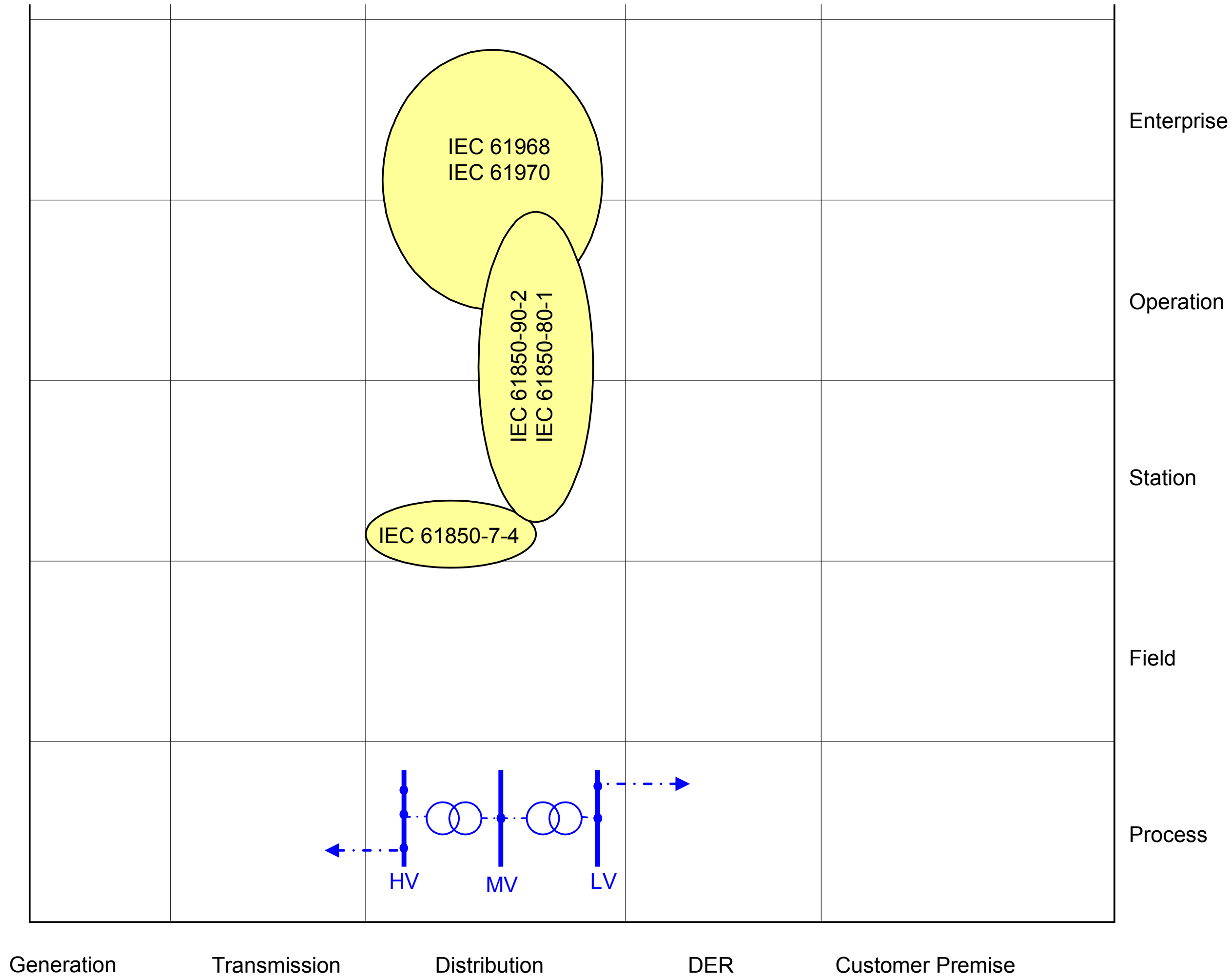


Figure 31 - Advanced Distribution Management System (ADMS) - Information layer

Standards Identified for Substation Automation are also relevant for the application of the Advanced Distribution Management System, because the Advanced Distribution Management System will retrieve online information from the substations in the Distribution Networks

8.3.3.4 List of Standards

Here is the summary of the standards which appear relevant to support The Advanced Distribution Management System (ADMS):

8.3.3.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by Dec 31st 2015 is considered as “available”.

Table 32 - Advanced Distribution Management System (ADMS) - Available standards

Layer	Standard	**Comments**
Communication, Information	IEC/EN 61850 (all parts)	See substation automation
General	IEC 62357	Reference architecture power system information exchange
Information	IEC 62361-100	CIM profiles to XML schema mapping
Communication and Information	EN 61970 (all parts)	Some issues will be relevant of this family of standards but focus in this family of standards is on transmission
General	EN 61968-1	Application integration at electric utilities - System interfaces for distribution management - Part 1: Interface architecture and general requirements
Information	EN 61968-2	Application integration at electric utilities - System interfaces for distribution management - Part 2: Glossary
Information	EN 61968-3	Application integration at electric utilities - System interfaces for distribution management - Part 3: Interface for network operations
Information	EN 61968-4	Application integration at electric utilities - System interfaces for distribution management - Part 4: Interfaces for records and asset management
Information	EN 61968-6	Application integration at electric utilities - System interfaces for distribution management - Part 6: Interfaces for maintenance and construction
Information	EN 61968-8	Application integration at electric utilities - System interfaces for distribution management - Part 8: Interface Standard For Customer Support
Information	EN 61968-9	Application integration at electric utilities - System interfaces for distribution management - Part 9: Interfaces for meter reading and control
Information	EN 61968-11	Application integration at electric utilities - System interfaces for distribution management - Part 11: Common information model (CIM) extensions for distribution
Information	EN 61968-13	Application integration at electric utilities - System interfaces for distribution management - Part 13: CIM RDF Model exchange format for distribution
Communication	IEC 61968-100	Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)

8.3.3.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 33 - Advanced Distribution Management System (ADMS) - Coming standards

Layer	Standard	**Comments**
General	*IEC 62357*	Reference architecture power system information exchange
General	*EN 61968-1*	Application integration at electric utilities - System interfaces for distribution management - Part 1: Interface architecture and general recommendations
Information	*EN 61968-3*	Application integration at electric utilities - System interfaces for distribution management - Part 3: Interface for network operations
Information	*EN 61968-11*	Application integration at electric utilities - System interfaces for distribution management - Part 11: Common information model (CIM) extensions for distribution
Information	*EN 61968-13*	Application integration at electric utilities - System interfaces for distribution management - Part 13: Common distribution power system model profiles
Information	*EN 61970-301*	Energy management system application program interface (EMS-API) - Part 301: Common Information Model (CIM) Base
Communication, Information	*IEC/EN 61850*	See substation automation
Communication	*IEC 62351-4* *IEC 62651-6* *IEC 62351-7* *IEC 62351-9* *IEC 62351-11* *IEC 62351-12* *IEC 62351-90-1*	Cyber-security aspects (refer to section 9.4)
Information	*IEC 62361-101*	Naming and design rules for CIM profiles to XML schema mapping
Information	*IEC 62361-102*	Power systems management and associated information exchange - Interoperability in the long term - Part 102: CIM - IEC 61850 harmonization

8.3.4 FACTS (Distribution)

8.3.4.1 System description

The system description is similar to the one used in for Transmission as described in 8.2.4.

8.3.4.2 Set of use cases

Here is a set of high level use cases which may be supported by FACTS.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 34 - FACTS (Distribution) - use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Controlling the grid (locally/ remotely) manually or automatically	Feeder load balancing	CI		
Managing power quality	(Dynamic) Voltage optimization at source level as grid support (VAR control)			
	Local Voltage regulation by use of Facts			
System and security management	Discover a new component in the system	C		I
	Configure newly discovered device automatically to act within the system	C		I
	Distributing and synchronizing clocks	I	C	
Grid stability	Stabilizing network after fault condition (Post-fault handling)			
	Monitoring and reduce power oscillation damping			
	Stabilizing network by reducing sub-synchronous resonance (Sub synchronous damping)			
	Monitoring and reduce harmonic mitigation	I		
	Monitoring and reduce voltage flicker	I		
Connect an active actor to the grid	Managing generation connection to the grid	CI		

8.3.4.3 Mapping on SGAM

8.3.4.3.1 Preamble

Considering that this system is not interacting with the “Enterprise”, “Market”, “Operation” and “Station” zones of the SGAM, only the “Process” and “Field” zones are shown in the here-under drawings.

8.3.4.3.2 Component layer

Mapping is similar to the one presented in 8.2.4.4.2 for FACTS in Transmission

8.3.4.3.3 Communication layer

Mapping is similar to the one presented in 8.2.4.4.3 for FACTS in Transmission

8.3.4.3.4 Information (Data) layer

Mapping is similar to the one presented in 8.2.4.4.4 for FACTS in Transmission

8.3.4.4 List of Standards

8.3.4.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by Dec 31st 2015 is considered as “available”.

Table 35 - FACTS (Distribution) – Available standards

Layer	Standard	**Comments**
Information	IEC 61850-80-1	Mapping of IEC/EN 61850 data model over 60870-5-101 and 104
Information	EN 61850-7-4	Core Information model
Information	IEC 61850-90-3	Using IEC/EN 61850 for condition monitoring
Communication, information	IEC 61850-90-2	Substation to control center communication
Communication	EN 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
Communication	EN 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)

8.3.4.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 36 - FACTS (Distribution) – Coming standards

Layer	Standard	**Comments**
Information	*IEC 61850-90-14*	Using IEC 61850 for FACTS modelling
Communication	*IEC 62351-4* *IEC 62651-6* *IEC 62351-7* *IEC 62351-9* *IEC 62351-11* *IEC 62351-12* *IEC 62351-90-1*	Cyber-security aspects (refer to section 9.4)

8.4 Distributed Energy Resources Operation System (including storage)

8.4.1 System description

DER system is responsible for operation and enterprise level management of the DER assets. It performs supervision and maintenance of the components, provides information to the operators and field crew personnel and controls of actual generation. It can act as a technical VPP (tVPP) interacting directly with the DSO or as a commercial VPP (cVPP) interacting with the energy market. The system may control one or more DERs which can be geographically distributed. These DERs could be single generation plants or could be combined with VPPs. The system provides information on the generation capabilities of the DER/VPP and the expected generation (forecast). It controls the actual generation and storage including VAR regulation and frequency support based on requests and schedules received from the market or DSO.

8.4.2 Set of use cases

The following high level use cases might be supported by a DER Operation systems.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 37 – DER Operation system – use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Monitoring the grid flows	Monitoring electrical flows	CI		
	Monitoring power quality for operation (locally)	C	I	
	Producing, exposing and logging time-stamped events	CI		
	Supporting time-stamped alarms management at all levels	CI		
	Capture, expose and analyse disturbance events	CI		
	Archive operation information	I	C	
Maintaining grid assets	Monitoring assets conditions	CI	C	
	Supporting periodic maintenance (and planning)		CI	
	Optimise field crew operation	C	C	I
	Archive maintenance information		CI	
Managing power quality	VAR regulation		CI	
	Frequency support		CI	
Operate DER(s)	DER process management with reduced power output		CI	
	DER performance management		CI	
	DER remote control (dispatch)		CI	
	Registration/deregistration of DER in VPP		CI	
	Aggregate DER as technical VPP		CI	
	Aggregate DER as commercial VPP		CI	
Connect an active actor to the grid	Managing microgrid transitions		CI	
	Managing generation connection to the grid		CI	
Blackout management	Black-out prevention through WAMPAC	CI (PMU)		?
	Shedding loads based on emergency signals	CX	I	
	Restore power after black-out			X

		Supported by standards		
Use cases cluster	**High level 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)		CI	
	Generation forecast (from local)		CI	
	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	
System and security management	Distributing and synchronizing clocks	See section 0		

It still has to be evaluated in detail which parts of the use cases are supported by existing or new IEC/EN 61850 standards and what is missing.

8.4.3 Mapping on SGAM

8.4.3.1 Preamble

The DER operation system interacts with the DER Asset and Maintenance Management system. In cases where the DER assets are owned or operated by the DSO, the DER operation systems AS might be part of the DSOs ADMS.

8.4.3.2 Component layer

The component zone architecture covers all zones.

- the Process zone with the DERs, inverters and related sensors and actors
- The Field zone with the DER unit controller
- The Station zone with the DER plant controller
- The Operation zone with the tVPP/EMS which may interact with the DSOs DMS in case of tVPP
- The Enterprise zone with the cVPP which interacts with the market platform or directly with an energy retailer.

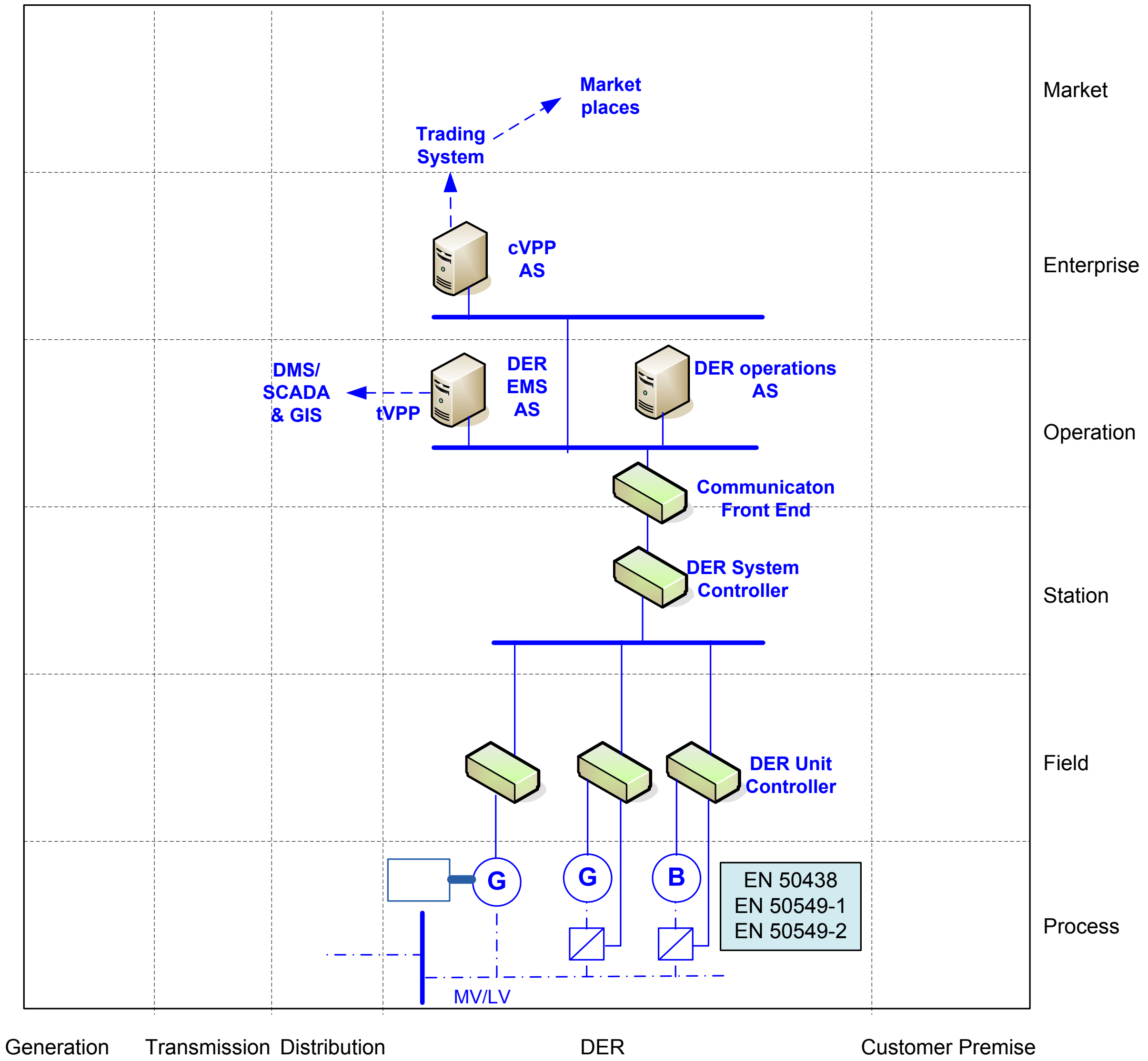


Figure 32 - DER Operation system - Component layer

8.4.3.3 Communication layer

EN 60870-5-101 and EN 60870-5-104 can also be used for vertical communication as shown in the Figure 33 below.
For the field/station to operations communication the IEC/EN 61850 communication protocols are used.
For the enterprise communication at the operation, enterprise and market zone the coming standard EN 61968-100 will be used.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

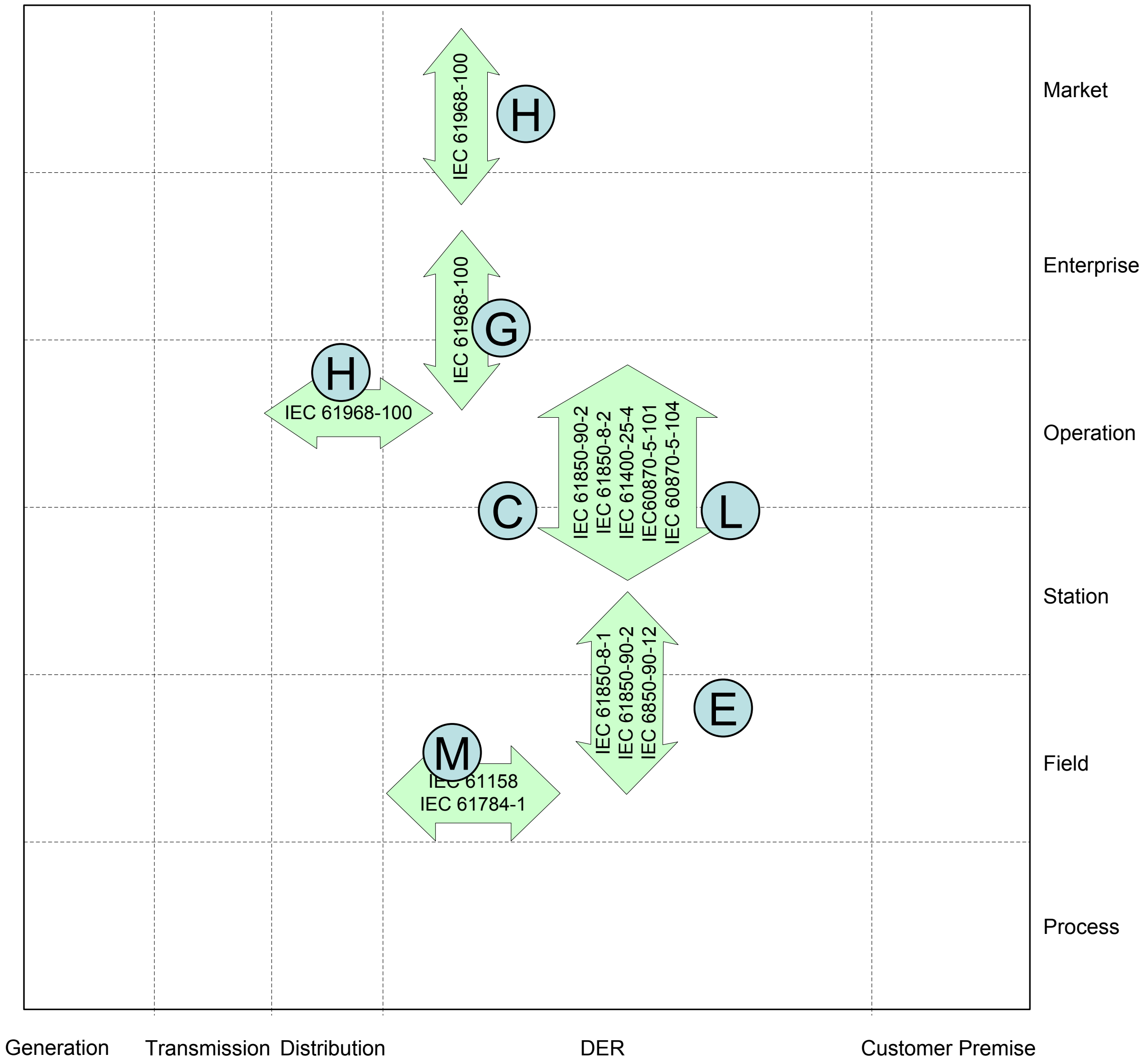


Figure 33 - DER Operation system - Communication layer

8.4.3.4 Information (Data) layer

The information exchange at the field/station to operations zone is based on the IEC/EN 61850 information model. Specific standards for DER EMS/VPP operation at the enterprise bus are currently not defined. Note that for market operations the OASIS EMIX and EnergyInterop and the IEC 62325 series specifications (available and coming) may apply. However the details for the whole DER domain are still under discussion and further investigation is needed.

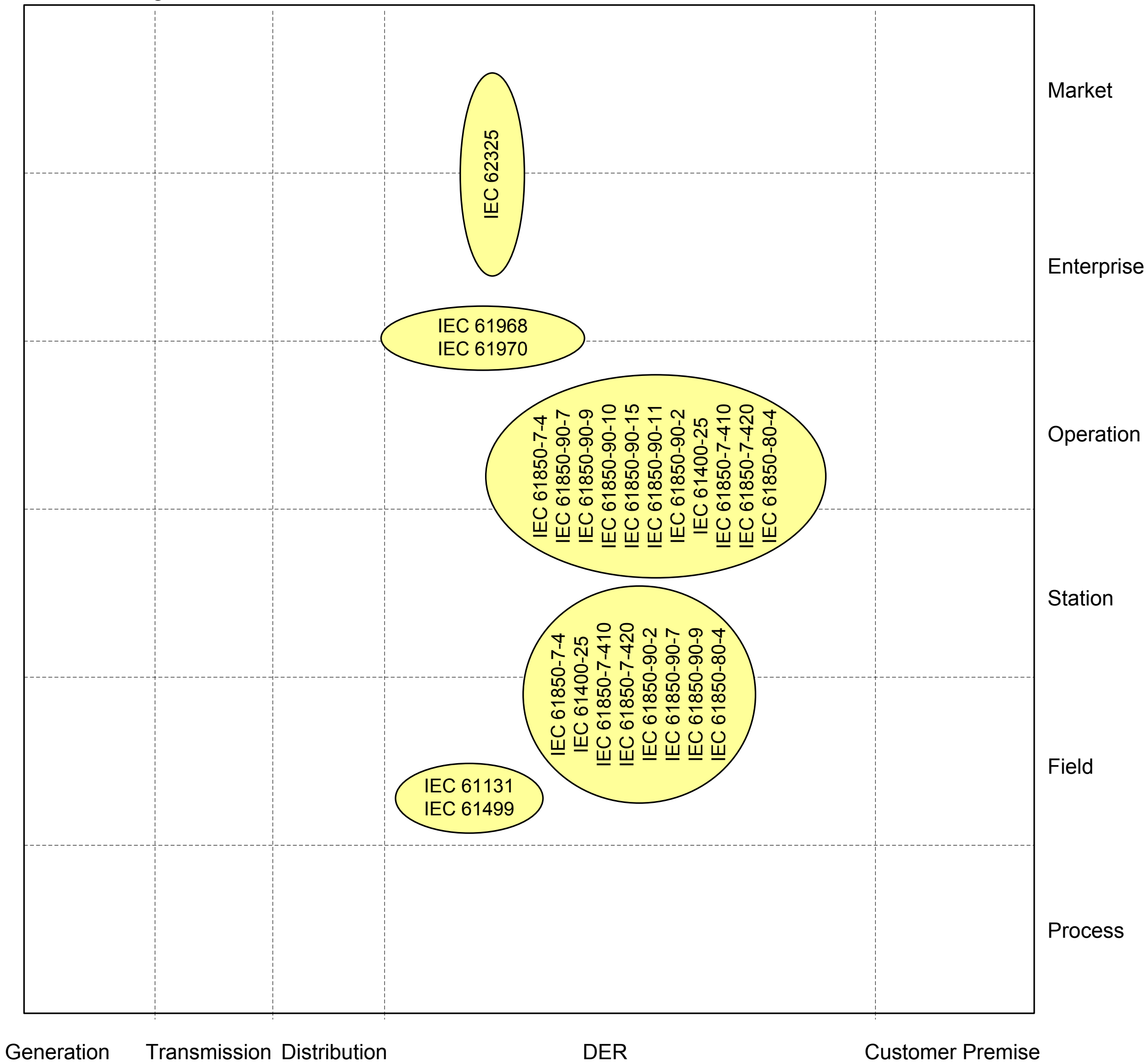


Figure 34 - DER operation system - Information layer

8.4.4 List of Standards

Here is the summary of the standards which appear relevant to DER Operation systems:

8.4.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 38 – DER Operation system – Available standards

Layer	Standard	Comments
Information	EN 61850-7-4 EN 61850-7-3 EN 61850-7-2 EN 61850-6	Core Information model and language for the IEC/EN 61850 series
Information	EN 61400-25-1, EN 61400-25-2, EN 61400-25-3, EN 61400-25-4	Wind farms
Information	EN 61850-7-410	Hydroelectric power plants
Information	EN 61850-7-420	DER
Information	IEC 61850-80-4	mapping of COSEM over IEC 61850
Communication, information	IEC 61850-90-2	Substation to control center communication
Information	IEC 61850-90-7	DER inverters
Communication	IEC 61850-90-12	Use of IEC 61850 over WAN
Information	EN 61131	Programmable controllers
Information	EN 61499	Distributed control and automation
Information	EN 61968 (all parts)	Distribution CIM
Information	EN 61970 (all parts)	Transmission CIM
Communication, Information	EN 62325 (all parts)	Framework market communication
Communication	EN 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
Communication	EN 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
Communication	EN 61850-8-1	IEC/EN 61850 communication except Sample values
Communication	EN 61158	Field bus
Communication	EN 62439	High availability automation Networks (PRP y HSR)
Communication	IEC 61784-1	Field bus
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)
Communication	EN 61968-100	Defines profiles for the communication of CIM messages using Web Services or Java Messaging System.
Component	IEC 60904 (all parts)	Photovoltaic devices
Component	IEC 61194	Characteristic parameters of stand-alone photovoltaic (PV) systems
Component	EN 61724	Photovoltaic system performance monitoring - Guidelines for measurement, data exchange and analysis
Component	EN 61730	Photovoltaic (PV) module safety qualification
Component	EN 61400-1	Wind turbines - Part 1: Design requirements
Component	EN 61400-2	Wind turbines - Part 2: Design requirements for small wind turbines
Component	EN 61400-3	Wind turbines - Part 3: Design requirements for offshore wind turbines
Component	IEC 62282	Fuel cell technologies
Component	IEC 62600 series	Marine energy
Component	EN 50438	Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks Maintenance of an existing standard (CLC TC 8X)

Layer	Standard	Comments
Component	CLC TS 50549-1	Requirements for the connection of generators above 16 A per phase to the LV distribution system - New Project (CLC TC 8X)
Component	CLC TS 50549-2	Requirements for the connection of generators to the MV distribution system - New Project (CLC TC 8X)
General	IEC 62746-3	Systems interface between customer energy management system and the power management system - Part 3: Architecture

2545

2546 ### 8.4.4.2 Coming standards

2547 In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal
2548 equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

2549 **Table 39 – DER Operation system – Coming standards**

Layer	Standard	Comments
Information	*EN 61850-7-4* *EN 61850-7-3* *EN 61850-7-2* *EN 61850-6*	Core Information model and language for the IEC/EN 61850 series
Information	*IEC 61850-90-9*	Batteries
Information	*IEC 61850-90-10*	Scheduling functions
Information	*IEC 61850-90-11*	Methodologies for modeling of logics for IEC/EN 61850 based applications
Information	*EN 61850-7-420*	Distributed energy resources logical nodes
Information	*IEC 61850-90-15*	DER System Grid Integration
Information	*IEC 61850-90-17*	Using IEC 61850 to transmit power quality data
Communication	*IEC 61850-80-5*	Guideline for mapping information between IEC 61850 and IEC 61158-6 (Modbus)
Communication	*IEC 61850-8-2*	Web-services mapping
Information	*IEC 61970-301*	Common information model (CIM) base
Information, Communication	*EN 61400-25-1,* *EN 61400-25-4,* *EN 61400-25-5,* *EN 61400-25-6,* *EN 61400-25-41*	Wind turbines communication
Component	prEN 50549-1-1	Requirements for generating plants to be connected in parallel with distribution networks - Part 1-1: Connection to a LV distribution network – Generating plants up to and including Type A
Component	prEN 50549-1-2	Requirements for generating plants to be connected in parallel with distribution networks - Part 1-2: Connection to a LV distribution network – Generating plants of Type B
Component	prEN 50549-1-2	Requirements for generating plants to be connected in parallel with distribution networks - Part 2: Connection to a MV distribution network
Component	prEN 50549-10	Requirements for generating plants to be connected in parallel with distribution networks - Part 10 Tests demonstrating compliance of units
Communication	IEC 62351-4 IEC 62651-6 IEC 62351-7 IEC 62351-9 IEC 62351-11	Cyber-security aspects (refer to section 9.4)

Layer	**Standard**	**Comments**
Information	*EN 61850-7-4* *EN 61850-7-3* *EN 61850-7-2* *EN 61850-6*	Core Information model and language for the IEC/EN 61850 series
	IEC 62351-12 IEC 62351-90-1	
Information	IEC 62361-102	Power systems management and associ
Information	*IEC 62361-102*	Power systems management and associated information exchange - Interoperability in the long term - Part 102: CIM - IEC 61850 harmonization
Communication, Information	*EN 62325*	Framework market communication
Component	*IEC 62898-2*	Technical requirements for Operation and Control of Micro-Grid
General	*IEC 62934*	Grid integration of renewable energy generation - Terms, definitions and symbols
General	*IEC 62786*	Distributed Energy Resources Interconnection with the Grid

8.5 Smart Metering systems

8.5.1 AMI system (M/441 scope)

The standardization supporting the Advanced Metering Infrastructure is covered under mandate M/441 [3] and co-ordinated by the Smart Metering Coordination Group (SM-CG). The following sections represent a summary of the results achieved, based exclusively on the SM-CG technical report TR 50572 [4] “Functional reference architecture for communications in smart metering systems”, the further SM-CG report at the end of 2012, and the latest SM-CG work programme.

The referred set of SM-CG standards is widely accepted, but the work of the SM-CG is ongoing, including work on smart metering use cases. Extensions considering new use cases and the evolution of new technologies will follow the rules set by SM-CG and be documented in subsequent reports.

In this report and particularly in this section, all references to standards related to the M/441 mandate [3] remain under the responsibility of the SM-CG, without excluding relevant standards which may be developed in other contexts.

8.5.1.1 System description

The AMI system refers to the whole advanced metering infrastructure covered by the M/441 mandate [3] supporting the deployment of smart meters. It includes the smart meter itself and external display device, in-home gateway (Local Network Access Point or LNAP), meter data concentrator (Neighborhood Network Access Point – NNAP), and Head-End System (HES).

The AMI provides services for the customer, the supplier and network operator and is used for automated meter reading and billing and a range of other activities which are considered in detail in the work of the M/441 mandate by the Smart Meter Co-ordination Group (SM-CG).

Within a smart grid, the AMI may also be used for network monitoring and control. Furthermore it might be used for demand response / demand side management in connection with demand and production (generation) flexibility systems. As stated in the SM-CG Technical Report (TR 50572) [4], this latter functionality is not in the M/441 scope [3] and can also be offered through alternative channels.

It should be noted that there may be revenue and operational meters further up the grid system (e.g. at the generation, transmission or distribution level). These are not considered part of the AMI system, which is focused on revenue metering at the customer premises level.

8.5.1.2 Set of use cases

Here is a set of high level use cases developed under the M/441 [3] which Member States may wish to implement via their AMI systems. The columns then consider relevant available or coming standards necessary to support these use cases.
To the extent that the AMI is used in connection with demand and production flexibility, these use cases should be read in conjunction with the use cases shown in this report under section 8.6.1.2 for the Aggregated prosumers management system.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 40 – AMI system – Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
(AMI) Billing	Obtain scheduled meter reading	CI		
	Set billing parameters	CI		
	Add credit	C		
	Execute supply control	CI		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
(AMI) Customer information provision	Provide information to consumer	CI		
(AMI) Configure events, statuses and actions	Configure meter events and actions	CI		
	Manage events	CI		
	Retrieve AMI component information	CI		
	Check device availability	CI		
(AMI) installation & configuration	AMI component discovery & communication setup	CI		
	Clock synchronization	CI		
	Configure AMI device	CI		
	Security (Configuration) Management	CI		
(AMI) Energy market events	Manage consumer moving in	CI		
	Manage customer moving out	CI		
	Manage customer gained	CI		
	Manage customer lost	CI		
(AMI) Collect events and status information	Manage supply quality	CI		

8.5.1.3 Mapping on SGAM

8.5.1.3.1 Preamble

The smart metering functional reference architecture is specified in CLC TR 50572 [4] according to Figure 35. In the following sections the smart metering architecture of Figure 35 is mapped into the SGAM architecture. Note that in the architecture in Figure 35 the Head End System is at the bottom of the diagram, in contrast to the order of the component layers in the SGAM architecture diagrams.
The objective of this section is to report on SM-CG conclusions, mandated by the M/441 [3].
Should any difference appear between the here-under section and current and subsequent SM-CG publications, then SM-CG one shall remain the reference.

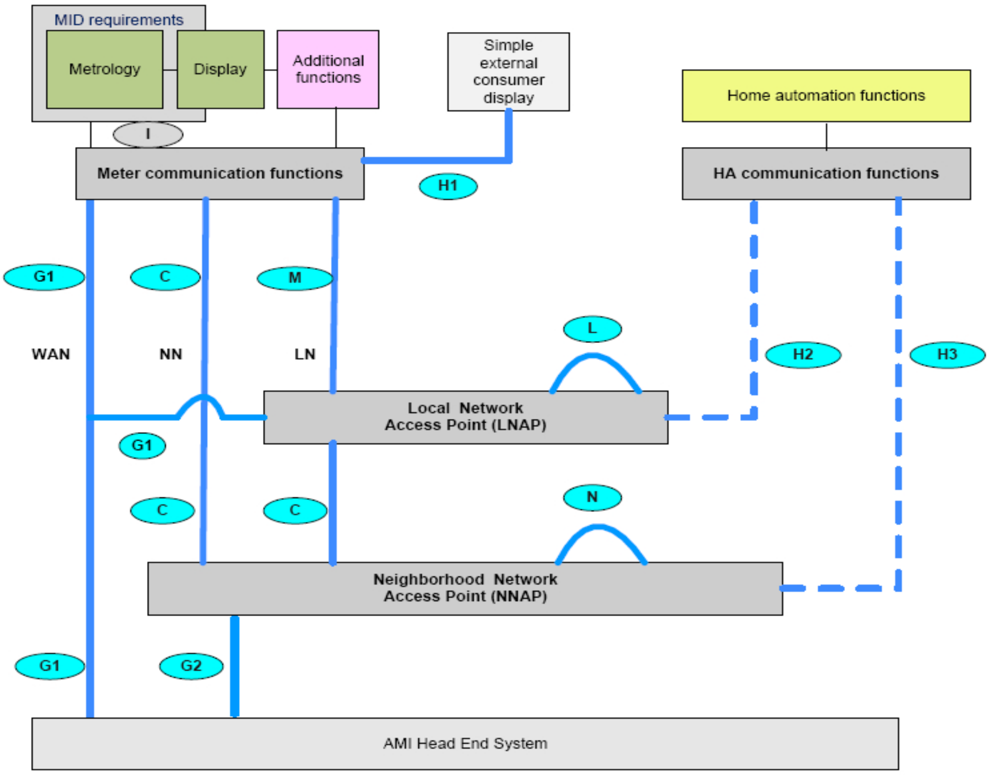


Figure 35: Smart Metering architecture according to CLC TR 50572

The diagrams in the sections below give examples of a mapping of a typical configuration based on the smart metering reference architecture on the SGAM.

Both in these diagrams of this section 8.5.1 and in similar ones in section 8.6.1, the split of the “customer premises” domain on the right is intended to illustrate a typical market model where assets in the home/building are not owned/operated by the electricity service supplier. However Member State market models vary e.g. as regards meter ownership and operation, and are subject to national structures and regulation, so this representation should not be seen as definitive.

8.5.1.3.2 Component layer

The exact composition of the AMI will depend on the configuration chosen. The following figure shows the components that may be part of the Advanced Metering Infrastructure. *Meters* for different media (Electricity, Gas, Heat and Water) represent the end devices on process and filed level. We distinguish between meters at (residential) customer premises (which are subject to metrological approvals -> MID[8]) and meters used in industrial, commercial environments or for grid automation purposes. The meter may have an interface to a *simple display* unit or, it may be interfaced to a proper *home automation system*.

Meters and home/building automation end devices may be interconnected via *LNAPs* (Local Network Access Point).

The NNAP (Neighborhood Network Access Point) is typically located at distribution station level. The NNAP may be part of a simple communication gateway or of a *data concentrator* offering comprehensive data processing features.

The meters are connected (directly or via LNAP and/or NNAP) to the *HES* (Head End System). The HES manages the data exchange with the meters and supervises the WAN/LAN communication.

[8] See Abbreviations Table 2

The *MDM* (Meter Data Management) system interfaces to the ERP systems and to the market systems. In particular, the MDM accepts metering tasks (e.g. data acquisition, command distribution,…) from the “superior” systems and returns the validated results. The communication with the AMI endpoints is done via the HES.

The components of the AMI are depicted diagrammatically in Figure 36 below. More details on the smart metering functional architecture can be found in the CEN/CLC/ETSI Technical Report 50572 [4].

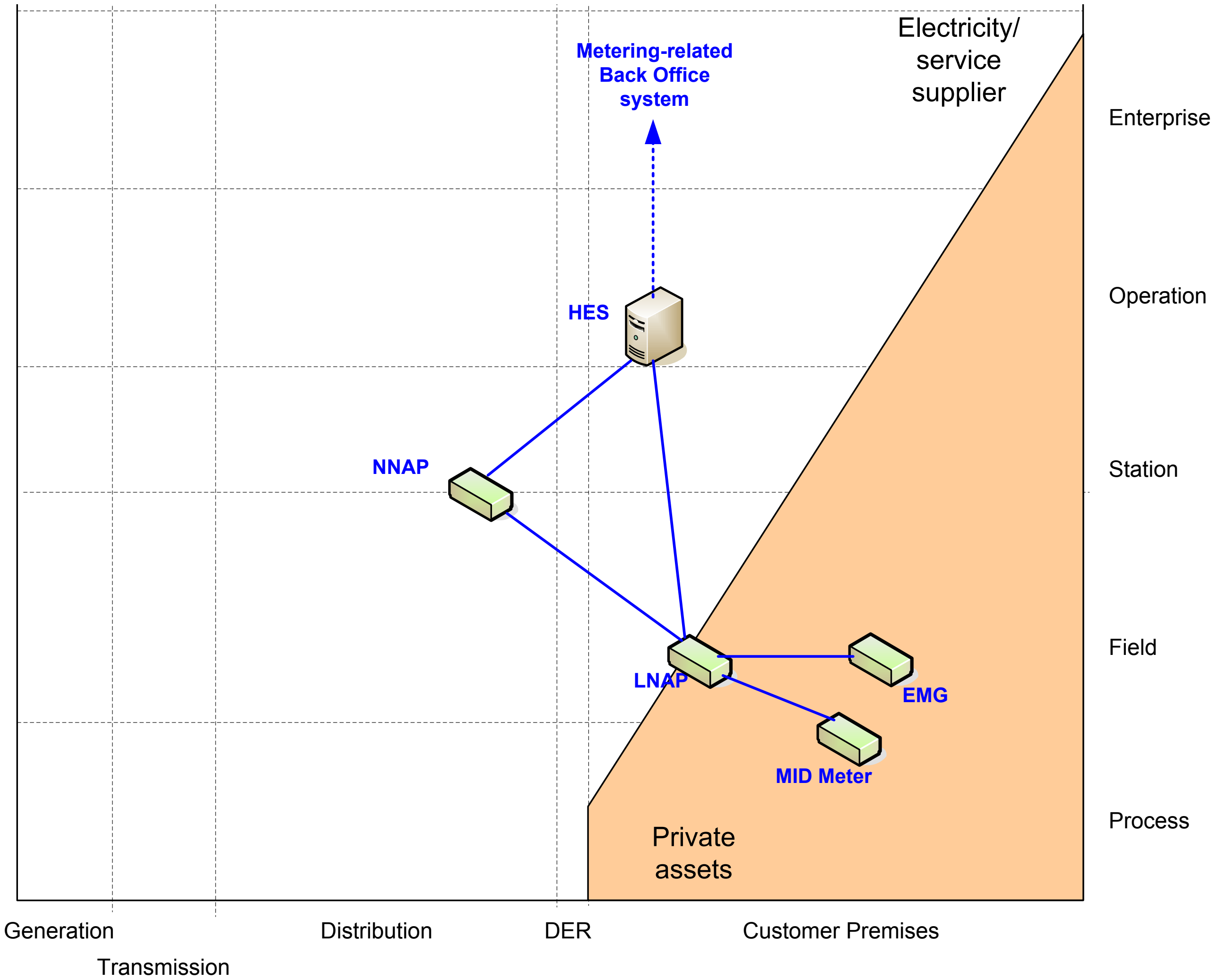


Figure 36: Smart Metering architecture (example) mapped to the SGAM component layer.

8.5.1.3.3 Communications layer

TR 50572 [4] sets out the SM-CG reference architecture, communications interfaces and associated standards used in the AMI. The principal interfaces are there referred to as M, C, G and H.

In the figure below, a mapping of this SM-CG architecture on the SGAM tool is displayed.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

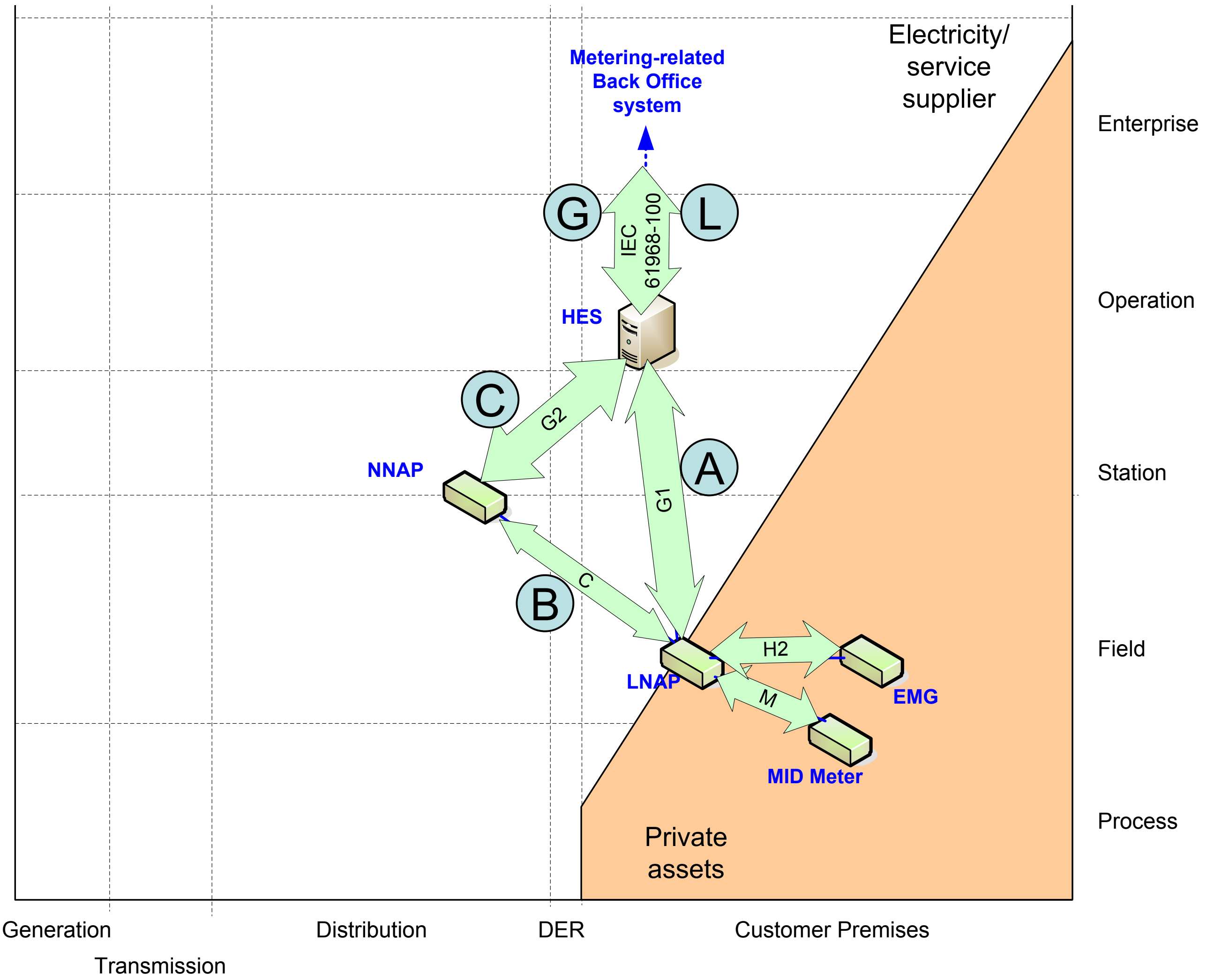


Figure 37: Smart Metering architecture (example) mapped to the SGAM communication layer.

8.5.1.3.4 Information (Data) layer

Considering data models for smart metering, there are various data models in use in Member States who have already implemented smart metering.

Individual discussions with standardization bodies from those Member States which have implemented or planning to implement Smart Metering has shown a broad consensus on using the IEC/EN 62056 COSEM model for future implementations.

To provide a migration path, mapping between the COSEM data model and the models of other established standards (in particular M-Bus, used with power and resource constrained devices) may be necessary.

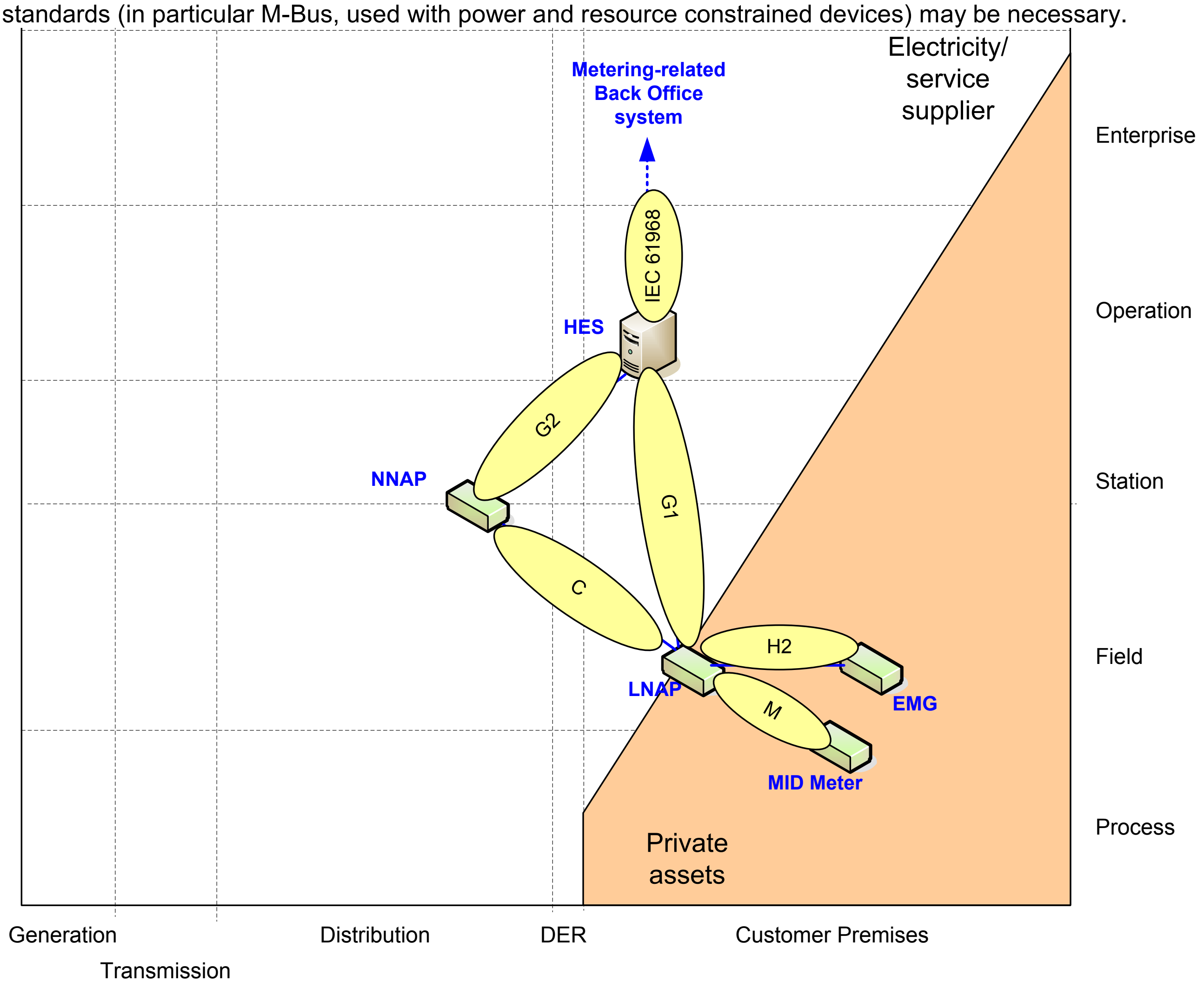


Figure 38: Smart Metering architecture (example) mapped to the SGAM information layer.

8.5.1.4 List of Standards

8.5.1.4.1 Legal metrology

Metering devices installed at domestic or light industry premises are covered by legal metrology. The European Measuring Instruments Directive (MID) 2004/22/EC defines the essential requirements for these meters. The list of harmonized standards supporting the MID can be found in https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/measuring-instruments_en

The metrological aspects of meters not used for domestic and light industry purposes are not covered by any EU directive.

Non-metrological aspects (e.g. communication protocols, data models, interoperability…) of smart meters are not covered by any EU directive.

In the following sections the metrological aspects of smart metering are not considered.

8.5.1.4.2 List of standards

In compliance with section 6.2.2, a standard (or "open specification") that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as "available", meanwhile a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as "Coming".

A list of communication standards which appeared relevant to support an AMI system were given in TR 50572 [4]. This list has been updated to reflect the M/441 report at the end of 2012 and the most recent SM-CG work programme (December 2013)[5] and subsequent updates, and completed with the coming standards.

Additional columns are provided to indicate which interface type is envisaged, with letters referring to the functional architecture given in Figure 35 (C, G1, G2, H2, M).

Note : Some standards contained in Table 41 and Table 42 may also support use cases of "Metering-related Back Office systems" (section 8.5.2) and of "Demand and production (generation) flexibility systems" as stated in section 8.6 below.

Because of the tight connection of this system with telecommunication standards, the tables below also include the list of appropriate communication standards (OSI layers 1 to 3).

Table 41 – AMI system – Standards (outside M/441 scope)

Layer	Available Standard	Coming Standard	Comments
Information	EN 61968 (all parts) EN 61968-9		EN 61968-9 For the link between HES and MDM, CIM Payload definition only. Interface for meter reading and control. Standard for interface between metering systems and other systems within the scope of EN 61968

Table 42 – AMI system – Standards (within M/441 scope)

Extract from SM-CG reports [4] & [5] and subsequent updates as well as the latest SM-CG work programme

AVAILABLE STANDARDS	Available	Coming	M	H1	H2/H3	C	G1	G2	L	N
CLC/TS 50568-4	X			x	x	x				
CLC/TS 50568-8	X			x	x	x				
CLC/TS 50590	X					x			x	x
CLC/TS 52056-8-4	X					x				
CLC/TS 52056-8-5	X					x				
CLC/TS 52056-8-7	X					x			x	x
EN 50065-1	X		x	x	x	x	x		x	x
EN 50090-3-1	X			x	x					
EN 50090-3-2	X			x	x					
EN 50090-3-3	X			x	x					
EN 50090-4-1	X			x	x					
EN 50090-4-2	X			x	x					
EN 50090-4-3	X			x	x					
EN 50090-5-1	X			x	x					
EN 50090-5-2	X			x	x					
EN 50090-5-3	X			x	x					
EN 50090-7-1	X			x	x					
CEN-CLC-ETSI/TR 50572	X		x	x	x	x	x	x	x	x

AVAILABLE STANDARDS	Available	Coming	M	H1	H2/H3	C	G1	G2	L	N
IEC 61334-4-32	X					x				
IEC 61334-4-511	X					x				
IEC 61334-4-512	X					x				
IEC 61334-5-1	X					x				
IEC 62056-1-0	X		x	x	x	x	x	x	x	x
IEC 62056-3-1	X		x			x				
IEC 62056-42	X		x	x			x			
IEC 62056-46	X		x	x		x	x			
IEC 62056-4-7	X					x	x	x		
IEC 62056-5-3	X		x	x		x	x	x		
IEC 62056-6-1	X		x	x		x	x	x		
IEC 62056-6-2	X		x	x		x	x	x		
IEC/TS 62056-6-9	X		x	x		x	x	x		
IEC 62056-7-3		X	x			x				
IEC 62056-7-5	X			x	x					
IEC 62056-7-6	X		x	x		x	x			
IEC 62056-8-20		X				x			x	
IEC 62056-8-3	X					x				
IEC 62056-8-6		X				x				
IEC/TS 62056-9-1	X							x		
IEC 62056-9-7	X						x			
EN 13321 series	X			x	x					
EN 13757-1	X		x	x	x	x				
EN 13757-2	X	X	x	x	x	x				
EN 13757-3	X	X	x	x	x	x				
EN 13757-4	X	X	x	x	x	x				
EN 13757-5	X		x	x	x	x				
EN 13757-6	X		x	x	x	x				
EN 13757-7		X	x	x	x	x				
EN 16836-1		X	x	x	x	x			x	
EN 16836-2		X	x	x	x	x			x	
EN 16836-3		X	x	x	x	x			x	
EN 14908 series	X		x	x	x	x			x	x
CLC prTR 50491-10		X		x	x					
EN 50491-11	X			x	x					
EN 50491-12		X		x	x					
IEEE 802.15.4 series	X		x	x	x	x	x	x	x	x
IEEE 1377	X		x			x	x	x	x	x
IEEE 1901.2	X		x	x	x	x	x	x	x	x
draft-ietf-6tisch-architecture		X	x	x	x	x	x	x	x	x
draft-ietf-6tisch-6top-interface		X	x	x	x	x	x	x	x	x
draft-ietf-6tisch-minimal		X	x	x	x	x	x	x	x	x
IETF RFC 6690 (CoAP)	X		x	x	x	x	x	x	x	x
IETF RFC 7252(CoAP)	X		x	x	x	x	x	x	x	x
IETF RFC 7390(CoAP)	X		x	x	x	x	x	x	x	x
IETF RFC 7641(CoAP)	X		x	x	x	x	x	x	x	x
IETF RFC 7959(CoAP)	X		x	x	x	x	x	x	x	x
IETF RFC 4919	X		x	x	x	x	x	x	x	x
IETF RFC 4944	X		x	x	x	x	x	x	x	x
IETF RFC 6206	X		x	x	x	x	x	x	x	x
IETF RFC 6282	X		x	x	x	x	x	x	x	x
IETF RFC 6550	X		x	x	x	x	x	x	x	x
IETF RFC 6551	X		x	x	x	x	x	x	x	x
IETF RFC 6552	X		x	x	x	x	x	x	x	x

AVAILABLE STANDARDS	Available	Coming	M	H1	H2/H3	C	G1	G2	L	N
IETF RFC 6775	X		x	x	x	x	x	x	x	x
ETSI/ES 202 630		X	x	x	x	x	x	x	x	x
ETSI/TE 103 118 (Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TR 101 531 (Release 1)	X		x	x	x	x	x	x	x	x
ETSI/TR 102 691 (Release 1 & Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TR 102 886	X		x	x	x	x	x	x	x	x
ETSI/TR 102 935	X		x	x	x	x	x	x	x	x
ETSI/TR 102 966 (Release 1)	X		x	x	x	x	x	x	x	x
ETSI/TR 103 055	X		x	x	x	x	x	x	x	x
ETSI/TR 103 167 (Release 1)	X		x	x	x	x	x	x	x	x
ETSI/TS 101 584 (Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 102 221	X		x	x	x	x	x	x	x	x
ETSI/TS 102 240	X		x	x	x	x	x	x	x	x
ETSI/TS 102 241	X		x	x	x	x	x	x	x	x
ETSI/TS 102 412	X		x	x	x	x	x	x	x	x
ETSI/TS 102 569	X		x	x	x	x	x	x	x	x
ETSI/TS 102 671	X		x	x	x	x	x	x	x	x
ETSI/TS 102 689 (Release 1 & Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 102 690 (Release 1 & Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 102 887-1	X		x	x	x	x	x	x	x	x
ETSI/TS 102 887-2	X		x	x	x	x	x	x	x	x
ETSI/TS 102 921 (Release 1 & Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 103 092 (Release 1 & Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 103 093 (Release 1 & Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 103 104 (Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 103 107 (Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 103 383		X	x	x	x	x	x	x	x	x
ETSI/TS 103 603 (Release 2)	X		x	x	x	x	x	x	x	x
ETSI/TS 103 908	X		x	x	x	x	x	x	x	x
ETSI/TS 122 368	X		x	x	x	x	x	x	x	x
ETSI/TS 123 401	X		x	x	x	x	x	x	x	x
ETSI/TS 136 201	X		x	x	x	x	x	x	x	x
ETSI/TS 136 211	X		x	x	x	x	x	x	x	x
ETSI/TS 136 212	X		x	x	x	x	x	x	x	x
ETSI/TS 136 213	X		x	x	x	x	x	x	x	x
ETSI/TS 136 214	X		x	x	x	x	x	x	x	x
ETSI/TS 136 216	X		x	x	x	x	x	x	x	x
ETSI/TS 136 300	X		x	x	x	x	x	x	x	x

AVAILABLE STANDARDS	**Available**	**Coming**	**M**	**H1**	**H2/H3**	**C**	**G1**	**G2**	**L**	**N**
ETSI/TS DTS/PLT-00031		**X**	x	x	x	x	x	x	x	x
ITU-T Recommendations G.9902	X			x		x			x	
ITU-T Recommendations G.9903	X	X		x		x			x	
ITU-T Recommendations G.9904	X			x		x			x	

8.5.2 Metering-related Back Office systems

8.5.2.1 System description

Metering-related Back Office systems refer to a range of back-office systems employed to use and manage data deriving from smart metering, mostly referring to the Meter data management (MDM) related application.

The drawing behind shows the typical hosted applications:

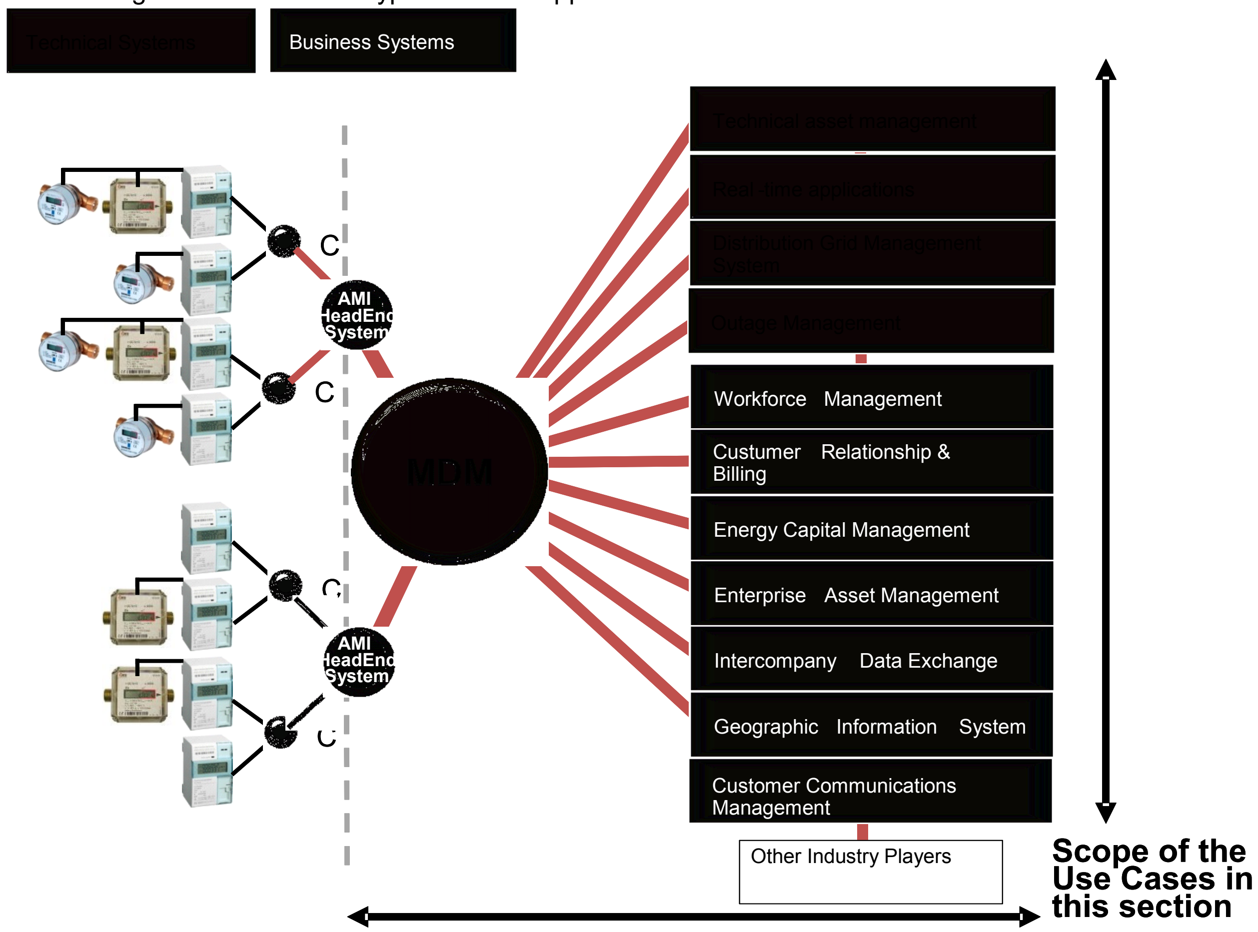


Figure 39 - Typical applications hosted by a metering-related back-office system

8.5.2.2 Set of use cases

Here is a set of Generic Use-Cases developed by ESMIG which may be supported by a Metering-related Back Office system.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.
Work is in hand to integrate these use cases with those identified for the AMI in section 8.5.1.2.

Table 43 - Metering-related Back Office system - use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Monitor AMI event	Install, configure and maintain the metering system	CI		
	Manage power quality data	CI		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
	Manage outage data	CI		
	Manage the network using metering system data	CI		
	Manage interference to metering system	CI		
	Enable and disable the metering system	CI		
	Display messages	CI		
	Facilitate der for network operation	CI		
	Facilitate demand response actions	CI		
	Interact with devices at the premises	CI		
	Manage efficiency measures at the premise using metering system data	CI		
	Demand side management	CI		
Billing	Obtain meter reading data	CI		
	Support prepayment functionality	CI		
	Manage tariff settings on the metering system	CI		
	Consumer move-in/move-out	CI		
	Supplier change	CI		

8.5.2.3 Mapping on SGAM

8.5.2.3.1 Preamble

Metering-related back office systems are widely different in nature, but have as their common element use of the AMI system.

8.5.2.3.2 Component layer

Metering-related back office systems may be understood as comprising such systems as the head-end system, meter data management system, asset and workforce management systems, distribution management systems (including SCADA), geographic information systems and outage management, inter-company data exchange, customer information and relationship management systems and consumer internet portals.

The components which may be envisaged in such systems are shown below.

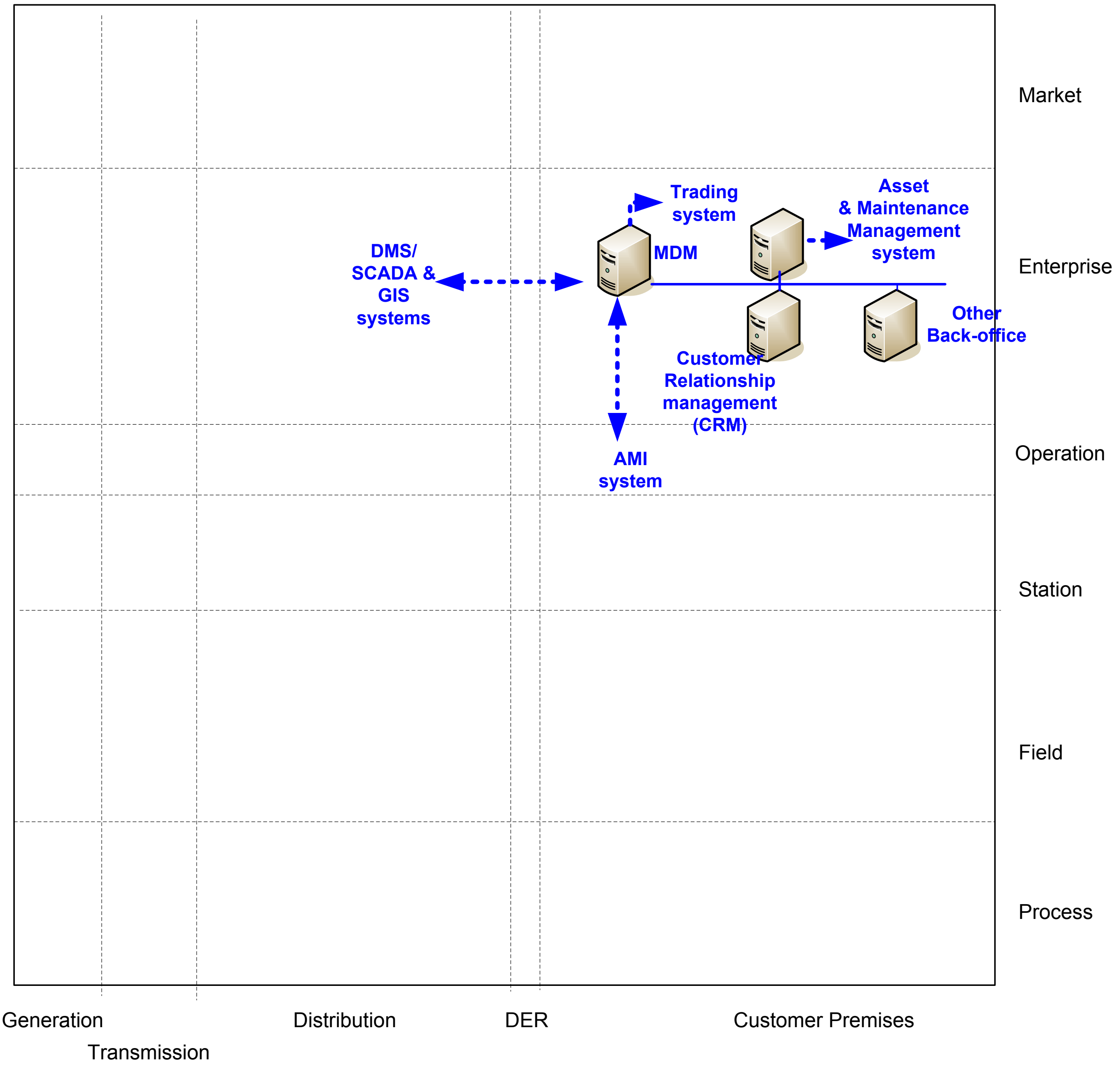


Figure 40 - Metering-related Back Office system - Component layer

8.5.2.3.3 Communications layer

The main communication standard likely to be applicable to such back-office systems is EN 61968-100.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

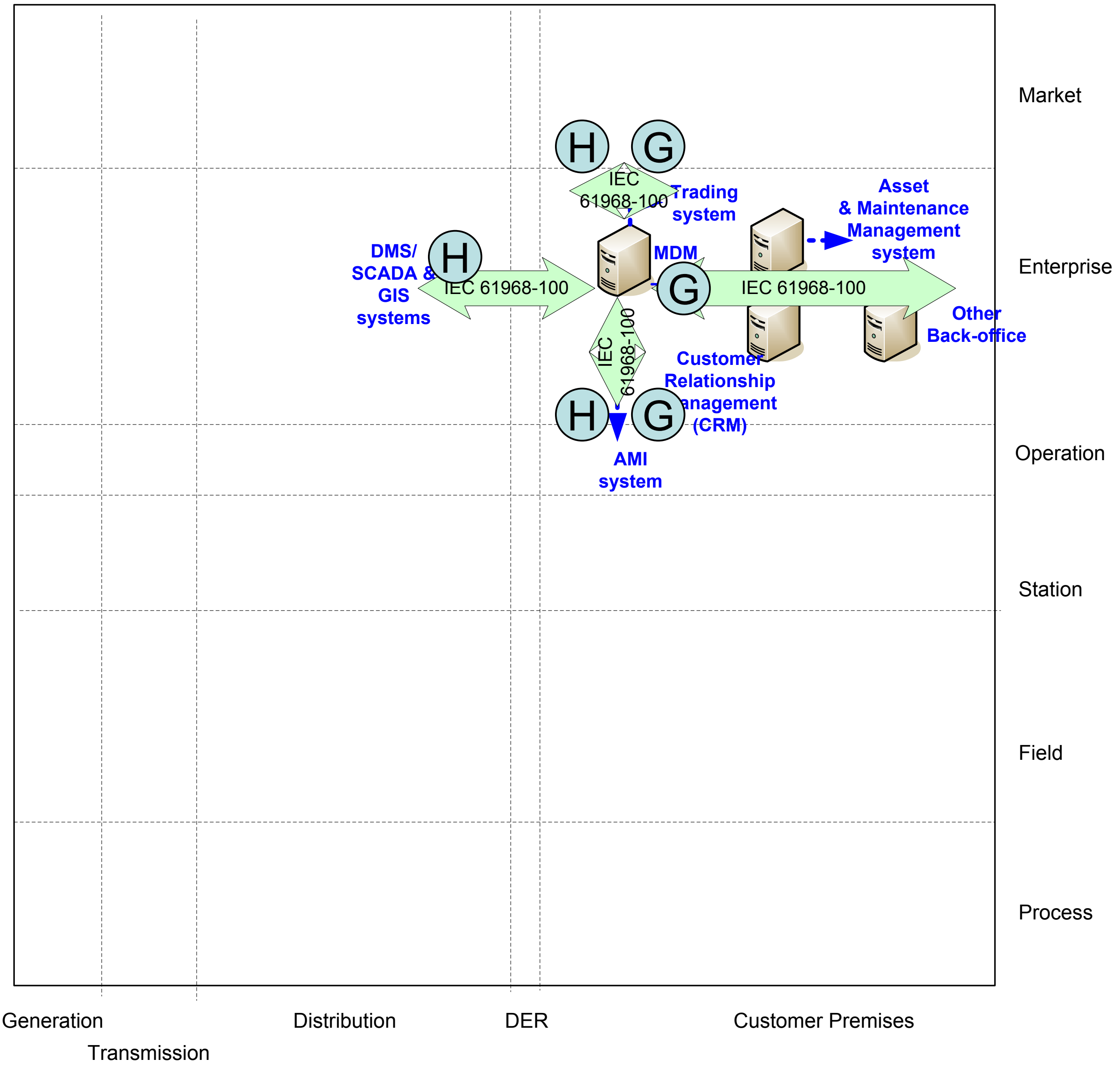


Figure 41 - Metering-related Back Office system - Communication layer

8.5.2.3.4 Information (Data) layer

The main information model standards are COSEM and EN 61968-9 (CIM for metering).

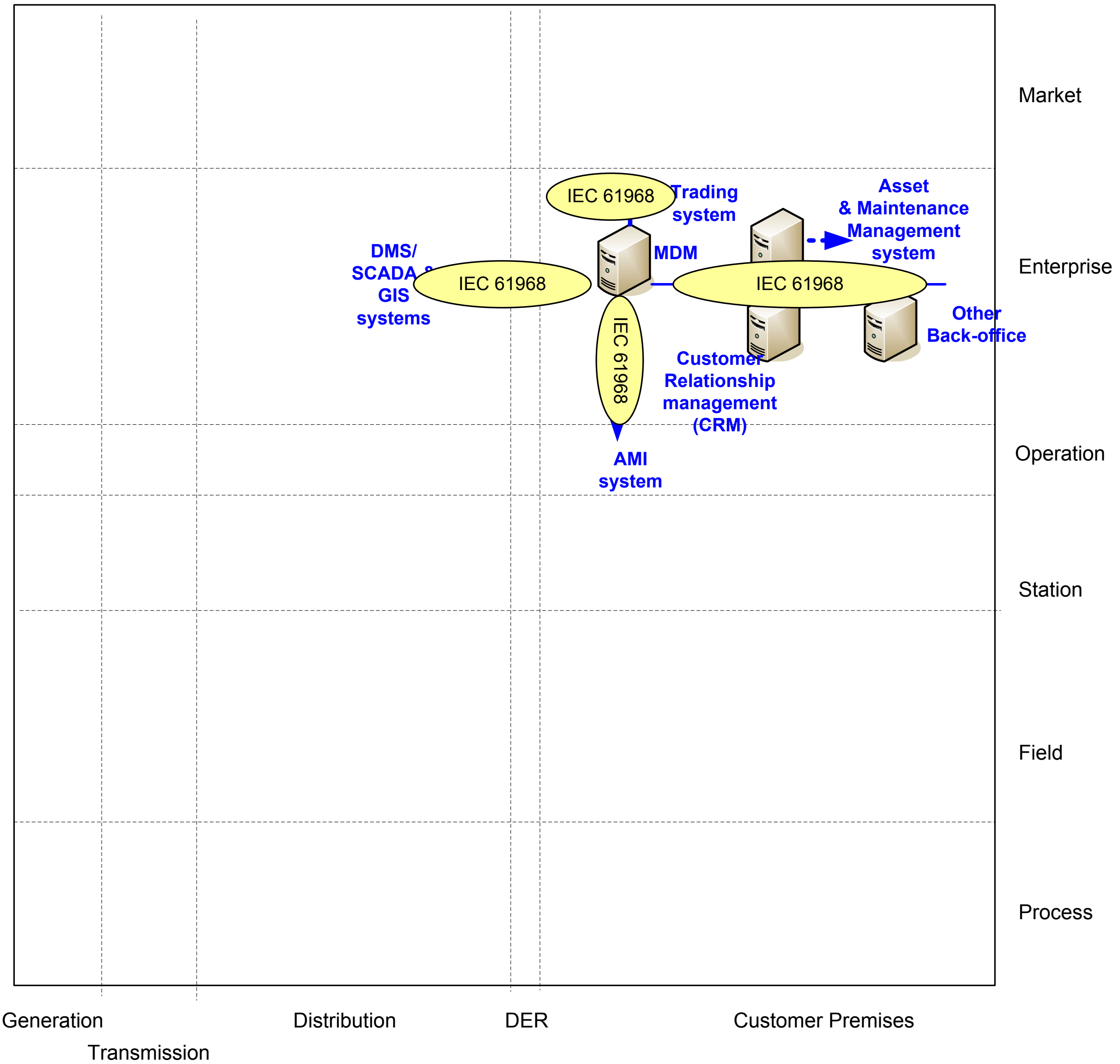


Figure 42 - Metering-related Back Office system - Information layer

8.5.2.4 List of Standards

Here is the summary of the standards which appear relevant to support metering back office systems:

8.5.2.4.1 Available standards

In compliance with section 6.2.2, a standard (or "open specification") that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as "available".

Table 44 - Metering-related Back Office system – Available standards

Layer	**Standard**	**Comments**
Communication	EN 61968 (all parts)	Interface architecture and general requirements.

Layer	Standard	Comments
Information	EN 61968-9	Interfaces for meter reading and control
Communication	EN 61968-100	Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)

8.5.2.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 45 - Metering-related Back Office system – Coming standards

Layer	Standard	Comments
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.4)

8.6 Demand and production (generation) flexibility systems

8.6.1 Aggregated prosumers management system

8.6.1.1 System description

The aggregated prosumers management system comprises the AMI itself, the HAN gateway, customer energy management systems (CEM), building management systems and Smart devices. These are elements in a demand response management system, which offers alternative channels to the home/building, the AMI being one of them.

8.6.1.2 Set of use cases

Here is a set of high level use cases which may be supported by an aggregated prosumers management system.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 46 - Aggregated prosumers management system - use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Demand and production (generation) flexibility	Receiving metrological or price information for further action by consumer or CEM	**CI**		
Demand and production (generation) flexibility	Direct load/generation control signals	**C**		**I**
Demand and production (generation) flexibility	Managing energy consumption or generation of DERs via local DER energy management system bundled in a DR program	**C**		**I**
System and security management	Registration/de-registration of smart devices	**C**		**I**
	Enabling remote control of smart devices	**C**		**I**

8.6.1.3 Mapping on SGAM

Flexibility can be effected directly by an enterprise (any authorized actor) by means of a suitable WAN communication management system linking the enterprise’s user management system with the energy management gateway at the customer premises level, and thence to Customer Energy Management System (CEM), smart appliances or generation equipment. Alternatively the AMI can be used, with communications routed via utility’s HES, NNAP and LNAP (dependent on the AMI configuration used).

8.6.1.3.1 Preamble

Interfaces where the demand response management system utilizes the AMI as the channel to the home/building were identified under the M/441 mandate [3] as the H2 and H3 interfaces (see CLC TR 50572 [4] and the reference architecture diagram included as Figure 35 in 8.5.1.1above).

H2 refers to communication between the Local Network Access Point (LNAP) and the Energy Management Gateway. H3 refers to communication between the Neighborhood Network Access Point (NNAP) and the Energy Management Gateway.

These links are being addressed by IEC TC57 WG21 and CLC TC 205 WG18. Their work program also considers the interface with the CEM and from there to connected devices – smart appliances, displays etc, which are not within the scope of M/490.

Note that the Energy Management Gateway and the Customer Energy Management System may be integrated.

The diagrams in the sections below give examples of a mapping of a typical configuration based on the smart metering reference architecture on the SGAM.

Both in these diagrams in section 8.6.1 and in similar ones in section 8.5.1, the split of the “customer premises” domain on the right is intended to illustrate a typical market model where assets in the home/building are not owned/operated by the electricity service supplier. However Member State market models vary e.g. as regards meter ownership and operation, and are subject to national structures and regulation, so this representation should not be seen as definitive.

The blue zone indicates that such a system may rely on the AMI system to carry some data.

8.6.1.3.2 Component layer

As outlined in the TR50572 reference architecture, the principal functional components used for flexibility purposes are the CEM and HAN, and – if utilizing the AMI - the smart meter, the LN & LNAP and NN & NNAP, the WAN, MDM and HES, as indicated below.

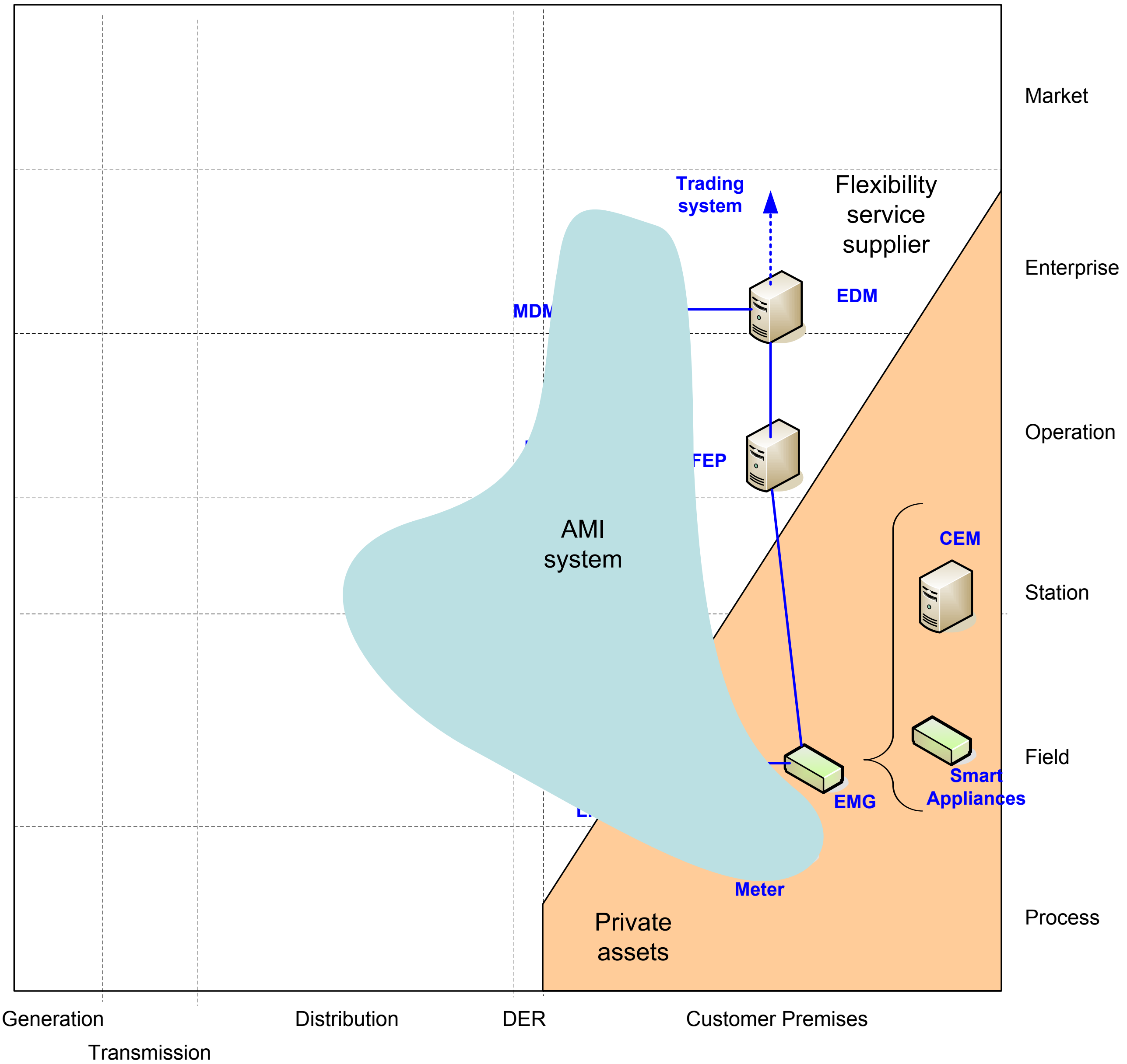


Figure 43 - Aggregated prosumers management system (example) - Component layer

8.6.1.3.3 Communications layer

TR 50572 sets out the relevant communications layers for these components and applications.

Further work is underway in IEC TC57 WG21 and CLC TC 205 WG18 to develop these.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

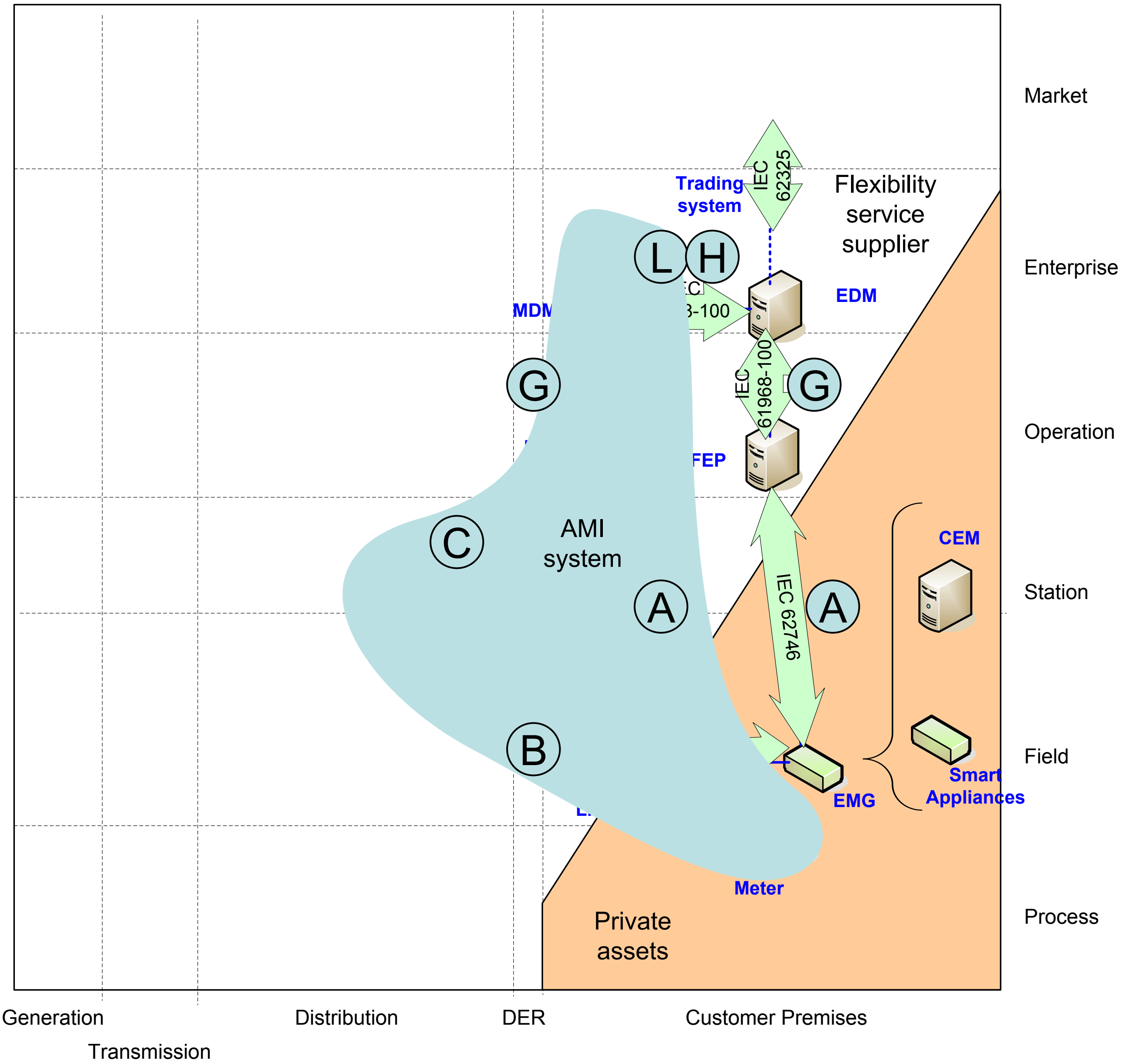
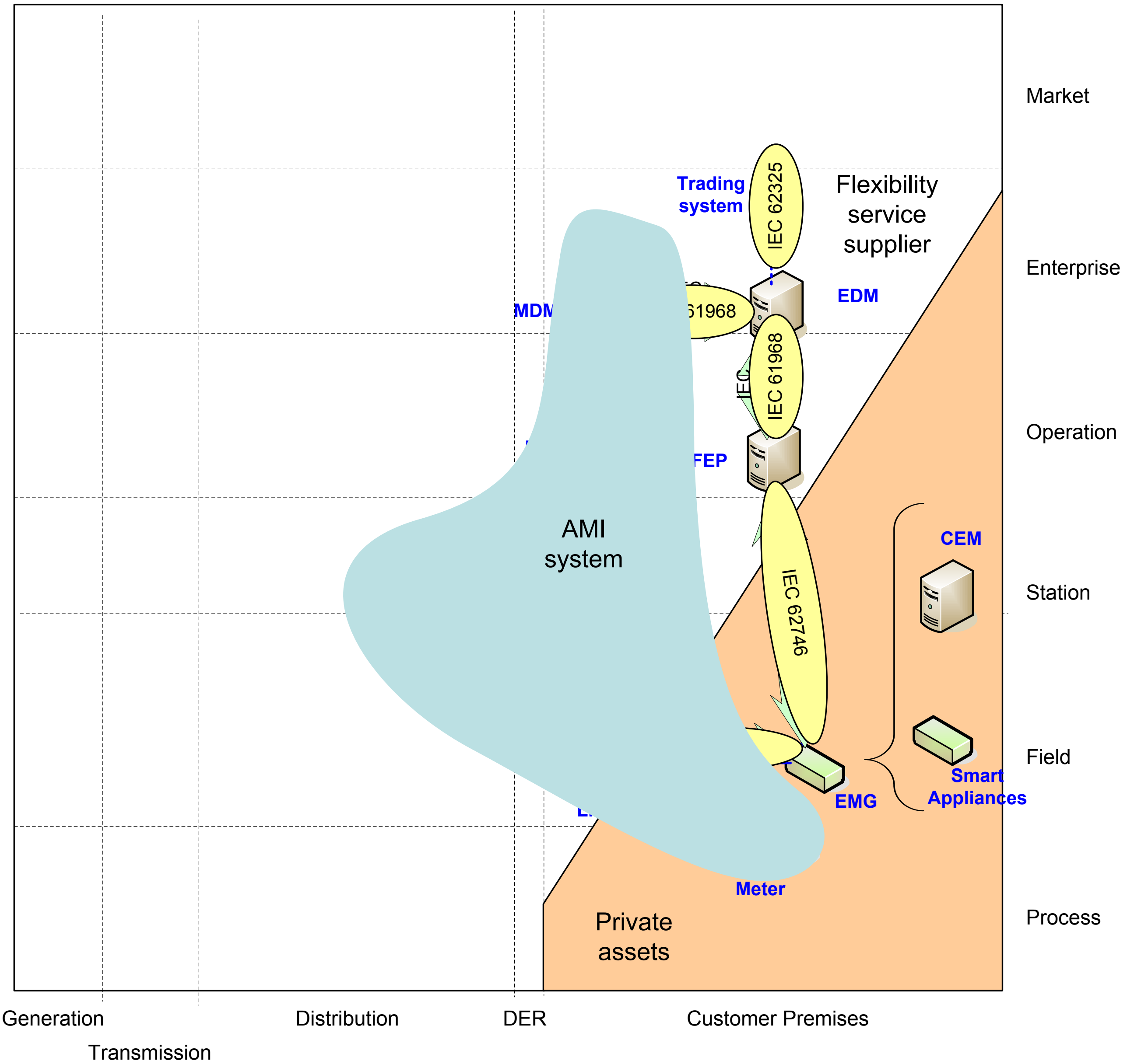


Figure 44 - Aggregated prosumers management system (example) - Communication layer

2857 *8.6.1.3.4 Information (Data) layer*

2858



2859

2860 **Figure 45 - Aggregated prosumers management system (example) - Information layer**

2861 8.6.1.4 List of Standards

2862 Here is the summary of the principal standards which appear relevant to support aggregated prosumers
2863 management systems:
2864 The list below should also be read in conjunction with those “available” or “coming” cross-cutting standards
2865 supporting the telecommunication technologies detailed in section 9, attached to the network types
2866 presented above (identified with their letter in the blue disks in Figure 44).
2867

2868 *8.6.1.4.1 Available standards*

2869 In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS
2870 or TR, …) by Dec 31st 2015 is considered as “available”.
2871 As for AMI system, which may participate to the building-up of such a system, we will rely on CLC TR 50572
2872 set of standards definition.
2873

Table 47 - Aggregated prosumers management system – Available standards

Layer	Standard	Comments
Information, Communication	EN 61968 (all parts)	
Information, Communication	(refer to 8.5.1.4)	Refer to AMI system section 8.5.1.4
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)
Communication, Information	IEC 62746-10-1	IEC/PAS based on OpenADR[9]
Communication, Information	EN 62325	Framework market communication

8.6.1.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 48 - Aggregated prosumers management system– Coming standards

Layer	Standard	Comments
Information	*EN 50491-12*	(pr) (fits CLC TR 50572 type H2/H3 needs) - Smart grid - Application specification. Interface and framework for customer energy management
Communication	*IEC 62746*[10]	System interfaces and communication protocol profiles relevant for systems connected to the Smart Grid
Information, Communication	*(refer to 8.5.1.4)*	Refer to AMI system section 8.5.1.4
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.4)
Communication, Information	*EN 62325*	Framework market communication

[9] Note : The cross-check between what Europe has considered as main use cases for DR and what IEC 62746-10-1(OpenADR) is offering is on-going.
This IEC/PAS 62746-10-1 is first proposed over simple HTTP transport layer, or over XMPP– refer to 9.3.5

[10] IEC 62746 is “transport” communication neutral in principle, but first mappingshould be proposed over XMPP at least – refer to 9.3.5

8.7 Marketplace system

8.7.1 Market places

8.7.1.1 System description

A marketplace refers to a system where buyers and sellers of a commodity (here related to electricity) meet to purchase or sell a product in a transparent and open manner according to guidelines called market rules.
We can differentiate several kinds of market places depending on the product sold on the marketplace:

- Wholesale electricity marketplace operated by power exchanges
- Marketplaces for products needed for grid reliability (transmission capacity, ancillary services, balancing energy) operated by Transmission System Operators
- Forward capacity markets to secure adequacy of supply
- Retail market places for instance to buy and sell flexibility

Furthermore markets can be differentiated based on geographical coverage starting from local markets (i.e. within a microgrid area) to regional, country wide and cross-country markets.
The marketplace systems are accessed by so-called market participants who can be electricity power producers, suppliers, industrial consumers, virtual power plants, aggregators, DER operators etc.

8.7.1.2 Set of use cases

This section lists a set of high level use cases relevant to market systems.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the "C", "I", "CI", "X" conventions are given in section 7.6.2.

Table 49 - Marketplace system - use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Operate wholesale electricity market	Receive energy offers and bids	CI[11]		
	Clear day-ahead market			X
	Clear intraday market			X
	Clear real-time market			X
	Publish market results	CI[12]	I[13]	
Grid reliability using market-based mechanisms	Manage (auction/resale/curtailment) transmission capacity rights on interconnectors	CI[14]		
	Consolidate and verify energy schedules	CI[15]		
	Operate (register/bidding/clearing/publishing) Ancillary Services Markets	CI[16]	I[17]	
	Solve balancing issues through Balancing Market	CI[18]	I[19]	

[11] IEC 62325-451-2 and IEC 62325-451-3 and IEC 62325-451-6

[12] IEC 62325-451-6 and IEC 62325-451-4

[13] ENTSO-E documents based on CIM for Capacity Allocation and Congestion Management guideline (publication of ptdf, critical network element, remedial action, etc.)

[14] IEC 62325-451-3

[15] IEC 62325-451-2

[16] IEC 62325-451-6

[17] Under development within ENTSO-E for the Electricity Balancing guideline. Some documents are already available for bidding and clearing

[18] IEC 62325-451-6

[19] Under development within ENTSO-E for the Electricity Balancing guideline. Some documents are already available for bidding and clearing

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
	Solve grid congestion issues through Balancing Market	CI[20]	I[21]	
Market Settlements	Perform M&V	CI[22]		
	Perform settlements	CI[23]		
Secure adequacy of supply	Operate Capacity Markets	C	I[24]	
Flexibility markets	Register Flexibility Markets	C	I[25]	

8.7.1.3 Mapping on SGAM

8.7.1.3.1 Preamble

Most of the use cases listed previously involve a central marketplace operator (whether the operator of a power exchange or TSO) and market participants. Hence those are mostly links between IT systems located at the market, enterprise and, in some cases, operation levels.

8.7.1.3.2 Component layer

The following components are involved:

- Trading systems at enterprise zone. Trading systems are used at various areas such as Generation and DER
- Operation systems at operation zone. They interact with trading systems to translate commercial/contractual positions into physical orders to be transmitted to lower zones (Process, Fields)

The following diagram summarizes the way components are linked.

[20] IEC 62325-451-6

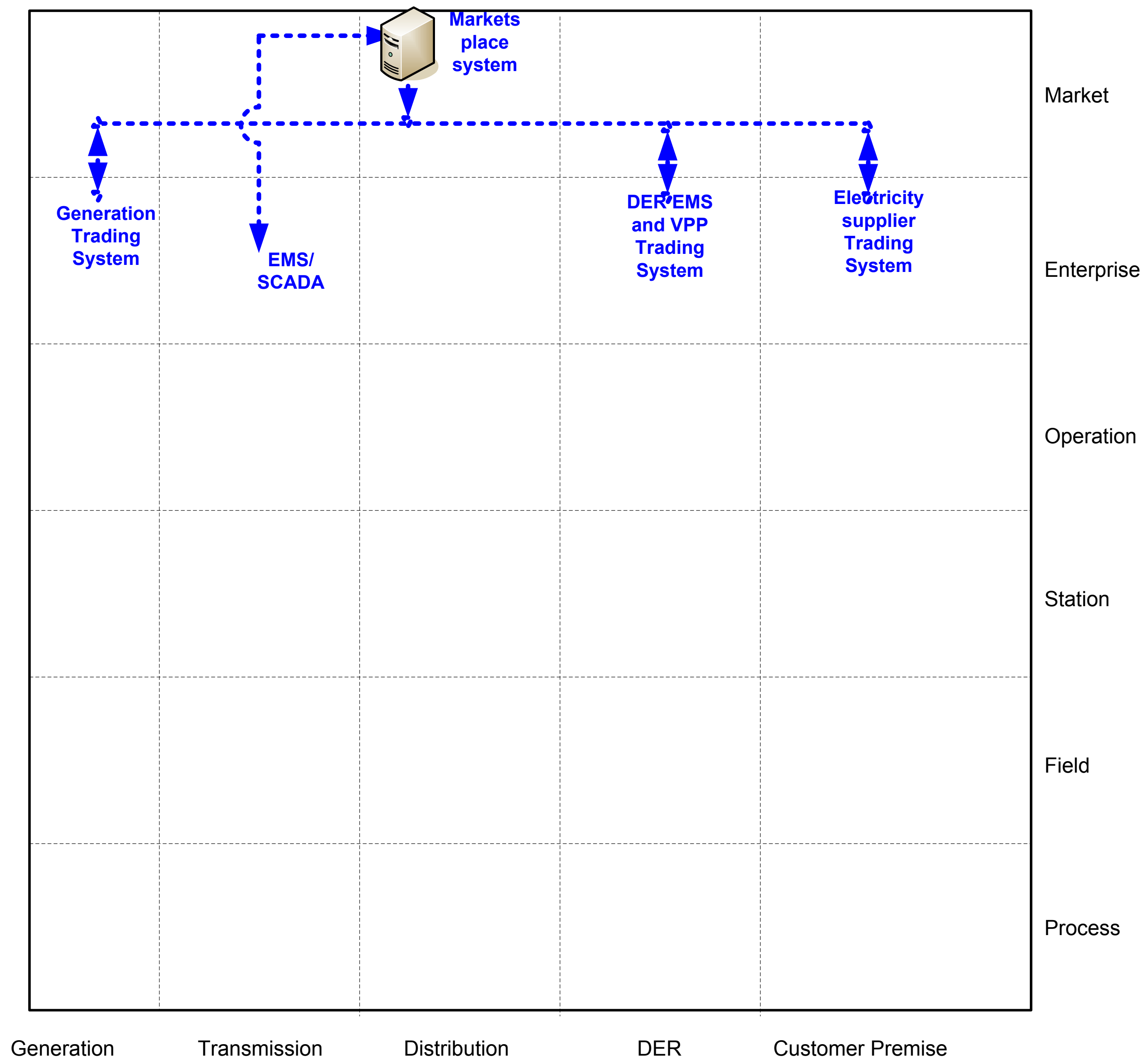
[21] Under development within ENTSO-E for the Electricity Balancing guideline. Some documents are already available for bidding and clearing

[22] IEC 62325-451-4

[23] IEC 62325-451-4

[24] Under development within ENTSO-E for the Electricity Balancing guideline.

[25] Under development within ENTSO-E for the Electricity Balancing guideline.



2917

2918 **Figure 46 - Marketplace system - Component layer**

2919

8.7.1.3.3 Communication layer

Markets involve data exchange between the central market place systems and market participants' IT systems (trading systems).
The communication layer is mostly around EN 62325-450 and 62325-451-1.
Worldwide standards such as SOA, XML, SOAP etc … are leveraged as much as possible according to Enterprise Service Bus pattern.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

This set of standards can be positioned this way on the communication layer of SGAM.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

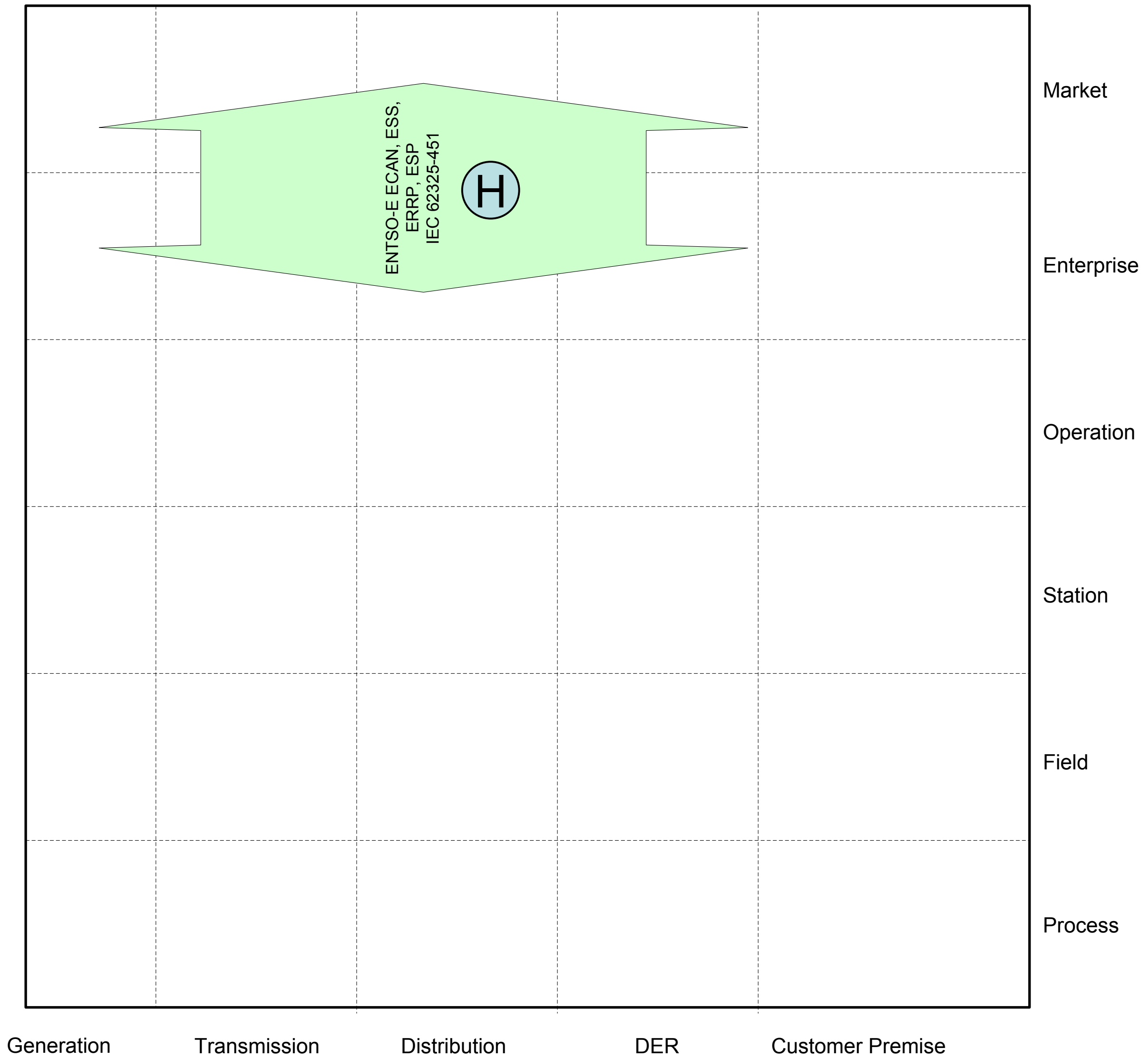


Figure 47 - Marketplace system - Communication layer

8.7.1.3.4 Information (Data) layer

Markets involve information exchange between the central market place systems and market participants IT systems (trading systems).
The information layer is mostly around IEC 62325-301 and 62325-351 using the ENTSO-E Market Data Exchange Standard (MADES) as a reference.
This set of standards can be positioned this way on the communication layer of SGAM.

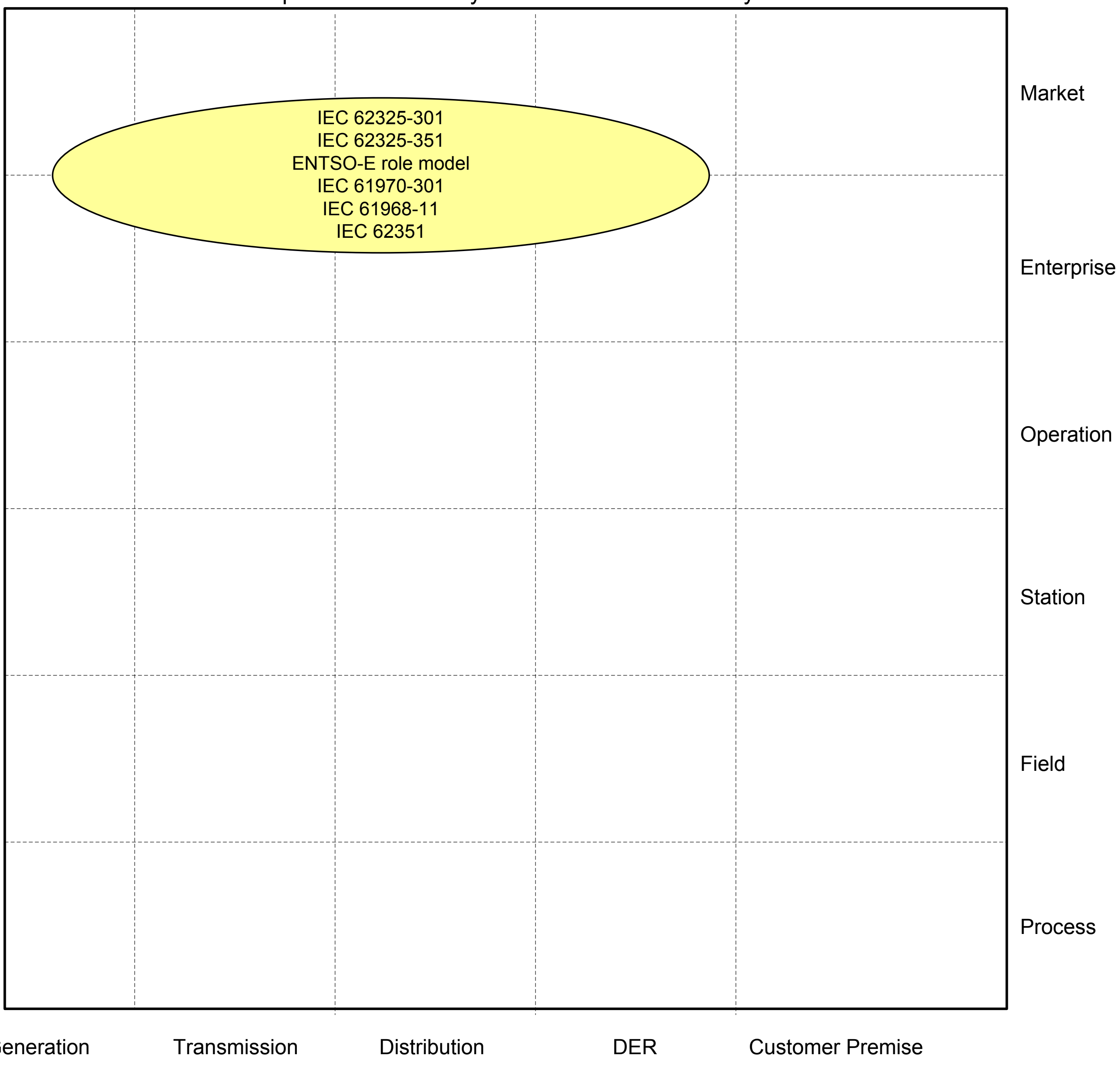


Figure 48 - Marketplace system - Information layer

8.7.1.4 List of Standards

The summary of the standards which appear relevant to support marketplace systems are listed hereafter

8.7.1.4.1 Available standards

In compliance with section 6.2.2, a standard (or "open specification") that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as "available".

Table 50 - Marketplace system – Available standards

Layer	Standard	Comment
Information	Harmonized Electricity Market Role Model	Joint ENTSO-E, ebIX ®, EFET
Information	ENTSO-E Metadata repository (EMR) glossary	ENTSO-E
Information	ENTSO-E Market Data Exchange Standard (MADES)	IEC 62325-503 TS – an IS is under development
Information	ENTSO-E Scheduling System (ESS)	Latest revision V4R1
Information	IEC 62325-451-2	Scheduling business process and contextual model for CIM European market
Information	ENTSO-E Reserve Resource Planning (ERRP)	Latest revision V5R0 Waiting publication of Electricity Balancing guideline and System Operation guideline
Information	ENTSO-E Capacity Allocation and Nomination (ECAN)	Latest revision V6R0
Information	IEC 62325-451-3	Transmission capacity allocation business process (explicit or implicit auction) and contextual models for European market
Information	ENTSO-E Settlement Process (ESP)	Latest revision V1R2
Information	IEC 62325-451-4	Settlement and reconciliation business process, contextual and assembly models for European market
Information	ENTSO-E acknowledgement process	Latest revision V5R1
Information	IEC 62325-451-1	Acknowledgement business process and contextual model for CIM European market
Information	ENTSO-E problem statement process and status request	Latest revision V3R0
Information	IEC 62325-451-5	Problem statement and status request business processes, contextual and assembly models for European market
Information	HVDC link process	ENTSO-E publication based on CIM
Information	Critical network element	ENTSO-E publication based on CIM
Information	Balancing publication	ENTSO-E publication based on CIM
Information	Generation and Load shift key	ENTSO-E publication based on CIM
Information	Weather process energy prognosis	ENTSO-E publication based on CIM
Information	Contingency list, remedial action and additional constraints (CRAC)	ENTSO-E publication based on CIM
Information	EN 61968/61970 (all parts)	Common Information model
Information	EN 61970-301	Common Information model
Information	EN 62325-301	Common Information model for markets
Communication	IEC 62325-503	(TS) Market data exchanges guidelines for the IEC 62325-351 profile
Communication	IEC 62325-504	(TS) Utilization of web services for electronic data interchanges on the European energy market for electricity
Information	EN 62325-351	Framework for energy market communications – Part 351: CIM European Market Model Exchange Profile
Information	EN 62361-100	Power systems management and associated information exchange – Interoperability in the long term – Part

Layer	Standard	Comment
		100: Naming and design rules for CIM profiles to XML schema mapping
Information	EN 62325-450	Framework for energy market communications - Part 450: Profile and context modeling rules

8.7.1.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 51 - Marketplace system – Coming standards

Layer	Standard	Comment
Information	*EN 61968/61970 (all parts)*	New CIM edition
Information	*EN 62325-301*	Framework for energy market communications – Part 301: Common Information Model (CIM) Extensions for Markets
Information	*EN 62325-351*	(available 2016-01-15) Framework for energy market communications – Part 351: CIM European Market Model Exchange Profile
Information	*EN 62325-451-1*	(Available 2016-07-29)
Information	*IEC/EN 62325-451-6*	(Available 2016-05-04) Transparency Regulation
Information	*IEC 62361-101*	Common Information Model Profiles

8.7.2 Trading systems

8.7.2.1 System description

Trading systems are used by market participants to interact with other market participants or with central market places. Trading Systems encompass various functions which cover but are not limited to front-office (contract management, deal capture, bidding, risk management etc.) and back-office (settlements). Market participants are generators, suppliers, industrial consumers, virtual power plants, aggregators, DER operators etc.

8.7.2.2 Set of use cases

This section lists a set of high level use cases relevant to trading systems.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 52 - Trading system - use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Trading front office operation	Capture and manage contracts			X
	Bid into energy markets			X
	Compute optimized assets schedules to match commercial contracts			X
	Send assets schedules to operation systems			X
	Bid into ancillary services markets			X
	Purchase transmission capacity rights	CI		
	Nominate schedules to system operator	CI		
	Send market schedules to operation systems			X
	Publish market results			X
Trading back office operation	Perform measurement and validation (M&V)			X
	Perform shadow settlements			X

8.7.2.3 Mapping on SGAM

8.7.2.3.1 Preamble

Most of the use cases listed previously involve market participants and interactions between them or with central market places. Hence those are mostly links between IT systems located at the Market, Enterprise and some cases Operation levels.
Communication with physical process is assumed to be performed via EMS, DMS, DER operation desk etc.

8.7.2.3.2 Component layer

The following components are involved:

- Markets: central market place trading systems will interact with
- Operation Systems at Operation zone. They interact with Trading Systems to translate commercial/contractual positions into physical orders to be transmitted to lower zones (Process, Fields)

The following diagram summarizes the way components are linked.

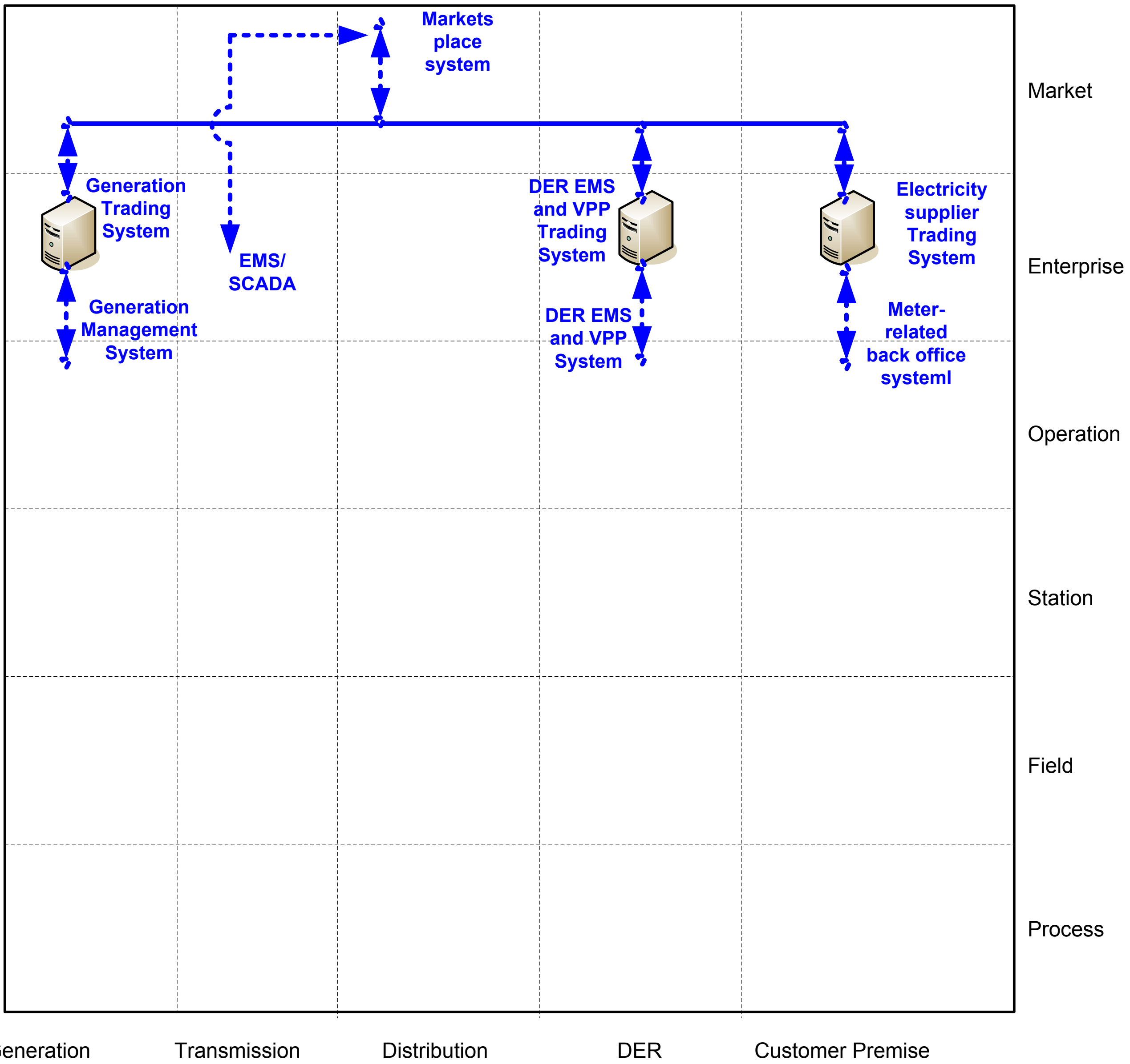


Figure 49 - Trading system - Component layer

8.7.2.3.3 Communication layer

Trading systems involve data exchange between the central marketplace systems and market participants operation IT systems.
The communication layer with markets is mostly around EN 62325-450 and 62325-451-1 for interaction with marketplaces, using the ENTSO-E Market Data Exchange Standard (MADES) as a reference.
However, most of the business processes at trading system level have not been standardized yet. One can note however the work performed by ebIX ® and EFET on this matter.
This set of standards can be positioned this way on the communication layer of SGAM.

Please refer to section 9.4 for getting details on cyber-security standards and more specifically on where and how to apply the IEC 62351 standard series and/or other cyber-security mechanisms.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

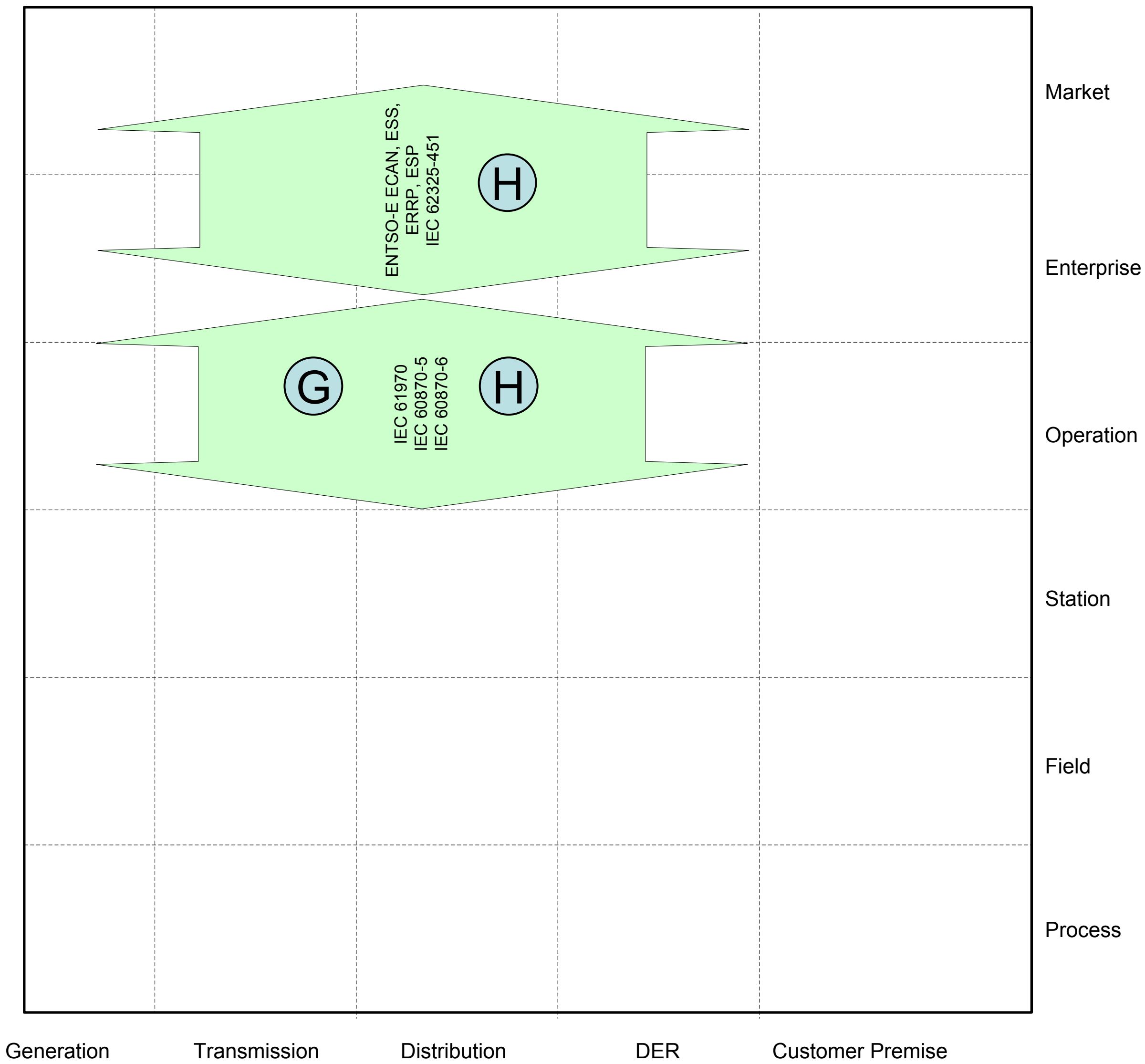


Figure 50 - Trading system - Communication layer

8.7.2.3.4 Information (Data) layer

Trading Systems involve information exchange between the central market place systems and market participant's operation systems.
The information layer is mostly around IEC 62325, 61970 and 61968 (including the 61968-11 dealing with Common information model (CIM) extensions for distribution).
This set of standards can be positioned this way on the communication layer of SGAM.

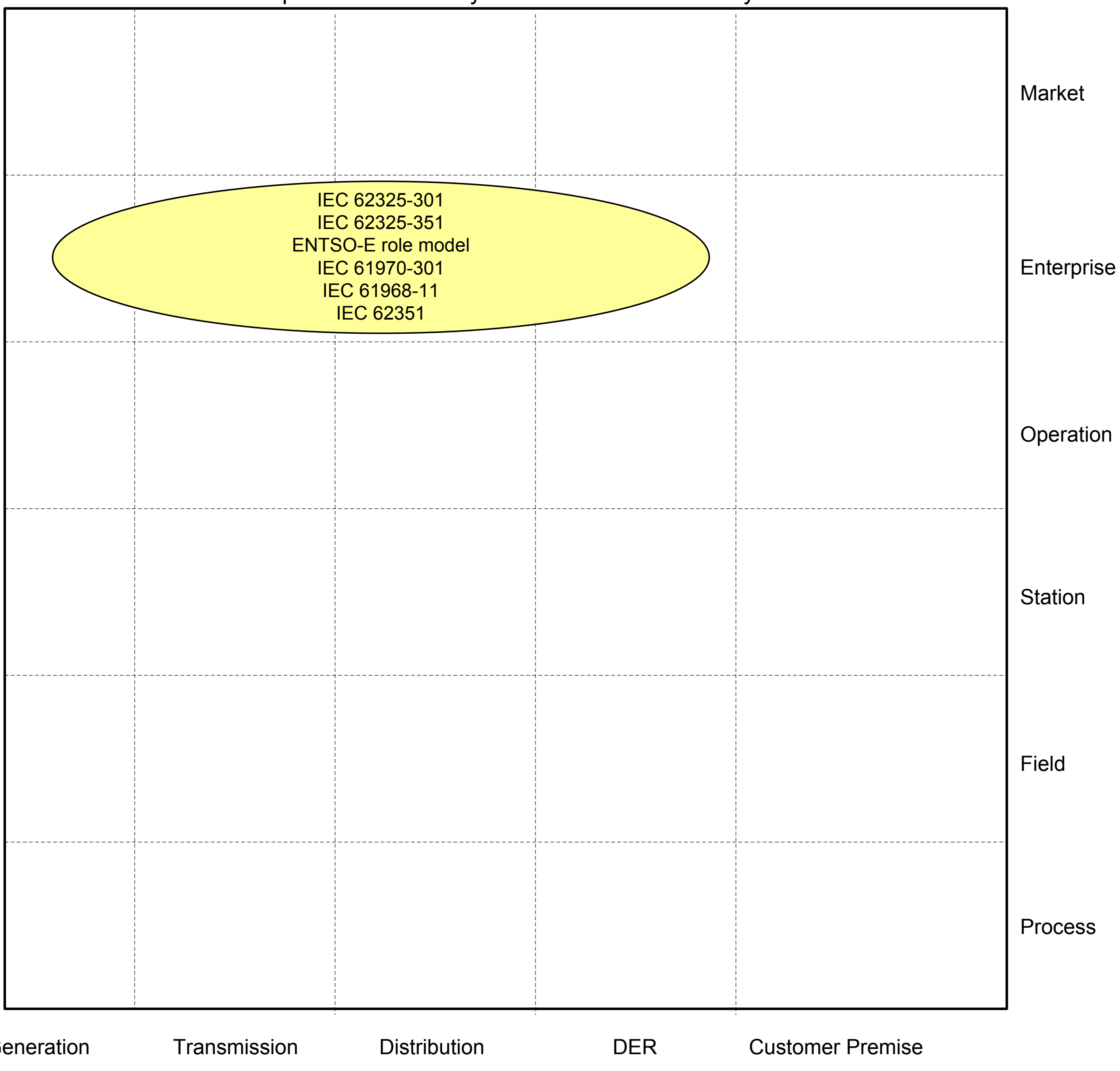


Figure 51 - Trading system - Information layer

8.7.2.4 List of Standards

Beside IEC work (mostly 62325), some work has been initiated by ebIX ® and EFET.
The purpose of ebIX ®, the European forum for energy Business Information eXchange, is to advance, develop and standardize the use of electronic information exchange in the energy industry. The main focus is on interchanging administrative data for the internal European markets for electricity and gas.
EFET is a group of more than 100 energy trading companies from 27 European countries dedicated to stimulate and promote energy trading throughout Europe.
The summary of the standards which appear relevant to support marketplaces systems are listed below.

8.7.2.4.1 Available standards

3022 In compliance with section 6.2.2, a standard (or "open specification") that has reached its final stage (IS, TS
3023 or TR, …) by Dec 31st 2015 is considered as "available".

3024 **Table 53 - Trading system – Available standards**

Layer	Standard	Comment
Information	Harmonized Electricity Market Role Model	Joint ENTSO-E, ebIX ®, EFET
Information	ENTSO-E Metadata repository (EMR) glossary	ENTSO-e
Information	ENTSO-E Market Data Exchange Standard (MADES)	IEC 62325-503 TS – an IS is under development
Information	ENTSO-E Scheduling System (ESS)	Latest revision V4R1
Information	IEC 62325-451-2	Scheduling business process and contextual model for CIM European market
Information	ENTSO-E Reserve Resource Planning (ERRP)	Latest revision V5R0 Waiting publication of Electricity Balancing guideline and System Operation guideline
Information	ENTSO-E Capacity Allocation and Nomination (ECAN)	Latest revision V6R0
Information	IEC 62325-451-3	Transmission capacity allocation business process (explicit or implicit auction) and contextual models for European market
Information	ENTSO-E Settlement Process (ESP)	Latest revision V1R2
Information	IEC 62325-451-4	Settlement and reconciliation business process, contextual and assembly models for European market
Information	ENTSO-E acknowledgement process	Latest revision V5R1
Information	IEC 62325-451-1	Acknowledgement business process and contextual model for CIM European market
Information	ENTSO-E problem statement process and status request	Latest revision V3R0
Information	IEC 62325-451-5	Problem statement and status request business processes, contextual and assembly models for European market
Information	HVDC link process	ENTSO-E publication based on CIM
Information	Critical network element	ENTSO-E publication based on CIM
Information	Balancing publication	ENTSO-E publication based on CIM
Information	Generation and Load shift key	ENTSO-E publication based on CIM
Information	Weather process energy prognosis	ENTSO-E publication based on CIM
Information	Contingency list, remedial action and additional constraints (CRAC)	ENTSO-E publication based on CIM
Information	EN 61968/61970 (all parts)	Common Information model
Information	EN 61970-301	Common Information model
Information	EN 62325-301	Common Information model for markets
Communication	IEC 62325-503	(TS) Market data exchanges guidelines for the IEC 62325-351 profile
Communication	IEC 62325-504	(TS) Utilization of web services for electronic data interchanges on the European energy market for electricity

Layer	Standard	Comment
Information	EN 62325-351	Framework for energy market communications – Part 351: CIM European Market Model Exchange Profile
Information	EN 62361-100	Power systems management and associated information exchange – Interoperability in the long term – Part 100: Naming and design rules for CIM profiles to XML schema mapping
Information	EN 62325-450	Framework for energy market communications - Part 450: Profile and context modeling rules

8.7.2.4.2 Coming standards

In compliance with section 6.2.2,¸a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 54 - Trading system – Coming standards

Layer	Standard	Comment
Information	*EN 61968/61970 (all parts)*	New CIM edition
Information	*EN 62325-301*	Framework for energy market communications – Part 301: Common Information Model (CIM) Extensions for Markets
Information	*EN 62325-351*	(available 2016-01-15) Framework for energy market communications – Part 351: CIM European Market Model Exchange Profile
Information	*EN 62325-451-1*	(Available 2016-07-29)
Information	*IEC/EN 62325-451-6*	(Available 2016-05-04) Transparency Regulation
Information	*IEC 62361-101*	Common Information Model Profiles

8.8 E-mobility System

8.8.1 System description

E-mobility comprises all elements and interfaces which are needed to efficiently operate Electric Vehicles including the capability to consider them as a flexibility resource in a Smart Grid system.

E-Mobility is one option for a Smart Grid in respect to the integration of energy storage and therefore the integration of renewable energies. Furthermore it would serve the conservation of individual mobility in times of decreasing fossil fuel supply. The full scope of its capability, however, can only be achieved by seamless integration into a Smart Grid architecture. E-Mobility provides a large, flexible load and storage capacity for the Smart Grid. This however depends on the use cases, some of which are not capable of contributing to these advantages. Basic charging (charging the car at an existing plug today) does not offer the full scope of possibilities from a Smart Grid perspective. Battery swapping scenarios only contribute insofar as the batteries serve Smart Grid functions within the swapping station, not in the car itself.

A seamless integration can be provided through bidirectional power flow, utilization of manageable loads and maximum information exchange between onboard and grid automation, including price information.

E-Mobility will serve the following functions:

- a primary, secondary and tertiary reserve

- a manageable load
- power system stabilization
- power quality
- load leveling
- load shedding
- individual mobility (not relevant for Smart Grid)
- energy conservation (increased efficiency compared to combustion engines)

under the constraint of fulfilling environmental constraints

Total electrification of vehicles will furthermore promote the role of IEC standards in the vehicle domain. This must urgently be dealt with, however it is not within the scope of a Smart Grid discussion.

8.8.2 Mapping on SGAM

8.8.2.1 Preamble

There are many different cases on how e-mobility systems may be architectured, and also many possibilities for having such systems interfaced to the Grid (operator, supplier, e-mobility service provider). The drawings given below are just here to depict the possible usage of the considered standards.

8.8.2.2 Component layer

The E-mobility System component architecture may be interfaced following the here-under schema.

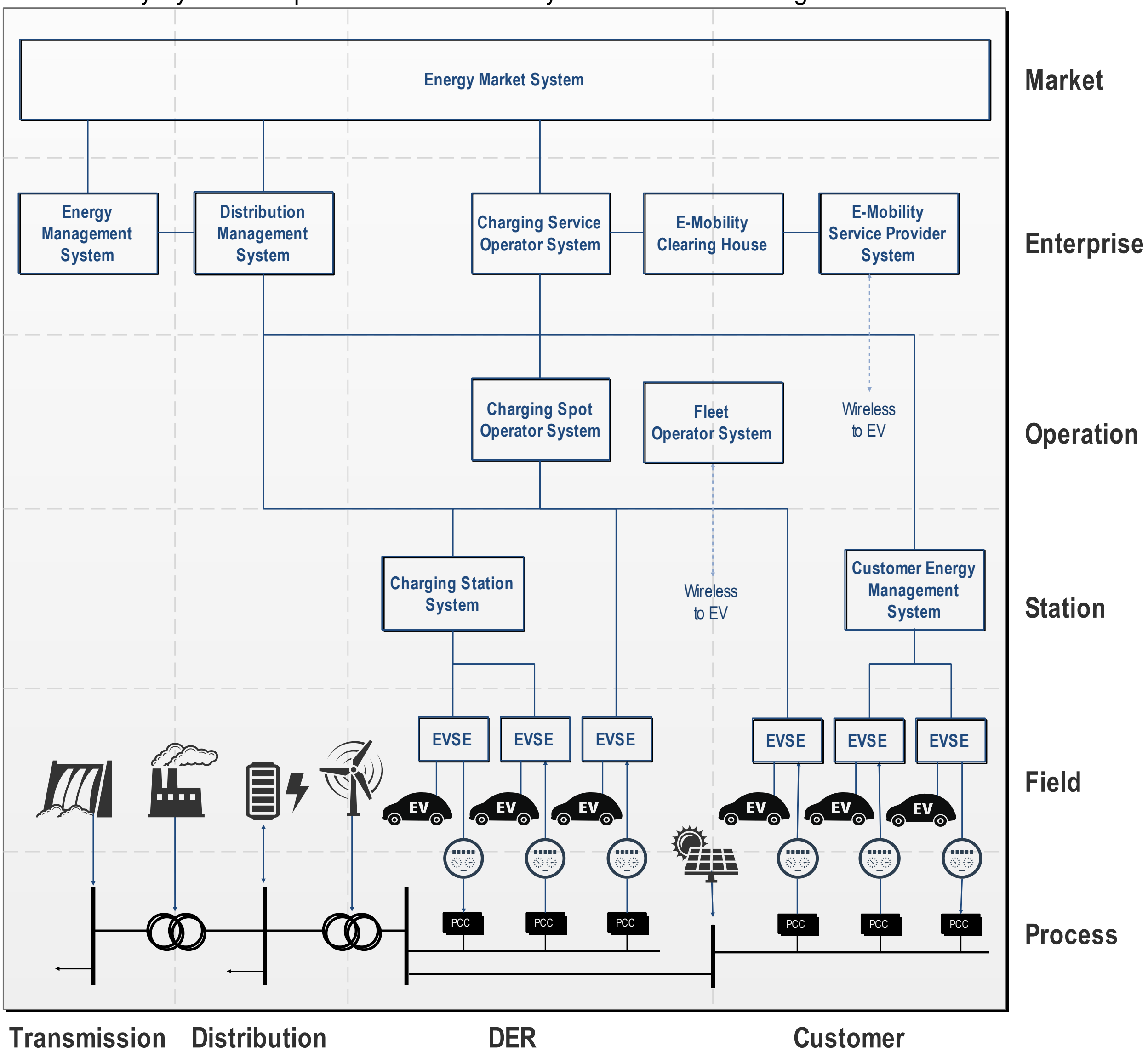


Figure 52 – E-mobility system (example) - Component layer

8.8.2.3 Link between SGAM and E-mobility standardization groups

Different standardization groups are working directly or in-directly with E-mobility on top-level close to market and energy management, on a medium-level for operation and management of systems or on the very detailed level close to the process and the Electric Vehicle.

Figure 52 gives and overview of the different E-mobility standards and the general mapping to the SGAM zones.

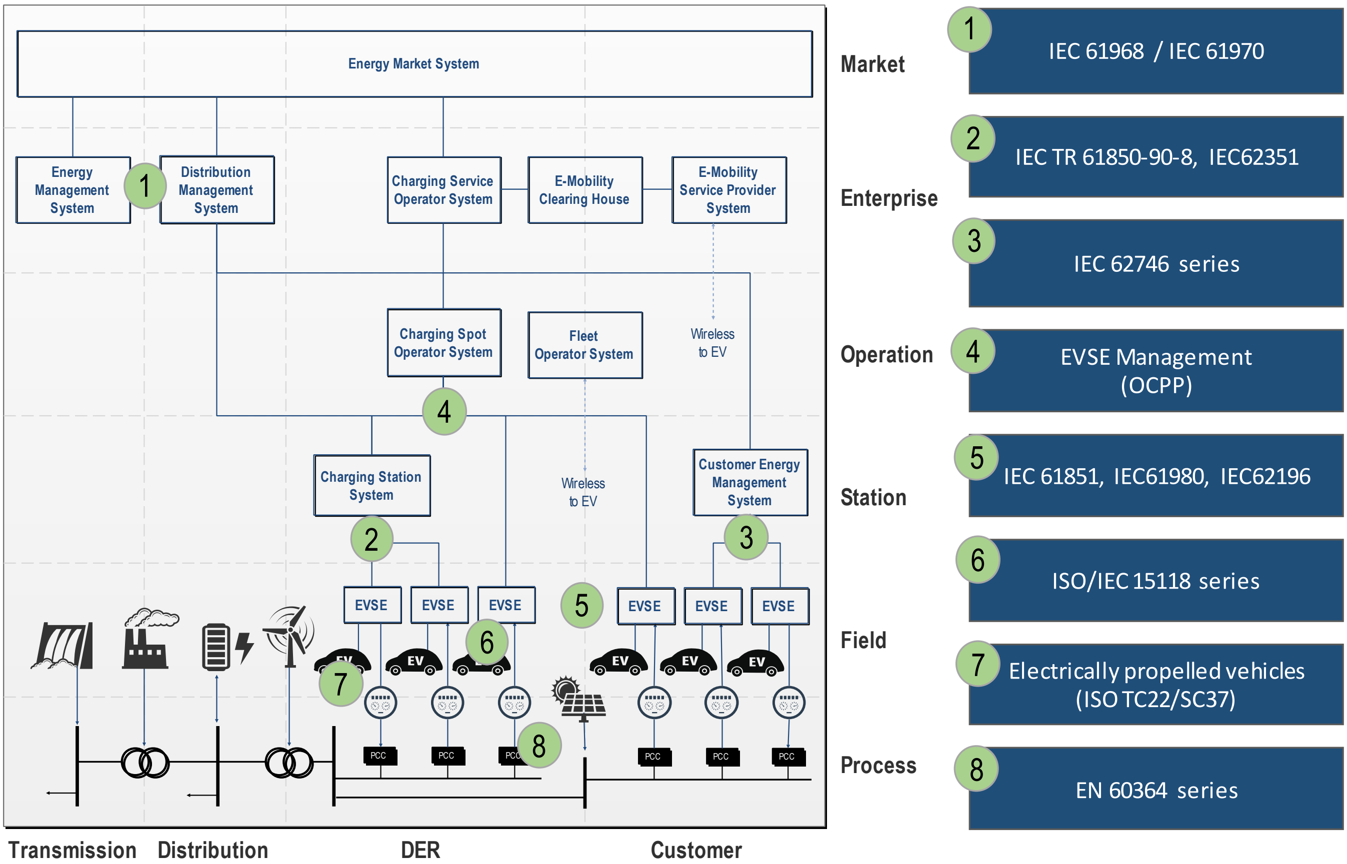


Figure 53 – E-mobility system (example) and link to E-mobility standards

For a more detailed list of E-Mobility standards and mapping to the SGAM layers, see section 8.8.3

8.8.3 List of Standards

8.8.3.1 Available standards

Please refer to section 6.2.2 for the definition of the criteria considered in this report for stating that a standard is “available”.

Table 55 - E-mobility system - Available standards

Layer	Standard	Comments
Information, Communication	EN 61968 (all parts)	Common Information Model (CIM) / Distribution Management
Information, Communication	EN 61970 (all parts)	Energy management system application Program interface (EMS-API
Information, Communication	EN 61850-7-420	Communication networks and systems for power utility automation

Layer	Standard	Comments
Information, Communication	ISO/IEC 15118 (all parts)	Road vehicles – Communication protocol between electric vehicle and grid
Information, Communication	ISO/IEC 15118-1	Road vehicles - Vehicle to grid communication interface - Part 1: General information and use-case definition
Information, Communication	ISO/IEC 15118-2	Road vehicles - Vehicle to grid communication interface - Part 2: Network and application protocol requirements
Information, Communication	ISO/IEC 15118-3	Road vehicles - Vehicle to grid Communication Interface - Part 3: Physical and data link layer requirements
Information, Communication	ISO/IEC 15118-4	Road vehicles - Vehicle to grid communication interface - Part 4: Network and application protocol conformance test
Information, Communication	ISO/IEC 15118-5	Road vehicles - Vehicle to grid communication interface - Part 5: Physical layer and data link layer conformance test
Information, Communication	ISO/IEC 15118-6	Road vehicles - Vehicle to grid communication interface - Part 6: General information and use-case definition for wireless communication
Information, Communication	ISO/IEC 15118-7	Road vehicles - Vehicle to grid communication interface - Part 7: Network and application protocol requirements for wireless communication
Information, Communication	ISO/IEC 15118-8	Road vehicles - Vehicle to grid communication interface - Part 8: Physical layer and data link layer requirements for wireless communication
Information	IEC 61850-90-8	IEC 61850 object models for electric mobility
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.4)
Communication	EN 62443	Industrial communication networks – Network and system security
Information, Communication, Component	EN 61851 (all parts)	Electric vehicle conductive charging system
Component	EN 61851-1	Electric vehicle conductive charging system – General requirements
Component	EN 61851-21	Electric vehicle requirements for conductive connection to an a.c./d.c. supply
Component	EN 61851-22	Electric vehicle conductive charging system – a.c. electric vehicle charging station
Component	EN 61851-23	Electric vehicle conductive charging system – d.c electric vehicle charging station
Communication	EN 61851-24	Electric vehicle conductive charging system – Control communication protocol between off-board d.c. charger and electric vehicle
Information	EN 61851-31	Data interface for recharging of electric road vehicles supplied from the a.c. main
Information	EN 61851-32	Data interface for the recharging of electric road vehicles supplied from an external d.c. charger
Component	IEC 60783	Wiring and connectors for electric road vehicles
Component	IEC 60784	Instrumentation for electric road vehicles
Component	IEC 60785	Rotating machines for electric road vehicles
Component	IEC 60786	Controllers for electric road vehicles

Layer	Standard	Comments
Component	EN 60364-4-41	Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock
Component	EN 60364-5-53	Selection and erection of electrical equipment - Isolation, switching and control
Component	EN 60364-5-55	Selection and erection of electrical equipment - Other equipment - Clause 551: Low-voltage generating set
Component	EN 60364-7-712	Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems
Component	EN 60364-7-722	Requirements for special installations or locations - Supply of Electrical Vehicle
Component	ISO 8713	Electrically propelled road vehicles - Terminology
Component	IEC 61894	Preferred sizes and voltages of battery monoblocs for electric vehicle applications
Component	EN 61980 (all parts)	Electric equipment for the supply of energy to electric road vehicles using an inductive coupling
Component	IEC 61981	On board electric power equipment for electric road vehicles
Component	EN 61982 (all parts)	Secondary batteries for the propulsion of electric road vehicles
Component	EN 62196	Plugs, socket-outlets, vehicle couplers and vehicle inlets – Conductive charging of electric vehicles
Component	ISO 6469	Electrically propelled road vehicles - Safety specifications

Note: standards related to clock management, safety, or EMC are mentioned in further dedicated sections.

Other standards:
Many standards from SAE J series may apply to this domain.

8.8.3.2 Coming standards

Please refer to section 6.2.2 for the definition of the criteria considered in this report for stating that a standard is “coming” up.

Table 56 - E-mobility system - Coming standards

Layer	Standard	Comments
Information, Communication	*EN 61968 (all parts)*	Common Information Model (CIM) / Distribution Management
Information, Communication	*EN 61970 (all parts)*	Energy management system application Program interface (EMS-API
Information, Communication, Component	*IEC 62351*	Cyber-security aspects (refer to section 9.4)

8.9 Micro-grid systems

8.9.1 System description

A micro-grid system refers to the real-time information system and all the elements needed to support all the relevant operational activities and functions needed to run a micro-grid. It improves the information made available to operators at control room, as well as to micro-grid users. It improves the overall efficiency of operation of the micro-grid, as well as it may optimize the use of related assets.

Such system is usually made of one or many interconnected IT systems, connected to field communicating devices or sub-systems, through the use of communication systems. It may also include the components needed to enable field crew to operate the micro-grid from the field.
A micro-grid system provides following major functions:

- SCADA, real time monitoring and control of the micro-grid
- Capabilities to distributed electricity to any micro-grid users
- Capabilities to protect and maintain the related micro-grid assets
- Automation capabilities to ensure balance of demand and supply
- Automation capabilities to handle islanding, connection and disconnection

It may also include “commercial related activities”, and then may also include:

- Trading capabilities
- Electricity supply and associated metered related backoffice capabilities

Based on local DER’s and micro-grid primary devices, a micro-grid system needs to maintain its stability, voltage, frequency and reliability.
While in the grid connected mode a micro-grid system may interface to an EMS or DMS to perform various grid support functions such as:

1. Peak Management
2. Responsive Reserves
3. Peak Management
4. Ancillary Services
5. Grid Voltage Support (VARS)
6. Backup Emergency Power

While in the islanded mode a micro-grid system may be called on to perform the following functions:

1. Islanding on requests
2. Islanding on emergency
3. Grid Synchronizing & (re-) Connection
4. Balancing Supply & Demand
5. Black Start in islanding mode
6. Network Configuration
7. Active/Reactive Power Compensation/Voltage Control
8. Economic Dispatch
9. Load Control

From a domain prospective, micro-grids are “Smart Grids in small” and may cover 3 main domains – Distribution, DER and Customer premises, and then encompass systems from these same domains.Figure 54 below outlines the components, subsystems, and interfaces which make up a micro-grid system. With these interfaces defined, a set of standards can be identified.

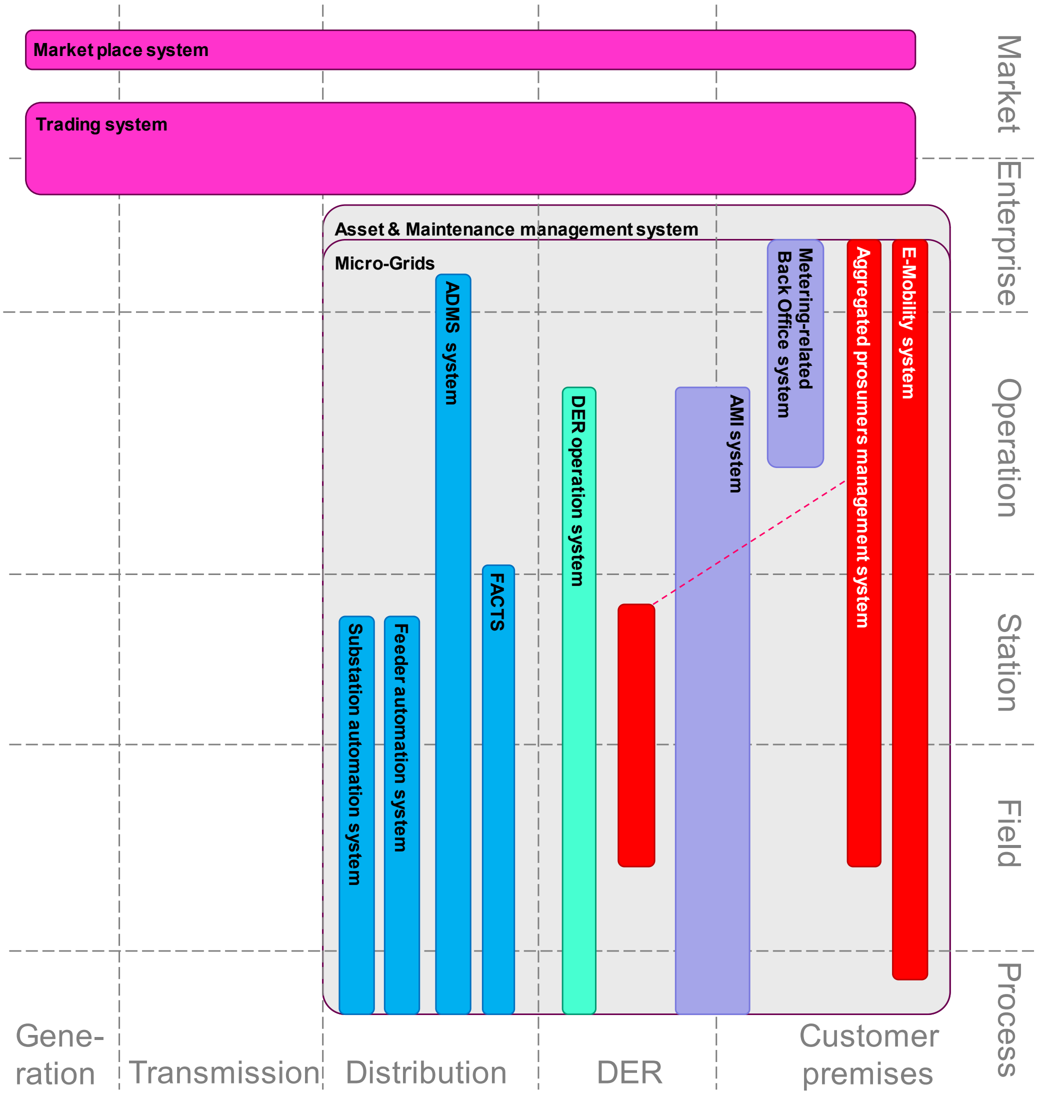


Figure 54 – Micro-grids – possible domains and systems breakdown

8.9.2 Set of use cases

Here is a set of high level use cases which may be supported by a substation automation system. The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 57 – Industrial automation system - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Handling Micro-grid scenarios	Islanding on requests	C		I
	Islanding on emergency	C		I
	Grid Synchronizing & (re-) Connection	C		I
	Balancing Supply & Demand	C		I

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
	Black Start in islanding mode	C		I

8.9.3 Mapping on SGAM

In order not to duplicate information already depicted in this report, the best is to rely on the already described mapping of the underlying systems micro-grids are composed of: to be found from section 8.3.

8.9.4 List of Standards

8.9.4.1 Available standards

Please refer to section 6.2.2 for the definition of the criteria considered in this report for stating that a standard is “available”.
Web service related standards are described in 9.3.5.
Rather than duplicating lists of standards, we prefer referring to the corresponding systems which can be included in a Micro-Grid

Table 58 - Micro-Grids system - Available standards

Layer	Standard	Comments
Information, Communication	(refer to 8.3.3)	refer to the ADMS systems depicted in 8.3.3
Information, Communication	(refer to 8.3.2)	refer to Feeder Automation systems depicted in 8.3.2
Information, Communication	(refer to 8.3.1)	refer to Substation Automation systems depicted in 8.3.1
Information, Communication	(refer to 8.4)	refer to the DER operation system depicted in 8.4
Information, Communication	(refer to 8.5.1)	refer to the AMI system depicted in 8.5.1
Information, Communication	(refer to 8.5.2)	refer to Metering related back-office systems depicted in 8.5.2
Information, Communication	(refer to 8.6)	refer to the Demand and production flexibility systems depicted in 8.6
Information, Communication	(refer to 8.8)	refer to E-mobility systems depicted in 8.8
Information, Communication	(refer to 8.10.1)	refer to Assets management systems depicted in 8.10.1
Information, Communication	(refer to 8.10.6)	refer to Weather forecast systems depicted in 8.10.6

8.9.4.2 Coming standards

Please refer to section 6.2.2 for the definition of the criteria considered in this report for stating that a standard is “coming” up.

Table 59 - Micro-Grids system - Coming standards

Layer	*Standard*	Comments
Information, Communication	(refer to 8.3.3)	refer to the ADMS systems depicted in 8.3.3
Information, Communication	*(refer to 8.3.2)*	refer to Feeder Automation systems depicted in 8.3.2

Information, Communication	(refer to 8.3.1)	refer to Substation Automation systems depicted in 8.3.1
Information, Communication	*(refer to 8.4)*	refer to the DER operation system depicted in 8.4
Information, Communication	*(refer to 8.5.1)*	refer to the AMI system depicted in 8.5.1
Information, Communication	*(refer to 8.5.2)*	refer to Metering related back-office systems depicted in 8.5.2
Information, Communication	*(refer to 8.6)*	refer to the Demand and production flexibility systems depicted in 8.6
Information, Communication	*(refer to 8.8)*	refer to E-mobility systems depicted in 8.8
Information, Communication	*(refer to 8.10.1)*	refer to Assets management systems depicted in 8.10.1
Information, Communication	*(refer to 8.10.6)*	refer to Weather forecast systems depicted in 8.10.6
Component	*IEC 62898-1*	Microgrids - Guidelines for planning and design
Component	*IEC 62898-2*	Microgrids - Guidelines for operation and control
Component	IEC 62898-3-1	Microgrids - Technical Requirements - Protection requirements in microgrids
Component	IEC 60364-8-2	Low voltage electrical installation – prosumer’s installation

8.10 Administration systems

8.10.1 Asset and Maintenance Management system

8.10.1.1 System description

Asset and Maintenance Management system refers to the information system and all the elements needed to support the team in charge of managing the system assets along its total lifecycle. It is used to help maximize the value of the related assets over their lifecycles, and help preparing future plans (long term planning, mid-term optimization, extension, refurbishment) and also the associated maintenance work.

Such a system is usually made of one or many interconnected IT systems, possibly connected to field communicating devices or sub-systems, through the use of LAN/WAN communication systems.
The Application covers the different business processes containing the different maintenance methods (corrective, periodic and condition based) and maintenance models of related assets.
Asset and maintenance management systems are used in the Generation, Transmission, Distribution and DER domain.

8.10.1.2 Set of use cases

The following high level use cases might be support by an asset and maintenance management system.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 60 – Assets and maintenance management system - use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Monitoring the grid flows	Producing, exposing and logging time-stamped events	CI		
Maintaining grid assets	Monitoring assets conditions	C	CI	I
	Supporting periodic maintenance (and planning)	CI	C	I
	Optimise field crew operation	C	C	I
	Archive maintenance information	CI	C	I
System and security management	Discover a new component in the system		C	I
	Distributing and synchronizing clocks	CI		

Note that for some domains standards are already available or under development (i.e. Distribution) while for other Domains standards are under development or are not yet available (i.e. Transmission, DER)

8.10.1.3 Mapping on SGAM

8.10.1.3.1 Preamble

A single entity of an Asset and maintenance management system is shown as an overlay that can be applied to the specific domains. It should be noted that the specific standards especially at the information layer may be different for the different domains.
The Asset Management System interacts with the domain management and operation systems (e.g. EMS, DMS), GIS and SCADA systems. Condition monitoring and field force management is shown as part of the Asset Management System with the related interaction with the field components.
Most information regarding maintenance and condition of components is captured by the field force workers and the laptops they use in the field. Detailed condition assessment (information) models of assets are not (yet) available in standards.

Generation distinctive feature: an important part of condition monitoring is related to rotating machines vibration monitoring. Appropriate information and communication solutions are different than those that are used for control, monitoring and common condition monitoring. The existing standard IEC 61400-25-6 is an excellent example of the possibility to use existing wind turbines control and monitoring solutions to support

common condition monitoring, but of the necessity to extend these solutions to fully support wind turbines condition monitoring. The same reasoning is applicable to the generation using other fuels.
The consequence is that components dedicated to condition monitoring may coexist in parallel with control and monitoring components down to the Field Zone.

8.10.1.3.2 Component layer

The Asset Management component architecture ranges from the process to the enterprise zone.

- At the Enterprise zone the Asset Management system itself is located.
- At the Operation zone the Condition Monitoring systems are located.
- The Station and Field zone provide the communication with the sensors that monitor the assets and with the field force.
- The assets are located at the Process zone

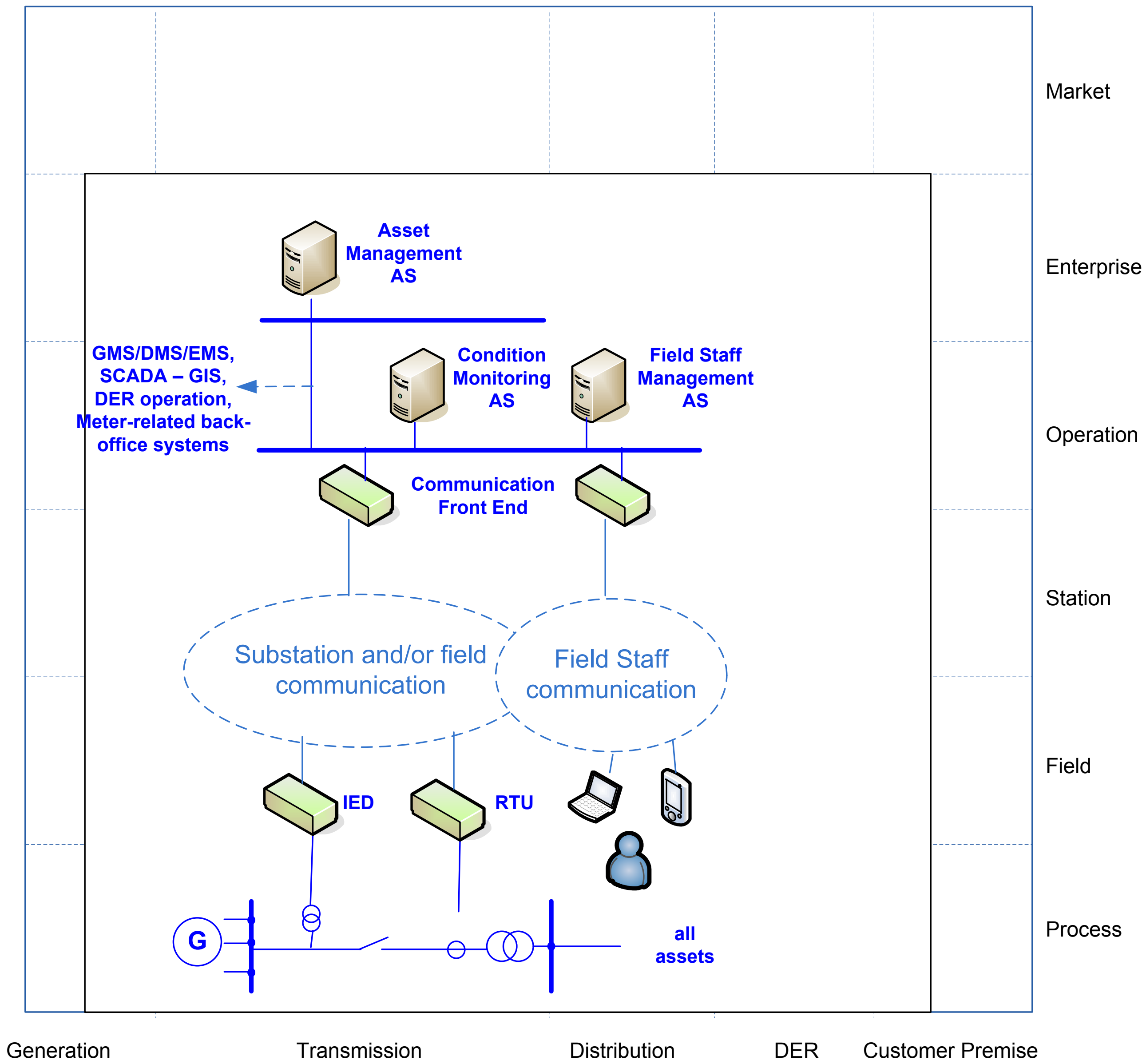


Figure 55 - Assets and maintenance management system - Component layer

8.10.1.3.3 Communication layer

The communication between the field, station and operations is done via IEC/EN 61850 or through EN 60870-5-101/104. For the enterprise bus communication between the operation and enterprise zone components the coming standard EN 61968-100 is used.

Note: EN 61968-100 is defined for the EN 61968 information models, but the same web services approach can be applied to the EN 61970 information models. For field force communication the substation to operations communication infrastructure and dedicated networks (e.g. mobile networks) can be used. Section 7.1 describes the different telecommunication networks.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

Figure 56 - Assets and maintenance management system - Communication layer

8.10.1.3.4 Information (Data) layer

For the condition monitoring information exchange between the field/station and operations zone the coming standard IEC 61850-90-3 will be used. EN 61968 and EN 61970 standards in general apply for providing asset management related information. Specifically IEC 61698-4 and the coming standard EN 61968-6 define CIM interfaces for asset and maintenance management for the distribution domain. For the other domains no specific asset and maintenance management standards exist.

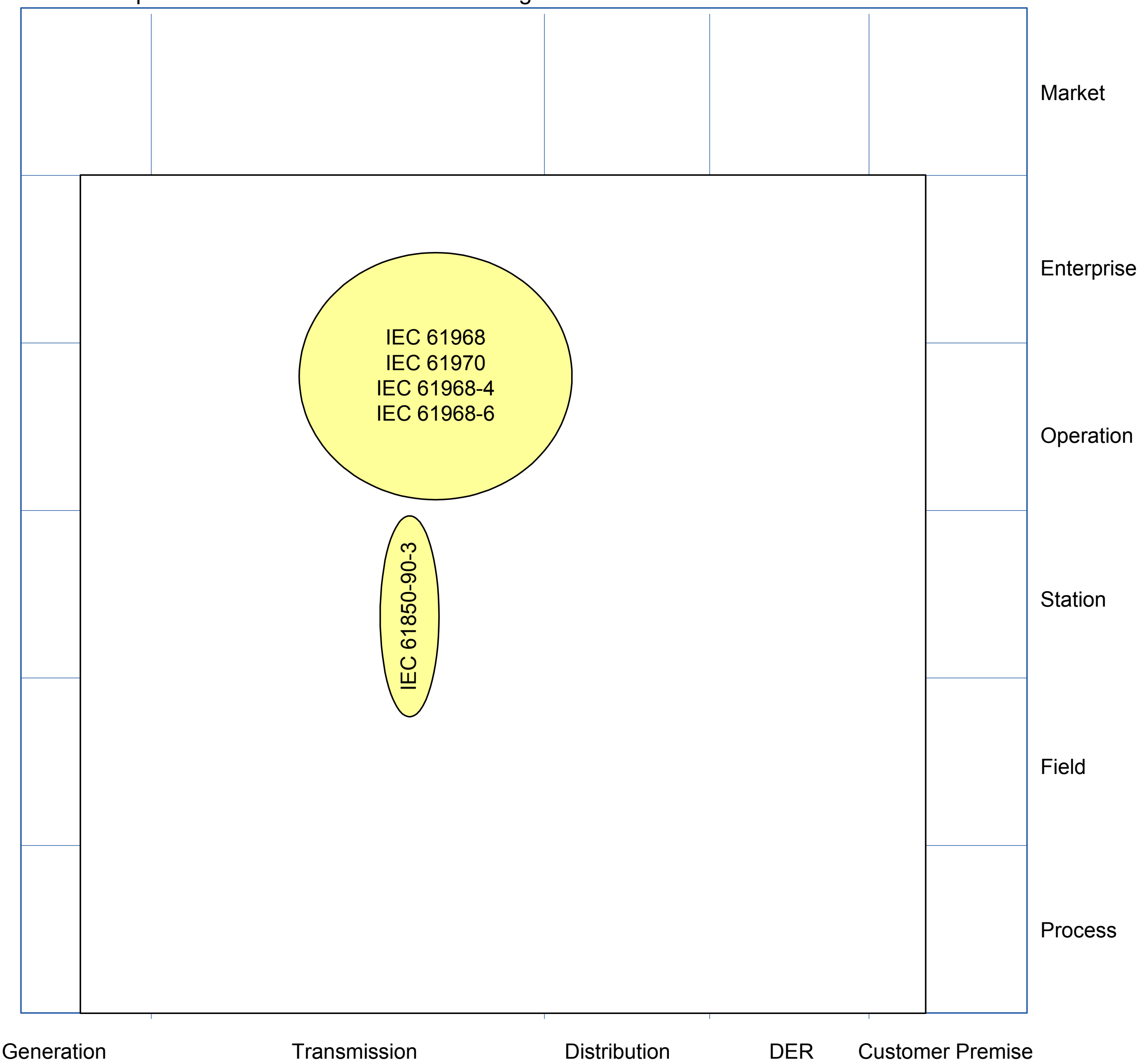


Figure 57 - Assets and maintenance management system - Information layer

8.10.1.4 List of Standards

Here is the summary of the standards which appear relevant to transmission asset management systems:

8.10.1.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 61 – Assets and maintenance management system – Available standards

Layer	Standard	Comments
Information	IEC 61360	Common Data Dictionary

Information	IEC 61850-90-3	Using IEC/EN 61850 for condition monitoring
Information	IEC 61850-80-1	Mapping of IEC/EN 61850 data model over 60870-5-101 and 104
Communication, information	IEC 61850-90-2	Substation to control center communication
Information, communication	EN 61400-25	Edition 1 - Set of standards more specific to wind turbines and wind farms
Information	EN 61968 (all parts)	CIM Distribution
Information	EN 61968-4	Interfaces for records and asset management
Information	IEC 61968-6	Interfaces for maintenance and construction
Information	EN 61970 (all parts)	CIM Transmission
Communication	EN 61850-8-1	IEC/EN 61850 communication except Sample values
Communication	EN 60870-5-101	Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks
Communication	EN 60870-5-104	Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for EN 60870-5-101 using standard transport profiles
Communication	EN 61968-100	Defines profiles for the communication of CIM messages using Web Services or Java Messaging System.
Communication	IEC 61850-90-12	Network Engineering Guidelines for IEC/EN 61850 based systems using Wide Area Networks
Component	EN 60076 series	Power transformers
Component	EN 62271-1 series	High voltage switchgear and controlgear
Component	EN 62271-2 series	High voltage switchgear and controlgear assemblies
Component	EN 61897	Overhead lines - Requirements and tests for Stockbridge type aeolian vibration dampers

8.10.1.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 62 – Assets and maintenance management system – Coming standards

Layer	**Standard**	**Comments**
Information, communication	*EN 61400-25*	Edition 2 - Set of standards more specific to wind turbines and wind farms
Communication	*IEC 61850-8-2*	IEC/EN 61850 communication mapping on Web-services

8.10.2 Communication network management system

8.10.2.1 System description

Communication Network management systems are concerned with the management of the communication networks used for Smart Grid communication. These are for example wide area (WAN), local area (LAN), access and Neighborhood area (NAN) networks. For more details on communication networks see clause 0.

When communicating devices, including the communication functions of end devices, have the ability to be managed remotely regarding their communication capabilities, they are usually called “managed devices”, and the network having this property is called “managed network”

A managed network consists of two key components:

- Manager device with network management system
- Managed device with agent

A network management system executes applications that monitor and control managed devices. The network management systems provide the bulk of the processing and memory resources required for network management. One or more network management systems may exist on any managed network and different management systems might be used for different network domains and zones.

Various network management standards exist for the different communication network technologies. In this clause we focus on management of the IP layer and can only provide a rough overview. For other communication network technologies and more details please refer to the specific technologies.

It should be noted that the responsibility for network management usually is with the network owner. A distribution network operator for example will manage its own enterprise and control center LAN while in case of leased line or VPN services the management of the underlying network providing these services is the responsibility of the communication service provider who owns the underlying network.

8.10.2.2 Set of use cases

Possibly any Use Cases which is supported by communicating features is possibly concerned with managing the health of the communication system it is using.

Practically any IP based system may support a communication network management system encompassing part or all communicating devices.

8.10.2.3 Mapping on SGAM

8.10.2.3.1 Preamble

It is mostly not possible to map a communication network management system onto the SGAM, as such systems being independent from the Smart Grid domains and zones and have their own architectural structure. It is therefore shown as a simple overlay on the SGAM.

8.10.2.3.2 Component layer

The managed devices can be any type of communication device, including end devices (e.g. routers, access servers, switches, bridges, hubs, IP telephones, IP video cameras and computer hosts). It is also recommended that most of communicating end devices which serve a smart grid function such as IEDs, controllers, computers, HMIs, to be “manageable” from a communication point of view.

A managed device is a network node that implements an SNMP interface that allows unidirectional or bidirectional access to node-specific information. Managed devices exchange node-specific information with the network management system. An agent is a network-management software module that resides on a managed device. An agent has local knowledge of management information and translates that information to or from an SNMP specific form.

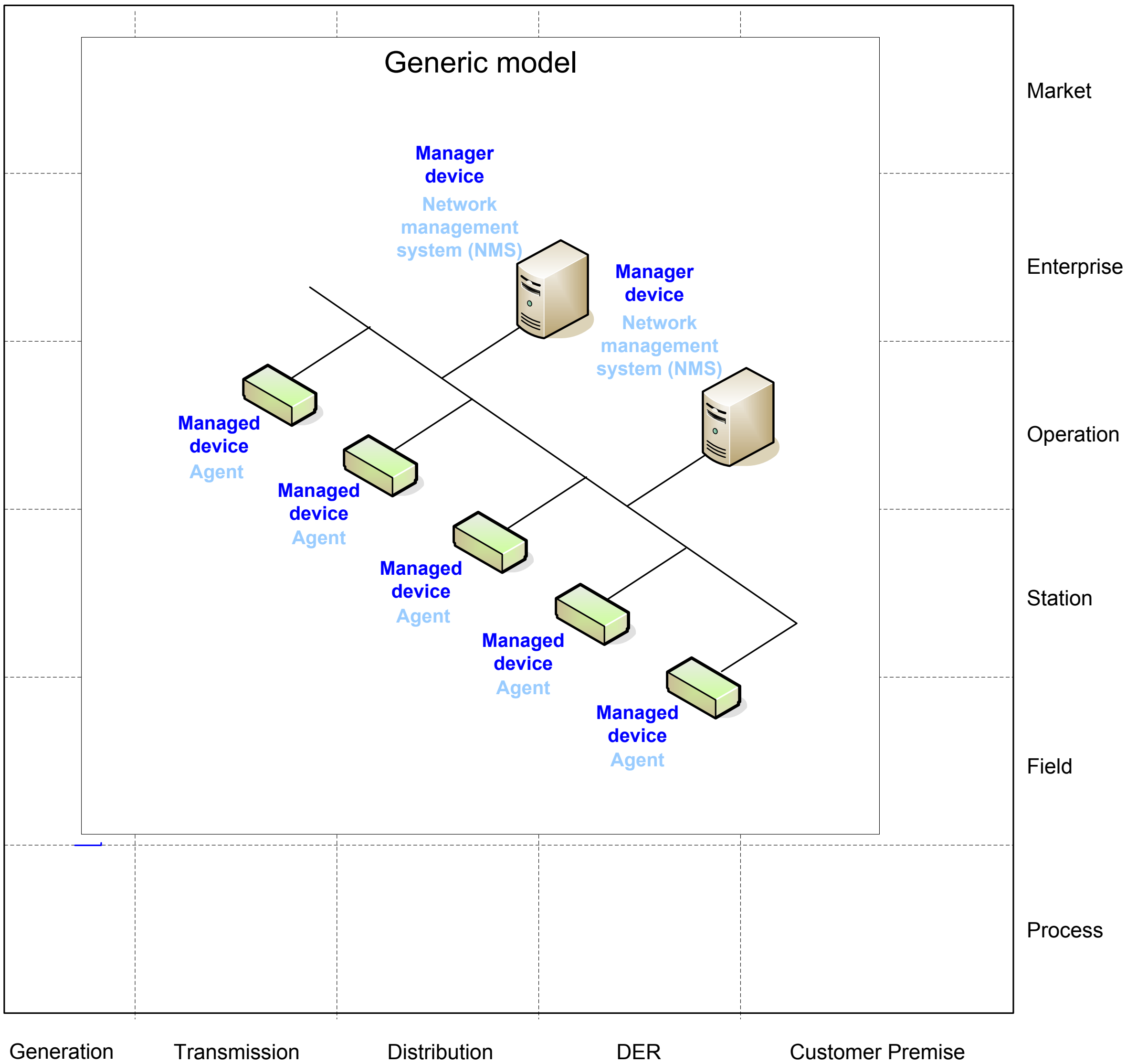


Figure 58 – Communication network management - Component layer

8.10.2.3.3 Communication layer

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

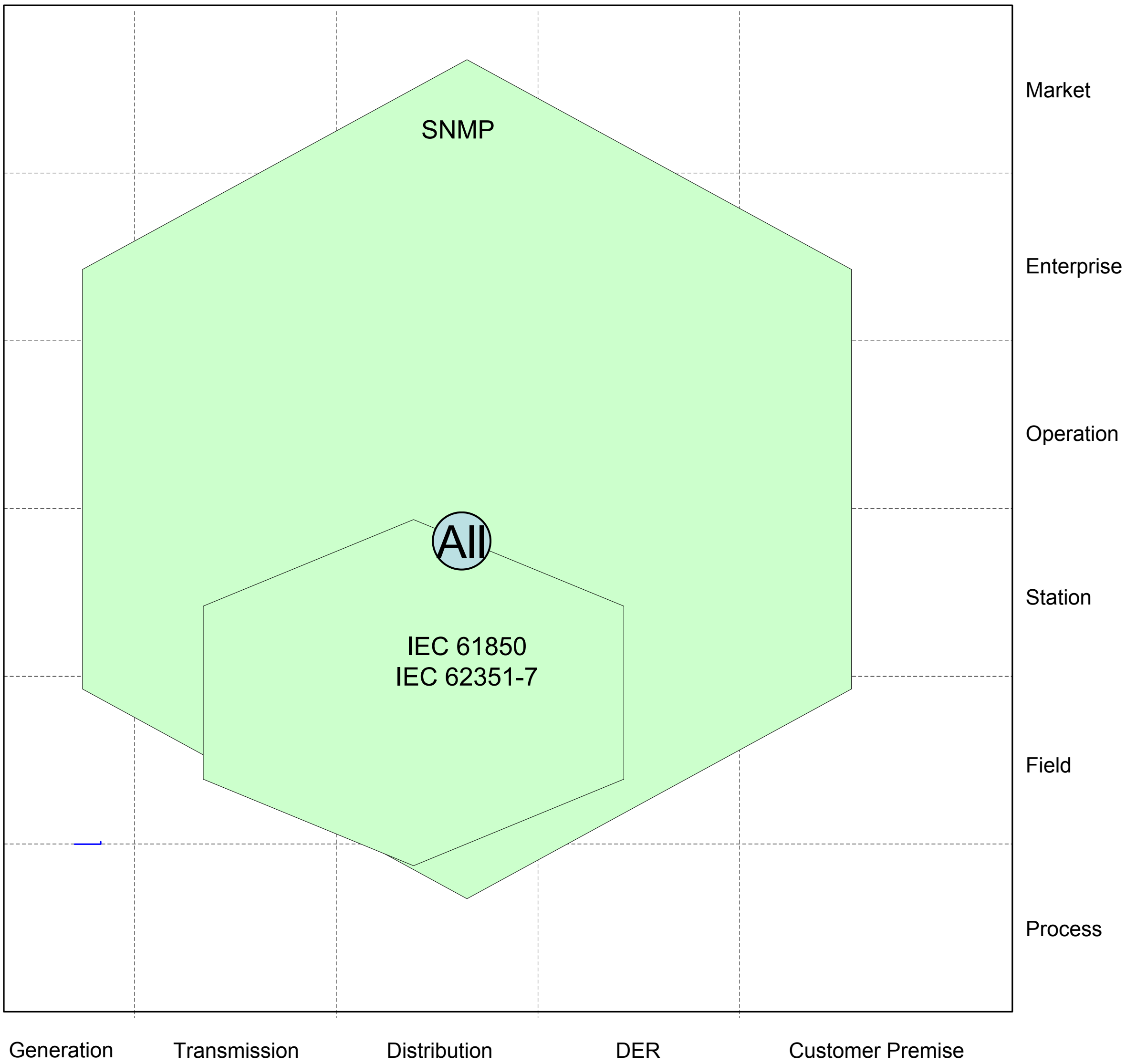


Figure 59 - Communication network management - Communication layer

8.10.2.3.4 Information (Data) layer

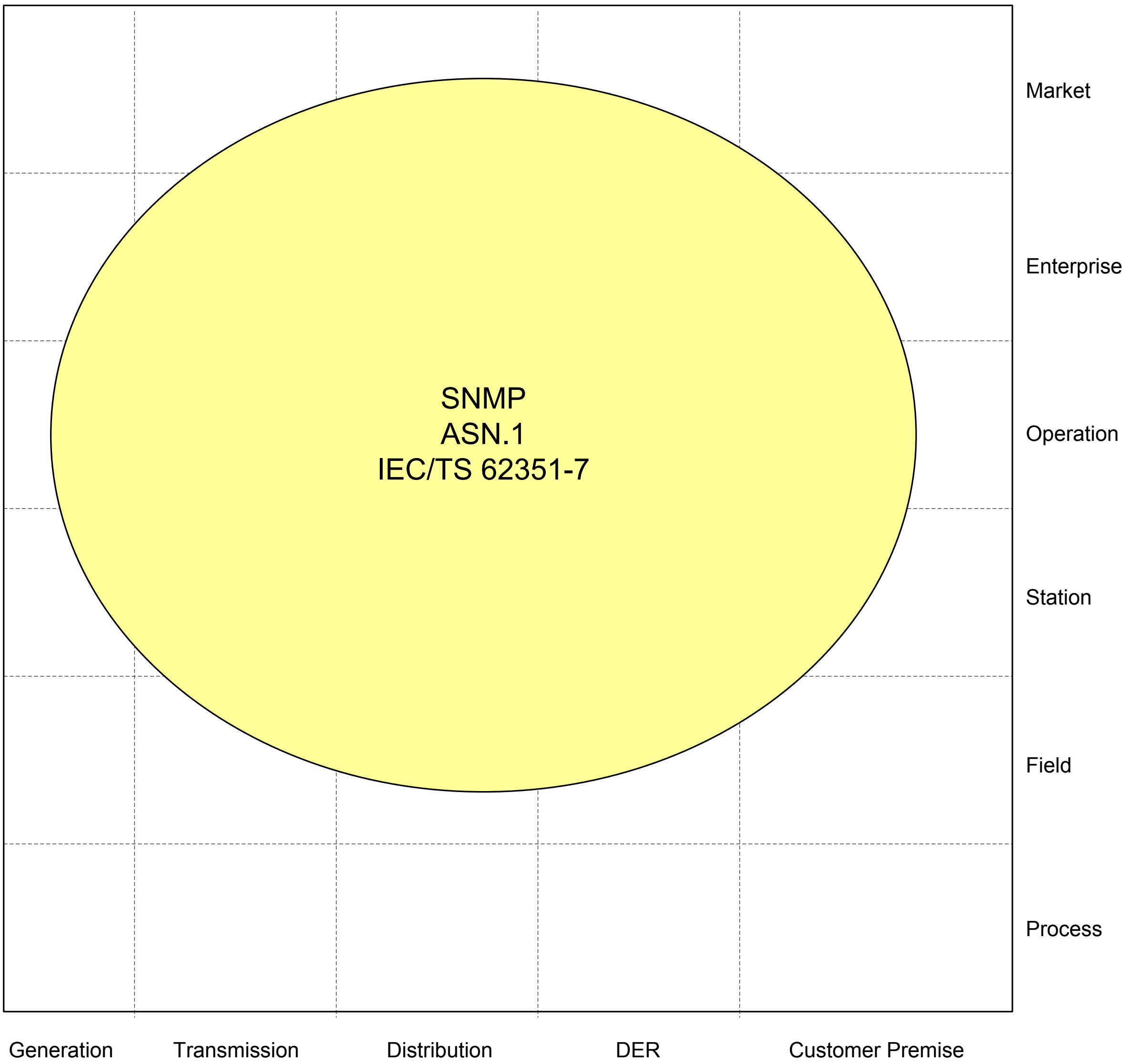


Figure 60 - Communication network management - Information layer

8.10.2.4 List of Standards

8.10.2.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 63 - Communication network management - Available standards

Layer	Standard	Comments
Information, Communication	IEC 62351-7	Security through network and system management
Information, Communication	IETF RFC 5343, IETF RFC 5590, IETF RFC 4789 IETF RFC 3584	SNMPv3. Internet-standard protocol for managing devices on IP networks, and co-habitation with former SNMP releases
Information, Communication	IETF RFC 6241, IETF RFC 7803	NETCONF: The Network Configuration Protocol (NETCONF) provides mechanisms to

Layer	Standard	Comments
		install, manipulate, and delete the configuration of network devices
Information, Communication	IETF RFC 6020	**YANG** [1] is a data modeling language for the definition of data sent over the NETCONF network configuration protocol
Communication	IETF RFC 768	UDP/IP
Communication, Information	IEC 61850-90-4	Network Engineering Guidelines for IEC/EN 61850 based systems (including Ethernet technology, network topology, redundancy, traffic latency, traffic management by multicast and VLAN). This document also proposes a data model /SCL extension to expose information related to network management onto IEC 61850, mostly based on SNMP tags

8.10.2.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 64 - Communication network management - Coming standards

Layer	Standard	Comments
Communication, Information	*IEC 61850-90-12*	Network Engineering Guidelines for IEC/EN 61850 based systems using Wide Area Networks

8.10.3 Clock reference system

8.10.3.1 System description

Many Smart Grids systems need a unified global time and then synchronized clocks, distributed among all the components in order to support some specific use cases, such as accurate time stamping for events logging, alarming but also more and more to perform very time-critical algorithms based on digital time-stamped measurement samples, such as the “Sample values” specified by the IEC 61850.
The clock reference system refers to the system and all elements needed to support clock master definition, time distribution and clock synchronization services to ensure a unified time management within the system. It is usually made of a collection of one or many clock servers, transmission systems, relay stations, tributary stations and data terminal equipment capable of being synchronized.
The clock reference system will be highly dependent on the needed clock accuracy, from seconds accuracy (for example for DER process control), to millisecond(s) for electricity related events, down to sub-microsecond for digital samples.
Clock reference may be local reference time (the importance being that all components clocks share the same time reference) or absolute reference time (the importance being that all clock refers to the same absolute time reference). The last case may be also consider even if the requirement is only to get a same local reference time within the system, when it may be of easier deployment to rely on the absolute reference time, provided for example by the GPS system, than distributing a local reference time.

8.10.3.2 Set of use cases

Time information may be associated to mostly any use cases, and then such system may be contributing to any use cases.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 65 - Clock reference system – use cases

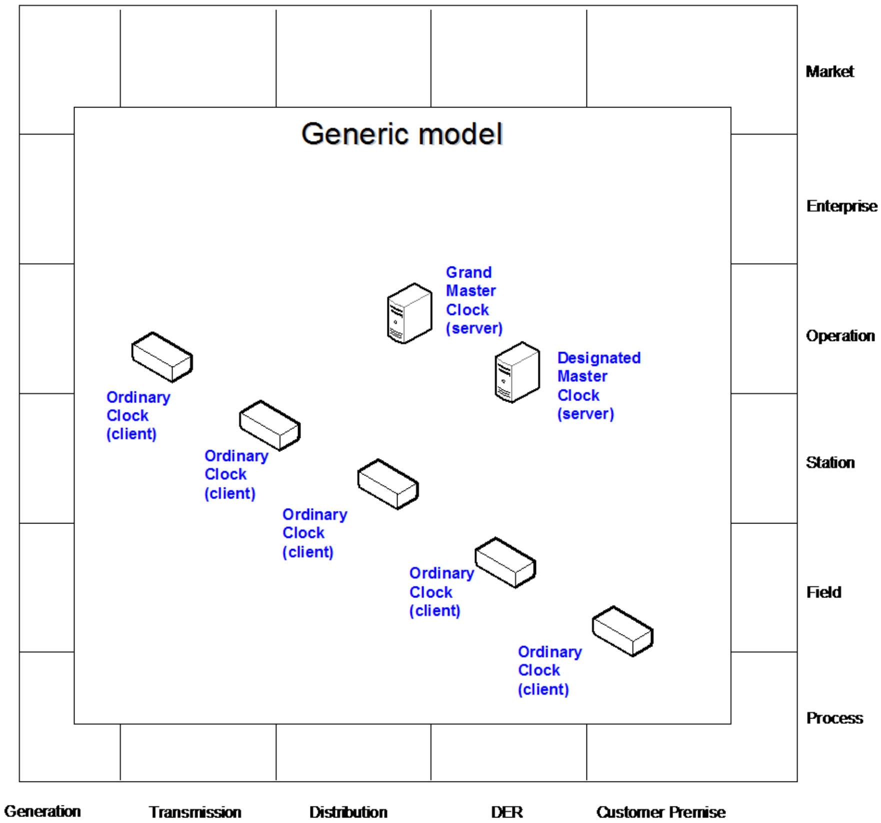
		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
System and security management	Distributing and synchronizing clocks	**I**	**C**	

8.10.3.3 Mapping on SGAM

8.10.3.3.1 Preamble:

It is mostly not possible to map such a clock reference system onto the SGAM, such system being independent from the domains and the zones, and in general re-using some existing communication capabilities of the concerned systems.
However, clock accuracy requirement may be different in different systems and then their implementation request different mechanisms of even time model to support the expected functionalities.
Except for high accuracy, in many cases, clock synchronization is not requiring specific capabilities of the communication network itself, used for distributing the time. However, and specifically when using PTP, all components used between the clock master and the “ordinary clocks” have to comply with PTP specification, to achieve the expected performance.

3385 *8.10.3.3.2 Component layer*



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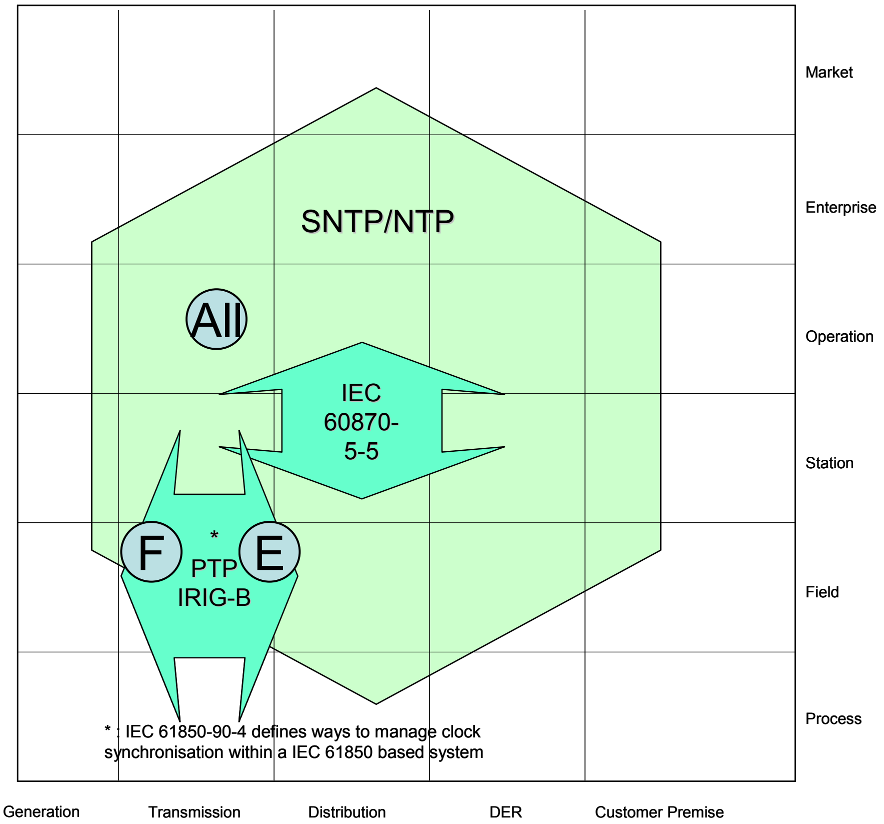
3387 **Figure 61 – Clock reference system - Component layer**

3388 *8.10.3.3.3 Communication layer*

3389 Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.



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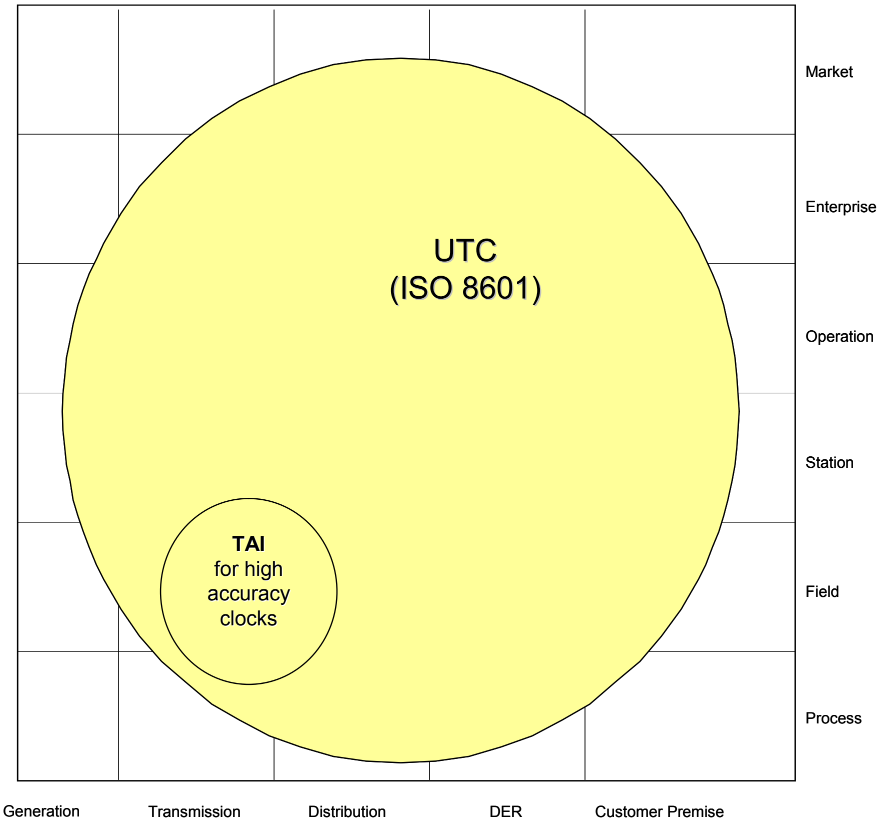
3391 **Figure 62 – Clock reference system - Communication layer**

3392 *8.10.3.3.4 Information (Data) layer*



3393

3394 **Figure 63 – Clock reference system - Information layer**

8.10.3.4 List of Standards

8.10.3.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 66 - Clock reference system – Available standards

Layer	Standard	Comments
Information	ISO 8601 (EN 28601)	Data elements and interchange formats — Information interchange — Representation of dates and times. Coordinated Universal Time (UTC)
Communication	EN 60870-5-5	Telecontrol equipment and system – including time synchronization basic application
Communication	IEC 61588 (IEEE 1588)	PTP (Precision Time Protocol)
Communication	IEC 61850-90-5	PAS
Communication	IEC 61850-90-4	Network Engineering Guidelines for IEC/EN 61850 based systems (including clock synchronization guidelines)
Communication	EN 62439-3	Time management for PRP network mecanism
Communication	IETF RFC 5905	NTP – Network Time protocol
Communication	IETF RFC 4330	SNTP – Simplified Network Time protocol
Communication	IEEE C37.118	PTP profile - IEEE standard for Synchrophasors for Power Systems
Communication	IEEE C37.238:2011	PTP Profile - IEEE standard for Power System Applications
Communication	IRIG 200-98	IRIG Time codes

8.10.3.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 67 - Clock reference system – Coming standards

Layer	Standard	Comments
Communication	IEC 61850-9-3	Communication networks and systems for power utility automation - Part 9-3: Precision time protocol profile for power utility automation

8.10.4 Authentication, Authorization, Accounting Systems

8.10.4.1 System Description

Authentication, Authorization, Accounting (AAA) refers to information systems used to grant granular access to a device or a service by controlling what a given user or system can access and how.

Authentication is the process to authenticate an identity (a user or a system). The process verifies that the person or system is really the one it claims to be by verifying evidence. This is usually done using credentials such as login/passwords, one-time-passwords, digital certificates…

Authorization is the process to identify what a given identity is allowed to perform on a given system. It describes what the "rights" of the identity over the system are. In other words it describes to what extent the identity is allowed to manipulate the system. For example, the rights of an Operating System user on the file system (what can be read, what can be modified, what can be executed) or access rights of a system over the network (what the system is allowed to connect to).

Accounting is the process that measures the resources consumed by the identity for billing, auditing and reporting. Accounting systems is also used to record events. Usually the following type of information is recorded: Identity, Authentication success/failure, Authorization success/failure, what is accessed, when the access starts, when the access stops and any other relevant information related to the service delivered.

The technical discussion of an AAA system should always be done in the context of a target scenario for which a security threat and risk analysis has been done. This builds the base for deriving security requirements for access control for users, machines, and processes (applications). Analyzing the way a user is granted access locally to an operating system is different even if there are similarities than analyzing the way a user can remotely access a system or the way a system can access a system on Local Area Network or over the Internet thru a Virtual Private Network.

The choice has been made in the present chapter to consider the scenario of a remote access to a Substation Automation System as defined in section 8.3.1.

The following picture is taken from IEC/TR 62351-10 and shows such a substation automation scenario. As shown in the figure, access is controlled using a remote access server (circled in red in the figure below).

Figure 64: AAA Example in a Substation Automation Use Case

Access protection for zones or subnets is typically done by using AAA (Authentication, Authorization, and Accounting). AAA builds basically on three components, the supplicant (the person or components that wants to access the substation), the authenticator (the ingress access switch) and the authentication server (performing the actual authentication, authorization, and accounting).

In case of AAA there exist supporting standards like the EAP (Enhanced Authentication Protocol) framework defined by the IETF. EAP allows authentication and key establishment and can be mapped to protocols like IEEE 802.1x for the communication between the supplicant and the authenticator or RADIUS (Remote Authentication Dial In User Service) for the communication between authenticator and the authentication server as depicted in the figure below.

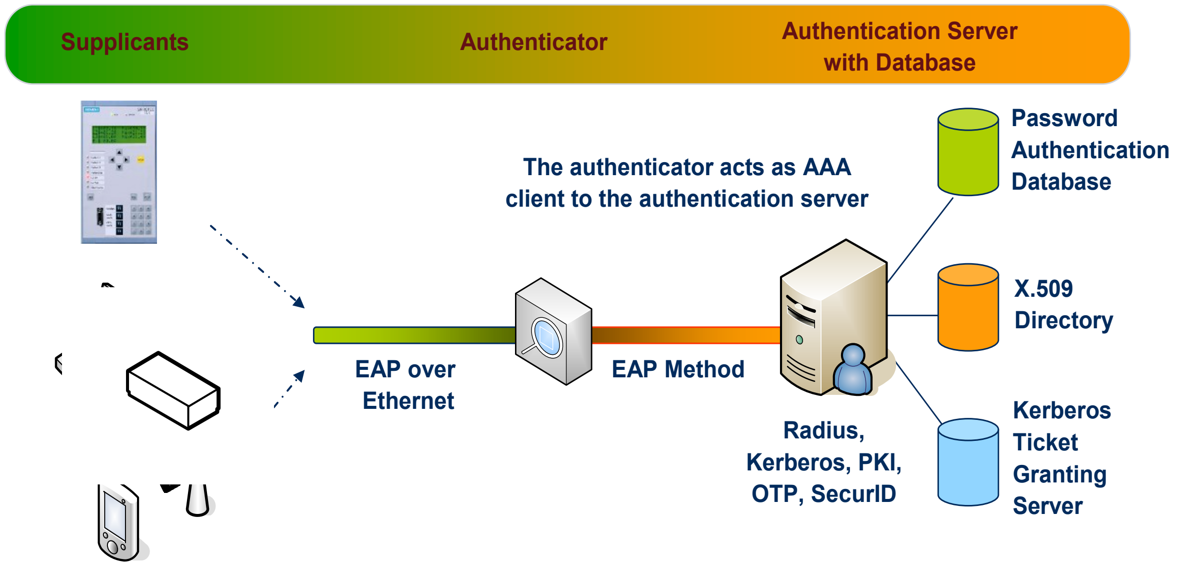


Figure 65: EAP Overview

There exist also further means for the communication between the authenticator and the authentication server. One example is TACACS+ (Terminal Access Controller Access-Control System). In contrast to RADIUS, it uses TCP for communication.

The current approach used for remotely accessing a substation often relies on the application of a VPN connection based on IPSec. The termination of the VPN in the substation is connected with the AAA infrastructure to ensure that only authenticated and authorized connections are possible. This may be achieved by using a dedicated component, a VPN gateway.

In the future, the security may be enhanced especially for connections using IEC 61850 or IEC 60870-5-104. For these protocols IEC 62351 defines specific security means, which can be directly applied to protect the communication, allowing for an end-to-end security relationship terminating in the substation. Hence, this protection does not necessarily require a specific VPN connection to protect the communication. It is expected that VPN connections will still provide a value as there are other connections, e.g., Voice over IP, which can be protected using the VPN tunnel. Also, as IEC 62351 allows to protect the communication regarding integrity and/or confidentiality the combination of IEC 62351 security measures with a dedicated VPN may contribute to a security in depth model, providing multiple layer of defense.

Additional possibilities, which may be used to further support remote access control, are provided by IEC 62351-8 (RBAC, Role based Access Control) in conjunction with IEC 61850. IEC 62351-8 allows fine grained role based access control using X.509 certificates and corresponding private keys. This allows extension of access control also within the substation. Hence, it allows further restriction of access or rights for operative or management actions within the substation. Note that IEC 62351-8 may be used in conjunction with LDAP to fetch RBAC specific credentials from a repository.

The report of the Cyber Security and Privacy Group of the SEG-CG specifically addresses the topic of access control with respect to users and software processes for local and remote authentication for substation control. Here the focus lies on different measures for authentication and access control to cope with the security levels in IEC 62443-3-3.

8.10.4.2 Set of use cases

Here is a set of high level use cases which may be supported by an AAA system for a Remote Access Solution (in that example applied to a Substation Automation System).
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 68 - AAA systems - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Access Control (Substation Remote Access Example)	Local access to devices residing in a substation, with substation local authentication and authorization	X		
	Local access to devices residing in a substation, with higher level support (e.g., control center) for authentication and authorization	X		
	Remote access to devices residing in a substation, with substation local authentication and authorization using a separate VPN	X		
	Remote access to devices residing in a substation, with higher level support (e.g., control center) for authentication and authorization using a separate VPN	X		
	Remote access to devices residing in a substation, with substation local authentication and authorization using communication protocol inherent security means.	X	X	
	Remote access to devices residing in a substation, with higher level support (e.g., control center) for authentication and authorization using a communication protocol inherent security means.	X	X	
System and security management	User Management	(X)		
	Role Management	X		
	Rights/Privileges Management	X		
	Certificate Management		X	
	Events Management		X	

Note that in the table for the general user management and role management solution standards are referred to in terms of Identity and Access Management (IAM). For requirement standards addressing the organizational handling ISO/IEC 27001, ISO 27002, and ISO 27019 are referenced here.

Access control based on authentication of persons or components in these use cases can be provided by different means like:

- Username / Password
- X.509 Certificates and corresponding private keys
- Security Tokens (like one-time-password-generators, smart cards, RFID token, etc…)

Please note that authentication means can also be directly derived from the used EAP method during network access. Through different EAP methods EAP basically allows the application of all of the stated authentication means in the bullet list above.

Depending on the use case, these means may be applied just locally, requiring the authorization handling to be performed locally as well. This may include the local management of accessing peers (persons or devices), roles, and associated rights. Moreover, these means may be used as part of the communication protocols on different OSI layers. A further option is to delegate the access control from the station level to the operation level. This leads to access control decisions by an AAA server residing in a control center for example.

8.10.4.3 Mapping on SGAM

8.10.4.3.1 Preamble

It is important to consider that, from a standard point of view there are a lot of similarities between distribution substation automation system, transmission and generation substations, especially when it comes to remote access. For an easy reading of the document only the distribution substation automation is mapped as example use case. The general approach can also be applied to other scenarios, like transmission or generation and also to remotely access smart metering systems like data collection points, which constitute the first layer of data accumulation.

Considering that this system is not interacting with the “Enterprise” and “Market” zones of the SGAM, only the “Process”, “Field”, “Station” and “Operation” zones will be shown.

8.10.4.3.2 Component Layer

The base representation of the component layer is provided by the substation automation use case. The additional component used here is the AAA server. The AAA server allows the storage of the authentication information and access rights of dedicated users (or roles) or components necessary to access to the substation. The AP (Access Point) is the ingress equipment supporting authentication and access control communicating with the AAA authentication server. The AAA authentication server may reside on station level (providing also authentication and authorization support if the connection to the control center is lost) or in the control center (typical). This is shown in the figure below by the two AAA authentication servers connected with the access switch with dotted lines. The AP may be the switch already available or an additional component (like a VPN Gateway) as marked in red in the following figure.

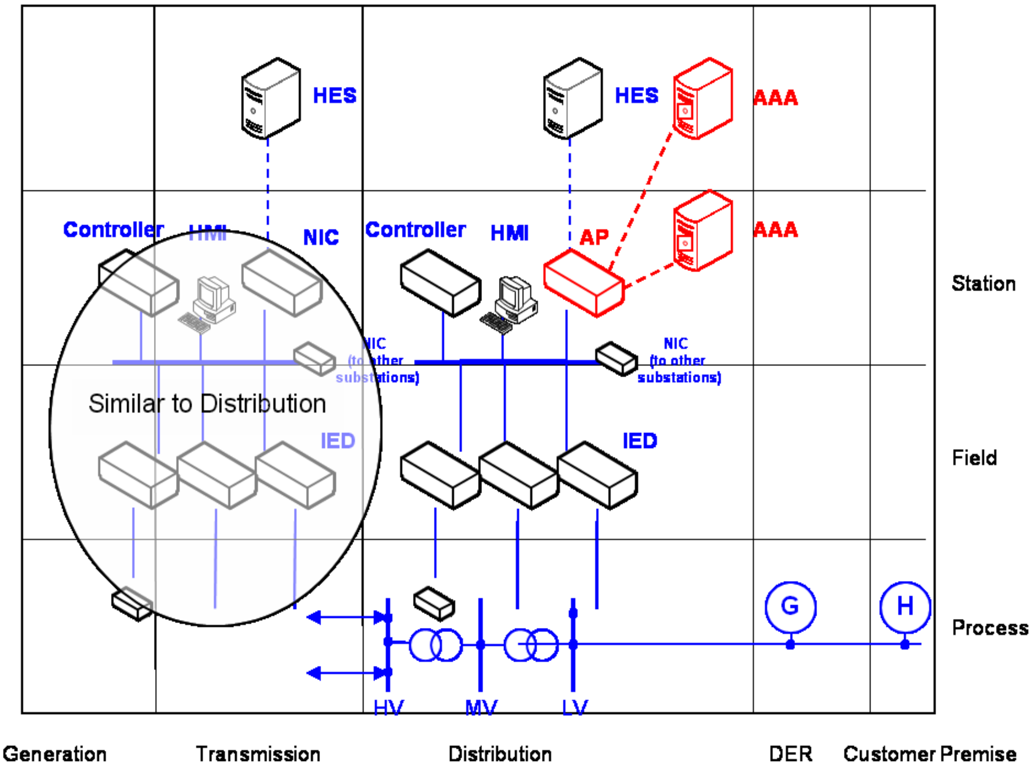


Figure 66 - Mapping of Standards used in the AAA Example on SGAM - Component Layer

8.10.4.3.3 Communication Layer

As stated before, there are two main options for remotely accessing a substation. Either using a separate VPN connection or protocol specific security features.

For the VPN connection IPSec is assumed to be applied. Network access control is often performed, before the IPSec connection is actually established (e.g., using EAP (Encapsulated Authentication Protocol) on OSI layer 2. Examples can be given by dial-up connections using PPP.

EAP is a container protocol allowing the transport of different authentication methods which provide different functionality. The base protocol is defined in RFC 3748. EAP allows the specification of dedicated methods to be used within the container. The functionality supported ranges from plain unilateral authentication to mutual authentication with session key establishment. From the cryptographic strength of the authentication, there is also a range from plain passwords to X.509 certificate based authentication.

Examples for EAP authentication methods include (not complete) for instance: EAP-MD5, EAP-MS-CHAP2, EAP-TLS, EAP-TTLS, EAP-FAST, EAP-PSK, EAP-PAX, EAP-IKEv2, EAP-AKA, EAP-MD5, EAP-LEAP, EAP-PEAP, EAP-SIM, EAP-Double-TLS, EAP-SAKE and EAP-POTP. These methods are typically defined in separate IETF documents.

While EAP is typically used for network access authentication, there may be the need to further distinguish access within the substation. For example to access certain protection devices or a substation controller, also considering the role of the accessing entity is necessary to determine the allowed actions connected with the role. IEC 62351-8 provides a solution to support role based access control based on specific credentials (e.g., enhanced X.509 public key certificates or X.509 attribute certificates), which can be applied in the context of applied security protocols. An example is given by the application of these credentials in TLS, which can be used according to IEC 62351-3 and IEC 62351-4 to protect the IEC 61850 communication performed over TCP connections. Here, the X.509 certificates are used in the context of authentication and session key negotiation to protect the TCP channel using the T-profile. This approach may be followed within a substation but also to access the substation from outside, with or without relying on a VPN connection. In fact, in the latter case, TLS provides the secure channel and thus works as a VPN for the TCP connection. In contrast to IPSec here only the specific protocol employing TLS is protected, while IPSec basically provides a secure tunnel between the substation and the remote point allowing tunneling different protocols. If IPSec is used it is assumed that it will be terminated at the ingress point of the substation. If used combined with TLS, the TLS protection reaches deeper into the substation. Moreover, IEC 62351-4 (currently under revision) also provides different application layer security mechanisms (A-profiles), allowing for application of the X.509 credential within the context of an MMS session. This allows for an even more application oriented access control.

For the use case shown here, two protocol families build the base namely IEC 61850 and IEC 60870-5. Especially for the outside communication the TCP based variants are applied allowing an easy application of IEC 62351 functionality. Note that the main focus here is on IEC 62351-8 as it supports the access control functionality:

- Within the substation, IEC 61850-8-1 (for any kind of data flows except sample values) and IEC 61850-9-2 (for sample values) are used to support the selected set of generic Use Cases.
  IEC 61850-90-4 provides detailed guidelines for communication inside a substation.
  IEC 61850 is used for connecting protection relays.
- Outside the substation, “vertical communications” uses IEC 60870-5-104 or IEC 61850, while horizontal communications can rely on IEC 61850-90-5 (full mapping over UDP) or IEC 61850-90-1 (tunneling).

Future vertical communication may rely on IEC 61850-90-2 (guideline for using IEC 61850 to control centers) to provide a seamless architecture, based on IEC 61850. A new mapping of IEC 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 61850 outside the substation, while facilitating its deployment.

This set of standards can be positioned this way on the communication layer of SGAM.

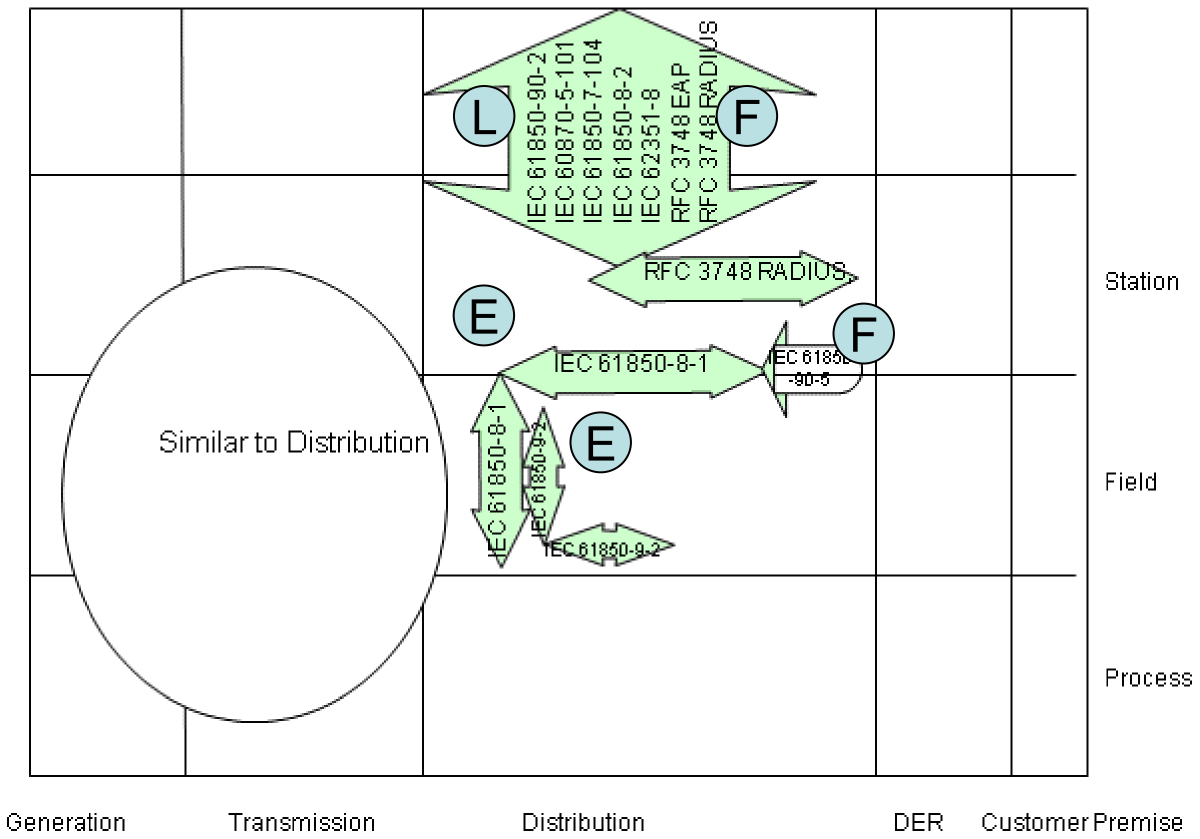


Figure 67 - Mapping of Standards used in the AAA Example on SGAM - Communication Layer

8.10.4.3.4 Information (Data) Layer

The information layer of substation automation is mostly based on the IEC 61850 information model. Security is added by the definition of the security credential formation within IEC 62351-8. Moreover, IEC 62351-9 is currently being worked on to define the key management for IEC 62351 security services. This especially addresses the handling of X.509 key material, which is typically provided as part of a Public Key Infrastructure (PKI). In addition, the referenced IETF documents connected with network access (EAP, RADIUS, etc.) also define the necessary information elements.

For the sake of simplicity, only the security specific data models are referenced here:

- IEC 62351-8: Role Based Access Control, definition of credential formats (note that it is planned that the current IEC 62351-8 will revised to also include the handling to specify custom based roles in addition to the pre-defined roles in the standard
- IEC 62351-9: Key management (CDV available)
- RFC 3748: EAP, additionally the RFCs handling/defining EAP methods
- RFC 2865: RADIUS

For protocols, which are not IEC 61850 native, such as the IEC 60870-5-101 or 104, a mapping of IEC 61850 information model is possible using the IEC 61850-80-1, enabling users of these technologies to use the power of data modeling (and then more seamless integration) without changing communication technologies.

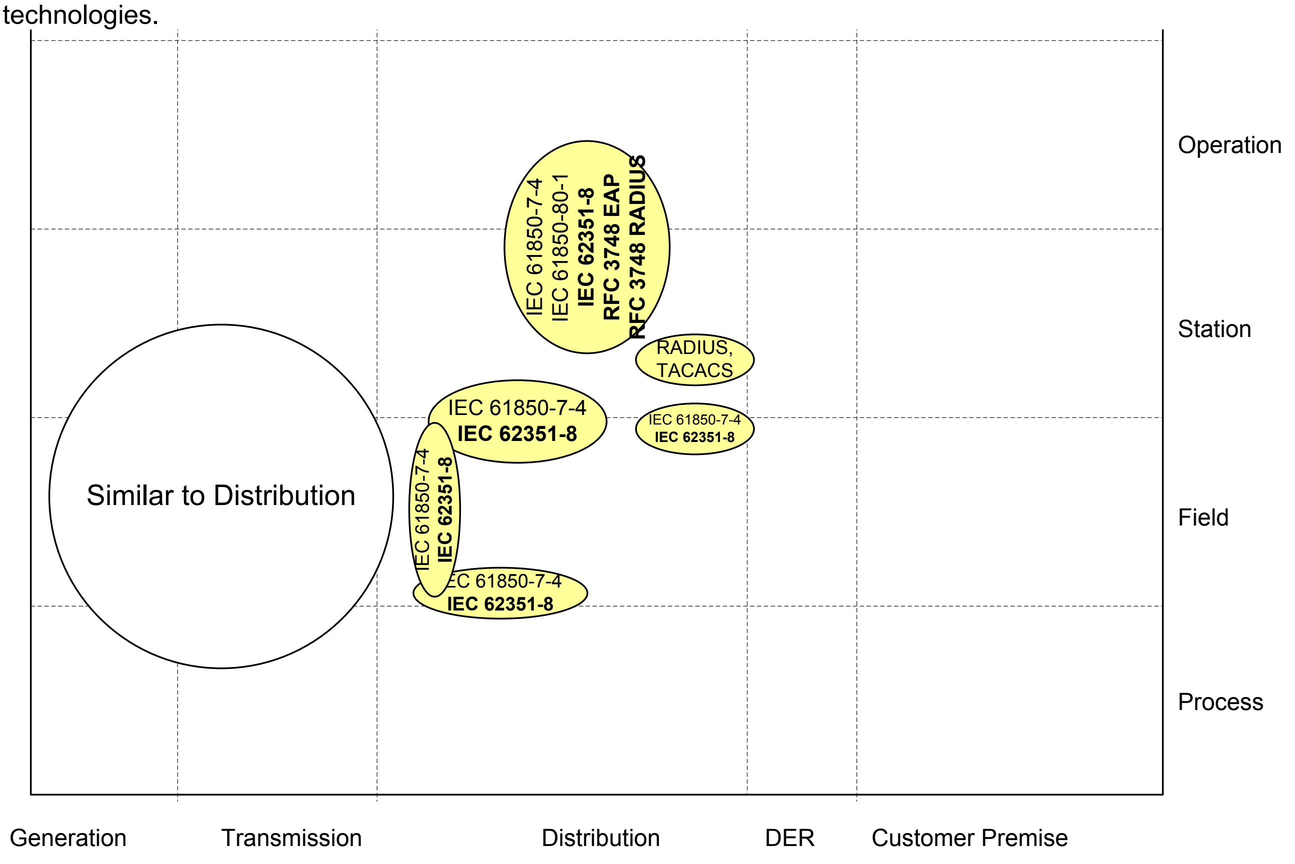


Figure 68 - Mapping of Standards used in the AAA Example on SGAM - Information Layer

8.10.4.4 List of Standards

The following two subsections provide a summary of standards which appear relevant to support AAA systems.

8.10.4.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

The following list provides an overview of applicable standards for AAA. Note that the list does not claim to be complete.

Table 69 - AAA system - Available standards

Layer	Standard	Comments
Information	IEC 62351-8	Definition of Role Based Access Credentials
Information	IETF RFC 4962	Guidance for Authentication, Authorization, and Accounting (AAA) Key Management
Communication	IEC 62351-3 + IEC 62351-4 + IEC 62351-8	Protection of TCP-based IEC 61850 with RBAC on transport (TLS) or application (MMS) layer
Communication	IEC 62351-3 + IEC 62351-5 + IEC 62351-8	Protection of TCP-based IEC 60870-5-104 with RBAC on transport (TLS) layer
Information	IETF RFC 2865	RADIUS (Remote Authentication Dial In User Service)
Communication	IETF RFC 2759	EAP MS-CHAP2
Communication	IETF RFC 3748	EAP Base Protocol (includes EAP MD5)
Communication	IETF RFC 4764	EAP PSK (Pre-Shared Key)
Communication	IETF RFC 5106	EAP IKEv2
Communication	IETF RFC 5216	EAP TLS
Communication	IETF RFC 5281	EAP TTLSv1.0
Information, Communication	IEC 61850-90-4	Guidelines for communication within substation

8.10.4.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015Dec 31st 2015 is considered as “Coming”.

Table 70 - AAA system - Coming standards

Layer	Standard	Comments
Information, Communication	*IEC 62351-90-1*	Definition of categories of actions to be associated with a role/right to ease the administrative handling of rights and role associations. (DC in 08/2016)
Information, Communication	*IEC 62351-7*	Revision of the existing part 7 to support fine grained monitoring utilizing SNMP to support AAA (CDV in 05/2016)
Information, Communication	*IEC 62351-8*	Revision of the existing part 8 to include more profiles for RBAC as well as the possibility to define custom based roles.
Information, Communication	*IEC 62351-9*	(CDV in 02/2016) Key Management for IEC 62351 security services, targeting the management of asymmetric and symmetric as well as group based security credentials.
Information, Communication	*IEC 62351-14*	New part targeting the support of fine grained eventing and logging utilizing syslog SNMP to support AAA (CD in 03/2017)
Information, Communication	*IEC 61850-90-2*	Guidelines for communication to control centers
Communication	*IEC 61850-8-2*	IEC 61850 Specific communication service mapping (SCSM) – Mappings to web-services

8.10.5 Device remote management system

The device management system is a system helping system users to manage connection/disconnection/firmware update and maintenance of devices in a system. It can be used as a configuration server to store device configuration and helping changing a failed device with a new one, ensuring the exact same setting used in this new devices.
End 2015 no specific standard is really supporting such features, which however may become crucial in the future with extended use of complex electronic devices on the field. Some pre-work seems to have started in IEC TC57, but no clear outcome is planned yet.

8.10.6 Weather forecast and observation system

8.10.6.1 System description

A weather forecast and observation system refers to the system and all elements needed to perform weather forecast and observation calculation and to distribute the calculated geospatially referenced information to all connected other systems such as Distribution management systems, Transmission management systems, DER/Generation management systems, EMS or VPPs systems for DER, … enabling in many cases optimized decision processes or automation.
It generally comprises a secured IT system, usually relying on an SOA infrastructure, possibly interconnected to international weather observation and/or connected to a number of weather sensors.

8.10.6.2 Set of use cases

A weather forecast system is generally capable of providing forecast updates, in a solicited or unsolicited manner, such as:

- General atmospheric forecast
- Watches/Warnings (future)

In addition, it may also provide weather observations which can be solicited or unsolicited, and may or will cover information such as:

- Observed lightning (future)
- Current Conditions
- Storm approaching data (future) such as :
  - Precipitation timer
  - Future lightning (currently US only)
  - Storm corridors (currently US only)

Consequently here is the list of high level use cases possibly supported by a Weather forecast and observation system.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.6.2.

Table 71 - Weather forecast and observation system - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Demand and production (generation) flexibility	Load forecasting	I		
Weather condition forecasting & observation	Wind forecasting	C	I	
	Solar forecasting	I		
	Temperature forecasting	I		
	Providing weather observations	I	I	
	Situational alerting		X	

8.10.6.3 Mapping on SGAM

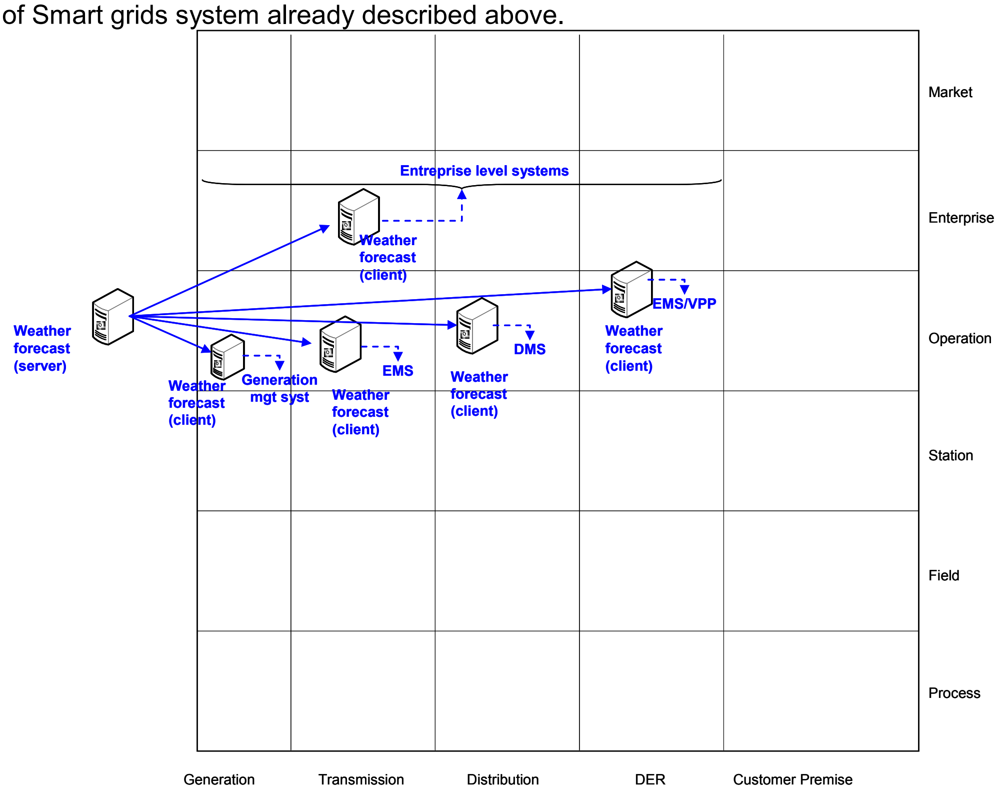
8.10.6.3.1 Preamble

A weather forecast system is not really attached to any SGAM domains or zones, so its mapping over SGAM is not providing real value.

However breaking down such a system using the SGAM layers is useful:

3699 ***8.10.6.3.2 Component layer***

3700 A weather forecast system mostly acts as a server. The clients of the weather forecast services are any type
3701 of Smart grids system already described above.

3702 

3703 **Figure 69 - Weather forecast and observation system - Component layer**

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8.10.6.3.3 Communication layer

The most common communication protocol used for handling exchange with a weather forecast system for a request/response based service is web services (please refer to section 9.3.5 for further details)

Supporting subscribe and publish service for unsolicited data may request to get a network connection available from registration to receiving the data.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.3.2.

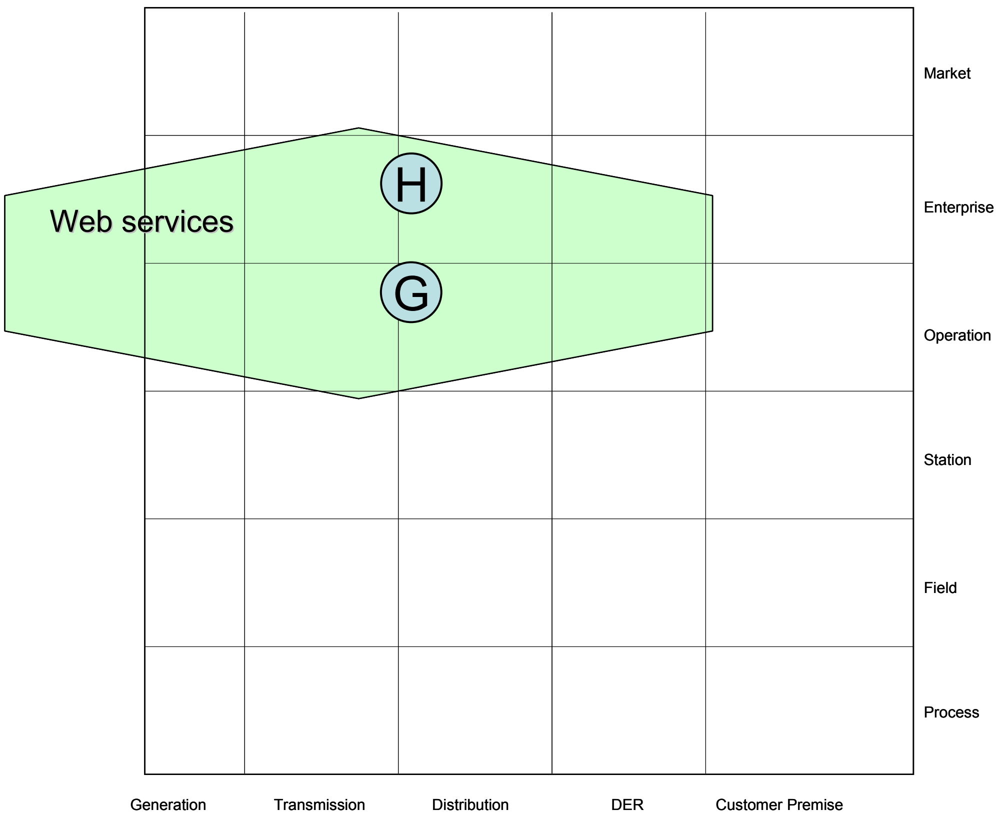

Figure 70 - Weather forecast and observation system - Communication layer

8.10.6.3.4 Information (Data) layer

Even if not perfect WXXM 1.1 XML interface standard, as developed by the US Federal Aviation Administration (FAA) and the European Organisation for the Safety of Air Navigation (EUROCONTROL), is providing a good basis for weather exchange model. GML inheritance may not be needed and some data types may be lacking.

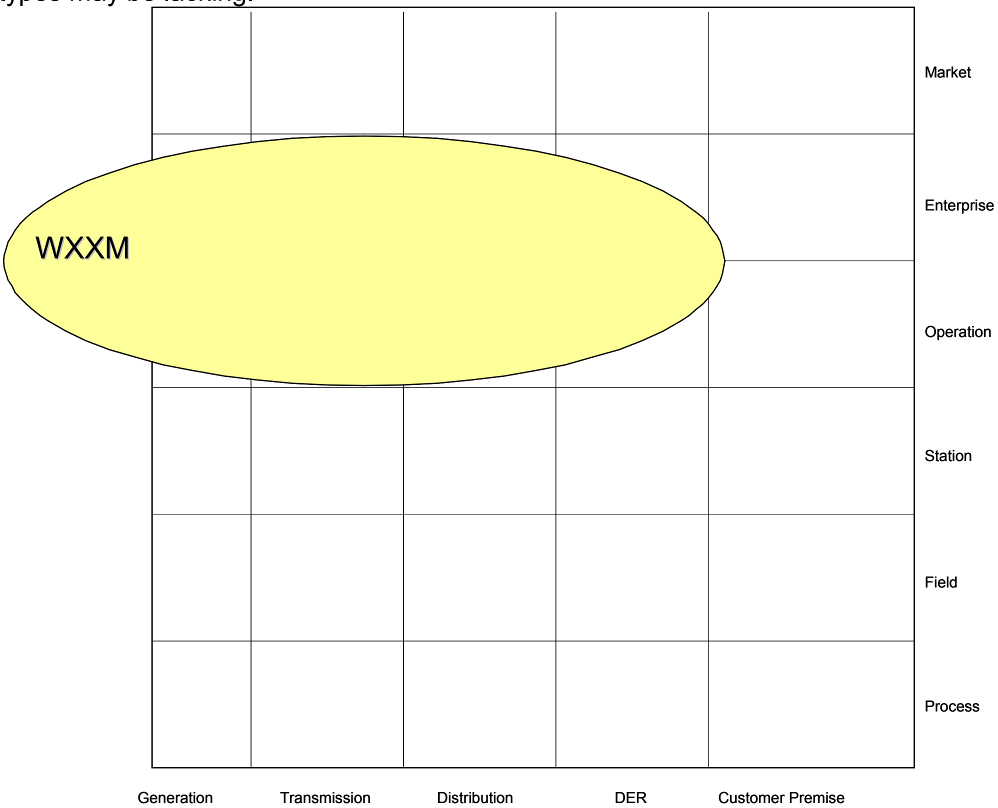

Figure 71 - Weather forecast and observation system - Information layer

In the future Extended WXXM or WMO METCE by adding a Smart Grid (SG) Weather Exchange Model Extension may be considered. The use of the SG Weather Exchange Model Extension will enable the geospatial aspect of the data and provide area capabilities rather than just point.

Some business rules that need to be taken into consideration are but are not limited to:

- Data elements must be optional and not required to allow businesses to entitle users with different combinations of data elements. The data elements must also be able to be specified in the request and meta-data provided about units of measure and other supporting request information.
- Multiple locations must be able to be requested and returned.
- Request modifiers must be defined to allow selection of datasets to be queried. If this doesn't fit in to the extension then a request schema must be created. Currently the schema defines the request as well as the response.

8.10.6.4 List of Standards

8.10.6.4.1 Available standards

In compliance with section 6.2.2, a standard (or "open specification") that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as "available".
Web service related standards are described in 9.3.5.
The tables below describe the standards which are often considered in addition to section 9.3.5.

Table 72 - Weather forecast and observation system - Available standards

Layer	Standard	Comments
Communication	ISO 19142	OpenGIS Web Feature Service 2.0 Interface Standard
Information	NCAR WXXM	Weather Exchange Model. https://wiki.ucar.edu/display/NNEWD/WXXM
Communication	OGC	Open geospatial Consortium http://www.opengeospatial.org/
Information	EN 61850-7-4	Part of IEC 61850 focusing on Weather Observation data model
Information	EN 61400-25-4	Part of IEC 61400-25-4 focusing on Weather Observation data model
Information	WMO METCE	WMO (World Meteorological Organization) METCE (Weather Water and Climate exchange)

8.10.6.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 73 - Weather forecast and observation system - Coming standards

Layer	Standard	Comments
Information	NCAR WXXM	Weather Exchange Model. Next release
Information	IEC 61850-90-3	Condition monitoring data model

Note : IEC TC57 (WG16) has also engaged a work to extend CIM to include an "Environmental Data" model.

9 Cross-cutting technologies and methods

This section defines technologies and standard method which apply to all systems defined in section 8. The applicability of all the standards listed in this section therefore has to be seen in the context of the specific system requirements and usage areas.

9.1 System approach

9.1.1 Use cases approach

The Smart grids are complex systems mixing a large number of technologies, expecting a high level of interoperability. Standardization in this world, as stated above, imply a large number of standards produced by many different technical committees.
Then a single and consistent eco-system is required to achieve a consistent work.

As stated within the first iteration of the mandate [1] a first step consisted in defining and setting-up “sustainable processes”. More specifically, use cases were needed for the description of Smart Grid functionalities. Several committees are already using use cases for their internal work.
IEC SG3 (Smart Grids Strategic committee now substituted by the System Committee 1 “Smart Energy”- SYC1) demanded IEC TC8 as coordinating committee to develop further the existing use case method (based on the existing IEC/PAS 62559) in order to adopt it to standardization processes and to collect use cases in the field of smart grid together with other TCs. IEC TC8 WG5 and WG6 were formed with the respective tasks to define “Method & Tools” to support such an approach and to populate the repository with Generic Use Cases for several Smart Grids domains (for each domain a domain core team (DCT) was formed)

Available and coming standards are listed below :

Table 74 – 9.1.1 Use cases approach - Available standards

Layer/Type	Standard	Comments
General	IEC 60050 series	International Electrotechnical Vocabulary also available on www.electropedia.org
General	EN 61360	Database standards – may be a good support for incremental approach of the Smart grid (example : Actors list or use cases management)
Function	IEC/PAS 62559	Template for specifying Energy systems–related use cases
Function	EN 62559-2	Use case methodology. Part 2: Definition of use case template, actor list and requirement list

Table 75 – Use cases approach - Coming standards

Layer/Type	Standard	Comments
Function	*EN 62559-1*	Use case methodology. Part 1: Use Case Approach in Standardization - Motivation and Processes
Function	*EN 62559-3*	Use case methodology. Part 3: Definition of use case template artefacts into an XML serialized format
Function	*EN 62913-1*	Generic Smart Grid Requirements - Part 1: Specific application of Method & Tools for defining Generic Smart Grid Requirements
Function	*EN 62913-2-1*	Generic Smart Grid Requirements - Part 2-1: Grid related Domains
Function	*EN 62913-2-2*	Generic Smart Grid Requirements - Part 2-2: Market related Domain
Function	*EN 62913-2-3*	Generic Smart Grid Requirements - Part 2-3: Resources connected to the Grid Domains

Function	*EN 62913-2-4*	Generic Smart Grid Requirements - Part 2-4: Electric Transportation Domain
Function	*EN 62913-2-5*	Generic Smart Grid Requirements - Part 2-5: Support Functions Domains

3780

9.1.2 Product Identification

With reference to the (unambiguous) identification of products in the network, it is important to consider the standards which establish the general principles for the structuring of systems including structuring of the information about systems (Reference Designation System, RDS).

By applying the structuring principles very large sets of information in a complex installation can be handled efficiently to support asset management. The structuring principles and the rules for reference designations are applicable to objects of both physical and non-physical character. The principles laid down are general and are applicable to all technical areas. They can be used for systems based on different technologies or for systems combining several technologies.

Furthermore, rules and guidance are given for the formulation of unambiguous reference designations for objects in any system, where also requirements for a product data structure are already included.

The reference designation identifies objects for the purpose of correlating information about an object among different kinds of documents, and for labelling of components corresponding to the objects.

Based on these basic principles, VGB PowerTech association further developed a globally applied Reference Designation System for Power Plants (RDS-PP) which is already widely used in the area of wind energy and associated asset management systems and documentation, but the same principles also generally apply for all distributed energy resources in the Smart Grid. In addition, German IG EVU association developed application rules for a designation system (IG EVU-001-A) especially for grid related objects based on these principles.

There is also a technical guideline for the designation and management of Technical Plant Data which was developed by VGB PowerTech association (VGB-S-821-00, VGB B102 and VGB-S-831-00) which may be relevant for this gap in addition.
VGB PowerTech is currently working on application guidelines for grids and new technologies in order to further support planning, operation and asset management.

We therefore aim that already existing and applied work, applicable for all technical domains, systems and products as specifically mentioned in this gap, need to be appropriately considered to support asset management as specifically mentioned.

Table 76 – Product Identification and Classification - Available standards

Layer/Type	Standard	Comments
General - Identification	EN 81346-1	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 1: Basic rules
General - Classification	EN 81346-2	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 2: Classification of objects and codes for classes
General - Classification	EN 81346-3	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 3: Application rules for a reference designation system
General - Classification	EN 81346-10	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designation - Part 10: Power plants
General - Identification	EN 62507-1	Requirements for identification systems enabling unambiguous information interchange – Part 1: Principles and methods

General - Classification	EN 61355-1	Classification and designation of documents for plants, systems and equipment - Part 1: Rules and classification tables
General - Identification	EN 61666	Industrial systems, installations and equipment and industrial products - Identification of terminals within a system
General - Identification	EN 61175-1	Industrial systems, installations and equipment and industrial products – Designation of signals
General – product description	EN 61360 series ISO 13583	Standard data element types with associated classification scheme for electric components available from <http://std.iec.ch/iec61360>
General – product description	ISO 13584	Industrial automation systems and integration - Parts library (PLIB).
General – product description	IEC/PAS 62569-1	Generic specification of information on products - Part 1: Principles and methods

Table 77 - Identification and Classification of objects - Coming standards

Layer/Type	Standard	Title and comments
General – product description	IEC 62569 series	*(New edition)Generic specification of information on products*

9.2 Data modeling (Information layer)

9.2.1 Description

Because of the increasing need of Smart Grid stakeholders, to deploy solutions offering a semantic level of interoperability, data modeling appears as the corner stone and foundation of the Smart grid framework.

In addition data modeling seems much more stable than communication technologies, which makes this foundation even more important.

Currently the European framework relies on 3 main pillars, as far as data modeling is concerned, represented in Figure 72.

The same figure represents also the 3 harmonization work (i.e the definition of unified shared semantic sub-areas, or formal transformation rules) which needs to be performed in order to allow an easy bridging of these semantic domains:

- Harmonization between CIM (supported through the EN 61970, EN 61968) and IEC 61850 (supported through the EN 61850 series), mostly to seamlessly connect the field to operation and enterprise level
- Harmonization between CIM (supported through the EN 61970, EN 61968) and COSEM (supported through the EN 62056 series), mostly to seamlessly interconnect electricity supply and grid operation
- Harmonization between COSEM (supported through the EN 62056 series) and IEC 61850 (supported through the EN 61850 series), where smart metering may co-habit with Power Utility Automation systems

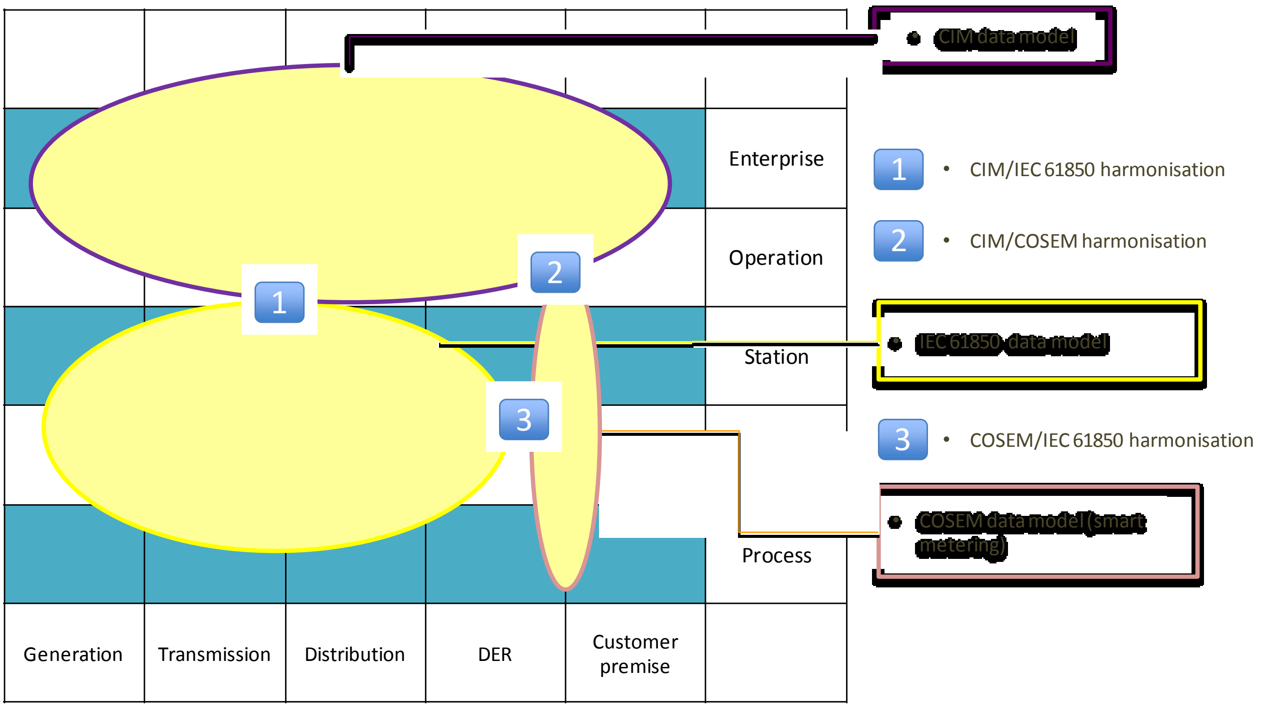

Figure 72 - Data modelling and harmonization work (Information layer) mapping

9.2.2 List of Standards

9.2.2.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 78 - Data modeling - Available standards

Layer	Standard	Comments
Information	IEC/EN 61850 (all parts)	
Information	EN 62056 (parts: 6-1 and 6-2)	COSEM
Information	EN 61970 (all parts)	Part of the CIM family
Information	EN 61968 (all parts)	Part of the CIM family
Information	IEC 62361 (all parts)	Rules for Power Utilities data model
Information	EN 62325 (all parts)	CIM derived data model for Energy Market information exchange
Information	IEC 61850-80-4	mapping of COSEM over IEC 61850

9.2.2.2 Coming standards

In compliance with section 6.2.2,¸a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 79 - Data modeling - Coming standards

Layer	Standard	Comments
Information	*IEC 62056-6-9*	mapping between the Common Information Model CIM (IEC 61968-9) and DLMS/COSEM (IEC 62056) data models and message profiles

Layer	Standard	Comments
Information	*IEC 62361-102*	harmonisation of data models between CIM and IEC 61850

9.3 Communication (Communication layer)

9.3.1 Description

A secure, reliable and economic power supply is closely linked to fast, efficient and dependable telecommunication services.

A telecommunication service is any service provided by a telecommunication network through a communications system. A communications system is a collection of individual communications networks and communication end points capable of interconnection and interoperation to form an integrated whole.

The planning and implementation of communications systems, needed to support the expected services mentioned above, requires the same care as the installation of the power supply systems themselves.

One way to categorize the different types of telecommunications networks is by means of transmission:

- Wireless: communication through the air
- Wire line: communication through cable dedicated to telecommunications services
- Power line: communication through cable designed for electric power transmission, but used for carrying data too.

Wireless communications may have to comply with local or regional regulations (such as the Radio Equipment Directive (RED) 2014/53/EU for Europe and FERC in USA).

For Smart Grid communication architecture/technology, products based on specifications from various bodies (e.g. the IETF, IEEE, W3C) have been deployed widely, notably in the area of IP protocols and web services. In the below section, the list of standards/specifications takes into account the ones which fulfill market requirements.

9.3.2 Communication network type breakdown

Depending on the Smart Grid target applications, different types of communication networks and also collections of communication networks using different transmission technologies may be selected in order to transmit and deliver Smart Grid data.
The following network types could be defined for the Smart Grids[26]:

- **(A) Subscriber Access Network**
  networks that provide general broadband access (including but not limited to the internet) for the customer premises (homes, building, facilities). They are usually not part of the utility infrastructure and provided by communication service providers, but can be used to provide communication service for Smart Grid systems covering the customer premises like Smart Metering and Aggregated prosumers management.

- **(B) Neighborhood network**
  networks at the distribution level between distribution substations and end users. It is composed of any number of purpose-built networks that operate at what is often viewed as the “last mile” or Neighborhood Network level. These networks may service metering, distribution automation, and public infrastructure for electric vehicle charging, for example.

- **(C) Multi-services backhaul Network**
  networks at the distribution level upper tier, which is a multi-services tier that integrates the various

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[26] Notes :
1 - Home and building automation systems are not covered in this document as they are outside of the scope of the mandate. Only the interface to such systems are in the scope
2 - for specific security requirements, please refer to 9.4 and SG-CG/SGIS report [11]

sub layer networks and provides backhaul connectivity in two ways: directly back to control centers 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. This network may serve Advanced Metering or Distribution Automation types of services.

- **(D) Low-end intra-substation network**
  Network inside secondary substations or MV/LV transformer station. It usually connects RTUs, circuit breakers and different power quality sensors.

- **(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).

- **(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.

- **(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.

- **(H) Backbone Network**
  Inter-enterprise or campus networks, including backbone Internet network, as well as inter-control centre networks..

- **(L) Operation Backhaul Network**
  Networks that can use public or private infrastructures, mostly to support remote operation.. They usually inter-connect network devices and/or subsystems to the “Operation level” over a wide area (region or country).

- **(N) Home and Building integration bus Network**
  Networks that interconnect home / building communicating components and sub-systems to form a home or building management sub-system or system

- **(M) Industrial Fieldbus Area Network**
  Networks that interconnect process control equipment mainly in power generation (bulk or distributed) in the scope of smart grids.

Figure 73 below provides a mapping of the different Smart Grid networks to the SGAM model.
Note : where a circle is tangent to a zone, this means that the corresponding network type can support the interface with the tangent zone.

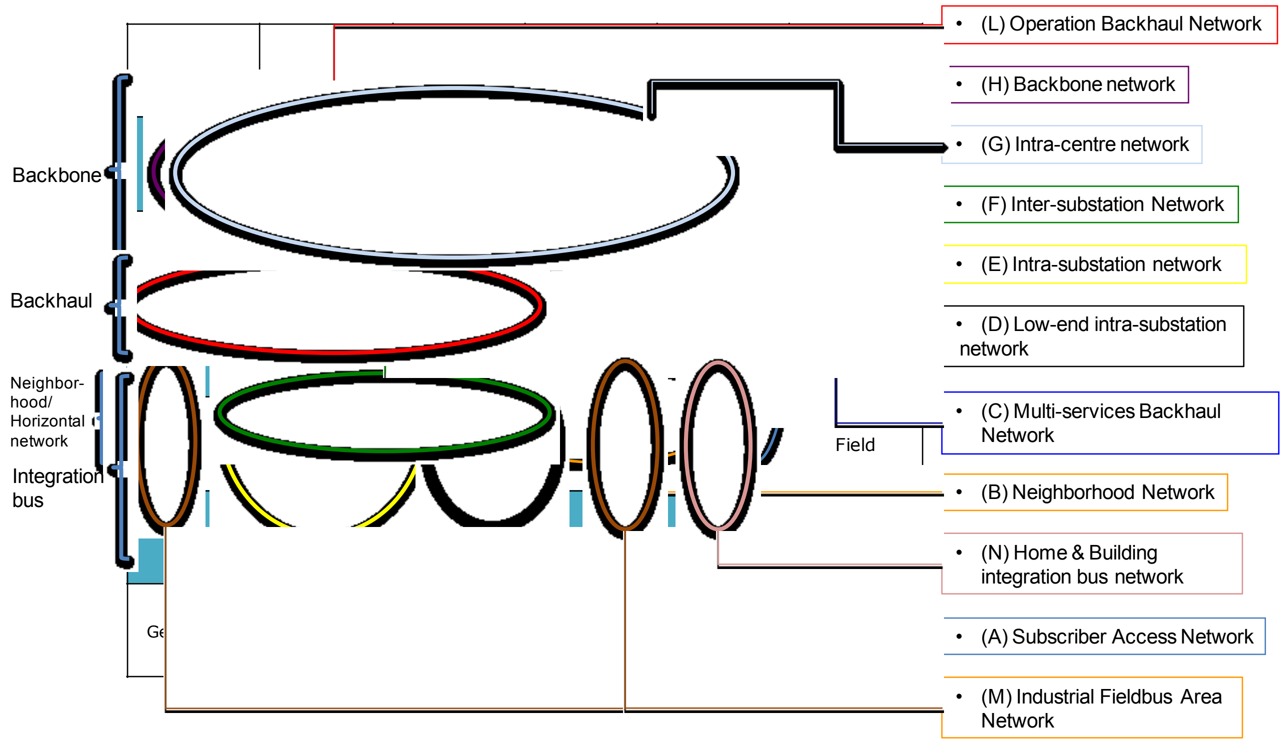

Figure 73 - Mapping of communication networks on SGAM

Note 1: These areas are a mapping example and cannot be normative to all business models.

Note 2: It is assumed that that sub-networks depicted in the above figure are interconnected (where needed) to provide end-to-end connectivity to applications they support. VPNs, Gateways and firewalls could provide means to ensure network security or virtualization.

9.3.3 Applicability of communication standards to Smart Grid networks

The following table provides an applicability statement indicating the standardised communication technologies to the Smart Grid sub-networks depicted in the previous sub-clause. The choice of a technology for a sub-network is left to implementations, which need to take into account a variety of deployment constraints.

Note: This report addresses communication technologies related to smart grid deployment. It includes communication architecture and protocols that could be used in smart metering deployments as well as other use cases (like feeder automation, FLISR etc.). For AMI only specific standards, please refer more specifically to CEN/CLC/ETSI TR 50572 [4] and other future deliverables as listed in SMCG_Sec0074_DC_M441WP-1 (V0.6) Work Program [5].

Each line in the Table 80 identifies a family of communication standards. These families are used to classify the standards in the table below.

More information on these families and associated technologies could be found in the Annex F of the Reference Architecture report [9].

Table 80 - Applicability statement of the communication technologies to the smart grid sub-networks

		Subscriber Access Network	Neighborhood network	Multi-services backhaul Network	Low-end intra-substation network	Intra-substation network	Inter substation network	Intra-Control Centre / Intra-Data Centre network	Backbone Network	Operation Backhaul Network	Home and Building integration bus Network	Industrial Fieldbus Area Network
		A	B	C	D	E	F	G	H	L	N	M
IEEE protocols (MAC-PHY)												
	IEEE 1901.2 Narrow band PLC		■	▨							■	
	IEEE 1901 Broad band PLC	■	■	■							■	
	IEEE 802.15.4 wireless Low Power	▨	■								■	▨
	IEEE 802.11 (WIFi)	▨	■	■	■	■	▨				■	▨
	IEEE 802.3/1 (Ethernet)				■	■		■	▨		■	▨
	IEEE 802.16 (Wimax)	■	■	■							▨	
IETF protocols (Layer 3, 4 and above)												
	IPv4	■	■	■	■	■	■	■	■	■	■	▨
	IPv6	■	■	■	■	■	■	■	■	■	■	▨
	RPL / 6LowPan / 6TiSCH		■								■	
	IP MPLS / MPLS TP			▨			■	■	■	■		
	XMPP		■	■			■			■	■	
ITU Protocols												
	SDH/OTN	▨	▨	■	▨	▨	■	■	■	■	▨	
	DSL/PON	■	■	■			▨	■	■			
	DWDM	▨	▨	▨	▨	▨	■	■	■	■	▨	
	Narrow band PLC (Medium & Low voltage)		■	▨							■	
	Narrow band PLC (High & very High voltage)					▨	■					
	Broadband PLC	■	■	■							■	
ANSI standards												
	SONET / SONET NG	▨	▨	■	■	■	■	■	■	■	▨	
ETSI / 3GPP Protocols												
	ETSI TS 102 887 Wireless (IEEE 802.15.4g)	▨	■								■	
	GSM / GPRS / EDGE	▨	■	▨								
	3G / WCDMA / UMTS / HSPA	■	■	■					▨	▨		
	ETSI TS 103 908		■	▨							■	
	4G LTE/LTE-A	■	■	■			■		■	▨		
EN standards												
	EN 61334		■								▨	
	EN 14908		■	▨							■	■
	EN 50090		■	▨							■	
	EN 13757		▨								▨	■
IEC standards												
	IEC 61158											■
	IEC 61850		▨	▨	■	■	■			▨		
	IEC 60870-5									■		
LPWA (Low Power Wide Area)	LORA, NB-IOT, UNB…	■	▨							▨	■	
Higher layer comm protocol		■	■	■			■	■	■	■	■	

Legend
■ Mostly used
▨ May be used

* : refer to the set of protocols presented in section 9.3.5

9.3.4 List of Standards

The standards that follow are those that reference communication protocols (mostly focusing on L1, L2, L3 of the OSI protocol stack) for smart grid communications. Many standards are part of wider multipart standards.

Only standards which are relevant for the communication, according the OSI Layer model, are listed in this section.

9.3.4.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 81 - Communication - Available standards

Layer	Category (ies)	Standard	Comments
General		ISO/IEC 7498-1	(1994) Information Technology – Open Systems Interconnect – Basic Reference Model: The Basic Model
General		ITU-T I.322	(02/99) - Generic protocol reference model for telecommunication networks
Communication	IP MPLS	IETF RFC 5654	Requirements of an MPLS Transport Profile
Communication	IP MPLS	IETF RFC 5921	A Framework for MPLS in Transport Networks
Communication	IP MPLS	IETF RFC 3031	Multiprotocol Label Switching Architecture
Communication	IP MPLS	IETF RFC 3032	MPLS Label Stack Encoding
Communication	IP MPLS	IETF RFC 4090	Fast Reroute Extensions to RSVP-TE for LSP Tunnels, http://www.ietf.org/rfc/rfc4090.txt
Communication	IP MPLS	IETF RFC 6178	Label Edge Router Forwarding of IPv4 Option Packets
Communication	IPv4, IPv6	IETF RFC 791	Internet Protocol
Communication	IPv4, IPv6	IETF RFC 2460	Internet Protocol, Version 6 (IPv6) Specification
Communication	IPv4, IPv6	IETF RFC 4944	Transmission of IPv6 Packets over IEEE 802.15.4 Networks -. http://www.rfc-editor.org/rfc/rfc4944.txt
Communication	IPv4, IPv6	IETF RFC 6272[27]	Internet Protocols for the Smart Grid. http://www.rfc-editor.org/rfc/rfc6272.txt
Communication	IPv4, IPv6	IETF RFC 6282	Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks
Communication	IPv4, IPv6, IP MPLS	IETF RFC 5086	Structure-Aware Time Division Multiplexed (TDM) Circuit Emulation Service over Packet Switched Network (CESoPSN)
Communication	IPv4, IPv6, IP MPLS	IETF RFC 4553	Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP)
Communication	IEEE 802.11	IEEE 802.11	A list of standards is available under this link http://standards.ieee.org/about/get/802/802.11.html
Communication	IEEE 802.1	IEEE 802.1	A list of standards is available under this link http://standards.ieee.org/about/get/802/802.1.html
Communication	IEEE 802.3	IEEE 802.3	A list of standards is available under this link http://standards.ieee.org/about/get/802/802.3.html
Communication	IEEE 802.16	IEEE 802.16	A list of standards is available under this link http://standards.ieee.org/about/get/802/802.16.html
Communication	IEEE 802.15.4	IEEE 802.15.4	A list of standards is available under this link http://web.archive.org/web/20080224053532/http://shop.ieee.org/ieeestore/Product.aspx?product_no=SS95552

[27] RFC 6272 is an informational RFC. It is listed in this table because it makes reference to several standard track RFCs which are relevant for Smart Grids

Layer	Category (ies)	Standard	Comments
Communication	ETSI TS 102 887	ETSI TS 102 887	- Electrocompatibility and radio spectrum Matters (ERM); Short Range Devices; Smart Metering Wireless Access Protocol (SMEP). Part 1; PHY Layer - Electrocompatibility and radio spectrum Matters (ERM); Short Range Devices; Smart Metering Wireless Access Protocol (SMEP). Part 2; MAC Layer
Communication	RPL/6LowPan	IETF RFC 4919	IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs): Overview, Assumptions, Problem Statement, and Goals
Communication	RPL/6LowPan	IETF RFC 6550	(ROLL) RPL IPv6 Routing Protocol for Low-Power and Lossy Network. A list of Internet RFCs is available under: http://tools.ietf.org/wg/roll draft-ietf-roll-minrank-hysteresis-of -11 2012-06-30 RFC Ed Queue draft-ietf-roll-security-framework draft-ietf-roll-p2p-measurement draft-ietf-roll-p2p-rpl draft-ietf-roll-trickle-mcast
Communication	RPL/6LowPan	IETF RFC 6551	(ROLL) Routing metrics
Communication	RPL/6LowPan	IETF RFC 6552	(ROLL) Objective Function Zero
Communication	RPL/6LowPan	IETF RFC 6206	(ROLL) Trickle
Communication	RPL/6LowPan	IETF RFC 6775	Neighbor Discovery Optimization for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)
Communication	6LowPan	IETF RFC 7388	Definition of Managed Objects for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)
Communication	6LowPan	IETF RFC 7400	6LoWPAN-GHC: Generic Header Compression for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)
Communication	6LowPan	IETF RFC 7428	Transmission of IPv6 Packets over ITU-T G.9959 Networks
Communication	6LowPan	IETF RFC 7668	IPv6 over BLUETOOTH(R) Low Energy
Communication	EN 13321	EN 13321-2	prEN 13321-2:2012-02: Open Data Communication in Building Automation, Controls and Building Management - Home and Building Electronic System Part 2: KNXnet/IP Communication
Communication	Narrow band PLC (Medium & Low voltage)	EN 61334	Distribution automation using distribution line carrier systems
Communication	EN 50090	EN 50090-2-1	System overview-Architecture (1994)
Communication	EN 50090	EN 50090-3-1	Aspects of application-Introduction to the application structure (1994)
Communication	EN 50090	EN 50090-3-2	Aspects of application-User process for HBES Class 1 (2004)
Communication	EN 50090	EN 50090-4-1	Media independent layers-Application layer for HBES Class 1 (2004)
Communication	EN 50090 Narrow band PLC (Medium & Low voltage)	EN 50090-4-2	Media independent layers–Transport layer, network layer and general parts of datalink layer for HBES Class 1 (2004)
Communication	EN 50090	EN 50090-4-3	Media independent layers -Communication over IP
Communication	EN 50090	EN 50090-5-1	Media and media dependent layers-Power line for HBES Class 1 (2005)
Communication	EN 50090	EN 50090-5-2	Media and media dependent layers-Network based on HBES Class1, Twisted Pair (2004)
Communication	EN 50090	EN 50090-7-1	System management-Management procedures (2004)
Communication	EN 14908	EN 14908-1	Control network protocol stack
Communication	EN 14908	EN 14908-2	Twisted-pair channel for networked control systems

Layer	Category (ies)	Standard	Comments
Communication	EN 14908 Narrow band PLC (Medium & Low voltage)	EN 14908-3	Power Line channel in the EN 50065-1 CENELEC C-Band
Communication	EN 14908	EN 14908-4	Transporting over Internet Protocol (IP) networks
Communication	EN 14908 Narrow band PLC (Medium & Low voltage)	ETSI TS 103 908	Power Line channel in the EN 50065-1 CENELEC A-Band
Communication	LTE/LTE-A	ETSI TS 136 300 / 3GPP TS 36.300	LTE Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 http://www.3gpp.org/ftp/Specs/html-info/36300.htm (ITU-R endorsement)
Communication	LTE/LTE-A	ETSI TS 136 201 / 3GPP TS 36.201	Evolved Universal Terrestrial Radio Access (E-UTRA); LTE physical layer; General description. (ITU-R endorsement)
Communication	LTE/LTE-A	ETSI TS 136 211 / 3GPP TS 36. 211	211 Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation. (ITU-R endorsement)
Communication	LTE/LTE-A	ETSI TS 136 212 / 3GPP TS 36.212	Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding. (ITU-R endorsement)
Communication	LTE/LTE-A	ETSI TS 136 213 / 3GPP TS 36.213	Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures. (ITU-R endorsement)
Communication	LTE/LTE-A	ETSI TS 136 214 / 3GPP TS 36.214	Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements.
Communication	LTE/LTE-A	ETSI TS 136 216 / 3GPP TS 36.216	Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer for relaying operation (ITU-R endorsement)
Communication	LTE/LTE-A	ETSI TS 123 401 / 3GPP TS 23.401	General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access
Communication	3G / WCDMA / UMTS / HSPA	ETSI TS 121 101	Overview of Technical Specifications and Technical Reports for a UTRAN-based 3GPP system (3GPP TS 21.101)
Communication	GSM / GPRS / EDGE	ETSI TS 141 101	Overview of Technical Specifications and Technical Reports for a GERAN-based 3GPP system (3GPP TS 41.101)
Communication	LTE/LTE-A, GSM/GPRS/EDGE, 3G/WCDMA/UMTS/ HSPA	ETSI TS 122 368 / 3GPP TS 22.368	Service requirements for Machine-Type Communications (MTC); Stage 1
Communication	LTE/LTE-A, GSM/GPRS/EDGE, 3G/WCDMA/UMTS/ HSPA	ETSI TS 123 682 / 3GPP TS 23.682	Architecture Enhancements to facilitate communications with Packet Data Networks and Applications
Communication	LTE/LTE-A	ETSI TS 123 402 / 3GPP TS 23.402	Architecture Enhancements for Non-3GPP Accesses (Release 10)
Communication	LTE/LTE-A, GSM/GPRS/EDGE, 3G/WCDMA/UMTS/ HSPA	ETSI TS 129 368 3GPP TS 29.368	Tsp interface protocol between the MTC Interworking Function (MTC-IWF) and Service Capability Server (SCS)
Communication	GSM/GPRS/EDGE	ETSI EN 301 502	Global System for Mobile communications (GSM);Harmonized EN for Base Station Equipment covering the essential requirements of article 3.2 of the R&TTE Directive
Communication	GSM/GPRS/EDGE,	ETSI EN 301 511	Global System for Mobile communications (GSM);Harmonized EN for mobile stations in the GSM 900 and GSM 1800 bands covering essential requirements under article 3.2 of the R&TTE directive

Layer	Category (ies)	Standard	Comments
Communication	LTE/LTE-A, 3G/WCDMA/UMTS/ HSPA	ETSI EN 301 908	Parts 1,2,3,6,7,3,11,13, 14,15,18 - IMT cellular networks;Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive
Communication	CDMA2000/UMB	ETSI EN 301 908	Parts 4, 5, 12, 16, 17 - IMT cellular networks;Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive
Communication	DSL/PON	IEEE 802.3	802.3 application for GEPON
Communication	DSL/PON	IEEE 802.3av	802.3av application for 10GEPON
Communication	DSL/PON	ITU-T G.991.1	High bit rate digital subscriber line (HDSL) transceivers
Communication	DSL/PON	ITU-T G.991.2	Single-pair high-speed digital subscriber line (SHDSL) transceivers
Communication	DSL/PON	ITU-T G.992.1	Asymmetric digital subscriber line (ADSL) transceivers
Communication	DSL/PON	ITU-T G.992.2	Splitterless asymmetric digital subscriber line (ADSL) transceivers
Communication	DSL/PON	ITU-T G.992.3	Asymmetric digital subscriber line transceivers 2 (ADSL2)
Communication	DSL/PON	ITU-T G.992.4	Splitterless asymmetric digital subscriber line transceivers 2 (splitterless ADSL2)
Communication	DSL/PON	ITU-T G.993.1	Very high speed digital subscriber line transceivers (VDSL)
Communication	DSL/PON	ITU-T G.993.2	Very high speed digital subscriber line transceivers 2 (VDSL2)
Communication	DSL/PON	ITU-T G.993.5	Self-FEXT cancellation (vectoring) for use with VDSL2 transceivers
Communication	DSL/PON	ITU-T G.994.1	Handshake procedures for digital subscriber line (DSL) transceivers
Communication	DSL/PON	ITU-T G.995.1	Overview of digital subscriber line (DSL) Recommendations
Communication	DSL/PON	ITU-T G.996.1	Test procedures for digital subscriber line (DSL) transceivers
Communication	DSL/PON	ITU-T G.996.2	Single-ended line testing for digital subscriber lines (DSL)
Communication	DSL/PON	ITU-T G.997.1	Physical layer management for digital subscriber line (DSL) transceivers
Communication	DSL/PON	ITU-T G.998.1	ATM-based multi-pair bonding
Communication	DSL/PON	ITU-T G.998.2	Ethernet-based multi-pair bonding
Communication	DSL/PON	ITU-T G.998.3	Multi-pair bonding using time-division inverse multiplexing
Communication	DSL/PON	ITU-T G.999.1	Interface between the link layer and the physical layer for digital subscriber line (DSL) transceivers
Communication	DSL/PON	ITU-T G.998.4	Improved Impulse Noise Protection (INP) for DSL Transceivers
Communication	DSL/PON	ITU-T G.983.1	Broadband optical access systems based on Passive Optical Networks (PON)
Communication	DSL/PON	ITU-T G.983.2	ONT management and control interface specification for B-PON
Communication	DSL/PON	ITU-T G.983.3	A broadband optical access system with increased service capability by wavelength allocation

Layer	Category (ies)	Standard	Comments
Communication	DSL/PON	ITU-T G.983.4	A broadband optical access system with increased service capability using dynamic bandwidth assignment
Communication	DSL/PON	ITU-T G.983.5	A broadband optical access system with enhanced survivability
Communication	DSL/PON	ITU-T G.984.1	Gigabit-capable passive optical networks (GPON): General characteristics
Communication	DSL/PON	ITU-T G.984.2	Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification
Communication	DSL/PON	ITU-T G.984.3	Gigabit-capable Passive Optical Networks (G-PON): Transmission convergence layer specification
Communication	DSL/PON	ITU-T G.984.4	Gigabit-capable passive optical networks (G-PON): ONT management and control interface specification
Communication	DSL/PON	ITU-T G.984.5	Gigabit-capable Passive Optical Networks (G-PON): Enhancement band
Communication	DSL/PON	ITU-T G.984.6	Gigabit-capable passive optical networks (GPON): Reach extension
Communication	DSL/PON	ITU-T G.984.7	Gigabit-capable passive optical networks (GPON): Long reach
Communication	DSL/PON	ITU-T G.987.1	10-Gigabit-capable passive optical networks (XG-PON): General requirements
Communication	DSL/PON	ITU-T G.987.2	10-Gigabit-capable passive optical networks (XG-PON): Physical media dependent (PMD) layer specification
Communication	DSL/PON	ITU-T G.987.3	10-Gigabit-capable passive optical networks (XG-PON): Transmission convergence (TC) layer specification
Communication	EN 60870-5	EN 60870-5-4 EN 60870-5-3 EN 60870-5-2 EN 60870-5-1	Telecontrol equipment and systems - Part 5 – lower layers of communication
Communication	EN 60870-5	EN 60870-5-101	Telecontrol equipment and systems - Part 5-101: Transmission protocols - Companion standard for basic telecontrol tasks
Communication	EN 60870-5	EN 60870-5-102	Telecontrol equipment and systems. Part 5-102 : transmission protocols. Companion standard for the transmission of integrated totals in electric power systems
Communication	EN 60870-5	EN 60870-5-103	Telecontrol equipment and systems - Part 5-103: Transmission protocols - Companion standard for the informative interface of protection equipment
Communication	EN 60870-5	EN 60870-5-104	Telecontrol equipment and systems - Part 5-104: Transmission protocols - Network access for EN 60870-5-101 using standard transport profiles
Communication	SDH/OTN	ITU-T G.707	Network node interface for the synchronous digital hierarchy (SDH)
Communication	SDH/OTN	ITU-T G.7042	Link capacity adjustment scheme for virtual concatenated signals.
Communication	SDH/OTN	ITU-T G.7041	Generic Framing Procedure (GFP)
Communication	SDH/OTN	ITU-T G.709	Interfaces for the Optical Transport Network (OTN)
Communication	SDH/OTN	ITU-T G.798	Characteristics of optical transport network hierarchy equipment functional blocks
Communication	SDH/OTN	ITU-T G.781	Synchronization layer functions
Communication	SDH/OTN	ITU-T G.872	Architecture of optical transport networks
Communication	SDH/OTN	ITU-T G.783	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks

Layer	Category (ies)	Standard	Comments
Communication	SDH/OTN	ITU-T G.803	Architecture of transport networks based on the synchronous digital hierarchy (SDH)
Communication	IEC 61850	EN 61850-8-1	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
Communication	IEC 61850	EN 61850-9-2	Ed. 2.0:2011- Communication networks and systems in substations - Part 9-2: Specific Communication Service Mapping (SCSM) - Sampled values over ISO/IEC 8802-3
Communication	IEC 61850	IEC 61850-90-1	Ed. 1.0:2010 - Communication networks and systems for power utility automation - Part 90-1: Use of IEC/EN 61850 for the communication between substations
Communication	IEC 61850	IEC 61850-90-4	Communication networks and systems for power utility automation - Network engineering guidelines
Communication	IEC 61850	IEC 61850-90-5	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
Communication, Information	IEC 61850	EN 61850-7-1	Ed. 2.0:2011- Communication networks and systems for power utility automation - Part 7-1: Basic communication structure - Principles and models
Communication	EN 13757	EN 13757-4	Communication systems for meters and remote reading of meters – Part 4: wireless meter readout (radio meter reading for operation in SRD bands)
Communication	EN 13757	EN 13757-5	Communication systems for meters and remote reading of meters – Part 5: wireless relaying
Communication	Narrow band PLC (High & very High voltage)	IEC 62488-1 (Formerly EN60663) - Part 1	Planning of analogue and digital power line carrier systems operating over EHV/HV/MV electricity grids.
Communication	Broadband PLC	ISO/IEC 12139-1	Telecommunications and information exchange between systems — Powerline communication (PLC) — High speed PLC medium access control (MAC) and physical layer (PHY)
Communication	Broadband PLC	ITU-T G.9960 ITU-T G.9961 ITU-T G.9962 ITU-T G.9963 ITU-T G.9964	Unified high-speed wireline-based home networking : ITU-T G.9960 (PHY) ITU-T G.9961 (DLL) ITU-T G.9962 (MIMO) ITU-T G.9963 (MIMO G.hn) ITU-T G.9964 (PSD)
Communication	Narrow band PLC (Medium & Low voltage)	ITU-T G.9901	ITU-T G.9901 (NB-PLC PSD)
Communication	Narrow band PLC (Medium & Low voltage)	ITU-T G.9902	ITU-T G.9902 (G.hnem)
Communication	Narrow band PLC (Medium & Low voltage)	ITU-T G.9903	ITU-T G.9903 (G3-PLC)
Communication	Narrow band PLC (Medium & Low voltage)	ITU-T G.9904	ITU-T G.9904 (PRIME)
Communication	Narrow band PLC (Medium & Low voltage)	ITU-T G.9905	ITU-T G.9905 (Routing)
Communication	Narrowband wireless”	ITU-T G.9959	ITU-T G.9959 (Z-Wave) Short range narrowband digital radio communication transceivers – PHY & MAC layer specifications
Communication	G.fast	ITU-T G.9700	Fast access to subscriber terminals (FAST) - Power spectral density specification (G.fast PSD)
Communication	Broadband PLC	IEEE 1901	Broadband over Power Line Networks

Layer	Category (ies)	Standard	Comments
Communication	Broadband PLC	IEEE 1901.2	Standard for Low Frequency (less than 500 kHz) Narrow Band Power Line Communications for Smart Grid Applications
Communication	M2M	ETSI TR 101 531	Machine-to-Machine communications (M2M); Reuse of Core Network Functionality by M2M Service Capabilities -
Communication	M2M	ETSI TR 102 935	Machine-to-Machine communications (M2M);. Applicability of M2M architecture to Smart Grid Networks
Communication	M2M	ETSI TR 102 966	Machine-to-Machine communications (M2M); Interworking between the M2M Architecture and M2M Area Network technologies
Communication	M2M	ETSI TR 103 167	Machine-to-Machine Communications (M2M); Threat analysis and counter-measures to M2M service layer
Communication	M2M	ETSI TS 101 584	Machine-to-Machine Communications (M2M);. Study on Semantic support for M2M Data
Communication	M2M	ETSI TS 102 689	Machine-to-Machine communications (M2M); M2M service requirements
Communication	M2M	ETSI TS 103 092	Machine-to-Machine communications (M2M); OMA DM compatible Management Objects for ETSI M2M
Communication	M2M	ETSI TS 103 093	Machine-to-Machine communications (M2M); BBF TR-069 compatible Management Objects for ETSI M2M
Communication	M2M	ETSI TS 103 104	Machine-to-Machine communications (M2M); Interoperability Test Specification for CoAP Binding of ETSI M2M Primitives
Communication	M2M	ETSI TS 103 107	ETSI TS 103 107 Machine-to-Machine communications (M2M); Service layer interworking with 3GPP2 networks
Communication	M2M	ETSI TS 103 603	Machine-to-Machine communications (M2M); Service layer interworking with 3GPP networks
Communication	LPWA	LoRaWAN Specification 1.0	LoRaWAN™ Specification
Communication	LPWA	3GPP Release 13 NB-IOT	Narrow Band IOT
Communication	LPWA	GS LTN 001	Low Throughput Networks (LTN); Use Cases for Low Throughput Networks
Communication	LPWA	GS LTN 002	Low Throughput Networks (LTN); Functional Architecture
Communication	LPWA	GS LTN 003	Low Throughput Networks (LTN); Protocols and Interfaces

9.3.4.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 82 - Communication - Coming standards

Layer	Standard	Comments
Communication	*EN 50491-12*	Smart Grid interface and framework for Customer Energy Management
Communication	*IEC 62746*	IEC 62746- x: Systems Interface between Customer Energy Management and the Power management Systems
Communication	*CLC prTS 50586*	CENELEC/prTS 50586: OSGP (Open Smart Grid Protocol) - Communication protocols, data structures and procedures
Communication	*CLC prTS 50568-4*	CENELEC/prTS 50568-4 ‘Electricity metering data exchange - The Smart Metering Information Tables and

Layer	Standard	Comments
		Protocols (SMITP) suite - Part 4: Physical layer based on SMITP B-PSK modulation and SMITP Data Link Layer’
Communication	*CLC prTS 50568-8*	CENELEC/prTS 50568-8 ‘Electricity metering data exchange - The DLMS/COSEM suite - Part 8: PLC profile based on SMITP B-PSK modulation - Including: The original-SMITP PLC profile based on SMITP B-PSK modulation, the original-SMITP Local data exchange profile and the original-SMITP IP profile
Communication	*CLC prTS 50590*	CENELEC/prTS 50590 - Electricity metering data exchange - CX 1 Lower layer specification - Part X: Physical layer, data link layer and network layer
Communication	*IEC 61850-8-2*	Mapping of IEC/EN 61850 communication services over the Web services
Communication	*EN 50412-4*	(pr) Broadband PLC – LRWBS - Power line communication apparatus and systems used in low-voltage installations in the frequency range 1,6 MHz to 30 MHz
Communication	*ITU-T G.9701*	Fast access to subscriber terminals - G.fast PHY
Communication	*ITU-T G.9903*	ITU-T G.9903 (G3-PLC) - revision
Communication	*Draft-ietf-detnet-problem-statement*	Deterministic Networking Problem Statement
Communication	*Draft-ietf-detnet-use-case-10*	Deterministic Networking Use Cases
Communication	*draft-ietf-6tisch-architecture*	Architecture for IPv6 over the TSCH mode of IEEE 802.15.4e
Communication	*draft-ietf-6tisch-6top-interface*	Architecture for IPv6 over the TSCH mode of IEEE 802.15.4e
Communication	*draft-ietf-6tisch-minimal*	Architecture for IPv6 over the TSCH mode of IEEE 802.15.4e
Communication	*LPWA*	LoRaWAN specification further realeases
Communication	*LPWA*	NB-IOT 3GPP further realeases

9.3.5 Higher layer communication protocols

Smart grid applications and standards rely heavily on Web Services for the higher layers protocols. Web Services are defined to be the methods to communicate between applications over communication networks, generally IP based. Two major classes of Web Services can be distinguished (the pros/cons of each class are beyond the scope of this document):

- RESTfull Web Services (Representational State Transfer): applications are fully defined via representations (e.g. XML) of resources that can be manipulated using a uniform interface that is composed of four basic interactions, i.e. CREATE, UPDATE, DELETE and READ. Each of these operations is composed of request and response messages. The most common implementation of REST is HTTP, whereby the REST operations are mapped into the HTTP methods: CREATE is mapped on HTTP POST, READ on HTTP GET, UPDATE on HTTP PUT and DELETE on HTTP DELETE. However other implementations are possible: CoAP (Constrained Application Protocol), XMPP (Extensible Messaging and Presence Protocol), etc.

- SOAP/RPC based Web Services: applications expose interfaces that are described in machine processable format, the Web Service Description Language (WSDL). It is also possible for applications to interact through SOAP interfaces which provide a means to describe message format. These message are often transported over HTTP and encoded using XML.

More information on these two classes of Web Services is provided by the W3C under this link: http://www.w3.org/TR/ws-arch/#relwwwrest

NOTE: This section focuses on Web Service as a general technology for information exchange between Smart Grid applications over communication networks. Other more system specific solutions like MMS/ACSE which are part of the relevant standards (e.g. IEC 61850-8-1) of the specific systems listed in section 8. Also the specific usage of web services is defined by the system relevant upcoming standards in section 8 (i.e. IEC 61850-8-2, IEC 61968-100).

9.3.5.1 List of Standards

9.3.5.1.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 83 - Higher level communication protocols - Available

Layer	Category (ies)	Standard	Title
Communication	XML	W3C REC-xml-20001006	W3C, Extensible Markup Language (XML) 1.0
Communication	Web Services (general)	W3C WD-ws-arch-20021114	W3C, Web Services Architecture
Communication	XML	W3C REC-xml-names	Name spaces in XML
Communication	HTTP	IETF RFC 2616	Hypertext Transfer Protocol -- HTTP/1.1
Communication	SOAP	W3C RECsoap12-part1-20070427	SOAP Version 1.2 Part 1: Messaging Framework
Communication	SOAP	W3C REC-soap12-part2-20070427	SOAP Version 1.2 Part 2: Adjuncts, Section 7: SOAP HTTP Binding,
Communication	SOAP	OASIS, wsdd-soapoverudp-1.1-spec-pr-01	OASIS Standard, SOAP-over-UDP
Communication	Web Services (general)	IETF RFC 5246	The TLS Protocol, Version 1.2
Communication	Web Services (general)	W3C, REC-ws-addrcore-20060509	Web Services Addressing 1.0
Communication	SOAP	W3C, RECws-addr-soap-20060509,	Web Services Addressing 1.0 - SOAP Binding
Communication	Web Services (general)	OASIS, wsdd-discovery-1.1-spec-os	Web Services Dynamic Discovery (WS-Discovery)
Communication	Web Services (general)	W3C, SUBM-WSEventing-20060315	Web Services Eventing (WS-Eventing)
Communication	WSDL	W3C, NOTEwsdl-20010315	Web Services Description Language (WSDL) 1.1,
Communication	WSDL	W3C, SUBM-wsdl11soap12-20060405	WSDL 1.1 Binding Extension for SOAP 1.2
Communication	REST	ETSI TS 102 690	Machine-to-Machine communications (M2M); Functional architecture
Communication	REST	ETSI TS 102 921	Machine-to-Machine communications (M2M); mIa, dIa and mId interfaces
Communication	XMPP	IETF RFC 6120	Extensible Messaging and Presence Protocol
Communication	XMPP	IETF RFC 6121	Extensible Messaging and Presence Protocol : Instant Messaging and Presence
Communication	XMPP	IETF RFC 6122	Extensible Messaging and Presence Protocol : Address Format
Communication	XMPP	IEC 62746-10-1	IEC PAS – openADR for demand-response

Layer	Category (ies)	Standard	Title
Communication	CoAP	IETF RFC 6690	The Constrained Application Protocol (CoAP)
Communication	CoAP	IETF RFC 7252	The Constrained Application Protocol (CoAP)
Communication	CoAP	IETF RFC 7390	The Constrained Application Protocol (CoAP)
Communication	CoAP	IETF RFC 7641	The Constrained Application Protocol (CoAP)
Communication	CoAP	IETF RFC 7959	The Constrained Application Protocol (CoAP)
Communication	Secured communication	W3C XML Digital Signature	XML Signature Syntax and Processing
Communication	Secured communication	W3C XML Encryption	XML Encryption Syntax and Processing

9.3.5.1.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as "Coming".

Table 84 - Higher level communication protocols - Coming

Layer	Standard	Comments
Communication	*CoAP draft-ietf-core*	Follow up / update of CoAP protocol

9.4 Security

This section is summarizing the main outcomes of the SGIS report [11], related to standards and standardization.

9.4.1 Cyber Security Standardization landscape

Smart Grid Set of Security Standards investigated into selected standards and followed the identified gaps regarding their resolution in the associated standardization committees.

The Smart Grid Set of Security Standards investigates into selected standards along the work already been done as part of the SG-CG SGIS in the phase 1 (2011-2012) and phase 2 (2013-2014). The goal of the current working period (2015-2016) is to follow the already identified standards as well as investigating into new, upcoming standards, to discuss their applicability and suitability for smart grid scenarios and use cases. As in the past, the goal, besides the discussion of applicability is the identification of potential gaps and based on this the interworking with the associated standardization committee in terms of feedback and proposals as far as possible.

The security standards focused in this working period are distinguished into requirements standards (type 1) and solution standards (type 2 and type 3) as listed below. Please note that the distinction in requirements standards and solution standards is a simplification of the type1, 2 and 3 standards from SGIS phase 1 [11]. In the following the requirement standards summarize the abstract security requirements, while the solution standards describe a realization targeting interoperability between different vendor's products.

Requirement standards considered (The 'What')

- ISO/IEC 27001: Information technology — Security techniques — Information security management systems — Requirements
- ISO/IEC 27002: Information technology — Security techniques — Code of practice for information security management ISO/IEC TR 27001
- ISO/IEC TR 27019: Information technology - Security techniques - Information security management guidelines based on ISO/IEC 27002 for process control systems specific to the energy utility industry

- IEC 62443-2-4: Security for industrial automation and control systems - Network and system security - Part 2-4: Requirements for Industrial Automation Control Systems (IACS) solution suppliers
- IEC 62443-3-3: Security for industrial automation and control systems, Part 3-3: System security requirements and security levels
- IEC 62443-4-2: Security for industrial automation and control systems, Part 4-2: Technical Security Requirements for IACS Components
- IEEE 1686: Substation Intelligent Electronic Devices (IED) Cyber Security Capabilities
- IEEE C37.240: Cyber Security Requirements for Substation Automation, Protection and Control Systems

Solution standards considered (The 'How')

- ISO /IEC 15118: Road vehicles – Vehicle-to-Grid Communication Interface, Part 8: Physical and data link layer requirements for wireless communication
- ISO / IEC 61850-8-2: Communication networks and systems for power utility automation - Part 8-2: Specific communication service mapping (SCSM) - Mapping to Extensible Messaging Presence Protocol (XMPP)
- IEC 62351-x: Power systems management and associated information exchange – Data and communication security
- IEC 62743: Industrial communication networks – Wireless communication network and communication profiles - ISA 100.11a
- IETF draft-weis-gdoi-iec62351-9: IEC 62351 Security Protocol support for the Group Domain of Interpretation (GDOI)
- IETF draft-TLS1.3: TLS Version 1.3

Note: This section below has not been written to specifically include the Smart Metering related standards. Some specific requirements and standards may be needed to implement a smart metering AMI system The detailed and specific list of standards to consider for deploying such a system is defined and given by the SM-CG in [4] and subsequent reports.

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Standards were analyzed through two axes as illustrated in the figure hereunder. The first one is their relevance for Organizations (Smart Grid operators) and products and services (product manufacturer and service providers). The second one is their relevance from a technical point of view and their relevance from an organizational point of view.

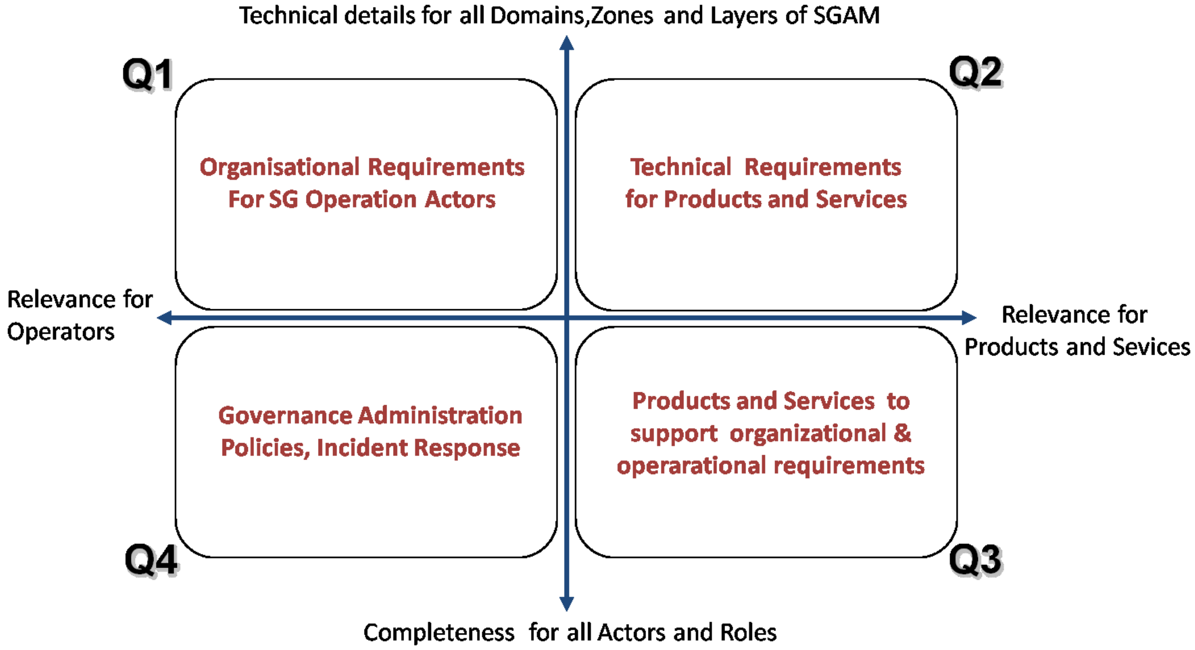

Figure 74 - SGIS Standards Areas

While mapping a standard to the diagram in the figure above, it is shown on an abstract level, which scope and to what level of detail the standards addresses each of the four quadrants. Moreover, also addressed is the relevance of the standards for organizations (Smart Grid operators) as well as products and services (product manufacturer and service providers).

Figure 75 below shows the mapping of the selected standards to the standards areas under the following terms:

- **Details for Operation**: The standard addresses organizational and procedural means applicable for all or selected actors. It may have implicit requirements for systems and components without addressing implementation options.
- **Relevance for Products**: The standard directly influences component and/or system functionality and needs to be considered during product design and/or development. It addresses technology to be used to integrate a security measure.
- **Design Details**: The standard describes the implementation of security means in details sufficient to achieve interoperability between different vendor's products for standards on a technical level and/or procedures to be followed for standards addressing organizational means.
- **Completeness**: The standard addresses not only one specific security measure but addresses the complete security framework, including technical and organizational means.

The color code in the Figure 75 shows the origin domain of the considered standards. What can be clearly seen, based on the coloring, is that for Smart Grids standards from different domains are applicable.

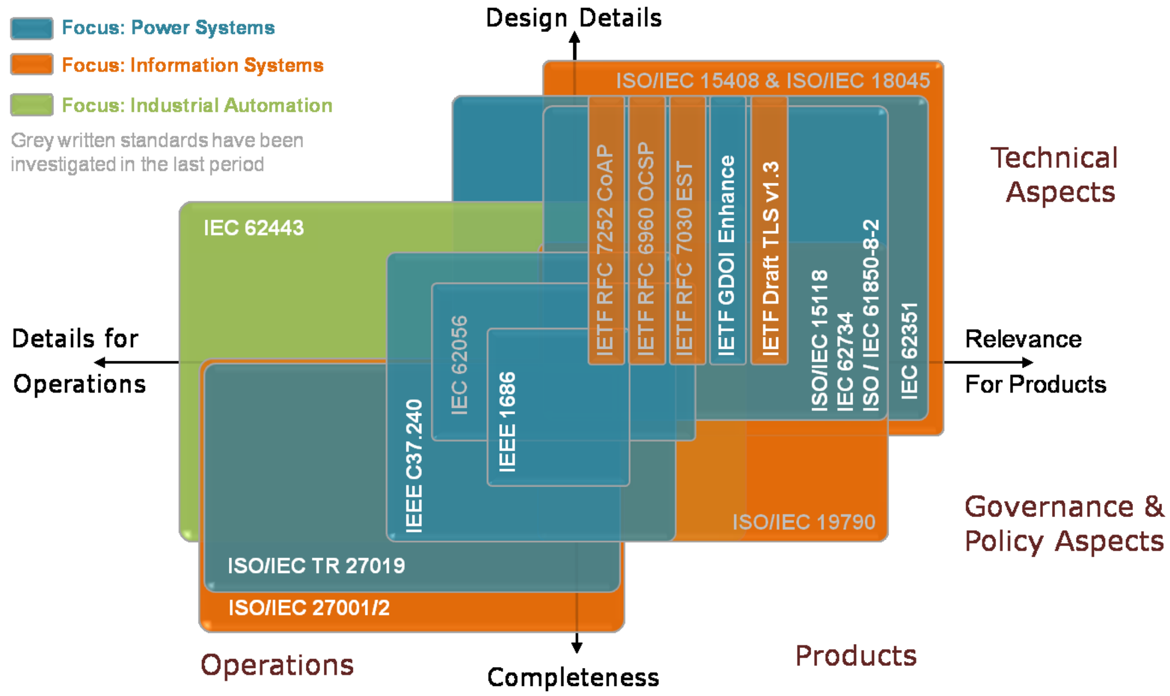

Figure 75: Security Standard Coverage

The following drawing shows the applicability and scope of each of the standards considered as part of this working period of the SGIS from a somewhat different perspective. The differentiation in the drawing is as following:

- **Guideline:** The document provides guidelines and best practice for security implementations. This may also comprise pre-requisites to be available for the implementation.
- **Requirement**: The document contains generic requirements for products, solutions or processes. No implementation specified.
- **Realization:** The document defines implementation of security measures (specific realizations). Note, if distinction possible, the level of detail of the document raises from left to right side of the column.
- **Vendor:** Standard addresses technical aspects relevant for products or components
- **Integrator:** Standard addresses integration aspects, which have implications on the technical design, are relevant for vendor processes (require certain features to be supported), or require product interoperability (e.g., protocol implementations).
- **Operator:** Standard addresses operational and/or procedural aspects, which are mainly focused on the service realization and provisioning on an operator site.

The color code from Figure 75 is kept also in the following picture. Some of the standards only cover partly a certain vertical area. The interpretation of a partly coverage is that the standard may not provide explicit requirements for the vendor / integrator / operator. Standards covering multiple horizontal areas address requirements and also provide solution approaches on an abstract level. For the implementation additional standards or guidelines may be necessary.

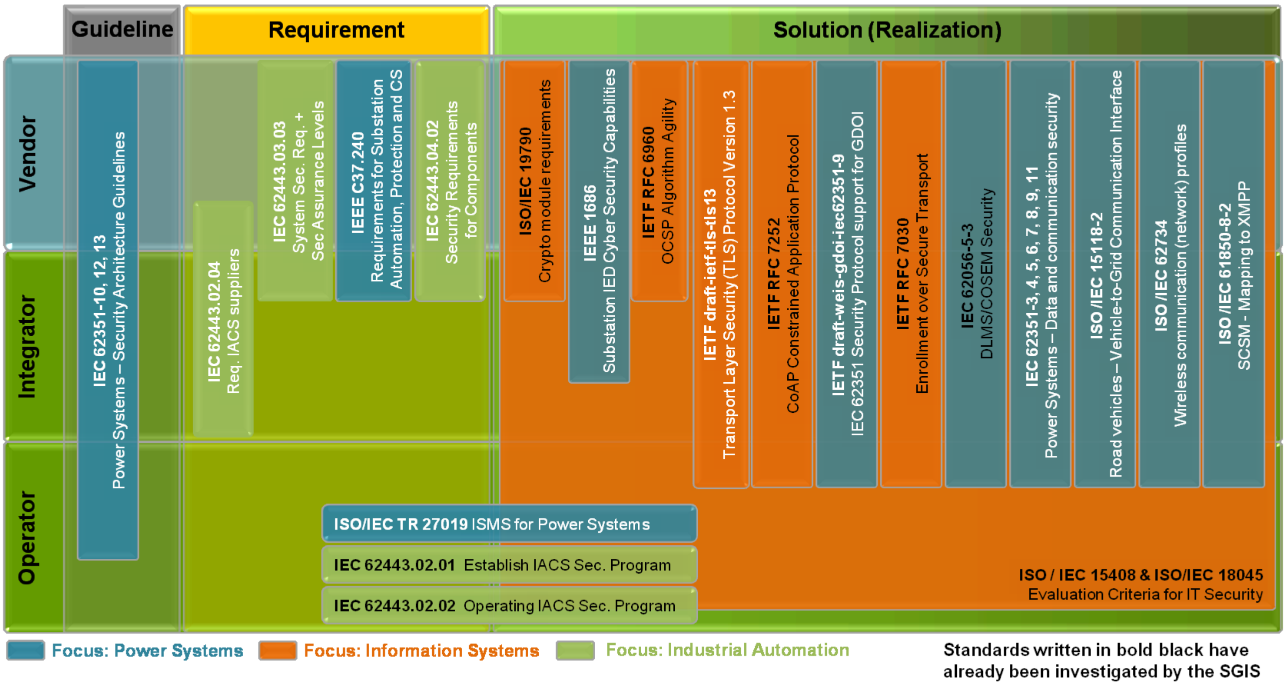

Figure 76: Security standard applicability

The conclusion of this study is key information for the Smart Grid Information Security Landscape. As shown above (Figure 75 and Figure 76) there are several standards available and mature to be utilized in Smart Energy Grid applications. Nevertheless there is still a need for investigating in further standards and their coverage of Smart Energy Grid specific needs. Hence, this exercise (standards gap analysis) is a continuous process, which will require further investigation into existing and upcoming standards addressing the evolution of the Smart Grid information security needs. This evolution is especially driven through new use cases, incorporating communication interactions between new Smart Energy Grid roles and entities.

Besides the investigation into the standard directly, the report focuses on the applicability of specific standards in the context of access to DER and access to substations. Especially the latter is investigated in the context of the IEC 62443 framework. The advantage here is the direct application of defined security levels that cope with the strength of a specific attacker and thus require certain technical means. In combination with IEC 62351, this allows a comprehensive protection concept on cyber security in the implementation and offers a reference model to address cyber security on system level.

Also, the SGIS security impact levels (SGIS-SL) from the last SGIS report [11], which have been defined with the objective to create a bridge between electrical grid operations and information security, have been investigated together with the security impact levels defined in NISTIR 7628 Rev1. This approach provides a better base for “translating” between specific scenarios for North America and Europe in the context of information security.

9.4.2 List of standards

9.4.2.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 85 - Security - Available standards

Layer/type	Standard	Comments
General	IEC 62351-1	IEC/TS 62351-1:2007: Does not provide a dedicated technical solution, rather explains the applicability of the IEC 62351 series
General	IEC 62351-2	IEC/TS 62351-2:2008: Does not provide a dedicated technical solution, rather explains the glossary of the IEC 62351 series
Component, communication, information, function	IEC 62351-3	(IS) IEC 62351-3: 2014: Depends on the usage of TCP/IP, provides TLS profiling
Component, communication, information, function	IEC 62351-4	IEC/TS 62351-4:2007: Depends on the usage of TCP/IP and MMS
Component, communication, information, function	IEC 62351-5	IEC/TS 62351-5 ed.2:2013: Depends on the usage of EN 60870-5 and serial protocols
Component, communication, information, function	IEC 62351-6	IEC/TS 62351-6:2007: Depends on the usage of GOOSE and SMV
Component, communication, information, function	IEC 62351-7	IEC/TS 62351-7:2010: Depends on the usage of network management protocols/functions
Component, communication, information, function	IEC 62351-8	IEC/TS 62351-8:2011: Defines Role-Based Access Control and associated credentials to be used in the context of IEC 62351
Component, communication, information, function	IEC 62351-10	IEC/TR 62351-10:2012: Provides an overview about and motivation of application of security in power systems
Communication, Information, function	IEC 61850-90-5	TR describing exchanging synchrophasor data between PMUs, WAMPAC (Wide Area Monitoring, Protection, and Control), and between control center applications; Contains a comprehensive security model for the underlying routable profile; GDOI is used for key management
Communication, Information, function	IEC 62443-3-3	IS describing System Security Requirements and Security Levels for industrial communication networks
Communication, Information, function	ISO/IEC 15118-2	describes the communication interface between an electric vehicle and the charging spot including security
Communication, Information, function	IEC 62056-5-3	EN 62056-5-3 describes the COSEM application layer, including security
Communication, Information, function	EN 61400-25	Set of standards describing also web service mapping for wind power
Information , function	ISO/IEC 27001	describes requirements for information security management
Information , function	ISO/IEC 27002	Information security management guidelines- Code of practice for information security management
Information , function	ISO/IEC 27019	(TR) Information security management guidelines for process control systems used in the energy utility industry on the basis of ISO/IEC 27002
Communication	IETF RFC 2617	HTTP Authentication: Basic and Digest Access Authentication
Communication	IETF RFC 2759	EAP MS-CHAP2
Communication, Information	IETF RFC 2865	RADIUS (Remote Authentication Dial In User Service)
Communication, Information, function	IETF RFC 3711	SRTP, to protect video surveillance data or customer service (VoIP)

Layer/type	Standard	Comments
Communication, Information	IETF RFC 3748	EAP Base Protocol (includes EAP MD5)
Communication, Information	IETF RFC 3923	End-to-End Signing and Object Encryption for XMPP
Communication, Information, function	IETF RFC 4210	Certificate Management Protocol
Communication, Information, function	IETF RFC 4211	Certificate Request Message Format
Communication, Information, function	IETF RFC 4301	IPSec, may be used to realizes VPNs, Or for any other type of IPSec based security mechanisms
Communication, Information, function	IETF RFC 4302	IPSec, may be used to realizes VPNs, Or for any other type of IPSec based security mechanisms
Communication, Information, function	IETF RFC 4303	IPSec, may be used to realizes VPNs; Or for any other type of IPSec based security mechanisms
Communication	IETF RFC 4422	SASL Security
Communication, Information, function	IETF RFC 4962	AAA, Network Access, e.g., for service or remote access
Communication	IETF RFC 5106	EAP IKEv2
Communication	IETF RFC 5216	EAP TLS
Communication, Information, function	IETF RFC 5246	TLS, can be applied, whenever point-to-point TCP/IP needs to be protected
Communication, Information, function	IETF RFC 5247	EAP Framework, Framework for key management, can be used for any type of endpoint, Network Access, e.g., for service or remote access
Communication, Information, function	IETF RFC 5272	Certificate Management over CMS
Communication, Information, function	IETF RFC 5274	CMC Compliance Requirements
Communication, Information, function	IETF RFC 5280	Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile, Base specification for X.509 certificates and certificate handling
Communication	IETF RFC 5281	EAP TTLSv1.0
Communication, Information, function	IETF RFC 6272	Identifies the key infrastructure protocols of the Internet Protocol Suite for use in the Smart Grid
Communication, Information, function	IETF RFC 6347	DTLS, Alternative to TLS in UDP-based; meshed-type of networks; can be applied, whenever point-to-point UDP/IP needs to be protected
Communication, Information, function	IETF RFC 6407	GDOI, used, e.g., to provide key management for IEC 61850-90-5
Communication	IETF RFC 6749	The OAuth 2.0 Authorization Framework
Communication	IETF RFC 6750	The OAuth 2.0 Authorization Framework: Bearer Token Usage
Communication, Information	IEEE 802.1X	Specifies port based access control, allowing the restrictive access decisions to networks based on dedicated credentials. It defines the encapsulation of EAP over IEEE 802, also known as EAP over LAN or EAPOL. Includes also the key management, formally specified in IEEE 802.1AF
Communication, Information	IEEE 802.1AE	Specifies security functionality in terms of connectionless data confidentiality and

Layer/type	Standard	Comments
		integrity for media access independent protocols. Specifies a security frame format similar to Ethernet
Communication, Information	IEEE 802.1AR	Specifies unique per-device identifiers and the management and cryptographic binding of a device to its identifiers
General	IEEE 1686	defines functions and features that must be provided in substation intelligent electronic devices to accommodate critical infrastructure protection programs
General	IEEE P2030	provides a Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System
Communication, Information, function	ETSI TCRTR 029	General overview of features specified on ETSI side
Communication, Information, function	ETSI ETR 332	Security Techniques Advisory Group (STAG); Security requirements capture
Communication, Information, function	ETSI ETR 237	Security Techniques Advisory Group (STAG); Baseline security standards; Features and mechanisms
Communication, Information, function	ETSI ES 202 382	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Security Design Guide; Method and proforma for defining Protection Profiles
Communication, Information, function	ETSI ES 202 383	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Security Design Guide; Method and proforma for defining Security Targets
Communication, Information, function	ETSI EG 202 387	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Security Design Guide; Method for application of Common Criteria to ETSI deliverables
Communication, Information, function	ETSI TS 102 165-1	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Methods and protocols; Part 1: Method and proforma for Threat, Risk, Vulnerability Analysis
Communication, Information, function	ETSI TS 102 165-2	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Methods and protocols; Part 2: Protocol Framework Definition; Security Counter Measures
Communication, Information, function	ETSI EG 202 549	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Design Guide; Application of security countermeasures

Layer/type	Standard	Comments
		to service capabilities
Communication, Information, function	ETSI TR 185 008	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Analysis of security mechanisms for customer networks connected to TISPAN NGN R2
Communication, Information, function	ETSI TR 187 012	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); NGN Security; Report and recommendations on compliance to the data retention directive for NGN-R2
Communication, Information, function	ETSI TS 187 016	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); NGN Security; Identity Protection (Protection Profile)
Communication, Information, function	ETSI TR 102 419	Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Security analysis of IPv6 application in telecommunications standards
function	ETSI TS 101 456	Electronic signatures
function	ETSI TR 102 437	Electronic signatures
function	ETSI TS 102 042	Electronic signatures
function	ETSI TR 102 572	Electronic signatures
function	ETSI TS 102 573	Electronic signatures
function	ETSI TS 102 689	Requirements
function	ETSI TS 102 690	Architecture
function	ETSI TS 102 921	Protocols
function	ETSI TR 103 167	Threat Analysis
communication , information	ETSI TS 100 920	Communication, information for mobile (3GPP, GSM, CDMA…) telecommunication infrastructures
Communication, Information	ETSI TS 133 203	Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommu nications System (UMTS); LTE; 3G security; Access security for IP-based services (3GPP TS 33.203 version 8.8.0 Release 8)
Communication, Information	ETSI TS 133 210	Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); 3G security; Network Domain Security (NDS); IP network layer security (3GPP TS 33.210 version 6.6.0 Release 6)
Communication, Information	ETSI TS 133 234	Universal Mobile Telecommu nications System (UMTS); LTE; 3G security; Wireless Local Area Network (WLAN) interworking security (3GPP TS 33.234 version 10.1.0 Release 10)
Communication, Information	ETSI TS 133 310	Universal Mobile Telecommunications System (UMTS); LTE; Network Domain Security (NDS); Authentication Framework

Layer/type	Standard	Comments
		(AF) (3GPP TS 33.310 version 10.5.0 Release 10)
Communication, Information	ETSI TS 102 225	Communication, information for mobile (3GPP, GSM, CDMA…) telecommunication infrastructures. Secure packet protocol for remote administration of security element
Communication, Information	ETSI TS 102 226	Communication, information for mobile (3GPP, GSM, CDMA…) telecommunication infrastructures. Remote administration of Security element
Communication, Information	ETSI TS 102 484	Communication, information for mobile (3GPP, GSM, CDMA…) telecommunication infrastructures. Local Secure Channel to security element
Communication, Information	ETSI TS 187 001	Communication, information for fixed (IP based…) telecommunication infrastructures. Security Requirements
Communication, Information	ETSI TS 187 003	Communication, information for fixed (IP based…) telecommunication infrastructures. Threat Analysis
Communication, Information	ETSI TR 187 002	Communication, information for fixed (IP based…) telecommunication infrastructures. Security Architecture
Communication, Information	W3C XML Digital Signature	Provide security features for XML encoded data
Communication, Information	W3C XML Encryption	Provide security features for XML encoded data

9.4.2.2 Coming Standards

In compliance with section 6.2.2,¸a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 86 - Security - Coming standards

Layer/type	Standard	Comments
Component, communication, information, function	*IEC 62351-4*	(IS)Targets the enhancements of MMS security (A-profile) with a secure session concept
Component, communication, information, function	*IEC 62351-6*	(IS)Depends on the usage of GOOSE and SMV
Component, communication, information, function	*IEC 62351-7*	(IS)Defines network management objects and their mapping to SNMP, FDIS currently planned for end of 2016
Component, communication, information, function	*IEC 62351-9*	(IS)Defines management of necessary security credentials and parameters in the context of IEC 62351, CD released end of 2013
Component, communication, information, function	*IEC 62351-11*	(IS)Focus on XML Security for files to ensure that the receiver gets information about the sensitivity of the data received
Component, communication, information, function	*IEC 62351-12*	(TR)Focus on resilient DER integration
Component, communication, information, function	*IEC 62351-14*	(IS) Defines security events and their mapping to syslog, CD currently planned for Q1/2017

Layer/type	Standard	Comments
Communication, Information, function	*ISO/IEC 15118 (all parts)*	describes the interface between an electric vehicle and the charging spot including security
Information, Communication	*IEC 62351-90-1*	(TR) Definition of categories of actions to be associated with a role/right to ease the administrative handling of rights and role associations.
Information, Communication	*IEC 62351-90-2*	(TR) Investigates means in monitoring encrypted communication.
Information, Communication	*ISO/IEC 27009*	Information technology -- Security techniques – Sector-specific application of ISO/IEC 27001
Information, Communication	*ISO/IEC 29190*	Information technology -- Security techniques – Privacy capability assessment model
Component, communication, information, function	*IEEE 1588 v3*	Time synchronization including security functionality

9.5 Connection to the grid and installation of DER (Distributed Energy Resources – Component layer))

9.5.1 Context description

In parallel with the liberalization of the energy markets, the decentralized generation of electrical power as well as energy storage becomes more and more important. The installation of these energy resources near to the consumers offers economic and ecological benefits. They can sometimes provide heating and/or cooling services in addition to electricity.

In order that the smart grid can provide its benefits, such massive introduction of DER requires appropriate grid connection and operational rules as well as product specifications.
The purpose of the standards is to provide installation and connection rules for distributed energy resources while contributing, as a complement to the regulatory framework (as defined in the coming European grid code “Requirements for generators”), to:

- System security, especially control of frequency and voltage in steady and disturbed states. This also includes the capability to provide ancillary services, especially for voltage support by smart reactive power management. Frequency support by active power droops is also feasible.

- Quality of the supply, especially preventing excessive voltage variations;

- Safety of persons, especially preventing undesired islanding and un-eliminated faults;

- Reasonable network development/reinforcement costs.

At the demand side level DER and micro grids raise new safety and protection issues. The multi-sources and bi-directional aspects have to be covered by installation rules.

9.5.2 List of Standards

9.5.2.1 Available standards

In compliance with section 6.2.2, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as “available”.

Table 87 - Connection to the grid and installation of DER - Available standards

Layer	Standard	Comments
Component	EN 62446	Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection
Component	EN 61000-4-30	Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods
Component	IEC 62257 (all parts)	(TS) Recommendations for small renewable energy and hybrid systems for rural Electrification
Component	EN 60364 (all parts)	Electrical installations of buildings – Selection and erection of electrical equipment – Other equipment– generating set Note: Especially the two following parts - 551.6 Additional requirements for installations where the generating set provides a supply as a switched alternative to the public supply (stand-by systems) - 551.7 Additional requirements for installations where the generating set may operate in parallel with the public supply system
Component	EN 61400 (all parts)	Wind turbines
Component	EN 50438	Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks Note: In Europe EN 50438 provide with requirements for connection of micro-generators (currently under revision).
Component	TS 50549-1	Requirements for generating plants to be connected in parallel with distribution networks - Part 1: Connection to a LV distribution network, above 16 A
Component	TS 50549-2	Requirements for generating plants to be connected in parallel with distribution networks - Part 2: Connection to a MV distribution network
Information	IEC 61850-90-7	Object models for Inverter based DER – including ancillary services interface
Component	EN 50110-1	Operation of electrical installations
Component	*IEC 62749*	(TS) Characteristics of electricity at supply terminals of public networks: power quality assessment

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4213 ### 9.5.2.2 Coming standards

4214 In compliance with section 6.2.2,¸a standard that has successfully passed the NWIP process (or any formal
4215 equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.
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4217 **Table 88 - Connection to the grid and installation of DER - Coming standards**

Layer	Standard	Comments
Component	*IEC 62786*	DER interconnection with the grid
Component	*IEC 61400-21*	Wind turbines - Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines
Component	*IEC 61400-27-1*	Wind Turbines - Part 27-1: Electrical simulation models for wind power generation
Component	*EN 50438*	Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks Note: In Europe EN 50438 provide with requirements for connection of micro-generators (currently under revision).
Component	**prEN 50549-1-1*	Requirements for generating plants to be connected in parallel with distribution networks - Part 1-1: Connection to a LV distribution network – Generating plants up to and including Type A

Layer	Standard	Comments
Component	**prEN 50549-1-2*	Requirements for generating plants to be connected in parallel with distribution networks - Part 1-2: Connection to a LV distribution network – Generating plants of Type B
Component	**prEN 50549-2*	Requirements for generating plants to be connected in parallel with distribution networks - Part 2: Connection to a MV distribution network
Component	**prEN 50549-10*	Requirements for generating plants to be connected in parallel with distribution networks - Part 10 Tests demonstrating compliance of units

*****These standards are intended to be used as a technical reference for connection agreements between DNOs and electricity producers and to demonstrate compliance with COMMISSION REGULATION (EU) 2016/631 (Requirements for Generators). They are intended to supersede EN 50438 and TS 50549.

9.6 EMC & Power Quality

9.6.1 Definitions

Electromagnetic compatibility (EMC) is the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

Power quality (PQ) encompasses characteristics of the electric current, voltage and frequencies at a given point in an electric power system, evaluated against a set of reference technical parameters.
NOTE - These parameters might, in some cases, relate to the compatibility between electricity supplied in an electric power system and the loads connected to that electric power system.

9.6.2 General

9.6.2.1 Power Quality

Power quality refers usually to the obligations of the Network Operators.

The power quality levels given in standards can be used for customer relationship or for reporting towards the Authorities. When comparable, the specified levels are close to the Compatibility levels given in the EMC standards. They cover appropriately the huge majority of locations under acceptable economic conditions, despite the differences in situations, provided that:

- For mass-market products, emission requirements in standards are regularly and appropriately updated to take into account the development of markets and changes in technologies,
- For large installations, emission levels are effectively controlled, e.g. through connection agreements,
- Network operators make use of appropriate methodologies and engineering practices, e.g. based on planning levels and **IEC TR 61000-3-6, 3-7, 3-13** and/or **3-14**.

Massive introduction of Distributed Energy Resources can impact the quality of supply experienced by network users in a number of ways. Examples like magnitude of the supply voltage, harmonic emission and resonances, increased level of flicker and single rapid voltage changes, increased number of interruptions due to incorrect operation of the protection are being discussed in several publications. Some impacts are local, others are global; some impacts are minor and occur only for extreme locations, other impacts are major and more general.

EN 50160:2010 specifies the characteristics of electricity supplied to customers (at the entry point of user's installation) up to 150 kV.

9.6.2.2 EMC

Electromagnetic Compatibility is a prerequisite for all applications and products and is therefore not limited and not unique to Smart Grids. It is governed by the Directive 2014/30/EU relating to electromagnetic compatibility.
For the Smart Grid to function properly and coexist with other electrical and electronic systems, it must be designed with due consideration for electromagnetic emissions and for immunity to various electromagnetic phenomena.

EMC must be addressed effectively if the Smart Grid is to achieve its potential and provide its benefits when deployed.

The design and operation of a Smart Grid shall be consistent with relevant EMC Standards and, in particular with the EMC Compatibility Standards **EN 61000-2-2** (LV) and **EN 61000-2-12** (MV).

For a number of “smart” applications (e.g. Electric Vehicle or PLC in the metering domain), EMC will be a major issue. This will then include compliance with the **EN 61000** and **550XX** series, besides specific product standards, if any.

When designing a Smart Grid that utilizes equipment operating in the frequency range 9kHz to 400Ghz, the user shall show that equipment complies also with the relevant emission requirements of standards such as **EN 55011**, **EN 55022** or **EN 55032**.
In terms of equipment immunity, IT equipment used within a Smart Grid shall comply with the requirements of **EN 55024** or **prEN 55035** (to be published).

If no product standard (or product family standard) comprising of EMC part(s) exists, the requirements of the relevant generic EMC standards apply. Particular attention will be paid to prEN 61000-6-5 (Generic standards – Immunity for equipment used in power station and substation environment), standard under development, succeeding IEC TS 61000-6-5. It is the task of this generic standard to specify a set of essential requirements, test procedures and generalized performance criteria applicable to products or systems operating in this electromagnetic environment.

9.6.2.3 Immunity and emission in the frequency range from 2 kHz to 150 kHz

The change in use of the electricity, especially by the introduction of power electronics equipment (Active Infeed Converters (AIC) are contributing to many solutions for smart grids) in residential or commercial environment, increasing the occurrence of voltage components above the frequency range of harmonics up to 150 kHz, requires the consideration of this frequency range for ensuring EMC. It appeared to be advisable to urge EMC Committees, as well as those Product Committees defining EMC requirements in their product standards (TC 22, TC 13, TC57, SC205A …), to review the existing standards or develop new ones in view of covering the abovementioned gap in EMC standardization.

Technical input in this domain can be found in several reports/publications such as CLC SC205A Study Report on Electromagnetic Interference between Electrical Equipment / Systems in the Frequency Range below 150 kHz ed. 2 (SC205A/Sec0339/R, April 2013). Nevertheless, further studies are necessary before a full set of standards providing with immunity and emission requirements can be established.

On the basis of the data available at present, basic publications such as those dealing with Compatibility Levels (***EN 61000-2-2*** *and* ***EN 61000-2-12****)* are in progress*.* Immunity test methods and levels are included in ***EN 61000-4-19****.* Emission limits will follow.

9.6.2.4 Power Quality in a smart grid context

A Smart Grid is expected to be flexible, and consequently Power Quality should be addressed in an appropriate way, considering high penetration of distributed energy resources (DER) and new ways of operating the networks (intentional islands, micro-grids, Virtual Power Plants…).

Standards specifying connection of Distributed Energy Resources to the grid, such as **EN 50438 Ed2** and **CLC TS 50549** consider the contribution of DER to voltage control, by means of active and/or reactive power management. IEC projects (IEC TS 62898 series: Microgrids) consider power quality in the context of islanding networks.

9.6.2.5 Immunity and emission requirements applicable to Distributed Energy Resources

IEC TR 61000-3-15 (Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network) has been published (2011/09). IEC SC 77A is preparing specific emission standards for DG systems: resp. IEC 61000-3-16 for harmonics and IEC 61000-3-17 for dips and voltage fluctuations.

Another task is to standardize how to give a limitation to the disturbance emissions by installations containing DER and to fairly allocate the ability of HV, MV or LV networks to absorb disturbance emissions among present and possibly forthcoming connected equipment at sites in networks. The work implies the extension of IEC TR 61000-3-6, IEC TR 61000-3-7, IEC TR 61000-3-13 and IEC TR 61000-3-14.
A new CIGRE C4 working group is going to be set up to prepare the revision of these four IEC technical reports dealing with emissions limits for installations (IEC 61000-3-6, 3-7, 3-13 and 3-14). A three year program is scheduled in CIGRE; then the standardization work will start in IEC SC77A WG8.

9.6.3 List of standards

9.6.3.1 Available standards

In compliance with section 6.2.2, a standard (or "open specification") that has reached its final stage (IS, TS or TR, …) by Dec 31st 2015 is considered as "available".

Table 89 - EMC - Power Quality - Available standards

Layer/Type	Standard	Comments
EMC	EN 61000 Series	Electromagnetic compatibility
EMC	EN 61000-6-1	Electromagnetic compatibility (EMC) – Generic standards – Immunity for residential, commercial and light-industrial environments
EMC	EN 61000-6-2	Electromagnetic compatibility (EMC) – Generic standards – Immunity for industrial environments
EMC	EN 61000-6-3	Electromagnetic compatibility (EMC) – Generic Standards – Emission standard for residential, commercial and light-industrial environments
EMC	EN 61000-6-4	Electromagnetic compatibility (EMC) – Generic Standards – Emission standard for industrial environments
EMC	IEC TS 61000-6-5	Electromagnetic compatibility (EMC) – Generic standards - Immunity for power station and substation environments
EMC	IEC 61000-3-6	(TR) EMC - Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
EMC	IEC 61000-3-7	(TR) EMC - Limits – Assessment of emission limits for the connection of fluctuating

Layer/Type	Standard	Comments
		installations to MV, HV and EHV power systems
EMC	IEC 61000-3-13	(TR) EMC - Limits – Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems
EMC	IEC 61000-3-14	(TR) EMC - Assessment of emission limits for the connection of disturbing installations to LV power systems
EMC	IEC 61000-3-15	(TR) Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network
EMC	EN 55011	Industrial, scientific and medical equipment — Radio-frequency disturbance characteristics — Limits and methods of measurement.
EMC	EN 55022	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement
EMC	EN 55032	Electromagnetic compatibility of multimedia equipment - Emission requirements
EMC	EN 55024	Information technology equipment - Immunity characteristics - Limits and methods of measurement
EMC	EN 50065-2-3	Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz -- Part 2-3: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 3 kHz to 95 kHz and intended for use by electricity suppliers and distributors
EMC	EN 50065-7	Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz - Part 7: Equipment impedance
EMC	CLC TR 50579	Electricity metering equipment - Severity levels, immunity requirements and test methods for conducted disturbances in the frequency range 2 -150 kHz
Power Quality	EN 50160	Voltage characteristics of electricity supplied by public electricity networks
Power Quality	CLC TR 50422	Application Guide for EN 50160 - Maintenance of an existing report, including (informative) annexes on impact of DER and voltage/current components in the 2-150kHz range
EMC	EN 61000-6-5	Electromagnetic compatibility (EMC) – Generic standards - Immunity for power station and substation environments
EMC	EN 61000-4-30	Power Quality measurement methods including an (informative) annex for measurement methods in the 2-150kHz range
EMC	EN 61000-4-19	Immunity to conducted, differential mode disturbances in the frequency 2 – 150 kHz at a.c. ports.

4345

9.6.3.2 Coming standards

In compliance with section 6.2.2, a standard that has successfully passed the NWIP process (or any formal equivalent work item adoption process) by Dec 31st 2015 is considered as “Coming”.

Table 90 - EMC - Power Quality - Coming standards

Layer/Type	Standard	Comments
EMC	*EN 55035*	(pr) Electromagnetic compatibility of multimedia equipment - Immunity requirements IEC CISPR/I
EMC	**EN 61000-2-2*	(pr) Compatibility Levels for Low-Frequency Conducted Disturbances and Signaling in Public Low-Voltage Power Supply Systems. Maintenance of an existing standard. Investigation has started in view of addressing the 2-150 kHz frequency range: IEC 77A/773/RR (2011/10)
EMC	**EN 61000-2-12*	(pr) Compatibility Levels for Low-Frequency Conducted Disturbances and Signaling in Public Medium-Voltage Power Supply Systems. Maintenance of an existing standard. Investigation has started in view of addressing the 2-150 kHz frequency range: IEC 77A/774/RR (2011/10)
EMC	*IEC/EN 61000-3-16*	Electromagnetic compatibility (EMC) - Part 3-16: Limits - Limits for harmonic current emissions for LV generators
EMC	*IEC/EN 61000-3-17*	Electromagnetic compatibility (EMC) - Part 3-17: Limits - Limitation of voltage changes, voltage fluctuations and flicker for LV generators

*EMC emission requirements will follow the Compatibility Levels

9.7 Functional Safety

Functional safety is becoming an increasing concern related to smart grids, because of the new ways of designing, operating and maintaining grids, and also because of the new means used for performing the expected functions and reaching the expected performance.
All these changes lead to new system behavior, more complex, with a higher mix of technologies, with a higher number of actors, and also with the appearance of potential new common modes of failure.

Functional safety approach can provide for each targeted systems listed above, methods and tools to Analyze the new risks attached to any type of unexpected events, to identify possible causes, to evaluate their impacts and to estimate their probability of occurrence, and finally to evaluate the efficiency of mitigation solutions.

EN 61508 standard series and possible companion standards are then a set of key standards to support functional safety approach.

Table 91 - Functional safety - Available standards

Layer/Type	Standard	Comments
Functional safety	EN 61508	Functional safety of electrical/electronic /programmable electronic safety-related systems
Functional safety	EN 61511 series	Functional safety – Safety instrumented systems for the process industry sector

Functional safety	EN 61010-2-201	Safety requirements for electrical equipment for measurement, control and laboratory use - Part 2-201: Particular requirements for control equipment

10 List of standards

This section brings together the standards listed above, and should be read in conjunction with the description and qualification in the appropriate sections.

10.1 CEN/CENELEC

CEN/CENELEC standards and latest status can be found on the Internet following the link below :
http://www.cenelec.eu/dyn/www/f?p=104:105:138807253975801::::FSP_LANG_ID:25
ou
http://standards.cen.eu/dyn/www/f?p=CENWEB:105::RESET

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
CLC prTR 50422		X																												X	
CLC prTR 50491-10		X												X	X																
CLC TS 50549-1	X								X			X																X			
CLC TS 50549-2	X								X			X																X			
CLC TS 50568-4	X													X	X											X					
CLC TS 50568-8	X													X	X																
CLC prTS 50586		X												X	X											X					
CLC TS 50590	X													X	X																

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
CLC TS 52056-8-4	X													X	X																
CLC TS 52056-8-5	X													X	X																
CLC TS 52056-8-7	X													X	X																
CLC TR 50579	X																												X		
EN 13321 series	X													X	X																
EN 13321-2																										X					
EN 13757-1	X													X	X																
EN 13757-2	X	X												X	X																
EN 13757-3	X	X												X	X																
EN 13757-4	X	X												X	X											X					
EN 13757-5	X													X	X											X					
EN 13757-6	X													X	X											X					
EN 13757-7		X												X	X											X					
EN 14908 series	X													X	X																
EN 14908-1																										X					
EN 14908-2																										X					
EN 14908-3																										X					

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 14908-4																										X					
EN 16836-1		X												X	X											X					
EN 16836-2		X												X	X											X					
EN 16836-3		X												X	X											X					
EN 50065-1	X													X	X																
EN 50065-2-3	X																												X		
EN 50065-7	X																												X		
EN 50090-2-1																										X					
EN 50090-3-1	X													X	X											X					
EN 50090-3-2	X													X	X											X					
EN 50090-3-3	X													X	X																
EN 50090-4-1	X													X	X											X					
EN 50090-4-2	X													X	X											X					
EN 50090-4-3	X													X	X											X					
EN 50090-5-1	X													X	X											X					
EN 50090-5-2	X													X	X											X					
EN 50090-5-3	X													X	X																
EN 50090-7-1	X													X	X											X					
EN 50160	X																													X	
EN 50412-4		X																								X					

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 50438	X											X																X			
EN 50491-11	X													X	X																
EN 50491-12		X												X	X											X					
EN 55011	X																												X		
EN 55022	X																												X		
EN 55024	X																												X		
EN 55032	X																												X		
EN 55035		X																											X		
EN 60076 series	X																		X												
EN 60364 (all parts)	X																											X			
EN 60364-4-41	X															X															
EN 60364-5-53	X															X															
EN 60364-5-55	X															X															
EN 60364-7-712	X															X															
EN 60364-7-722	X															X															
EN 60870-5-1																										X					
EN 60870-5-101	X		X	X	X	X	X	X	X	X		X							X							X					
EN 60870-5-102																										X					
EN 60870-5-103	X		X	X		X		X	X																	X					

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 60870-5-104	X		X	X	X	X	X	X	X	X		X							X							X					
EN 60870-5-2																										X					
EN 60870-5-3																										X					
EN 60870-5-4																										X					
EN 60870-5-5																					X										
EN 60870-6	X				X																										
EN 60870-6-2	X				X																										
EN 60870-6-501	X				X																										
EN 60870-6-502	X				X																										
EN 60870-6-503	X				X																										
EN 60870-6-601	X				X																										
EN 60870-6-701	X				X																										
EN 60870-6-702	X				X																										
EN 60870-6-802	X				X																										
EN 61000 Series	X																												X		
EN 61000-2-12		X																											X		
EN 61000-2-2		X																											X		
EN 61000-4-19	X																												X		
EN 61000-4-30	X																											X	X		
EN 61000-6-1	X																												X		

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 61000-6-2	X																												X		
EN 61000-6-3	X																												X		
EN 61000-6-4	X																												X		
EN 61000-6-5	X																												X		
EN 61131	X		X									X																			
EN 61158	X		X	X				X				X																			
EN 61175-1	X																							X							
EN 61334	X																									X					
EN 61355-1	X																							X							
EN 61360	X		X																X					X							
EN 61400 (all parts)	X	X																										X			
EN 61400-1	X		X									X																			
EN 61400-2	X		X									X																			
EN 61400-25 (all parts)	X	X							X										X								X				
EN 61400-25-1	X	X	X									X																			
EN 61400-25-2	X		X									X																			
EN 61400-25-3	X		X									X																			
EN 61400-25-4	X	X	X									X											X								

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 61400-25-5		X	X									X											X								
EN 61400-25-6		X	X									X											X								
EN 61400-25-41		X	X									X											X								
EN 61400-3	X		X									X																			
EN 61499	X		X									X																			
EN 61508 (all parts)	X																														X
EN 61511 (all parts)	X																														X
EN 61010-2-201	X																														X
EN 61666	X																							X							
EN 61724	X											X																			
EN 61727	X																											X			
EN 61730	X											X																			
EN 61850-3	X			X				X																							
EN 61850-6	X	X	X	X		X	X	X	X			X																			
EN 61850-7-1	X																									X					
EN 61850-7-2	X	X	X	X		X	X	X	X			X																			
EN 61850-7-3	X	X	X	X		X	X	X	X			X																			
EN 61850-7-4	X	X	X	X		X	X	X	X	X		X											X								

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 61850-7-410	X	X	X	X				X	X			X																			
EN 61850-7-420	X	X		X				X	X			X				X															
EN 61850-8-1	X		X	X		X		X	X			X							X							X					
EN 61850-9-2	X	X	X	X		X		X	X																	X					
EN 61851 (all parts)	X															X															
EN 61851-1	X															X															
EN 61851-21	X															X															
EN 61851-22	X															X															
EN 61851-23	X															X															
EN 61851-24	X															X															
EN 61851-31	X															X															
EN 61851-32	X															X															
EN 61869	X	X		X		X		X	X																						
EN 61897	X																		X												
EN 61968 (all parts)	X			X				X	X			X	X		X	X	X	X	X						X						
EN 61968-1	X	X	X	X				X	X		X																				
EN 61968-100	X		X								X	X	X						X												
EN 61968-11	X	X	X	X				X	X		X																				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 61968-13		X		X				X	X		X																				
EN 61968-2	X		X								X																				
EN 61968-3	X	X	X	X				X	X		X																				
EN 61968-4	X		X								X								X												
EN 61968-6	X		X								X								X												
EN 61968-8	X										X																				
EN 61968-9	X		X								X		X	X	X																
EN 61970 (all parts)	X			X				X	X		X	X				X	X	X	X						X						
EN 61970-1	X		X		X																										
EN 61970-2	X		X		X																										
EN 61970-301	X	X	X	X	X			X	X		X	X				X	X	X	X												
EN 61970-302		X	X		X																										
EN 61970-401	X		X		X																										
EN 61970-452	X		X		X																										
EN 61970-453	X		X		X																										
EN 61970-456	X		X		X																										
EN 61970-458		X	X		X																										
EN 61970-501	X		X		X																										
EN 61970-502-8	X	X	X		X																										

	Maturity		**Generation**	**Transmission**				**Distribution**				**DER**	**Customer premises**				**Market**		**Administration**					**Crosscutting**							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 61970-552	X		X		X																										
EN 61980 (all parts)	X															X															
EN 61982 (all parts)	X															X															
EN 62056 (all parts)	X	X																							X						
EN 62196	X															X															
EN 62271-1 series	X																		X												
EN 62271-2 series	X																		X												
EN 62325 (all parts)	X				X							X			X										X						
EN 62325-301	X	X	X														X	X													
EN 62325-351	X		X														X	X													
EN 62325-450	X		X														X	X													
EN 62325-451-1	X	X	X														X	X													
EN 62325-451-2	X		X														X	X													
EN 62325-451-3	X		X														X	X													

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 62325-451-4	X		X														X	X													
EN 62325-451-5	X		X														X	X													
EN 62325-451-6		X	X														X	X													
EN 62325-503	X		X														X	X													
EN 62325-504	X		X														X	X													
EN 62439	X		X	X				X	X			X																			
EN 62439-3	X	X																			X										
EN 62443	X															X															
EN 62446	X																											X			
EN 62507-1	X																							X							
EN 62541-1	X		X																												
EN 62541-10	X		X																												
EN 62541-2	X		X																												
EN 62541-3	X		X																												
EN 62541-4	X		X																												
EN 62541-5	X		X																												
EN 62541-6	X		X																												
EN 62541-7	X		X																												
EN 62541-8	X		X																												
EN 62541-9	X		X																												

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
EN 62559-1																								X							
EN 62559-2	X																							X							
EN 81346	X																							X							

10.2 ETSI

ETSI standards and latest status can be found on the Internet following the link below :
http://www.etsi.org/standards-search

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ETSI EG 202 387	X																										X				
ETSI EG 202 549	X																										X				
ETSI EN 301 502	X																									X					
ETSI EN 301 511	X																									X					
ETSI EN 301 908	X																									X					
ETSI EN 303 204	X	X																													
ETSI ES 202 382	X																										X				
ETSI ES 202 383	X																										X				
ETSI ES 202 630		X												X													X				
ETSI ETR 237	X																										X				
ETSI ETR 332	X																										X				
ETSI TCRTR 029	X																										X				
ETSI TE 103 118	X													X						X							X				
ETSI TR 101 531	X													X												X					
ETSI TR 102 419	X																										X				
ETSI TR 102 437	X																										X				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ETSI TR 102 572	X																										X				
ETSI TR 102 691	X													X																	
ETSI TR 102 886	X													X																	
ETSI TR 102 935	X													X												X					
ETSI TR 102 966	X													X												X					
ETSI TR 103 055	X													X																	
ETSI TR 103 167	X													X												X	X				
ETSI TR 185 008	X																										X				
ETSI TR 187 002	X																										X				
ETSI TR 187 012	X																										X				
ETSI TS 100 920	X																										X				
ETSI TS 101 456	X																										X				
ETSI TS 101 584	X													X												X					
ETSI TS 102 042	X																										X				
ETSI TS 102 165-1	X																										X				
ETSI TS 102 165-2	X																										X				
ETSI TS 102 221	X													X																	
ETSI TS 102 225	X																										X				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ETSI TS 102 226	X																										X				
ETSI TS 102 240	X													X																	
ETSI TS 102 241	X													X																	
ETSI TS 102 412	X													X																	
ETSI TS 102 484	X																										X				
ETSI TS 102 569	X													X																	
ETSI TS 102 573	X																										X				
ETSI TS 102 671	X													X																	
ETSI TS 102 689	X													X												X	X				
ETSI TS 102 690	X													X												X	X				
ETSI TS 102 887	X													X												X					
ETSI TS 102 921	X													X												X	X				
ETSI TS 103 092	X													X												X					
ETSI TS 103 093	X													X												X					
ETSI TS 103 104	X													X												X					
ETSI TS 103 107	X													X												X					
ETSI TS 103 383		X												X																	
ETSI TS 103 603	X													X												X					
ETSI TS 103 908	X													X												X					
ETSI TS 121 101	X													X												X					

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ETSI TS 122 368	X													X												X					
ETSI TS 123 401	X													X												X					
ETSI TS 123 402	X																									X					
ETSI TS 123 682	X																									X					
ETSI TS 129 368	X																									X					
ETSI TS 133 203	X																										X				
ETSI TS 133 210	X																										X				
ETSI TS 133 234	X																										X				
ETSI TS 133 310	X																										X				
ETSI TS 136 201	X													X												X					
ETSI TS 136 211	X													X												X					
ETSI TS 136 212	X													X												X					
ETSI TS 136 213	X													X												X					
ETSI TS 136 214	X													X												X					
ETSI TS 136 216	X													X												X					
ETSI TS 136 300	X													X												X					
ETSI TS 141 101	X													X												X					
ETSI TS 187 001	X																										X				
ETSI TS 187 003	X																										X				
ETSI TS 187 016	X																										X				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ETSI TS DTS/PLT-00031		X												X																	
GS LTN 001	X																									X					
GS LTN 002	X																									X					
GS LTN 003	X																									X					

10.3 IEC

IEC standards and latest status can be found on the Internet following the link below :
http://www.iec.ch/dyn/www/f?p=103:105:0::::FSP_LANG_ID:25

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IEC 61400-21		X																										X			
IEC 61400-27-1		X																										X			
IEC 60050 series																								X							
IEC 60255	X		X																												
IEC 60255-24	X			X				X	X																						
IEC 60633	X						X																								
IEC 60700-1	X						X																								
IEC 60783	X															X															
IEC 60784	X															X															
IEC 60785	X															X															
IEC 60786	X															X															
IEC 60904 series	X											X																			
IEC 60919	X						X																								
IEC 61000-3-13	X																												X		
IEC 61000-3-14	X																												X		
IEC 61000-3-15	X																												X		

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IEC 61000-3-16		X																											X		
IEC 61000-3-17		X																											X		
IEC 61000-3-6	X																												X		
IEC 61000-3-7	X																												X		
IEC 61194	X											X																			
IEC 61334-4-32	X													X	X																
IEC 61334-4-511	X													X	X																
IEC 61334-4-512	X													X	X																
IEC 61334-5-1	X													X	X																
IEC 61512	X		X																												
IEC 61784-1	X		X									X																			
IEC 61803	X						X																								
IEC 61804	X		X																												
IEC 61850-80-1	X		X	X		X	X	X	X	X									X												
IEC 61850-80-4	X			X				X	X			X													X						
IEC 61850-80-5		X	X	X				X	X			X																			
IEC 61850-8-2		X	X	X		X		X	X			X							X			X				X					
IEC 61850-10-210		X	X																												
IEC 61850-90-1	X		X	X		X		X	X																	X					

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IEC 61850-90-10		X										X																			
IEC 61850-90-11		X	X	X				X	X			X																			
IEC 61850-90-12	X			X				X	X			X							X	X											
IEC 61850-90-13		X	X																												
IEC 61850-90-14		X					X			X																					
IEC 61850-90-15		X										X																			
IEC 61850-90-17		X	X	X				X	X			X																			
IEC 61850-90-2	X		X	X		X	X	X	X	X		X							X			X									
IEC 61850-90-3	X			X		X	X	X	X	X									X				X								
IEC 61850-90-4	X		X	X		X		X	X											X	X	X				X					
IEC 61850-90-5	X			X		X		X	X												X					X	X				
IEC 61850-90-6		X		X				X	X																						
IEC 61850-90-7	X			X				X	X			X																X			
IEC 61850-90-8	X															X															
IEC 61850-90-9		X										X																			
IEC 61894	X															X															
IEC 61954	X						X			X																					
IEC 61981	X															X															
IEC 61987	X		X																												
IEC 62056-1-0	X													X	X																

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IEC 62056-3-1	X													X	X																
IEC 62056-42	X													X	X																
IEC 62056-46	X													X	X																
IEC 62056-4-7	X													X	X																
IEC 62056-5-3	X													X	X												X				
IEC 62056-6-1	X													X	X																
IEC 62056-6-2	X													X	X																
IEC 62056-6-9	X													X	X										X						
IEC 62056-7-3		X												X	X																
IEC 62056-7-5	X													X	X																
IEC 62056-7-6	X													X	X																
IEC 62056-8-20		X												X	X																
IEC 62056-8-3	X													X	X																
IEC 62056-8-6		X												X	X																
IEC 62056-9-1	X													X	X																
IEC 62056-9-7	X													X	X																
IEC 62257 (all parts)	X																											X			
IEC 62264	X		X																												
IEC 62271-3	X	X		X				X	X																						

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IEC 62282	X																														
IEC 62351 -all parts)	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X													
IEC 62351-1	X																										X				
IEC 62351-10	X																										X				
IEC 62351-11		X	X	X	X	X	X	X	X	X	X	X															X				
IEC 62351-12		X	X	X	X	X	X	X	X	X	X	X															X				
IEC 62351-2	X																										X				
IEC 62351-3	X																					X					X				
IEC 62351-4	X	X	X	X	X	X	X	X	X	X	X	X										X					X				
IEC 62351-5	X																										X				
IEC 62351-6	X	X	X	X	X	X	X	X	X	X	X	X															X				
IEC 62351-7		X	X	X	X	X	X	X	X	X	X	X								X							X				
IEC 62351-8	X																					X					X				
IEC 62351-9		X	X	X	X	X	X	X	X	X	X	X										X					X				
IEC 62351-90-1		X	X	X	X	X	X	X	X	X	X	X										X					X				
IEC 62357	X	X									X																				
IEC 62361 (all parts)	X										X														X						
IEC 62361-100	X		X		X						X																				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IEC 62361-101		X	X		X						X						X	X													
IEC 62361-102		X	X	X	X			X	X		X	X													X						
IEC 62443-3-3		X																				X					X				
IEC 62488-1 (Formerly EN 60663 Part 1)	X																									X					
IEC 62600 series	X											X																			
IEC 62689-1		X		X				X	X																						
IEC 62689-2		X		X				X	X																						
IEC 62689-3		X		X				X	X																						
IEC 62689-4		X		X				X	X																						
IEC 62689-100		X		X				X	X																						
IEC 62746		X													X											X					
IEC 62746-10-1	X														X											X					
IEC 62746-3	X		X												X											X					
IEC 62749	X																											X			
IEC 62786		X										X																X			
IEC 62898-2		X										X																X			
IEC 62934		X										X																X			

	Maturity		**Generation**	**Transmission**				**Distribution**				**DER**	**Customer premises**				**Market**		**Administration**					**Crosscutting**							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IEC/EN 61850 (all parts)	X	X			X						X														X						
IEC/PAS 62559	X																							X							

10.4 ITU

ITU standards and latest status can be found on the Internet following the link below :
http://search.itu.int/Pages/AdvancedSearch.aspx

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ITU-T G.7041	X																									X					
ITU-T G.7042	X																									X					
ITU-T G.707	X																									X					
ITU-T G.709	X																									X					
ITU-T G.781	X																									X					
ITU-T G.783	X																									X					
ITU-T G.798	X																									X					
ITU-T G.803	X																									X					
ITU-T G.872	X																									X					
ITU-T G.9700	X																									X					
ITU-T G.9701		X																								X					
ITU-T G.983.1	X																									X					
ITU-T G.983.2	X																									X					
ITU-T G.983.3	X																									X					
ITU-T G.983.4	X																									X					
ITU-T G.983.5	X																									X					

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ITU-T G.984.1	X																									X					
ITU-T G.984.2	X																									X					
ITU-T G.984.3	X																									X					
ITU-T G.984.4	X																									X					
ITU-T G.984.5	X																									X					
ITU-T G.984.6	X																									X					
ITU-T G.984.7	X																									X					
ITU-T G.987.1	X																									X					
ITU-T G.987.2	X																									X					
ITU-T G.987.3	X																									X					
ITU-T G.9901	X																									X					
ITU-T G.9902	X																									X					
ITU-T G.9903	X	X												X	X											X					
ITU-T G.9904	X													X	X											X					
ITU-T G.9905	X													X	X											X					
ITU-T G.991.1	X																									X					
ITU-T G.991.2	X																									X					
ITU-T G.992.1	X																									X					
ITU-T G.992.2	X																									X					
ITU-T G.992.3	X																									X					

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ITU-T G.992.4	X																									X					
ITU-T G.993.1	X																									X					
ITU-T G.993.2	X																									X					
ITU-T G.993.5	X																									X					
ITU-T G.994.1	X																									X					
ITU-T G.995.1	X																									X					
ITU-T G.9959	X													X	X											X					
ITU-T G.996.1	X																									X					
ITU-T G.996.2	X																									X					
ITU-T G.9960	X																									X					
ITU-T G.9961	X																									X					
ITU-T G.9962	X																									X					
ITU-T G.9963	X																									X					
ITU-T G.9964	X																									X					
ITU-T G.997.1																										X					
ITU-T G.998.1																										X					
ITU-T G.998.2																										X					
ITU-T G.998.3																										X					
ITU-T G.998.4																										X					
ITU-T G.999.1																										X					

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration						Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ITU-T I.322																										X					

10.5 ISO

ITU standards and latest status can be found on the Internet following the link below :
http://www.iso.org/iso/fr/home/store/catalogue_ics.htm

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ISO/IEC 15118 (all parts)	X															X											X				
ISO/IEC 15118-1	X															X															
ISO/IEC 15118-2	X															X											X				
ISO/IEC 15118-3	X															X															
ISO/IEC 15118-4	X															X															
ISO/IEC 15118-5	X															X															
ISO/IEC 15118-6	X															X															
ISO/IEC 15118-7	X															X															
ISO/IEC 15118-8	X															X															
ISO 19142	X																						X								
ISO 6469	X															X															
ISO 8601 (EN 28601)	X					X															X										
ISO 8713	X															X															
ISO/IEC 12139-1	X																									X					
ISO/IEC 27001	X																										X				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ISO/IEC 27002	X																										X				
ISO/IEC 27009		X																									X				
ISO/IEC 29190		X																									X				
ISO/IEC 7498-1	X																									X					
ISO/IEC 27019	X																										X				

4412 ## 10.6 Other bodies

4413

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ENTSO-E acknowledgement process	X																X	X													
ENTSO-E Capacity Allocation and Nomination (ECAN)	X																X	X													
Harmonized Electricity Market Role Model	X																X	X													
ENTSO-E Market Data Exchange Standard (MADES)	X																X	X													
ENTSO-E Reserve Resource Planning (ERRP)	X																X	X													

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
ENTSO-E Scheduling System (ESS)	X																X	X													
ENTSO-E Settlement Process (ESP)	X																X	X													
IEC 61588 (IEEE 1588)	X	X				X															X						X				
IEEE 1344	X					X																									
IEEE 1377	X													X	X																
IEEE 1686	X																										X				
IEEE 1901	X																									X					
IEEE 1901.2	X	X												X												X					
IEEE 802.1	X																									X					
IEEE 802.11	X																									X					
IEEE 802.15.4	X	X												X												X					
IEEE 802.16	X																									X					
IEEE 802.1AE	X																										X				
IEEE 802.1AR	X																										X				
IEEE 802.1X	X																										X				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IEEE 802.3	X																									X					
IEEE 802.3av	X																									X					
IEEE C37.118	X					X															X										
IEEE C37.238:2011	X																				X										
IEEE P2030	X																										X				
IETF RFC 7388	X																									X					
IETF RFC 7400	X																									X					
IETF RFC 7428	X																									X					
IETF RFC 7668	X																									X					
IETF RFC 6690	X													X												X					
IETF RFC 7252	X													X												X					
IETF RFC 7390	X													X												X					
IETF RFC 7641	X													X												X					
IETF RFC 7959	X													X												X					
IETF RFC 2460	X																									X					
IETF RFC 2616	X																									X					
IETF RFC 2617	X																										X				
IETF RFC 2759	X																					X					X				
IETF RFC 2865	X																					X					X				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IETF RFC 3031	X																									X					
IETF RFC 3032	X																									X					
IETF RFC 3584	X																			X											
IETF RFC 3711	X																										X				
IETF RFC 3748	X																					X					X				
IETF RFC 3923	X																					X					X				
IETF RFC 4090	X																									X					
IETF RFC 4210	X																										X				
IETF RFC 4211	X																										X				
IETF RFC 4301	X																										X				
IETF RFC 4302	X																										X				
IETF RFC 4303	X																										X				
IETF RFC 4330	X																				X										
IETF RFC 4422	X																					X					X				
IETF RFC 4553	X																									X					
IETF RFC 4764	X																					X					X				
IETF RFC 4789	X																			X											
IETF RFC 4919	X													X												X					
IETF RFC 4944	X													X												X					
IETF RFC 4962	X																					X					X				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IETF RFC 5086	X																									X					
IETF RFC 5106	X																					X					X				
IETF RFC 5216	X																					X					X				
IETF RFC 5246	X																									X	X				
IETF RFC 5247	X																										X				
IETF RFC 5272	X																										X				
IETF RFC 5274	X																										X				
IETF RFC 5280	X																										X				
IETF RFC 5281	X																					X					X				
IETF RFC 5343	X																			X											
IETF RFC 5590	X																			X											
IETF RFC 5654	X																									X					
IETF RFC 5905	X																				X										
IETF RFC 5921	X																									X					
IETF RFC 6120	X																									X					
IETF RFC 6121	X																									X					
IETF RFC 6122	X																									X					
IETF RFC 6178	X																									X					
IETF RFC 6206	X													X												X					
IETF RFC 6272	X																									X	X				

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
IETF RFC 6282	X													X												X					
IETF RFC 6347	X																										X				
IETF RFC 6407	X																										X				
IETF RFC 6550	X													X												X					
IETF RFC 6551	X													X												X					
IETF RFC 6552	X													X												X					
IETF RFC 6749	X																										X				
IETF RFC 6750	X																										X				
IETF RFC 6775	X													X												X					
IETF RFC 7030	X																										X				
IETF RFC 6241	X																			X											
IETF RFC 7803	X																			X											
IETF RFC 6021	X																			X											
IETF RFC 768	X																			X											
IETF RFC 791	X																									X					
IRIG 200-98	X																				X										
NCAR WXXM	X	X																					X								
OASIS wsdd-discovery-1.1-spec-os	X																									X					

	Maturity		Gene ration	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
OASIS wsdd-soapoverudp-1.1-spec-pr-01	X																									X					
OGC	X																						X								
OPC UA part 11	X		X																												
OPC UA part PLCopen	X		X																												
W3C NOTE wsdl-20010315	X																									X					
W3C REC soap12-part1-20070427	X																									X					
W3C REC soap12-part2-20070427	X																									X					
W3C RECws-addr-core-20060509	X																									X					
W3C RECws-addr-soap-20060509,	X																									X					

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
W3C REC-xml-20001006	X																									X					
W3C REC-xml-names	X																									X					
W3C SUBM wsdl11soap12-20060405	X																									X					
W3C SUBM WSEventing-20060315	X																									X					
W3C WD-ws arch-20021114	X																									X					
LoRaWAN Specification 1.0	X	X																								X					
3GPP Release 13- NB-IOT	X	X																								X					
Draft-ietf-detnet-problem-statement		X																								X					

	Maturity		Generation	Transmission				Distribution				DER	Customer premises				Market		Administration					Crosscutting							
	Available	Coming	Generation management system	Substation automation systems	EMS Scada system	WAMPACs	FACTS	Substation automation systems	Feeder Automation System	FACTS	Advanced DMS	DER operation systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	e-mobility	Trading system	Market place system	Assets and maintenance management system	Communication network management	Clock reference system	AAA system	Weather forecast and observation system	System approach	Data modelling	Telecommunication	Security	Connecting DER	EMC	Power Quality	Functional safety
Draft-ietf-detnet-use-case-10		X																								X					
draft-ietf-6tisch-architecture		X												X												X					
draft-ietf-6tisch-6top-interface		X												X												X					
draft-ietf-6tisch-minimal		X												X												X					
W3C XML Digital Signature	X																									X	X				
W3C XML Encryption	X																									X	X				
WMO METCE	X																						X								

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4415

4416 # Annex A Detailed list of abbreviations

4417 **Table 92 - Abbreviations list - complete**

Abbreviation	Meaning
3GPP	3rd Generation Partnership Project
6LoWPAN	IPv6 over Low power Wireless Personal Area Networks
ADMS	Advanced Distribution Management System
ADSL	Asymmetric digital subscriber line
AMI	Advanced Metering Infrastructure
AMR	Advanced Meter Reading
AN	Access Network
ANSI	American National Standard Institute
AS	Application server
CA	Certificate Authority
CC	Control Center
CEM	Customer Energy Management (refer 7.7.2 for details)
CEN	European Committee for Standardization (Comité Européen de Normalisation)
CENELEC	European Committee for Electrotechnical Standardization (Comité Européen de Normalisation Electrotechnique)
CHP	Combined Heat and Power
CIM	Common Information Model (EN 61970 & EN 61968 series)
CIS	Customer Information System
CMC	Certificate Management over CMS
CMP	Certificate Management Protocol
CMS	Certificate Management Syntax
COMTRADE	Common Format for Transient Data Exchange (IEC 60255-24)
COSEM	Companion Specification for Energy Metering
CT	Current Transformer
cVPP	Commercial Virtual Power Plant
DA	Distribution Automation
DCS	Distributed Control System (usually associated with generation plant control systems)
DER	Distributed Energy Resources (refer 7.7.2 for details)
DIN	Deutsches Institut für Normung
DLMS	Distribution Line Message Specification
DMS	Distribution Management System (refer 7.7.2 for details)
DR	Demand Response
DSO	Distribution System Operator
eBIX®	(European forum for) energy Business Information Exchange
EC	European Commission
ECP	Electrical Connection Point
EDM	Energy Data Management
EFET	European Federation of Energy Traders
EGx	EU Smart Grid Task Force Expert Group x (1 to 3)
EMC	Electro Magnetic Compatibility

Abbreviation	Meaning
EMG	Energy Management Gateway (refer 7.7.2 for details)
EMS	Energy Management System (refer 7.7.2 for details)
ENTSO-E	European Network of Transmission System Operators for Electricity
ERP	Enterprise Resource Planning
ESO	European Standardization Organization
EST	Enrollment over Secure Transport
ETSI	European Telecommunications Standards Institute
EV	Electrical Vehicle
FACTS	Flexible Alternating Current Transmission Systems (refer 7.7.2 for details)
FEP	Front End Processor (refer 7.7.2 for details)
FLISR	Fault Location Isolation and Service Restoration
GIS	Geographic Information System (refer 7.7.2 for details)
GOOSE	Generic Object Oriented Substation Event (EN 61850-7-2)
GPS	Global Positioning System
GSE	Generic Substation Event (EN 61850-7-2)
GSM	Global System for Mobile
GSSE	Generic Substation State Event (EN 61850-7-2)
GWAC	GridWise Architecture Council
HAN	Home Area Network
HBES	Home and Building Electronic System
HDSL	High-bit-rate digital subscriber line
HES	Head-End System (refer 7.7.2 for details)
HSPA	High Speed Packet Access
HV	High Voltage
HVDC	High Voltage Direct Current
ICT	Information & Communication Technology
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPv6	Internet Protocol Version 6
IRIG	Inter-Range Instrumentation Group
IS	International Standard
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
ITU-T	ITU’s Telecommunication standardization sector (ITU-T)
JWG	Joint Working Group (of CEN, CENELEC and ETSI on standards for smart grids)
KNX	EN 50090 (also known as Konnex)
L2TP	Layer 2 Tunneling Protocol
LAN	Local Area Network
LNAP	Local Network Access Point (refer 7.7.2 for details)
LR	WPAN Low Rate Wireless Personal Area Network

Abbreviation	Meaning
LV	Low Voltage
M/490	Mandate issued by the European Commission to European Standardization Organizations (ESOs) to support European Smart Grid deployment [1]
MAC	Media Access Control
MADES	Market Data Exchange Standard
MDM	Meter data management (refer 7.7.2 for details)
MMS	Manufacturing Message Specification (ISO 9506)
MPLS	Multiprotocol Label Switching
MPLS-TP	MPLS Transport Profile
MV	Medium Voltage
NAN	Neighborhood Area Network
NIC	Network Interface Controller (refer 7.7.2 for details)
NNAP	Neighborhood Network Access Point (refer 7.7.2 for details)
NSM	Network and System Management (IEC 62351-7)
NWIP	New Work Item Proposal
OASIS	Organization for the Advancement of Structured Information Standards
OMS	Outage Management System (refer 7.7.2 for details)
OPC	OLE for Process Control
OPC UA	OPC Unified Architecture
OSI	Open System Interconnection
OSGP	Open Smart Grid Protocol
PEV	Plug-in Electric Vehicles (refer 7.7.2 for details)
PKI	Public Key Infrastructure
PLC	Power Line Carrier communication
PLC	Programmable Logic Controller
PV	Photo-Voltaic – may also refer to plants using photo-voltaic electricity generation
QoS	Quality of Service
RBAC	Role-Based Access Control (IEC 62351-8)
RPL	Routing Protocol for Low power and lossy networks (LLN)
SAS	Substation Automation System
SCADA	Supervisory Control and Data Acquisition (refer 7.7.2 for details)
SCEP	Simple Certificate Enrollment Protocol
SCL	System Configuration Language (IEC 61850-6)
SDO	Standards Developing Organization
SEG-CG	Smart Energy Grid Co-ordination Group, reporting to CEN-CENELEC-ETSI continuing the mission of the former SG-CG, since beginning of 2015.
SG	Smart Grid as defined in the M/490 mandate as well as in the JWG report [a1]
SGAM	Smart Grid Architecture Model – delivered by the SG-CG-RA team as part of the mandated deliveries of M/490, which proposes 3 different axes to map a Smart Grid feature (Domains, Zones and Layers) – details available in [9]
SG-CG	(continued by SEG-CG) Smart Grid Co-ordination Group, which reported to CEN-CENELEC-ETSI and was in charge of answering the M/490 mandate
SG-CG/FSS	Team of experts acting on behalf of the CEN-CENELEC-ETSI SG-CG to manage part of the mandated tasks as defined by SG-CG in the “First Set of Standards” package.

Abbreviation	Meaning
SG-CG/RA	Team of experts acting on behalf of the CEN-CENELEC-ETSI SG-CG to manage part of the mandated tasks as defined by SG-CG in the “Reference Architecture” package
SG-CG/SGIS	Team of experts acting on behalf of the CEN-CENELEC-ETSI SG-CG to manage part of the mandated tasks as defined by SG-CG in the “smart grid information security” package
SG-CG/SP	Team of experts acting on behalf of the CEN-CENELEC-ETSI SG-CG to manage part of the mandated tasks as defined by SG-CG in the “Sustainable Processes” package
SM-CG	Smart Metering Co-ordination Group, reporting to CEN-CENELEC-ETSI and in charge of answering the M/4441 mandate
SLA	Service Level Agreement
SNMP	Simple Network Management Protocol
SOA	Service Oriented Architecture (IEC/TR 62357)
SIPS	System Integrity Protection System
SyC	System Committee (IEC)
TC	Technical Committee
TDM	Time Division Multiplexing
TF	Task Force
TMS	Transmission Management System
TR	Technical Report
TS	Technical Specification
TSO	Transmission System Operator
tVPP	Technical Virtual Power Plant
UC	use case
UMTS	Universal Mobile Telecommunications System
VAR	Volt Ampere Reactive – unit attached to reactive power measurement
VLAN	Virtual Local Area Network
VoIP	Voice over IP
VPP	Virtual Power Plant
VT	Voltage Transformer
WAMPAC	Wide Area Measurement System (refer 7.7.2 for details)
WAN	Wide Area Network
WG	Working Group
WPAN	Wireless Personal Area Network
xDSL	Digital Subscriber Line
XML	Extensible Markup Language