SMART GRID

A revolutionary advancement of the traditional power grid

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Abstract- ***The conventional structure of the electrical power network had not been changed for a hundred years. In order to deal the challenges of the existing power grid, the new concept of smart grid has emerged. While current power systems are based on a solid information and communication infrastructure, the new smart grid needs a different and much more complex one, as its dimension is much larger. A strong conception should be set up in order to ensure an efficient information flow and a precise handling of the different critical components contributing in that intelligent network knowing by a lot of constraints as the limit energy of the sensor batteries and their restricted bandwidth. So the challenge is to cope with all these compulsions to build an efficacious infrastructure witch respond to the smart grid concerns.***

Keywords- Smart grid, infrastructure, limits, constraints, challenges.

I. INTRODUCTION

Traditional power system has to ensure all or some of these four main operations what is called grid: Electricity generation, electricity transmission, electricity distribution, and electricity control. They are generally used to carry power from a few central generators to a large number of users or customers. View the huge amount of electricity demand and the complexity of power delivery network, and in order to make contribute more other green and powerful electricity sources, the traditional grid needed to be reinforced to respond to these challenges, so that, smart grid (SG) is an enhancement of the 20th century power grid.

The table1 represents a brief comparison between the old and the new electricity system.

In contrast, the SG uses two-way flows of electricity and information to create an automated and distributed advanced energy delivery network.

By utilizing modern information technologies, the SG is capable of delivering power in more efficient ways and responding to wide ranging conditions and events.

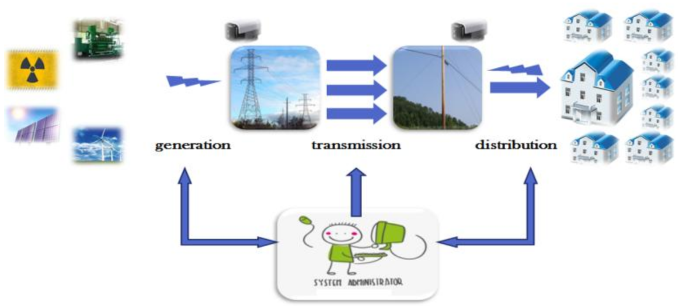

Figure 1. Smart grid motivation

In a SG, electricity can also be put back into the grid by users. For example, users may be able to generate electricity using solar panels at homes and put it back into the grid, or electric vehicles may provide power to help balance loads by "peak shaving" (sending power back to the grid when demand is high) [1]

Smart grid philosophy is a vision, it could be treated from a multiple dimensions, and a multiple topics should be interacted to release a performing system as: information and communication technology, computer science, automatisation, advanced electricity technology, networks, intelligent paradigm, mathematic modelisation, etc.

This paper aims to survey the smart grid concept, some definitions of their key components and network's sorts contributing into, smart grid communication infrastructure, and the constraints and challenges encountering and some solutions to overfly these difficulties to perform a reliable and advanced power system.

II. TERMINOLOGY

In this section, we underline some of the most commonly terms used is smart grid domain with their brief definitions [2]:

Advanced Metering: Technology which enables an automated bi-directional communication between the energy meter and the utility. The communication is not limited to meter data alone but also includes information about consumption, tariffs, alerts and complementary services.

- AMI: Automated or advanced metering infrastructure, utility infrastructure with two-way communications for metering and associated systems allowing delivery of a wide variety of services and applications to the utility and customer.

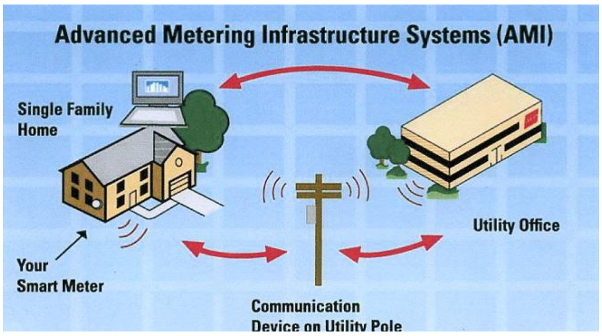

Figure 2. Advanced Metering Infrustructure

- DA: Distribution automation, a general term referring to a class of technology that lets electric utilities monitors and remotely control their power distribution networks with two-way computer networking and computerized data handling.
- Distributed Generation: Power generation at the point of consumption. Generating power on-site, rather than centrally, eliminates the cost, complexity, interdependencies, and inefficiencies associated with transmission and distribution. Like distributed computing (i.e. the PC) and distributed telephony (i.e. the mobile phone), distributed generation shifts control to the consumer.
- Real Time Metering: Metering that records consumer use in the same time frame as pricing changes in the market, typically hourly or more frequently
- Smart grid: A smart grid is an electricity network that can intelligently integrate the behavior and actions of all its users to ensure a sustainable, economic and secure electricity supply. As a tool that provides much-needed flexibility, smart grids offer potential benefits to the entire electricity value chain (generators, TSOs, DSOs, suppliers and consumers) and to society as a whole.
- Smart meter: A smart meter is an essential device that integrates data collection and communication within smart grids. Thus, many smart grid functionalities cannot be deployed without smart metering. Supplemented by in-home displays and portal solutions, smart meters contribute to higher customer awareness. Using open standards, smart meters will enable dynamic pricing, in turn incentivizing customers' involvement. In doing so, they will catalyze the development of retail markets and enable enlarged business models like network operation and asset management. Later on, they will be integrated with home appliances and home automation networks.

Figure 3. Smart meter

III. OVERVIEW

The interoperability of three main systems has to be set up in order to accomplish the SG purpose [1] : Smart infrastructure system, smart protection system and the smart communication system.

A. Smart infrastructure system:

The smart infrastructure system is the energy, information, and communication infrastructure underlying the SG. It supports two-way flow of electricity and information. Note that it is straightforward to understand the concept of “two-way

flow of information.” “Two-way flow of electricity” implies that the electric energy delivery is not unidirectional anymore.

Reported that smart grid infrastructure could be divided on three subsystems: the smart energy subsystem, the smart information subsystem, and the smart communication subsystem.

- The smart energy subsystem is responsible for advanced electricity generation, delivery, and consumption.
- The smart information subsystem is responsible for advanced information metering, monitoring, and management in the context of the SG.
- The smart communication subsystem is responsible for communication connectivity and information transmission among systems, devices, and applications in the context of the SG.

B. Smart management system:

The smart management system is the subsystem in SG that provides advanced management and control services and functionalities. The key reason why SG can revolutionize the grid is the explosion of functionality based on its smart infrastructure. With the development of new management applications and services that can leverage the technology and capability upgrades enabled by this advanced infrastructure, the grid will keep becoming “smarter.” The smart management system takes advantage of the smart infrastructure to pursue various advanced management objectives. Thus far, most of such objectives are related to energy efficiency improvement, supply and demand balance, emission control, operation cost reduction, and utility maximization.

C. Smart protection system:

The smart protection system is the subsystem in SG that provides advanced grid reliability analysis, failure protection, and security and privacy protection services. By taking advantage of the smart infrastructure, the SG must not only realize a smarter management system, but also provide a smarter protection system which can more effectively and efficiently support failure protection mechanisms, address cyber security issues, and preserve privacy.

IV. SMART GRID METERING AND COMMUNICATION TECHNOLOGIES

A communications system is the key component of the smart grid infrastructure [3]. With the integration of advanced technologies and applications for achieving a smarter electricity grid infrastructure, a huge amount of data from different applications will be generated for further analysis, control and real-time pricing methods. Hence, it is very critical for electric utilities to define the communications requirements and find the best communications infrastructure to handle the output data and deliver a reliable, secure and cost effective service throughout the total system. Electric utilities attempt to get customer’s attention to participate in the smart grid system, in order to improve services and efficiency. Demand side management and customer participation for efficient electricity usage are well understood, furthermore, the outages after disasters in existing power structure also focus the attention on the importance of the relationship between electric grids and communications systems.

Different communications technologies supported by two main communications media, i.e., wired and wireless, can be used for data transmission between smart meters and electric utilities. In some instances, wireless communications have some advantages over wired technologies, such as low cost infrastructure and ease of connection to difficult or unreachable areas. However, the nature of the transmission path may cause the signal to attenuate. On the other hand, wired solutions do not have interference problems and their functions are not dependent on batteries, as wireless solutions do.

Basically, two types of information infrastructure are needed for information flow in a smart grid system. The first flow is from sensor and electrical appliances to smart meters, the second is between smart meters and the utility's data centers. As suggested in [4], the first data flow can be accomplished through power line communication or wireless communications, such as ZigBee, 6LowPAN, Z-wave and others. For the second information flow, cellular technologies or the Internet can be used. Nevertheless, there are key limiting factors that should be taken into account in the smart metering deployment process, such as time of deployment, operational costs, the availability of the technology and rural/urban or indoor/outdoor environment, etc. The technology choice that fits one environment may not be suitable for the other.

[4] Reports that an AMI includes several communication networks, identified according to their spatial scope:The Wide Area Network (WAN) serves as a communication link between head ends in the local utility network and either data concentrators or smart meters. This network uses long-range and high-bandwidth communication technologies, such as WiMAX, cellular (3G, EVDO, EDGE, GPRS, or CDMA), satellite, Power Line Communication (PLC), and Metro Ethernet. The scale of this network could reach several million nodes. Neighborhood Area Networks (NANs) ensure communication between data concentrators or access points and smart meters that play the role of interfaces with a Home Area Network (HAN). The scale of this network ranges from a few hundred to tens of thousands of nodes and finally, Field Area Networks (FANs) allow the utility workforce to connect to equipment in the field.

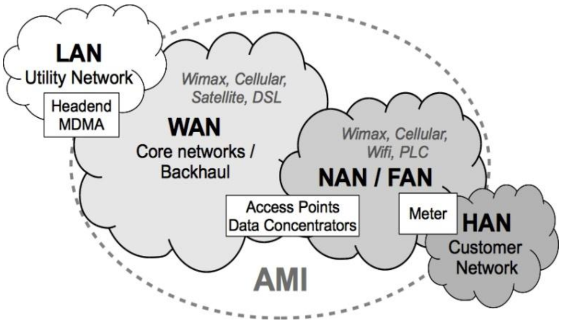

Figure 4. AMI networks

V. SMART GRID INFORMATION TECHNOLOGIES:

In SG, an immense amount of data and information will be generated from metering, sensing, monitoring, etc. SG must support advanced information management. The task of the information management is data modeling, information analysis, integration, and optimization [2]. The purpose of the information management is that any flowing data through the communication network should be meaningfully supported by different devices or equipment that shares it for various use fields from one side. The stored data in SG systems must also keep the same meaning for the foresighted versions in order to ensure a stable steady transit phases when updating SG application for their latest versions.

A gigantesque servers and machine should be allowed to support the huge capacity of information, data bases, metering and sensing data generated hourly, but unfortunately it's not enough with a traditional information treatment systems that is not able to deal with this challenge accordingly, so an advanced systems of information feted with data mining and machine learning algorithms are indispensable in order to address those issues that could minimize data size with the same features as the original ones which called the data optimization. To put it in the nutshell, the aim of SG data modeling is provide a guide to creating persistent, displayable, compatible, transferable, and editable data representation for use within the emerging SG

VI. SMART GRID CYBER SECURITY:

Cyber security in the Smart Grid is a new area of research that has attracted rapidly growing attention in the government, industry and academia. In this paper, we presented a comprehensive survey of security issues in the Smart Grid. [5] introduced the communication architecture and security requirements, analyzed security vulnerabilities through case studies, and discussed attack prevention and defense approaches in the Smart Grid.

In order to ensure secure and reliable services, initially, we have to understand the objectives and the security requirements to cope with before providing a comprehensive treatment of cyber security in the context of energy delivery and management, in that context, tree main security objectives have been adopted by the NIST Smart Grid interoperability [6]:

- Availability: Ensuring timely and reliable access to and use of information is of the most importance in the Smart Grid. This is because a loss of availability is the disruption of access to or use of information, which may further undermine the power delivery.
- Integrity: Guarding against improper information modification or destruction is to ensure information nonrepudiation and authenticity. A loss of integrity is the unauthorized modification or destruction of information and can further induce incorrect decision regarding power management.
- Confidentiality: Preserving authorized restrictions on information access and disclosure is mainly to protect personal privacy and proprietary information. This is in particular necessary to prevent unauthorized disclosure of information that is not open to the public and individuals.

Availability, integrity, and confidentiality are three high-level cyber security objectives for the Smart Grid. In addition to such high-level objectives, the NIST report [6] also recommends specific security requirements for the Smart Grid, including both cyber security and physical security. Specifically, the cyber security part specifies detailed security issues and requirements related to Smart Grid information and network systems; and the physical security part specifies requirements pertaining to physical equipment and environment protection as well as employee and staff security policies.

VII. Conclusion:

This paper represents a tryout of smart grid survey; we discussed a brief history about smart grid creation, some important terminology to know in that context, we have already exposed the main subsystem contributing in smart grid technology with their signification.

The smart metering and communication technologies have been also decorticated in order to clarify the smart grid complexity vision witch is the network of networks.

Another important thing was view in a particular section, the smart grid information, the necessity of modeling and optimizing information was justified in order to make an optimal, unique and representative model to be well treated in the smart grid functionalities.

And finally, we discussed the cyber security aspect by underling first the objectives and security requirements to deal with in order to build a secure and efficient operations witch respond to smart grid constraints and provide a perfect quality of services to defy challenges.

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