CEN-CENELEC-ETSI Smart Grid Coordination Group

November 2012

CEN-CENELEC-ETSI Smart Grid Coordination Group

First Set of Standards

Change tracking

Note :

- Versions noted in italic are internal to the FSS 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
2.0 (released)	Nov 16th 2012	L. Guise	Editorial changes on ROLL related standards - p
2.0 (beta release)	Nov 15th 2012	L. Guise	Comments_V4.6.xls treatment (510comments treated out of 510) – after the latest "sanity check"
1.19 (2.0 alpha release)	Nov 13th 2012	L. Guise	Comments_V4.5.xls treatment (492 comments treated out of 492)
1.18	Internal	L. Guise	Comments_V4.4.xls treatment (422 comments treated out of 491)
1.17	Nov 7th 2012	L. Guise	Comments_V4.3.xls treatment (327 comments treated out of 491)
1.16	Nov 7th 2012	L. Guise	Comments_V4.2.xls treatment (299 comments treated out of 487)
1.15	internal	L. Guise	Comments_V4.xls treatment
1.14	Nov 2d 2012	L. Guise	Comments_V3.xls treatment (249 comments treated out of 469)
1.13	Nov 1st 2012	L. Guise	Comments_V2.xls treatment (159 comments treated)
1.12	Oct 26th 2012	L. Guise	Comments_V0.xls treatment (137 comments treated)
1.11	Oct 16th 2012	L. Guise	Titles top and bottom of pages - updated
1.1	Oct 16th 2012	L. Guise	Merge with the addendum for AMI standards SGCG_Sec_0042_DC - addendum - with textual input and M441 standards V2.pdf
1.0	Oct 2d 2012	L. Guise	First official draft release for circulation to SG-CG stakeholders

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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], and is a first step in the mandated consistency work process.

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 first 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.

Finally, the draft of this report circulated to all SG-CG stakeholders from Oct 2d 2012 to Nov 2d 2012. The FSS team received about 500 comments, which were all submitted to the group of experts (made from experts from all groups of SG-CG). Most of them were fully resolved, receiving the full consensus of the FSS group. The result is detailed in the comments resolution file [a5]. A specific cautious was brought to ensure the alignment of all SG-CG reports from all groups. Few of them need some further investigation, not compatible with the targeted deadline of the report, and will be answered in a further release of this report. These are explicitly sorted and mentioned in the comment resolution file [a5].

2 References

Reference document :

[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

[5] CEN-CENELEC-ETSI Smart Metering Coordination Group - M/441 – Work Program (SMCG_Sec0025_DC_V0.0.3)

[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

[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' v.2.1, (SGCG_Sec0028_DC), Brussels, 2011.
[8] CEN-CENELEC-ETSI Smart Grid Coordination Group, ' Programme of standardisation work for the Smart Grid' (SGCG_Sec0032_DC (version 1.6)), Brussels, 2012
[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
[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
[12] Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations
[13] New Regulation on EU standardization – adopted Oct 4th 2012 - PE-CONS 32/12 and 13876/12 ADD1.

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
[a4] IEV : International Electrotechnical Vocabulary – published as IEC 60050
[a5] CEN-CENELEC-ETSI Smart Grid working Group, First set of standards, ‘Comments resolution related to the draft “First set of standards” report SGCG_Sec_0042_DC published on Oct 2d 2012’ (SGCG_FSS_0049_CC), Brussels, Nov 16th 2012.
[a6] IEC 62357 : Reference Architecture – Power System management.

3 Terms

Note : Definitions of Smart grid components (shown in the Smart Grid system mappings) are given in 7.6.2.

3.1.1 AVAILABLE

a standard is identified as AVAILABLE when it has reached its final stage (IS, TS or TR, …) by June 30th 2012

3.1.2 COMING

a standard is identified as “COMING” when it has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012

3.1.3 Smart Grids

Refer to [1]. A Smart Grid is 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

3.1.4 standard

a standard is a technical specification approved by a recognized standardization body, with which compliance is not compulsory (According to [12], the Directive 98/34/EC). Please refer to 6.3 for further details

3.1.5 system

a typical industry arrangement of components and systems, based on a single architecture, serving a specific set of use cases.

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 7.6.2.

Table 1 – Network typology abbreviations

Abbreviation	Meaning
A	Subscriber access network
B	Neighborhood network
C	Field area network
D	Low-end intra-substation network
E	Intra-substation network
F	Inter substation network
G	Intra-control centre / intra-data centre network
H	Enterprise network
I	Balancing network
J	Interchange network
K	Trans-regional / trans-national network
L	Wide and Metropolitan Area Network
M	Industrial ieldbus area network

Note ; this list is needed to better understand the graphics related to communication standards in the system sections. It is extracted from section 9.2.2.

Table 2 – Abbreviations list extract

Abbreviation	Meaning
AMI	Advanced Metering Infrastructure
AS	Application Server
CEM	Customer Energy Management (refer 7.6.2 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 7.6.2 for details)
DMS	Distribution Management System (refer 7.6.2 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 7.6.2 for details)
EMS	Energy Management System (refer 7.6.2 for details)

Abbreviation	Meaning
ENTSO-E	European Network of Transmission System Operators for Electricity
ESO	European Standardization Organization
ETSI	European Telecommunications Standards Institute
DIN	Deutsches Institut für Normung
FACTS	Flexible Alternating Current Transmission Systems (refer 7.6.2 for details)
FEP	Front End Processor (refer 7.6.2 for details)
GIS	Geographic Information System (refer 7.6.2 for details)
GSM	Global System for Mobile
HAN	Home Area Network
HBES	Home and Building Electronic System
HES	Head End system (refer 7.6.2 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
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 7.6.2 for details)
NNAP	Neighborhood Network Access Point (refer 7.6.2 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 7.6.2 for details)
MID	Measuring Instruments Directive
MV	Medium Voltage
NAN	Neighborhood Area Network
NIC	Network Interface Controller (refer 7.6.2 for details)
NWIP	New Work Item Proposal
OASIS	Organization for the Advancement of Structured Information Standards
OMS	Outage Management System (refer 7.6.2 for details)
PEV	Plug-in Electric Vehicles (refer 7.6.2 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 7.6.2 for details)
SG	Smart Grid as defined in the M/490 mandate [1] as well as in the JWG report [a1]

Abbreviation	Meaning
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	Smart Grid Co-ordination Group, reporting to CEN-CENELEC-ETSI and 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
WAMS	Wide Area Measurement System (refer 7.6.2 for details)
WAN	Wide Area Network
W3C	World Wide Web Consortium
WG	Working Group

5 Executive Summary

As the result of the mandated work requested through the M/490 mandate [1], this report intends to build a first list of standards, enabling or supporting the deployment of Smart Grid systems in Europe.

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.**
This report fully relies on the work performed by the 3 other main parts of Smart Grid Co-ordination Group (SG-CG) committed to fulfill the M/490 [1] expected deliverables (Reference Architecture, Sustainable processes, 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. Then possibly all available standards may not be reflected in this report.

At the end this guide includes about 24 types of Smart Grid systems, more than 400 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 why this report is called “First 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.

6 Objectives, rules and expected usage of this report

This section is mostly replicating the content of [6], previously validated in July 2012 by SG-CG stakeholders.

6.1 Content of this report

This report results from the CEN-CENELEC-ETSI experts' assessment, and is intended to depict the portfolio of European and/or International standards which may be used to support Smart Grids deployment in Europe.
The goal of this report is **to facilitate interoperable solutions based on standards**[2]. This 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 provides a **selection guide, setting out :**

- **for the most common Smart Grid systems** as introduced in the report "Reference Architecture for the Smart Grid" – functional breakdown [9],
- the set of possible "Generic use cases" (ref glossary) they can support,
- and **which standards may be used, where, and for which purpose**.

6.2 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 6.3.1 and 6.3.2. 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 6.3.2). 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 6.3.2 are not part of this report.

6.3 How to select standards?

All standards identified in this report have been selected applying the following rules.
These rules are also compliant with the new Regulation on EU standardization [13][3].

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[2] According to [12], the Directive 98/34/EC, "a standard is a technical specification approved by a recognised standardisation body, with which compliance is not compulsory"

[3] Chapter IV of [13] on "ICT technical specifications",article13 of the new upcoming Regulation (officially to come up in some few weeks) 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".
Article 14 of the new upcoming Regulation says:
"The ICE 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, and Regulation 2342/2002".
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.

6.3.1 Standardization body ranking

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

1. the report has identified standards from the European Organizations, CEN, CENELEC or ETSI, where available,
2. where no standards were available from 1, then the report has considered ISO, IEC or ITU standards
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:

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 report 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.

6.3.2 Maturity level

Two maturity levels of the standards are considered:

- A standard that has reached its final stage (IS, TS or TR, …) by June 30th 2012, is identified as “AVAILABLE”
- A standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012, is identified as “COMING”

According to the mandate M/490[1], which introduces the need for further iterations (clause 4.4), 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).

6.3.3 Release management

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

6.4 Process for "List of Standards" update

6.4.1 Why “first”?

The mandate [1] 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 first attempt in building the framework of standards which can support Smart Grids deployment in Europe, however also stating in the clearest way what is available and what is coming (based on the known standardization work and the triggers defined above).

6.4.2 Updating process

Further the section 4.4 of the mandate [1] clearly opened the path for further iterations of this work, in order to update the mandated deliverables.

The current report may be then updated, periodically, based on the above mentioned iterations.

6.5 Toward seamless interoperability

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 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 "First 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,
- 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.

7 Main guidelines

7.1 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 “First 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 7.3.
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 7.4.2). This mapping shows then which standards are to be considered and where to use them.

Standards are selected from Standardization bodies, following the ranking method proposed in section 6.3. For each of the listed standards “maturity information” according to section 6.3.2 and 6.3.3 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 7.4.4 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 9.2 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.

7.2 SGAM introduction

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

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 to the present 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.

7.2.1 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 [a6]). 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.

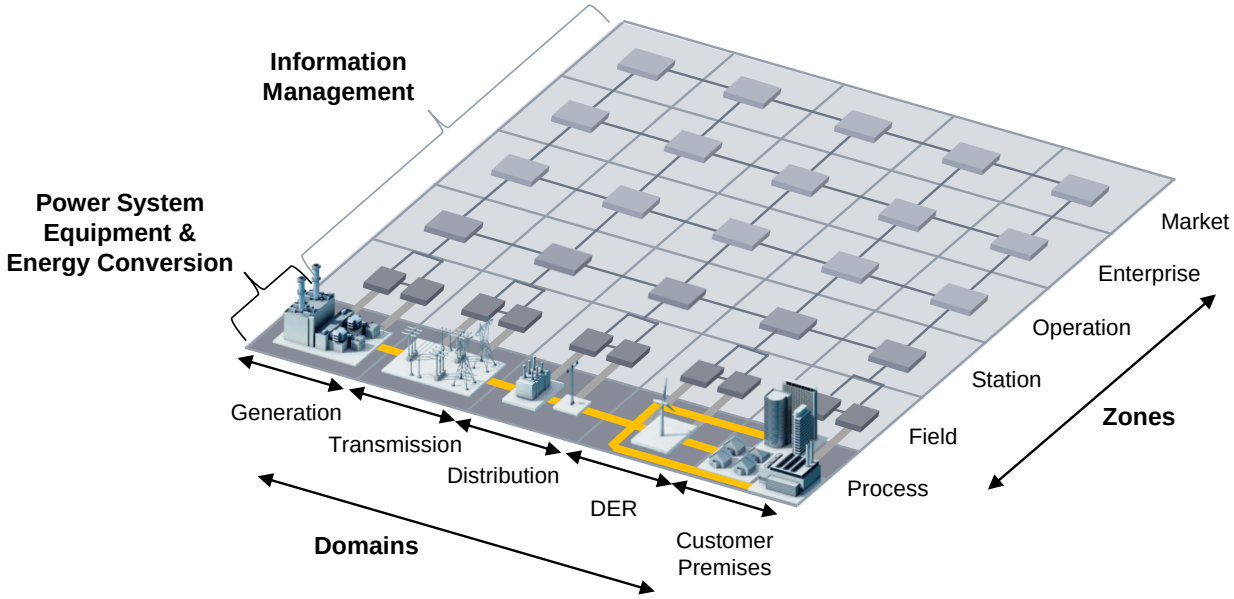


Figure 1: Smart Grid plane - domains and hierarchical zones

7.2.2 SGAM Interoperability Layers

As already introduced above in the introduction to 7.2, the interoperability categories described in [a2] are aggregated into five abstract interoperability layers (refer to Figure 2).

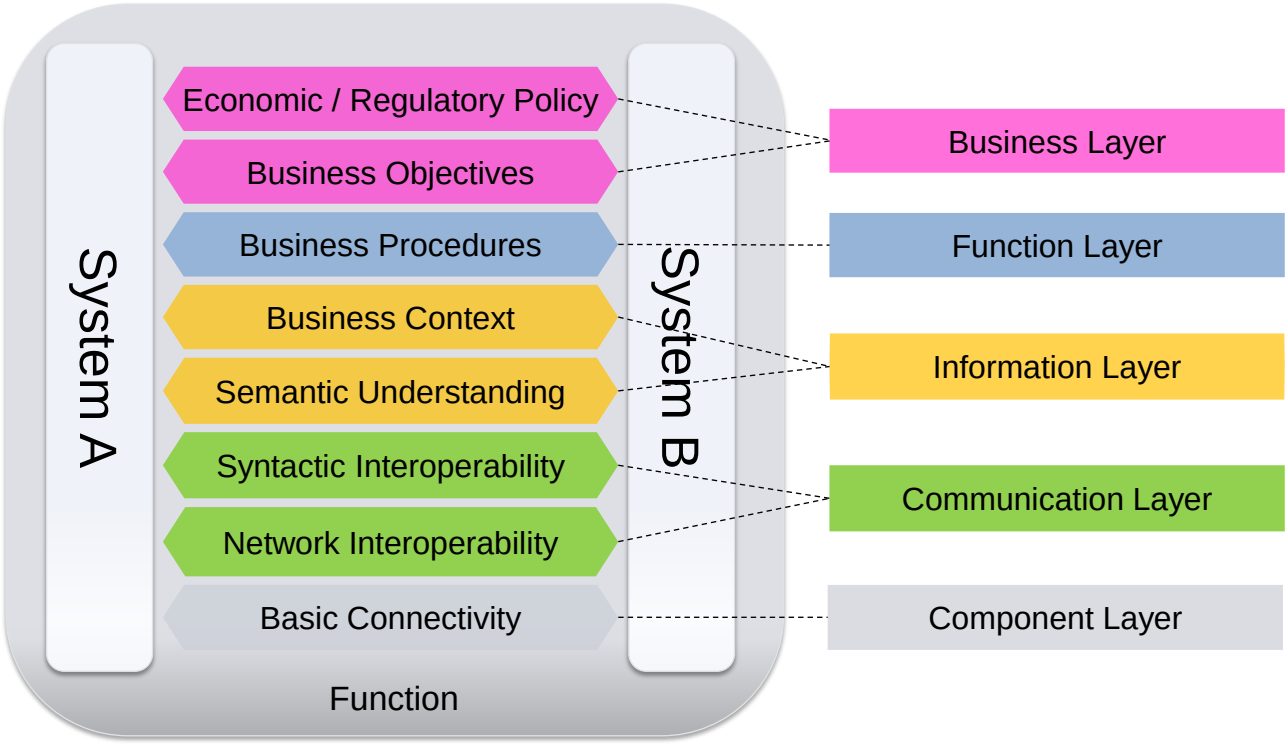


Figure 2: Grouping into interoperability layers

7.2.3 SGAM Framework

The SGAM framework is established by merging the concept of the interoperability layers defined in section 7.2.2 with the previously introduced smart grid plane. This merge results in a model (see Figure 3) which spans three dimensions:

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

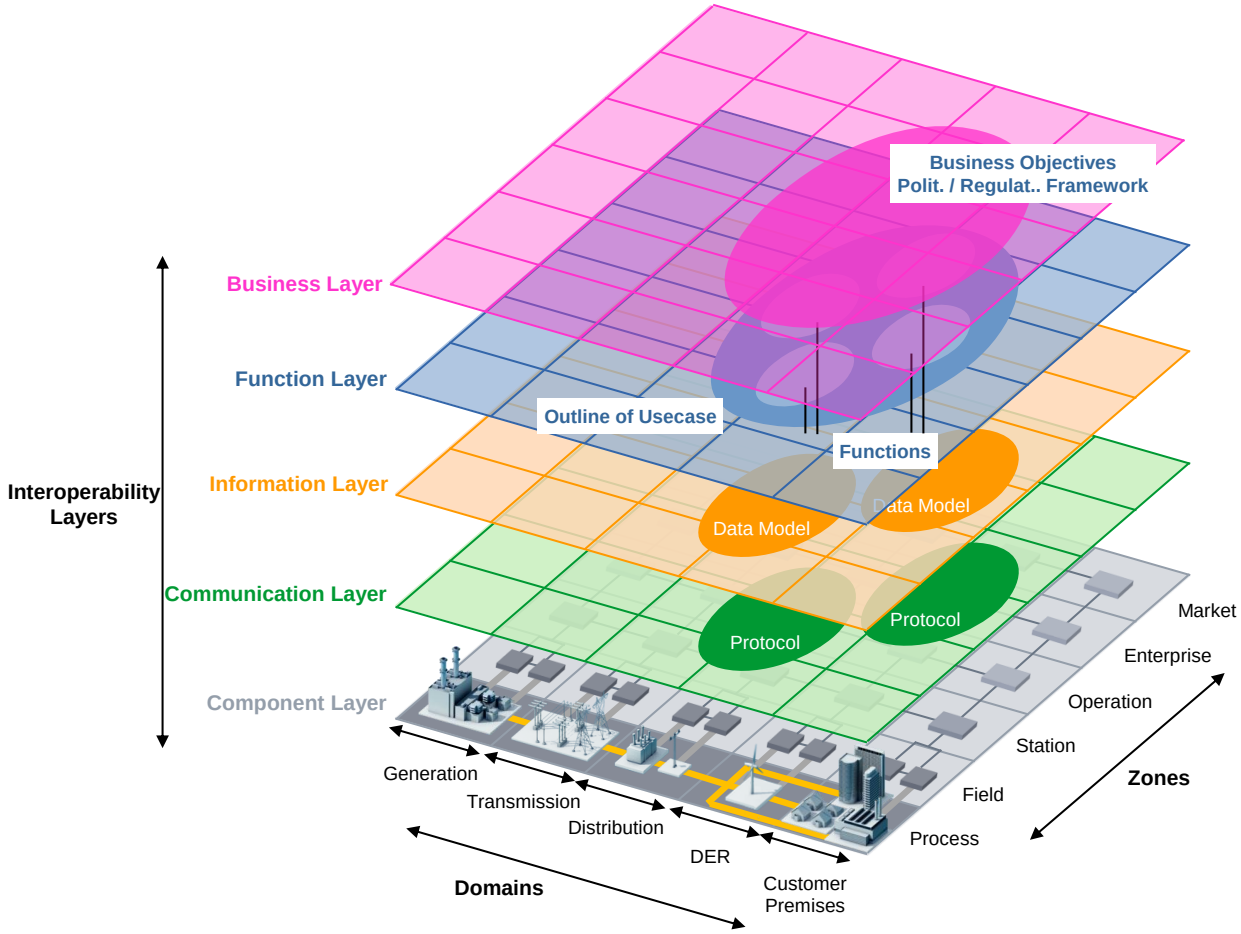


Figure 3: the SGAM framework

7.3 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, …)

Table 3 - Smart Grids - list of the main systems

Domain or Function	Systems
Generation	Generation management system
Transmission management system	Substation automation system
	WAMS Wide Area Measurement System
	EMS SCADA system
	Flexible AC Transmission Systems FACTS
Distribution management systems	Substation automation system
	Feeder automation/smart reclosers system
	Distributed power quality control system
	DMS SCADA system & GIS system
	FACTS system
DER management systems	DER operation system
	DER EMS and VPP system
Smart Metering systems	AMI system
	Metering back office system
Demand and production (generation) flexibility systems	Aggregated prosumers management system
Marketplace system	Marketplace system
	Trading system
E-mobility (connection to grid)	E-mobility systems
Administration systems	Asset and maintenance mgt system
	Communication network management system
	Clock reference system
	Authentication authorization accounting system
	Device remote configuration system
	Weather observation and forecast 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”.
2. HVDC systems will be considered in further revisions of the present document.

7.4 Mapping of systems on SGAM Smart Grid Plane

7.4.1 Overview

An overall view of all these systems onto the SGAM plane allows positioning each system in the domains and zones as shown in Figure 4. Note that not all administrative systems and cross-cutting technologies are shown in order to keep the figure readable.

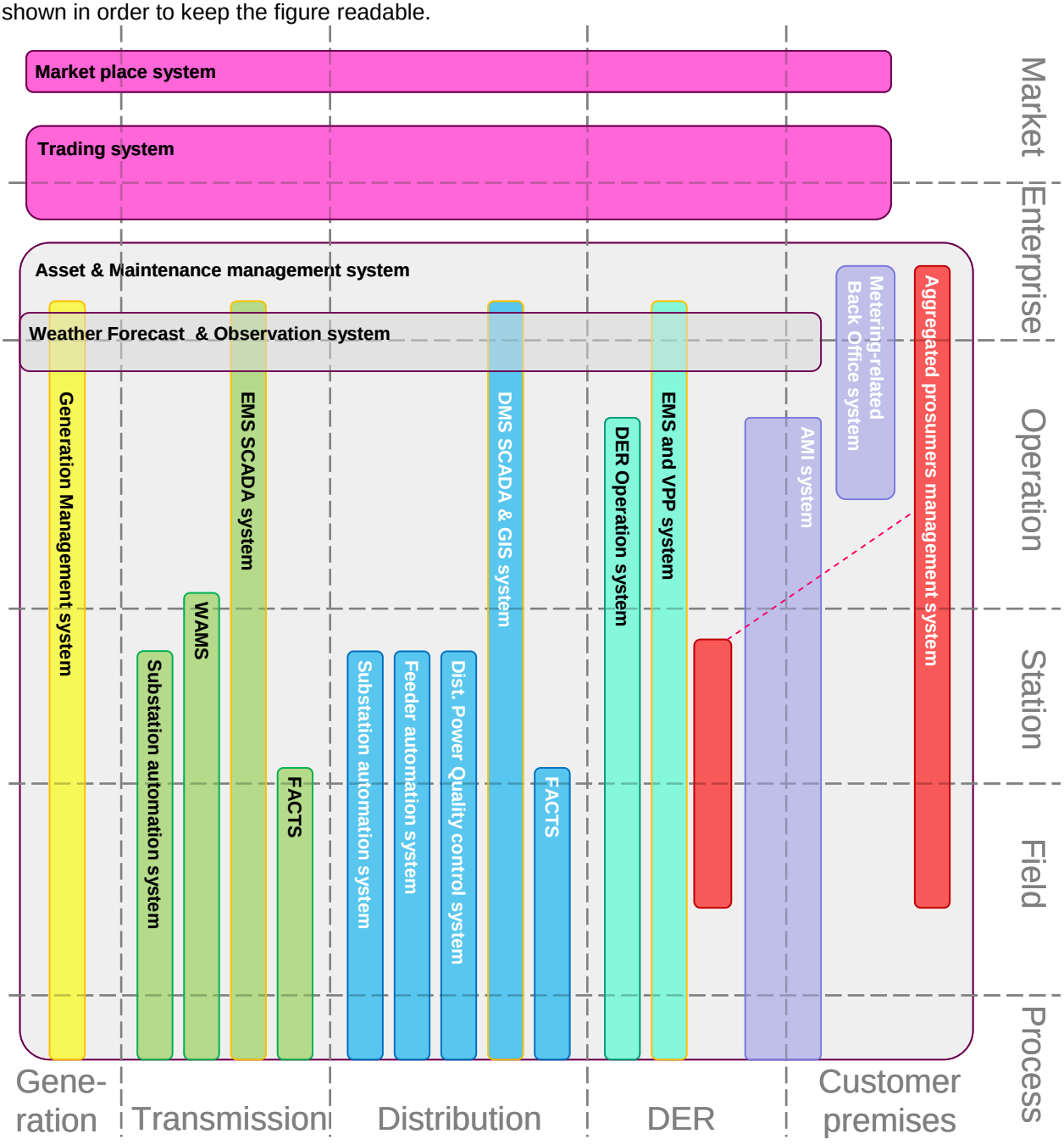


Figure 4 - Mapping of Smart Grids systems to the SGAM model

7.4.2 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 7.2.3. 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

7.4.3 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:

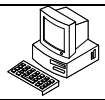
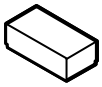
- To be accurate enough to show the typical usage of standards
- To be generic enough not to “dictate” any preferences regarding such system arrangement.

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 4 - 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 5 - Typical links used for system mapping on SGAM

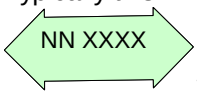
Graphical representation	Description	Comment
	Electrical connection between process level component	Showing the presence of a electrical network,
	Communication path between two (or more) components	Showing the presence of a communication network
	Communication between a component and another system	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

7.4.4 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 that way

  where NN indicates the standard body[4], and XXXX indicates the standard reference
- Communication technologies corresponding more to OSI layers 1 to 4 are described in section 9.2. 13 types of network have been identified, which are noted by letters from “A” to “M”.
  More specifically the communication standards categories able to fulfill the requirement of the considered type(s) of network are listed in the Table 77 (on a per type of network basis). The detailed list of communication standards, related to each standard categories, are given in Table 78 and Table 79.
- The two parts mentioned above are bound graphically by the adding to 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 bound is 

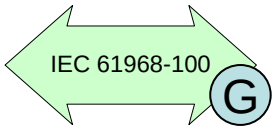
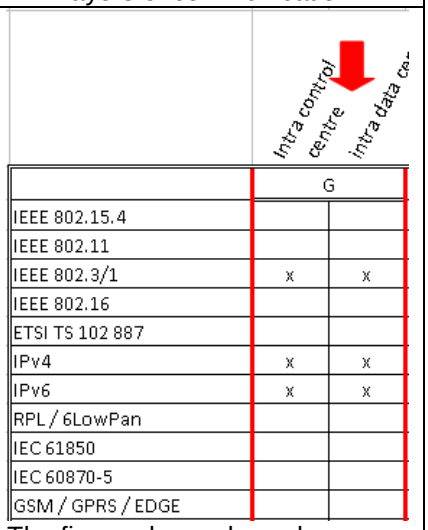
  .

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.

[4] 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 6 – 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 9.2.2. Then the **Table 77 in section 9.2.2.2 indicates which standard(s) category may support the lower OSI layers of a communication network of type "G".** In that example, Table 77 indicates that the gategories IEEE 802.3/1, IPv4 … standards may fit (the screenshot on the right shows how to understand the usage of Table 77).	 The figure above shows how Table 77 may contribute to select the appropriate lower OSI layer communication standards category for a given type of network

7.4.5 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 standard are shown on the drawing using a yellow ellipse such as

where NN indicates the standard body[5], and ZZZZ indicates the standard reference.

7.5 Smart Grid Generic use cases

7.5.1 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 7.
Then further in the document, for each systems (refer to the list above in Table 3), a specific section will describe the detailed list of supported UCs.

Table 7 – Summary list of Smart Grid Generic use cases

Use cases cluster	High level use cases

[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

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 WAMS
	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)
	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

Use cases cluster	High level use cases
	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
	Solve grid congestion issues through Balancing Market
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)

Use cases cluster	High level use cases
(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...)
	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	Collect metered data (for revenue purpose)
	Cross border transmission systems

Use cases cluster	High level use cases
measurements	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

7.5.2 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 8.
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 8 - 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 requirement for the considered UC but no specific standardization activity covering the information layer is fitting the triggers yet (ref 6.3) 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

7.6 Inputs from IEC SG3 – The Smart Grid Component plane

These inputs are based on the current working IEC SMB SG3 version available on Oct 1st, 2012. The future final IEC release of [a3] may be further refined, compared to the extraction provided below.

7.6.1 Component plane

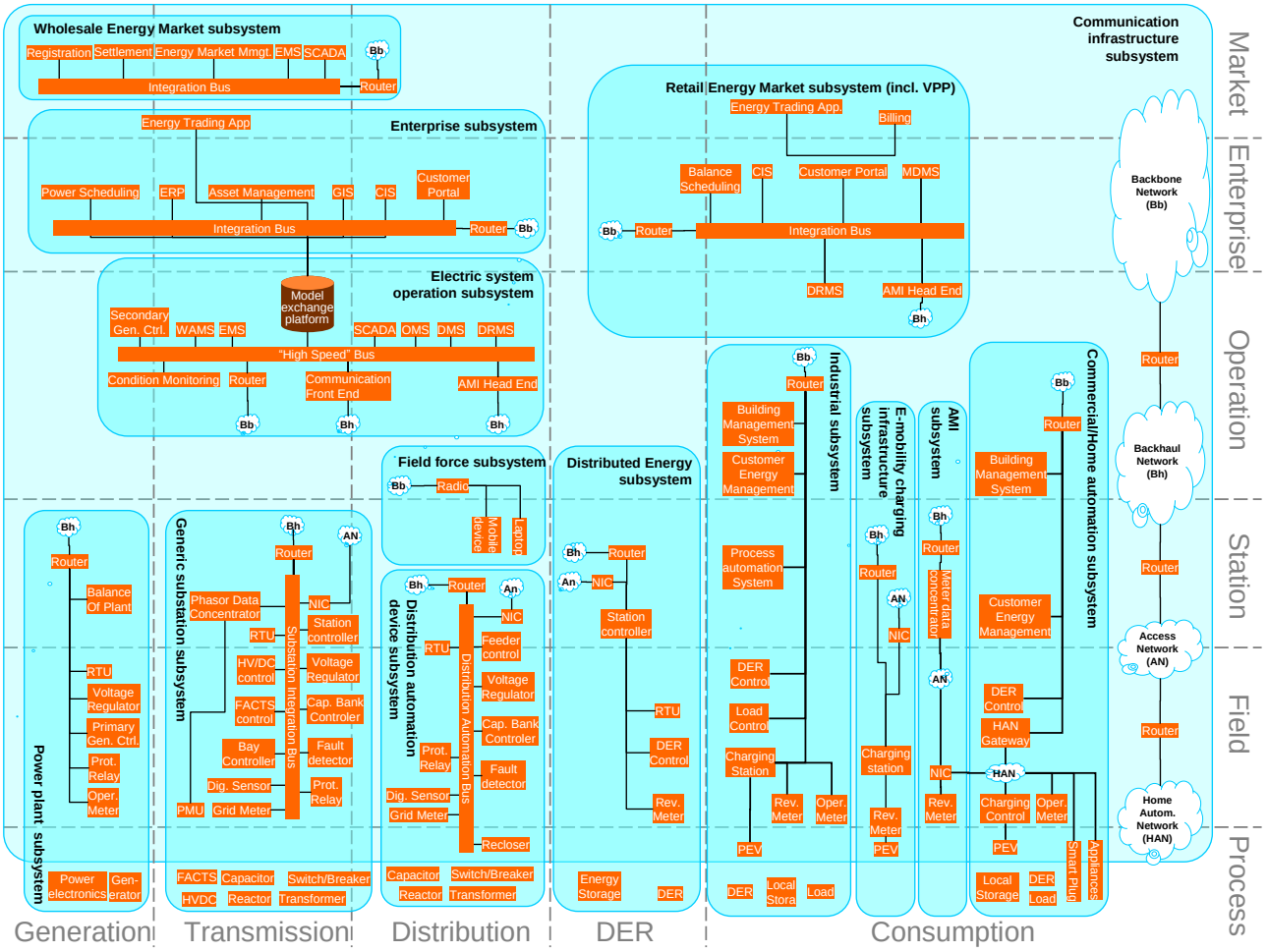


Figure 5 - IEC SG3 - Smart Grid mapping chart

7.6.2 List of components

This list of Smart Grid components provided in Table 9, provided by IEC SG3, will be used further in the document to complete the SGAM mapping of each system at the component layer:
This list not only depicts each components, but also introduces where relevant the possible interaction of this component with other components and/or systems.

Table 9 - Smart Grid Component list (IEC SG3)

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.
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

Component	Description
	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 Ssystem	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.
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

Component	Description
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
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

Component	Description
	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
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.

Component	Description
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
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 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. WAMS) 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

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 7.5.2.

Table 10 - 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)			X
	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			
	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.

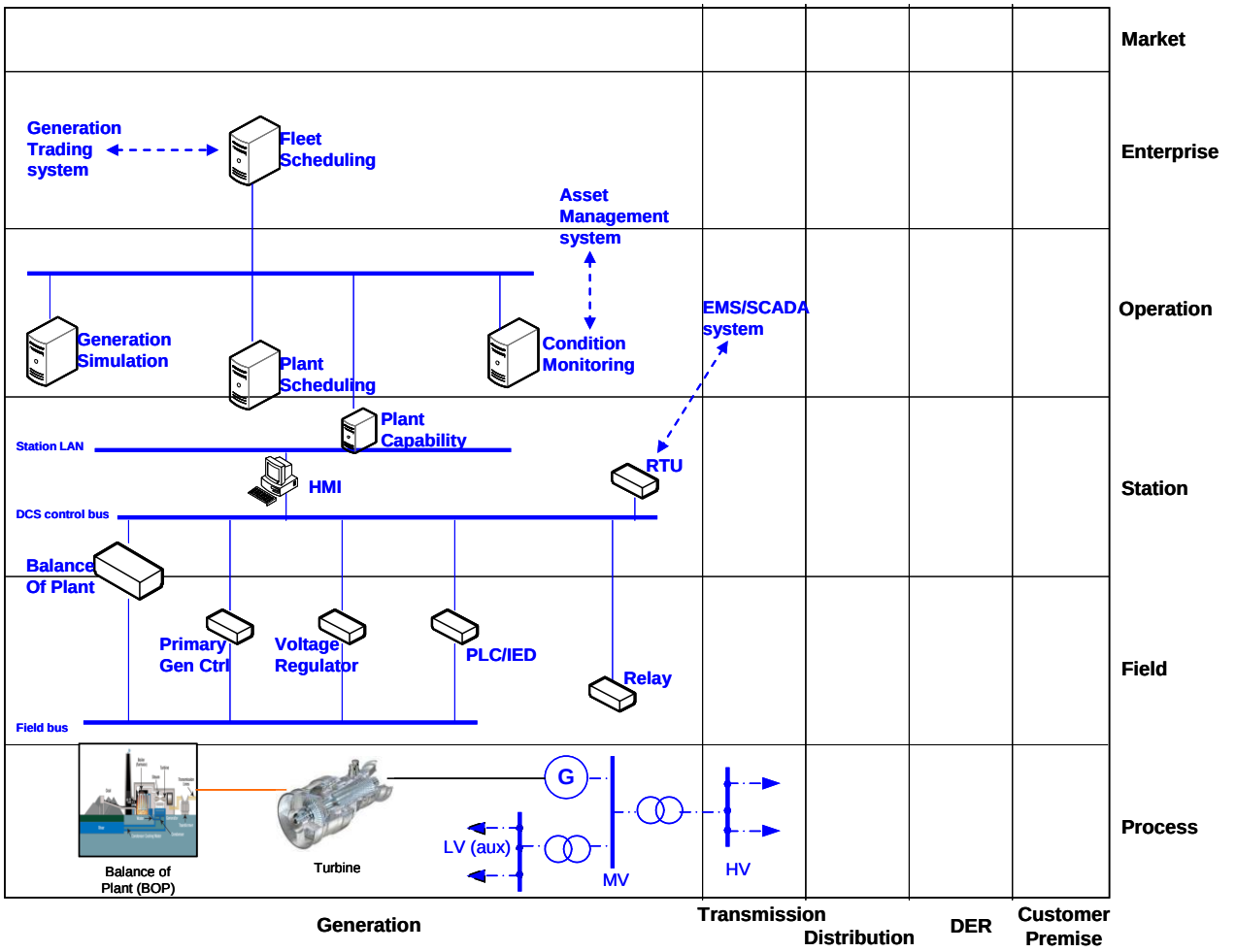


Figure 6 - Generation management system - Component layer

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 9.3 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 9.2.2.

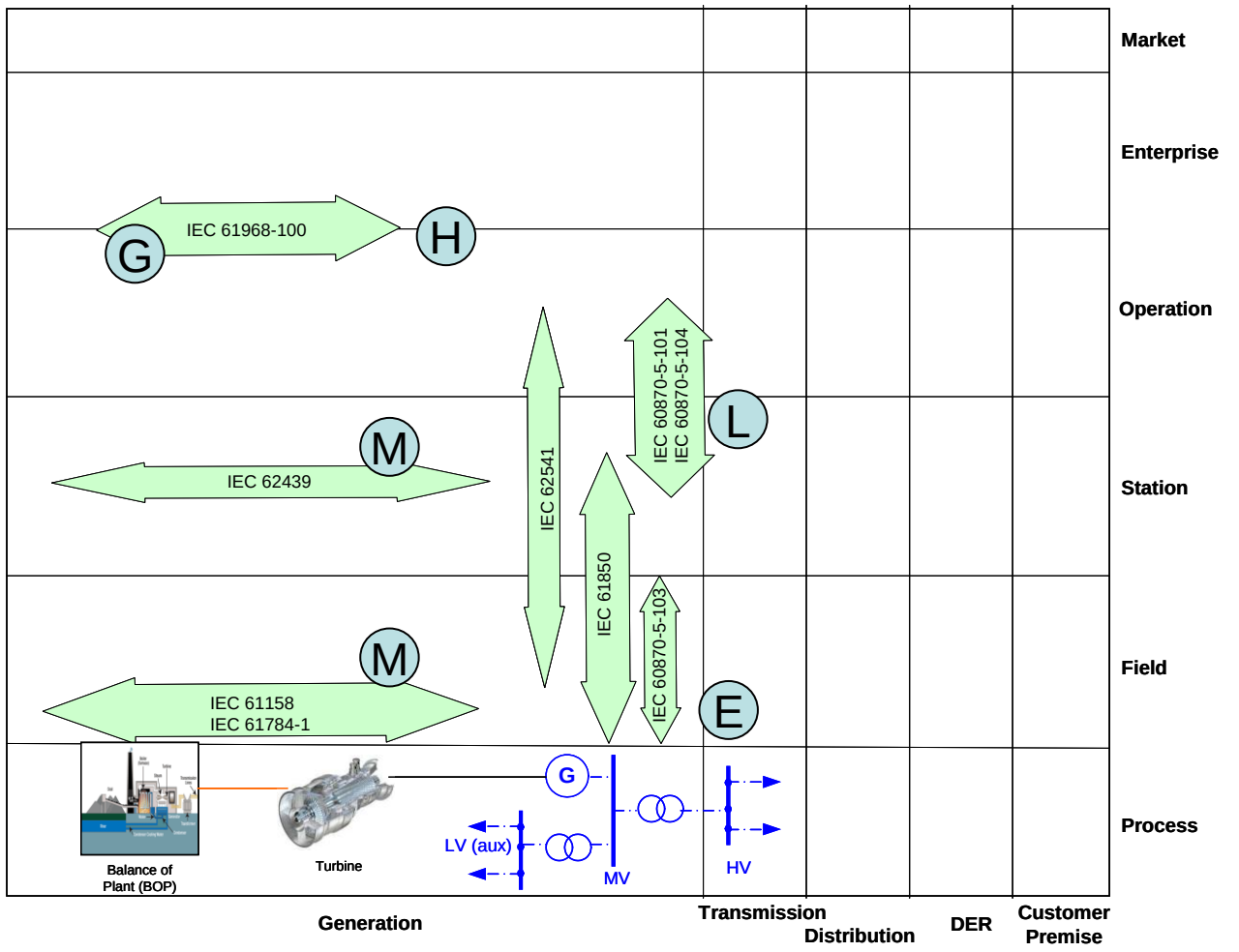


Figure 7 - Generation management system - Communication layer

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 IEC 61131, with associated work in progress IEC 61499 and IEC 61804
- Plant electrical devices are standardized within the IEC/EN 61850 family, with work in progress for other field devices: EN 61400-25-2 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.

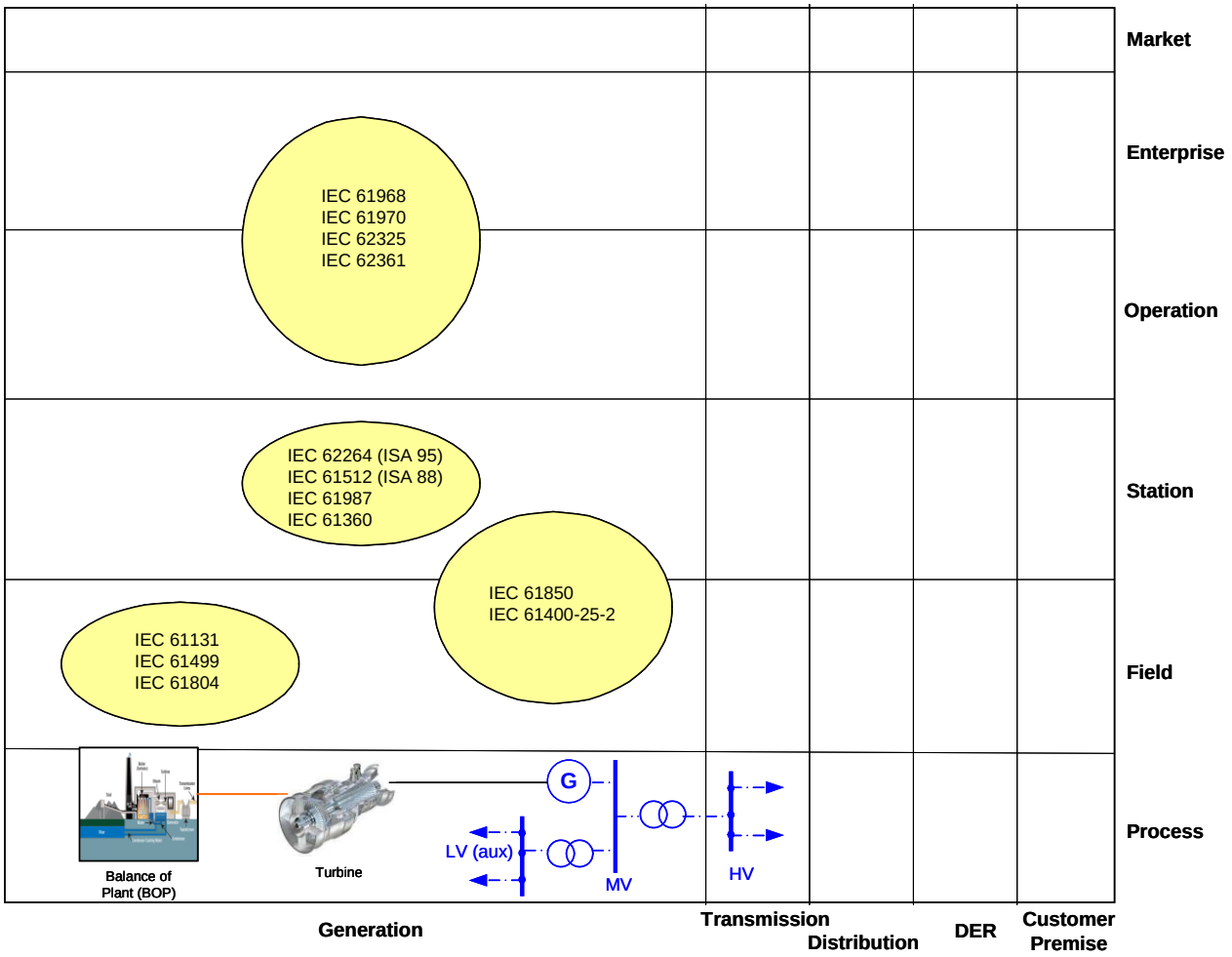


Figure 8 - Generation management system - Information layer

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, a standard (or "open specification") that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as "available".

Table 11 - Generation management system - Available standards

Layer	Standard	Comments
Information	IEC 61131	Programmable controllers
Information	IEC 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 EN 61968-3	Application integration at electric utilities - System interfaces for distribution management

Layer	Standard	Comments
	EN 61968-4 EN 61968-9 EN 61968-11	
Information	EN 61970-1 EN 61970-2 EN 61970-301 EN 61970-401 EN 61970-453 EN 61970-501	Energy management system Application Program Interface
Information	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 61400-25-2	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
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
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	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 9.3)

8.1.1.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 12 - Generation management system - Coming standards

Layer	Standard	Comments
Information	*EN 61968-6*	Application integration at electric utilities - System interfaces for distribution management
Information	*EN 61970-452* *EN 61970-456* *EN 61970-458* *EN 61970-502-8* *EN 61970-552*	Energy management system Application Program Interface for 61970

Layer	Standard	Comments
Information	*IEC 62325-301* *IEC 62325-351* *EN 62325-450* *IEC 62325-451-1* *IEC 62325-451-2* *IEC 62325-451-3*	CIM information model (Market profiles)
Information	*IEC 62361-100* *IEC 62361-101*	CIM information model (profiling rules)
Information	*IEC 61850-90-13*	Steam and gas turbines
Communication	*EN 61968-100*	Application integration at electric utilities - System interfaces for distribution management Implementation profiles
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services
Communication	*IEC 61850-90-4*	Guidelines for communication within substation
Communication, Information	*IEC 61850-90-2*	Guidelines for communication to control centers
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

8.2 Transmission management system

8.2.1 Substation automation system (Transmission)

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.

8.2.1.2 Set of use cases

Refer to 8.3.1.2

8.2.1.3 Mapping on SGAM

Refer to 8.3.1.3

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, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as “available”.

Table 13 - Substation automation system (Transmission) - 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	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)
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	
Communication	EN 60870-5-103	
Communication	EN 60870-5-104	
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

Layer	Standard	Comments
		C37.118. May also be relevant for use between substations
Component	EN 61869	Instrument transformers
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.3)

8.2.1.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 14 - Substation automation system (Transmission) - Coming standards

Layer	Standard	Comments
Communication, Information	*IEC 61850-90-2*	Guidelines for communication to control centers
Information	*IEC 61850-90-4*	Network management
Information	*IEC 61850-90-3*	Condition monitoring
Information	*IEC 61850-90-7*	PV inverters
Information	*IEC 61850-90-11*	Methodologies for modeling of logics for IEC/EN 61850 based applications
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services
Communication	*IEC 61850-90-4*	Guidelines for communication within substation
Component	*IEC 62271-3*	High-voltage switchgear and controlgear; Part 3:Digital interfaces based on IEC 61850
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 9.3)

8.2.2 Wide Area Measurement System (WAMS)

8.2.2.1 System description

The objectives of a WAMS system are to protect power systems from instabilities and collapses with continues 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 WAMS provide comprehensive protection covering the whole power system. The system utilizes phasors, which are measured with high time accuracy with PMU units installed in the power system. WAMS can be seen as a complement to SCADA, FACTS and Substation Automation systems for a region/country power network.

8.2.2.2 Set of use cases

Here is a set of high level use cases which may be supported by a WAMS.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.5.2.

Table 15 - WAMS - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Blackout management	Black-out prevention through WAMS	C		

System and security management	Distributing and synchronizing clocks	C		

8.2.2.3 Mapping on SGAM

8.2.2.3.1 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.

8.2.2.3.2 Component layer

The WAMS 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: WAMS 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.

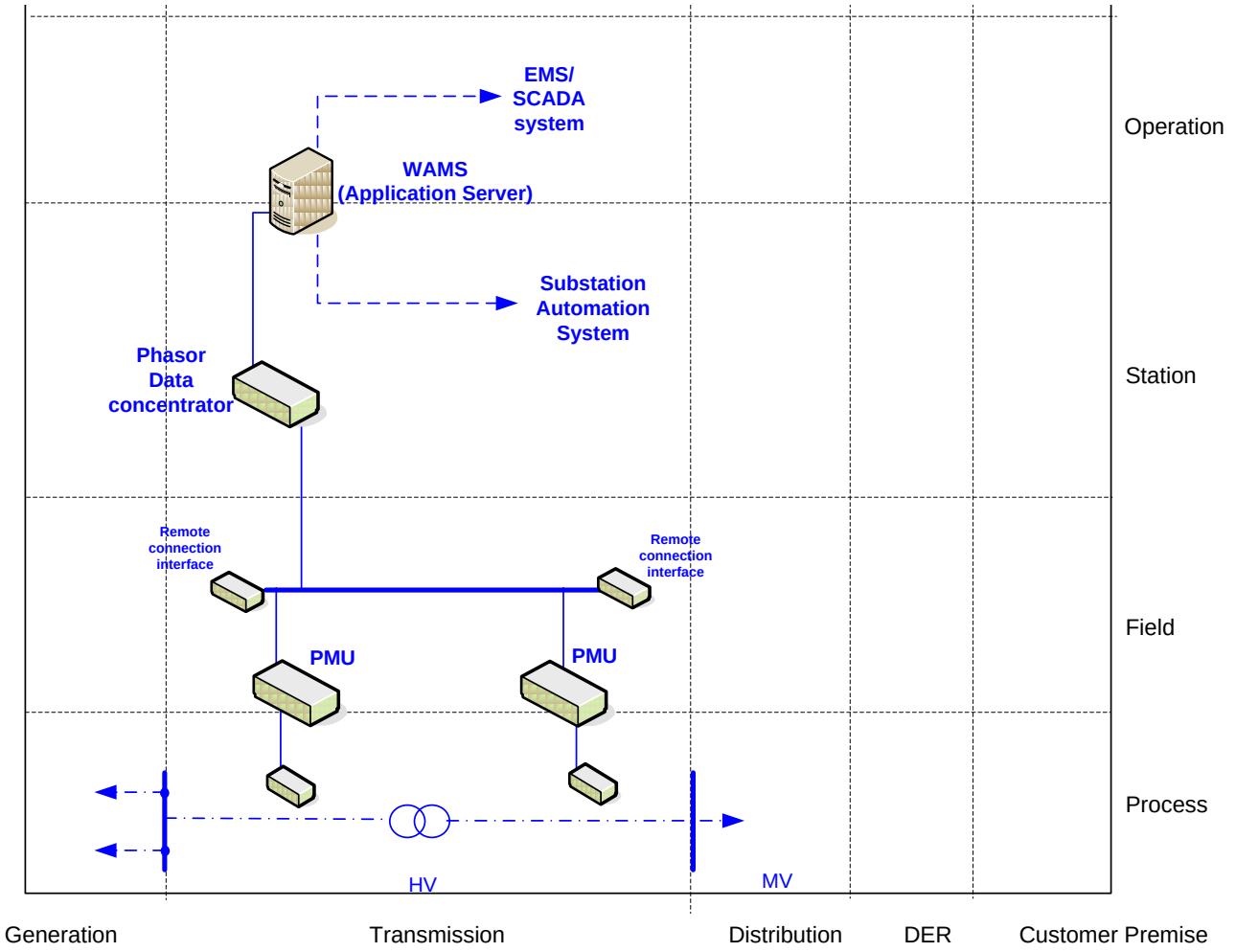


Figure 9 - WAMS - Component layer

8.2.2.3.3 Communication layer

Communication protocols can be used either:

- Within the WAMS, 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 9.3 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 9.2.2.

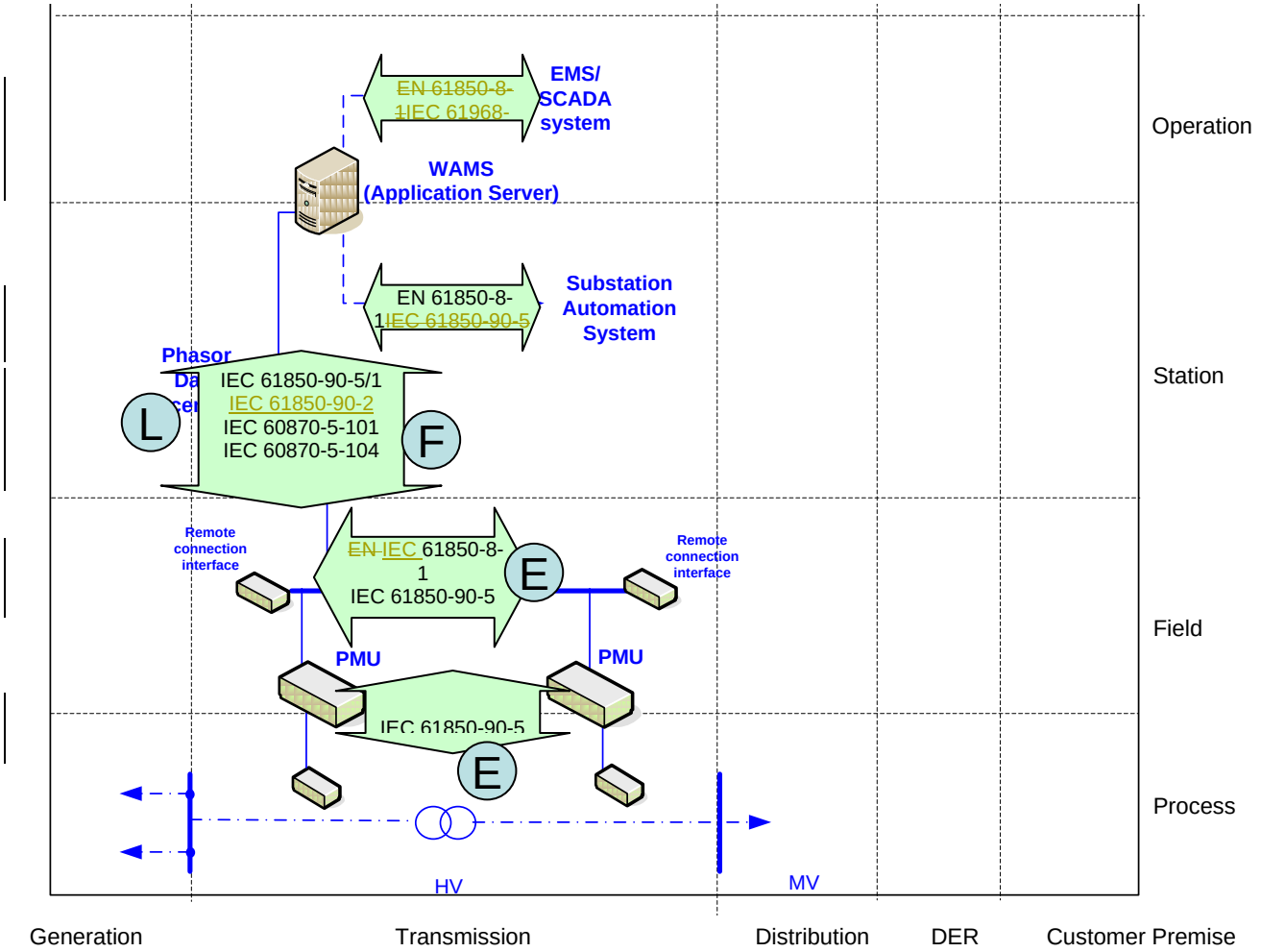


Figure 10 - WAMS - Communication layer

8.2.2.3.4 *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 61850-90-4: Network management
- 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.

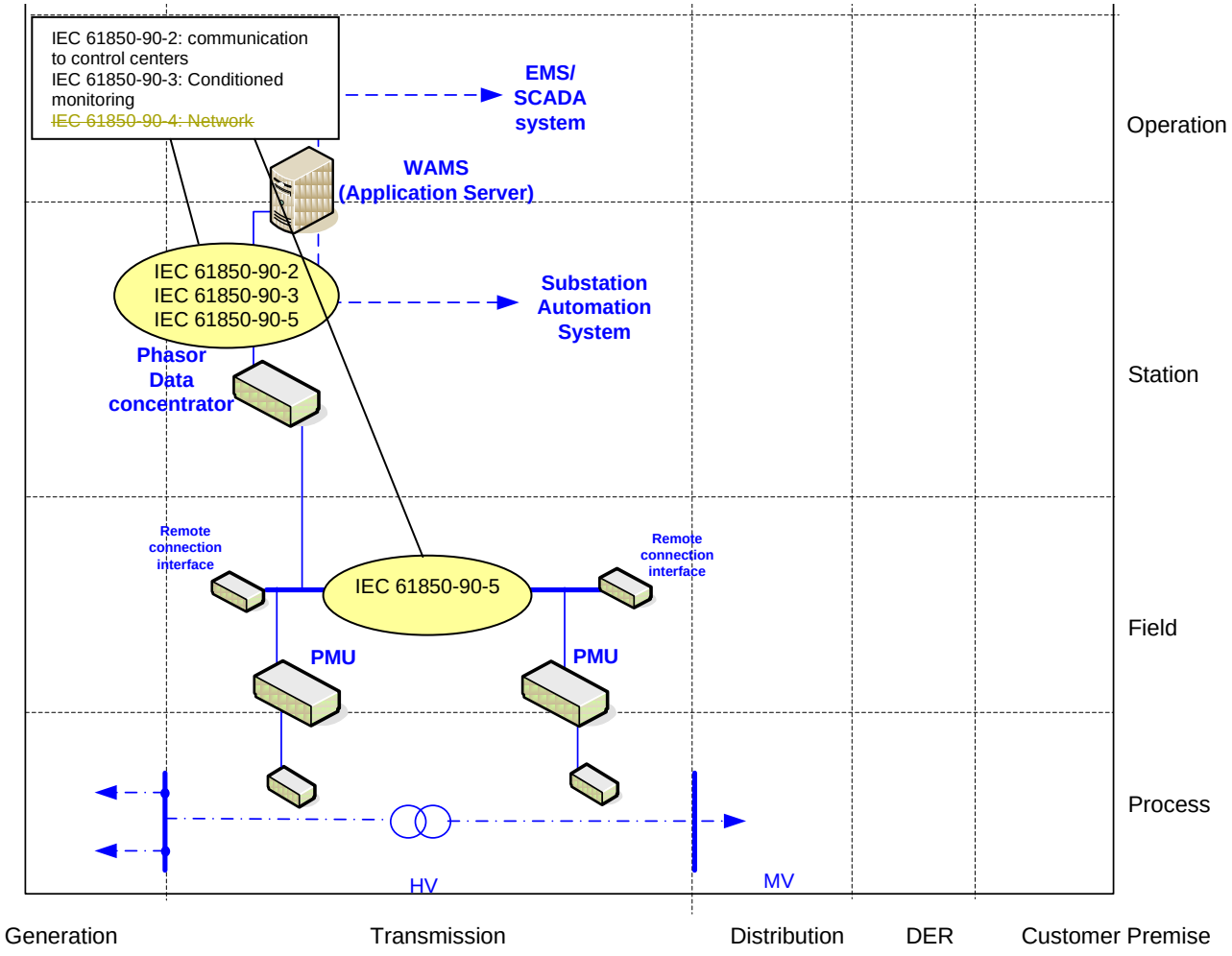


Figure 11 - WAMS - Information layer

8.2.2.4 List of Standards

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

8.2.2.4.1 *Available standards*

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as “available”.

Table 16 - WAMS - 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
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	IEEE 1588	PTP (Precision Time protocol)
Information	ISO 8601 (EN 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 9.3)

8.2.2.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 17 - WAMS - Coming standards

Layer	Standard	Comments
Communication, Information	*IEC 61850-90-2*	Communication to control centers
Information	*IEC 61850-90-4*	Network Engineering Guidelines for IEC/EN 61850 based system (including clock synchronization guidelines)
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 9.3)

8.2.3 EMS SCADA system

8.2.3.1 System Description

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.

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 7.5.2.

Table 18 - 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 WAMS			
	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		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
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 on-line available 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.

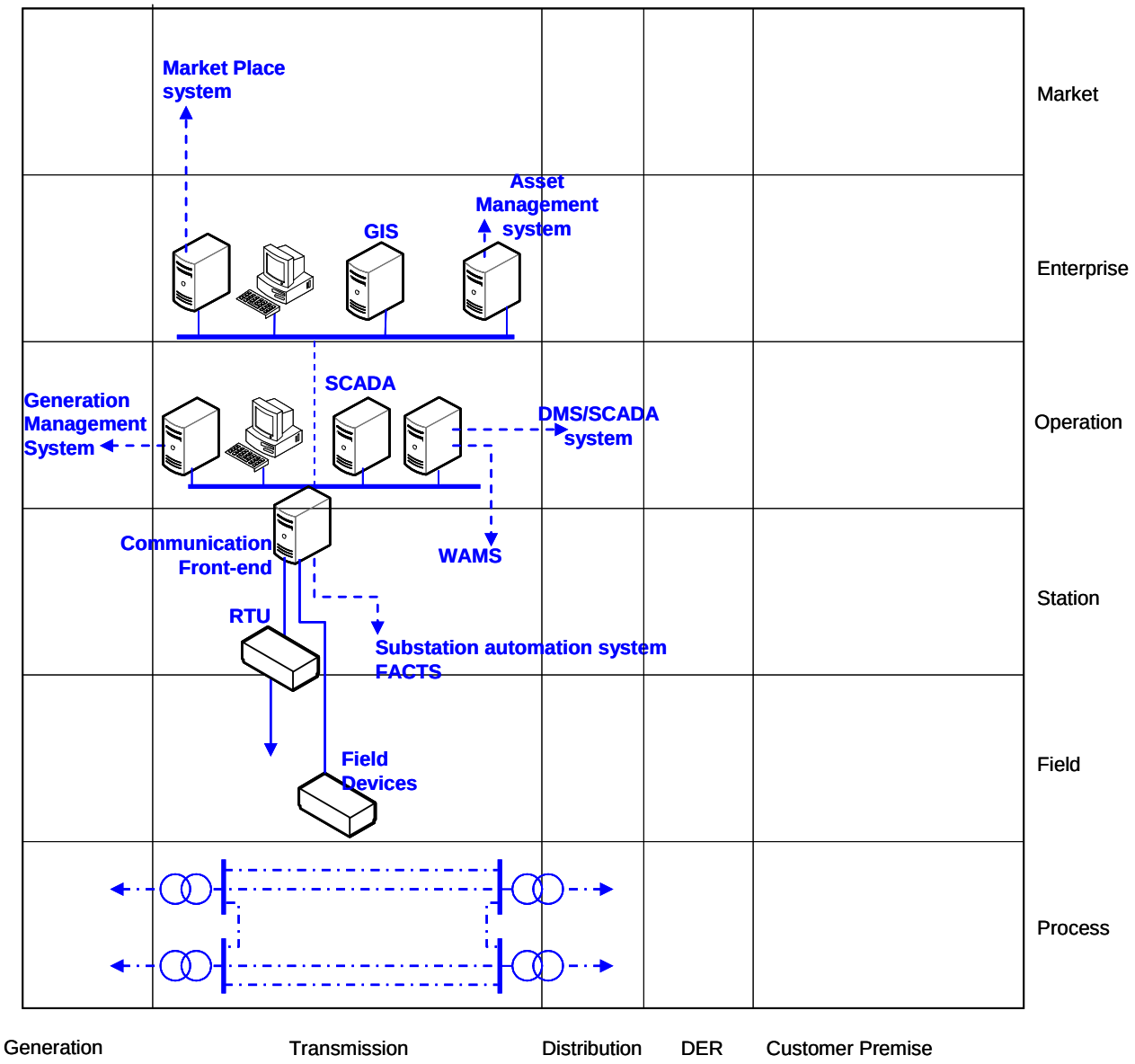


Figure 12 - EMS SCADA system - Component layer

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 interact 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 to 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 9.3 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 9.2.2.

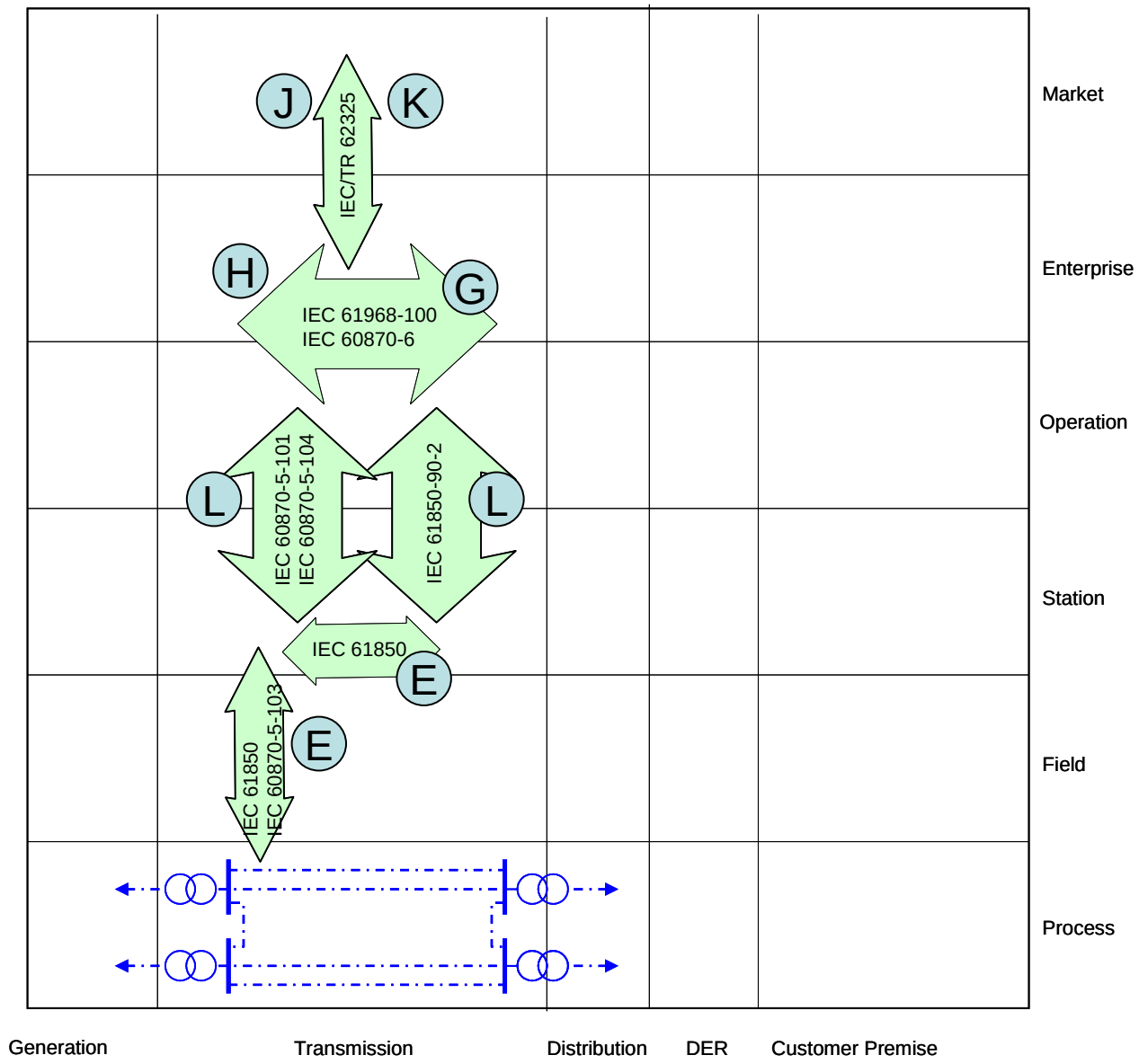


Figure 13 - EMS SCADA system - Communication layer

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.

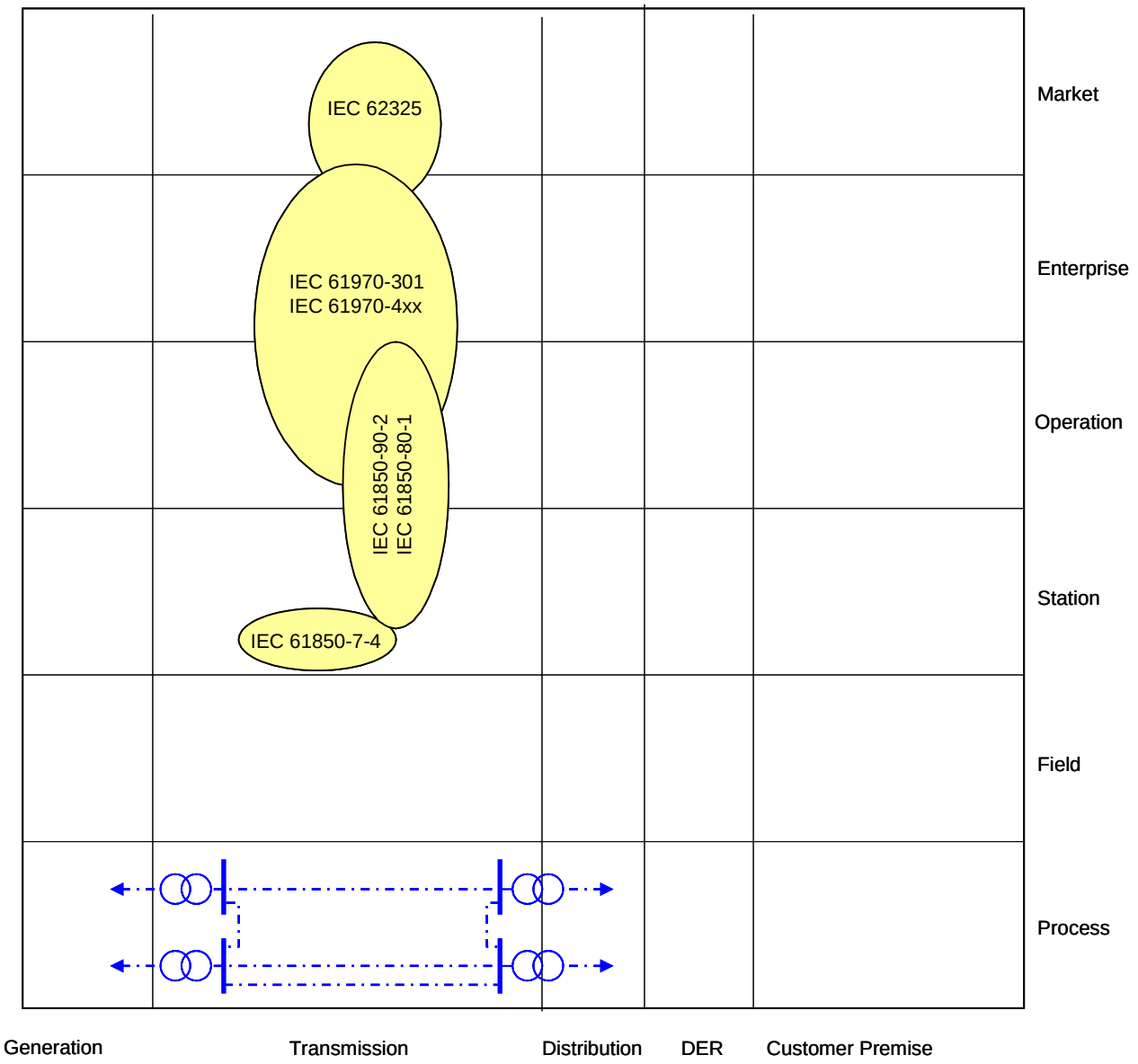


Figure 14 - EMS SCADA system - Information layer

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, 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, a standard (or "open specification") that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as "available".

Table 19 - EMS SCADA system - Available standards

Layer	Standard	Comments
Information	EN 61970-1 EN 61970-2 EN 61970-301	Energy management system Application Program Interface

Layer	Standard	Comments
	EN 61970-401 EN 61970-453 EN 61970-501	
Communication	IEC/TR 62325	Framework market communication
Communication	EN 60870-5-101 EN 60870-5-104 EN 60870-6	Telecontrol protocols
Information	IEC/EN 61850 (all parts)	See substation automation system in 8.3.1
Information	IEC 62361	Harmonization of quality codes
General	IEC 62357	Reference architecture power system information exchange
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.3)

8.2.3.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 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 20 - EMS SCADA system - Coming standards

Layer	Standard	Comments
Information & Communication	*IEC/EN 61850*	See Substation automation paragraph
Information	*EN 61970-452*	Energy management system Application Program Interface (EMS-API) - Part 452: CIM Static Transmission Network Model Profiles
Information	*EN 61970-456*	Energy management system application program interface (EMS-API) - Part 456: Solved power system state profiles
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
Information	*EN 61970-552*	Energy management system Application Program Interface (EMS-API) - Part 552: CIM XML Model Exchange Format
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

8.2.4 Flexible AC Transmission Systems (FACTS)

8.2.4.1 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:

- **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.
- **Increased power transmission 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.
- **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

8.2.4.2 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 7.5.2.

Table 21 - 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		

8.2.4.3 Mapping on SGAM

8.2.4.3.1 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.

8.2.4.3.2 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.

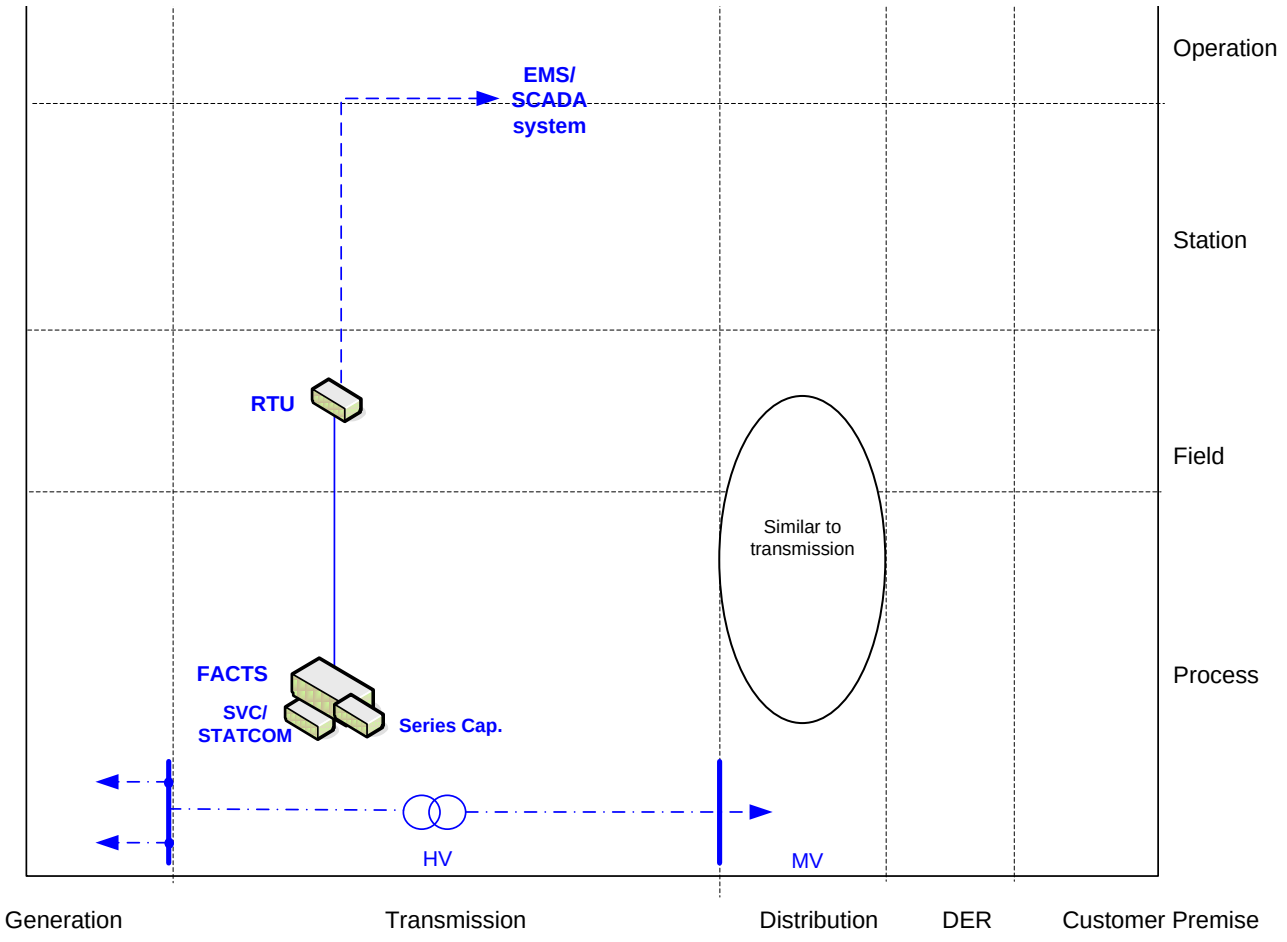


Figure 15 - FACTS - Component layer

8.2.4.3.3 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 9.3 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 9.2.2.

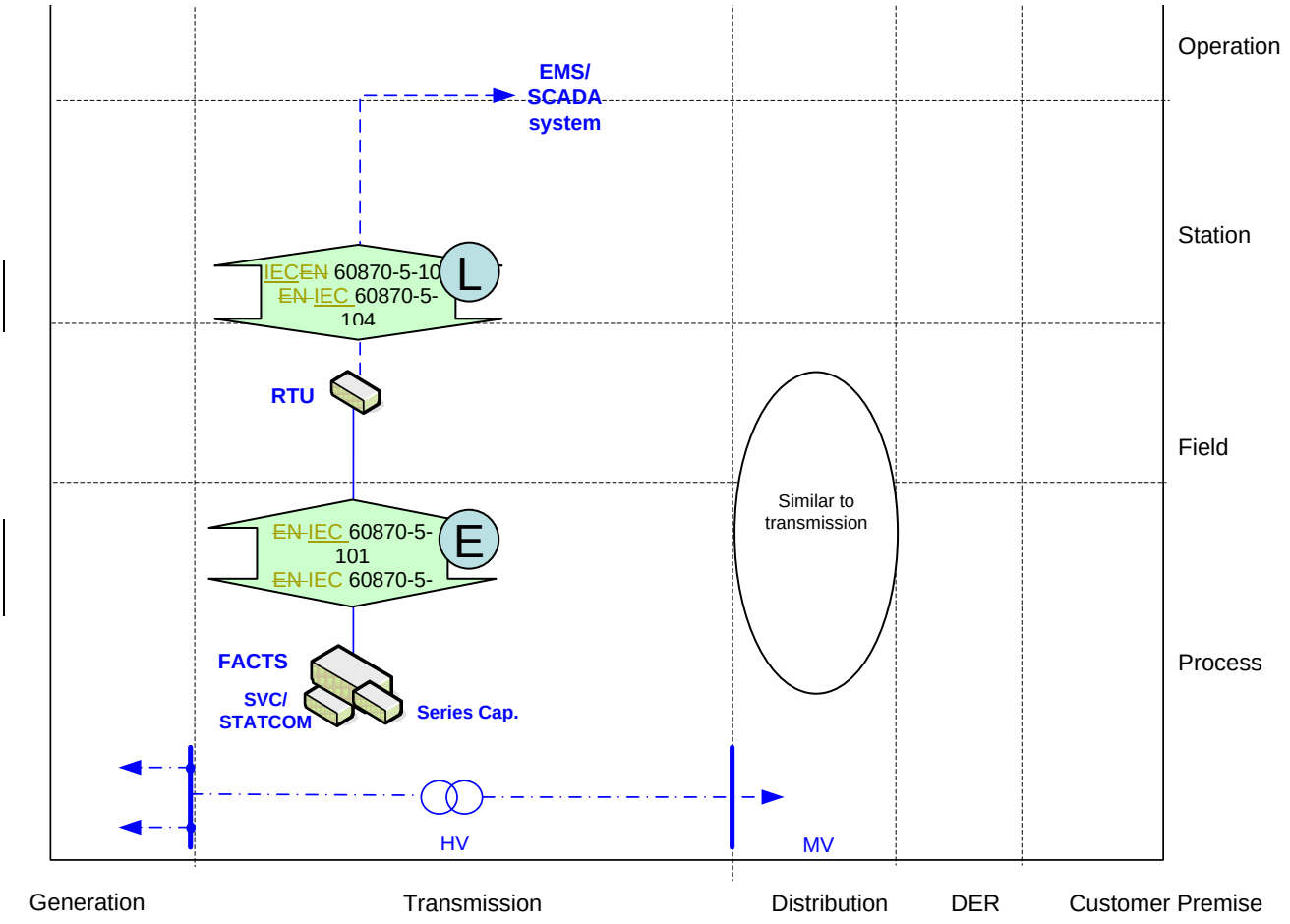


Figure 16 - FACTS - Communication layer

8.2.4.3.4 Information (Data) layer

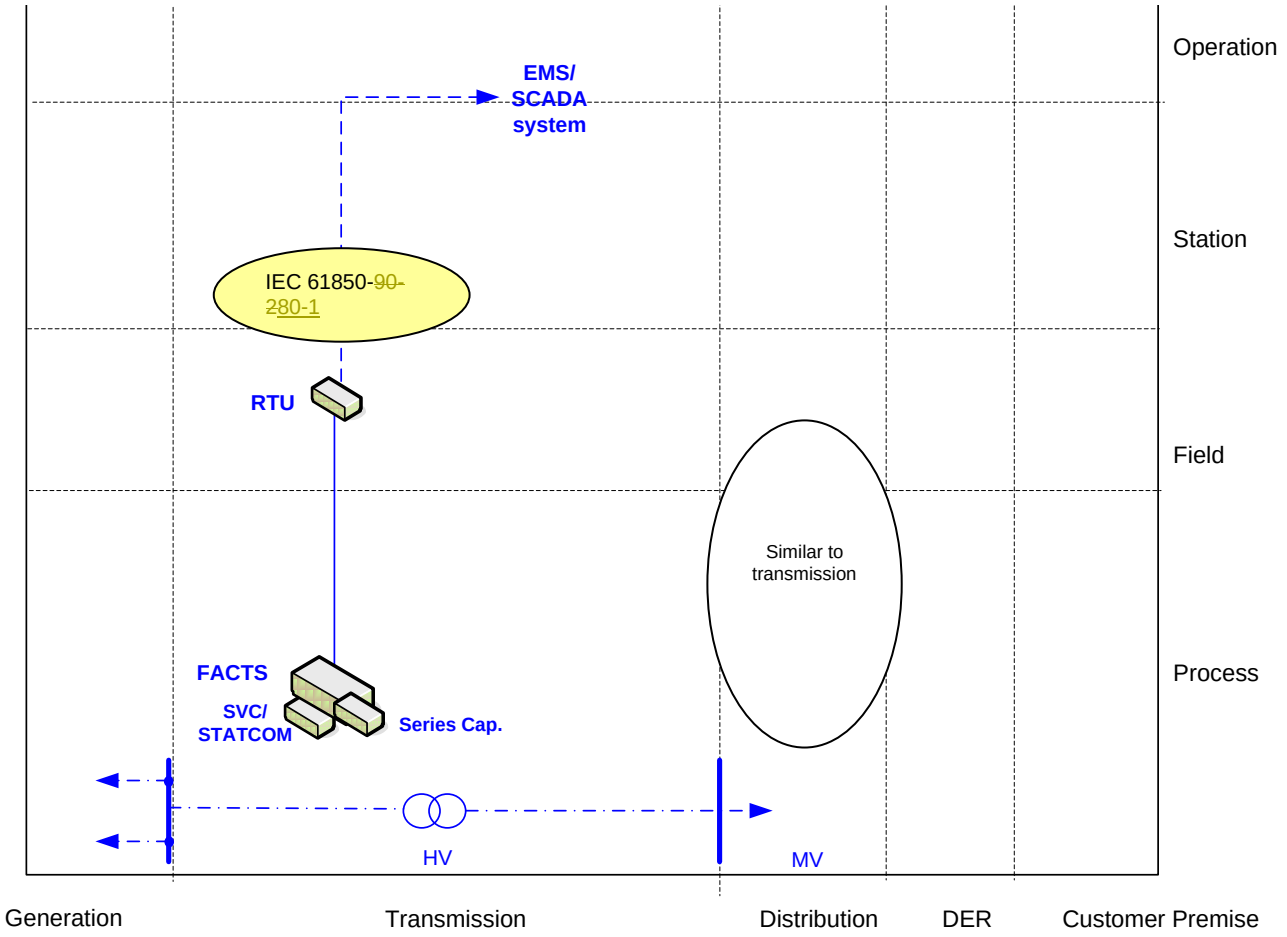


Figure 17- FACTS - Information layer

8.2.4.4 List of Standards

8.2.4.4.1 Available standards

In compliance with section 6, a standard (or "open specification") that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as "available".

Table 22- 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
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 9.3)

8.2.4.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 23 - FACTS - Coming standards

Layer	Standard	Comments
Communication, information	*IEC 61850-90-2*	Substation to control center communication
Information	*IEC 61850-90-3*	Using IEC/EN 61850 for condition monitoring
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

8.3 Distribution management systems

8.3.1 Substation Automation System

8.3.1.1 System Description

The Substation Automation System refers to the system and all the elements needed to perform automated operation of a substation, and of connected assets (grid lines, loads...).
The typical considered operations are protection functionalities, automatic equipment control for network reconfiguration, including possibly feeder reconfiguration, automatic power quality regulation …

Substation automation system may also act as a remote terminal for upper levels of grid monitoring and control for operation (monitoring & control) 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 system is often implemented in the Distribution, Transmission, Generation domains. It can also be implemented on large industrial 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.

8.3.1.2 Set of high level 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 7.5.2.

Table 24 - 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 the grid flows	Monitoring electrical flows	CI		
	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 assets conditions	C	I	
	Supporting periodic maintenance (and planning)	C	I	
	Archive maintenance information	CI		
Controlling the grid (locally/	Switch/breaker control	CI		
	Feeder load balancing	CI		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
remotely) manually or automatically	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		

8.3.1.3 Mapping on SGAM

8.3.1.3.1 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.

8.3.1.3.2 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 7.6.2, 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

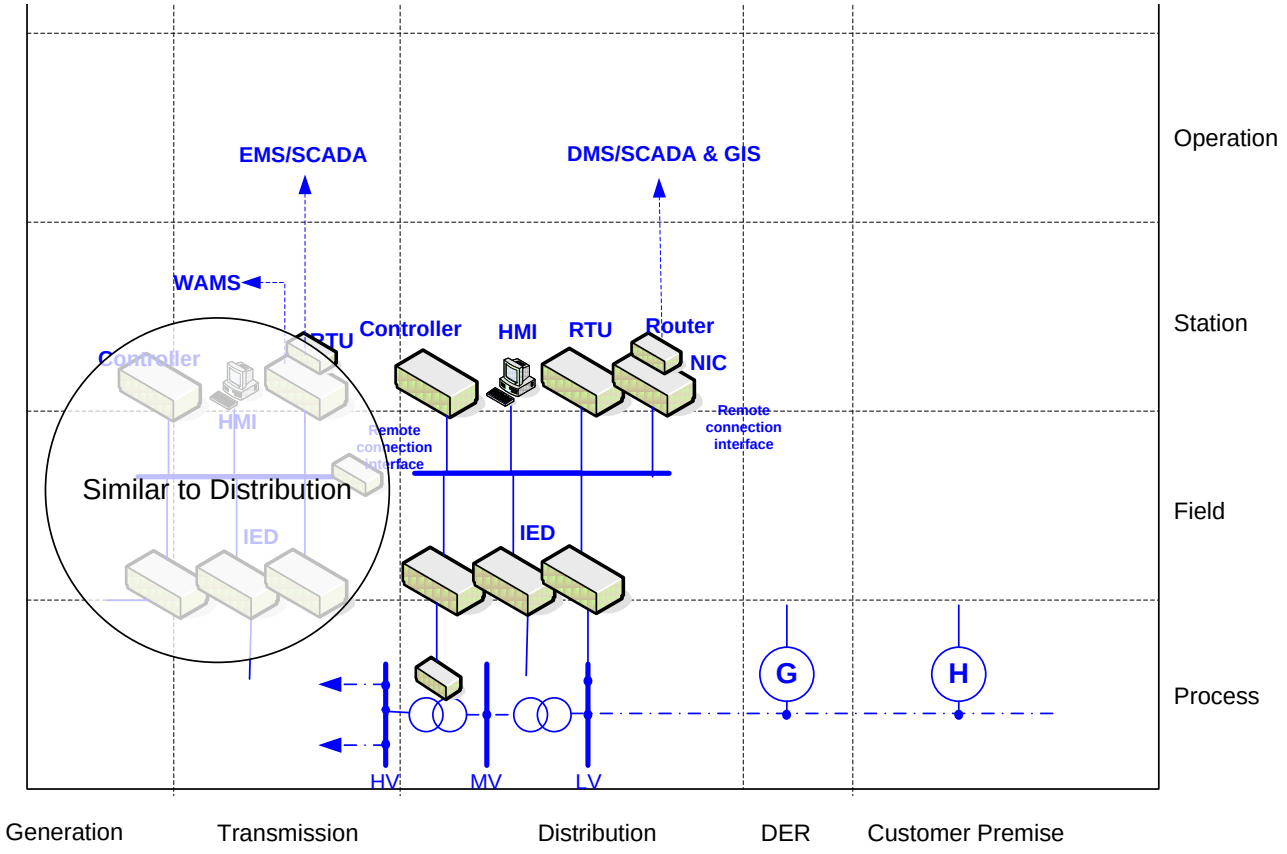


Figure 18 - Substation automation system - Component layer

8.3.1.3.3 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 9.3 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 9.2.2.

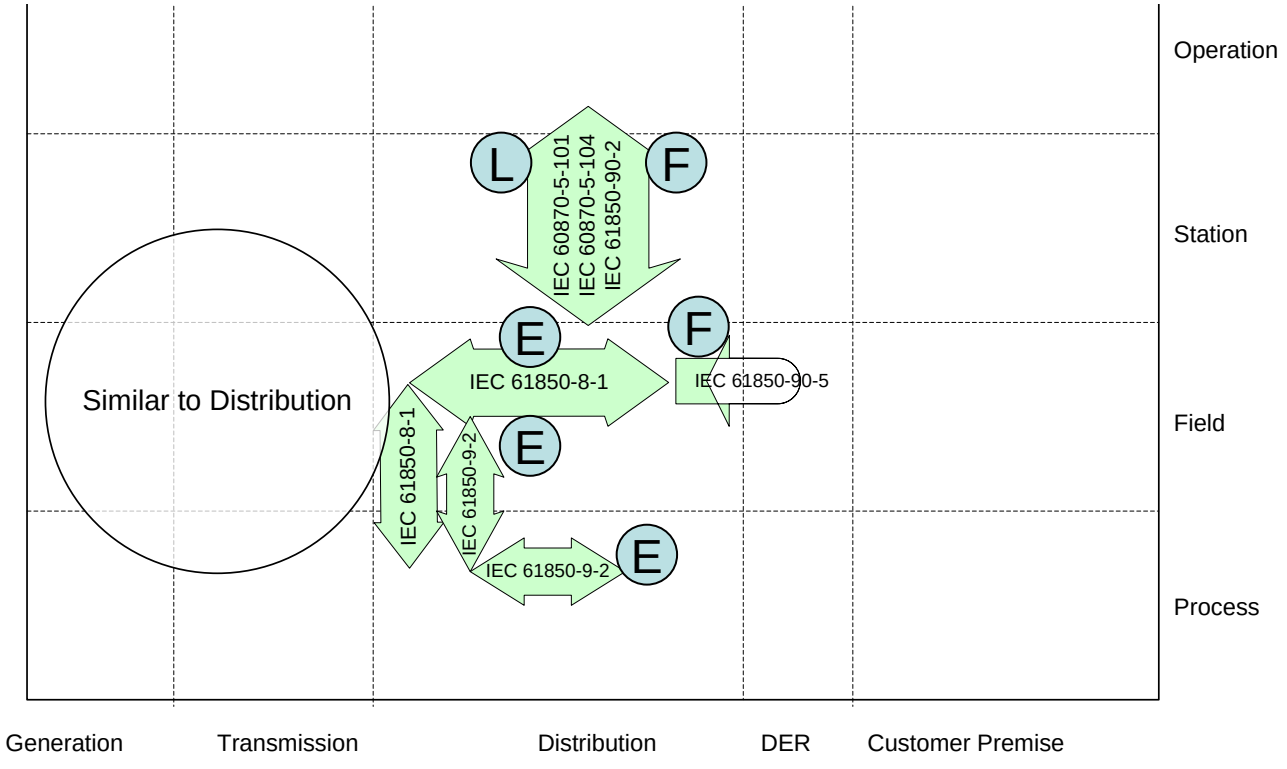


Figure 19 - Substation automation system - Communication layer

8.3.1.3.4 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.

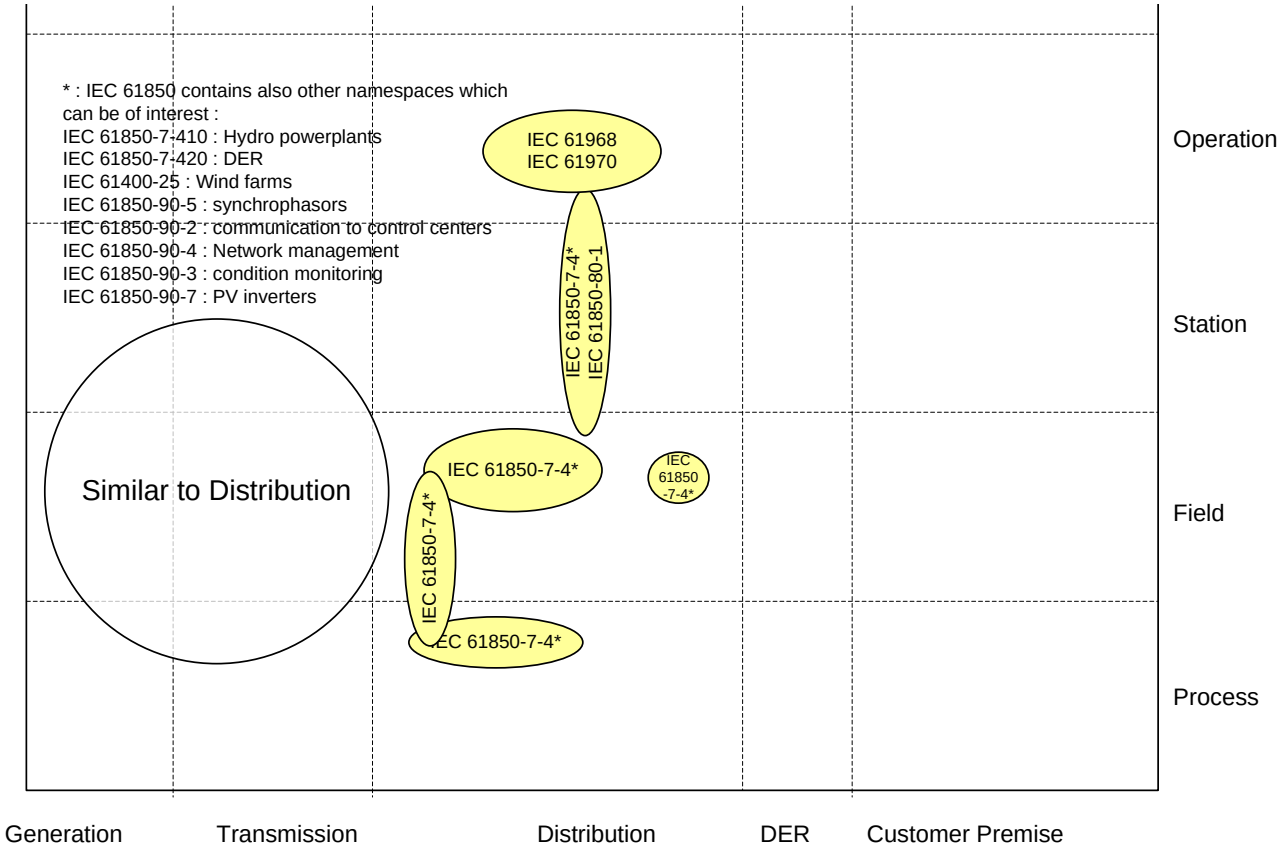


Figure 20 - Substation automation system - Information layer

8.3.1.4 List of Standards

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

8.3.1.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as “available”.

Table 25 - Substation automation system - Available standards

Layer	Standard	Comments
Information	EN 61850-7-4 EN 61850-7-3	Core Information model and language for the IEC/EN 61850 series

Layer	Standard	Comments
	EN 61850-7-2 EN 61850-6	
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	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)
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. 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 9.3)

8.3.1.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 26 - Substation automation system - Coming standards

Layer	Standard	Comments
Communication, Information	*IEC 61850-90-4*	Guidelines for communication within substation
Communication, information	*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 61850-90-6*	Guideline for use of IEC/EN 61850 on Distribution automation
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services

Layer	Standard	Comments
Component	*IEC 62689*	Current and Voltage sensors or detectors, to be used for fault passage indication purposes
Component	*IEC 62271-3*	High-voltage switchgear and controlgear; Part 3:Digital interfaces based on IEC 61850
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 9.3)

8.3.2 Feeder automation system (including smart field switching device 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) or feeder reconfiguration.

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 7.5.2.

Table 27 - Feeder Automation System - Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING** (CI[6])	**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	Switch/breaker control	CI		

[6] 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[6])	**Not yet**
(locally/ remotely) manually or automatically	Enable multiple concurrent levels of control (local-remote)	CI		
Reconfiguring the network in case of fault	Supporting reclosing sequence	CI		
	Supporting source switching	CI		
	Supporting automatic FLISR	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 but not in the derivation to the MV/LV transformer.

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 mainly switching (i.e. circuit-breakers, switches and disconnectors) 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.
- 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.

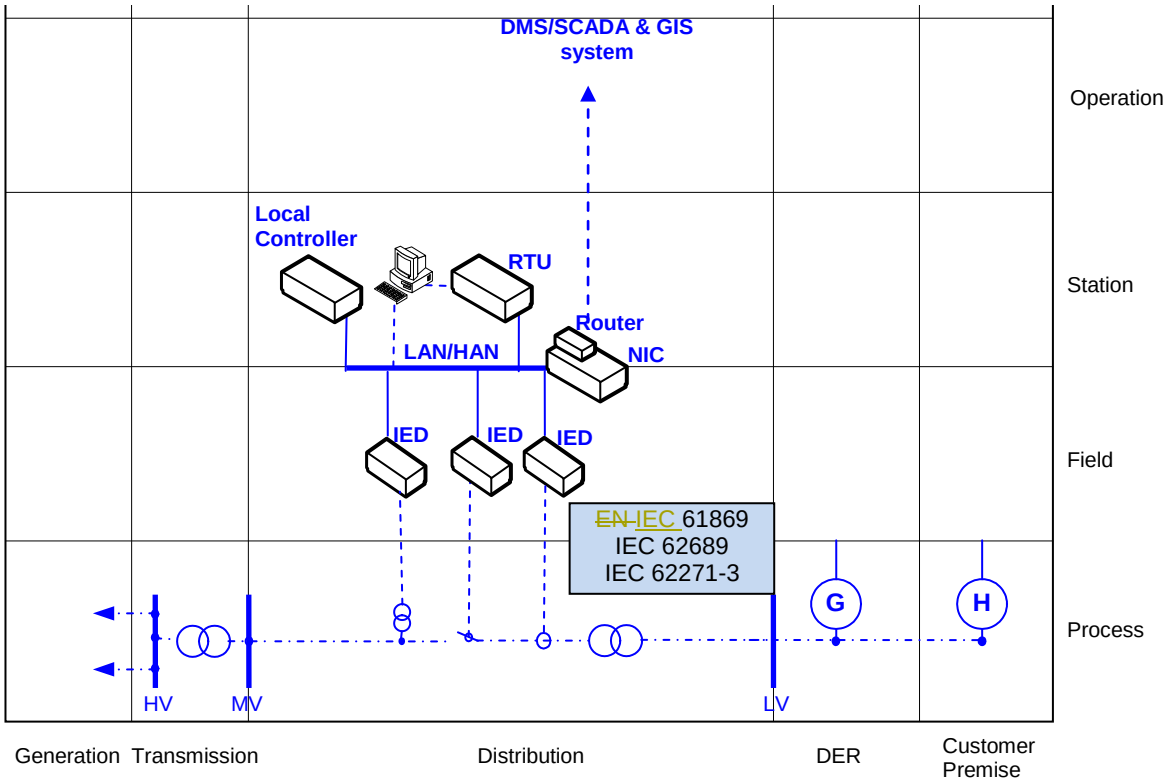


Figure 21 - Feeder automation system - Component layer

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 9.3 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 9.2.2.

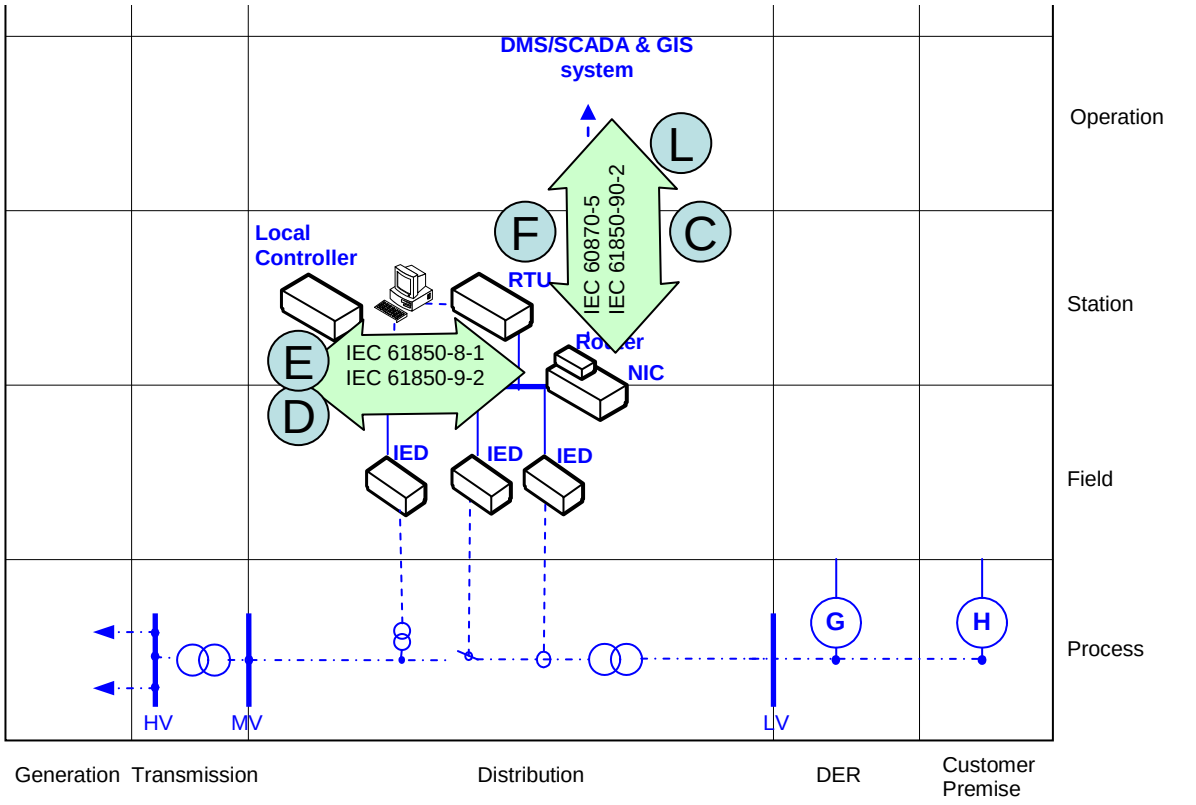


Figure 22 - Feeder automation system - Communication layer

8.3.2.3.4 Information (Data) layer

The information layer of feeder automation or smart reclosers 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 switching 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.

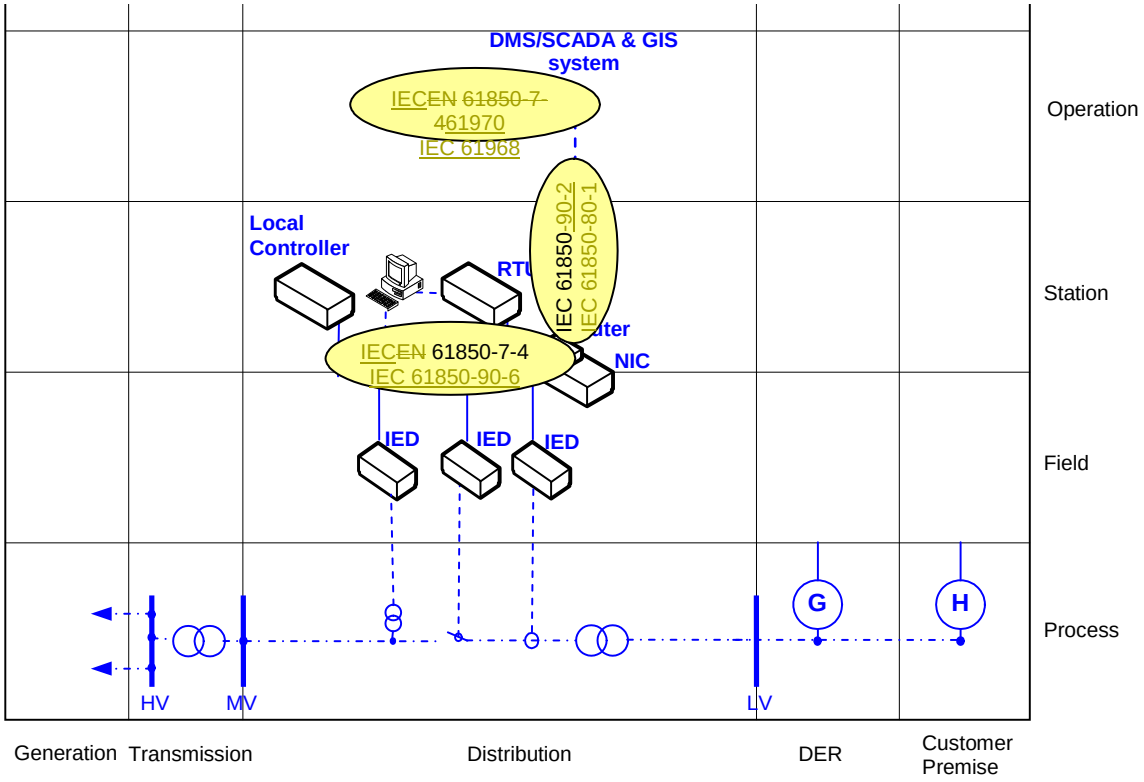


Figure 23 - Feeder automation system - Information layer

8.3.2.4 List of Standards

8.3.2.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as “available”.

Table 28 - 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	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)
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	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-

Layer	Standard	Comments
		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 9.3)

8.3.2.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 29 - Feeder automation system - Coming standards

Layer	Standard	Comments
Information, Communication	*IEC 61850-90-2*	Guidelines for communication to control centers
Information, Communication	*IEC 61850-90-4*	Network engineering guidelines for communication within substation - Network management
Information, Communication	*IEC 61850-90-6*	Guideline for use of IEC/EN 61850 on Distribution automation
Information	*IEC 61850-90-3*	Condition monitoring
Information	*IEC 61850-90-7*	PV inverters
Information	*IEC 61850-90-11*	Methodologies for modeling of logics for IEC/EN 61850 based applications
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services
Component	*IEC 62689*	Current and Voltage sensors or detectors, to be used for fault passage indication purposes
Component	*IEC 62271-3*	High-voltage switchgear and controlgear; Part 3:Digital interfaces based on IEC 61850
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 9.3)

8.3.3 Distributed Power Quality control system

8.3.3.1 System description

A Distributed Power Quality control system refers to the system and all the elements needed to perform automated Power Quality regulation on the MV side and/or on the LV side placed on the MV network along the feeder and on derivations up to the LV board of MV/LV transformer substation.
The typical considered operations are monitoring of quality control parameters (i.e. V, I, f, THD, dips, surges,…) as well as Volt/VAR and frequency/W distributed regulation through active control.

8.3.3.2 Set of use cases

Here is a set of high level use cases which may be supported by distributed power quality control system. The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.5.2.

Table 30 - Distributed power quality control systems – Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING (CI[7])**	**Not yet**
Monitoring the grid flows	Monitoring electrical flows	CI		
	Monitoring power quality for operation (locally)	CI		
	Producing, exposing and logging time-stamped events	CI		
	Capture, expose and analyze disturbance events	CI		
Managing power quality	Voltage regulation	X		
	VAR regulation	X		

8.3.3.3 Mapping on SGAM

8.3.3.3.1 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 drawings below.

8.3.3.3.2 Component layer

On the SGAM representation of the component layer the current transformer 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 distributed Power Quality control 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 MV electrical network and LV lines mainly switching VAR regulator, MV/LV transformer regulator and measuring elements (i.e. current and voltage sensors/transformers). The representation on the SGAM is generic and does not correspond necessarily to a specific example. Note that volt/VAR and frequency control of DERs (represented as G in Figure 24) 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 control and monitor the process of the MV electrical network and LV lines, mainly IEDs (which mostly handle monitoring and control features, NIC (the controller of the LAN or HAN) and Router (the remote connection interface).

[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 Distributed Power Quality Control systems scope, both at communication and information levels

- 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.

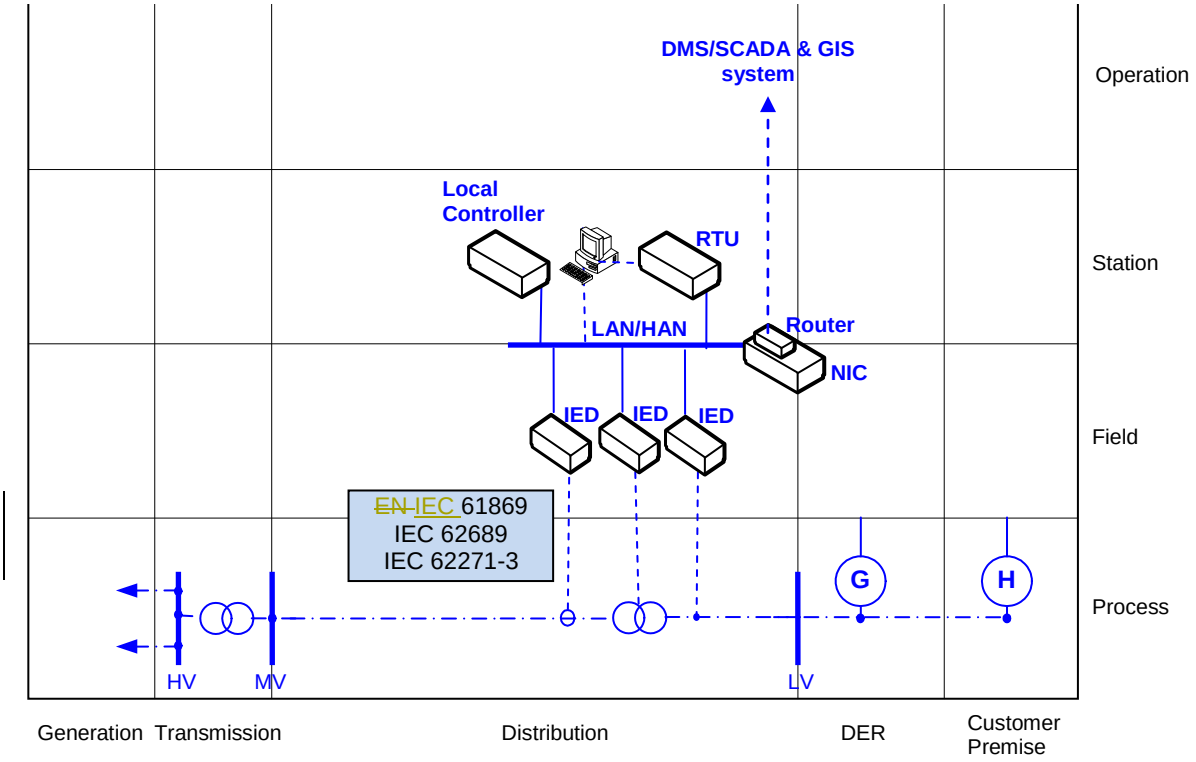


Figure 24 - Distributed power quality control systems - Component layer

8.3.3.3.3 Communication layer

The set of communication protocols standards are close to the one mentioned for the MV/LV automated substation system as mentioned in 8.3.1.3.3 (i.e. a possibly specific case of implementation of substation automation system).

Please refer to section 9.3 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 9.2.2.

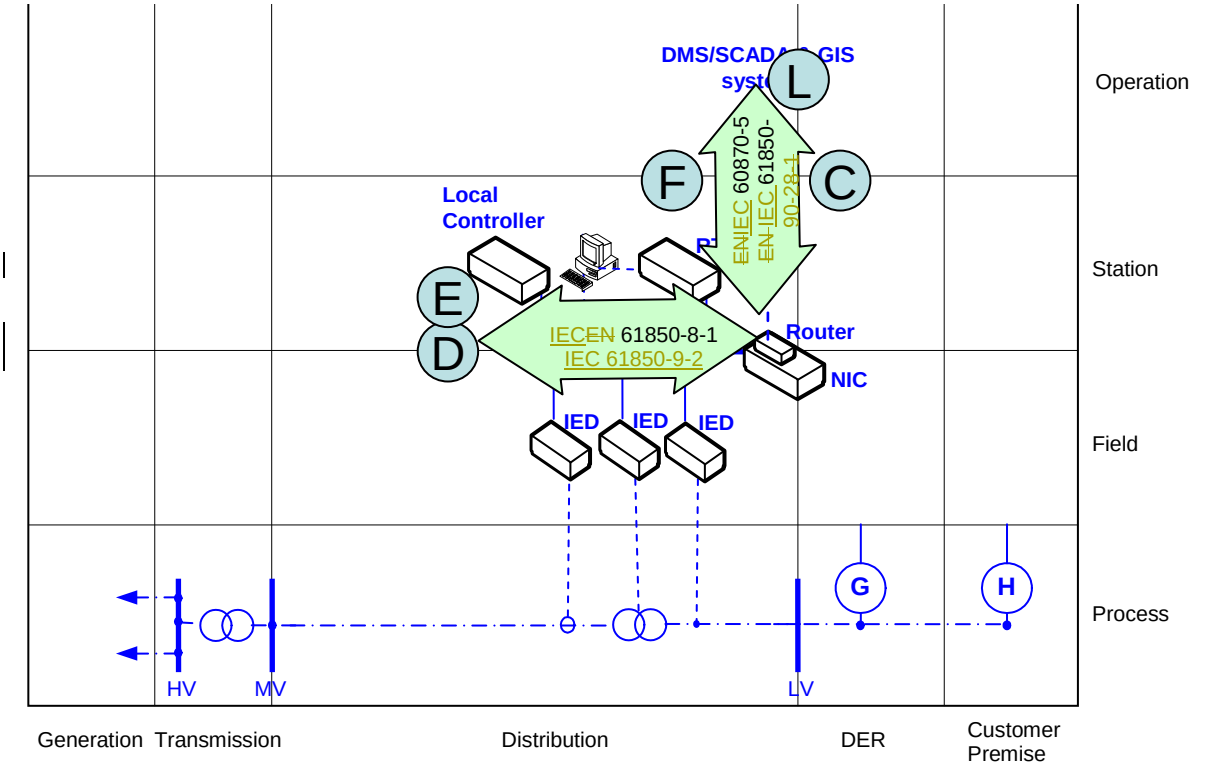


Figure 25- Distributed power quality control systems - Communication layer

8.3.3.3.4 Information (Data) layer

The information layer of distributed Power Quality control is mostly based on the IEC/EN 61850 information model.
We have indicated that EN 61850-7-4 is the core part depicting this model at each location, 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.

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 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.

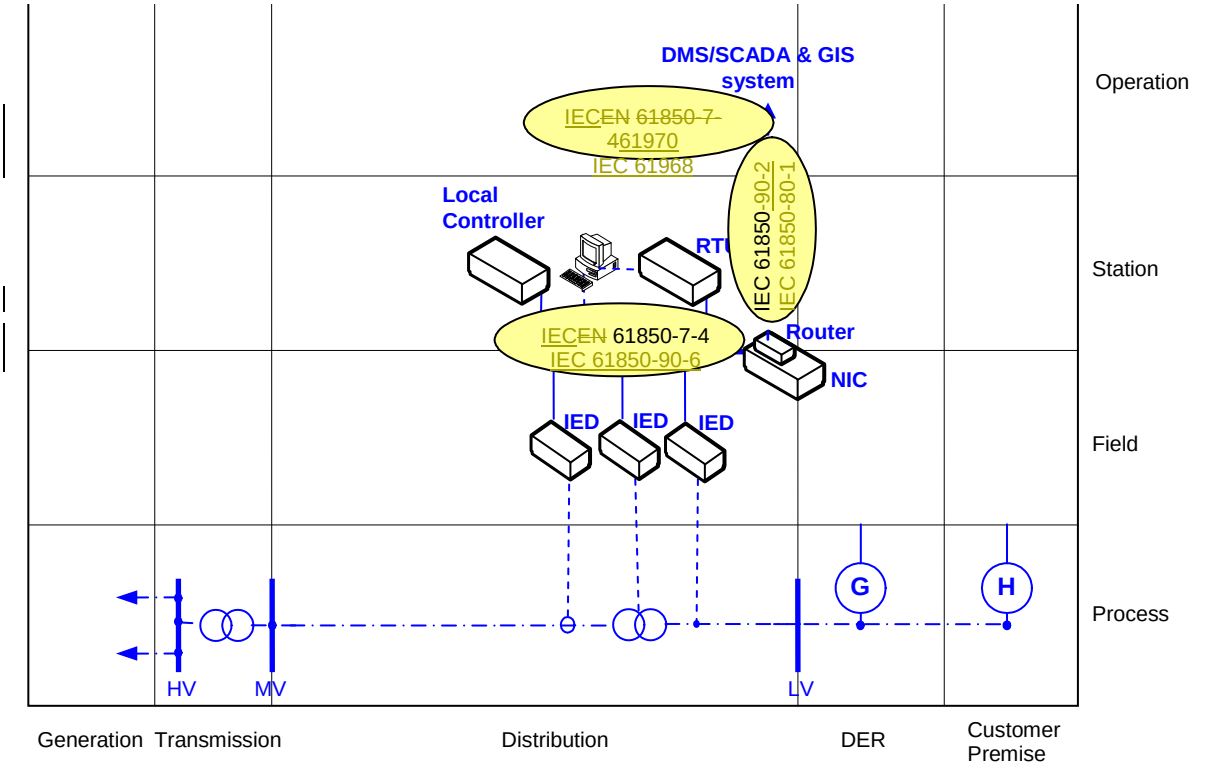


Figure 26- Distributed power quality control systems - Information layer

8.3.3.4 List of Standards

8.3.3.4.1 Available standards

In compliance with section 6, a standard (or "open specification") that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as "available".

Table 31 - Distributed power quality control systems - 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	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)
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

Layer	Standard	Comments
		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 9.3)

8.3.3.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 32 - Distributed power quality control systems - Coming standards

Layer	Standard	Comments
Information, Communication	*IEC 61850-90-2*	Guidelines for communication to control centers
Information, Communication	*IEC 61850-90-4*	Guidelines for communication within substation - Network management
Information	*IEC 61850-90-3*	Condition monitoring
Information	*IEC 61850-90-7*	PV inverters
Information, Communication	*IEC 61850-90-6*	Guideline for use of IEC/EN 61850 on Distribution automation
Communication	*IEC 61850-8-2*	IEC/EN 61850 Specific communication service mapping (SCSM) – Mappings to web-services
Component	*IEC 62689*	Current and Voltage sensors or detectors, to be used for fault passage indication purposes
Component	*IEC 62271-3*	High-voltage switchgear and controlgear; Part 3: Digital interfaces based on IEC 61850
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 9.3)

8.3.4 DMS SCADA and GIS system

8.3.4.1 System Description

DMS 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 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 field crew to operate the network from the field.
DMS SCADA 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.

8.3.4.2 Set of high level use cases

The set of high level use cases which may be supported by a DMS SCADA 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 7.5.2.

Table 33 - DMS SCADA and GIS 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	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	C		I
	Supporting periodic maintenance and planning	C	I	
	Optimize field crew operation		C	I
Manage Commercial relationship for electricity supply	Registration/deregistration of customers		C	I
Operate DER(s)	Registration/deregistration of DER in VPP		C	I
	Aggregate DER as technical VPP		C	I
	Aggregate DER as commercial VPP		C	I
Controlling the grid (locally/ remotely) manually or automatically	Switch/breaker control	CI		
	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	Supporting reclosing sequence	X		
	Supporting source switching	X		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
of fault	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		

8.3.4.3 Mapping on SGAM

8.3.4.3.1 Preamble:

The DMS SCADA 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 operator.
The GIS system interacts with the DMS SCADA, Asset and Maintenance management system (GMAO), the CIS and EMS/VPP system.

8.3.4.3.2 Component layer

The DMS SCADA 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 DMS SCADA System in 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 DMS SCADA 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 (DMS SCADA, 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 DMS SCADA system, and associated components:

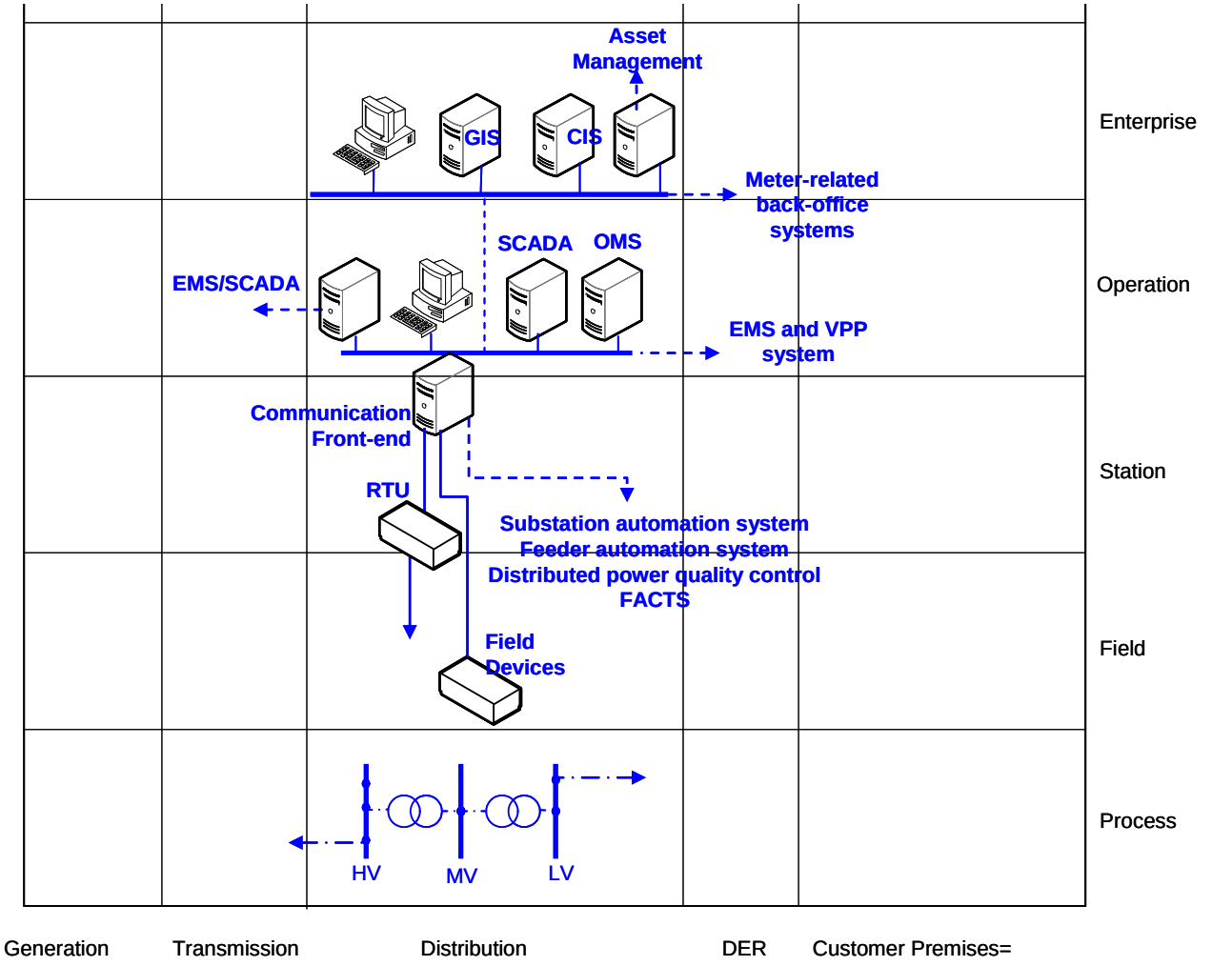


Figure 27 - DMS SCADA and GIS system - Component layer

8.3.4.3.3 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 DMS SCADA can be positioned as is shown in diagram below representing the communication layer of SGAM.

Please refer to section 9.3 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 9.2.2.

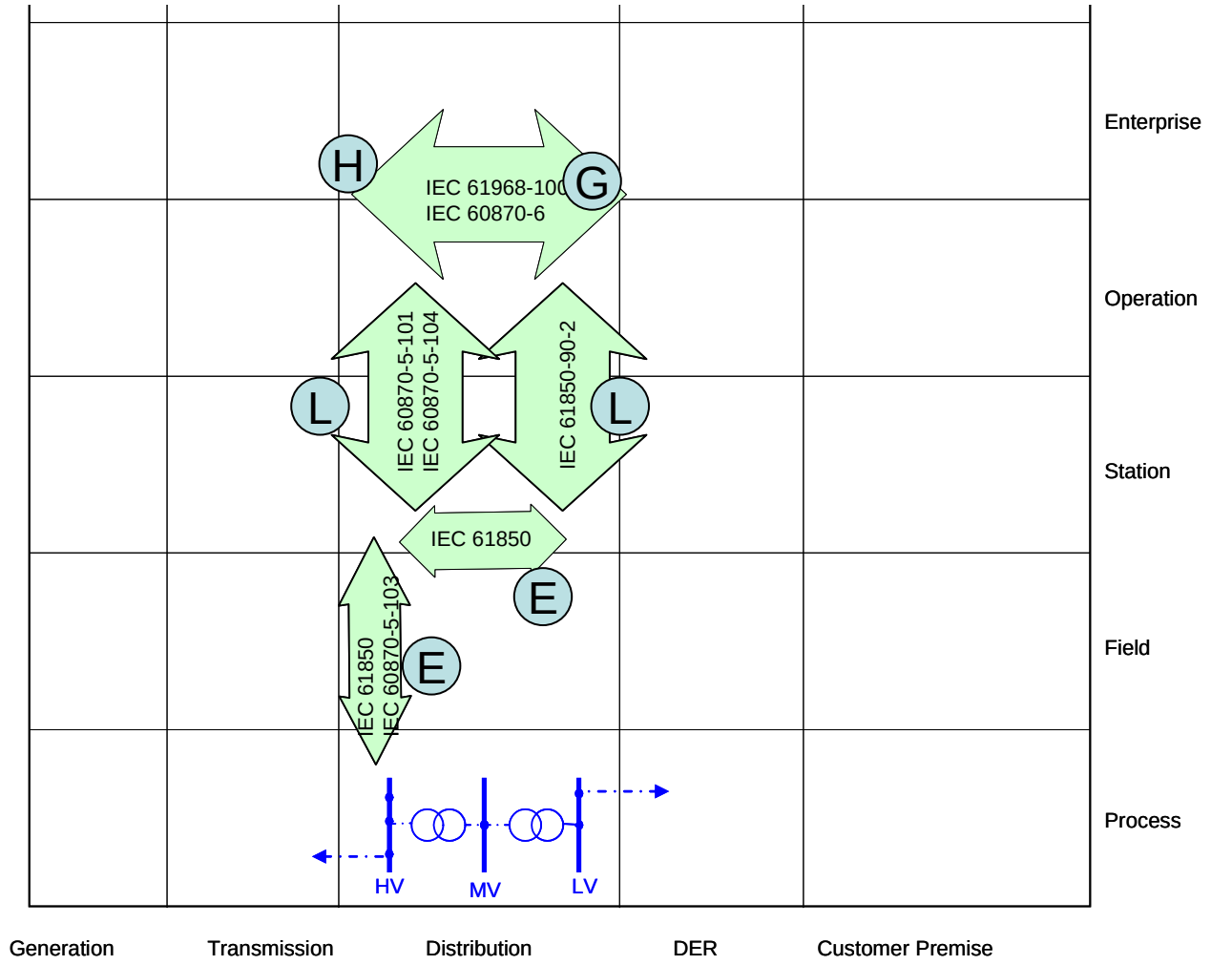


Figure 28 - DMS SCADA and GIS system - Communication layer

8.3.4.3.4 Information (Data) layer

DMS SCADA makes use of the information models at station and operation level of course. For DMS SCADA 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.

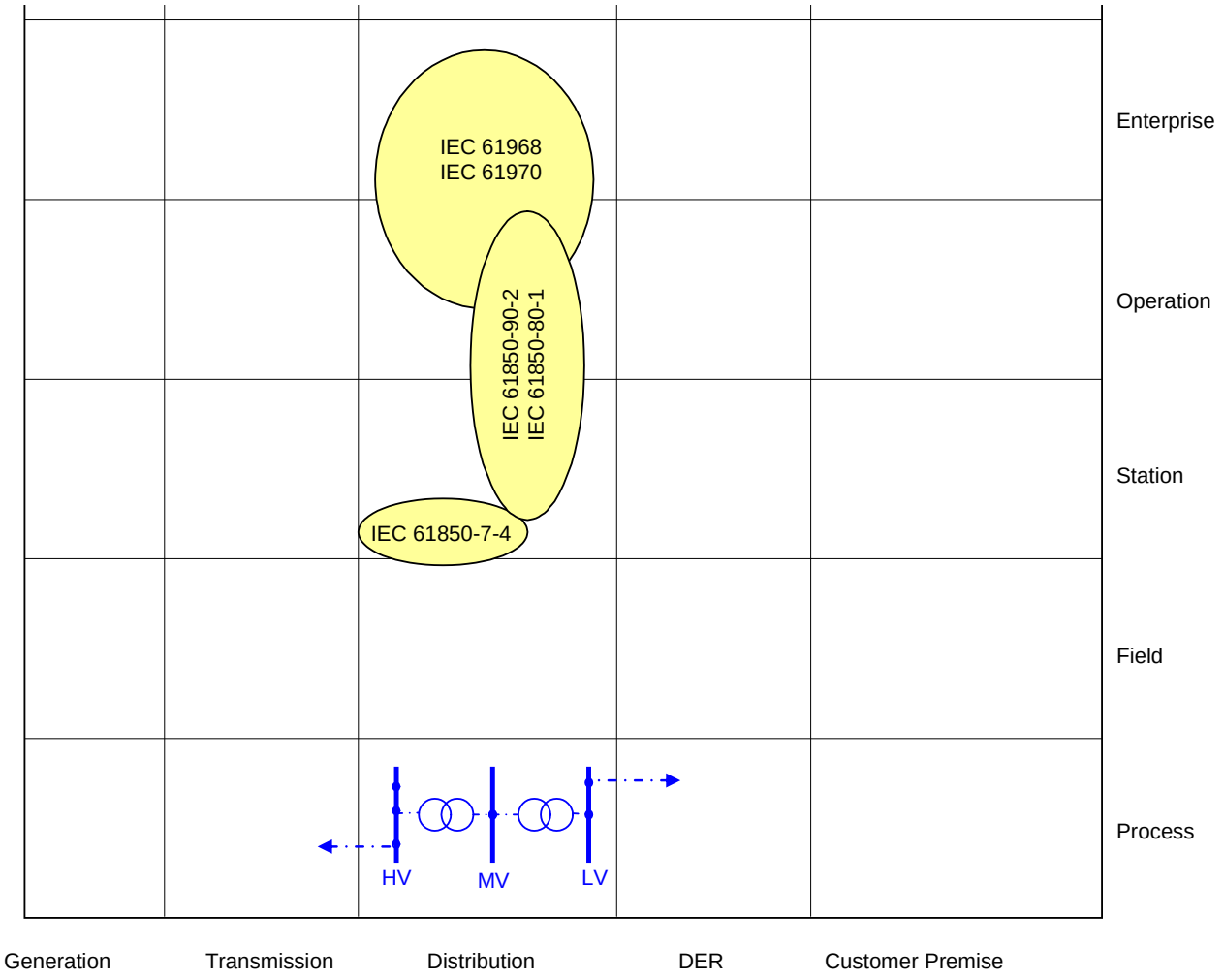


Figure 29 - DMS SCADA and GIS system - Information layer

Standards Identified for Substation Automation are also relevant for the application of the DMS SCADA system, because the DMS SCADA system will retrieve online information from the substations in the Distribution Networks

8.3.4.4 List of Standards

Here is the summary of the standards which appear relevant to support The DMS SCADA and GIS system:

8.3.4.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as “available”.

Table 34 - DMS SCADA and GIS system - 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	Harmonization Q-codes
Information	IEC 62361-100	Naming and design rules for CIM profiles to

Layer	Standard	Comments
		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	IEC/TS 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 61968-9	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 62351-1	Power systems management and associated information exchange - Data and communications security - Part 1: Communication network and system security - Introduction to security issues
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.3)

8.3.4.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 35 - DMS SCADA and GIS system - Coming standards

Layer	Standard	Comments
General	*EN 61968-1*	Application integration at electric utilities - System interfaces for distribution management - Part 1: Interface architecture and general recommendations
Communication	*EN 61968-100*	Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation profiles
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 61968-6*	Application integration at electric utilities -

Layer	Standard	Comments
		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: Interface for meter reading and control
Communication, Information	*IEC/EN 61850*	See substation automation
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

8.3.5 FACTS (Distribution)

8.3.5.1 System description

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

8.3.5.2 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 7.5.2.

Table 36 - 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		

8.3.5.3 Mapping on SGAM

8.3.5.3.1 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.

8.3.5.3.2 Component layer

Mapping is similar to the one presented in 8.2.4.3.2 for FACTS in Transmission

8.3.5.3.3 Communication layer

Mapping is similar to the one presented in 8.2.4.3.3 for FACTS in Transmission

8.3.5.3.4 Information (Data) layer

Mapping is similar to the one presented in 8.2.4.3.4 for FACTS in Transmission

8.3.5.4 List of Standards

8.3.5.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as “available”.

Table 37 - 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
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 9.3)

8.3.5.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 38 - FACTS (Distribution) – Coming standards

Layer	Standard	Comments
Information	*IEC 61850-90-3*	Using IEC/EN 61850 for condition monitoring
Communication, information	*IEC 61850-90-2*	Substation to control center communication
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

8.4 DER management systems

8.4.1 DER operation system

8.4.1.1 System description

DER operation system is responsible for operation of the DER assets. It performs supervision and maintenance of the components and provides information to the operators and field crew personnel and interacts with the DER EMS/VPP system for the control of the generation. The system may control one or more DERs which can be geographically distributed. These DERs could be single generation plants or could be combined to VPPs.

8.4.1.2 Set of use cases

The following high level use cases might be supported by a DER operation system.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.5.2.

Table 39 – DER operation system – use cases

		Supported by standards		
Use case cluster	**Primary 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, ...)	C	I	
	Perform networked security logic (Interlocking, local/remote)	C	I	
	Set/change protection parameters	CI		
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 analyze disturbance events	CI		
	Archive operation information	I	C	
Maintaining grid assets	Monitoring assets conditions	CI	C	
	Supporting periodic maintenance (and planning)		CI	
	Optimize 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	CI		
	DER process management with reduced power output	CI		
	DER performance management		CI	
	DER remote control (dispatch)		CI	

		Supported by standards		
Use case cluster	**Primary use cases**	**AVAILABLE**	**COMING**	**Not yet**
	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	Restore power after black-out			?
Demand and production (generation) flexibility	Receiving metrological or price information for further action by consumer or CEM		CI	
	Generation forecast (from remote)		C	I
	Generation forecast (from local)		C	I
	Participating to electricity market	I	CI	
	Managing energy consumption or generation of DERs via local DER energy management system bundled in a DR program		CI	
	Managing energy consumption or generation of DERs and EVSE via local DER energy management system to increase local self-consumption			
	Registration/deregistration of DER in DR program		CI	
System and security management	Discover a new component in the system		CI	
	Configure newly discovered device automatically to act within the system		CI	
	Distributing and synchronizing clocks	CI (See section 8.9.3)		

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.

8.4.1.3 Mapping on SGAM

8.4.1.3.1 Preamble

The DER operation system interacts with the DER EMS/VPP system and 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 DMS/SCADA system.

8.4.1.3.2 Component layer

The DER Operation system is made of 4 zones of components:

- 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 Communication Front End of the DER operation system

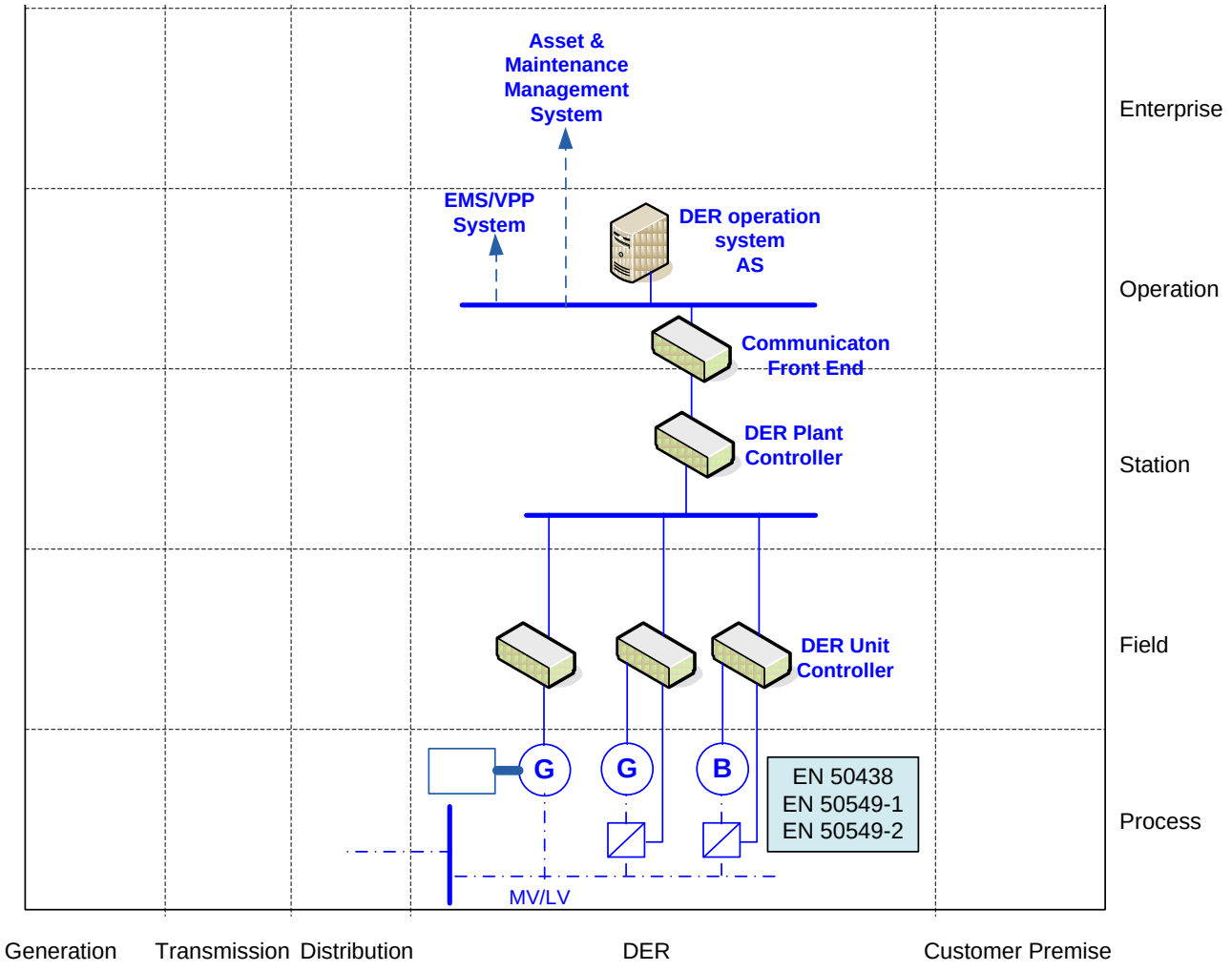


Figure 30 - DER operation system - Component layer

8.4.1.3.3 Communication layer

EN 61850-8-1 defines the communication for any kind of data flows except sample values. IEC 61850-90-2 defines the communication to the control center with IEC 61850-8-2 defining web-services mappings. EN 61400-25-4 defines the communication protocols specifically for wind turbines.
EN 60870-5-101 and EN 60870-5-104 can also be used for vertical communication as shown in the Figure 31 below.

EN 61158 defines industrial field bus communication and EN 61968-100 communication at the operations and enterprise levels.

Please refer to section 9.3 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 9.2.2.

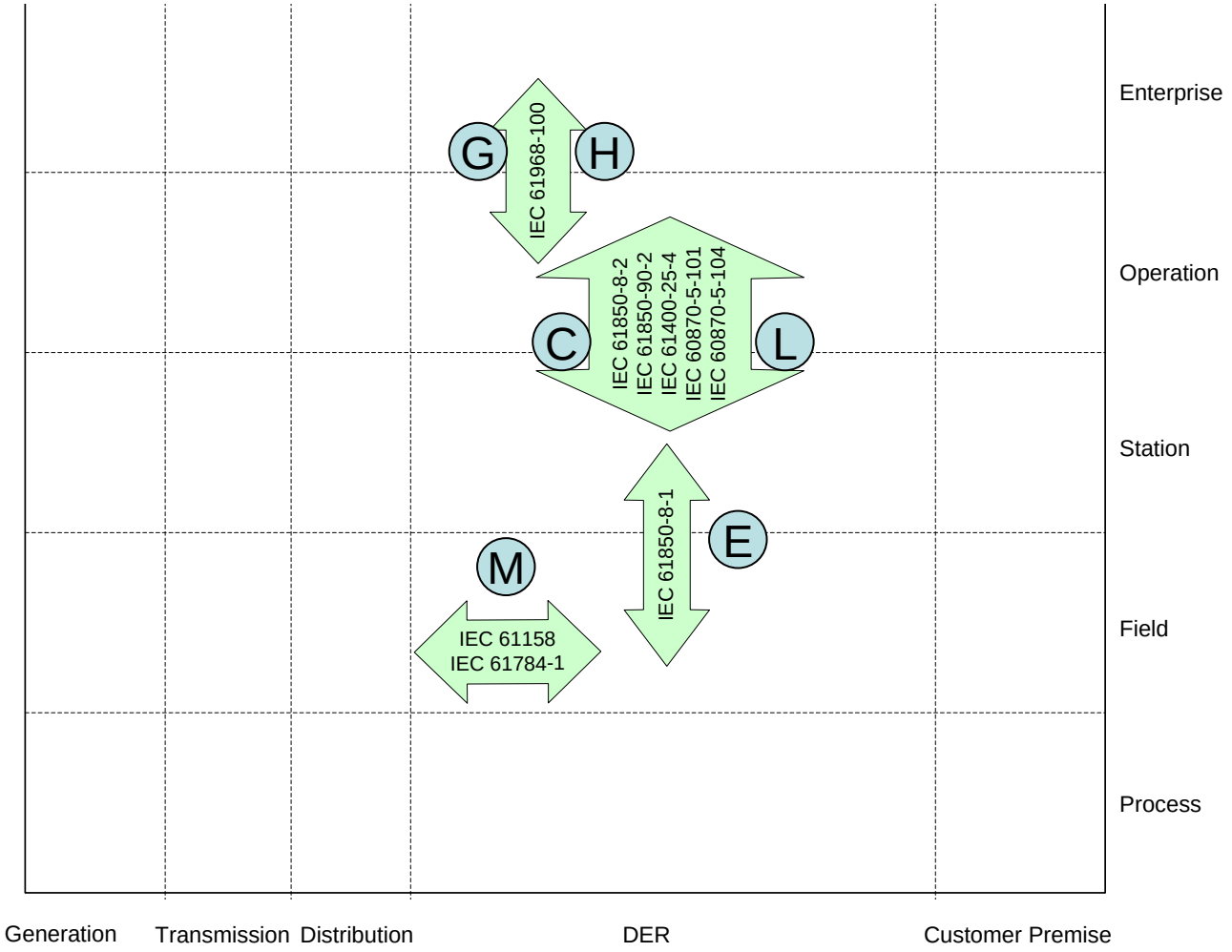


Figure 31 - DER operation system - Communication layer

8.4.1.3.4 Information (Data) layer

The information layer of DER operation is mostly based on the IEC/EN 61850 information model. EN 61850-7-4 is the core part depicting this model which is extended by various standards for DER operations:

- EN 61850-7-410: Hydroelectric power plants
- EN 61850-7-420: DER logical nodes
- EN 61400-25-2/3: Wind turbines
- IEC 61850-90-7: PV inverters
- IEC 61850-90-9: Batteries
- IEC 61850-90-10: Scheduling functions
- IEC 61850-90-15: Multiple Use DER

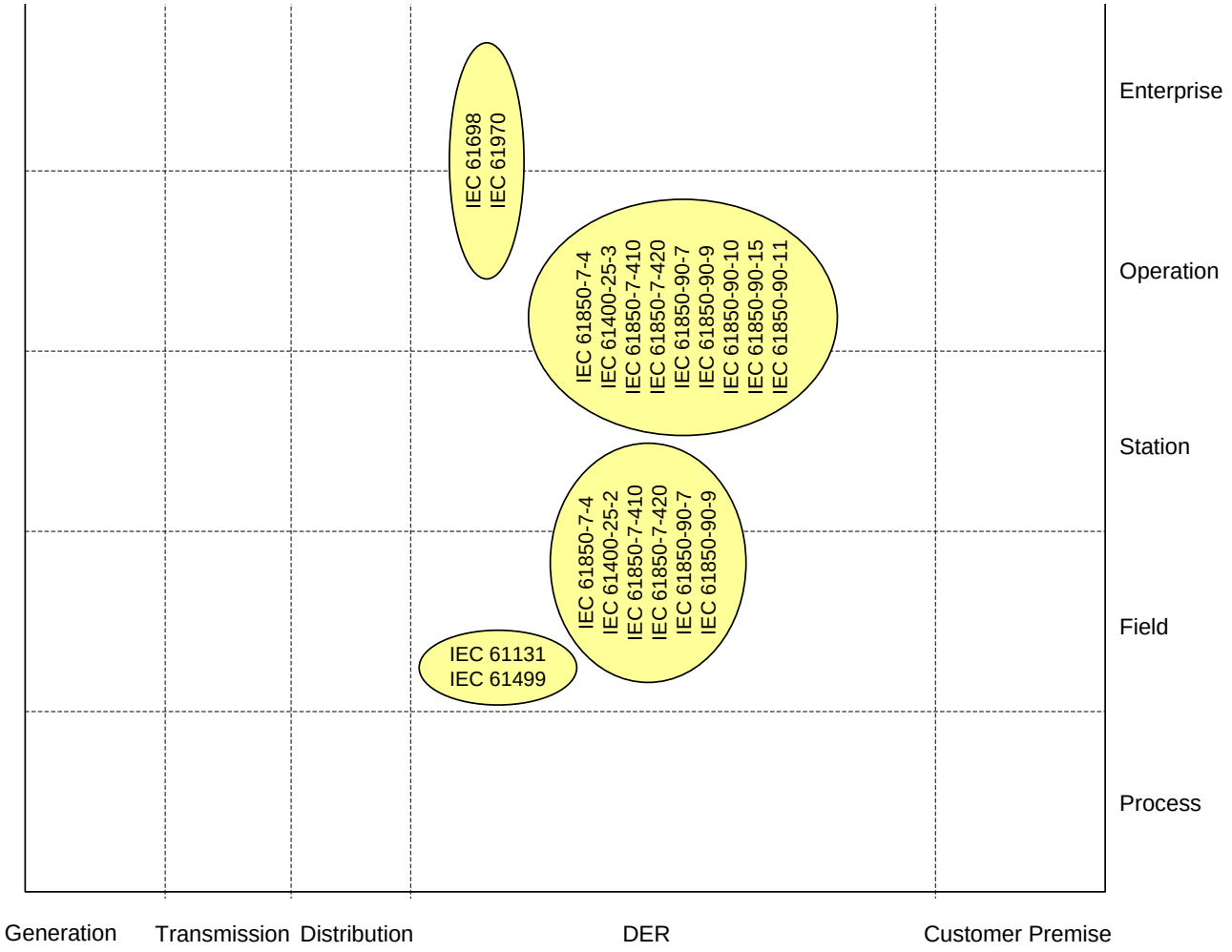


Figure 32 - DER operation system - Information layer

8.4.1.4 List of Standards

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

8.4.1.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR …) by June 30th 2012 is considered as “available”.

Table 40 – DER operation system – Available standard

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 61400-25-2	Wind turbines
Information	EN 61400-25-3	Wind turbines
Information	EN 61850-7-410	Hydroelectric power plants
Information	EN 61850-7-420	DER
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

Layer	Standard	Comments
		profiles
Communication	EN 61850-8-1	IEC/EN 61850 communication
Communication	EN 61400-25-4	Wind turbines communication
Communication	EN 61158	Field bus
Communication	IEC 61784-1	Field bus
Information	IEC 61131	Programmable controllers
Information	IEC 61499	Distributed control and automation
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)
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.3)

8.4.1.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 41 – DER operation system – Coming standards

Layer	Standard	Comments
Information	*IEC 61850-90-7*	DER inverters
Information	*IEC 61850-90-9*	Batteries
Information	*IEC 61850-90-10*	Scheduling functions
Information	*IEC 61850-90-15*	Multiple Use DER
Information	*IEC 61850-90-11*	Methodologies for modeling of logics for IEC/EN 61850 based applications
Communication, Information	*IEC 61850-90-2*	Substation to control center communication
Communication	*IEC 61850-8-2*	Web-services mapping
Communicaiton	*EN 61968-100*	Defines profiles for the communication of CIM messages using Web Services or Java Messaging System.
Component	*prEN 50438*	Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks Maintenance of an existing standard (CLC TC 8X)
Component	*prTS 50549-1*	Requirements for the connection of generators above 16 A per phase to the LV distribution system - New Project (CLC TC 8X)
Component	*prTS 50549-2*	Requirements for the connection of generators to the MV distribution system - New Project (CLC TC 8X)
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

8.4.2 DER EMS and VPP system

8.4.2.1 System description

DER EMS and VPP systems refer to the operation and enterprise management system and all the elements needed to control the generation process of a single DER entity or a set of DERs combined to a VPP. The DER EMS/VPP 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 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.

8.4.2.2 Set of use cases

The following high level use cases might be supported by a DER EMS and VPP systems.
The meanings of the three last columns (AVAILABLE, COMING, Not Yet) and of the “C”, “I”, “CI”, “X” conventions are given in section 7.5.2.

Table 42 – DER EMS and VPP 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 WAMS	CI (PMU)		?
	Shedding loads based on emergency signals	CI		
	Restore power after black-out			?
Demand and production (generation) flexibility	Receiving metrological or price information for further action by consumer or CEM		CI	
	Generation forecast (from remote)		C	I
	Generation forecast (from local)		C	I
	Participating to electricity market	I	CI	
	Managing energy consumption or generation of DERs via local DER energy management system bundled in a DR program		CI	
	Managing energy consumption or generation of DERs and EVSE via local DER energy management			

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
	system to increase local self-consumption			
	Registration/deregistration of DER in DR program		CI	
System and security management	Distributing and synchronizing clocks	See section 8.9.3		

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.

8.4.2.3 Mapping on SGAM

8.4.2.3.1 Preamble

The DER EMS/VPP System interacts with the DER operation system, weather forecast system (wind farms and PV), related DSO systems (power quality control, DMS/SCADA...) (tVPP) and the market (cVPP).

8.4.2.3.2 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.

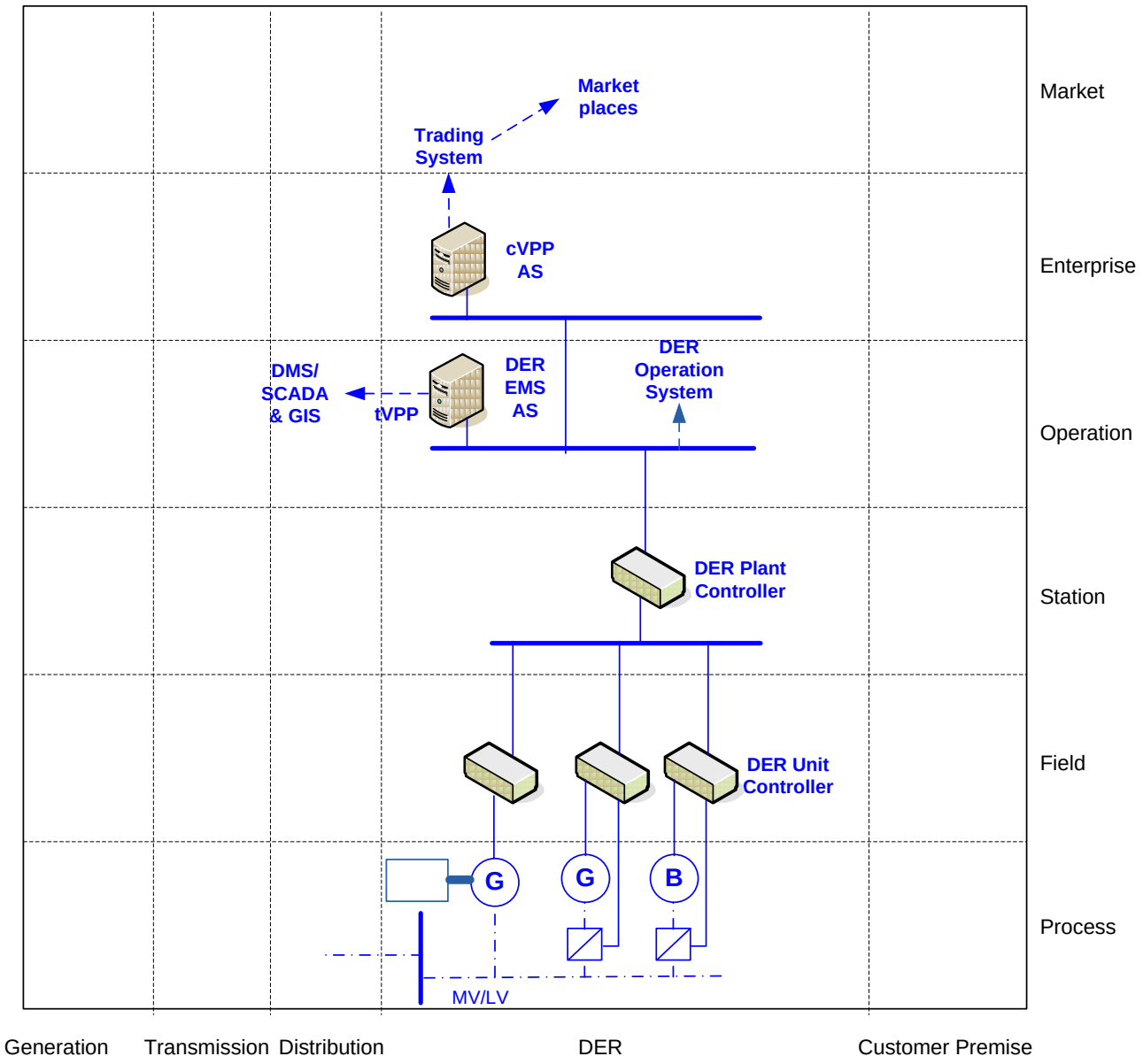


Figure 33 - DER EMS and VPP system - Component layer

8.4.2.3.3 Communication layer

EN 60870-5-101 and EN 60870-5-104 can also be used for vertical communication as shown in the Figure 34 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 9.3 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 9.2.2.

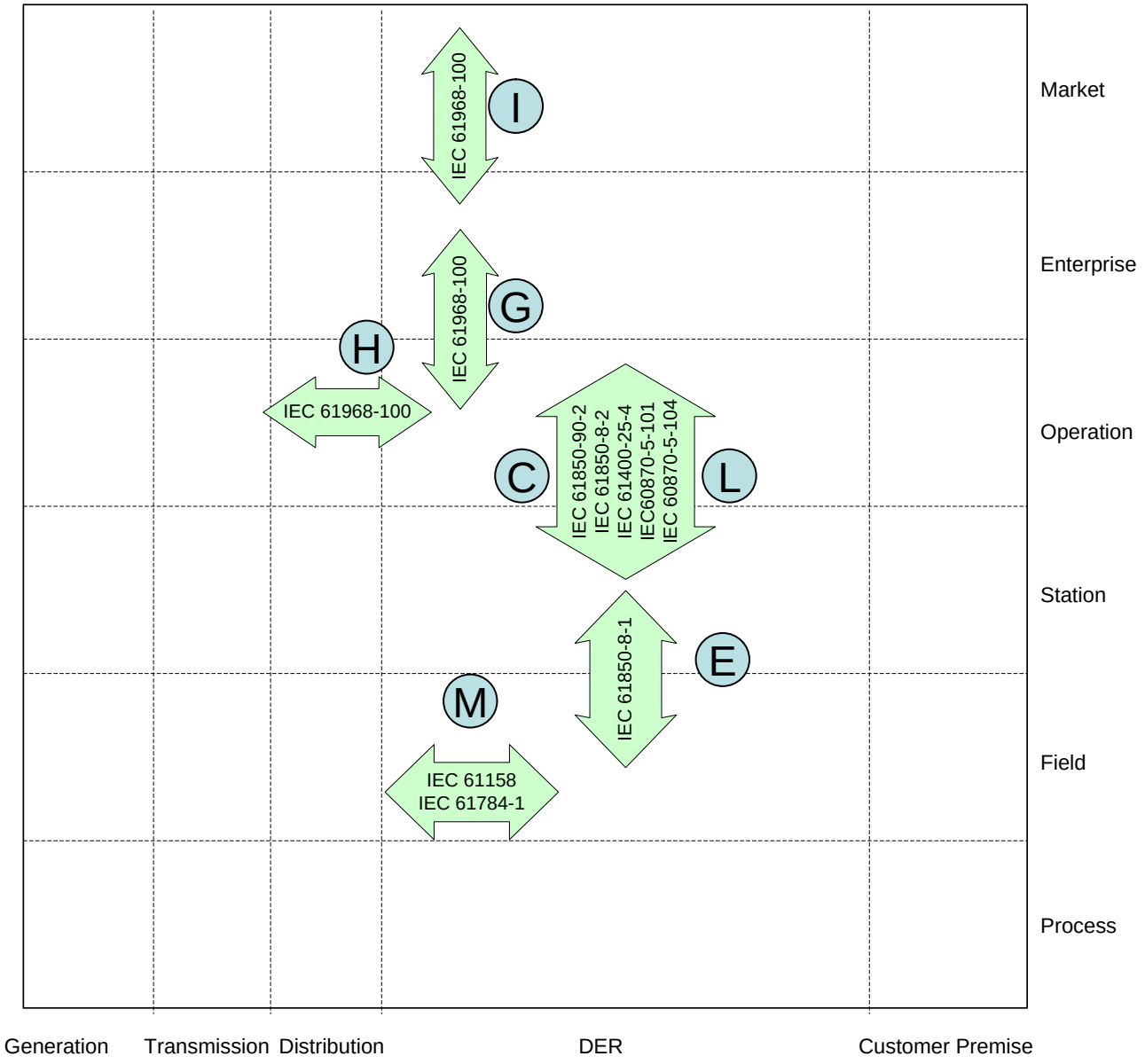


Figure 34 - DER EMS and VPP system - Communication layer

8.4.2.3.4 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.

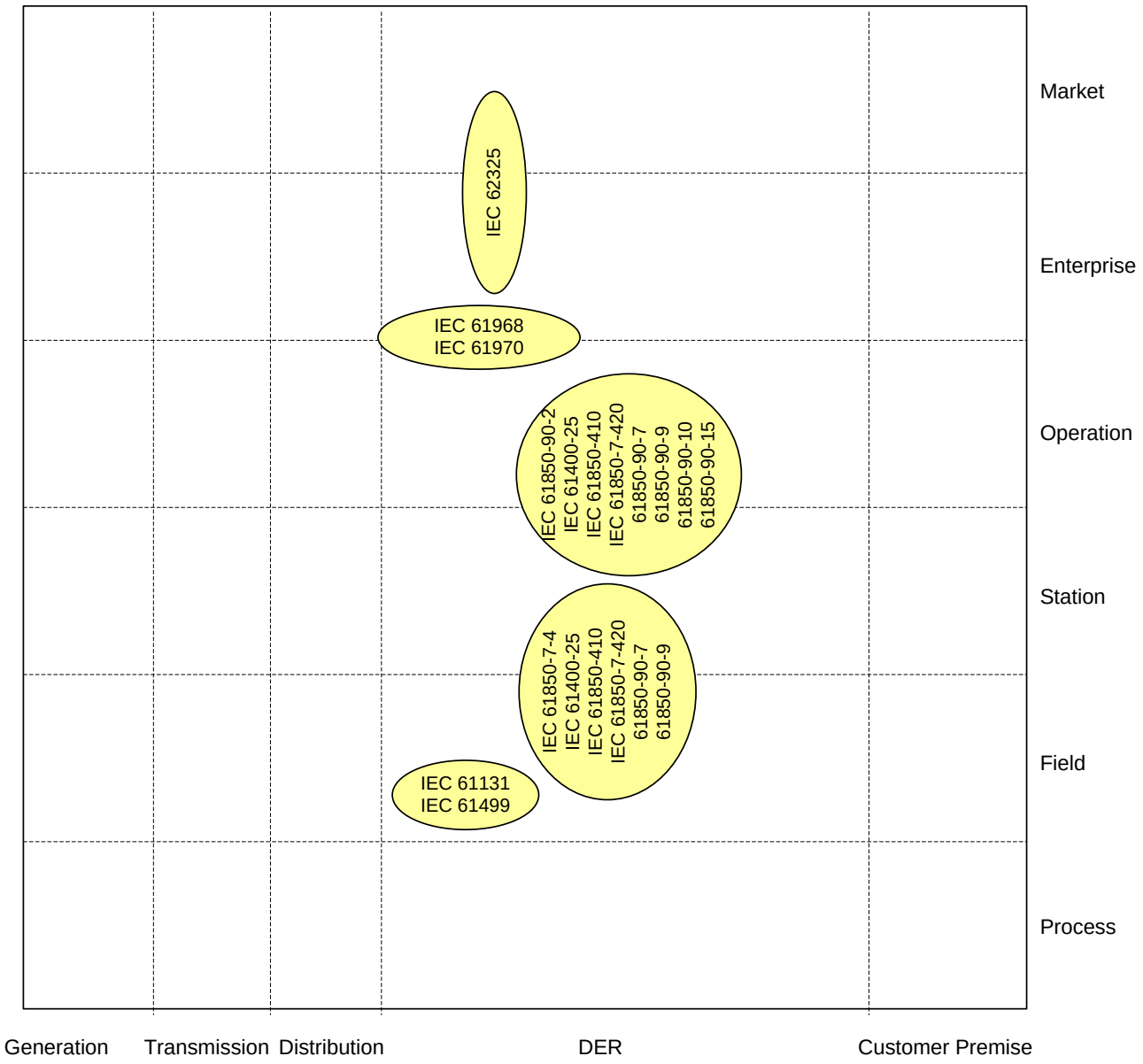


Figure 35 - DER EMS and VPP system - Information layer

8.4.2.4 List of Standards

Here is the summary of the standards which appear relevant to DER EMS and VPP systems:

8.4.2.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 43 – DER EMS and VPP 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 61400-25-2	Wind turbines
Information	EN 61400-25-3	Wind turbines
Information	EN 61850-7-410	Hydroelectric power plants
Information	EN 61850-7-420	DER

Layer	Standard	Comments
Information	IEC 61131	Programmable controllers
Information	IEC 61499	Distributed control and automation
Information	EN 61968 (all parts)	Distribution CIM
Information	EN 61970 (all parts)	Transmission CIM
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 61400-25-4	Wind turbines communication
Communication	EN 61158	Field bus
Communication	IEC 61784-1	Field bus
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.3)

8.4.2.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 44 – DER EMS and VPP system – Coming standards

Layer	Standard	Comments
Information	*IEC 61850-90-7*	DER inverters
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	*IEC 61850-90-15*	Multiple Use DER
Communication, information	*IEC 61850-90-2*	Substation to control center communication
Communication	*IEC 61850-8-2*	Web-services mapping
Communication	*EN 61968-100*	Defines profiles for the communication of CIM messages using Web Services or Java Messaging System.
Component	*prEN 50438*	Requirements for the connection of micro-generators in parallel with public low-voltage distribution networks Maintenance of an existing standard (CLC TC 8X)
Component	*prTS 50549-1*	Requirements for the connection of generators above 16 A per phase to the LV distribution system - New Project (CLC TC 8X)
Component	*prTS 50549-2*	Requirements for the connection of generators to the MV distribution system - New Project (CLC TC 8X)
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

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” and the SM-CG work programme of July 2012. These results will be supplemented by a further SM-CG report at the end of 2012.

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 7.5.2.

Table 45 – AMI system – Use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
(AMI) Billing	Obtain scheduled meter reading	**I**		
	Set billing parameters	**I**		
	Add credit			tba
	Execute supply control	**CI**		
(AMI) Customer information	Provide information to consumer	**CI**		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
provision				
(AMI) Configure events, statuses and actions	Configure meter events and actions	**CI**		
	Manage events	**CI**		
	Retrieve AMI component information	**CI**		tba for non metering devices
	Check device availability	**CI**		
(AMI) installation & configuration	AMI component discovery & communication setup	**CI**		tba for non metering devices
	Clock synchronization	**CI**		
	Configure AMI device	**CI**		tba for non metering devices
	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 36. In the following sections the smart metering architecture of Figure 36 is mapped into the SGAM architecture. Note that in the architecture in Figure 36 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.

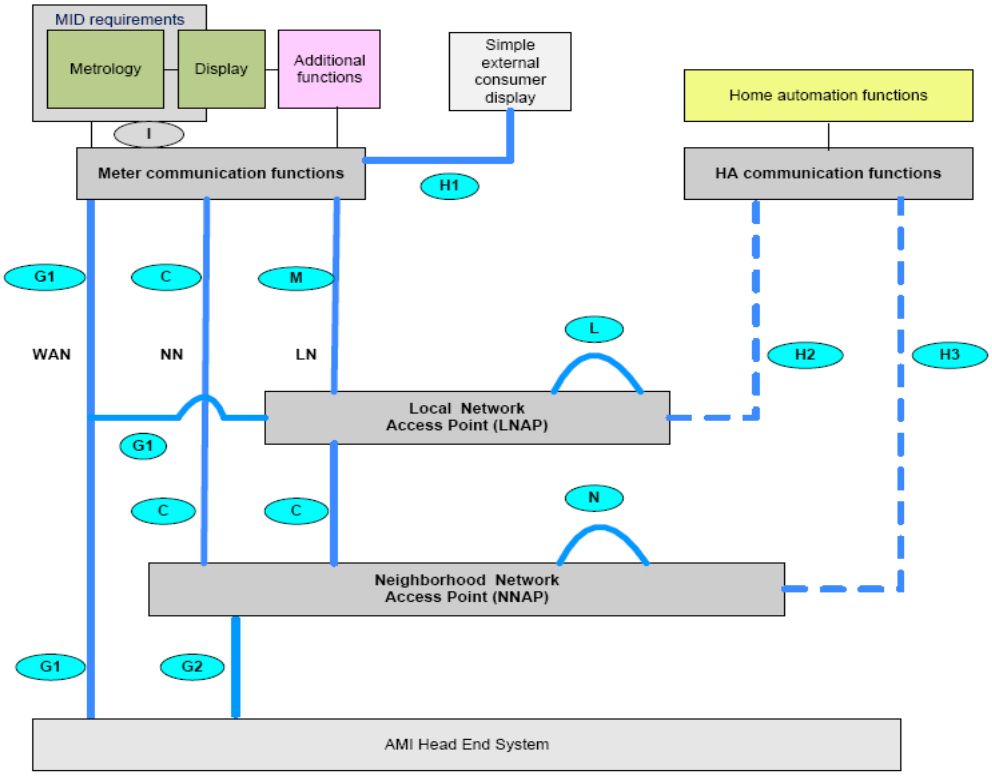


Figure 36: Smart Metering architecture according to CLC TR 50572

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 section 6.5.1.4.1

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 37 below. More details on the smart metering functional architecture can be found in the CEN/CLC/ETSI Technical Report 50572 [4].

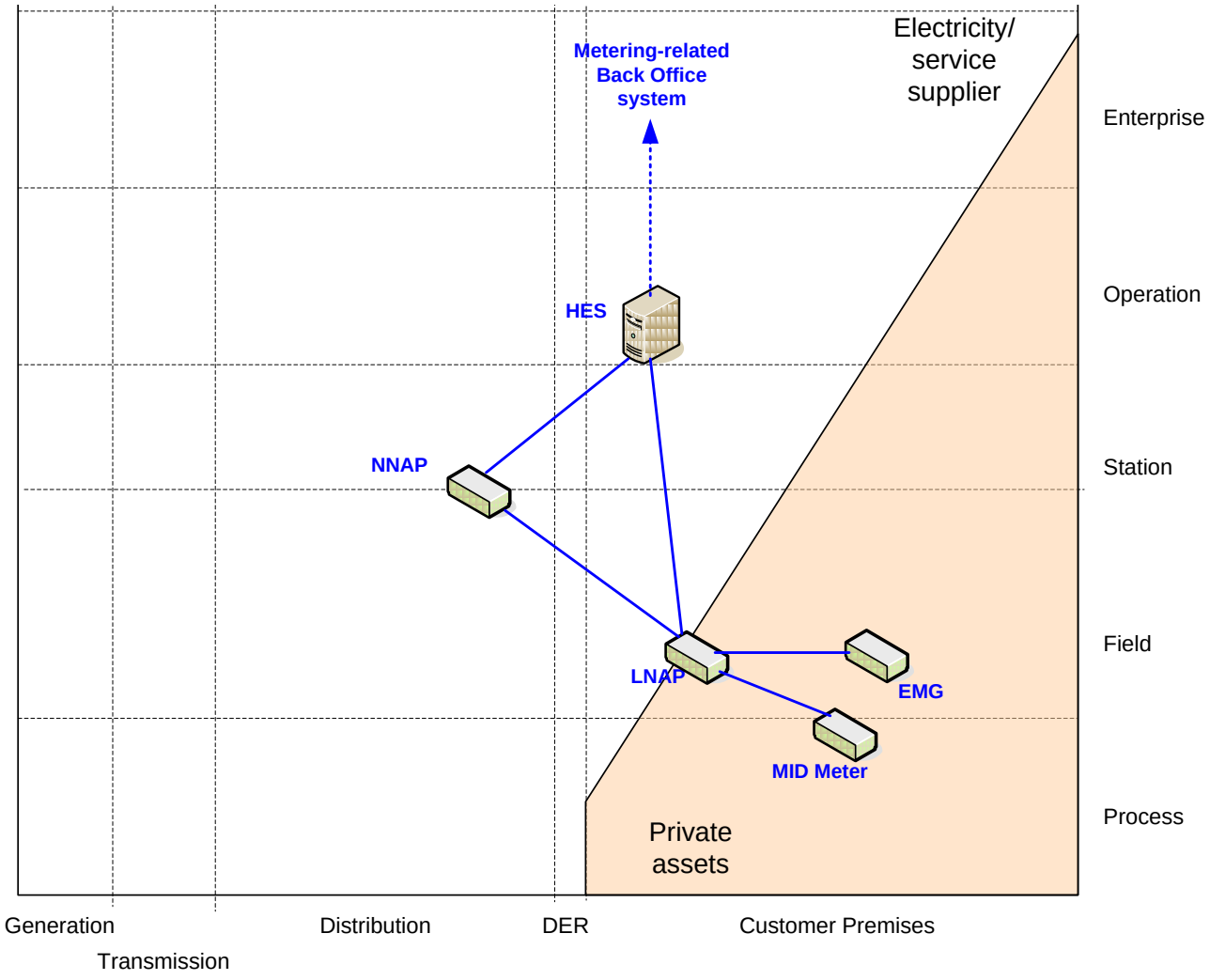


Figure 37: Smart Metering architecture (example) mapped to the SGAM component layer.

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, with in addition a reference to the network types defined in 9.2.2.

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.2.2.

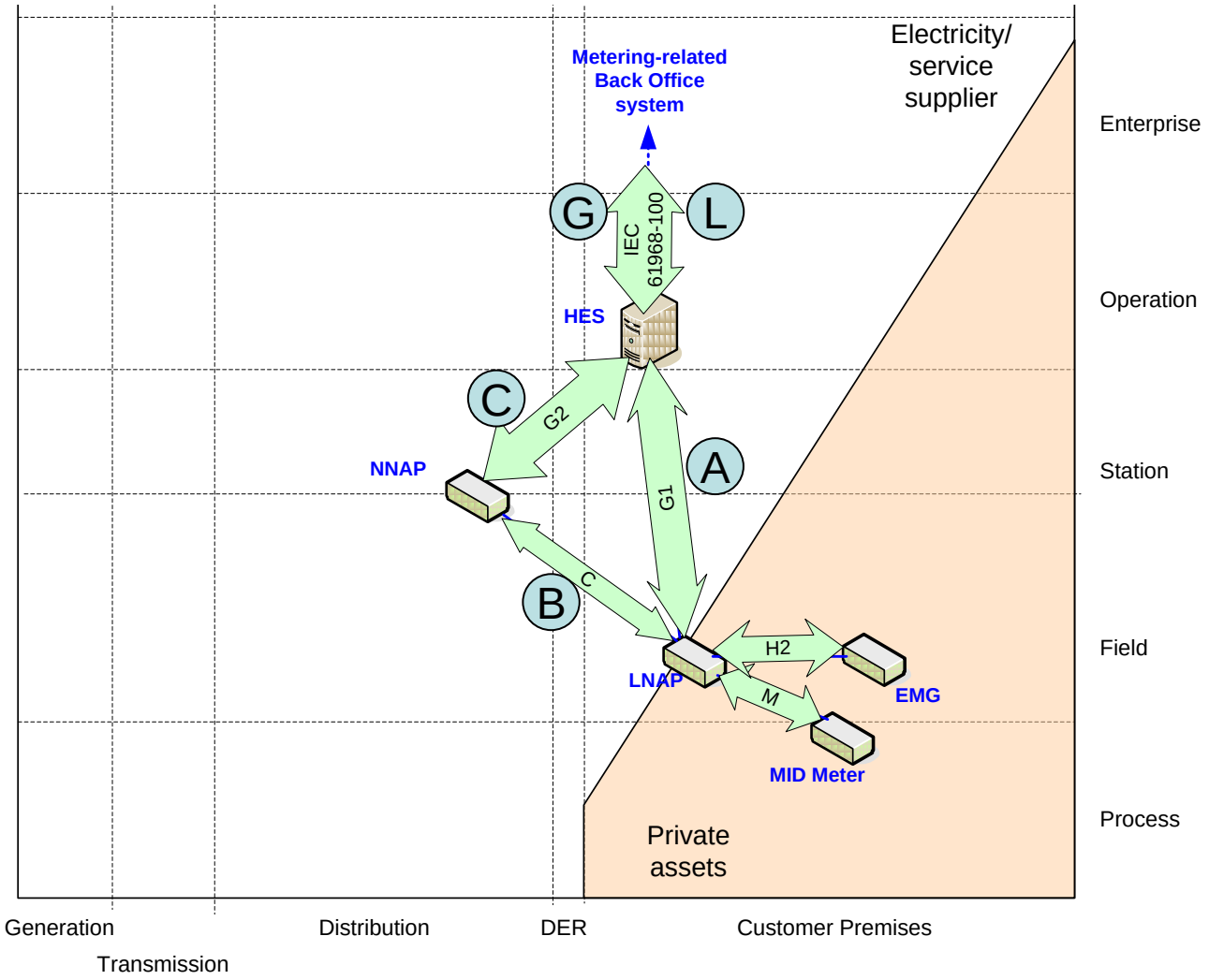


Figure 38: Smart Metering architecture (example) mapped to the SGAM communication layer.

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.

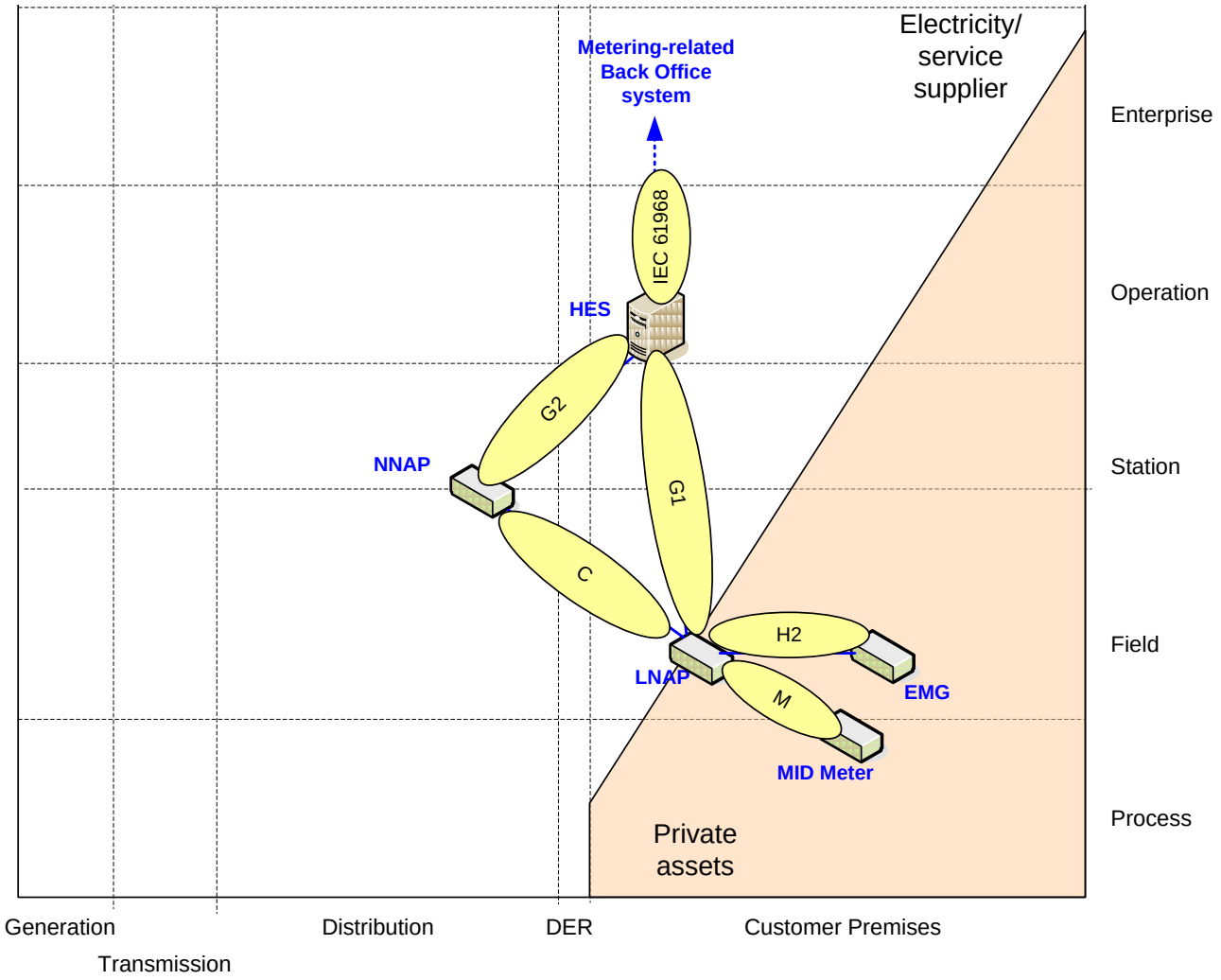


Figure 39: Smart Metering architecture (example) mapped to the SGAM information layer.

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 http://ec.europa.eu/enterprise/policies/european-standards/harmonised-standards/measuring-instruments/index_en.htm

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 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

A list of communications standards which appeared relevant to support an AMI system were given in TR 50572 [4].

In order to avoid conflicting publications, the current report explicitly relies on the CLC TR 50572 [4] conclusions completed with SM-CG work program [5].
Specifically, for these standards which are extracted from the above, additional columns are provided to indicate which interface type is envisaged, with letters referring to the functional architecture given in Figure 36 (C, G1, G2, H2, M).

Note : Some standards contained in Table 46 to Table 49 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.

Table 46 – AMI system – Available standards (outside M/441 scope)

Layer	Standard	Comments
Information	EN 61968 (all parts)	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 47 – AMI system – Available standards (within M/441 scope)

Extract from SM-CG conclusions [4] & [5].

AVAILABLE STANDARDS	M	H1	H2/H3	C	G1	G2	L	N
EN 50065-1	x	x	x	x	x		x	x
EN 50090-3-1		x	x					
EN 50090-3-2		x	x					
EN 50090-3-3		x	x					
EN 50090-4-1		x	x					
EN 50090-4-2		x	x					
EN 50090-4-3		x	x					
EN 50090-5-1		x	x					
EN 50090-5-2		x	x					
EN 50090-5-3		x	x					
EN 50090-7-1		x	x					
EN 61334-4-32				x				
EN 61334-4-511				x				
EN 61334-4-512				x				
EN 61334-5-1				x				
EN 62056-31	x			x				
EN 62056-42	x	x		x				
EN 62056-46	x	x		x				
EN 62056-47				x	x	x		
EN 62056-53	x	x		x	x	x		
EN 62056-61	x			x	x	x		
EN 62056-62	x			x	x	x		
EN 13321 series		x	x					
EN 13757-1	x	x	x	x				
EN 13757-2	x	x	x	x				
EN 13757-3	x	x	x	x				
EN 13757-4	x	x	x	x				
EN 13757-5	x	x	x	x				
EN 14908 series	x	x	x	x			x	x
IEEE 1377	x			x	x	x	x	x

The tables do not include the many ETSI standards identified under the M/441 mandate [3] as relevant to smart metering and which therefore apply to the AMI in a smart grid context. While some of these standards may appear in section 9 of this report, the approaches used in the two mandates are different, which would complicate alignment in this FSS report.

8.5.1.4.3 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

The following list should be read in conjunction with the standards mentioned in TR 50572 [4]. A further list of standards related to smart metering will be available at the end of 2012 and will be published as a deliverable under the M/441 mandate [3]. Other standards may be developed in due course.

The principal ‘coming’ standards are:

Table 48 – AMI system – Coming standards (outside M/441 scope)

Layer	Standard	Comments
Information	*EN 61968-9*	Application integration at electric utilities - System interfaces for distribution management - Part 9: Interface for meter reading and control

Table 49 – AMI system – Coming standards (within M/441 scope)

COMING STANDARDS	M	H1	H2/H3	C	G1	G2	L	N
prEN 13757-1	x	x	x	x				
prEN 13757-3	x	x	x	x				
prEN 13757-4	x	x	x	x				
prEN 13757-5	x	x	x	x				
prTR 50491-10		x	x					
prEN 50491-11		x	x					
prEN 50491-12		x	x					
prTS 50567-1				x				
prTS 50567-2				x				
prTS 50568-2								
prTS 50568-4		x	x	x				
prTS 50568-5		x	x	x		x		
prTS 50568-6		x	x	x		x		
prTS 50568-8		x	x	x				
prTS 50568-9						x		
prTS 50XXX (=OSGP)	x		x	x				
prTS 50XXX (=CX1)								
prTS 52056-8-4				x				
prTS 52056-8-5				x				
EN 62056-1-0	x	x	x	x	x	x	x	x
EN 62056-3-1	x			x				
EN 62056-3-2[9]								
EN 62056-4-7				x	x	x		
EN 62056-5-3	x	x		x	x	x		
EN 62056-5-8					x	x		
IEC/TS 62056-6-9	x			x	x	x		
FprEN 62056-6-1	x			x	x	x		
FprEN 62056-6-2	x			x	x	x		
FprEN 62056-7-6	x	x		x				

[9] The planned EN 62056-3-2 standard will be renamed as 62056-7-2.

COMING STANDARDS	M	H1	H2/H3	C	G1	G2	L	N
FprEN 62056-8-3				x				
FprEN 62056-9-7					x			
EN/TR 5YYYY	x	x	x	x	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:

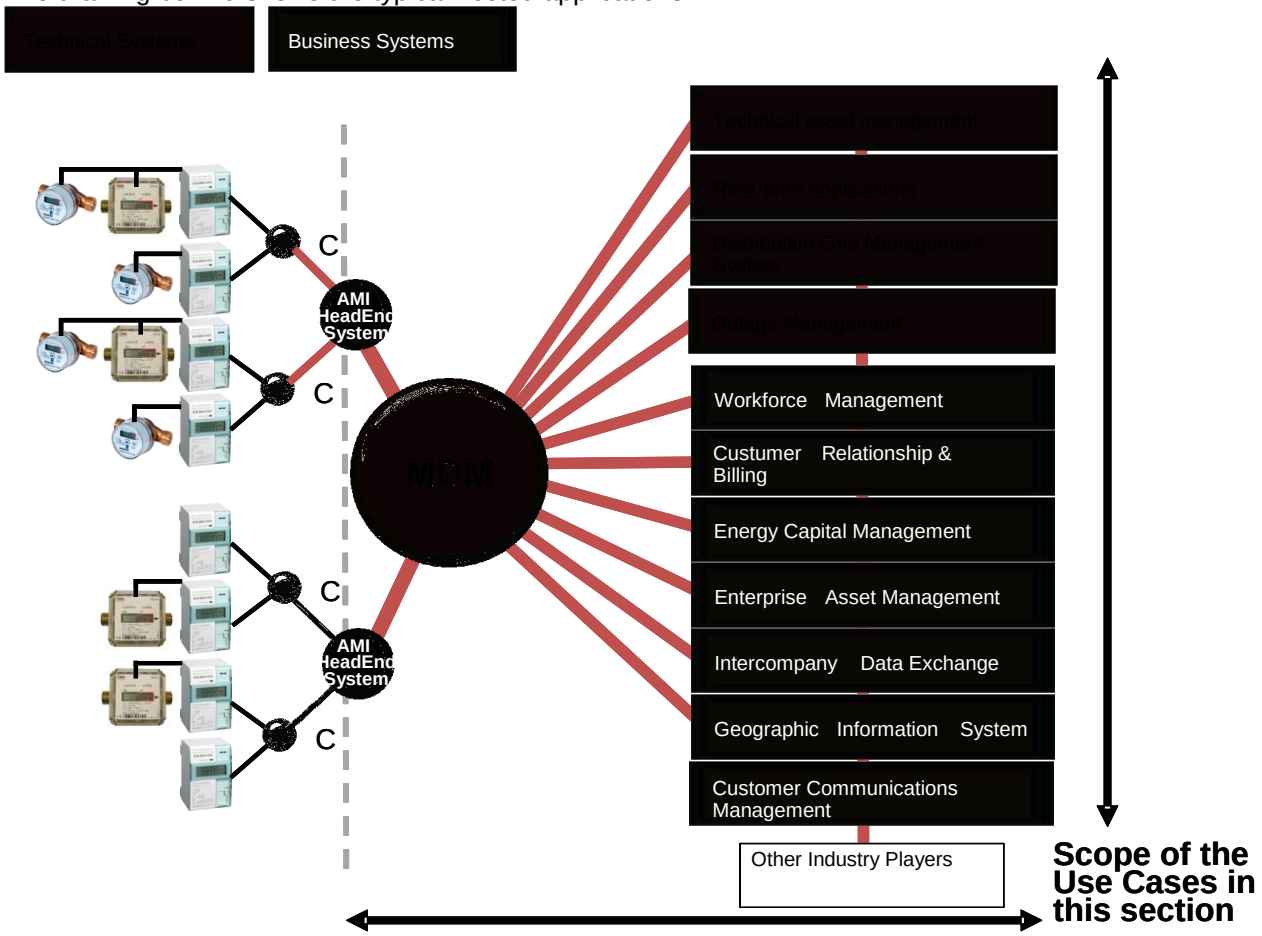


Figure 40 - Typical applications hosted by a metering-related back-office system

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 7.5.2.
Work is in hand to integrate these use cases with those identified for the AMI in section 8.5.1.2.

Table 50 - Metering-related Back Office system - use cases

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
Monitor AMI	Install, configure and maintain the	**CI**		

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
event	metering system			
	Manage power quality data	**CI**		
	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.

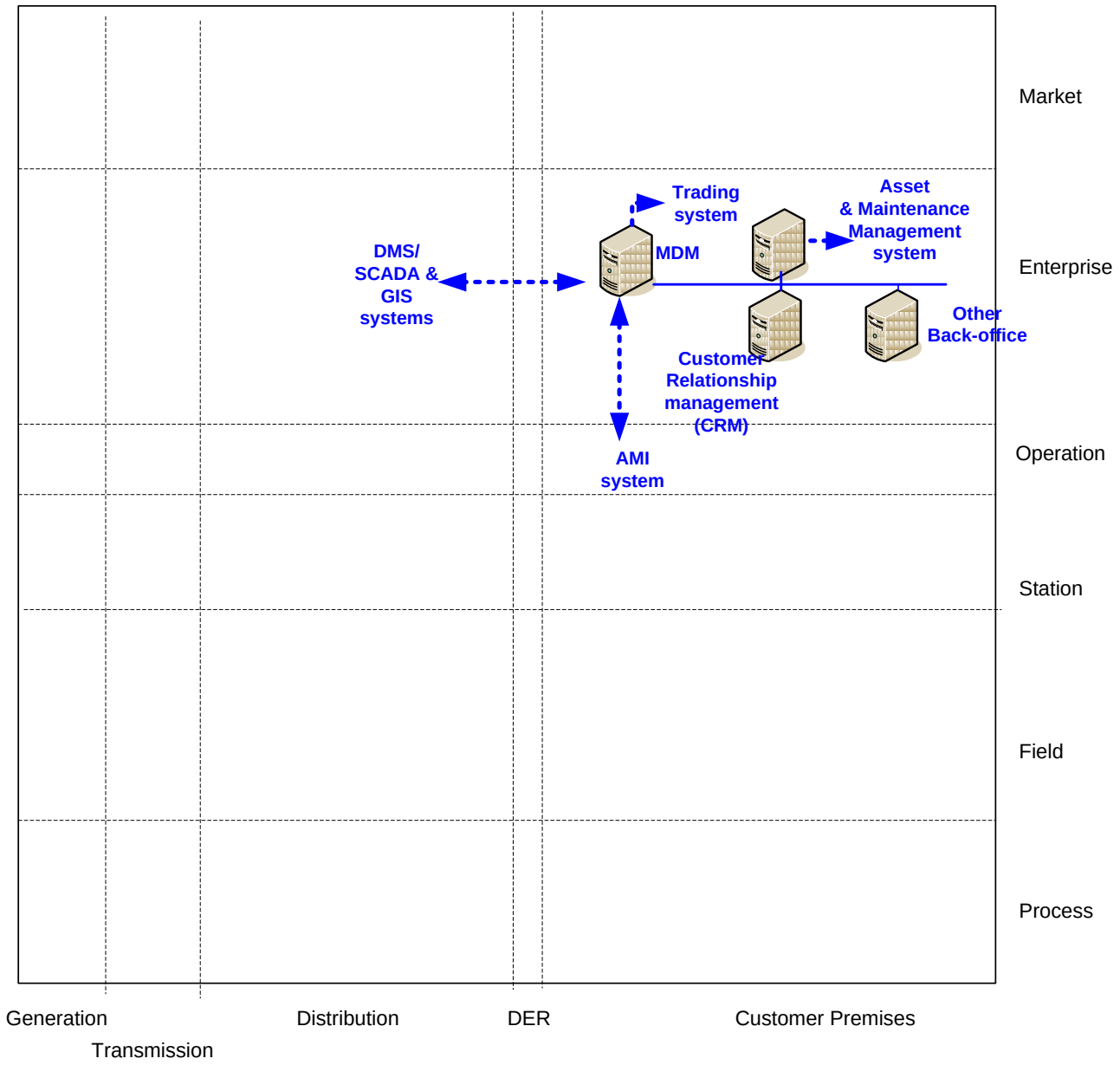


Figure 41 - Metering-related Back Office system - Component layer

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 9.3 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 9.2.2.

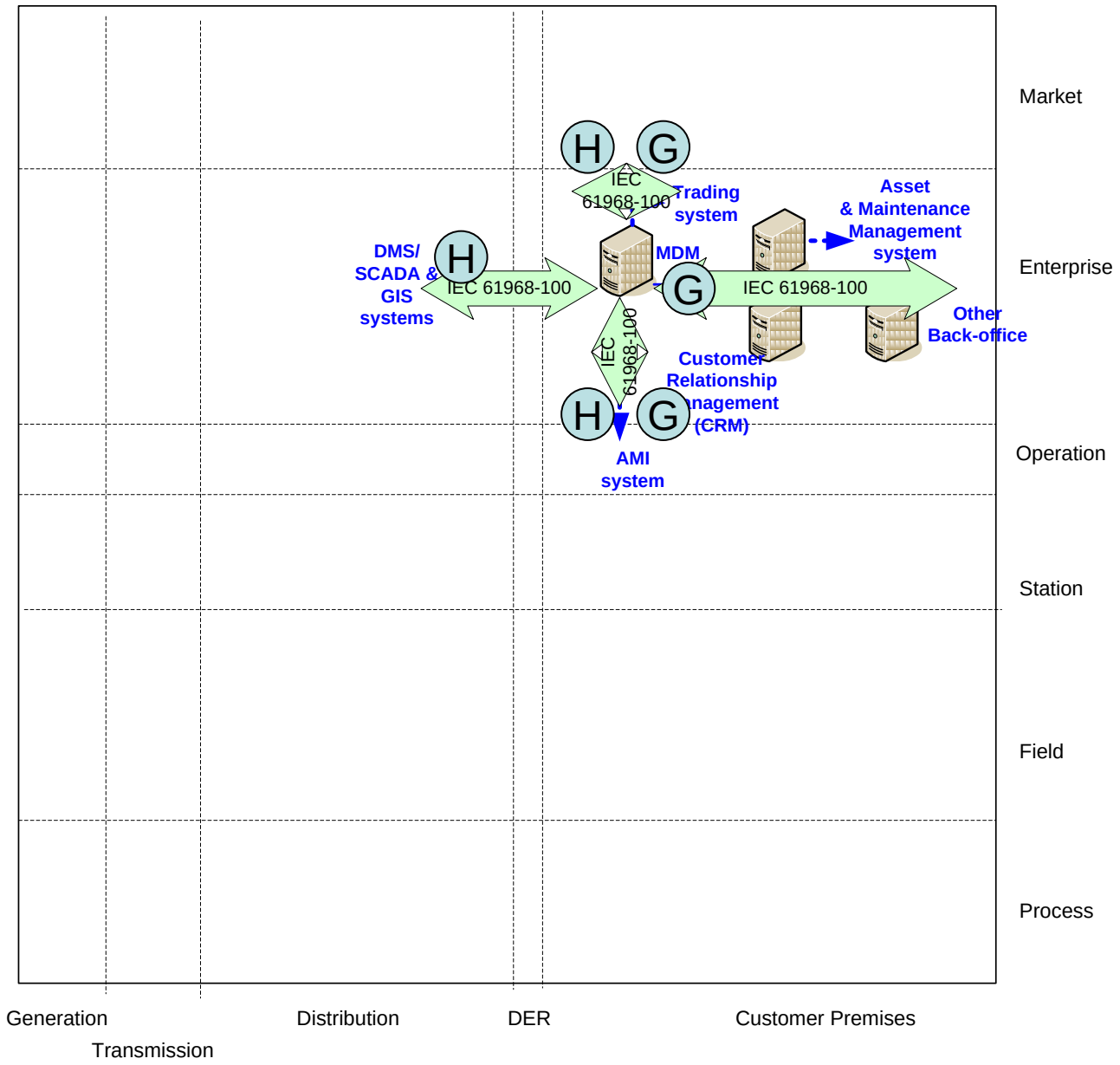


Figure 42 - Metering-related Back Office system - Communication layer

8.5.2.3.4 Information (Data) layer

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

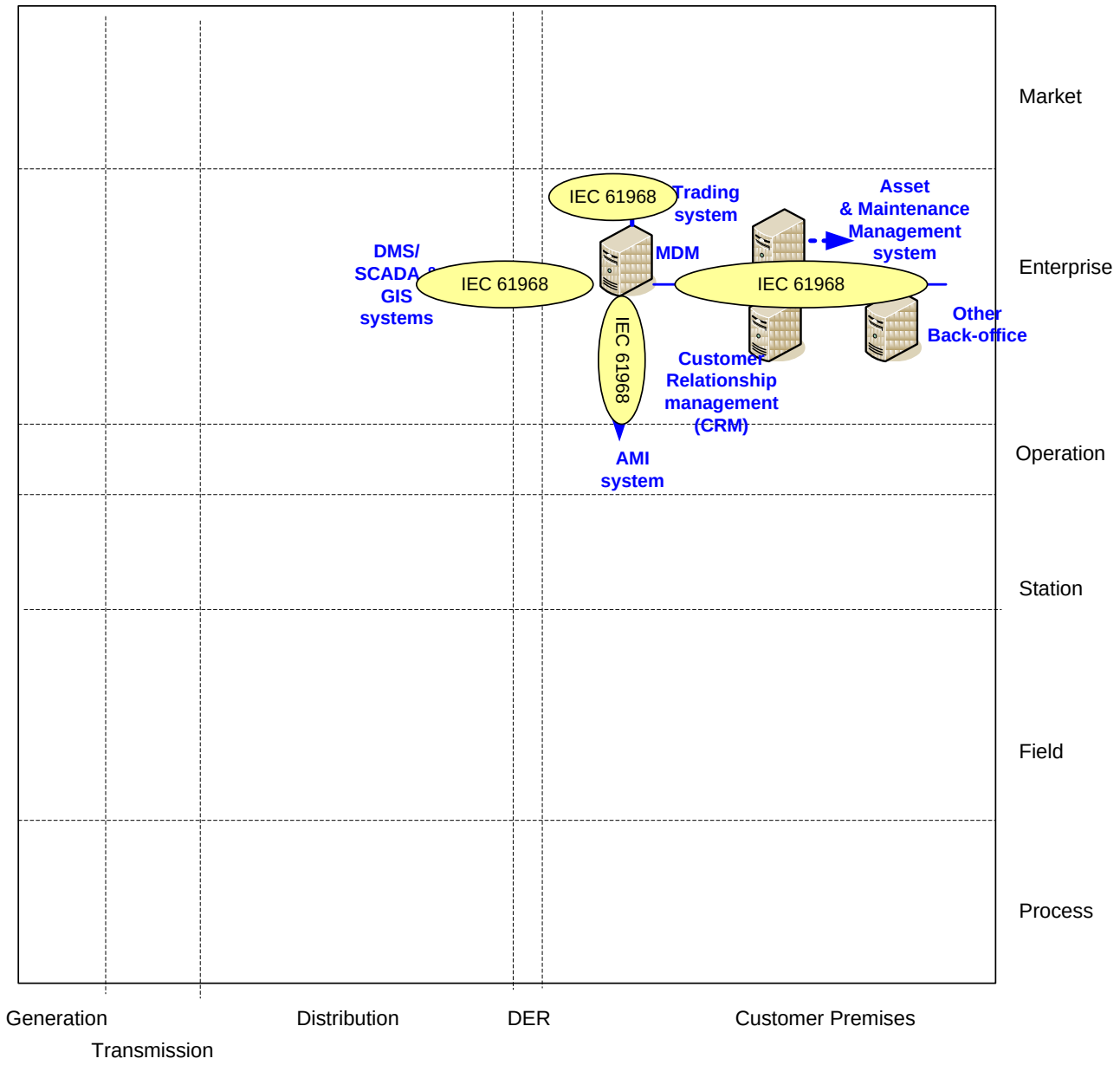


Figure 43 - Metering-related Back Office system - Information layer

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, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 51 - Metering-related Back Office system – Available standards

Layer	Standard	Comments
Information, Communication	IEC 62051-1	Glossary of terms related to DLMS/COSEM
Communication	EN 61968 (all parts)	Interface architecture and general requirements.
Information	EN 61968-9	Interfaces for meter reading and control
General	IEC 62357	Reference architecture for object models, services and protocols

Layer	Standard	Comments
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.3)

8.5.2.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 52 - Metering-related Back Office system – Coming standards

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 9.3)

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 7.5.2.

Table 53 - 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 36 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.

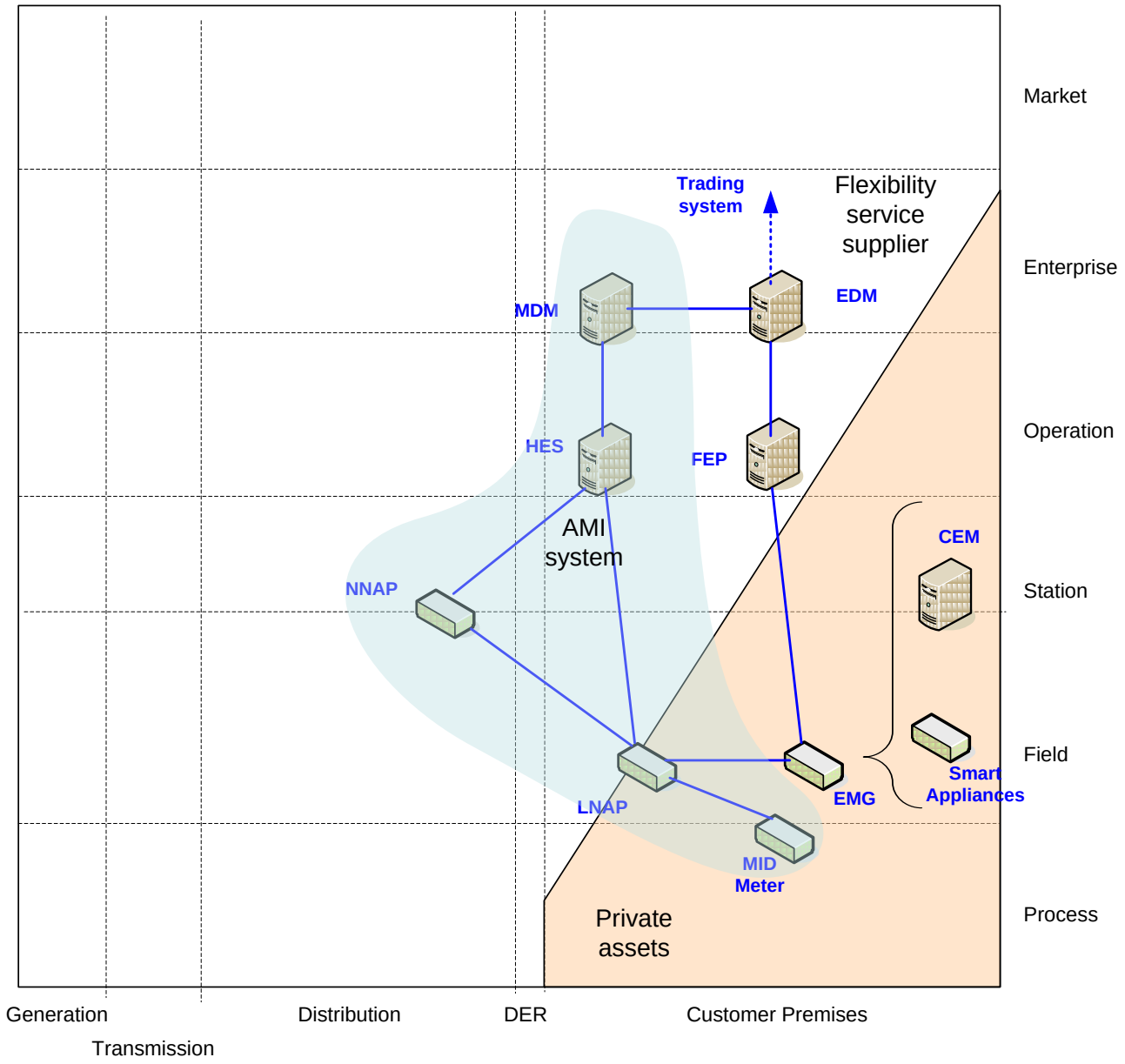


Figure 44 - Aggregated prosumers management system (example) - Component layer

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 9.3 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 9.2.2.

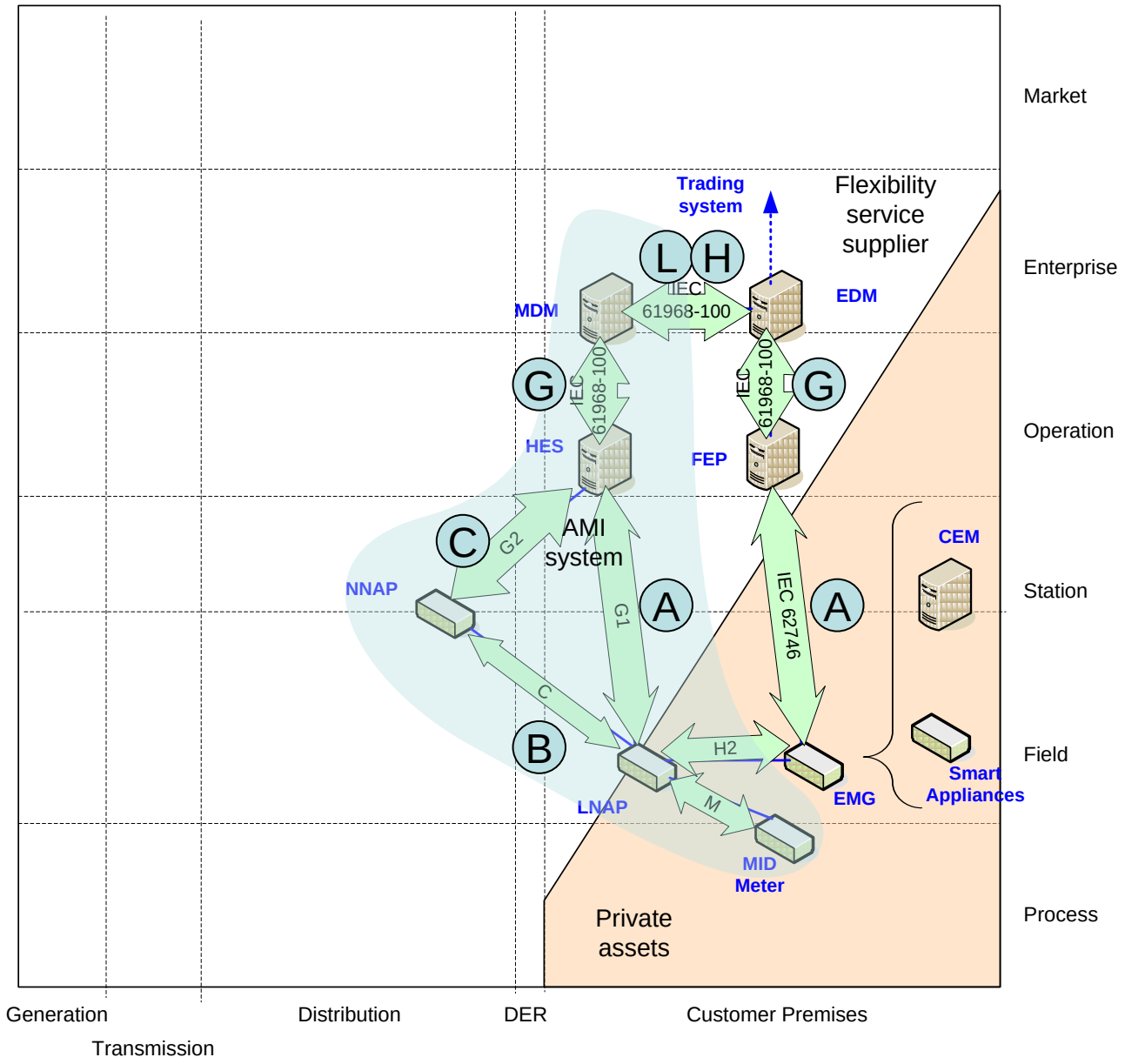


Figure 45 - Aggregated prosumers management system (example) - Communication layer

8.6.1.3.4 Information (Data) layer

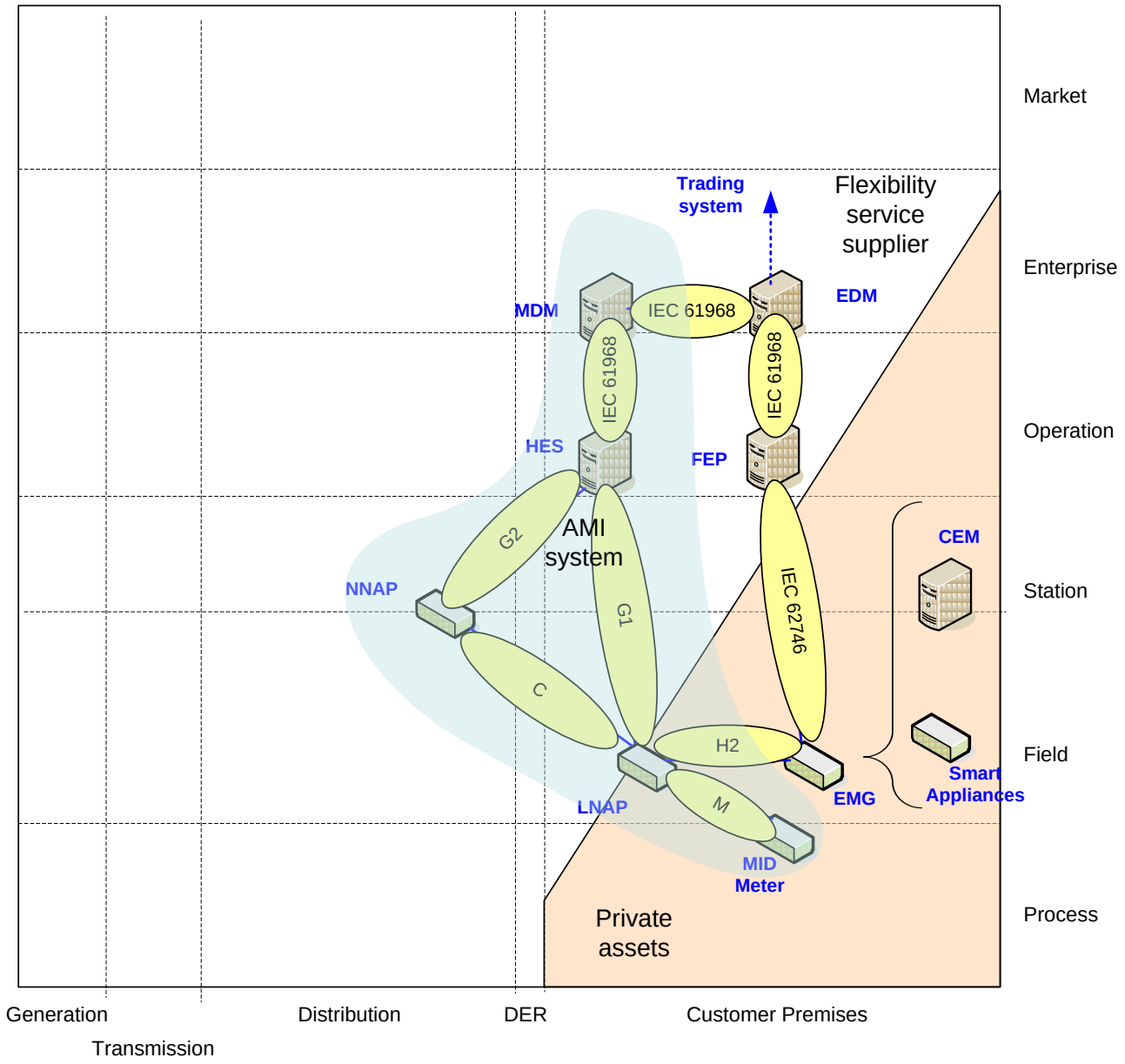


Figure 46 - Aggregated prosumers management system (example) - Information layer

8.6.1.4 List of Standards

Here is the summary of the principal standards which appear relevant to support aggregated prosumers management systems:
The list below should also be read in conjunction with those “available” or “coming” cross-cutting standards supporting the telecommunication technologies detailed in section 9.2, attached to the network types presented above (identified with their letter in the blue disks in Figure 45).

8.6.1.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.
As for AMI system, which may participate to the building-up of such a system, we will rely on CLC TR 50572 set of standards definition.

Table 54 - 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 9.3)

8.6.1.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 55 - Aggregated prosumers management system– Coming standards

Layer	Standard	Comments
Information	*prEN 50491-12*	(fits CLC TR 50572 type H2/H3 needs) - Smart grid - Application specification. Interface and framework for customer energy management
Communication	*IEC 62746*	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 9.3)

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 sell purchase 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 7.5.2.

Table 56 - 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			X
	Clear day-ahead market			X
	Clear intraday market			X
	Clear real-time market			X
	Publish market results			X
Grid reliability using market-based mechanisms	Manage (auction/resale/curtailment) transmission capacity rights on interconnectors	CI		
	Consolidate and verify energy schedules	CI		
	Operate (register/bidding/clearing/publishing) Ancillary Services Markets	CI		
	Solve balancing issues through Balancing Market	CI		
	Solve grid congestion issues through Balancing Market	CI		
Market Settlements	Perform M&V	CI		
	Perform settlements	CI		
Secure adequacy of supply	Operate Capacity Markets			X
Flexibility markets	Register Flexibility Markets			X

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 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.

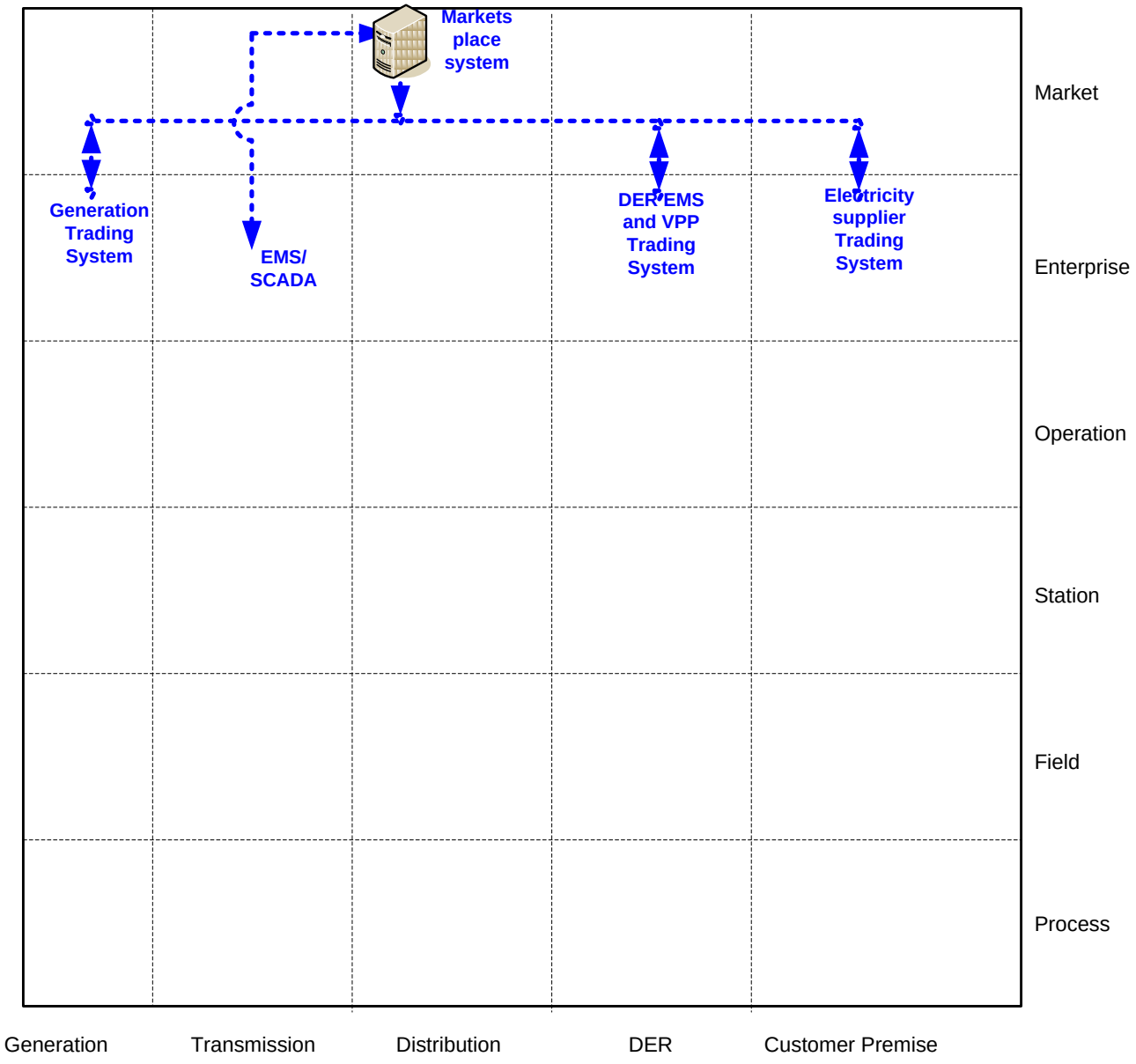


Figure 47 - Marketplace system - Component layer

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 9.3 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 9.2.2.

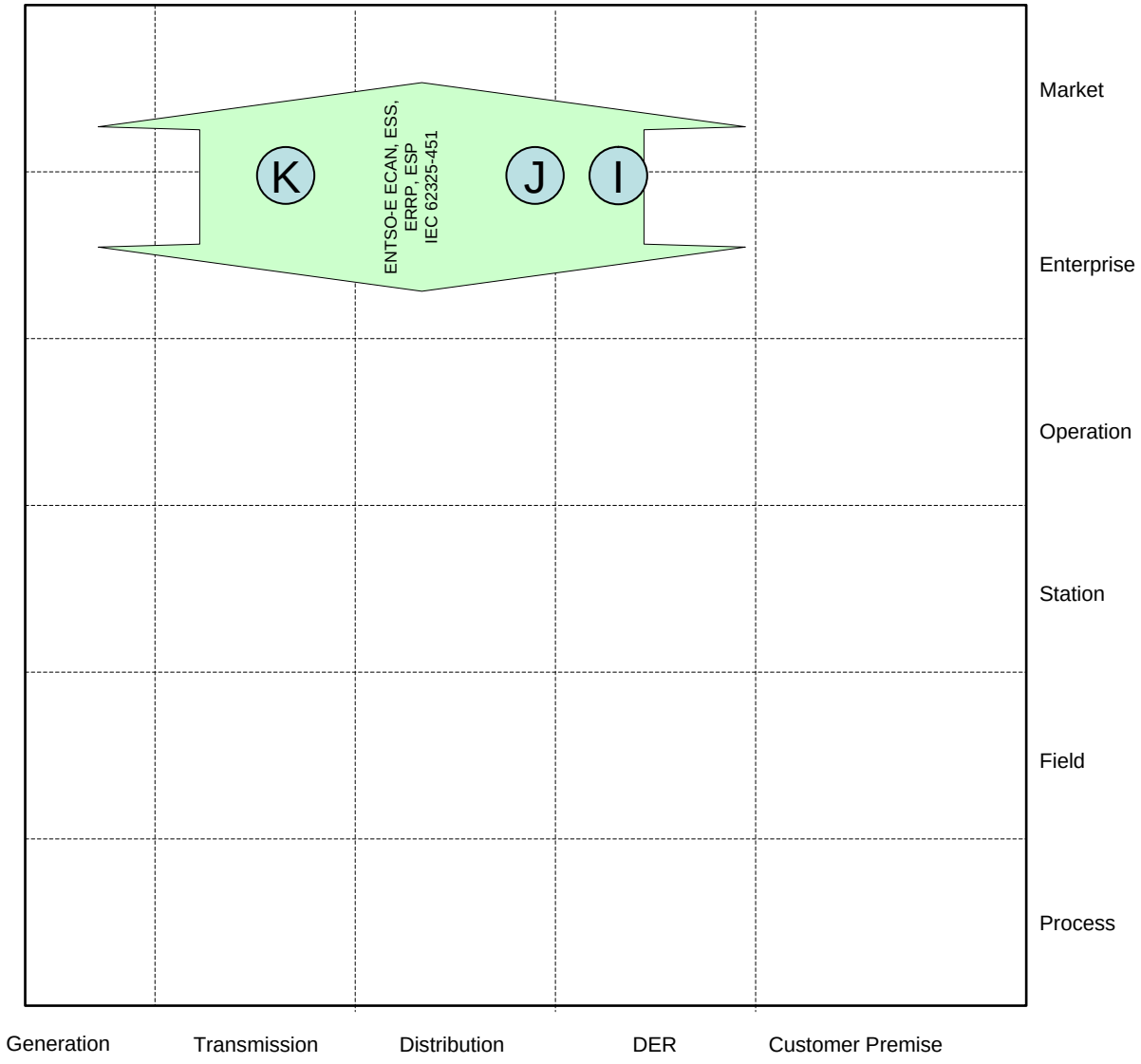


Figure 48 - Marketplace system - Communication layer

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.

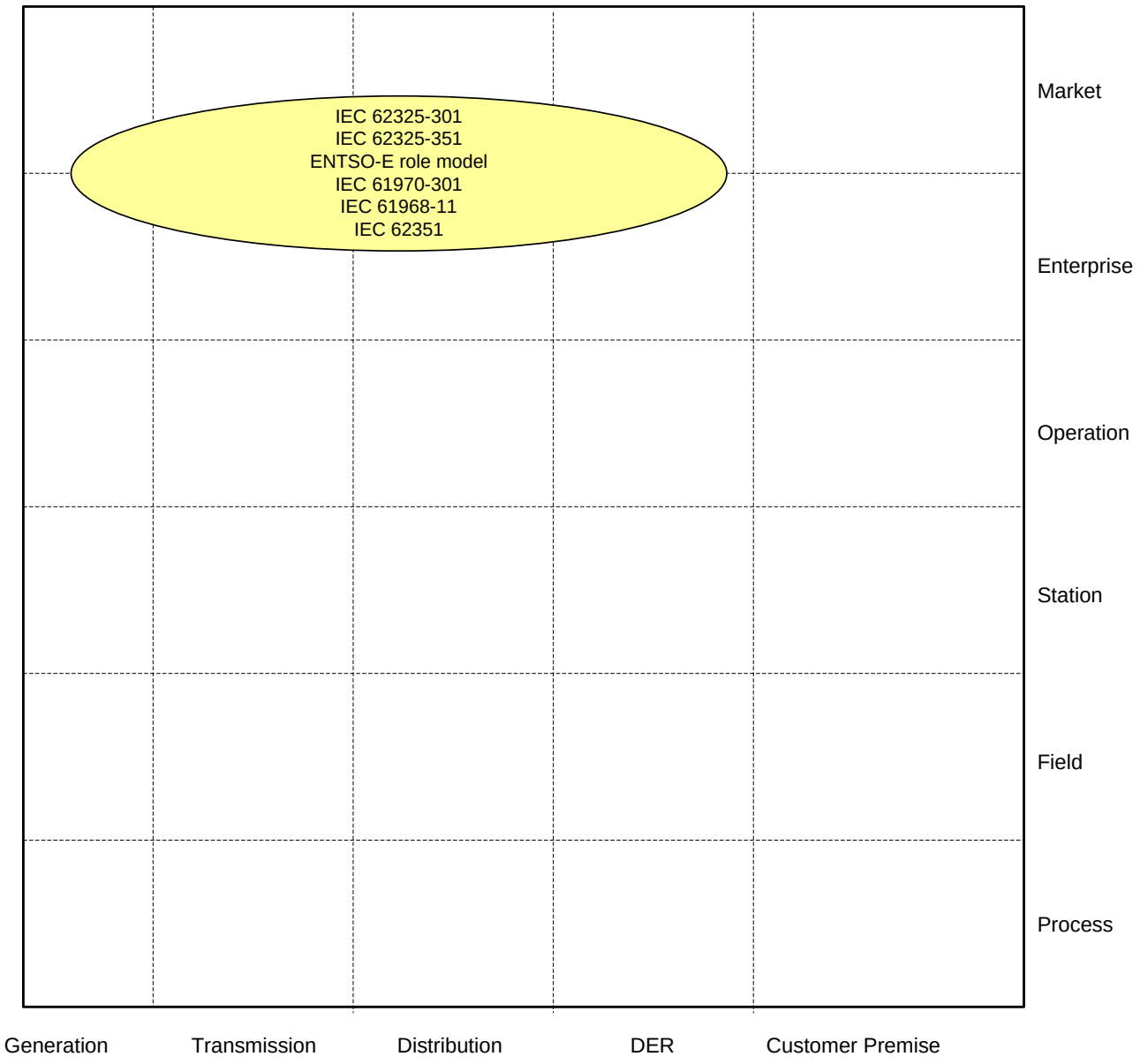


Figure 49 - Marketplace system - Information layer

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, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 57 - Marketplace system – Available standards

Layer	Standard	Comment
Information	ENTSO-E harmonized Role Model	Joint ENTSO-E, ebIX ®, EFET
Information	ENTSO-E Market Data Exchange Standard (MADES)	
Communication	ENTSO-E Scheduling System (ESS)	Latest revision V3R3
Communication	ENTSO-E Reserve Resource Planning (ERRP)	Latest revision V4R1
Communication	ENTSO-E Capacity Allocation and	Latest revision V5R0

Layer	Standard	Comment
	Nomination (ECAN)	
Communication	ENTSO-E Settlement Process (ESP)	Latest revision V1R2
Communication	ENTSO-E acknowledgement process	Latest revision V5R1
Information	EN 61968/61970 (all parts)	Common Information model
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.3)

8.7.1.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 58 - Marketplace system – Coming standards

Layer	Standard	Comment
Information	*IEC 62325*	Power systems management and associated information exchange
Information	*IEC 62325-301*	Framework for energy market communications – Part 301: Common Information Model (CIM) Extensions for Markets
Information	*IEC 62325-351*	Framework for energy market communications – Part 351: CIM European Market Model Exchange Profile
Communication	*EN 62325-450*	Framework for energy market communications - Part 450: Profile and context modeling rules
Communication	*IEC 62325-451-1*	Acknowledgement business process and contextual model for CIM European market
Information	*EN 61970-301*	New edition
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

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 7.5.2.

Table 59 - 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

		Supported by standards		
Use cases cluster	**High level use cases**	**AVAILABLE**	**COMING**	**Not yet**
	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.

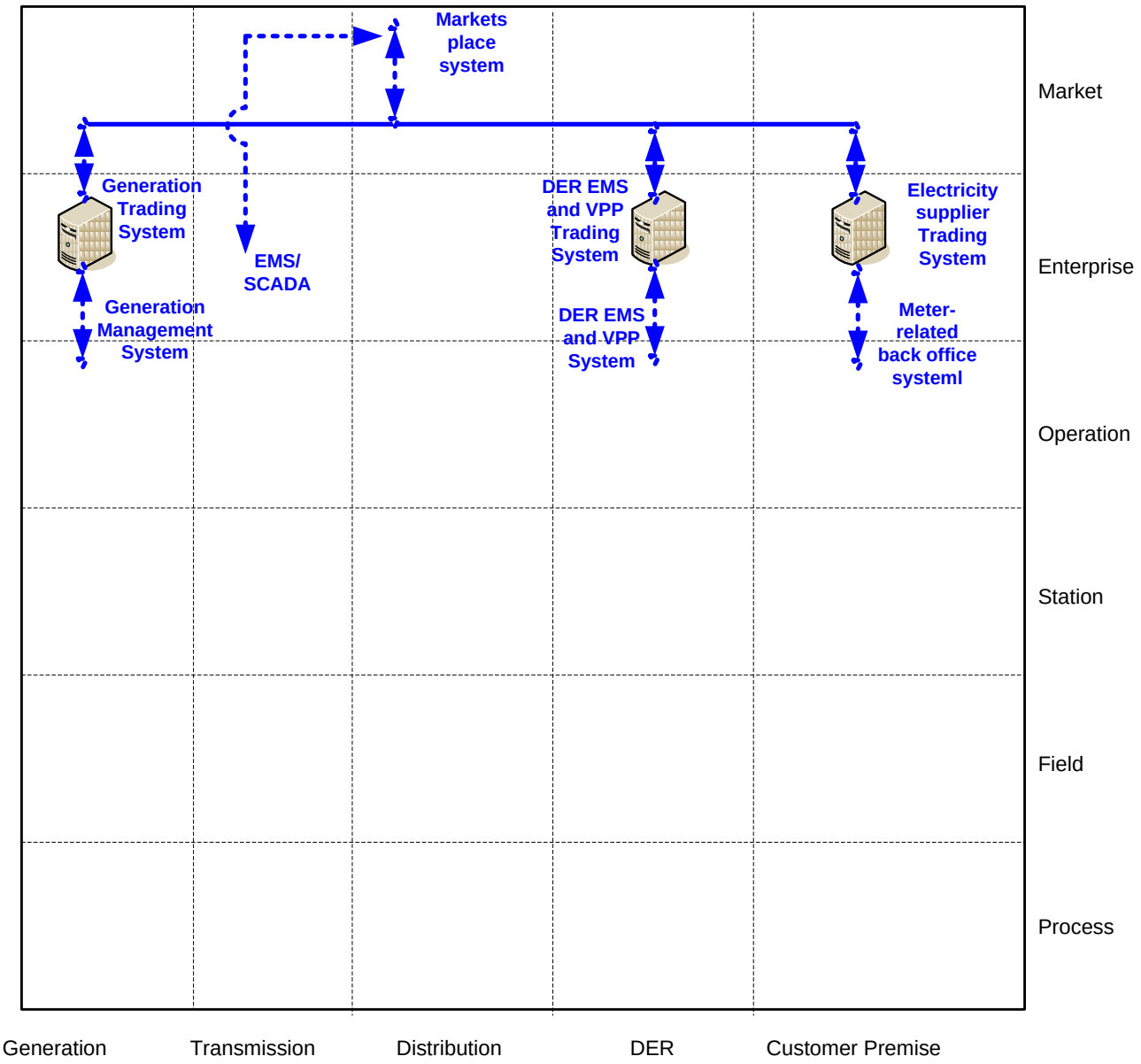


Figure 50 - Trading system - Component layer

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 perform 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 9.3 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 9.2.2.

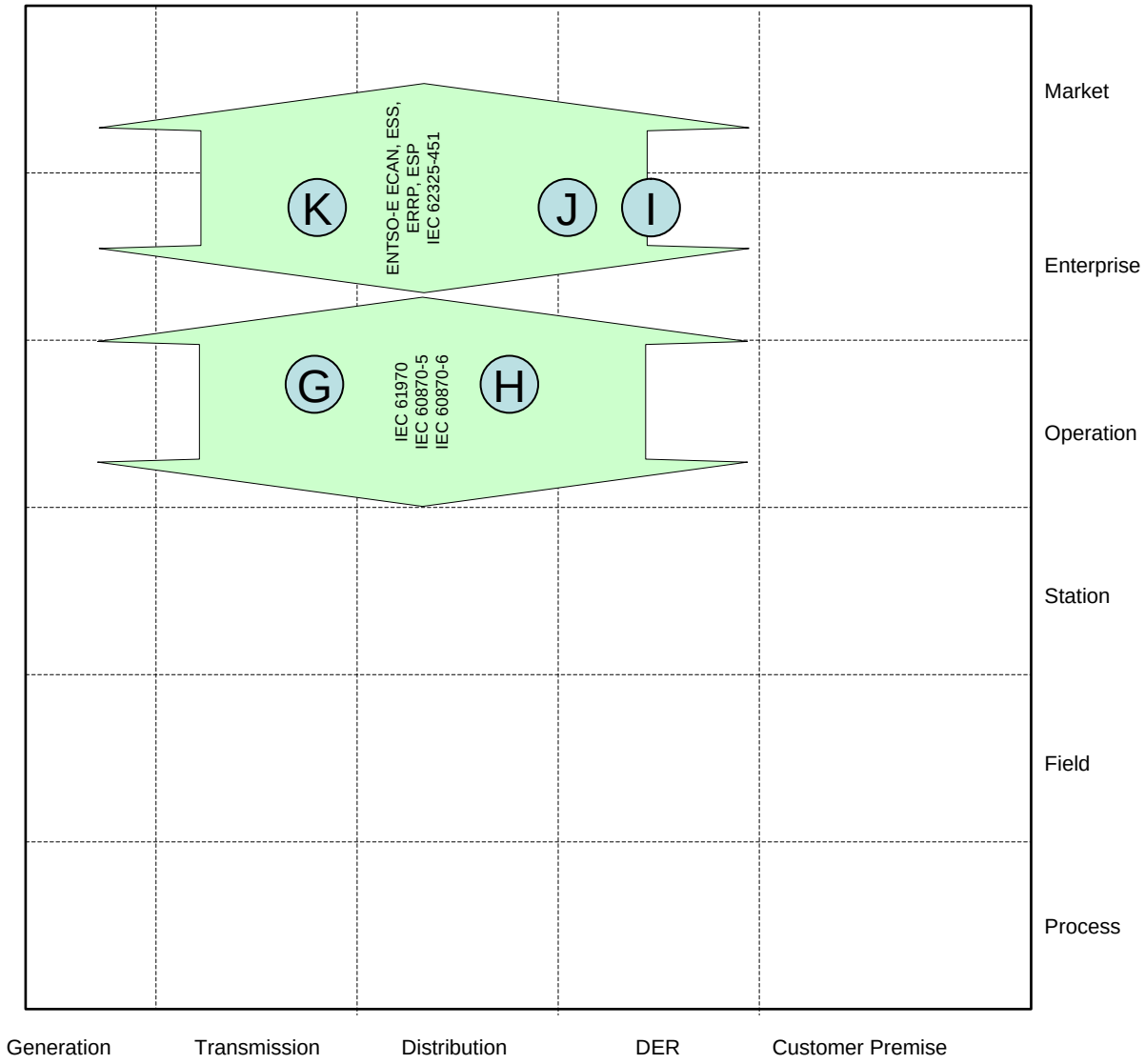


Figure 51 - Trading system - Communication layer

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.

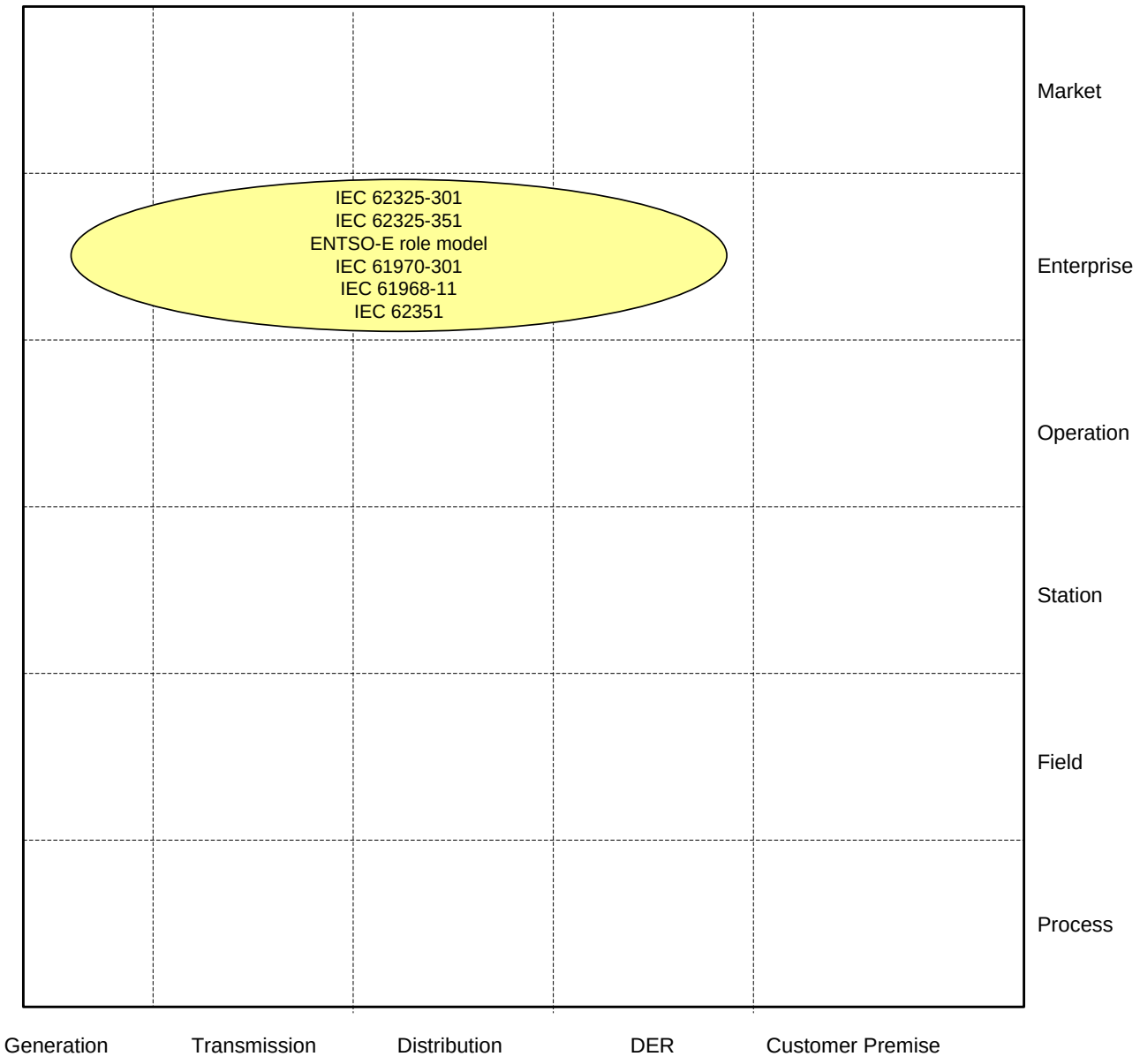


Figure 52 - Trading system - Information layer

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

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 60 - Trading system – Available standards

Layer	Standard	Comment
Information	ENTSO-E harmonized Role Model	Joint ENTSO-E, ebIX ®, EFET
Information	ENTSO-E Market Data Exchange	

Layer	Standard	Comment
	Standard (MADES)	
Communication	ENTSO-E Scheduling System (ESS)	Latest revision V3R3
Communication	ENTSO-E Reserve Resource Planning (ERRP)	Latest revision V4R1
Communication	ENTSO-E Capacity Allocation and Nomination (ECAN)	Latest revision V5R0
Communication	ENTSO-E Settlement Process (ESP)	Latest revision V1R2
	ENTSO-E acknowledgement process	Latest revision V5R1
Information	EN 61970 (all parts)	
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 60870-6	
Communication	IEC 62351 (all parts)	Cyber-security aspects (refer to section 9.3)

8.7.2.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 61 - Trading system – Coming standards

Layer	Standard	Comment
Information	*IEC 62325*	Power systems management and associated information exchange
Information	*IEC 62325-301*	Framework for energy market communications – Part 301: Common Information Model (CIM) Extensions for Markets
Information	*IEC 62325-351*	Framework for energy market communications – Part 351: CIM European Market Model Exchange Profile
Communication	*EN 62325-450*	Framework for energy market communications - Part 450: Profile and context modeling rules
Communication	*IEC 62325-451-1*	Acknowledged business process and contextual model for CIM European market
Communication	*IEC 62351 (all parts)*	Cyber-security aspects (refer to section 9.3)

8.8 E-mobility (connection to grid)

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

The Standardization work within the E-mobility domain is currently on-going under the leadership of the E-Mobility co-ordination group (EM-CG), and a working group for ‘Smart Charging’ was specifically built-up to define role model, associated use cases and to identify standards for E-mobility. Work results are due by end of 2012.

In order to avoid duplication or even divergence, this section of the current FSS report will consequently remain empty. However, as soon as CEN-CENELEC-ETSI agreed material is available, this report will be updated with the E-mobility domain material.

8.9 Administration systems

8.9.1 Asset and Maintenance Management system

8.9.1.1 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 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.

8.9.1.2 Set of use cases

The following high level use cases might be support by a 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 7.5.2.

Table 62 – 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 (refer to 8.9.3)		

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)

8.9.1.3 Mapping on SGAM

8.9.1.3.1 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.

8.9.1.3.2 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

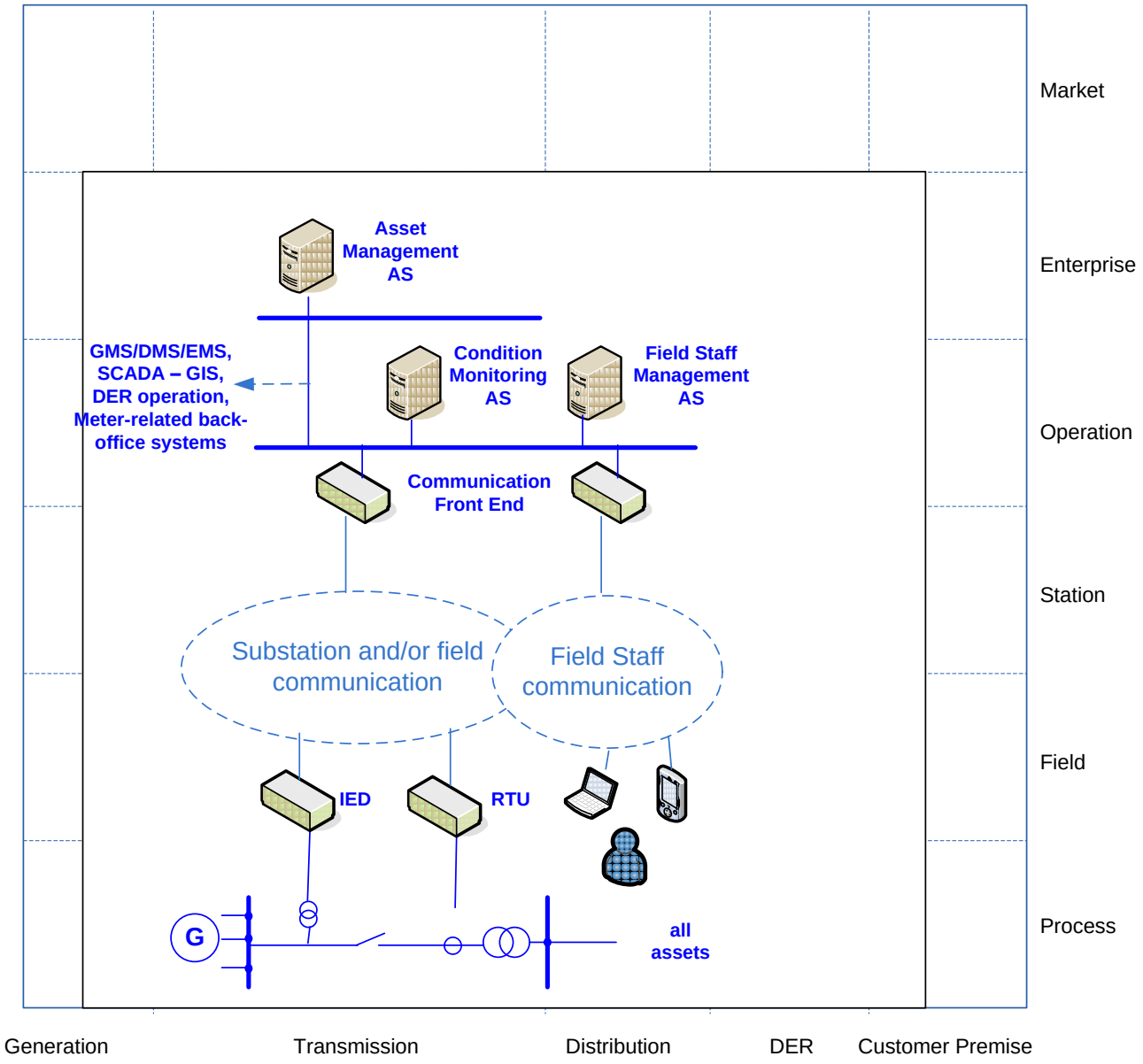


Figure 53 - Assets and maintenance management system - Component layer

8.9.1.3.3 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 that 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 9.2.2.

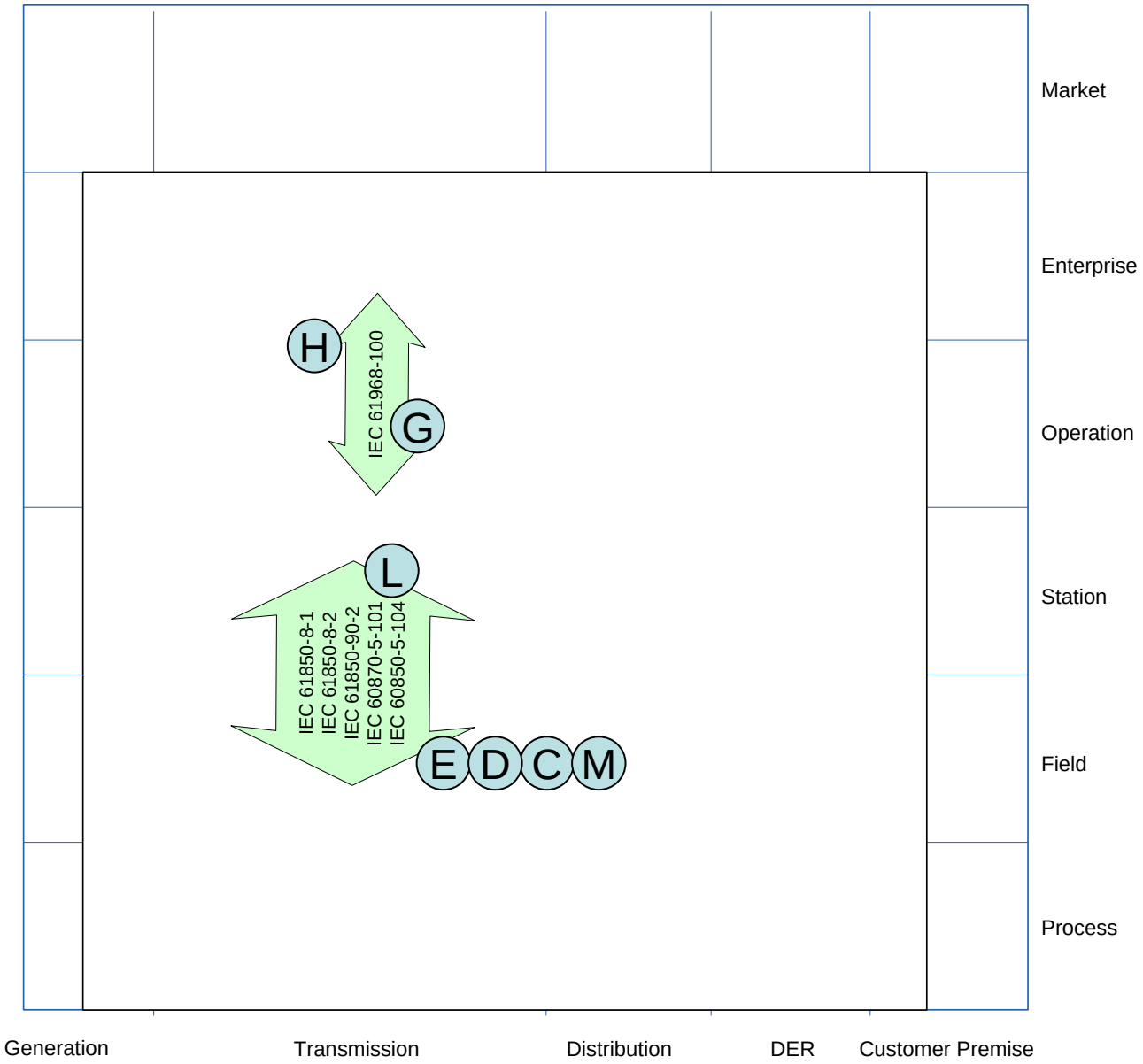


Figure 54 - Assets and maintenance management system - Communication layer

8.9.1.3.4 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.

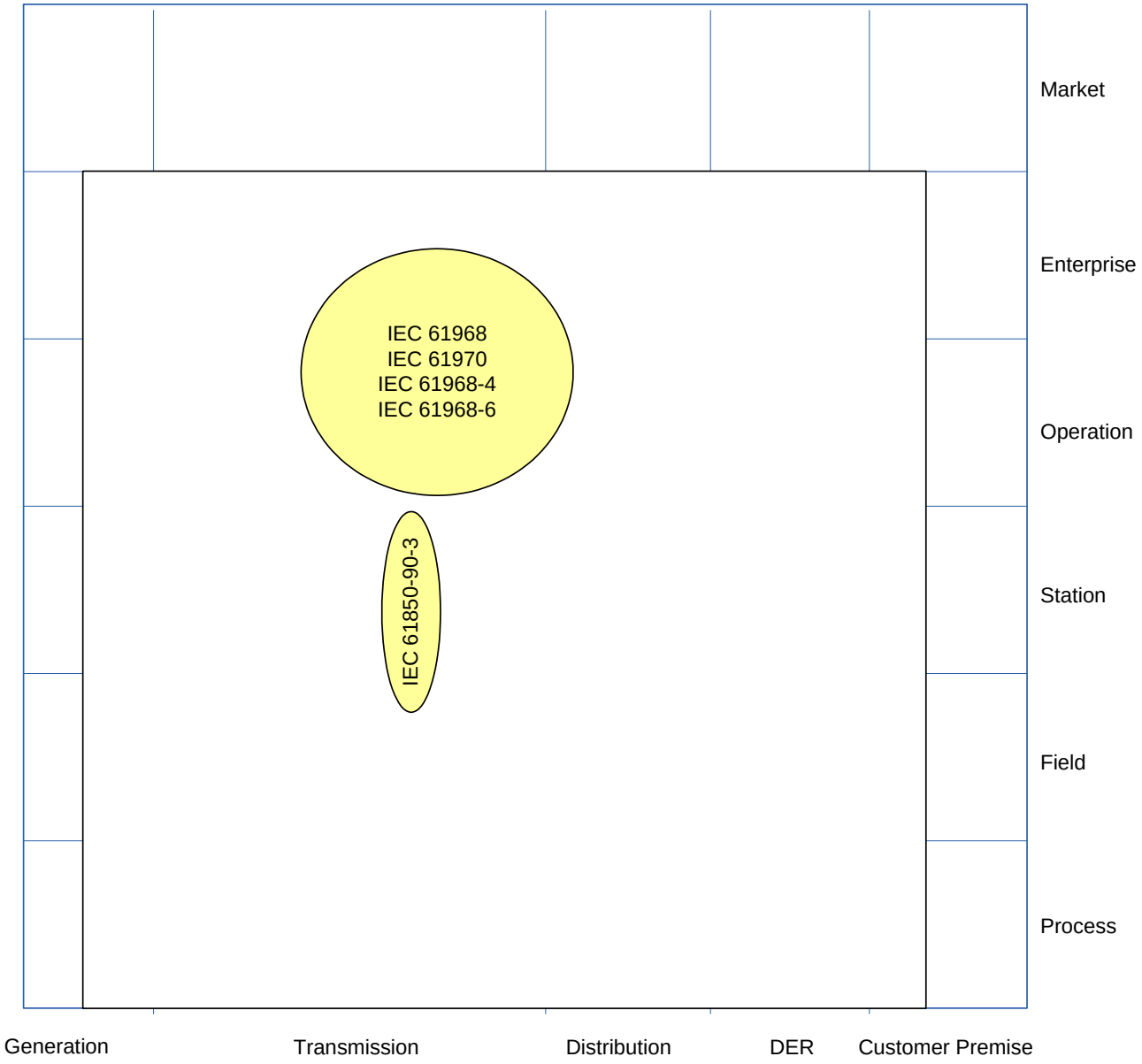


Figure 55 - Assets and maintenance management system - Information layer

8.9.1.4 List of Standards

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

8.9.1.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 63 – Assets and maintenance management system – Available standards

Layer	Standard	Comments
Information	IEC 61850-80-1	Mapping of IEC/EN 61850 data model over 60870-5-101 and 104
Information, communication	EN 61400-25	Edition 1 - Set of standards more specific to wind turbines and wind farms
Information	EN 61968-4	Interfaces for records and asset management
Information	EN 61968 (all parts)	CIM Distribution
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

8.9.1.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 64 – Assets and maintenance management system – Coming standards

Layer	Standard	Comments
Information	*IEC 61850-90-3*	Using IEC/EN 61850 for condition monitoring
Information, communication	*EN 61400-25*	Edition 2 - Set of standards more specific to wind turbines and wind farms
Information	*EN 61968-6*	Interfaces for maintenance and construction
Communication, information	*IEC 61850-90-2*	Substation to control center communication
Communication	*IEC 61850-8-2*	IEC/EN 61850 communication mapping on Web-services
Communication	*EN 61968-100*	Defines profiles for the communication of CIM messages using Web Services or Java Messaging System.

8.9.2 Communication network management system

8.9.2.1 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 9.2.

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.

8.9.2.2 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.

8.9.2.3 Mapping on SGAM

8.9.2.3.1 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.

8.9.2.3.2 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.

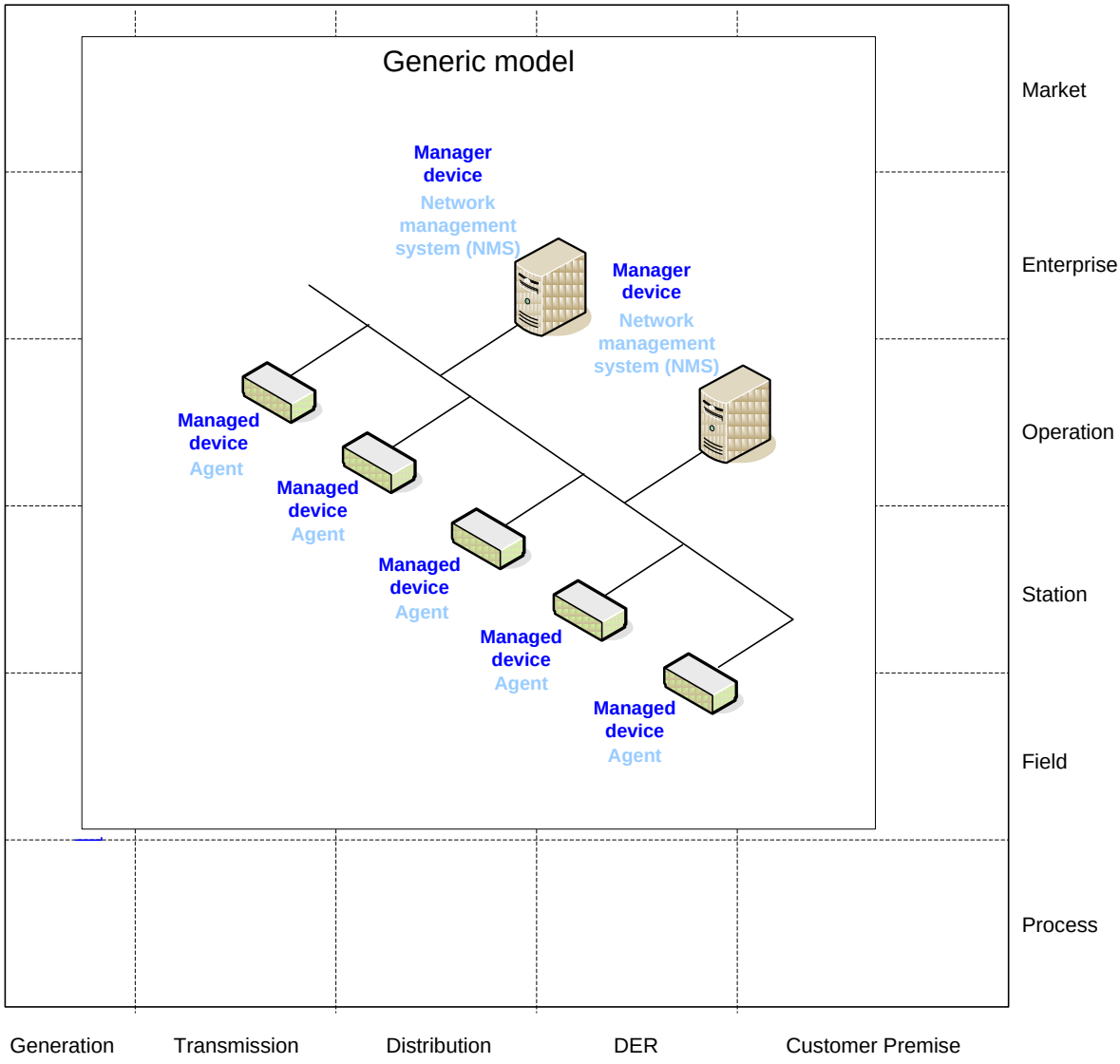


Figure 56 – Communication network management - Component layer

8.9.2.3.3 Communication layer

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.2.2.

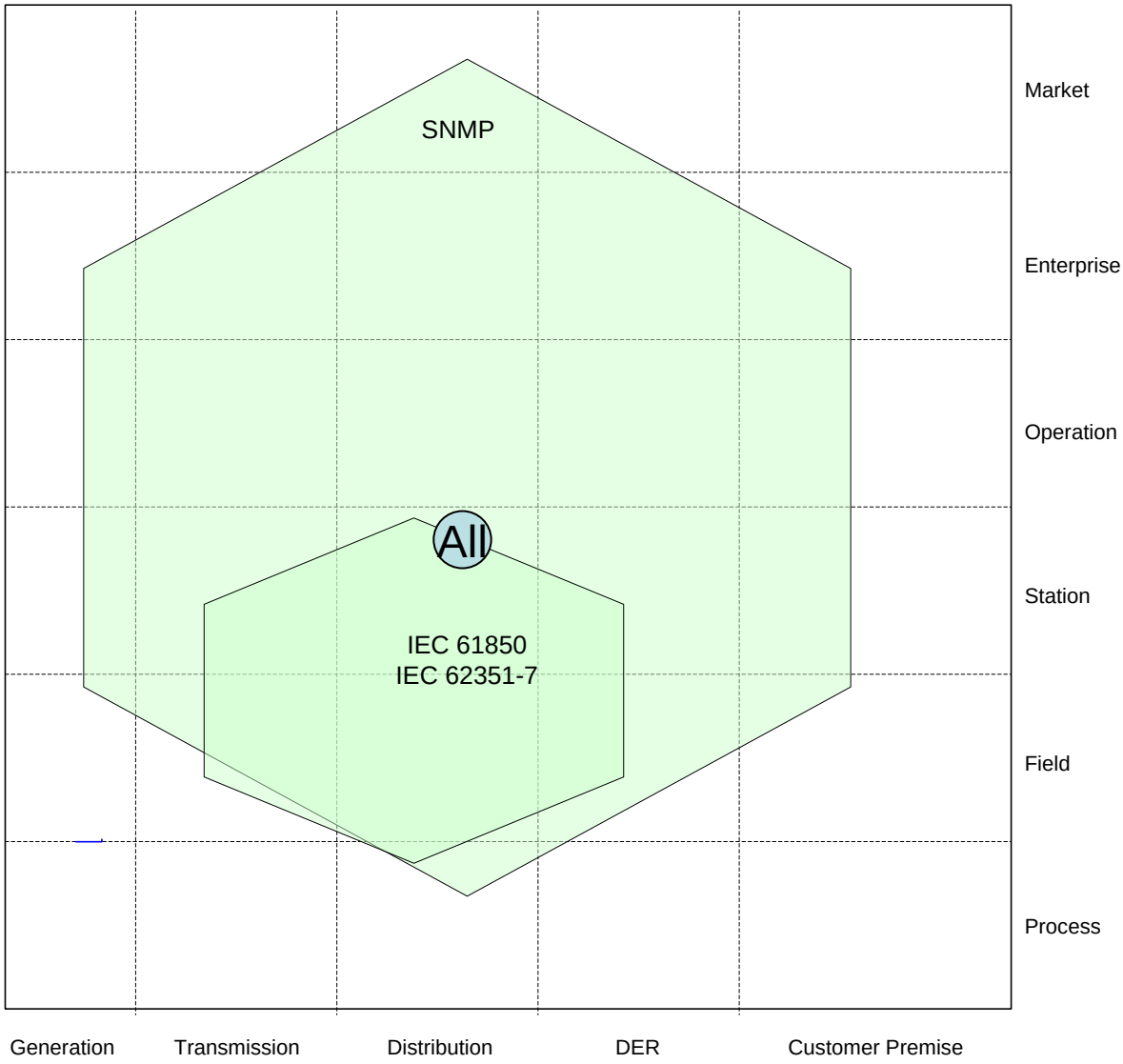


Figure 57 - Communication network management - Communication layer

8.9.2.3.4 Information (Data) layer

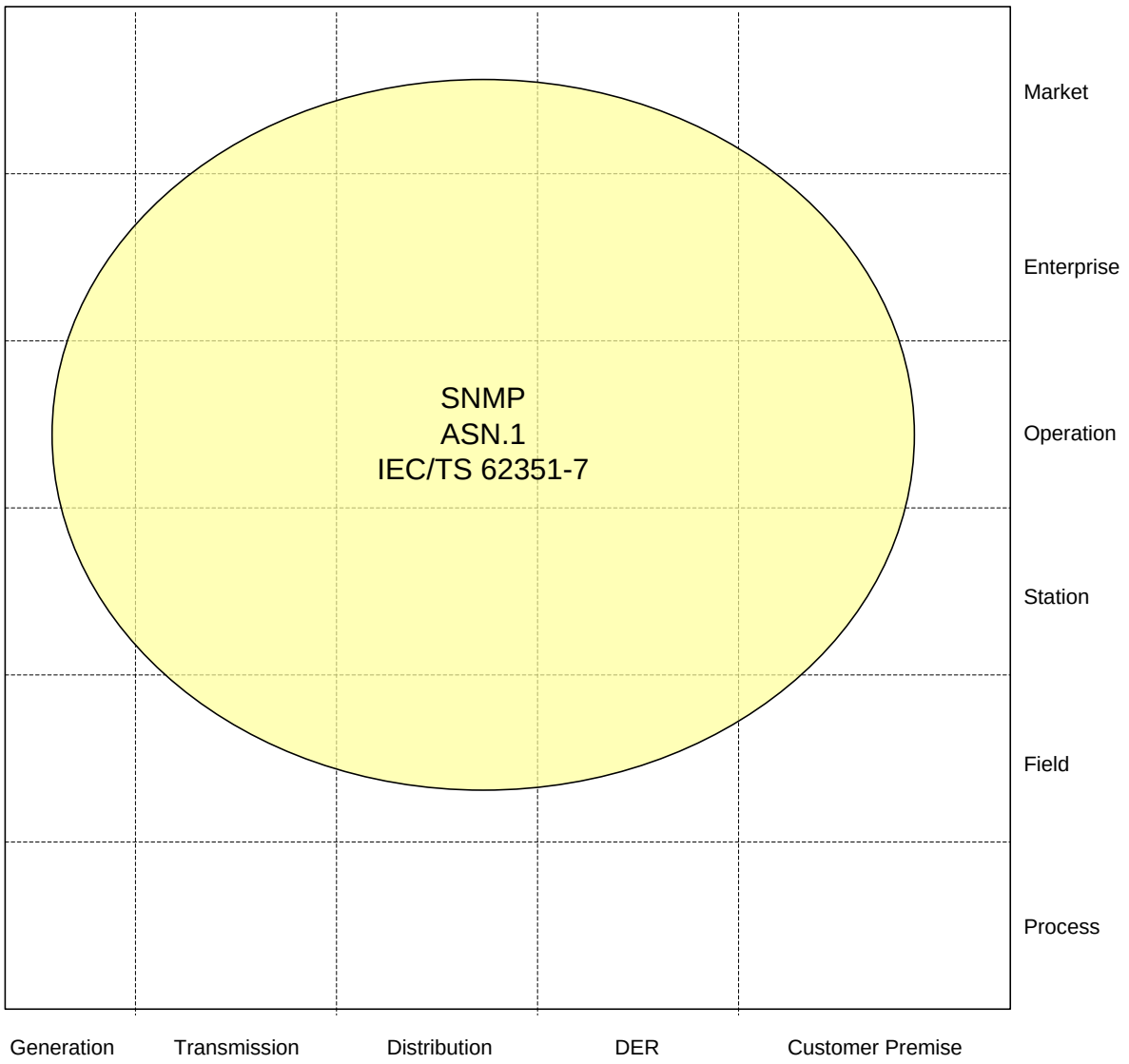


Figure 58 - Communication network management - Information layer

8.9.2.4 List of Standards

8.9.2.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 65 - 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
Communication	IETF RFC 768	UDP/IP

8.9.2.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 66 - Communication network management - Coming standards

Layer	Standard	Comments
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

8.9.3 Clock reference system

8.9.3.1 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.

8.9.3.2 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 7.5.2.

Table 67 - 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**	

8.9.3.3 Mapping on SGAM

8.9.3.3.1 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.

8.9.3.3.2 Component layer

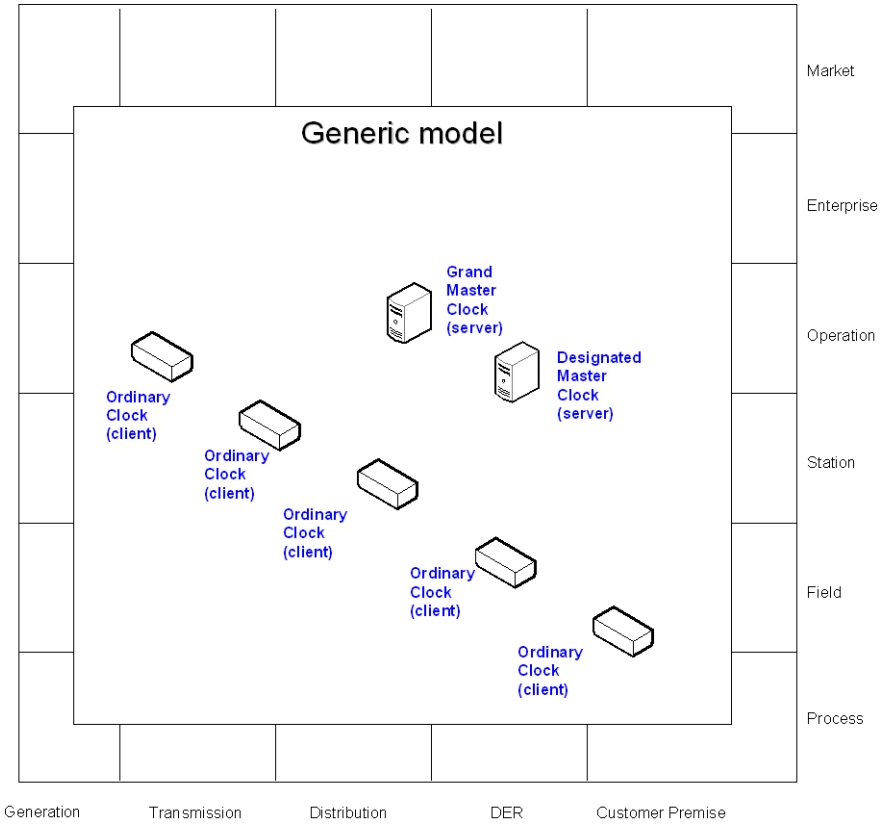


Figure 59 – Clock reference system - Component layer

8.9.3.3.3 Communication layer

Note: the letters in the blue disks shown in the diagram below refer to the network types defined in 9.2.2.

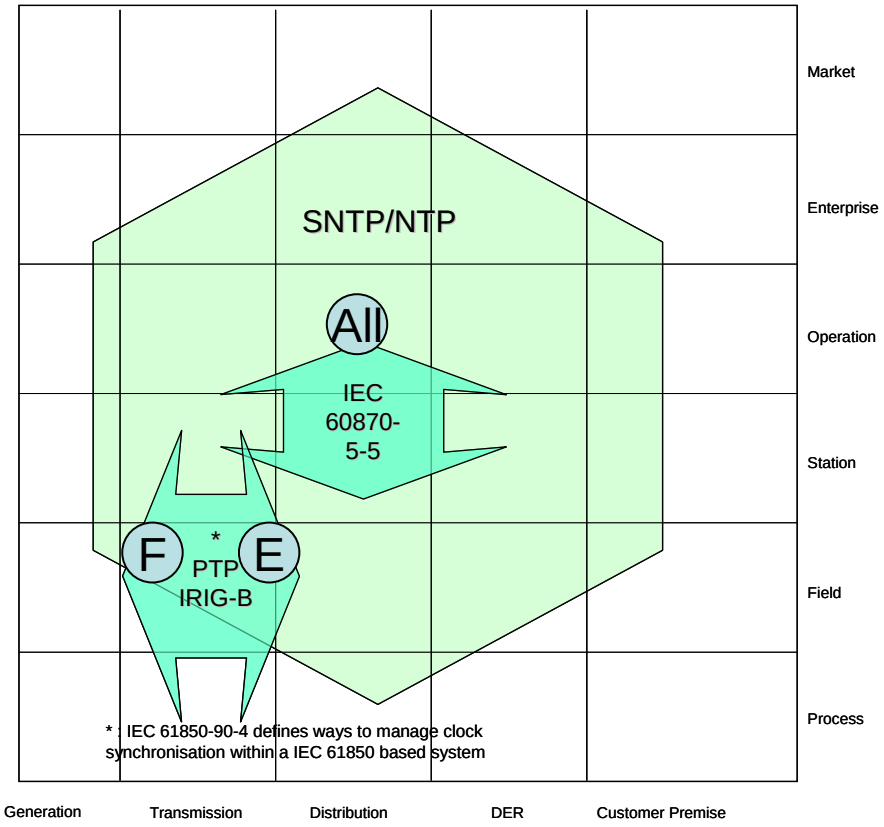


Figure 60 – Clock reference system - Communication layer

8.9.3.3.4 Information (Data) layer

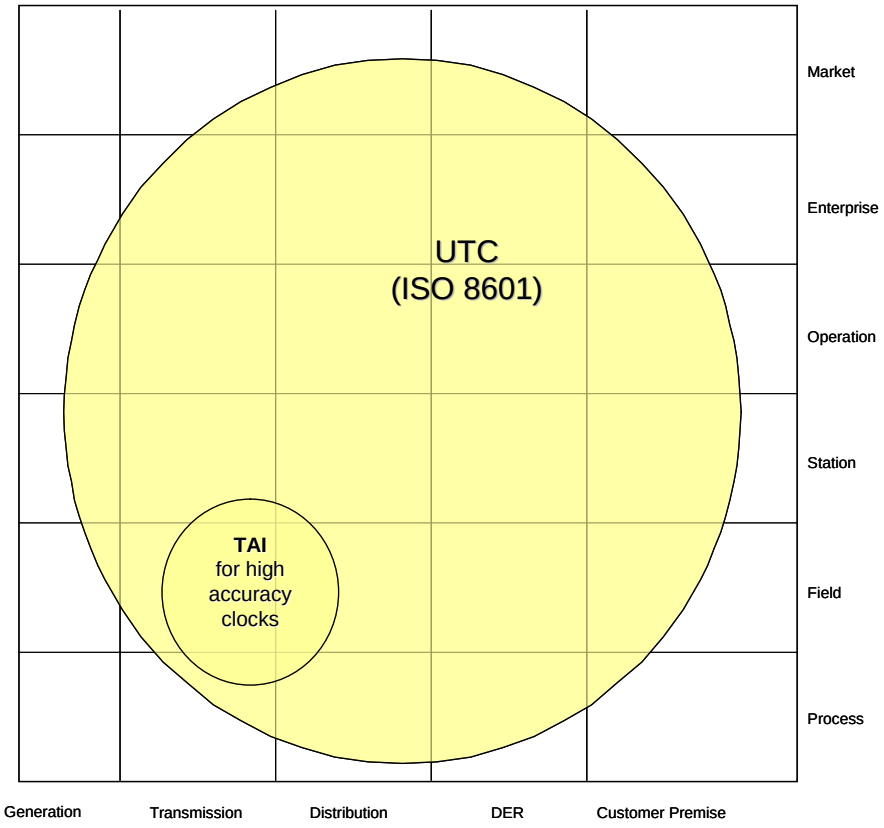


Figure 61 – Clock reference system - Information layer

8.9.3.4 List of Standards

8.9.3.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 68 - 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	IETF RFC 5905	NTP – Network Time protocol
Communication	IETF RFC 4330	SNTP – Simplified Network Time protocol
Communication	EN 60870-5-5	Telecontrol equipment and system – including time synchronization basic application
Communication	IEEE 1588	PTP (Precision Time Protocol)
Communication	IEC 61850-90-5	
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

8.9.3.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 69 - Clock reference system – Coming standards

Layer	Standard	Comments
Communication	*IEC 61850-90-4*	Network Engineering Guidelines for IEC/EN 61850 based systems (including clock synchronization guidelines)

8.9.4 Authentication, Authorization, Accounting Systems

8.9.4.1 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.

When it comes to technically look at an AAA system it is difficult to do the exercise without having a context. Even if the same kind of actions is performed, the way they are performed and they can be described depends on the context and the technical architecture used in that context. 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).

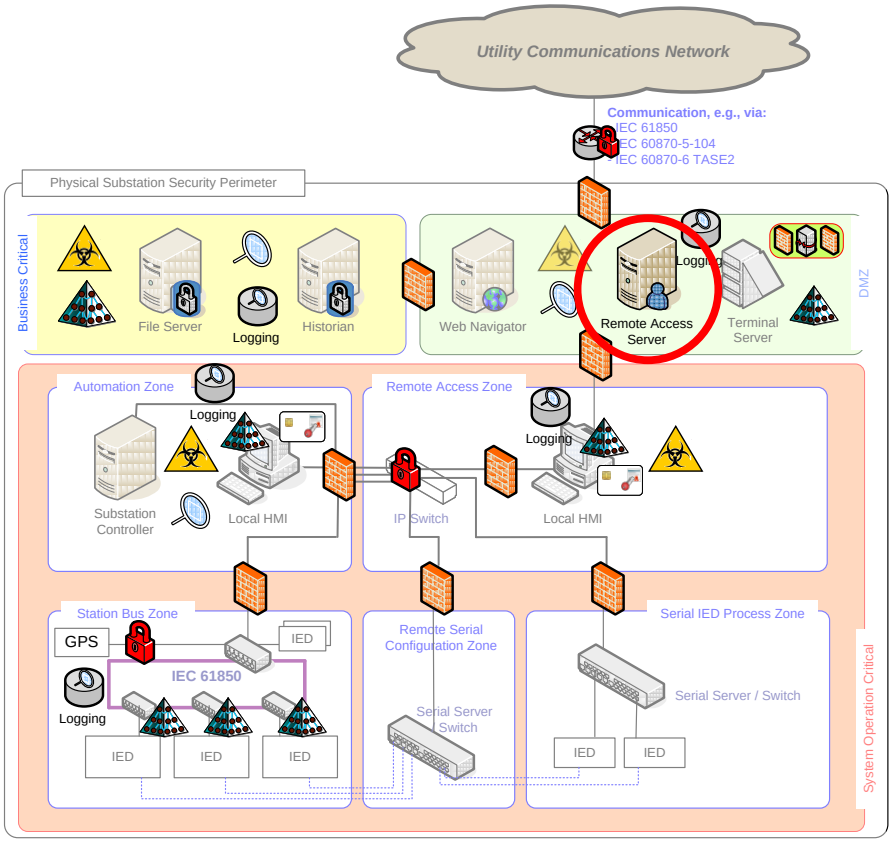


Figure 62: AAA Example in a Substation Automation Use Case

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.

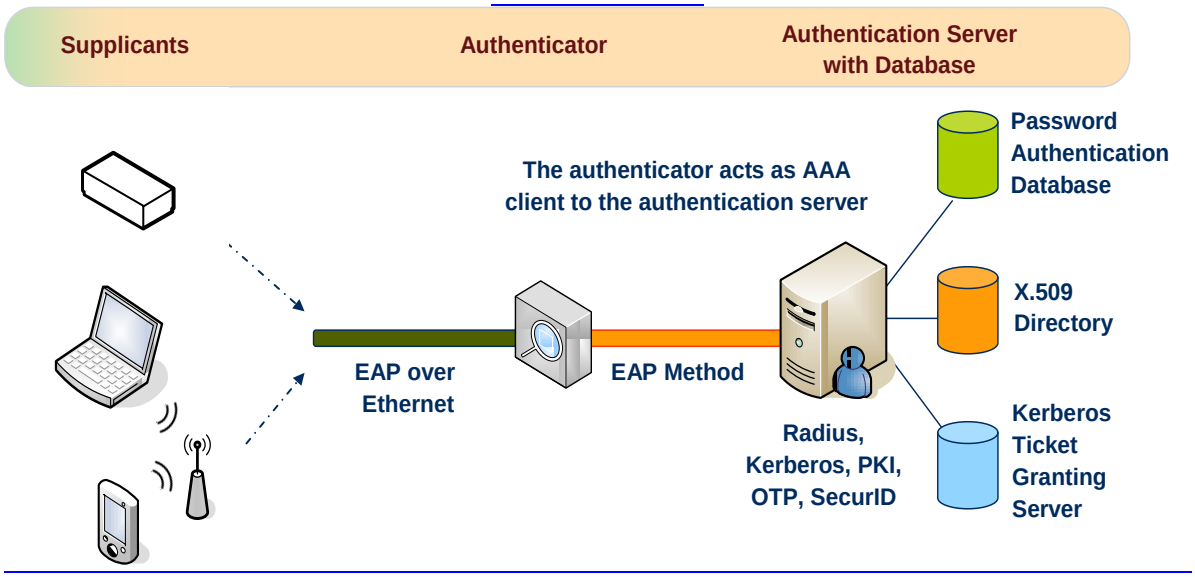


Figure 63: EAP Overview

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. This termination of the VPN in the substation is connected with the AAA infrastructure to ensure that only authenticated and authorized connections are possible. This is often 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 means 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.

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.

8.9.4.2 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 7.5.2.

Table 70 - 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			
	Role Management			
	Rights/Privileges Management			
	Certificate Management			
	Events Management		X	

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.

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.

8.9.4.3 Mapping on SGAM

8.9.4.3.1 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.

8.9.4.3.2 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 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.

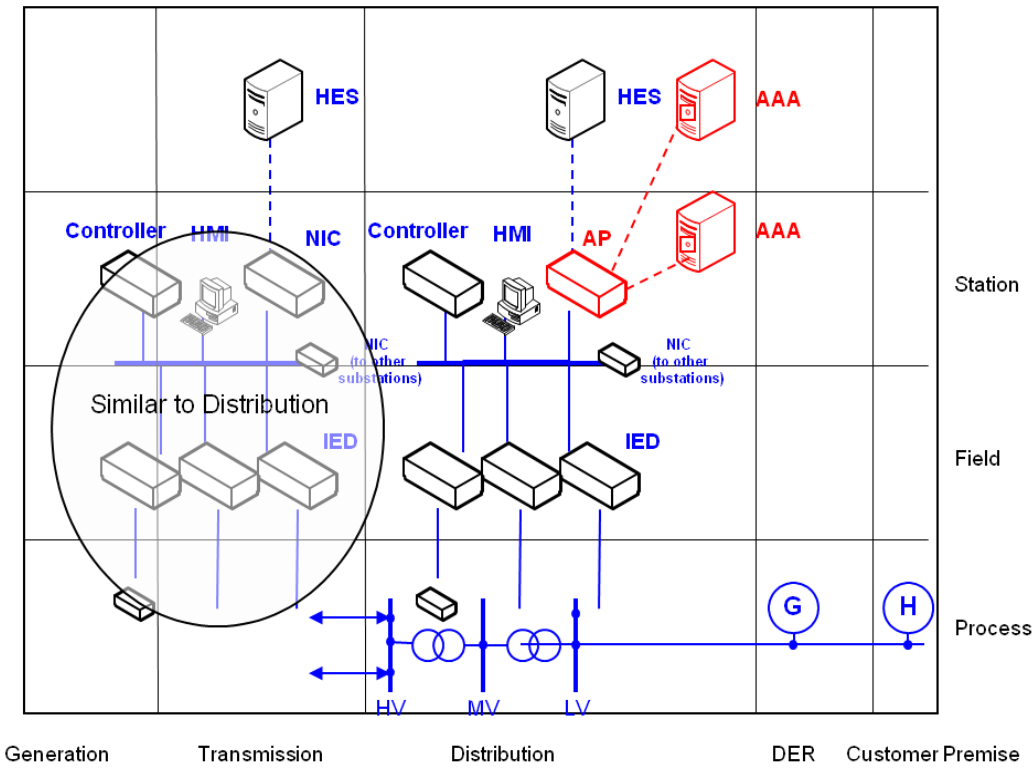


Figure 64 - Mapping of Standards used in the AAA Example on SGAM - Component Layer

8.9.4.3.3 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. IEC 62351-8 provides a solution to support role based access control based on specific credentials, 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. This approach may be followed within a substation but also to access the substation from outside, 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 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.

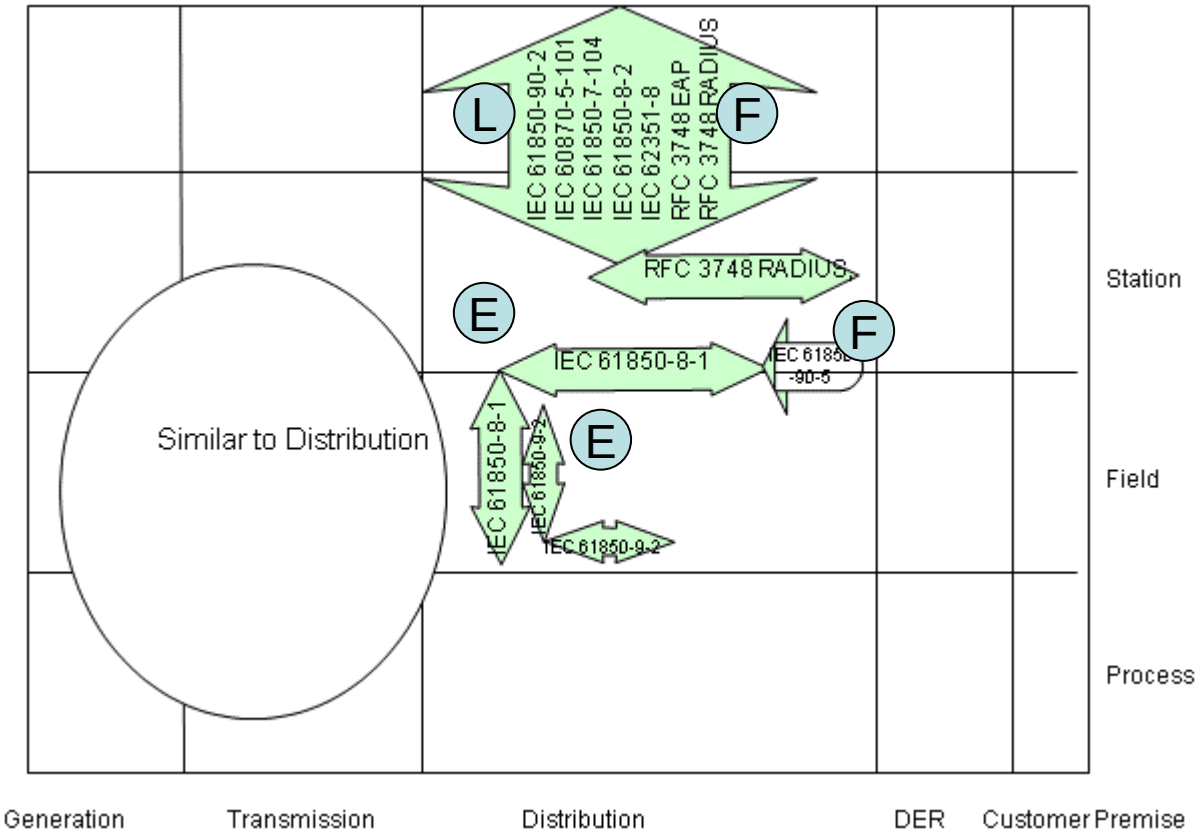


Figure 65 - Mapping of Standards used in the AAA Example on SGAM - Communication Layer

8.9.4.3.4 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. In addition, the 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
- 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.

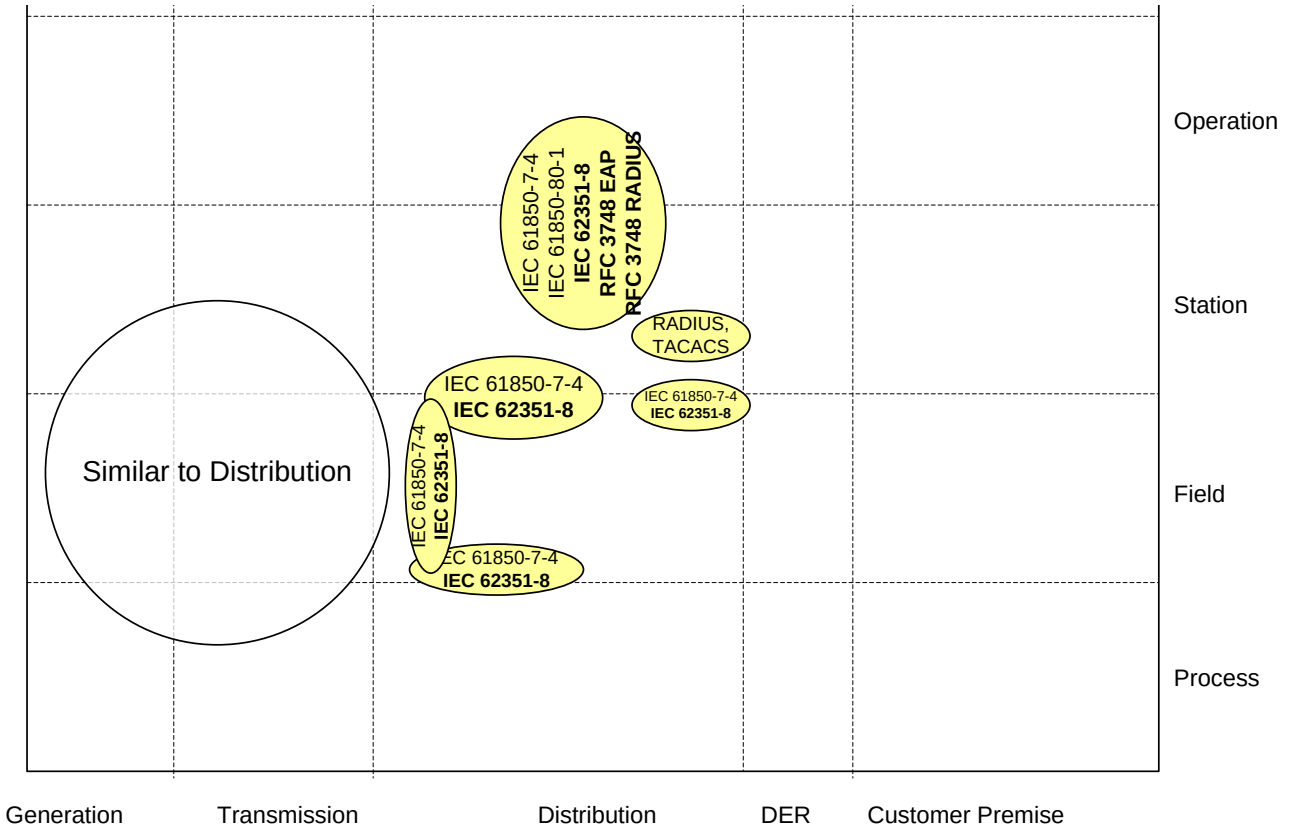


Figure 66 - Mapping of Standards used in the AAA Example on SGAM - Information Layer

8.9.4.4 List of Standards

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

8.9.4.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 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 71 - 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 or IEC 60870-5-104 communication using TLS together with RAC credentials
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

8.9.4.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 72 - AAA system - Coming standards

Layer	Standard	Comments
Information	*IEC 62351-3 ed2*	TLS profiling for TCP/IP
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 61850-8-2*	IEC 61850 Specific communication service mapping (SCSM) – Mappings to web-services

8.9.5 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 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 2012 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.

8.9.6 Weather forecast and observation system

8.9.6.1 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.

8.9.6.2 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 7.5.2.

Table 73 - 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	

8.9.6.3 Mapping on SGAM

8.9.6.3.1 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:

8.9.6.3.2 Component layer

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

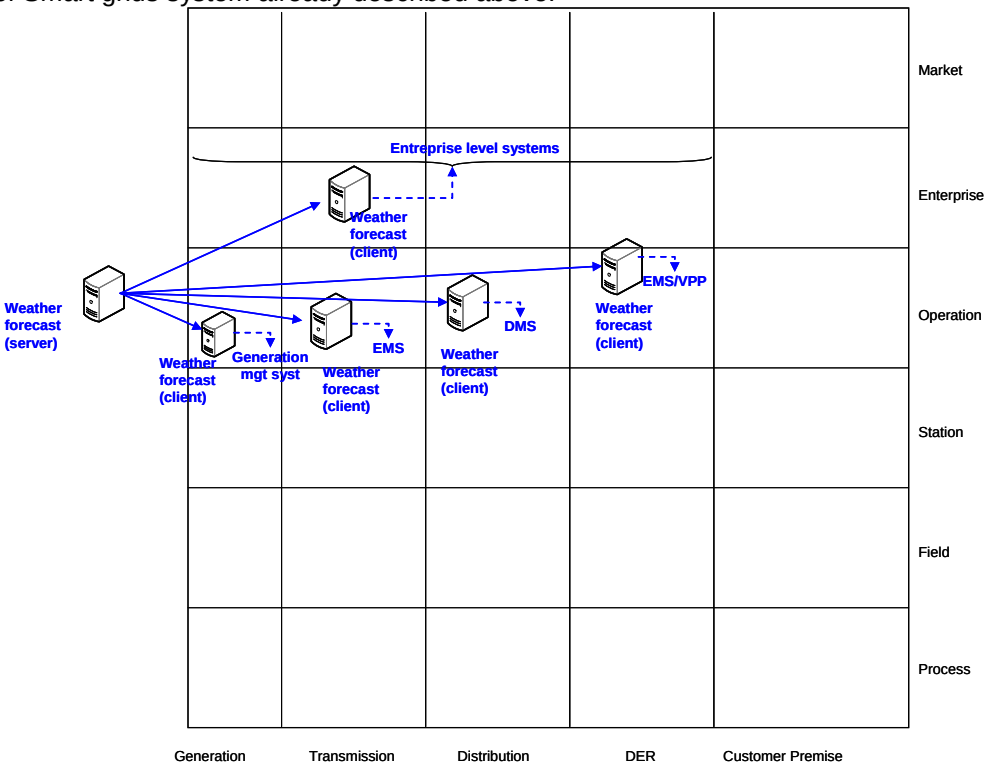


Figure 67 - Weather forecast and observation system - Component layer

8.9.6.3.3 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 9.2.3 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 9.2.2.

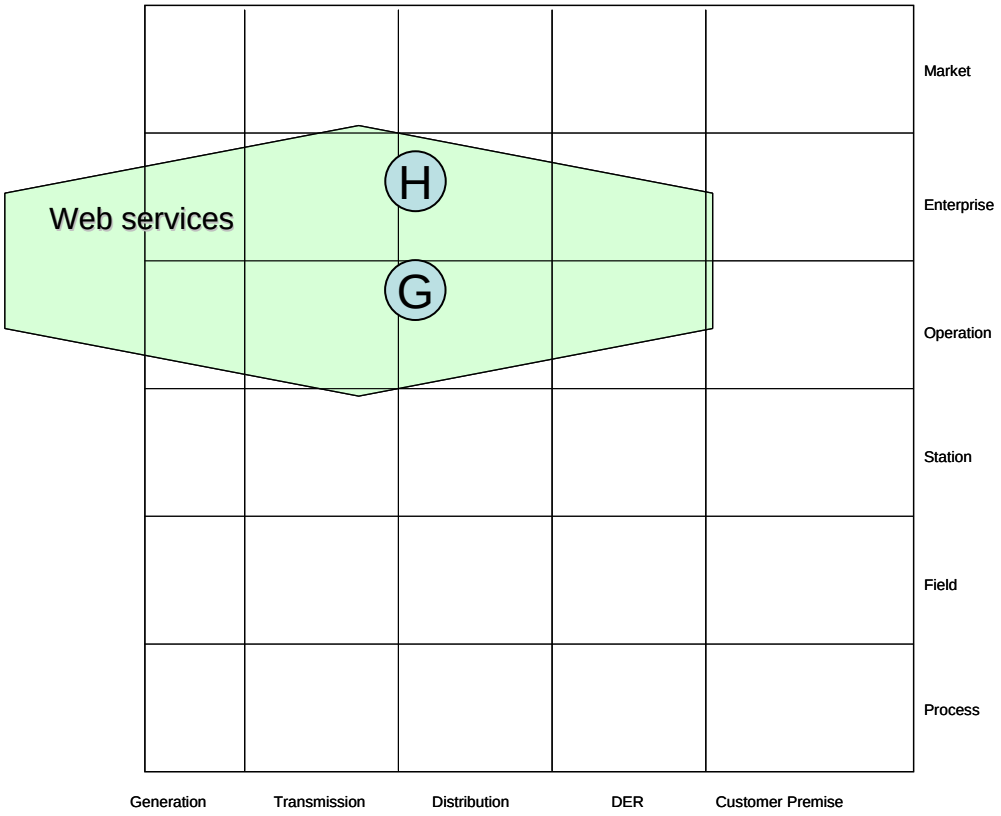


Figure 68 - Weather forecast and observation system - Communication layer

8.9.6.3.4 Information (Data) layer

Even if not perfect WXXM 1.1 XML interface standard is providing a good basis. GML inheritance may not be needed and some data types may be lacking.

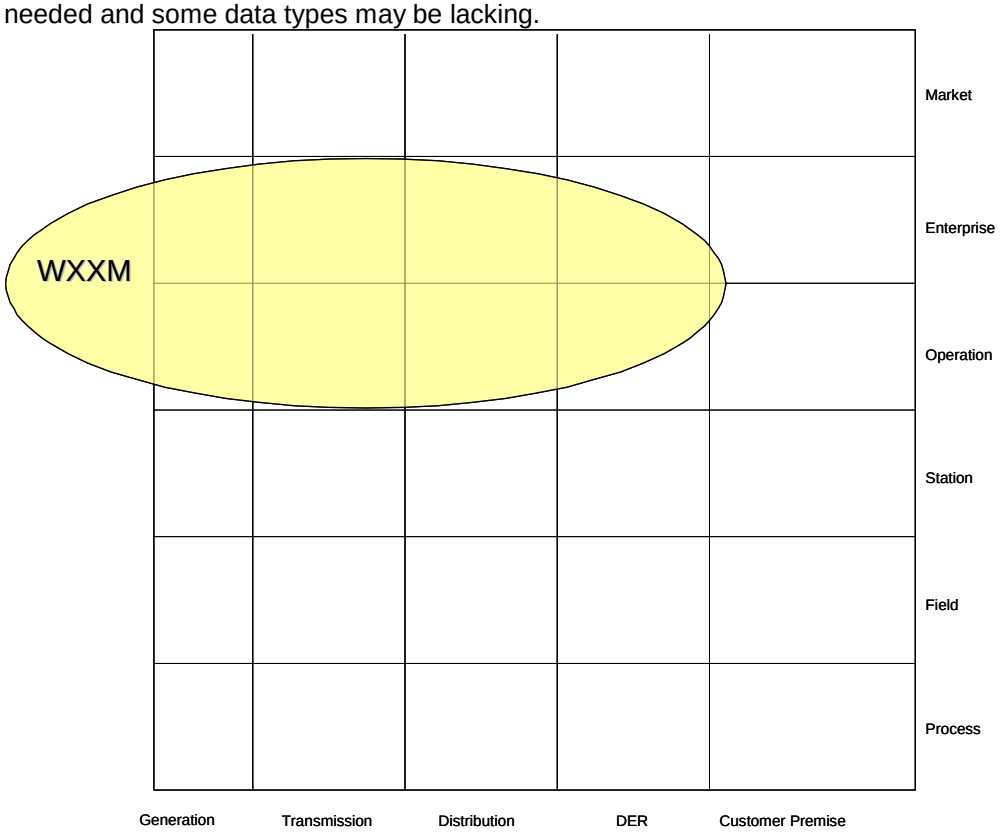


Figure 69 - Weather forecast and observation system - Information layer

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.

8.9.6.4 List of Standards

8.9.6.4.1 Available standards

In compliance with section 6, a standard (or "open specification") that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as "available".
Web service related standards are described in 9.2.3.
The tables below describe the standards which are often considered in addition to section 9.2.3.

Table 74 - Weather forecast and observation system - Available standards

Layer	Standard	Comments
Communication	ISO 19142	OpenGIS Web Feature Service 2.0 Interface Standard

Layer	Standard	Comments
Information	NCAR WXXM	Weather Exchange Model. The release V1.1 seems appropriate https://wiki.ucar.edu/display/NNEWD/WXXM

8.9.6.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 75 - Weather forecast and observation system - Coming standards

Layer	Standard	Comments
Information	WMO METCE	WMO (World Meteorological Organization) METCE (Weather Water and Climate exchange) . Release scheduled for July 2013. Release candidate 1 is scheduled for October of this year
Information	NCAR WXXM	Weather Exchange Model. The release v.20

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

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 mandate [1] a first step consists in defining and setting-up “sustainable processes”. More specifically, use cases are needed for the description of Smart Grid functionalities. Several committees are already using use cases for their internal work.
IEC Strategic Group 3 “Smart Grids” (SG3) demands 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 Ad hoc Group 4 (AHG 4) is coordinating the task and defined several domain core teams (DCT) and a subgroup “Method & Tools”.

This aim goes fully in line with the work achieved by the SG-CG/SP group, reported as [10], and a close cooperation and exchange of experience and ideas is ensured in order to avoid conflicting double work.

Working on use cases also evolves the definition of new terms which can be used within the terminology (e.g. for the International Electrotechnical Vocabulary of IEC (IEV, www.electropedia.org). Setting-up a library of use cases, cross-cutting many technology domains is only efficient defining a frame of consistency. Such frame includes:

- Common list of actors and their exact role (refer to annex I)
- Common words (functions, data, services, …)

Table 76 – System 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

Many evolutions of this eco-system are in the pipe such as the use case template update (8/1307/NP), but have not reached yet the triggers defined in 6.3.

9.2 Telecommunication

The following section is based on the SGCG RAWG report [9], Annex F.

9.2.1 Introduction

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 scope of applications in telecommunications services associated to electrical networks is to provide machine to machine services for the acceptance, transmission and delivery of the messages.

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
- Powerline: communication through cable designed for electric power transmission, but used for carrying data too.

Wireless communications must be compliant with Telecommunication Directive 99/05/CE. According to that Directive telecommunication equipments are classified in two classes:

- Class 1 equipments (http://cept.org/ecc/topics/short-range-device-regulations-and-indicative-list-of-equipment-sub-classes-in-accordance-with-the-rtte-directive-(19995ec)) can be used in all the EU countries without restrictions
- Class 2 equipments can be used according to restrictions published in National Frequency Tables (http://www.cept.org/eco/eco-tools-and-services/efis-eco-frequency-information-system/national-frequency-tables).

Some examples of class 2 equipments for electrical network:

- Netherlands & Belgium & Cyprus, Meter Reading System: 169.4-169.475 MHz
- Hungary, Meter Reading System 169.4-169.475 MHz & 169.4875-169.5875 MHz
- Spain, UN-74: 166.9-167.5 MHz, 171.5-172.1 MHz, 415.3-415.8 MHz, 425.3-425.8 MHz

The Official Journal of the European Union regularly publishes the titles and references of the harmonized standards under the directive 99/05/EC. All equipment connected by radio and/or through public telecommunication networks, shall comply with directive 99/05/EC and harmonized standards are used for presumption of conformity. The defined standards & versions in Official Journal of the European Union as harmonized standard, covering essential requirements under article 3.2 of the R&TTE directive (1999/5/EC) is available, this is subject to regular revision & may be updated as a result of this study.

For Smart Grid communication architecture/technology, products based on specifications from industry consortia (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. The SGCG RAWG report, Annex F provides further detailed information on standards pertaining to Smart Grid communications.

The remaining of this section is structured as follows:
Section 9.2.2 provides an overview of communications networks (layer 1 to layer 3 according to the OSI layers). Standards/specifications listed in this section are grouped according to standards families where each family has applicability statement to Smart Grid communications sub-networks.
Section 9.2.3 provides a list of higher level communication protocol standards/specifications (layer 4 and above) used to support Smart Grid applications.

Note: The section below has not been written to specifically include the Smart Metering related standards. Some specific requirement 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.

9.2.2 Communications networks for the Smart Grid

9.2.2.1 Introduction

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[10]:

- **(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) Field Area Network**
  networks at the distribution level upper tier, which is a multi-services tier that integrates the various sub layer networks and provides backhaul connectivity in two ways: directly back to control centers via the WAN (defined below) 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.

- **(D) Low-end intra-substation network**
  networks 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) **Enterprise Network**

[10] 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 9.3 and SG-CG/SGIS report [11]

enterprise or campus networks, as well as inter-control centre networks. Since utilities typically have multiple control centres and multiple campuses that are widely separated geographically.

- **(I) Balancing Network**
  networks that interconnect generation operators and independent power producers with balancing authorities, and networks those interconnect balancing authorities with each other. In some emerging cases, balancing authorities may also dispatch retail level distributed energy resources or responsive load.

- **(J) Interchange network**
  networks that interconnect regional reliability coordinators with operators such as transmission operators and power producers, as well as networks that connect wholesale electricity markets to market operators, providers, retailers, and traders. In some cases, the bulk markets are being opened up to small consumers, so that they have a retail-like aspect that impacts networking for the involved entities.

- **(K) Trans-Regional / Trans-National network**
  networks that interconnect synchronous grids for power interchange, as well as emerging national or even continental scale networks for grid monitoring, inter-tie power flow management, and national or continental scale renewable energy markets. Such networks are just beginning to be developed.

- **(L) Wide and Metropolitan Area Network**[11]
  networks that can use public or private infrastructures. They inter-connect network devices over a wide area (region or country) and are defined through SLAs (Service Level Agreement).

- **(M) Industrial Fieldbus Area Network**
  networks that interconnect process control equipment mainly in power generation (bulk or distributed) in the scope of smart grids.

[11] Several of the shown networks could be based on WAN technologies. However since those networks
- can be run / managed by different stakeholders,
- could provide different level of security or different SLAs

they are depicted separately. It should be noted however that this is a logical view and that in practice multiple logical networks can be implemented using a single WAN technology. Implementation design choices are beyond the scope of this report

Figure 70 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.

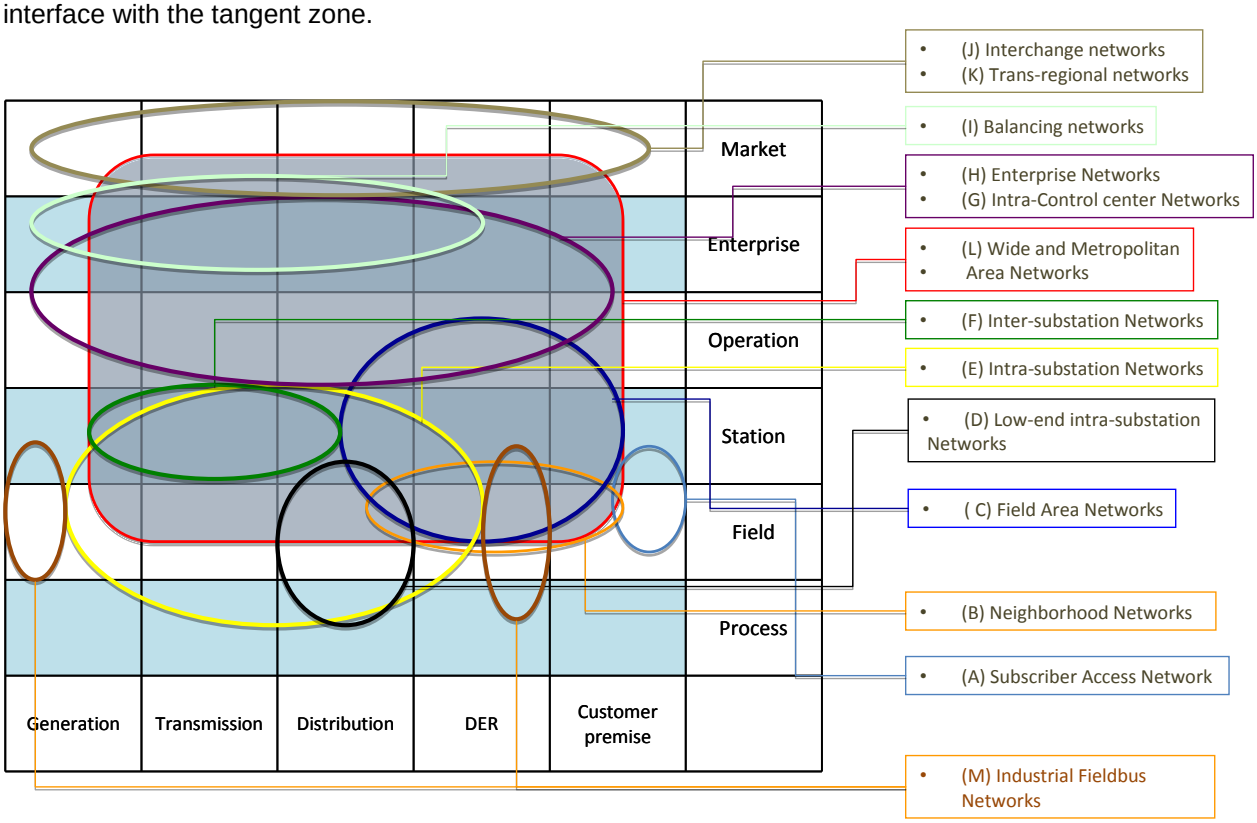


Figure 70 - Mapping of communication networks on SGAM

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.

9.2.2.2 Applicability of communication standards to Smart Grid networks

The following Table 77 provides an applicability statement indicating the standardized communication technologies to the Smart Grid sub-networks depicted in the previous sub-clause. As mentioned in [9], 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 to CEN/CLC/ETSI TR 50572 [4] and other future deliverables as listed in SMCG_Sec0025_DC_V0.3 Work Program [5].

Each line in the Table 77 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 77 - Applicability statement of the communication technologies to the smart grid sub-networks

	Subscriber access network	Neighbourhood Network	Field area	Low-end intra substation	Intra-substation	Inter-substation	Intra control centre	intra data centre	Enterprise	Balancing	Interchange	Trans regional	Trans national	WAN	Industrial Fieldbus
	A	B	C	D	E	F	G		H	I	J	K		L	M
Narrow band PLC (Medium & Low voltage)	x	x	x												
Narrow band PLC (High & very High voltage)					x	x									
Broadband PLC	x	x													
EN 14908		x	x												
EN 50090		x	x												
IEEE 802.15.4	x	x	x												
IEEE 802.15.4	x	x	x												
IEEE 802.11	x	x		x	x										
IEEE 802.3/1				x	x		x	x	x						x
IEEE 802.16	x	x	x												
ETSI TS 102 887		x	x												
IPv4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
IPv6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
RPL / 6LowPan	x	x	x												
IEC 61850		x	x	x	x	x								x	
IEC 60870-5				x	x	x								x	
GSM / GPRS / EDGE	x	x												x	
3G / WCDMA / UMTS / HSPA	x	x					x	x	x	x	x	x	x	x	
LTE/LTE-A	x	x	x	x		x	x	x	x	x	x	x	x	x	
SDH/OTN	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
IP MPLS / MPLS TP	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
EN 13757		x													
DSL/PON	x	x				x								x	
Higher layer * comm protocol	x	x	x			x	x	x	x	x	x	x	x	x	

* : refer to the set of protocols presented in section 9.2.3

9.2.2.3 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.

9.2.2.3.1 Available standards

In compliance with section 6, a standard (or "open specification") that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as "available".

Table 78 - 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 MPLS WG	A list of standards is available under this link http://datatracker.ietf.org/wg/mpls/
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 6272[12]	Internet Protocols for the Smart Grid. http://www.rfc-editor.org/rfc/rfc6272.txt
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
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

[12] 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	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	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 (1995)
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
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[13]	ETSI TS 16 300 / 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 [13]	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 [13]	ETSI TS 136 211 / 3GPP TS 36. 211	211 Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation. (ITU-R endorsement)

[13] No harmonised version at this moment

Layer	Category (ies)	Standard	Comments
Communication	LTE/LTE-A [13]	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 [13]	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 [14]	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	LTE/LTE-A, GSM/GPRS/EDGE, 3G/CDMA/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/CDMA/UMTS/HSPA	ETSI TS 123 888 / 3GPP TR 23.888	System improvements for Machine-Type Communications (MTC)Service requirements for Machine-Type Communications (MTC);
Communication	LTE/LTE-A, GSM/GPRS/EDGE, 3G/CDMA/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 [14]	ETSI TS 124 312 / 3GPP TS 24.312	Access Network Discovery and Selection Function (ANDSF) Management Object (MO) (ITU-R endorsement)
Communication	LTE/LTE-A [14]	ETSI TS 123 402 / 3GPP TS 23.402	Architecture Enhancements for Non-3GPP Accesses (Release 10)
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

[14] No harmonised version at this moment

Layer	Category (ies)	Standard	Comments
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
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 60870-5-101	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

Layer	Category (ies)	Standard	Comments
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
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/TR 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/TR 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	3G / WCDMA / UMTS / HSPA	ETSI TS 121 101 3GPP TS 21.101	Overview of Technical Specifications and Technical Reports for a UTRAN-based 3GPP system
Communication	GSM / GPRS / EDGE	ETSI TS 141 101 3GPP TS 41.101	Overview of Technical Specifications and Technical Reports for a GERAN-based 3GPP system
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 (PHY) ITU-T G.9961 (DLL) ITU-T G.9962 (MIMO) ITU-T G.9964 (PSD)	Unified high-speed wireline-based home networking
Communication	Broadband PLC	IEEE 1901	Broadband over Power Line Networks

9.2.2.3.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 79 - Communication - Coming standards

Layer	Standard	Comments
Communication	*EN 50491-12*	Smart Grid interface and framework for Customer Energy Management
Communication	*IEEE P1901.2*	Standard for Low Frequency (less than 500 kHz) Narrow Band Power Line Communications for Smart Grid Applications
Communication	*IEC 62746*	IEC 62746- x: Systems Interface between Customer Energy Management and the Power management Systems
Communication	*prTS 50XXX*	CENELEC/prTS 50XXX: OSGP (Open Smart Grid Protocol) - Communication protocols, data structures and procedures
Communication	*prTS 50568-4*	CENELEC/prTS 50568-4 ‘Electricity metering data exchange - The Smart Metering Information Tables and Protocols (SMITP) suite - Part 4: Physical layer based on B-PSK modulation + Data Link Layer’, a PLC communication protocol intended for smart metering in the Neighbor Network (work in progress in CLC)
Communication	*prEN 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	*IEC 61850-90-4*	Communication networks and systems for power utility automation - Network engineering guidelines
Communication	*IEC 61850-8-2*	Mapping of IEC/EN 61850 communication services over the Web services
Communication	*prEN 50412-4*	Broadband PLC – LRWBS - Power line communication apparatus and systems used in low-voltage installations in the frequency range 1,6 MHz to 30 MHz

9.2.3 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).

9.2.3.1 List of Standards

9.2.3.1.1 Available standards

In compliance with section 6, a standard (or "open specification") that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as "available".

Table 80 - 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 102690	Machine-to-Machine communications (M2M); Functional architecture
Communication	REST	ETSI, TS 102921	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

9.2.3.1.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as "Coming".

Table 81 - Higher level communication protocols - Coming

Layer	Standard	Comments
Communication	CoAP draft-ietf-core-coap-11	Constrained Application Protocol (CoAP). More information available on : http://datatracker.ietf.org/doc/draft-ietf-core-coap/

9.3 Security

This section is summarizing the main outcomes of the SGIS report [11], related to standards and standardization.

9.3.1 Cyber Security Standardization landscape

The study of the current Smart Grid information security standards landscape started establishing an as-is of the existing smart grid relevant documents. This work led the SG-SG/SGIS group to identify the following documents as relevant for the analysis:

- ISO/IEC 27001
- ISO/IEC 27002
- IEC 62351
- NERC/CIP (US Standard)
- NISTIR-7628 (US Guidelines for Smart Grid Cyber Security)

Report from European task force on Smart Grid privacy and security and Joint Working Group have also been used as inputs for this study.

Note: The section below has not been written to specifically include the Smart Metering related standards. Some specific requirement 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.

To be chosen, documents had to be already published, widely known by Smart Grid stakeholders and well accepted both in Europe and US. The list is not exhaustive. The objective was to establish an analysis methodology and identify a **first set of standards** that could be used today to secure the Smart Grid. This first set of standards will have to grow and be maintained over time.

Standards were analyzed thru 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.

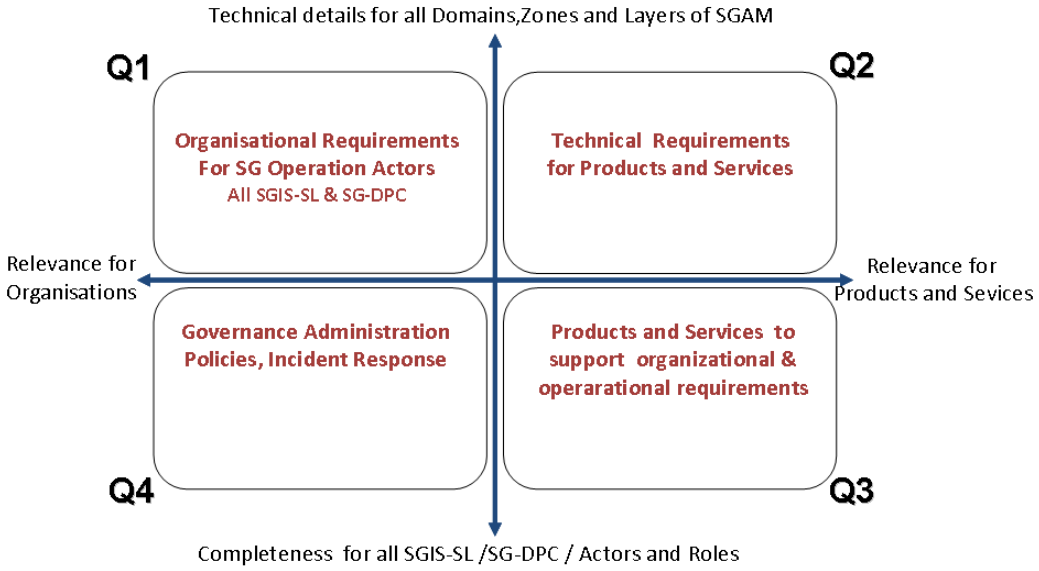


Figure 71 - SGIS Standards Areas

Using this representation the current SGIS Standards landscape with the documents analyzed can be established as illustrated in the figure hereunder:

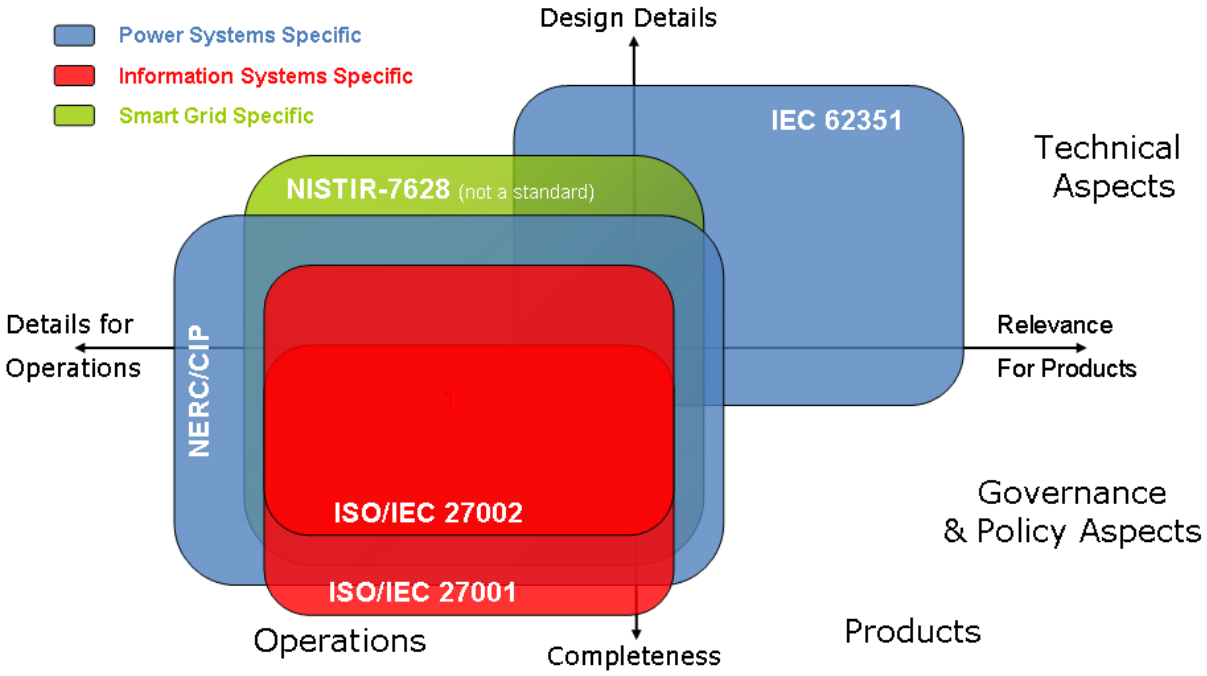


Figure 72 - Current SGIS Standard Landscape Analyzed

A first target is to have this current SGIS standard landscape “Smart Grid Ready”, i.e. by transforming the zones which are not green yet, into green one as illustrated below.

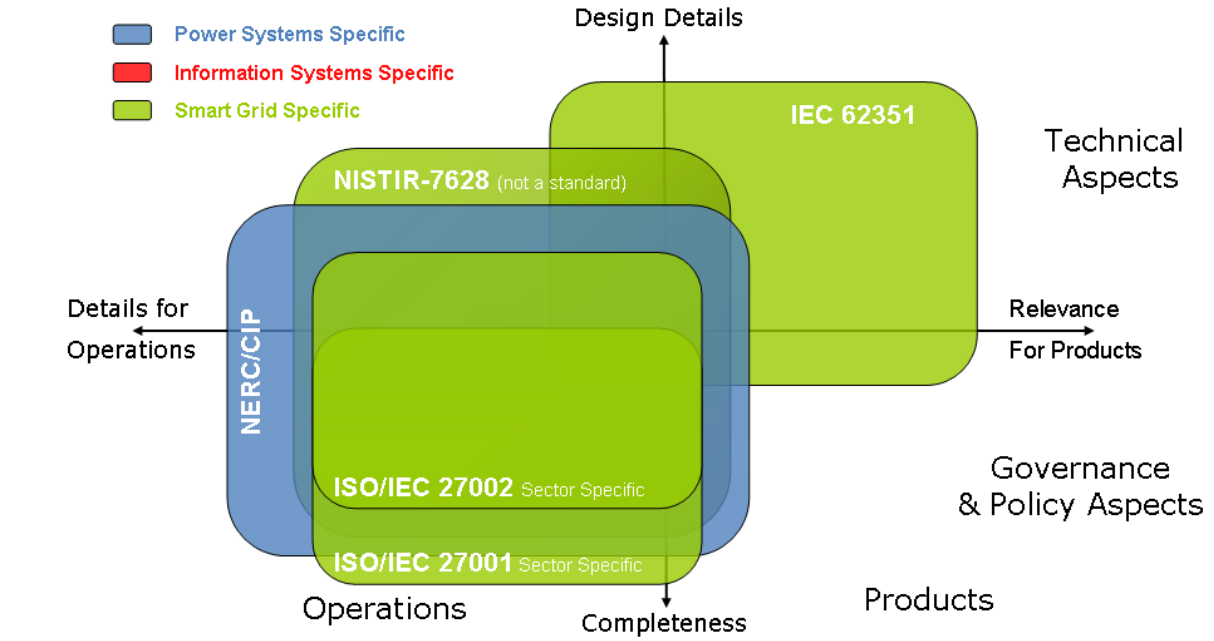


Figure 73 - SGIS Standard Landscape Target

This target is to be seen as a first step in the Smart Grid Information Security journey. The following picture illustrates the areas and anticipated status for SGIS-SL implementation in Standards at year end 2012.

In Figure 74, hereunder, the following standards typologies are used:

- **Requirement Standard - Type 1 Standard**
  - Requirement Standards are high level requirement standards, neutral from technology. Those requirements do not provide technical implementation options. (cf. [11] section 8 for details).
- **Implementation Standard - Type 2 Standard**
  - Implementation option standards describe many specific implementation options depending on domain and technologies used. (cf. [11] section 8 for details).
- **Standard profile for interoperability – Type 3 Standard**
  - To achieve interoperability – it is often required to limit (profile) the implementation options provided by Type 2 standards. (cf. [11] section 8 for details).
- **Type 1, Type 2 and Type 3 Standards Example**

One example for a type 1 standard is ISO 27002 providing security requirements on an abstract level. Security standards, which already exist and can be leveraged in smart grid security solutions belong to type 2 standards. An example can be given with TLS (RFC 5746) providing a self contained security solution. Nevertheless, the standard provides several options, which may even be negotiated between the communication peers. Hence, to optimize communication, IEC 62351-3 limits the available configuration options of TLS resulting in a profile, which in turn is a type 3 standard.

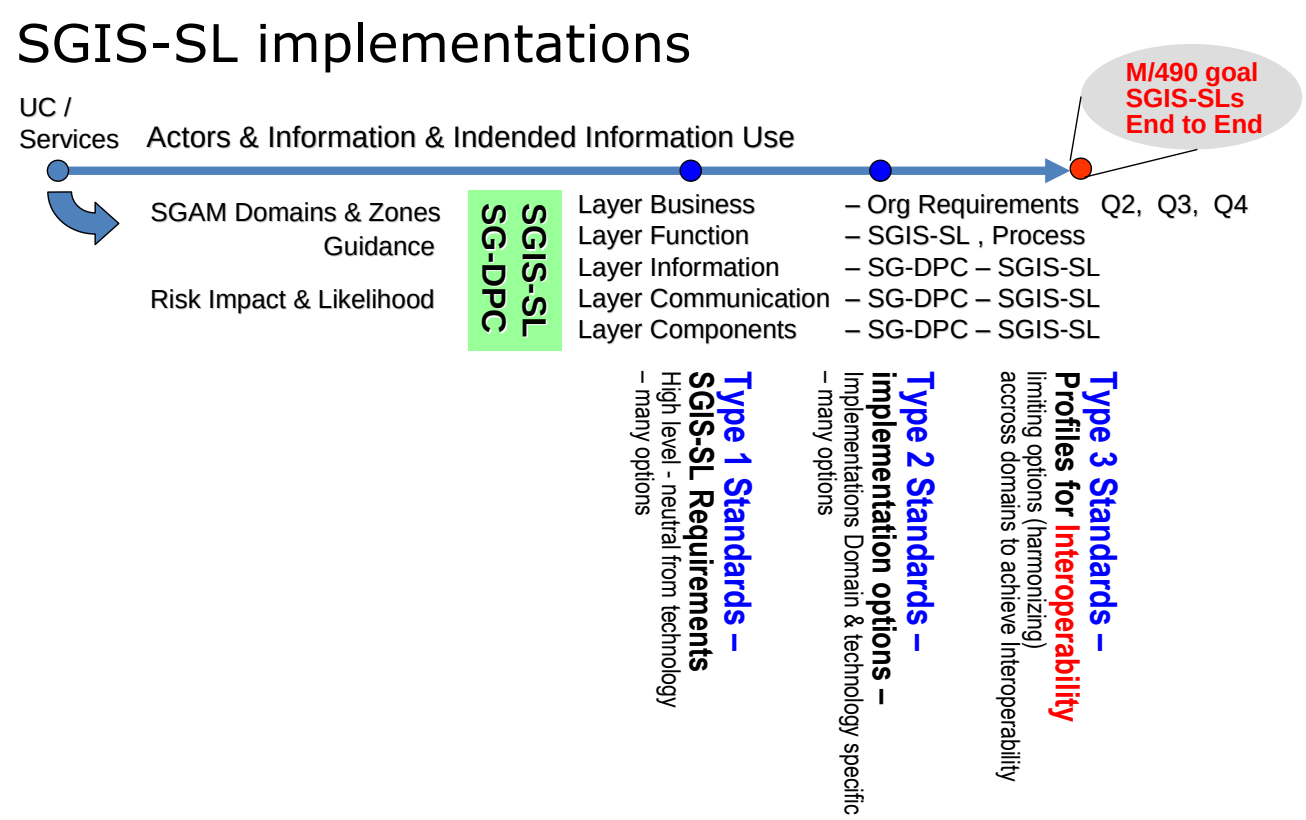


Figure 74 - SGIS Standards Landscape Target YE2012 Details

One item of this first step was to present recommendations related to IEC 62351 to IEC TC57:WG15. Recommendations have been made and target the technological advancement of the current standard to address recent technology advances and also to address further development to support smart grid use cases.

The second item identified was to establish a standard for the Smart Grid sector specific application of ISO/IEC 27002 standard. The DIN (Deutsches Institut für Normung) in the DIN SPEC 27009 - “Information security management guidelines for process control systems used in the energy utility industry on the basis of ISO/IEC 27002” document made a first proposal in this sense. Now this need has been recognized (ISO/IEC JTC1 resolution 58 : Nov2011). In response to this resolution ISO/IEC JTC1/SC27 launched a study period within working group to asses this need for an ISO/IEC 27002 standard specific for the Smart Grid sector.

But as stated this is only a first step. The ultimate goal is to identify SGIS requirement standards in all four quadrants to enforce SGIS-SL security requirements in all SGAM domains, zones and layers. The figure hereunder gives an overview of this ultimate goal.

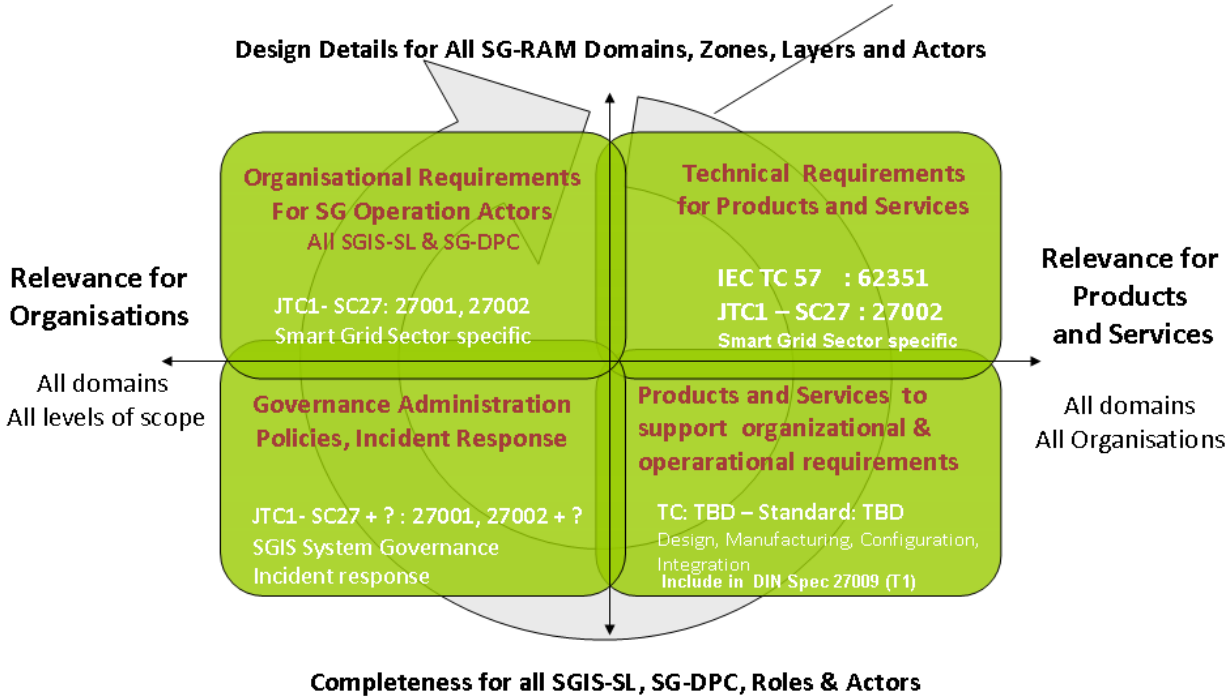


Figure 75 - SGIS Standards Ultimate Goal

The Smart Grid, as a system of systems, is heterogeneous and complex. Covering exhaustively all standards needed to secure the Smart Grid is a long and fastidious task. Smart Grid use cases are so numerous and different as are the technologies used to deliver the identified services that additional existing standards are to be considered. Some more can be found in SGCG-SGIS Report [11] Annex 2 – SGIS Standards List.

The conclusion of this study is key information for the Smart Grid Information Security Landscape. As shown above (Figure 72 about IEC-62351 and ISO\IEC 27002), the standards needed to establish the basis of the Smart Grid Information Security are available today. Nevertheless there is a need for additional standards to integrate Smart Grid specific needs.

But this exercise (standards gap analysis) cannot be one shot only. This should be a continuous exercise integrating the evolution of the Smart Grid information security needs. The remaining relevant question and challenge is to know if standards will be able to adapt to the pace of these evolutions.

9.3.2 List of standards

9.3.2.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 82 - Security - Available standards

Layer/type	Standard	Comments
General	IEC 62351-1	Does not provide a dedicated technical solution, rather explains the applicability of the IEC 62351 series
General	IEC 62351-2	Does not provide a dedicated technical solution, rather explains the glossary of the IEC 62351 series
Component, communication, information, function	IEC 62351-3	Depends on the usage of TCP/IP
Component,	IEC 62351-4	Depends on the usage of TCP/IP and MMS

Layer/type	Standard	Comments
communication, information, function		
Component, communication, information, function	IEC 62351-5	Depends on the usage of EN 60870-5 and serial protocols
Component, communication, information, function	IEC 62351-6	Depends on the usage of GOOSE and SMV
Component, communication, information, function	IEC 62351-7	Depends on the usage of network management protocols/functions
Component, communication, information, function	IEC 62351-8	Defines Role-Based Access Control and associated credentials to be used in the context of IEC 62351
Component, communication, information, function	IEC 62351-10	TR, 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	EN 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	DIN SPEC 27009	Information security management guidelines for process control systems used in the energy utility industry on the basis of ISO/IEC 27002, submitted to SC27 to become ISO 27019
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)
Communication, Information	IETF RFC 3748	EAP Base Protocol (includes EAP MD5)
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 4764	EAP PSK (Pre-Shared Key)
Communication, Information, function	IETF RFC 4962	AAA, Network Access, e.g., for service or remote access
Communication	IETF RFC 5106	EAP IKEv2

Layer/type	Standard	Comments
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 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, 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 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	
Communication, Information, function	ETSI ETR 237	
Communication, Information, function	ETSI ES 202 382	
Communication, Information, function	ETSI ES 202 383	
Communication, Information, function	ETSI EG 203 387	
Communication, Information, function	ETSI TS 102 165-1	

Layer/type	Standard	Comments
Communication, Information, function	ETSI TS 102 165-2	
Communication, Information, function	ETSI EG 202 549	
Communication, Information, function	ETSI TR 185 008	
Communication, Information, function	ETSI TR 187 012	
Communication, Information, function	ETSI TS 187 016	
Communication, Information, function	ETSI TR 102 419	
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	
Communication, Information	ETSI TS 133 210	
Communication, Information	ETSI TS 133 234	
Communication, Information	ETSI TS 133 310	
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 featuresz for XML encoded data

9.3.2.2 Coming Standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 83 - Security - Coming standards

Layer/type	Standard	Comments
Component, communication, information, function	*IEC 62351-3*	Depends on the usage of TCP/IP (Edition 2)
Component, communication, information, function	*IEC 62351-5*	Depends on the usage of EN 60870-5 and serial protocols (Edition 2)
Component, communication, information, function	*IEC 62351-6*	Depends on the usage of GOOSE and SMV (Edition 2)
Component, communication, information, function	*IEC 62351-9*	Defines management of necessary security credentials and parameters in the context of IEC 62351, CD currently planned for end of 2012
Component, communication, information, function	*IEC 62351-11*	Focus on XML Security for files to ensure that the receiver gets information about the sensitivity of the data received
Communication, Information, function	*IEC 15118*	describes the interface between an electric vehicle and the charging spot including security
Communication, Information, function	*EN 62056-5-3*	DLMS/COSEM security 2013 supposedly to become EN 62056-5-3:2013.

9.4 EMC & Power Quality

9.4.1 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.

9.4.2 General

9.4.2.1 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 being discussed in several publications include 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… 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.

9.4.2.2 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 DIRECTIVE 2004/108/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 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 in the frequency range 9kHz to 400Ghz, the user shall comply also with the emission requirements of **EN 55022** or **EN 55032**.
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.

9.4.3 Standardization work monitored under M/490

Some gaps have been identified in EMC standardization, especially:

- immunity and emission in the frequency range from 2 kHz to 150 kHz, in order to insure proper functioning of electronic equipment and of PLT services (PLT "intentional" emission levels are covered by EN 61000-3-8 and 61334-3-1);
- Power Quality in a smart grid context;
- Immunity and emission requirements applicable to Distributed Energy Resources.

The work underway in the ESOs intends to provide, in addition to the existing EMC and PQ standards, new standards or new edition of standards permitting a secure deployment of smart grids.

9.4.3.1 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 (SC205A/Sec0260/R, April 2010). 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****)* and Immunity test methods *(**prEN 61000-4-19**)* are in progress. Emission limits and Immunity Levels will follow.

9.4.3.2 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…).

The following maintenance projects should be noted:

- ***prTR 50422 Ed2:*** *Guide for the application of EN 50160*
- ***prEN 61000-4-30 Ed3:*** *power Quality measurement methods*

Draft Standards specifying connection of Distributed Energy Resources to the grid, such as **prEN 50438 Ed2** and **prTS 50549** consider the contribution of DER to voltage control, by means of active and/or reactive power management.

9.4.3.3 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 WGs are requested to consider and assess the recommendations in IEC TR 61000-3-15 and to report by 2013 about implementation in their IS, TR, TS, if any.

Next step is to standardize how to give a limitation to the disturbance emissions by DER equipment 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. Connected equipment may well be installation or other network(s). The work should originate from extension of IEC TR 61000-3-6, IEC TR 61000-3-7, IEC TR 61000-3-13 and IEC TR 61000-3-14.

9.4.4 List of standards

9.4.4.1 Available standards

In compliance with section 6, a standard (or “open specification”) that has reached its final stage (IS, TS or TR, …) by June 30th 2012 is considered as “available”.

Table 84 - 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	EN 61000-6-5	Electromagnetic compatibility (EMC) – Generic standards - Immunity for power station and substation environments
EMC	IEC TR 61000-3-15	Assessment of low frequency electromagnetic immunity and emission requirements for dispersed generation systems in LV network
EMC	IEC TR 61000-3-6	EMC - Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
EMC	IEC TR 61000-3-7	EMC - Limits – Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems
EMC	IEC TR 61000-3-13	EMC - Limits – Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems
EMC	IEC TR 61000-3-14	EMC - Assessment of emission limits for the connection of disturbing installations to LV power systems
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
Power Quality	EN 50160	Voltage characteristics of electricity supplied by public electricity networks

9.4.4.2 Coming standards

In compliance with section 6, a standard that has successfully passed the NWIP process (or any formal equivalent voting gates if NWIP is not within the standard process for issuing the considered standard) by June 30th 2012 is considered as “Coming”.

Table 85 - EMC - Power Quality - Coming standards

Layer/Type	Standard	Comments
Power Quality	*prTR 50422*	Guide for the application of EN 50160. Maintenance of an existing report, including (informative) annexes on impact of DER and voltage/current components in the 2-150kHz range
EMC	*prEN 55035*	Electromagnetic compatibility of multimedia equipment - Immunity requirements IEC CISPR/I
EMC	*prEN 61000-2-2*	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	*prEN 61000-2-12*	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	*prEN 61000-4-19*	Immunity to conducted, differential mode disturbances in the frequency 2 – 150 kHz at a.c. ports. New Project: IEC 77A/783/CD (2012/01)
EMC	*prEN 61000-4-30*	Power Quality measurement methods. Maintenance of an existing standard, including an (informative) annex for measurement methods in the 2-150kHz range: IEC 77A/7XX/CD (2012/02)

9.5 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 86 - Functional safety - Available standards

Layer/Type	Standard	Comments

Functional safety	*EN 61508*	Functional safety of electrical/electronic /programmable electronic safety-related systems

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

10.1.1 Available standards

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
EN 13321 series														X	X													
EN 13757-1														X	X													
EN 13757-2														X	X													
EN 13757-3														X	X													
EN 13757-4														X	X									X				
EN 13757-5														X	X									X				
EN 14908 series														X	X													
EN 14908-1																								X				
EN 14908-2																								X				
EN 14908-3																								X				

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
EN 14908-4																							X				
EN 50065-1														X	X												
EN 50065-2-3																									X		
EN 50065-7																									X		
EN 50090-2-1																							X				
EN 50090-3-1														X	X								X				
EN 50090-3-2														X	X								X				
EN 50090-3-3														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												
EN 50090-7-1														X	X								X				
EN 50160																										X	
EN 55011																									X		
EN 55022																									X		
EN 55024																									X		

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
EN 55032																									X		
EN 60870-5-101	X	X	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				
EN 60870-5-104	X	X	X	X	X	X	X	X	X		X	X				X		X						X				
EN 60870-5-5																				X								
EN 60870-6			X													X												
EN 61000 Series																									X			
EN 61000-6-1																									X			
EN 61000-6-2																									X			
EN 61000-6-3																									X			
EN 61000-6-4																									X			
EN 61000-6-5																									X			
EN 61158 (all parts)	X										X	X																
EN 61334-4-32														X	X													
EN 61334-4-511														X	X													
EN 61334-4-512														X	X													
EN 61334-5-1														X	X													
EN 61360	X																					X						

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
EN 61400-25		X				X	X	X										X							X			
EN 61400-25-2	X										X	X																
EN 61400-25-3											X	X																
EN 61400-25-4											X	X																
EN 61508																												X
EN 61850-6		X		X	X	X	X	X	X		X	X																
EN 61850-7-1																							X					
EN 61850-7-2	X	X		X	X	X	X	X	X		X	X																
EN 61850-7-3	X	X		X	X	X	X	X	X		X	X																
EN 61850-7-4	X	X		X	X	X	X	X	X		X	X																
EN 61850-7-410	X	X				X	X	X			X	X																
EN 61850-7-420		X				X	X	X			X	X																
EN 61850-8-1	X	X		X		X	X	X			X	X						X					X					
EN 61850-9-2	X	X		X		X	X																X					
EN 61869		X		X		X	X	X																				
EN 61968 (all parts)		X				X	X	X			X	X	X		X	X	X	X										
EN 61968-1	X									X																		
EN 61968-11	X									X																		
EN 61968-13										X																		

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
EN 61968-2	X																											
EN 61968-3	X									X																		
EN 61968-4	X									X								X										
EN 61968-9	X									X			X															
EN 61970 (all parts)		X				X	X	X		X	X	X				X	X	X										
EN 61970-1	X		X																									
EN 61970-2	X		X																									
EN 61970-301	X		X																									
EN 61970-401	X		X																									
EN 61970-453	X		X																									
EN 61970-501	X		X																									
EN 62056-31														X	X													
EN 62056-42														X	X													
EN 62056-46														X	X													
EN 62056-47														X	X													
EN 62056-53														X	X													
EN 62056-5-3																								X				
EN 62056-61														X	X													
EN 62056-62														X	X													

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
EN 62439	X					X	X	X																				
EN 62541-1	X																											
EN 62541-10	X																											
EN 62541-2	X																											
EN 62541-3	X																											
EN 62541-4	X																											
EN 62541-5	X																											
EN 62541-6	X																											
EN 62541-7	X																											
EN 62541-8	X																											
EN 62541-9	X																											

10.1.2 Coming standards

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
EN 13321-2																								X				
EN 50491-12																								X				
EN 61400-25																		X										
EN 61869		X		X		X	X	X																				
EN 61968-1										X																		
EN 61968-100	X									X	X	X	X					X										
EN 61968-11										X																		
EN 61968-6	X									X								X										
EN 61968-8										X																		
EN 61968-9										X			X	X	X													
EN 61970-301																	X											
EN 61970-452	X		X																									
EN 61970-456	X		X																									
EN 61970-458	X		X																									
EN 61970-502-8	X		X																									
EN 61970-552	X		X																									

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
EN 62056-1-0														X	X													
EN 62056-3-1														X	X													
EN 62056-3-2														X	X													
EN 62056-4-7														X	X													
EN 62056-5-3														X	X										X			
EN 62056-5-8														X	X													
EN 62325-450	X															X	X											
EN/TR 5YYYY														X	X													
FprEN 62056-6-1														X	X													
FprEN 62056-6-2														X	X													
FprEN 62056-7-6														X	X													
FprEN 62056-8-3														X	X													
FprEN 62056-9-7														X	X													
prEN 13757-1														X	X													
prEN 13757-3														X	X													
prEN 13757-4														X	X													
prEN 13757-5														X	X													
prEN 50412-4																								X				
prEN 50438											X	X																

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
prEN 50491-11														X	X													
prEN 50491-12														X	X													
prEN 55035																									X		
prEN 61000-2-12																									X		
prEN 61000-2-2																									X		
prEN 61000-4-19																									X		
prEN 61000-4-30																									X		
prTR 50422																										X	
prTR 50491-10														X	X													
prTS 50549-1											X	X																
prTS 50549-2											X	X																
prTS 50567-1														X	X													
prTS 50567-2														X	X													
prTS 50568-2														X	X													
prTS 50568-4														X	X								X					
prTS 50568-5														X	X													
prTS 50568-6														X	X													
prTS 50568-8														X	X													
prTS 50568-9														X	X													

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
prTS 50XXX																								X				
prTS 50XXX (=OSGP)														X	X													
prTS 50XXX (=CX1)														X	X													
prTS 52056-8-4														X	X													
prTS 52056-8-5														X	X													

10.2 ETSI

10.2.1 Available standards

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ETSI EG 202 549																								X			
ETSI EG 203 387																								X			
ETSI ES 202 382																								X			
ETSI ES 202 383																								X			
ETSI ETR 237																								X			
ETSI ETR 332																								X			
ETSI TCRTR 029																								X			
ETSI TR 102 419																								X			
ETSI TR 102 437																								X			
ETSI TR 102 572																								X			
ETSI TR 103 167																								X			
ETSI TR 185 008																								X			
ETSI TR 187 002																								X			
ETSI TR 187 012																								X			
ETSI TS 100 920																								X			

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ETSI TS 101 456																								X			
ETSI TS 102 042																								X			
ETSI TS 102 165-1																								X			
ETSI TS 102 165-2																								X			
ETSI TS 102 225																								X			
ETSI TS 102 226																								X			
ETSI TS 102 484																								X			
ETSI TS 102 573																								X			
ETSI TS 102 689																								X			
ETSI TS 102 690																							X	X			
ETSI TS 102 921																							X	X			
ETSI TS 102 887																							X				
ETSI TS 103 908																							X				
ETSI TS 121 101																							X				
ETSI TS 122 368 / 3GPP TS 22.368																							X				
ETSI TS 123 401 / 3GPP TS 23.401																							X				
ETSI TS 123 402 / 3GPP TS 23.402																							X				

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ETSI TS 123 682 / 3GPP TS 23.682																								X				
ETSI TS 123 888 / 3GPP TR 23.888																								X				
ETSI TS 124 312 / 3GPP TS 24.312																								X				
ETSI TS 133 203																									X			
ETSI TS 133 210																									X			
ETSI TS 133 234																									X			
ETSI TS 133 310																									X			
ETSI TS 136 201 / 3GPP TS 36.201																								X				
ETSI TS 136 211 / 3GPP TS 36.211																								X				
ETSI TS 136 212 / 3GPP TS 36.212																								X				
ETSI TS 136 213 / 3GPP TS 36.213																								X				
ETSI TS 136 214 / 3GPP TS 36.214																								X				
ETSI TS 136 216 / 3GPP TS 36.216																								X				
ETSI TS 141 101																								X				

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ETSI TS 16 300 / 3GPP TS 36.300																								X				
ETSI TS 187 001																									X			
ETSI TS 187 003																									X			
ETSI TS 187 016																									X			

10.3 IEC

10.3.1 Available standards

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
IEC 60050 series																							X					
IEC 60255	X																											
IEC 60255-24						X	X	X																				
IEC 61131	X										X	X																
IEC 61499	X										X	X																
IEC 61512	X																											
IEC 61784-1	X										X	X																
IEC 61804	X																											
IEC 61850-80-1		X		X	X	X	X	X	X									X										
IEC 61850-90-1	X	X		X		X	X	X																X				
IEC 61850-90-5		X		X		X	X	X												X				X	X			
IEC 61968-2										X																		
IEC 61987	X																											
IEC 62051-1													X															
IEC 62264	X																											

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
IEC 62325			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				
IEC 62351-10																								X				
IEC 62351-2																								X				
IEC 62351-3																					X			X				
IEC 62351-4																					X			X				
IEC 62351-5																								X				
IEC 62351-6																								X				
IEC 62351-7																			X					X				
IEC 62351-8																					X			X				
IEC 62357			X							X			X															
IEC 62361			X							X																		
IEC 62361-100										X																		
IEC 62488-1 (Formerly EN 60663 Part 1)																							X					
IEC TR 61000-3-13																									X			
IEC TR 61000-3-14																									X			
IEC TR 61000-3-15																									X			

Standard	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
IEC TR 61000-3-6																										X		
IEC TR 61000-3-7																										X		
IEC/EN 61850 (all parts)			X							X																		
IEC/PAS 62559																							X					

10.3.2 Coming standards

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
IEC/ISO 15118																									X			
IEC/EN 61850 (all parts)			X							X																		
IEC 61850-8-2	X	X		X		X	X	X			X	X						X			X			X				
IEC 61850-90-10											X	X																
IEC 61850-90-11		X					X				X	X																
IEC 61850-90-13	X																											
IEC 61850-90-15											X	X																
IEC 61850-90-2	X	X		X	X	X	X	X	X		X	X						X			X							
IEC 61850-90-3		X		X	X	X	X	X	X									X										
IEC 61850-90-4	X	X		X		X	X	X											X	X	X			X				
IEC 61850-90-6						X	X	X																				
IEC 61850-90-7		X				X	X	X			X	X																
IEC 61850-90-9											X	X																
IEC 62056-6-9														X	X													
IEC 62271-3		X				X	X	X																				
IEC 62325																X	X											

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
IEC 62325-301	X															X	X											
IEC 62325-351	X															X	X											
IEC 62325-451-1	X															X	X											
IEC 62325-451-2	X																											
IEC 62325-451-3	X																											
IEC 62351 (all parts)	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X											
IEC 62351-11																									X			
IEC 62351-3																									X			
IEC 62351-3 ed2																					X							
IEC 62351-5																									X			
IEC 62351-6																									X			
IEC 62351-9																									X			
IEC 62361-100	X																											
IEC 62361-101	X																											
IEC 62689						X	X	X																				
IEC 62746															X													

10.4 ITU

10.4.1 Available standards

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ITU-T G.7041																								X				
ITU-T G.7042																								X				
ITU-T G.707																								X				
ITU-T G.709																								X				
ITU-T G.781																								X				
ITU-T G.783																								X				
ITU-T G.798																								X				
ITU-T G.803																								X				
ITU-T G.872																								X				
ITU-T G.983.1																								X				
ITU-T G.983.2																								X				
ITU-T G.983.3																								X				
ITU-T G.983.4																								X				
ITU-T G.983.5																								X				
ITU-T G.984.1																								X				

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ITU-T G.984.2																								X				
ITU-T G.984.3																								X				
ITU-T G.984.4																								X				
ITU-T G.984.5																								X				
ITU-T G.984.6																								X				
ITU-T G.984.7																								X				
ITU-T G.987.1																								X				
ITU-T G.987.2																								X				
ITU-T G.987.3																								X				
ITU-T G.991.1																								X				
ITU-T G.991.2																								X				
ITU-T G.992.1																								X				
ITU-T G.992.2																								X				
ITU-T G.992.3																								X				
ITU-T G.992.4																								X				
ITU-T G.993.1																								X				
ITU-T G.993.2																								X				
ITU-T G.993.5																								X				
ITU-T G.994.1																								X				

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ITU-T G.995.1																								X				
ITU-T G.996.1																								X				
ITU-T G.996.2																								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				
ITU-T G.9960																								X				
ITU-T G.9961																								X				
ITU-T G.9962																								X				
ITU-T G.9964																								X				
ITU-T I.322																								X				

10.5 ISO

10.5.1 Available standards

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ISO 19142																					X						
ISO 8601 (EN 28601)				X																X							
ISO/IEC 12139-1																							X				
ISO/IEC 27001																								X			
ISO/IEC 27002																								X			
ISO/IEC 7498-1																							X				

10.6 Other bodies

10.6.1 Available standards

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
3GPP TS 21.101																								X				
3GPP TS 41.101																								X				
DIN SPEC 27009																									X			
ENTSO-E acknowledgement process																X	X											
ENTSO-E Capacity Allocation and Nomination (ECAN)																X	X											
ENTSO-E harmonized Role Model																X	X											
ENTSO-E Market Data Exchange Standard (MADES)																X	X											
ENTSO-E Reserve Resource Planning (ERRP)																X	X											

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
ENTSO-E Scheduling System (ESS)																X	X											
ENTSO-E Settlement Process (ESP)																X	X											
IEEE 1344				X																								
IEEE 1377														X	X													
IEEE 1588				X																X								
IEEE 1686																							X					
IEEE 1901																							X					
IEEE 802.1																							X					
IEEE 802.11																							X					
IEEE 802.15.4																							X					
IEEE 802.16																							X					
IEEE 802.1AE																								X				
IEEE 802.1AR																								X				
IEEE 802.1X																								X				
IEEE 802.3																							X					
IEEE 802.3av																							X					
IEEE C37.118				X																X								
IEEE C37.238:2011																				X								

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
IEEE P2030																								X				
IETF MPLS WG																							X					
IETF RFC 2460																							X					
IETF RFC 2616																							X					
IETF RFC 2617																								X				
IETF RFC 2759																				X				X				
IETF RFC 2865																				X				X				
IETF RFC 3031																							X					
IETF RFC 3032																							X					
IETF RFC 3584																		X										
IETF RFC 3711																								X				
IETF RFC 3748																				X				X				
IETF RFC 4090																							X					
IETF RFC 4301																								X				
IETF RFC 4302																								X				
IETF RFC 4303																								X				
IETF RFC 4330																			X									
IETF RFC 4553																							X					
IETF RFC 4764																				X				X				

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
IETF RFC 4789																			X									
IETF RFC 49192																							X					
IETF RFC 4962																					X			X				
IETF RFC 5086																							X					
IETF RFC 5106																					X			X				
IETF RFC 5216																					X			X				
IETF RFC 5246																							X	X				
IETF RFC 5247																								X				
IETF RFC 5280																								X				
IETF RFC 5281																					X			X				
IETF RFC 5343,																			X									
IETF RFC 5590,																			X									
IETF RFC 5654																							X					
IETF RFC 5905																				X								
IETF RFC 5921																							X					
IETF RFC 6120																							X					
IETF RFC 6121																							X					
IETF RFC 6122																							X					
IETF RFC 6178																							X					

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
IETF RFC 6206																								X				
IETF RFC 6272																								X	X			
IETF RFC 6347																									X			
IETF RFC 6550																								X				
IETF RFC 6551																								X				
IETF RFC 6552																								X				
IETF RFC 6407																									X			
IETF RFC 6749																									X			
IETF RFC 768																			X									
IETF RFC 791																								X				
IRIG 200-98																				X								
NCAR WXXM																						X						
OASIS wsdd-discovery-1.1 -spec-os																								X				
OASIS wsdd-soapoverudp-1.1 -spec-pr-01																								X				
OPC UA part 11	X																											
OPC UA part PLCopen	X																											
W3C NOTE																								X				

	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
Standard	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
wsdl-20010315																												
W3C REC soap12 part2-20070427																							X					
W3C REC soap12-part1-20070427																							X					
W3C REC xml-20001006																							X					
W3C REC xml-names																							X					
W3C RECws addr-core-20060509																							X					
W3C RECws addr-soap-20060509,																							X					
W3C SUBM wsdl11soap12-20060405																							X					
W3C SUBM WSEventing-20060315																							X					
W3C WD-ws arch-20021114																							X					
W3C XML Digital Signature																								X				
W3C XML Encryption																								X				

10.6.2 Coming standards

Standard	Generation	Transmission				Distribution					DER		Smart Metering		Demand and Production Flexibility	Market		Administration					Cross-cutting					
	Generation management system	Substation automation systems	EMS Scada system	WAMS	FACTS	Substation automation systems	Feeder Automation	Distributed Power Quality control system	FACTS	DMS SCADA and GIS system	DER management systems	DER EMS and VPP systems	Metering-related Back Office system	AMI system (refer to CLC TR 50572)	Aggregated prosumers management system	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	Telecommunication	Security	EMC	Power Quality	Functional safety
CoAP draft-ietf-core-coap-11																								X				
IEEE P1901.2																								X				
NCAR WXXM																						X						
WMO METCE																						X						

Annex A Detailed list of abbreviations

Table 87 - Abbreviations list - complete

Abbreviation	Meaning
3GPP	3rd Generation Partnership Project
6LoWPAN	IPv6 over Low power Wireless Personal Area Networks
ADSL	Asymmetric digital subscriber line
AMI	Advanced Metering Infrastructure
AMR	Advanced Meter Reading
AN	Access Network
ANSI	American National Standard Institute
AS	Application server
CC	Control Center
CEM	Customer Energy Management (refer 7.6.2 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
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 7.6.2 for details)
DIN	Deutsches Institut für Normung
DLMS	Distribution Line Message Specification
DMS	Distribution Management System (refer 7.6.2 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
EMG	Energy Management Gateway (refer 7.6.2 for details)
EMS	Energy Management System (refer 7.6.2 for details)
ENTSO-E	European Network of Transmission System Operators for Electricity
ERP	Enterprise Resource Planning
ESO	European Standardization Organization
ETSI	European Telecommunications Standards Institute

Abbreviation	Meaning
EV	Electrical Vehicle
FACTS	Flexible Alternating Current Transmission Systems (refer 7.6.2 for details)
FEP	Front End Processor (refer 7.6.2 for details)
FLISR	Fault Location Isolation and Service Restoration
GIS	Geographic Information System (refer 7.6.2 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 7.6.2 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
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 7.6.2 for details)
LR	WPAN Low Rate Wireless Personal Area Network
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 7.6.2 for details)
MMS	Manufacturing Message Specification (ISO 9506)
MPLS	Multiprotocol Label Switching
MPLS-TP	MPLS Transport Profile

Abbreviation	Meaning
MV	Medium Voltage
NAN	Neighborhood Area Network
NIC	Network Interface Controller (refer 7.6.2 for details)
NNAP	Neighborhood Network Access Point (refer 7.6.2 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 7.6.2 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 7.6.2 for details)
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 7.6.2 for details)
SCL	System Configuration Language (IEC 61850-6)
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	Smart Grid Co-ordination Group, reporting to CEN-CENELEC-ETSI and 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
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
TC	Technical Committee
TDM	Time Division Multiplexing

Abbreviation	Meaning
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
WAMS	Wide Area Measurement System (refer 7.6.2 for details)
WAN	Wide Area Network
WG	Working Group
WPAN	Wireless Personal Area Network
xDSL	Digital Subscriber Line
XML	Extensible Markup Language