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Smart Grid - Needs and Requirements

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Abstract: The Smart Grid is a combination of the electric power and communications infrastructures. Smart grids have been proposed as a way to increase grid robustness and reduce consumption peaks and at the same time decrease electricity costs for the end users. All the visions of the Smart Grid share one common, critical need: communications. Without proper communications, the Smart Grid simply cannot exist. To gain a better understanding of the type of communication networks present in smart grids, the overall smart grid communications layer is often considered to consist of three types of networks, each having a distinct scale and range Wide Area Networks (WAN) , Field Area Networks (FAN) , Home Area Networks (HAN), Building Area Networks (BAN), and Industrial Area Networks (IAN).
Keywords: Field Area Networks (FAN), Home Area Networks (HAN), Information and communications technology (ICT), Smart Grids, Wide Area Networks (WAN).

I. INTRODUCTION

In most of the countries, the electrical and distribution systems were constructed when energy production was relatively cheap. The important aspect of the grid reliability was based on having excess capacity in the system, with unidirectional electricity flow to consumers from centrally dispatched power plants. The lack of investment, combined with an asset life of 40 years or more, has resulted in an inefficient and increasingly unstable electric system [1]. Climate change, rising fuel costs, outdated grid infrastructure and new power-generation technologies have changed the mindset of all stakeholders. It has been revealed that electric power causes approximately 25% of global greenhouse gas emissions and utilities are rethinking what the electricity system of the future should look like. The real-time monitoring of grid performance will improve grid reliability and utilization, reduce blackouts and increase financial returns on investments in the grid. These changes on the demand and supply side may require a new, more intelligent smart grid system that can manage the increasingly complex electric grid efficiently.

II. REAL TIME INFORMATION

Taking into account above mentioned challenges, the energy community starting to integrate information and communications technology (ICT) with electricity infrastructure. Technology enables the electric system to become “smart.” The real-time information allows utilities to manage the entire electricity system as an integrated framework, actively sensing and responding to changes in power demand, supply, costs, quality and emissions across various locations and devices. Similarly, better information enables consumers to manage energy use to meet their needs. These changes on both the demand and supply side require a new, more intelligent smart grid system that can manage the increasingly complex electric grid.

The systematic development of electric power networks to include better communications and make use of modern computer technology will provide more intelligent automation devices and better optimized systems than ever. It will enable utilities to meet regulatory requirements and customer demands for reliable power flow from both conventional and renewable energy sources (RES) [2]. The creation of a smart grid allows the addition of various kinds of information technology (IT), such as sensors, digital meters and a communications networks to the internet or to the dumb wires. A smart grid would be able to avoid outages, save energy and help other green undertakings, such as electric cars and distributed generation (DG).

The vision of smart grid gathers the latest technologies to ensure success, while keeping the high flexibility to adapt to further developments. Network technologies will improve the efficiency of supply by increasing power transfers and reducing energy losses, while power electronic technologies will improve the quality of electric supply. Developments in communications, metering and business systems will open up new opportunities at every level on the system to enable market signals to drive technical and commercial efficiency. Key elements of the smart grid vision include

Creating a toolbox of proven technical solutions that can be deployed rapidly and cost effectively, enabling existing grids to accept power injections from all energy resources.

Harmonizing regulatory and commercial frameworks to facilitate cross-border trading of both power and grid services, ensuring that they will accommodate a wide range of operating situations.

Establishing shared technical standards and protocols that will ensure open access, enabling the deployment of equipment from any chosen manufacturer.

Developing information, computing and telecommunication systems that enable businesses to utilize innovative service arrangements to improve their efficiency and enhance their services to customers.

Ensuring the successful interfacing of new and old designs of grid equipment to ensure interoperability of automation and control arrangements.

Future electricity grids are smarter in several ways. Firstly, customers are allowed to take an active part in the supply of electricity. DSM becomes a source of generation and savings are rewarded. Secondly, the new system offers greater efficiency. In addition, environmental concerns will be addressed, thanks to the exploitation of sustainable energy sources. The potential benefits are impressive, but the big challenge is that how they will be achieved.

The smart grid should have the following characteristics [3]

Adaptive, with less reliance on operators, particularly in responding rapidly to changing conditions

Predictive, in terms of applying operational data to equipment maintenance practices and even identifying potential outages before they occur

Integrated, in terms of real-time communications and control functions

Interactive between customers and markets

Optimized to maximize reliability, availability, efficiency and economic performance

Flexible, by fulfilling customers' needs while responding to the changes and challenges ahead

Accessible, by granting connection access to all network users, particularly for renewable power sources and high efficiency local generation with zero or low carbon emissions- Reliable, by assuring and improving security and quality of supply, consistent with the demands of the digital age with resilience to hazards and uncertainties

Economic, by providing best value through innovation, efficient energy management, competition and regulation

Secure from attack and naturally occurring disruptions.

There is a great deal of variation both within the power industry and academia to what exactly should be included under the umbrella of a smart grid, it is not only the concept of developing smart meters or home automation, rather there is much more to consider. For instance, according to [4], [5], [6], the smart grid refers to a way of operating the power system using communication technology, power electronic technologies and storage technologies to balance production and consumption at all levels, i.e. from inside of the customer premises all the way up to the highest voltage levels.

III. ROLE OF COMMUNICATION NETWORKS IN SMART GRIDS

Communication networks already play an important role in the power system. However, from a communication perspective, existing power grid networks suffer from several drawbacks [7], such as: (i) fragmented architectures, (ii) a lack of adequate bandwidth for two-way communications, (iii) a lack of inter-operability between system components, and (iv) the inability to handle increasing amount of data from smart devices. As we will show in the next sections, communication networks will play an even more crucial role in the development of smart grids, and hence are subject of many research efforts, studying the most efficient topology of the communication network, physical media, protocols, etc. [8]. To gain a better understanding of the type of communication networks present in smart grids, the overall smart grid communications layer is often assumed to consist of three types of networks, each having a distinct scale and range

Wide Area Networks (WAN) Provide communication between the electric utility and substations, and as such operate at the scale of the medium voltage network and beyond. WAN are typically high-bandwidth backbone communication networks that handle long-distance data transmission.

Field Area Networks (FAN), Neighborhood Area Networks (NAN) and Advanced Metering Infrastructure (AMI) provide communication for power distribution areas (low voltage network). FAN/NAN/AMI interconnect WAN and the Home/Building/Industrial Area Networks (HAN/BAN/IAN) of the end-users.

Home Area Networks (HAN), Building Area Networks (BAN), and Industrial Area Networks (IAN) provide communication between electrical appliances and smart meters within the home, building or industrial complex. Various smart grid applications have specific (challenging) communication requirements [9], and in the next subsections we present some high level examples showcasing the need for communication for measurement/monitoring and control. The latter calls for combining accurate models of information and communications technology (ICT) components as well as power networks, e.g., allowing the impact of such controls on power system transients [10]. In the context of such smart grid applications, some examples of communication requirements and performance metrics are [7], [9].

Latency requirements are concerned with the time required to send data from a source to a destination. Certain application, such as real-time state estimation using PMU data requires very low latency (few tens of ms). For applications such as smart meters data collection or demand response the latency requirements are less critical (up to seconds).

Data rate requirements are concerned with the speed at which data can be sent, i.e., the data volume that can be sent within a certain period of time. For example, video data used in wide area monitoring and control requires high data rates, whereas data rates for AMI can be low.

Reliability requirements deal with ensuring the communication system remains available and is able to send data. Remote protection applications require a very reliable communication network to ensure the safe operation of the grid.

Security requirements aim to protect the system from a wide range of attacks. Concepts related to security are confidentiality (i.e., prevent the disclosure of information to unauthorized parties), integrity (i.e., maintain and assure the accuracy and consistency of data over its entire life-cycle), availability (i.e., the information must be available when needed), authenticity (i.e., validate that parties are who they claim to be), and non-repudiation.

Power line communication (PLC) reuses existing power wires for data communication. i.e., the power grid itself becomes the communication network. Different types of PLC technology exist [11]: (i) ultra narrowband PLC technology operating in 300 to 3000 Hz range with very low bit rate (100 bps), (ii) low data rate (few kilobits per seconds) narrowband PLC operating in the 3-500 kHz range, (iii) high data rate narrowband PLC (500 kbps), (iv) broadband PLC operating in 1.5–30 MHz range and data rates up to 200 Mbps. Narrowband PLC technologies that operate over the medium voltage or low voltage power grids have been proposed by e.g., PRIME [12], PLC G3 [13], and IEEE 1901.2 initiatives. Targeted applications include monitoring (e.g., AMI), grid control, etc. Broadband PLC is being used for e.g., home multimedia services. However, PLC is challenging because the communication channel, i.e., the power grid, was not designed for that purpose

IV. MOTIVATION TO BUILD SMART GRID

Recently, energy saving and energy security have become major issues. We are facing energy deficiency in some countries which not only impacts economics, society and development of the country, but also results in the global warming. A set of recent developments are about to change this picture and put the electricity networks under pressure to change. The drivers for change are both external to the network, like preparing for a low-carbon future by reducing greenhouse gas, as well as internal, like the need for replacement of an ageing infrastructure. Traditional solutions can be considered to resolve issues posed by the new challenges, e.g., building new lines and substations to integrate more renewable generation whereas the smart grids approach would involve the development of more ICT solutions in the network to allow a higher penetration of renewable connected to existing lines and substations. In this case the traditional approach would give a solution, but it would be much more expensive and might not be feasible because it offers great resistance to build new infrastructure. This does not mean that more traditional infrastructure is not needed even with the “smart grids” approach, but it means that the smart grids approach is looking for the most efficient way to meet the new challenges and will be less expensive in the long run. As a matter of fact, three major components of the smart grids are distributed intelligence, communication technologies and automated control systems.

The overall objective of maintaining and even reinforcing electric power security has to be accomplished in an economic optimal way integrating conventional and non-conventional power plants controllable and non-controllable into the power system operation. To control the power systems, the smart grid has been proposed by integrating ICT, RES, control and instrumentation.

A. Smart Grid developments in India

The growth rate in India has been raised recently as its government implements reforms to encourage foreign investments and improve infrastructure and basic living conditions for its citizens. However, India is losing money in the form of electric grid losses. The opportunities for building the smart grid are high. Building a modern and intelligent grid is the key requirement to keep economic growth continuously. It is only with a reliable, financially secure smart grid that India can provide a stable environment for investments in electric infrastructure, a prerequisite to fixing the fundamental problems with the grid. Without having it, India will not be able to keep pace with the growing electricity needs of its cornerstone industries and will fail to create an environment for growth of its high-tech and telecom sectors.

India’s grid is in need of major improvements. This neglect has accumulated in a variety of system failures:

Poorly planned distribution networks

Overloading of system components

Lack of reactive power support and regulation services

Low metering efficiency and bill collection

Power theft.

V. CONCLUSION

Smart grid is a new idea for electricity networks across the Europe. Smart grids are customer driven market places and this technology provides cost-efficient grid and market connection for consumers and DG. Smart grids enable efficient operation of centralized and DG, offer services to promote consumer level energy efficiency and guarantee uninterrupted and high-quality supply of energy. Traditional grid includes centralized power generation and at distribution level one-directional power flow and weak market integration. Smart grids include centralized and distributed power generation produced substantially by RES. They integrate distributed resources (i.e. generation, loads, storages and electricity vehicles) into energy markets and power systems. Smart grids can be characterized by controllable multi-directional power flow. Smart metering has been seen as an essential part of the vision of smart grids. Remote readable energy meter is being developed to be intelligent equipment (i.e. interactive customer gateway) including, in addition to traditional energy metering, different kind of new advanced functions based on local intelligence and power electronic applications. The major objectives of smart power networks are to increase the efficiency and to maintain safety and reliability of the electricity networks by transforming the current electricity grids into an interactive (customers/operators) service network and to remove the technical obstacles to the large-scale installation and fully integration of RES.

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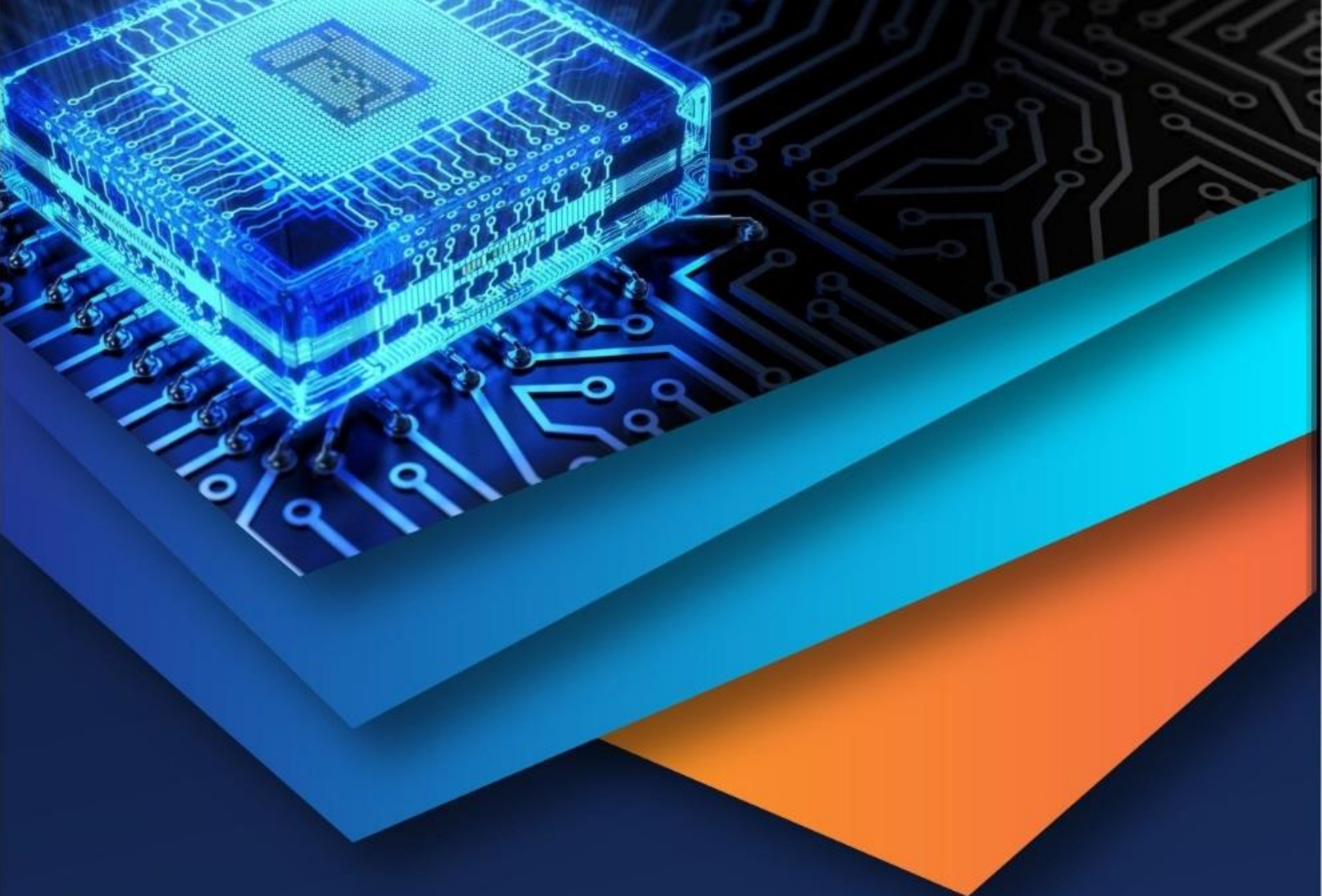

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