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General requirements for a Smart Grid architecture – remarks on standards for implementation

***Abstract**. The paper presents importance of standardization and potential standards relevant for Smart Grid implementation mainly focused on ICT standards. Short overview of current work performed by different bodies round the world is presented. The paper presents some recommendation based on the SEESGEN-ICT EU project and reports prepared by JWG (Joint Working Group) and NERC (North American reliability Corporation).*

***Streszczenie.** W artykule omówiono problematykę procesu standaryzacji w architekturach Elektroenergetycznych Sieci Inteligentnych - głównie standardów związanych z obszarem ICT. Zaprezentowano krótki opis efektów prac prowadzonych przez organizacje zajmujące się standaryzacją oraz rekomendacje projektów z tego zakresu. (**Problematyka procesu standaryzacji w architekturach Elektroenergetycznych Sieci Inteligentnych**)*

Keywords: Smart Grids, ICT standards.
Słowa kluczowe: Inteligentne sieci, architektura Smart Grid, standardy, ICT

Introduction

A great number of different projects run all over the world focuses on use cases and general requirements for a Smart Grid reference architecture. The architecture of this new distributed system with the fully interactive infrastructure must be designed and validated with wide implementation of standards. The process of developing standards for Smart Grid is a very big challenge. The great number of different stakeholders (producers, consumers, ICT suppliers), short time before reaching 20-20-20 targets to reduce carbon emissions and to secure the energy supply makes this task more difficult. For Smart Grid, it is not just important to change or establish an individual standard but to adapt the organization and processes for standardization[1].

The ICT has a significant role to play in changing current energy systems and energy consumers habits into a new green economy and lifestyle. Traditional Grid SCADA with some additional automation systems are used for monitoring energy production transmission and distribution of the energy. SCADA system is a crucial component in traditional utility/energy sector. But this hierarchical system is not prepared for massive DER and RES intrusion. Those system are not design and not prepared for supporting new business aggregators, integrators and more active customer behaviors. Future Smart Grid demands new ICT solutions. The future Smart Grids will consists of 3 interacting infrastructures [2]:

- Automation, control and management systems of the physical energy infrastructure management systems;
- Business Management Systems;
- Other Information Management Systems (ICT).

The new information management system should be design implemented and maintained in a way that supports new business opportunities for different stakeholders ensuring [2]:

- Balancing Intermittent production,
- Meeting social goals of Energy Efficiency,
- Meeting customer requirements,
- Meeting economic goals,
- Managing interactions with SCADA systems.

European Smart Grid standardization work

The European Commission Directorate-General (DG) for Energy by the group of mandated Experts Group has created a Smart Grid Task Force that highlighted the importance of standards for as one of the most successful Smart Grids deployment factor. The main idea of European Future Smart Grids provides development of communications, metering and new business systems on each level of energy market as basic element of energy efficiency. To fulfill this vision a set of proven technical solutions, shared technical standards and protocols ready to use in with different type of equipment installed in the power Grid should be established. For the ICT solutions standardization is the most important frame that allows to connect devices from different producers to the Smart Grid with the best quality and proper price. Standards allows to achieve such a elements like: interoperability, defining data models, protocols, communications and information exchange, improving security, safety of the new products and systems.

Report prepared by European Technology Platform SmartGrids: Strategic Deployment Document (SDD), released in April 2010, Deployment Priority #4 IC emphasis the importance of ICT as a instrument of new business and new stakeholders coordination.

The most important for wide Smart Grid deployment is industry support. For that reason European Strategic Energy Technology Plan (SET-Plan) was established in 2007. The European Electricity Grid Initiative (EEGI) published detailed roadmap for implementation of Smart Grids 2010-2018. In November 2009 a Smart Grid Task Force was established to advise the Commission on the policy/regulatory directions. It is run by Commission's Directorate General for Energy Policy (DG ENER) in collaboration of with 6 Directorates and about 25 European associations.

To facilitate the technical level the European Commission issued in 2009 mandated of European standardization organizations CEN, CENELEC and ETSI to cooperate in development of open system architecture. They have formed a Joint Working Group and the result of their work is presented in the report of standardization requirements for European vision.

Smart Grid standardization work

A lot of activities can be noticed around the world. Such a bodies like ISO, IEC, 3GPP and some national comities has done a lot of work that need to be considered because of their influence to the European standardization work. The work done in the area of international standardization can be find in IEC roadmap (the standards from IEC TC 57 Seamless Integration Architecture [3] (IEC TR62357 seems to be the most important), for the European standardization a lot work was published by Smart Grids Task Force (EG1 report on services and functionalities, EG2 report on data handling, security and protection). All standards defined by China are very important and must carefully examined, because it is the main producer of the Grid and home equipment and infrastructure.

The table below presents short survey of some important standards work done by different bodies.

Table 1. The result of standardization bodies work based on [1]

organisation	Work results
European Standarization Mandate M/441 and Smart Meter Co-ordination Group	Standards as a voluntary technical specifications and general technical rules for products and systems on the market. 6 aspects of Smart metering considered and examined (support of the functions depends on the country): reading and transmission of measurements, two-way communication between meter and market participant, support of various tariff models and payment systems, remote deactivation and start/finish supply, communication with of he house devices, support of display of data in real time.
German Standarization Roadmap E-Energy/Smart Grid	A position paper on the German Smart Grid Standarization that provides recommendation for necessary fields of action, international cooperation and strategy. Research done showed that a lot of standard already exists. Recommendation: existing standards like IEC TC 57 should be used and be the started point for further work mainly for cooperation. System approach should consider also other media and other domains.
IEC Strategic Group 3 “Smart Grid Report”	A roadmap for standards and recommendation. Over 100 standards were identified described and prioritized. 12 application areas and 6 general topics were examined. 44 recommendations prepared. IEC TC 57 recommended as a basic. Now working on Mapping Tool to support Smart Grid project managers.
NIST Interoperability Framework	A phase plan intended to accelerate identification of standard. Description of an abstract reference model and identification of 80 essential standards, 14 key areas and gaps for a new standards identified. The work refers to North America standards like ASHRAE and IEEE.
Japanese Industrial Standards Committee	Standards as a fundamental element in the achievement of interoperability. A report published in 2010 established a roadmap to internalization standardization for Smart Grid. 7 main fields of business were identified an 26 priority actions areas assigned. Special core aspects of Japanese economy were identified.
The state Grid Corporation of China- SGCC Framework	Smart Grid standardization roadmap defined Defines 8 domains, 26 technical fields and 92 series of standards.

As it can be seen a lot of work was done, but still there is a strong need for European Standardization Organizations (ESOs) to coordinate their effort to put into effect their work to market.

ICT standardization

Typical Power Grid is a centralized network coordinated by traditional Power utilities.

Power companies are not willing to lose control of the Grid and are not eager to use more communication and open technology. Firstly because of the service level is not yet justified, secondly - the are not enough service guarantee from communication companies. What is more it is still not clarified who is responsible for outages and maintenance. Traditional SCADA systems includes several protocols like: Modbus RTU, RP-570, Profibus and Conitel (vendor specific solutions). In more modern systems they were replaced by open standard protocols like DNP3 (Distributed Network Protocol), mainly applied in North America, and IEC sets of protocols developed under the IEC TC57. It obvious that the industry is now moving to nonproprietary protocols.

In many countries regulatory aspects of Smart Grids are not fully clarified and taking under consideration European Union they differ in members law. The lack of regulations ensuring that investment in new ICT will not lead to losses can be seen as one of the most important factor of slower deployment. It is necessary for the business to work under stable clear rules.

In new intelligent Grid many different stakeholders have to receive and exchange data. Consumers and businesses can make decision only if they receive a proper and actual information offered in Smart Grids by ICT solutions. For this purpose a complex, proven ICT architecture is needed.

So far there is no a clearly defined communication architecture or the transition plan needed that will meet the requirements of the modern Grid to achieve. Vendors who supply sensors, IEDs, DER, and other end-use devices are hesitating to invest in these products until universal standards are adopted [2.] Mature solutions are able to optimize and upgrade the current power systems and reduce CO_2 emission. For mature solutions preparation of guide of development presenting standards is a key issue.

Many European project consider the importance of ICT in Smart Grids. One of them is SEESGEN-ICT (Supporting Energy Efficiency in Smart GENeration Grids through ICT 2009-2010). Research done by project team confirmed that the IEC 60870-5 and DNP3 based protocols are gradually being replaced by more modern IEC standards based on TCP/IP. New globally accepted IEC standards are IEC 61850 and Common Information Model (IEC 61968 and IEC 61970). It was also highlighted that Common Information Model (IEC International Electrotechnical Model 61970/61968) is recommended standard for the exchange of data between systems. The model consists of two standards IEC 61970 and IEC 61968 with universal elements such as dictionaries, interfaces and data models. UML (Unified Modelling Language) is used for model design. Also new standards for communication with distributed energy resources are based on IEC 61850 and CIM principles. IEC 61850 is based on the latest version of the Manufacturing Message Specification MMS (ISO 9506). IEC 61850 and CIM are also being harmonized [2].

Most presented solutions consider AMI (Advanced Meter Infrastructure) and embedded control devices connected to the local network as a main parts of the infrastructure. In Europe OPENmeter project is addressed to prepare solutions in this area.

Web Technologies [2]

Internet technology based on its protocols and service oriented architecture are nowadays solutions for a new business models.

Future Smart Grid coordination must be considered as management of the resources (action and data for matching supply-demand) and setting up SLA (Service Level Agreements) between all energy market stakeholders. SEESGEN-ICT recommends IEC TC 57 Seamless Integration reference Architecture – IEC TR 62357 for intra grid application management.

It must be noticed that different Smart Grid solutions typically have different IT components. As reports of SEESGEN-ICT Project shows using standard components and platforms in creating new applications in a cost effective way as well as using SLA functionality can make real cloud computing solutions. The SEESGEN-ICT project group has tested Platform as a Service using terminology of Cloud Computing and suggest Infrastructure as a Services solutions towards Smart grid as a Service.

Recommended architecture for models that do not demand real time response is XML web services. It must be noticed that it is not suitable for process control and monitoring. The project experience shows that XML structure[2]:

- leverages several standards to enable data transfer between applications on remote computers allowing,
- technologies and tools (web servers, libraries, APIs, etc) leverage the evolving security standards, user authentication, data transfers, data states and a lot more,
- applications programmers can rapidly build and deploy XML web services using existing tools and frameworks
- XML web services provide that all-important independence from any hardware or software platform.

Following limitations of XML were also considered:

- limitation of transfer OPC data seamlessly from one computer to another using a “standard” interface. Implementations show that the transfer either suffer from extremely high bandwidth or suffer a slow update rate;
- XML messages are very large in comparison to similar DCOM messages that carry the same information, and their sheer size makes them difficult to transport en masse.
- more, the origins of XML as a document format with little to no boundaries in terms of element size or depth that are accessible outside a post-processing / parsing context make it less than optimal for the use as a data exchange format and protocol due in large part to the inability to reliably stream-process, filter and monitor its contents in real-time.

The various standards that are available currently at the distribution Grid level have been explained in many works. The scheme and description of standards can be found in [4]. The scheme presenting use of standards can be also find in [5].

Necessary steps and prioritization of actions recommended by JWG report[1]

Joint Working Group is working on report that provides overview of standards and current activities that are the c step o fulfill the European vision of Smart Grid (based on the Smart Grids Task Force of the European Commission initiatives). The survey was done to prepare a list of existing dictionaries standards sources of definitions according to roadmap structure covering following groups:

- general architecture and concept of the Smart Grid,
- communication,
- information security,
- system aspects and crosscutting issues,
- generation transmission and distribution,
- Smart metering,
- industry energy management,
- in house automation,
- market and actors.

The report shows current status of standardization in cross-cutting and domain-specific topics, gives some detailed recommendations and shows a list of gaps for groups of cross cutting problems (reference architecture, data communication interface, Smart Grid information security, others), domain specific topics (generation, transmission, distribution, Smart metering, industry, home and building) market and actors (roles and responsibilities, recommendation to European Standardization Organizations).

The reports defined 6 major recommendation for further European standardization work:

1. further works with adequate bodies and groups of stakeholders based on identified gaps with possibilities to consider more topics like energy storage and security supply,
2. process of standardization must be based on existing international work but also has to support European produces,
3. Increasing the implementation of currently proven solutions and existing mature domain communication with further standardization of interfaces;
4. concentration on generic standards that are flexible for new R&D development and market needs,
5. creating of a single repository for Smart Grid use cases to start detail work on standards,
6. setting the processes to fit the lack of maturity of many Smart Grid applications.

As the most important further activities JWG report highlights:

- a prioritization of the identified gaps and recommendations based on defined set of criteria,
- developing complete and flexible European reference architecture,
- creating European Smart Grid use cases to start a continuous process o identifying gaps in standards.

Necessary steps and prioritization of standards actions recommended by NERC report

NERC report is devoted to its Reliability Standards.

One of the main recommendation is to enhance NERC reliability standards according to continuous Smart Grid evaluation. The necessity to support coordination among relevant SDO (Standard Development Organizations) and activities like NIST Priority Action Plan to harmonize are strongly highlighted. Report shows some area of importance for this work. As one of the example time synchronization of PMU(Phasor Measurement Units) in real time and differences and overlaps between IEEE C37.118 and IEC 61850 is described. Regarding Cyber Security NERC report noticed that the there is number of existing standards for example set of NISTR 7628 documents that work properly while using separately, but when they are using merged together may be in conflict with each other. Therefore recommendations and maps included in NISTR 7628 must be applied. Future work with Canadian Legislative, Regulatory and standards setting bodies for ensuring coordinated and harmonized standards [6].

Summary

The success of rapid Smart Grids deployment rely on proper integration of real-time application and monitoring, advanced communication enabling bidirectional energy and information flow in reliable, efficient and secure way from generation source via aggregators to end users. Smart Grids technologies change the existing distribution systems what demands new tools and new techniques based on proven standards.

As the paper shows a lot of work was done, but further coordination of standard bodies to increase harmonization in standard development is necessary. Fulfilling the gaps and overlaps described in presented reports must be a first step of this work. The solutions for overcoming lack of standardization can be wide use of open standards and non proprietary solutions. Open standard guarantee interoperability between different vendors devices and can be used in provider-independed platforms.

One of the biggest barrier in Smart Grids deployment is insufficient cyber security. To provide to consumer energy in reliable and effective way the integrity of distribution control command is essential. For the safety-critical applications of adaptive protection and reconfiguration integrity of outage data is significant. Must be also noticed that some consumers are not willing to show their energy consumption habits. For that reasons cyber security standards should be included in ICT solutions. To ensure reliability of the system cyber security must be seen as one of the most important Smart Grids deployment factor.

Transformation, replacement, upgrading and transitions of technologies used for SCADA systems towards standard open protocols such as EIC 61850 might take time to be globally adapted. Security, integrity and information protection related to network and information management can be implemented by proper use and embedding of VPN solutions.

REFERENCES

[1] JWG-Smart-Grid-report_V1-0_2010-12-17-all-figures.pdf
[2] SEESGEN-ICT http://seesgen-ict.erse-web.it
[3] IEC Smart Grid Standardization Roadmap, by SMB Smart Grid Strategic Group (SG3) June 2010; Edition 1.0 http://www.iec.ch/SmartGrid/downloads/sg3_roadmap.pdf
[4] De Craemer K. , Deconinck G., Analysis of state-of-the-art Smart metering communication standards, *IEEE Benelux Young Researchers Symposium* 2010 in Electrical Power Engineering, Leuven, Belgium, March 29-30, 2010;
[5] Matusiak B.E., Pamuła A., Zieliński J. S., Narzędzia ICT w sterowaniu zachowaniem klienta w inteligentnych sieciach energetycznych, w *Komputerowo Zintegrowane Zarządzanie* pod red. R. Knosali, Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją, Opole 2011, Tom II, str. 88-97
[6] Reliability Consideration from the Integration of Smart Grid

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