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International Smart Grid Roadmaps and their Assessment

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Abstract

In US and Europe many approaches and efforts exist with different viewpoints and focuses on what is understood as smart grids. One agreement of almost all approaches is the need for standardization to operate smart grids. Thus, several roadmaps and studies, mainly dealing with smart grid standardization, were developed. However, these documents are also focusing different parts of smart grid realizations and were mainly devised independently from each other. In this contribution, an overview on the most important approaches is given and furthermore, a set of identified core standards is introduced. Though, to make reliable statements about the approaches it is necessary to have a methodology enabling comparability and measurability. Hence, the Smart Grid Maturity Model (SGMM) is presented as a starting point for the assessment of projects and roadmaps. Since it does not meet all requirements for such assessments, because it was developed to assess utilities and follows a one-size-fits-all approach, a configuration approach based on several parameters, representing significant characteristics, is suggested.

Keywords: standardization, roadmap, smart grid, technology, maturity model.

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1. Introduction

In the energy domain novel problems have to be faced in the future on both the transmission and distribution layer, due to increasing decentralized generation. One possible solution coping with those problems are the so called smart grids, which are, amongst others, aiming at enhancing the efficiency of the overall energy supply system. Some criteria for smart grids are the active participation of customers, new generation and storage concepts, enabling novel services, products as well as markets and an energy supply system which is as cost effective and reliable as possible [1].

Within such a technical and economic challenging system a lot of stakeholders have to interact with each other, which leads to a high degree of complexity that has to be handled. New challenges arise i.e. for intelligent grid components, communication systems, data management, information and data security and new software applications [2]. To solve the implied integration and interoperability problems and to realize smart grids, it is necessary to develop a new Information and Communication Technologies (ICT) infrastructure [3]. Furthermore, the use of standards is an established means to cope with interoperability and integration problems and thus realize economic efficient solutions [4].

2. Motivation

Smart grids have to be open systems to allow the necessary amount of access between participating parties. Only then, a smart evolution of the power system is possible. An open system, in return, needs standardization to fulfil manifold interoperability requirements and to be run in an efficient way. Without standardization (i.e. in terms of data models and interfaces) the costs for integration of components as well as applications would be enormous. The German

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Survey	Approaches
Part 1 [11]	US NIST IOP Roadmap
	IEC SMB SG 3 Roadmap
	German BMWi E-Energy Program
	German BDI initiativ – Internet der Energie
	Microsoft SERA
	CIGRE D2.24
	European Union: Mandate CEN/CENELEC M/441
	Japanese METI Smart Grid roadmap
Part 2 [12] (only additional approaches)	The State Grid Corporation of China - SGCC Framework)
	Korea's Smart Grid Roadmap 2030 from MKE
	CEN/CENELEC/ETSI Smart Grid Roadmap Group Report
	IEEE 2030
	Several national Roadmaps without focus on standardization

standardization strategy [5], for example, defines amongst others the following goals which can be achieved by the use of standards:

- Standardization as a strategic instrument supports the economic and social success.
- Standardization relieves the regulatory activities of the government.
- Standardization and Standard Developing Organization (SDOs) foster technology convergence.
- SDOs provide efficient processes and instruments.

Therefore, it is not surprising that lots of countries develop national standardization roadmaps (e.g. [6], [7] and [8]) as well as organizations and companies specify their own standardization strategies (e.g. [9]). Those roadmaps and studies are mainly developed by experts from different smart grid areas. Some of them recommend single standards or series of standards others identify future fields which will need standardization. Most of them, finally, give recommendations which go far beyond standardization itself, i.e. dealing with organizational and regulatory issues. In this regard, one of the most relevant areas for standardization is ICT [10]. International experts point out, that the IEC (International Electrotechnical Commission) provides an appropriate starting point for smart grid ICT standardization [11] and [12].

To cope with the large variety of different approaches, this contribution gives an overview on the most important studies and their recommendations. In a second step an assessment of the approaches is suggested. The SGMM (Smart Grid Maturity Model) is introduced as an established model to assess utilities. However, it cannot be used to assess and hence to compare projects and roadmaps, yet. Measurability and comparability, which are essential preconditions to optimize smart grids, can be achieved by adapting the SGMM.

3. Overview of Studies and Roadmaps

Within this section several important approaches are introduced. In [11] and [12] an overview on the most prominent initiatives before May 2010 and June 2010 respectively, is given. Table 1 lists the covered approaches. Additionally, the ISO/IEC JTC 1 Special Working Group on Smart Grid is part of the following section.

Table 1. Overview on addressed approaches within the surveys

One can easily recognize that it is very unlikely to have a one-size-fits-all solution for those smart grid requirements both in terms of technical solutions and its corresponding standardization requirements. Fig. 1 gives an overview on standards covered by the different approaches. In Fig. 1 only approaches currently considering or making recommendations for standards are listed, therefore IEEE P2030, Japan's, Korea's and the JTC1 roadmap are not shown. Regarding the IEC SMB SG 3 core (black) and high (dark grey) standards are differentiated. In addition, standards to be extended by the SGCC Framework are highlighted (light grey), too. The focus is on giving an overview on the consideration of international standards published by e.g. IEC or ISO, only a few national standards covered by several approaches are listed.

3.1. The German Roadmap E-Energy/Smart Grid

This In 2010, the national smart grid standardization roadmap for Germany [6] was published. The German roadmap focuses on the smart grid's Information and communications technology infrastructure and considers national and international standards exhaustively. The German Commission for Electrical, Electronic & Information Technologies (DKE), which is the German mirror committee of the International Electrotechnical Commission (IEC), initiated the development of the roadmap. Several experts from standards developing organizations (like DKE), governmental institutions (like the Federal Ministry of Economics and Technology – BMWi), utilities, vendors and research institutes (like OFFIS) participated in its development. After identification and analysis of several studies and initiatives a pre-study was made available for public comments and feedback was incorporated. The roadmap provides an overview on various international standardization efforts as well as specific recommendations for standards relating to different parts of the smart grid. Additionally, the term smart grid and the standardization in general are introduced. Based on the analysis of several standardization roadmaps and related approaches, challenges in the use of standards and common factors were identified. Key challenges identified comprise the harmonization of models in all respects (consideration of data models and semantics), the consideration of security, as an all-pervading cross-cutting topic, as well as the coordination and integration of different industries (like energy, ICT and manufacturing), participants (like households and commercial buildings) and networks (for ICT, transmission and distribution) within the smart grid. Even though the importance of international standards is outlined as crucial the roadmap emphasizes to consider regulatory, technical, political and organizational aspects as well to enable a smart grid. A key part of the roadmap is the description of more than 50 recommendations for standardization which are split up into cross-cutting topics and domain-specific areas and presented below:

Cross-cutting topics:

(i) General recommendations
(ii) Regulatory and legislative recommendations
(iii) Recommendations on information security, privacy and data protection
(iv) Recommendations on the area of communications
(v) Recommendations on the areas of architectures, communication and power system management processes
(vi) Recommendations on the safety, reliability and durability of products: domain-specific areas
(vii) Recommendations for the area of active distribution systems
(viii) Recommendations for the area of smart meters
(ix) Recommendations on the area of electromobility
(x) Recommendations for the area of storage
(xi) Recommendations for the area of load management/demand response
(xii) Recommendations for the area of building and in-house automation
(xiii) Recommendations for the area of distributed generation
(xiv) Recommendations for the area of transmission systems

Furthermore, from identifying core standards for the future smart grid in terms of ICT, also the development of new and the improvement of existing standards is considered. With the constitution of a German Smart Grid Standardization steering committee in July 2010, the initiative has gained momentum and a continuously development of the roadmap is planned. Currently, the roadmap is under discussion with national experts and an extension is planned for January 2011. Further versions of the roadmap should include e.g. multi-utility aspects (gas, heat and water), communication standards for further focal topics like market communications, High-Voltage Direct Current (HVDC) and Flexible Alternating Current Transmission System (FACTS).

In Fig. 1 the roadmap is depicted as the first column of the approaches. It obviously has a strong focus on IEC standards and covers a similar set as the IEC SMG SG 3 roadmap (see section 3.3). IEEE as well as US standards are not considered and also ISO standards are out of scope of the roadmap.

3.2. US NIST Interoperability Roadmap

The Energy Independence and Security Act (EISA) in the United States authorized the Department of Commerce (DoC) in 2007 to coordinate the development of an interoperability framework. The National Institute of Standards and Technology (NIST) is in charge of the coordination of this framework and aims at interoperability between and among smart grid systems and equipment with special respects to standards in the fields of ICT protocols and data models. To speed up the process and ensure continued development and implementation of standards as needs and opportunities arise and as technology advances NIST devised a three-phase plan consisting of:

Engagement of stakeholders via a participatory public process, to identify applicable standards and requirements but also gaps in currently available standards. For this purpose NIST has compiled and incorporated stakeholder inputs from several public workshops with the support of outside technical experts. In addition technical contributions from technical working groups and a cyber security coordination task group were also taken into account within the NIST coordinated standards-roadmap creation effort.

Establishment of a Smart Grid Interoperability Panel forum, for ensuring continued development of interoperability standards an organizational forum was launched in November 2009, the Smart Grid Interoperability Panel.[†]

Development and implementation of a framework for conformity testing and certification, according to NIST, testing and certification of how standards are implemented in smart grid devices, systems and processes is a core issue to ensure interoperability and security.

Further on, NIST designed a priority action plan (PAP) to support and foster the development of important standards; currently the PAP comprises the 18 tasks as shown in Table 2.

Table 2 shows that currently the PAP is headed in the right direction, most tasks are “On target”, only a few are on “Caution”, one is already completed and only two are on status “Late”.

The first version of the framework was published in 2009 as report from EPRI to NIST, including an abstract conceptual model consisting of about 80 standards, which were related to the smart grid directly or on a meta-level [13]. In addition, 15 key areas and gaps – where new or improved standards are needed – have been identified. Altogether, 16 core standards are recommended by NIST [2]. The later document, NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0, is the output of the first phase of the three phase NIST plan [2].

† See http://collaborate.nist.gov.

According to the interoperability roadmap standards listed are to be regarded as neither exhaustive nor exclusionary. Apart from the 16 core standards, additional standards, specifications, requirements, guidelines and reports for further review are presented and discussed, too. In addition to the NIST IOP Roadmap further information on Smart Grid Cyber security issues was published, see [14]. Current activities regarding NIST activities are provided on the NIST Smart Grid Collaboration Site, compare [13].

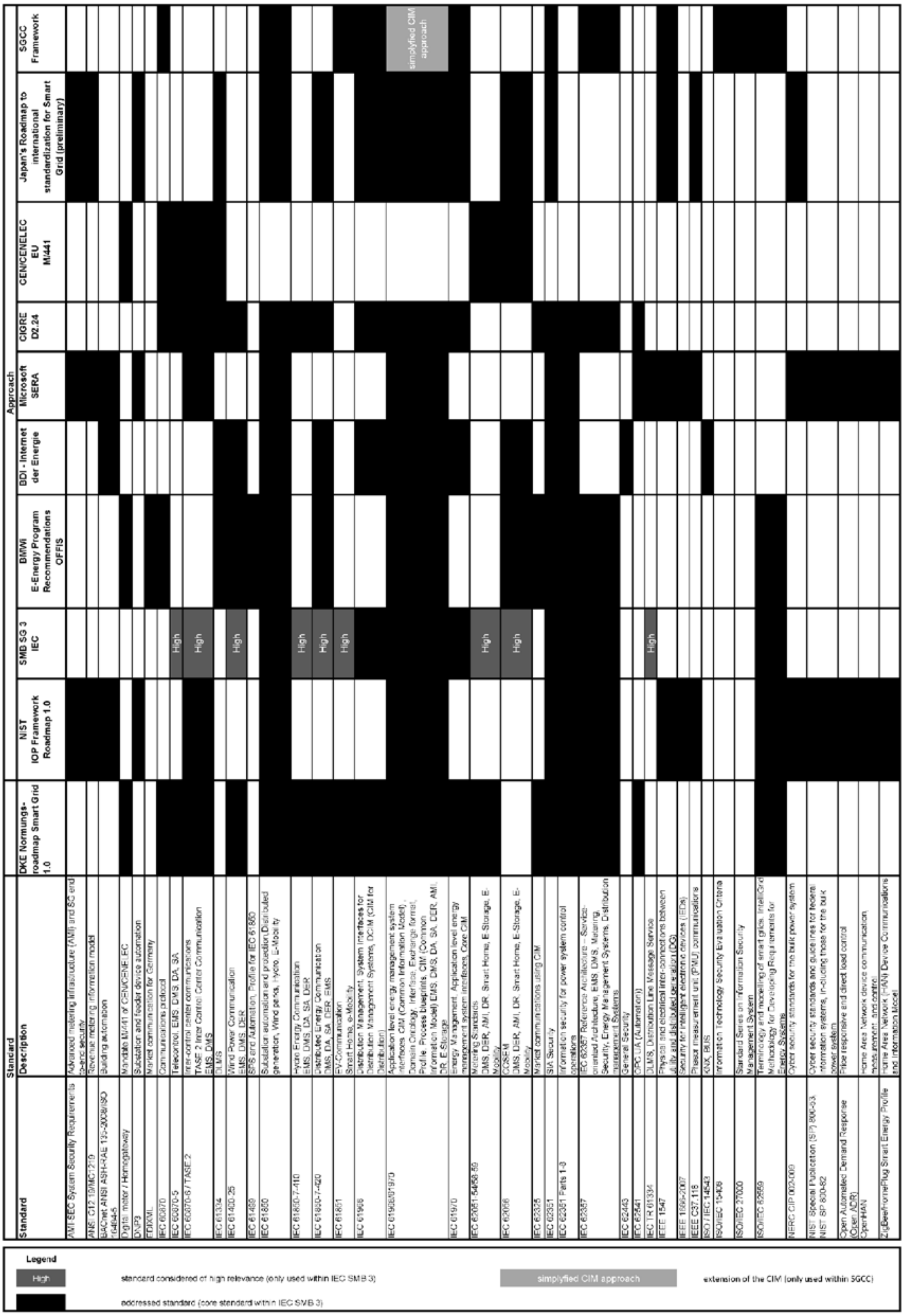

Figure 1. Overview on standards and related approaches based on [11] and [10]

The NIST roadmap is illustrated as second column in Fig. 1 and focuses on the one hand on US standards and on the other hand on IEEE and IEC standards, but also specific building automation and metering standards are considered. Combined with the German Standardization Roadmap (section 3.1) and the IEC SMG SG 3 (section 3.3) almost all recommended standards are considered.

Table 2. Overview on PAP Tasks and last known status [15][‡]

Nr.	Task	Status
0	Meter Upgradeability Standard	Complete
1	Role of IP in the Smart Grid	On target
2	Wireless Communications for the Smart Grid	Caution
3	Common Price Communication Model	Caution
4	Common Schedule Communication Mechanism	On target
5	Standard Meter Data Profiles	Late
6	Common Semantic Model for Meter Data Tables	Caution
7	Electric Storage Interconnection Guidelines	On target
8	CIM for Distribution Grid Management	On target
9	Standard DR and DER Signals	On target
10	Standard Energy Usage Information	On target
11	Common Object Models for Electric Transportation	Caution
12	Mapping IEEE 1815 (DNP3) to IEC 61850 Objects	On target
13	Harmonization of IEEE C37.118 with IEC 61850 and Precision Time Synchronization	On target
14	Transmission and Distribution Power Systems Model Mapping	Caution
15	Harmonize Power Line Carrier Standards for Appliance Communications in the Home	On target
16	Wind Plant Communications	Caution
17	Facility Smart Grid Information Standard	Late

3.3 IEC SMG SG 3 Roadmap

The SG 3 (Strategy Group “Smart Grids”) was appointed by the IEC Standardization Management Board (SMB) to develop a roadmap. In February 2010, a draft of version was published which included IEC standards and eleven high level recommendations. Finally, in June 2010, the current IEC Smart Grid Standardization Roadmap Edition 1.0 [4] was released. The IEC roadmap focuses on improved monitoring and control of all components within the network. Therefore, it is necessary to achieve a higher level of syntactic and semantic interoperability between all involved components and solutions. Increasing energy consumption, further spread of Decentralized Energy Resources (DER), sustainability of generation and distribution, competitive market prices, security of energy supply as well as the maturing infrastructure are seen as main drivers for the changing process. In contrast to other surveys the IEC roadmap focuses on identifying existing standards and potential gaps in the IEC portfolio and doesn’t analyze standards from other standards developing organizations (SDOs). The IEC followed a top-down approach for identifying standards as well as gaps and relied heavily on the description of the major applications of smart grids to identify requirements. Based on the captured requirements the IEC derived tasks and necessities for standardization, the procedure consisted of the following three main tasks:

- Capture and description of all functional and system management requirements of electric energy operations
- Evaluation and rating the impact of each functional and system management requirement on the design of an architecture
- Identification and briefly assessment of functions which could have significant impact on architectural designs

Within this procedure each sub system was described in the same structure of five topics description, requirements, existing standards, gaps and recommendations.

As a result, more than 100 standards have been identified, described and prioritized. Within the survey a differentiated analysis on available standards was performed, as a result five standard series are ranked as ”core” and nine as ”high priority”. The roadmap includes thirteen main application areas, six general topics and more than 40 recommendations overall [4]. As a summary five more general recommendations for IEC standardization were developed and listed below:

Recommendation G-1: Standardize necessary interfaces and product requirements and avoid standardizing applications and business models

Recommendation G-2: Promote IEC work on smart grid standardization through promotions and workshops, particularly, IEC Technical Report (TR) 62357

Recommendation G-3: Avoid standardization of technical connection criteria as these are subject to standards, regulations and various local specifications

Recommendation G-4: Strive for cooperation with stakeholders in the domain “markets”; here a lot of proprietary work is done. The IEC should seek close cooperation with organizations such as United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT) and United Nations Electronic Data Interchange for Administration, Commerce and Transport

[‡] For a current version see http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PriorityActionPlans. Only schedule status of the latest entry is listed, provided status on deliverables and resources are not considered within this table.

(UN/EDIFACT) as well as other important regulatory authorities and trade associations

Recommendation G-5: Acknowledge the work done by NIST and actively offer support in the identified prioritized action fields where the IEC is involved. Additionally offer consultation in other areas

In conclusion, the roadmap recommends IEC to promote the already available collection of (IEC-) standards in the field of smart grid and to seek a close cooperation with the NIST roadmap activities. To support selection and usage of relevant standards the IEC Mapping Tool, providing an overview on smart grid standards and several filter criteria, was developed see [16]. Latest information regarding smart grid activities of the IEC can be accessed at the IEC Smart Grid website, see [16].

The standards covered by the IEC roadmap are depicted in the third column of the approaches shown in Fig. 1. Except the standards IEC 62056 and IEC 61334 all of them are also recommended by the German Standardization Roadmap (section 3.1). The roadmap only recommends IEC standards and can thus be seen as a complementary approach to the others focusing standards outside the IEC.

3.4 German E-Energy Standardization Roadmap

Under the sponsorship of the BMWi in cooperation with the Federal Ministry of Environment, nature Conservation and Nuclear Safety (BMU), the public funded German E-Energy[§] program was established in 2008 [17]. Within a total of six model regions spread across Germany demonstration projects with different focuses are carried out to create the so called “Internet of Energy”. As a common basis for all projects, the BMWi commissioned the study to analyse the standardization environment of the six projects in late 2008. The intention of this study is to consistently provide information about existing standards, standards in process and additionally standards for ICT-based energy systems and their usage in the context of these on-going six projects. To achieve this, the standardization environment was examined based on expert interviews, literature research and the consortium's experiences of IEC and Institute of Electrical Electronics Engineers (IEEE) participation. In order to get a standards overview which is as accurate as possible, vertical and horizontal standards were considered. Additionally, similar initiatives of other countries (e.g. IntelliGrid from EPRI) and their experiences are considered.

The study gives recommendations concerning standards in software engineering, software architecture concepts, a functional standards architecture, the Common Information Model (CIM), substation automation, distributed energy communication, hydro energy communication, general communications, telecontrol, programmable logic controllers, market communication, security, home automation and smart metering. A focus of the study is on the two most important and largest standard series of the IEC TC 57 reference architecture, which are the CIM (IEC 61970 and IEC 61968 series) as an integration framework for IT services and market communications and IEC 61850 concerning substation automation, communication and telecontrol of distributed energy resources. Moreover, the security standards IEC 62351 and IEC 62443 as well as international and national best practices like North American Electric Reliability Council (NERC) Critical Infrastructure Protection (CIP) and the requirements of the German Association of Energy and Water Industries (BDEW) were considered. Beyond that, standards and proprietary protocols in the field of home automation and smart metering were analysed. It is emphasized, that it is harder to give particular recommendations for those areas.

These recommendations are not specific for the funded model regions and thus are also be useful for other smart grid realization projects. Besides IEC standards, the study focuses on converging technologies between the ICT and automation domains. The study served as basis for the national German roadmap [6] and as well as one of the input documents for the IEC roadmap.

Fig. 1 shows that this roadmap is the only one considering EDIXML for German market communication, hence there is a difference to the German Standardization Roadmap (section 3.1) which could also be expected to also recommend this standard. Furthermore, IEC 61499 is also only recommended by this roadmap. This is due to the broader focus of the roadmap having a wider scope as, for instance, the IEC SMG SG 3 roadmap (section 3.3).

3.5 German BDI Initiativ - Internet der Energie

The German Federation of German Industry (BDI) completed a study (”Internet of Energy – ICT for Energy Markets of the Future”) [18] in December 2008 and published it in February 2009. The study focuses on energy shortage, the regulatory environment, technical developments associated with increasing energy prices and the German electricity system including its ITC infrastructure. According to the study many components for a future smart grid (Internet of Energy) already exist but currently their interconnection is missing. The study assumes that only the integration of ICT technology together with electro technical devices provides maximum efficiency. Further on, the study outlines three scenarios, named electrical mobility, distributed generation, and energy trading and new services, towards a future smart grid.

Regarding analysis of standards, several standards were linked to a matrix consisting of four domains (decentralized

[§] http://www.e-energy.de/

energy generation, transport grids, energy quantity measurement and end consumption) and three layers (usage, usage and transport and transport and communication). Standardization is considered a major task within others. For standardization the following four main tasks were given:

- An improved harmonization and integration of existing standards and communication protocols
- Extend standardization to gas, water and heat
- Coordinated support for interoperability
- Development of open communication standards for new technologies

Apart from tasks considering standardization the BDI identifies five other major topics. For each topic the following measures are proposed to develop the current energy system towards a future smart grid:

Incentives, regulation and legislative framework

- Establishment of an contradiction-free regulatory framework
- Consideration of data privacy protection just from the beginning
- Creation of sustainable incentives for innovation for network operators
- Establishment of target-oriented economic incentives for energy efficient companies
- Promotion of innovative connected devices in households
- Promotion of electromobility

Promotion of R&D projects dealing with

- Multi-Utility projects
- Virtual power plants
- Flexible-AC-Transmission-Systems (FACTs) pilot projects within German and European Union for the Co-ordination of Transmission of Electricity (UCTE)-network
- Fundamental research regarding energy storage and transport
- Analysis of end user behaviour, incentive mechanisms and technology acceptance

Promotion methods and reorganization

- Improve coordination within R&D activities
- Focus on interdisciplinary research (like combining engineering, information technology and business and social sciences approaches)
- Certificate and award pioneers within intelligent energy usage
- Integration of public administration into the smart grid

Further education

- Interdisciplinary studies
- Extension of further education offers

Public relationships

- Communication of benefits of smart grids to the end user
- Confidence building

Compared to the other two German approaches (section 3.1 and section 3.4) this roadmap additionally recommends also the BACnet standard for building automation. Moreover, Fig. 1 shows that IEC 14543 (KNX) as well as IEC 62443 (general security) are also recommended for Germany. These additional recommendations are based on the scope of the BDI roadmap focusing automation as essential part of smart grids.

3.6 Microsoft SERA

The Smart Energy Reference Architecture (SERA) [9] was created in 2009 by Microsoft and shall represent an integrated reference architecture for a “smart energy ecosystem” which refers to the new utility landscape in smart grids and emphasizes the broad range of participants involved. According to their definition of reference architecture, it is aimed at providing a consistent framework that can guide the implementation within the “smart energy” domain. The SERA therefore identifies technological aspects and solution concepts along the entire electricity value chain from generation to the end user. With the reference architecture, it is intended to accelerate solutions development to become more cost-effective, secure and scalable. This goal is said to be reached primarily, but not necessarily, using Microsoft products. A close collaboration with power industry partners has been carried out to compile best practices (e.g. with Accenture, Alstom Power, AREVA, ESRI, Itron Inc. and OSIsoft Inc.) to take the power utilities IT infrastructure requirements into account.

SERA appreciates NIST work and wants to be seen ‘as a bridge from NIST standards to specific Microsoft products and technologies’.

In order to consider the future development of the smart grid economy which has implications for the reference architecture, it is motivated by arising demands and upcoming challenges on the business. Identified influential factors are split up into Energy Resources and Constraints (e.g. renewable energy, distributed generation, demand response and power quality monitoring), Business Factors (e.g. increased degree of automation, equipment collaboration and outsourcing) and Technology Enablers (e.g. advanced sensors, Advanced Metering Infrastructure (AMI) and new computing paradigms).

The architecture itself is made up of seven components, named Approach, User Experience, Collaboration, Information, Integration, Application Architecture, and Security, describing characteristics and requirements of implementations.

This includes among other things the description of quality attributes like performance and interoperability, the implementation should comply with (Approach); how interfaces provide users with access to information and services based on their roles with a focus on analysis, business intelligence and reporting (User Experience) and potential information and data exchange styles for collaboration. Furthermore, approaches concerning representation, management and exchange of smart grid-related information (Information) are outlined and it is proposed how data and systems participating in a smart grid can be integrated, e.g. with Service-oriented Architectures (SOA) supported by Cloud services. Requirements referring to application architecture and security are also briefly considered (Application Architecture and Security).

Especially in the context of information and integration, various standards taken from [13] and [4] are proposed for description and integration in the energy domain, as for example IEC 61970/61968 CIM. Being based on mainly technology independent standards, the architecture enables software vendors to create interoperable solutions.

Since the SERA deals with the implementations of standards recommended by the NIST (section 3.2) Fig 1. shows that almost the same standards are covered. Only the IEC 62541 OPC Unified Architecture is not explicitly recommended by the NIST and is used as implementation paradigm within the SERA.

3.7 CIGRE D2.24

The Conseil International des Grand Reseaux Électriques (CIGRE) Working Group (WG) D2.24 focuses on "EMS Architectures for the 21st Century" and wants to produce a complete and consistent specification of such architectures. In doing so their goal is to create a common architecture vision and identify common requirements for next generation energy and market management systems. It is intended to gain wide adoption in practice and to facilitate its implementation as a de-facto standard. Within the architecture development, the working group's key focus is on achieving a highly interoperable and reusable architecture. For this purpose the WG develops a common set of requirements and describes the architecture and its standard components.

The scope of the next generation energy and market management systems architecture is on real-time systems coupled with transmission grids and market systems, and should be extendable to generation and distribution.

Underlying the architecture development, ten design principles were defined, which are:

- Component-based and service-oriented architecture to enable integration and reusability within the utility
- Modularity based on businesses processes componentization
- High speed bus for real-time message exchange
- Common information model for data standards
- Built on industry standards
- Common user interface
- Security layer
- Common modeling tools integrating display and data maintenance transportable to future technologies
- Scalable for future use cases

CIGRE WG D2.24 sets the vision and requirements and is not responsible for setting any standards. To better incorporate standards in the architecture, a "category A liaison" between IEC TC 57 and CIGRE D2 has already been established, so that the developed architecture will be mainly based on IEC TC 57 standards and architectures [19].

All standards recommended by CIGRE WG D2.2.4 have been recommended by the previously introduced approaches (see Fig. 1). The focus of the recommendations is on IEC standards similar to IEC SMG SG 3 (section 3.3) but with a smaller scope.

3.8 CEN/CENELEC/ETSI Smart Meters Coordination Group to EU Mandate M/441

The introduction of intelligent metering systems (also called smart metering systems) is promoted by the European Union through different recent regulation. This regulation should lead to a wide rollout of smart meters in the electricity and gas domain in Europe. The main concern is to develop a greater awareness of energy efficiency by end users and as a result energy savings.

The EU Mandate M/441 issued by the European Union contains the standardization of smart meter functionalities and communications interfaces for the use in Europe. The result of this mandate consists of identified standards or technical documents and recommendation. In this context standards should be seen as voluntary technical specifications and general technical rules for products and systems on the market. The aims of standards are to secure interoperability, ensure system reliability and to protect the customers.

Together with different stakeholders CEN, CENELEC and ETSI formed the Smart Meters Co-Ordination Group (SM-CG) to consider the main issues addressed by the mandate. The following six aspects of smart metering are considered and the prevailing standards were examined [20]:

- Reading and transmission of measurements
- Two-way communication between the meter and a market participant (biller)
- Support by the meter for various tariff models and payment systems
- Remote meter deactivation and start/finish of supply
- Communication with devices in the household
- Support of a display or interface in the household for display of the meter data in real time

However, this list is not considered to be a minimum list of necessary functionalities and it is not proposed to establish a minimum set through standardization. The decision about the functionalities should be left to the individual country. Within the "Smart Meters Coordination Group" existing standards are classified in relation to these six functionalities and responsibilities delegated to individual standardization committees as shown in Fig. 2.

The general consideration of standardization contains the improvement of existing standards rather than creating a new one, but the European Standardization Organizations (ESO) shall take care to accept new work item proposals to ensure that new technologies, procedures and protocols can be adopted from the market. A detailed timetable has to be developed, yet.

The EU Mandate M/441 is specialized on smart metering and thus only a small set of standards is recommended as illustrated in Fig 1. As a result, this is the only approach not recommending IEC 61850, CIM and IEC 62351 as substation automation, general integration and SIA security are not considered by the mandate.

3.9 CEN/CENELEC/ETSI Joint Working Group Report on Standards for the Smart Grids

The European Union will most likely give an additional mandate like the M/441 mandate to the three European standardization bodies to work on smart grid standardization. A draft to provide an overview on the international landscape is currently under development by a chosen working group [21]. The main topics for the report enclose recommendations for cross-cutting topics like terminology, systems aspects, data communication reference architecture and data communication interfaces with the focus on sectional standards like e.g. Distribution Management Systems (DMS), Supervisory Control and Data Acquisition (SCADA), data models, Enterprise Resource Planning (ERP) interfaces. Additionally, the topic information security and domain specific topics for utilities are part of it.

Because of the numerous stakeholders, the necessary speed, many international activities and changing recommended solutions make standardization a difficult task for the ESO. This report investigates the status of European standardization but should not duplicate the extensive work already done in other regions. The main focus is concerning the organization of standardizations in Europe to give high-level recommendations with the following parameters:

- Use a top down approach
- Build up a flexible framework of standards
- Agree on an European set of use cases
- Align to international standards
- Reuse existing mature standards

The importance to adapt the organization and processes for standardization is seen as a critical issue and the establishment of the Joint Working Group is seen as a first step in the right direction.

In summary, the report [21] identifies and proposes the necessary steps to be taken concerning standardization of smart grids in Europe.

3.10 IEEE P2030

The IEEE P2030 project, sponsored by the IEEE Standards Coordinating Committee 21, develops a "Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-Use Applications and Loads" [22]. The aim according to IEEE is to provide guidelines for smart grid interoperability including knowledge base addressing terminology, characteristics, functional performance and evaluation criteria, and the application of engineering principles for smart grid interoperability of the electric power system with end-use applications and loads. Alternate approaches and best practices are also part of it.

To reach the goals, the following three task forces were established with approximately 150 participants and unprecedented collaboration of three IEEE Societies:

TF-1 Power Engineering Technology

- Power and Energy Society Centric
- Focusing on definition of the needs

TF-2 Information Technology

- IEEE Computer Society Centric

TF-3 Communications

- IEEE Communications Society Centric

TF-1 will focus on functional requirements of interoperability and draw as much as possible from existing efforts of others. TF-2 and TF-3 will take these identified requirements and develop interoperability guidelines for the domains protocol, architecture, transport, application, security privacy and other.

This project is traceable to the US governments EISA from the year 2007, so a close cooperation with NIST is to be expected. As a result the recommendations will be way similar and the recommended standards almost identical.

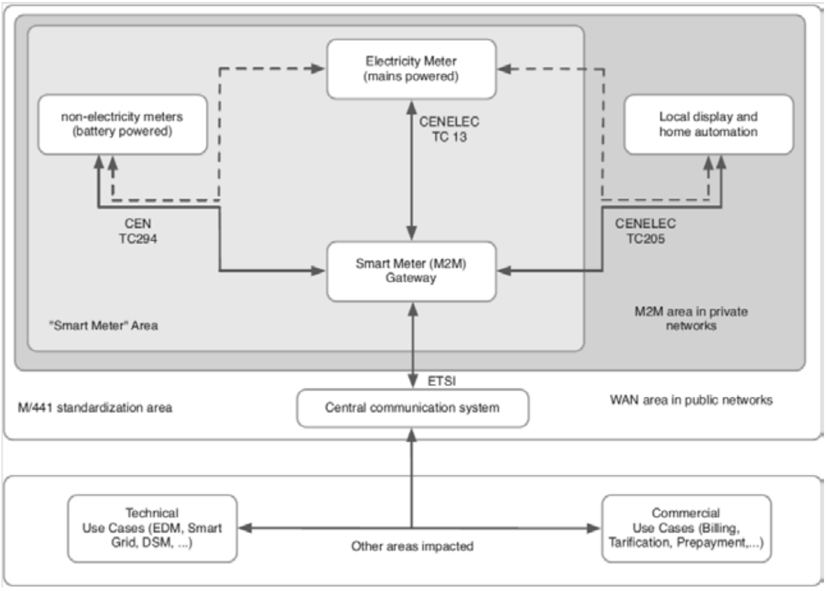

Figure 2. Summary of the proposed responsibilities for the standardization work [6]

3.11 Japanese International Standardization Roadmap for Smart Grid

The Ministry of Economy, Trade and Industry (METI) in Japan, started an Initiative, which resulted in a strategy group founding in August 2009 with the aim of promoting Japanese activities in the international standardization in the smart grid domain [23]. To reach the required interoperability standards are seen as a fundamental element.

The prevalent opinion within the strategy group is that the desired flexibility and expandability of the smart grid can only be achieved with an appropriate degree of standardization. In January 2010, a first report of a roadmap for the establishment was completed, providing a roadmap in close cooperation with other standardization organizations and countries. On the basis of a general picture of the future smart grid the following seven main fields of business were identified:

- Wide-Area Awareness in Transmission
- Supply Side Energy Storage
- Distribution Grid Management
- Demand/Response
- Demand-Side Energy Storage
- Electric Vehicles
- AMI Systems

Inside these fields 26 Priority Action Areas were assigned as follows:

1. Wide-area situational awareness (WASA) in transmission systems

2. Optimized controls for system storage cells
3. Optimized controls for distribution storage cells
4. Optimized controls for building/community energy storage
5. High-efficiency power conditioners for storage cells
6. Distribution automation systems
7. Power conditioners for distributed power supplies
8. Power electronic devices for distribution
9. Demand response networks
10. Home Energy Management Strategy (HEMS)
11. Building Energy Management Systems (BEMS)
12. Factory Energy Management System (FEMS)
13. Community Energy Management System (CEMS)
14. Fixed energy storage systems
15. Storage cell modules
16. Methods of assessing the salvage value of Electrical Vehicle (EV) storage cells
17. Quick EV charger-vehicle communications
18. Quick EV charger connectors
19. Quick EV charger unit design
20. Safety testing of lithium-ion batteries for vehicles
21. Vehicle-to-regular EV charger infrastructure communications
22. Infrastructure control of regular EV chargers
23. Wide-area meter access communications
24. Local meter access communications
25. Gas metering for AMI systems
26. Authentication method between meter communicators and higher-level systems

Additionally, special core aspects for the Japanese economy were also identified. The recommendations are almost full congruent with the recommendations from other organizations like IEEE, IEC and CEN/CENELEC due to the close cooperation. Advanced collaboration with other countries is planned for the future as well as an examination of the need for an implementation body by a private sector consortium along with government assistance policies.

The Japanese roadmap relies on a combination of recommended standards from the NIST roadmap (section 3.2) and the IEC roadmap (section 3.3) but additionally considers IEC 61334 DLMS for metering communications (see Fig. 1). Compared to the Chinese roadmap (section 3.12) almost all commonalities relate to CIM and IEC 61850 and their subparts.

3.12 SGCC Framework and Roadmap

The State Grid Corporation of China (SGCC) is a state-owned company which operates the largest part of China's power grid. They established the initial SGCC Framework and Roadmap for Strong and Smart Grid Standards [24] in 2009 as a guideline 'to develop corporate standards, as well as important reference for industrial, national and international standards'. Regarding the increasing demand and the Chinese market's size the framework put in place will also have a huge impact on all product vendors for a smart grid based on open standards as well as on other markets.

With the 'strong' and 'smart' grid SGCC wants to build an intelligent power system encompassing power generation, transmission, transformation, distribution, consumption and dispatching. The strong and smart grid is to mark a shift in the function of the power grid insofar as it is planned to become a more integrated and intelligent platform for the internet of things, internet network, communication network, radio, and TV networks beyond its function as a carrier of transmission and distribution of electricity.

SGCC considered current research and studies on international smart grid standards for their framework and roadmap which include e.g. IEC SG 3, NIST Interoperability Roadmap, IEEE P2030, CEN/CENELEC/ETSI Working Groups, German Standardization Roadmap and the Japanese METI Roadmap. In its first version, the SGCC framework hierarchically divides the subject matter – in the same order – into 8 domains, 26 technical fields and 92 series of standards. The eight domains comprise planning, power generation, transmission, substation equipment and communication, distribution, utilization, dispatching, and ICT. Within these domains, existing standards were identified as useful or respectively gaps were discovered.

To do so, the authors examined domestic and international smart grid relevant standards and named a first batch of 22 core standards "with close relation to smart grid construction, strong systematicity and wide coverage" to support the framework. Ten of these identified standards are domestic ones and twelve of them are international ones, which are listed in the following:

- ISO/IEC 62559: Terminology and modeling of smart grid
- IEC 61850: Standard series on Substation Communication network and System
- IEC 61968: Interface of Power Company Data Exchange Platform - Distribution Management System
- OGC Open GIS: Specifications on Open Geographical Data Interoperability
- IEEE 1547: Technology Regulations on Integration of Distributed Generations into Power Grid
- IEC 61851: Standard Series on Electric Vehicle Charging and Discharging
- IEC 61970: Standard Series on Application Program Interface of Energy Management Systems (EMS)
- IEC 60870: Standard Series on Transmission Control Protocol

- IEC 62351: Power System Management and Associated Information Exchange - Data and Communications Security
- IEC 62357: Power System Control and Associated Communications - Object Model, Service Facilities and Protocol Architecture with Reference
- ISO/IEC 27000 series: Standard Series on Information Security Management System
- ISO/IEC 15408: Information Technology Security Evaluation Criteria

With regard to the on-going development of the framework it is said that these core standards are subject to further adjustments.

As a long-term goal it is planned to further develop and improve the SGCC framework and roadmap and to participate in the formulation of national and international standards. This is laid down in a plan encompassing the phases “Planning and Trial”, “All-around construction” and “Leading and Enhancing” from 2009–2010, 2011–2015 and 2016–2020 respectively.

In each stage standardization is demanded on different levels to different degrees and it is finally desired to promote domestic standards into international standards. So far until the date of release of the first roadmap, SGCC started 228 demonstration projects of 21 categories, spread over 26 provinces and municipalities since August 2009 to realize the ‘strong and smart grid’.

The last column of Fig. 1 considers the Chinese standardization roadmap for smart grids. Compared to the other national roadmaps relatively few international standards are recommended but also lots of national standards are recommended but not depicted in the figure. IEC 27000 and IEC 15408, coping with IT security, are recommended by none of the other approaches and the main difference to the German roadmap (section 3.1).

3.13 Korea’s Smart Grid Roadmap

The Korean Smart Grid Institute under the Ministry of Knowledge Economy (MKE) designed a roadmap to build a nationwide smart grid until 2030 [25]. A three phase plan has been established with the focus on five domains, namely Smart Power Grid, Smart Consumer, Smart Transportation, Smart Renewables and Smart Electricity Service. The goal of the first phase from 2010 to 2012 is to concentrate on 10 already ongoing demonstration projects since 2005 and using the results to establish a proper technical platform for the future Korean smart grid. The projects include the following tasks:

- Development of Korean Energy Management System
- Development of Intelligent Transmission Network Monitoring and Operation System
- IT-based Control System for Bulk Power Transmission
- Development of Prototype for Advanced Substation Automation System based on the Digital Control Technology
- The Development of Power Equipment Monitoring System using active Telemetrics
- Development of Intelligent Distribution Management System
- Development of Power Line Communication (PLC) Ubiquitous Technology
- Power Semiconductor for Dispersed Generation and Industrial Inverter Application
- Development of integration Energy Management System (EMS) for the microgrid and application technology to real site
- Consumer Portal System for IT-based Energy Services Business

The next phase from 2013 to 2020 aims to provide intelligent services including AMI, Vehicle to Grid (V2G) an Virtual Power Plant (VPP) infrastructure, smart power trading Systems, smart new renewable-linked technologies, and a Urban Smart Power Grid development on a wide area scale. The last phase from 2021-2030 aims to establish the results on a nationwide scale with a national smart power grid operation, AMI-based automatic power trading, EV and charging service generalization, large scale new renewable supply infrastructure development, and an integrated power trading including service development. However, there has been no specific roadmap in using international standards so far, but cooperation with home appliances projects like the German E-Energy projects especially the EEbus series are established.

3.14 ISO/IEC JTC 1 Special Working Group on Smart Grid (SWG-Smart Grid)

The SWG-Smart Grid was established at October 2009 in Tel Aviv, because the Joint Technical Committee 1(JTC1) recognized the continuing and important evolution of smart grid technologies. Additionally, many standards consortia like the ones preparing the before mentioned studies and roadmaps are planning to develop smart grid standards [26]. The terms of reference for the SWG include the following points:

- Identify market requirements and standardization gaps for the smart grid especially interoperability standards in an international context
- Encourage the JTC 1 Subcommittees (SCs) to address the need for standardization of the identified points
- Promote the developed international standards
- Coordinate JTC 1 Smart Grid programs of work with other Organizations
- Develop JTC 1 Smart Grid strategic plan recommendations

The primary focus lies on standards supporting interoperability of smart electric grid technology and appropriate extensions to include automated gas, water and other metering systems and interfaces with home and building automation systems that are dependent on the same smart electric grid ICT infrastructure.

To support the SWG-Smart Grid, experts have been nominated by the national bodies of Canada, France, Germany, Japan, Republic of Korea, The Netherlands, Singapore, United Kingdom, The United States and also the JTC 1 Subcommittees SC 6, SC 22, SC 25, SC 32, and WG7. Additionally the group requested to establish liaisons relationships to IEC SMB SG 3, ISO/TC 215/WG 7, CEN/CENELEC/ETSI Joint Working Group on Smart Grid and Smart Meters, NIST Smart Grid Interoperability Panel, and Telecommunication Standardization Sector (ITU-T) Focus Group on Smart Grid. These entities are also responsible for most of the before mentioned studies and roadmaps so that it can be expected that there will be an interaction which could have an impact on future releases of the specific roadmaps/studies.

The first agreements accepted were to use the IEC SMB SG 3 architectural framework as a starting point and to focus on interoperability layer categories 1 through 7 (Basic Connectivity through Business Objectives). Periodically, conference calls are planned, so a steady progress can be expected.

4. Recommended Core Standards

As the previous section has already introduced different countries, organizations and vendors came up with their own roadmaps regarding the topic of smart grid standardization. Providing a different focus and definitions on the smart grid itself, it is clear that the scope of smart grids differs from country to country. Where solutions at the customer's site often have different focus from home appliances for demand response, peak shaping, home automation, other countries mainly focus on reducing non-technical losses through smart metering or improving the outage management for radial feeder systems. Also, political agendas differ. While reliability may be a scope for some countries to provide the security of supply for the digital economy, focusing on markets and economic benefits for the country other regions have a more sustainable energy vision in mind trying to reduce carbon dioxide emissions and to cope with distributed, renewable generation like Micro Combined Heat and Power (CHP), photo-voltaic, fuel cells or electric vehicles in the distribution grid.

Based on the table depicted in Fig. 1, the most striking and common standards are from the IEC TC 57 which will be introduced in the following section. According to the number of recommendations the following TC 57 standards are of highest importance from the perspective of most experts: Since national perspectives differ, organizational standards e.g. like IEEE ones have less impact on worldwide scale.

- IEC TR 62357: Reference Architecture [27]
- IEC 61968/61970: Common Information Model for EMS and DMS [28], [29], [30]
- IEC 61850: Intelligent Electronic Device (IED) Communications at Substation level and DER [31]
- IEC 62351: Vertical security for the TR 62357 [32]
- IEC 60870: Telecontrol protocols [33],[34],[35]
- IEC 62541: OPC UA – OPC Unified Architecture, Automation Standard [36]
- IEC 62325: Market Communications using CIM [37]

The following paragraphs are going to provide a short introduction to each of those core standards (mapping the TR 62357) being consensus among the relevant stakeholders:

IEC 61970/61968 – Common Information Model: originally designed as an EMS-API, the CIM was developed being an internal database model for EMS and SCADA systems but soon changed into a much more useful object-oriented approach to model all the relevant objects and their relations in the scope of electric distribution, transmission, and generation. The domain ontology is pretty large covering most aspects being focused on subparts of the model like generation, outage, documentation, transmission, wires, measurements, and so on. Major use cases for the CIM are system integration using pre-defined interfaces between the DMS IT and automation parts, custom system integration using Extensible Markup Language (XML) based payloads for the coupling of systems, and serializing topology data using Resource Description Framework (RDF) for state estimation, SCADA and GIS exchange. Most of IT Enterprise Application Integration (EAI) and SOA aspects in a modern electric utility can be covered using CIM.

IEC 61850 (IEC 61400-25) – Substation, DER, and Power Generation communication and automation: originally designed with the designation of enhancing the interoperability between systems from different vendors at substation level, the standard has outgrown its original purpose and has become an automation and control standard at the field level. Providing an abstract data model using table notation and (since 2011) a UML notation. An abstract communication system interface provides the technical mapping from the communication standards which can be exchanged as time and technology evolves to the core functions, status points and attributed of the physical systems modeled. The most crucial aspect is the System Configuration Language (SCL) defined in part 6. SCL allows to describe instances of complete systems including, devices and information flow between all entities involved (protection, control, monitoring).

IEC 62351 – Data and Communications Security: For the whole vertical integration between IT and field layer IEC 61850 and 61970 this standard series covers the information security aspects for the corresponding power system control operations.

IEC 60870-6 – TASE.2: Focusing on the actual communication link between SCADA systems, these communication protocol standards facilitate control center data exchange. The standards from this family define the electric power systems status and the control messages to be sent between Control Centers (CCs) of different Distribution System Operators (DSOs) and Transmission System Operators (TSOs).

IEC 62541 – OPC Unified Architecture: OPC UA is a new automation paradigm and standard series replacing the old Microsoft based and driven Classic OPC Data Access (DA). It provides several layers which can be used in context with the IEC 61850 and CIM, and provides two main serializations (binary and a web service).

IEC 62325 – Market communications using CIM: Of particular interest to achieve a complete vertical standardized semantic model is the use of CIM for market communications. While currently national regulators have often developed their own formats and semantics for the national process, the CIM will be of highest interest in this domain in the future.

5. The IEC TC57 Seamless Integration Reference Architecture

The main goal of the technical report "IEC TR 62357: Power System Control and associated Communications - Reference Architecture for Object models, Services and protocols" also most of the time called SIA (Seamless Integration Architecture) was originally to provide an overview on how the "IEC TC 57: Power System Control and Associated Communications" standards relate to each other and interact with different standards from other TCs [27]. While core standards have been identified by different national and international standardization roadmaps for smart grids, the previous section of this contribution has already outlined that most of those are related to the IEC TC 57. This leads to the main conclusion that the TR 62357 provides an overview and an architecture how the TC 57 standards should be used in context. This is of highest importance to the smart Grid, in terms of implementation. Fig. 3 shows the SIA from the international IEC perspective in its current version as of 2010.

Different layers can be distinguished. On vertical scope (C), security of data communications is of highest importance and focused by the IEC 62351 series. Each of the individual layers has got special requirements which are reflected by a part of 62351 dealing with those requirements. On top level (A), secondary IT technology like market communications, billing, asset management and geo information systems are addressed. Therefore, the CIM IEC 61970/61968 and its serialization are used. Since the CIM originally was seen as an EMS-API one focus is also the standardization of interfaces and payloads for EMS, DMS and SCADA. The CIM makes use of modern IT techniques like XML, RDF (Semantic Web application), and provides the possibility to implement many TR 62357 layers using a SOA. Those layers deal with primary and secondary IT and have to be integrated with both telecommunications and automations layers which are depicted in the lower layers (B) beyond the specific objects mappings layer. The main communication standard is the IEC 60870 providing SCADA to field automation data exchange. Within the substation IEC 61850 is gaining a strong momentum being the pre-dominant new standard. Also, IEC 61850 has been adopted for control and communication with distributed renewable energy producers like micro-CHPs, fuel cells, or PV. Apart from this, the metering and home automation scope is not within the general TC 57 scope and is standardized by different TCs or SDOs.

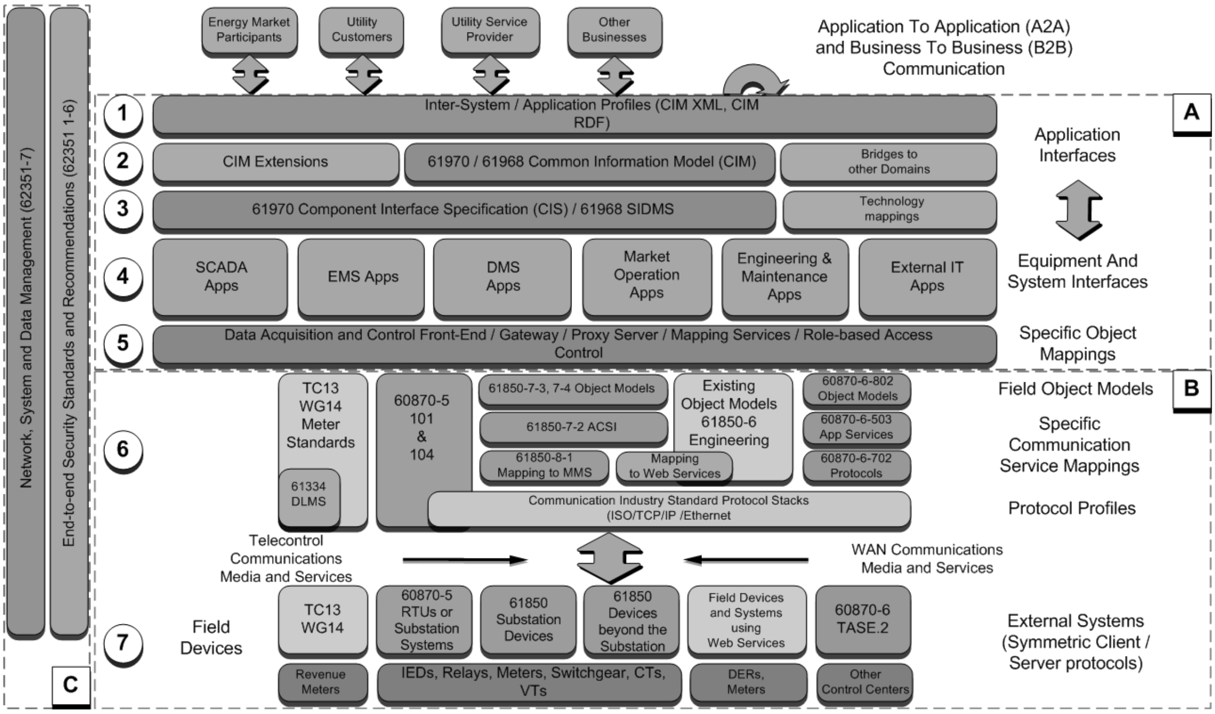

Figure 3. IEC TR 62357 Reference Architecture

6. Assessment

In the following section the SGMM is presented as a starting point for the assessment of projects and roadmaps. Since it does not meet all requirements for such assessments because it was developed to assess utilities and follows a one-size-fits-all approach a configuration approach based on several parameters representing significant characteristics is suggested.

6.1 SGMM

The SGMM was developed at the Software Engineering Institute (SEI) at Carnegie Mellon University as a management tool providing a common framework. It is under continuously development to increase its accessibility and to improve its capabilities in terms of assistance in planning, implementing, and managing smart grid transformations [38]. It helps organizations to identify where they are located on the smart grid landscape, to develop a shared smart grid vision and roadmap to prioritize options as well as to support decision making. Furthermore, it provides a communication based on a common language and the chance to compare to themselves and others from the community. Finally, organizations can measure their progress and prepare for and facilitate changes [36]. The model includes the following eight domains:

- Strategy, Management and Regulation (vision, planning, governance, stakeholder collaboration)
- Organization and Structure (culture, structure, training, communication, knowledge management)
- Grid Operations (reliability, efficiency, security, safety, observability, control)
- Work and Asset Management (asset monitoring, tracking and maintenance, mobile workforce)
- Technology (IT architecture, standards, infrastructure, integration, tools)
- Customer (pricing, customer participation and experience, advanced services)
- Value Chain Integration (demand and supply management, leveraging market opportunities)
- Societal and Environmental (responsibility, sustainability, critical infrastructure, efficiency)

In this context a domain is understood as a logical grouping of smart grid related capabilities and characteristics [39]. For each of the eight domains an organization can reach a maturity level within the range from 0 to 5.

The domains and the levels form a matrix which includes about 175 characteristics describing the organizations. To assess organization's level of maturity for each domain, organizations have to take part in a navigation process which contains five steps - including two workshops focusing on a comprehensive survey [40] - and is led by a SGMM navigator. After the process, organizations know their maturity regarding the eight domains and also identify the aspired levels for every domain.

The SGMM is a very detailed and complex model however it lacks some basic capabilities to be applicable for projects and roadmaps. The main disadvantage is that the model follows a one-size-fits-all approach which is not appropriate for assessing projects and roadmaps. Furthermore, it is only focusing on electric utility assessments. Finally, in some cases the criteria for the levels within the domains and the domains themselves are not consistent. For example, the technology domain includes IT architecture as well as tools which are independent and not comparable, so organizations could have different maturity levels of them. Moreover, it is possible to fulfill most of the criteria of a domain for level 4 without fulfilling the criteria from level 3. Thus, we suggest using parameters for the configuration of the SGMM, starting with the assessment survey as described in the following sections.

6.2. Configuration

As described in the last section the SGMM is a good starting point to develop a maturity model which is usable to assess also projects and roadmaps. In the first step a set of parameters which must be configured to cope with the new requirements was identified [41]. In expert workshops the parameters shown in Fig. 4 have been evaluated.

Parameter	Value								
Focal Topics	Grid Integration DER	Load Management	Distribution Grid Automation	Smart Metering	In-House Automation	Electric Vehicles		Transmission Grid Automation	
Crosscutting Issues	IT Security	Data Models		Terminology		Smart Grid Use Cases		Tooling	
ICT Dimensions	Architecture	ICT Data Models	Communication Link	Communication Interface		Data Consistency		Data Volume	
Smart Grid Definition	Economic			Sustainability			Reliability		
Market Structure	Unbundled		Nodal		Regional			Non Deregulated	
Line of Business	TSO	DSO	Service Provider	Customer	Operations	Market	Bulk Generation	SDO	Regulation
Value Chain	Internal (Intra-Utility)				External (Inter-Utility)				
Degree	Initiating		Enabling		Integrating		Optimizing		Pioneering

Figure 4. Configuration parameter for the use of the SGMM

To make the parameters applicable different values can be assigned to them:

- Focal Topics: Main areas of interest
- Crosscutting Issues: Considered crosscutting topics
- ICT Dimensions: Focused parts of the ICT infrastructure
- Smart Grid Definition: Reasons for participating in smart grids, views on smart grids
- Market Structure: Structure of the underlying market
- Line of Business: Addressed organizations, business areas
- Value Chain: Dimension (intra or inter) of value chain
- Degree: Aspired degree of participation

In the next step for each case (what means for each planned assessment) an appropriate configuration must be found. In that process each parameter can be assigned to one or more of its values. Depending on the configuration a specialized survey will be used for the assessment. Therefore, the SGMM survey [40] has to be revised so that for all possible configurations a single adaption exists.

Fig. 5 shows a sample configuration for The German Roadmap E-Energy/Smart Grid [6] that was used as a test case to adapt the SGMM survey [40]. Also, for the other approaches introduced in section 3 configurations were made to ensure the application of the parameter set.

Based on the sample configuration methodologies following [42] were applied to the SGMM survey [40]. For example, the technology domain needs a major revision regarding the questions on the five different layers. Many questions have to be added dealing with dimensions that are not covered so far. Also, existing questions have to be changed in the choice of their wording and their possible answers. This process leads to a large variety of questions for each level. For every configuration of the parameter set an appropriate subset of questions has to be chosen. Unfortunately, the SGMM assessment process – analysing the survey and measuring the maturity for the single domains – is not public. Thus, in the next step a prototyped rating process was developed and is still under development to achieve the aspired goals of comparability and measurability of smart grid projects and roadmaps.

Parameter	Value								
Focal Topics	*Grid Integration DER*	*Load Management*	*Distribution Grid Automation*	Smart Metering	*In-House Automation*	*Electric Vehicles*		Transmission Grid Automation	
Crosscutting Issues	*IT Security*	*Data Models*		*Terminology*		*Smart Grid Use Cases*		Tooling	
ICT Dimensions	*Architecture*	*ICT Data Models*	*Communication Link*	*Communication Interface*		Data Consistency		Data Volume	
Smart Grid Definition	Economic			*Sustainability*			Reliability		
Market Structure	*Unbundled*		Nodal		Regional			Non Deregulated	
Line of Business	TSO	*DSO*	Service Provider	*Customer*	Operations	*Market*	Bulk Generation	*SDO*	*Regulation*
Value Chain	Internal (Intra-Utility)				*External (Inter-Utility)*				
Degree	*Initiating*		*Enabling*		*Integrating*		*Optimizing*		*Pioneering*

Figure 5. Configuration for the German Roadmap E-Energy/Smart Grid

7. Summary

After discussing for the application of standards in the overall context of smart grids the most important approaches have been introduced. As a result, all standards recommendations were collected in an overview table and a core set of standards was identified whereas each standard was briefly presented. The IEC SIA as starting point for further standardization efforts was described. The second focus was on the assessment of projects and roadmaps to achieve comparability and measurability. It was shown that the SGMM can be configured to meet the requirements for such an assessment process. During the next steps the configuration parameter have to be evaluated in detail, the survey has to be adapted for all possible configurations, and the prototyped rating process has to be improved.

Summarizing, it is obvious that some standards will be indispensable to efficiently operate smart grids and to meet the upcoming integration and interoperability problems. Furthermore, the possibility to compare smart grid projects and roadmaps will be an additional benefit because it enables the measurability of their success.

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