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INVESTIGATION OF REQUIREMENTS TRANSFORM TO SMART GRID

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Abstract- In this study, the basic requirements for transforming classical power systems into smart grid are investigated. For this purpose, the classical centralized and distributed power networks are presented shortly. After that, the components of smart grid and basic smart grid standards as IEEE 2030 and IEEE 1547 are investigated. Also, the transformation examples about some nations are presented. At the end of the study, the basic requirements for transformation to smart grid are explained and discussed.

Keywords: Smart Grid Components, Transformation Requirements, Smart Gird Standards.

I. INTRODUCTION

The smart grid is introduced in the late 1990s since the insufficient infrastructure of the old or classic electric power systems for increasing consumer needs of the 21st Century. Smart grid holds the key to bring renewable energy options to scale and to make them more reliable and affordable. Also it offers a cleaner and more efficient way to solve the peak demand problem by collecting and evaluating more data from the power system elements and end-users equipment through advanced SCADA equipped with recent communication and information systems according to today's classic SCADA system.

Actually, smart grid has an important role for transition needs of economy to renewable energy. A truly smart grid would use digital wireless and wired communication technologies to manage the power system and existing resources more efficiently. Also it uses information technology to process and evaluated collected data [2].

The first practical large-scale examples are realized in the early 2000s. The first smart grid implementation is started in Italy in 2000 by Enel S.P.A. which is the country's largest energy provider to set up the Enel Telegestore Project. So far, this company has installed more than 30 million smart meters across Italy. On the other hand, the US started to set up its smart networks in Austin Texas in 2003. After that in Boulder, Colorado is considered the first fully functional smart city in the US with a network of more than 23000 smart meters with the moniker Smart Grid City. These studies are followed by the other countries such as Brazil, India, China, Russia, Japan, Australia, France, Germany and South Korea until now [1].

The technologies about smart grid provide cost-effective opportunities to meet these challenges, also help to the install of more energy efficient, more reliable and more sustainable energy system. These are done by "enabling and incentivizing customers" to arrange their demand in real time to regulate market and network situations, compatible all resources and storage elements, providing power quality to customer needs, optimizing the utilization and efficiency of generation, transmission and distribution assets, providing flexibility to unknown supply corruptions and outages [3].

The smart grid may be the solution. Smart sensors and intelligent controls, automated manageable switches and substations, advanced communications, information and other technologies will be able to combined all types of electric energy generation and storage systems, inhibit power outages and surges to a degree not possible now, give notice problems before they happen, and automatically heal itself if problems occur [4].

II. CLASSICAL POWER NETWORK

The traditional electric power networks are based on centralized generation plants delivered electric energy over unidirectional transmission and distribution systems utilized as star topology that transports electricity from where thermal, gas, nuclear plants or hydroelectric dams, for example to the homes, businesses and industries where it's consumed. The classical distribution system is a passive energy transportation network. It has no sufficient monitoring and control system to help management of the power system elements as quickly as possible in the event of a fault [5].

A. Centralized Power Networks

A classical centralized electric power network has star topology and generally, delivers electric energy from one power plant to the consumers around it. This grid has a few nodes with many connections, and also including many nodes with only a few connections [6]. Figure 1 shows centralized power networks.

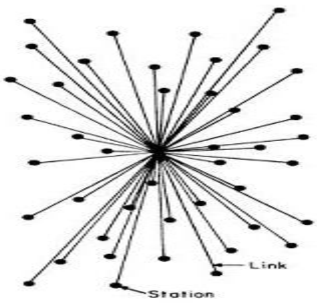

Figure 1. Centralized power networks [7]

B. Distributed Power Networks

This type of power network has a mesh topology and it is a power system including more cables in order to deliver electric power from the distributed power plants to the distributed end users. It accomplishes this duty by supplying electric energy from primary substations and transforming it to the distributed customer substations through both underground cables and above ground lines [8]. Figure2 shows distributed power networks.

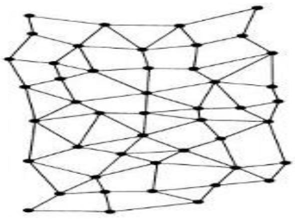

Figure 2. Distributed power networks [7]

III. COMPONENTS OF SMART GRID

Smart grid is an electricity power network using advanced two-way communications, information infrastructures. Also, it has analog and digital monitoring, management and control technologies for secure and reliable transportation of electric energy from all energy sources to different electricity demands of end-users [9].

A. Distributed Generation

Distributed generation (DG) is production of electric energy on small-scale power plants positioned near the electric loads they serve. It can be said that these networks include more renewable energy plants and their monitoring and controlling components as different from the classical distributed power networks. The components of DG often involve modular and small capacity generators which offer a number of potential benefits [9]. Figure3 shows distributed generation.

B. Communication and Information Infrastructure

Fundamental communications and information infrastructures, such as using private public service communication systems (wired or wireless mesh networks) and the other communication systems (Internet, cellular, cable or telephone) support data transmission for real-time operation without interruptions. The important computing and control software and enterprise resource planning software run over the communication devices in order to support the two-way communication of information between stakeholders for enabling more efficient use and management of the power network [10,11]. Table 1 shows us communication technologies which can be used in the sub-networks of smart grid.

Table 1. Communication Technologies Used In Smart Grid

Communication Technologies	Sub-Networks		
	HAN/BAN/IAN	NAN/FAN	WAN
Wired			
Fiberoptic	-	-	x
DSL	-	x	-
Coaxial Cable	-	x	-
Power Line (PLC)	x	x	-
Ethernet	x	x	-
Wireless			
Z-wave	x	-	-
Bluetooth	x	-	-
ZigBee	x	x	-
WiFi	x	x	-
WiMAX	-	x	x
Wireless Mesh	x	x	-
Cellular (2G)	-	x	x
Satellite	-	-	x

Three steps are taken to establish a methodology to map applications to communication infrastructures:

- In-depth evaluation for the application communications needs, which exposes any physical requirements such as speed of transmission, volume of data, error control and cyber security requirements, etc.
- Evaluation for overlaps in data and communications needs among the various applications, which allow the study of possible aggregation and the creation of common communication paths to Smart Grid applications to provide most of the data needed (Figure 4).
- Selection of communication media, topology, bandwidth, and other features based on the overall requirement of the applications, which allows selection of proper design characteristics to meet the application requirements [10, 11].

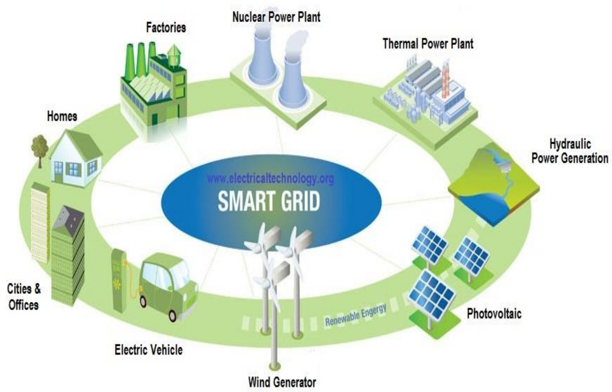

Figure 3. Distributed generation [12]

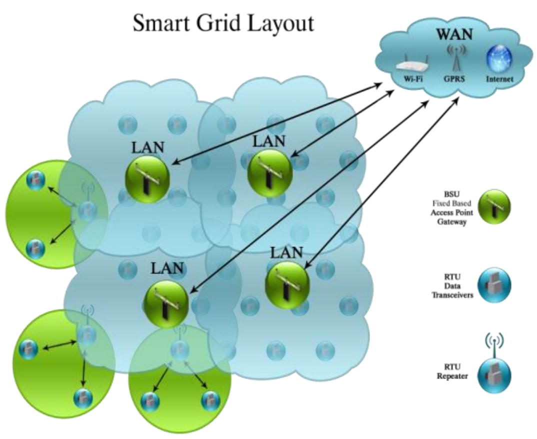

Figure 4. Communications smart grid [13]

C. Advanced Metering Infrastructure

With the idea of a smarter grid and two-way communications systems, Advanced Metering Infrastructure (AMI) technology allows the utilities to bill their consumers through a system that reads the electrical meters on a specified period basis. This system allows the meters to get read automatically instead of using manpower or otherwise known as meter readers to read all meters visually. In this study, the AMI shows the references for defining the next generation metering technologies. This technology features include [10]:

- Two way communication properties of the smart meters allow two-way information interchange.
- AMI enables self metering registration points to network.
- All smart equipment connected to smart grid are enabled auto-config after any communication failures.
- AMI system provides outage management systems.

Figure5 shows the data management of the meters.

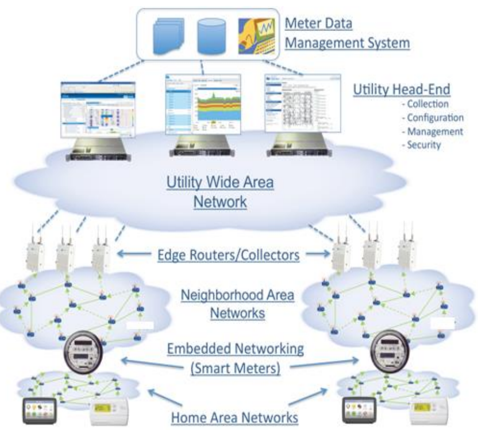

Figure 5. Meter data management [14]

Table 2 shows the smart grid status in nine European countries as a study [15].

Table 2.Smart grid status in nine European countries

Country	Smart grid status
Finland	The final hearing of new legislation that requires nearly full penetration of hourly metering and settlement by January 2014 is seen in December 2008.
France	The French electric network (ERDF) declared to start the first studies for a nationwide deployment of 33 million smart meters in July 2008.
Spain	Because of new Spanish regulations, Endesa and Iberdrola plan to deploy 10 million smart meters.
Ireland	A nationwide program is realised for the settlement of smart meters in 2013.
Netherlands	In July 2008, the Dutch parliament adopted revised legislation on smart metering, introducing a two-year trial period to ensure a relaxed mandated rollout. After that, the country's fourth-largest energy supplier Oxxio deployed over 100,000 smart meters in residential areas.
UK	The government started to install the smart meters in order to add 27 million household end-user to smart grid before 2021 with two years period in October 2008.
Germany	The German electricity utility RWE declared to install 100,000 smart meters as the first project of its kind in the country in February 2008.
Italy	Italy was the first country to start to install and use this technology in the first half of this decade. All 36 million electricity customers were covered by smart metering by 2011.
Denmark	The main electricity distribution companies of the countries are installed the smart meters.

IV. SMART GRID STANDARDS

Existing smart grid standards work as a bridge for two-way power and information transportation over advanced communication infrastructure which provides more robust connections between energy generation, distribution, delivery and consumption components of the power system. Smart grid standards needed to use information data management, communications and control. Smart grid system interoperability, design, and operational standards will allow near term and long term smart grid evolution [16].

A. IEEE 2030 Standards

- IEEE Std 2030: Guide for electric power system, consumer and load applications about smart grid interoperability of energy and information technologies.
- IEEE StdP2030.1: Draft guide for transportation infrastructure of electric energy.
- IEEE StdP2030.2: Draft guide for electric power infrastructure about the interoperability of energy storage systems.
- IEEE StdP2030.3: Draft guide about the test procedures of electric energy storage systems for electric power systems applications.[16] Figure6 shows evolution of smart grid interoperability source: IEEE std 2030.

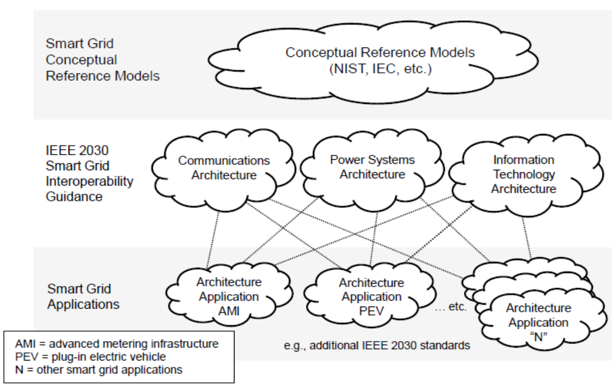

Figure 6. Evolution of smart grid interoperability source IEEE std 2030

B. IEEE 1547 Standards [17]

- IEEE Std 1547: Interconnection standard for distributed electric energy resources (published June 2003).
- IEEE StdP1547.1: Draft standard for conformance test procedures about the interconnection equipment of distributed electric energy resources.
- IEEE StdP1547.2: Draft application guide for interconnection of the distributed electric energy resources.
- IEEE StdP1547.3: Draft guide of the distributed electric energy resources for monitoring, information exchange and control.
- IEEE StdP1547.4: Draft guide for design, operation, and integration of the distributed electric energy resources.
- IEEE StdP1547.5: Draft guide for interconnection of electric power sources greater than 10 MVA to the power transmission grid.
- IEEE StdP1547.6: Recommended advices for interconnecting distributed resources with electric power systems distribution secondary networks.
- IEEE StdP1547.7: Draft guide to conduct distribution impact studies for DR interconnection.
- IEEE StdP1547.8: Draft recommended advices for establishing methods and procedures that provide supplemental support for implementation strategies for expanded use of IEEE Std 1547.

V. REQUIREMENTS OF TRANSFORMATION TO SMART GRID

The transformation of the classical power system into smart grid is a big challenge for the countries. Especially, the compatibility and interoperability problems for talking between devices used in smart grid and also interconnection to the neighbor power systems need to solution. At the end of this study, some approaches and requirements are presented to solve these problems in the light of IEEE 2030 and 1547 standards:

- Public awareness and acceptance of the smart grid by increasing a national vision and plans for obtaining the benefits of smart grid.
- Develop policies and regulations to provide a more ready environment in order to establish smart network. For this reason, the encouraging innovation, establishing standards for interoperability, and allowing more market-oriented and enterprising solutions become more important.
- The new researches, pilot studies and implementation efforts to improve the grid success provide to evaluate and understand new technologies, and also verify the economics and work force requirements for deploying them. These studies will increase succeed of a number of important objectives that contribute to smart infrastructure development [18].
- Provide real experience with a new technologies what is needed to integrate the technology and provide the basis for conducting a cost assessment of the technology [19].
- Allowing connection access to all end-users, especially for renewable electric energy sources and more efficiency local power generation with lowest carbon emissions [20].
- Transformation to the smart grid from a classical centralized electric power system by using multidirectional dynamic, interactive and real-time information and power exchange [21].
- Converting from an electromechanical system to a primarily digital one.
- Moving to an interactive grid that actively includes the consumers (or at least improves data and flexibility of end users) [21].

VI. CONCLUSIONS

The smart grid concept is the new approach to improve robustness of the power network, to increase the quality of electric energy and to increase the satisfaction of the costumers. The countries start to transform their power networks into smart grid, nowadays. But, some issues, especially the standardization for compatibility are the major problem standing in front of the countries. In this study, classical and smart power networks are presented. After that, the basic requirements for transformation are introduced and discussed by considering IEEE 2030 interoperability and IEEE 1547 interconnection standards. It is hoped that they will be a useful guide for future smart grid transformation studies.

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BIOGRAPHIES

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