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An Overview of: Smart Grid Security System

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ABSTRACT: For century, there has been no change in the fundamental structure of the electrical power grid and vehicle networks. Current hierarchical, centrally controlled grid of the electrical grid is not best for growing demand. To address the challenges of the existing power grid, the new concept of smart grid and smarter planet are under research. The smart grid can be considered as a modern electric power grid infrastructure for enhanced efficiency and reliability through automated control, high-power converters, modern communications infrastructure, sensing and metering technologies, and modern energy management techniques based on the optimization of ondemand, energy and network availability.[9]Smart Grid has been evolved as the innovative idea globally as a solution for the power demand problems. Countries worldwide are looking for an efficient implementation of the same. A lot of research is now going on the various issues and challenges on the implementation and real time operation of the various components of Smart Grid. This paper presents a review on different challenges of electric power system in smart grid aspects. This also gives an insight into the current status of the research and developments in the field of smart grid. Authors strongly believe that this survey article will be very much useful to the researchers for finding out the relevant references in the field.[1] A Smart grid is expected to be a modernization of the legacy electricity network. It Provides monitoring, protecting and optimizing automatically to operation of interconnected element. It converts from traditional centre generator and/or emerging renewable distributed generator through transmission network and distributed system to industrial consumers and/or home users with their thermostats, Electric vehicles and intelligent appliances.[2]This paper is a basic idea about the smart grid system and how it works.While the deployment of the smart grid, modernizing the nation's electric power infrastructure, is currently in the public eye with attention paid predominantly to deployment of advanced equipment, technologies and applications, a less prominent but equally vital factor to the smart grid's success is the need for a highly skilled electric power sector workforce. With the current labor force aging, a considerable number of the most knowledgeable workers in the power industry are heading toward retirement. Furthermore, even the most experienced workers often lack the updated skills and training needed to successfully support the advanced systems, tools and devices that make up the smart grid. An important aspect of the smart grid is communication and security. Supported by a grant from the National Science Foundation, and to train our students in the area of smart gird, a new course titled "Smart Grid Communications and Security" was developed and offered to train students with the required skills to succeed in this competitive job.[10]

KEYWORDS: Smart grid,ABT,Smart Metering

I. INTRODUCTION

India's natural resources are unevenly distributed as, coal resources are abundant in Bihar/Jharkhand, Odessa, West Bengal and hydro resources are mainly concentrated in northern and North-Eastern Region, etc., far away from the demand centre's. Further, acquiring Right-of-Way (ROW) for constructing transmission system is increasingly becoming difficult. To support a high penetration of intermittent solar and wind power generation, many regions are planning to add new high capacity transmission lines. These additional transmission lines strengthen grid synchronization, but will also increase the grid's short circuit capacity, and furthermore will be very costly. With a highly interconnected grid and variable renewable generation, a small grid failure can easily start cascading outages, resulting in large scale blackout. We introduce the "Smart grid," where large synchronous grids are divided into smaller segmented grids which are connected asynchronously; via multi leg IP addressed ac/dc/ac converters called digital grid routers. These routers communicate with each other and send power among the segmented grids through existing transmission lines, which have been repurposed as digital grid transmission lines. The digital grid can accept high penetrations of renewable power, prevent cascading outages, accommodate identifiable tagged electricity flows, record those transactions, and trade electricity as a commodity New and Renewable Energy.[3]

II.BACKGROUND

One of the first large network utilities was built by Thomas Alva Edison in 1882 in New York. Edison promoted direct current for electric power distribution, despite the disadvantages of this approach, namely in short distance between a

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power plant and its customers (2.4 km was the limit of effective distance), which meant that small power plants needed to be built in customer areas. New research in Europe and America has brought electric motors and transformers working with alternating current and with the help of Edison's major opponent George Westinghouse, the previously used direct current was replaced with the alternating current, which persisted till today. Alternating current could be efficiently transmitted over long distance and hence allowed power plants to be built outside inhabited areas, closer to input resources. The process of power transmission nowadays involves step up transformers that transform electricity into very high voltage to decrease transmission losses. Electricity is then transmitted over hundreds of kilometers of transmission network. Before distribution to end customers, the voltage is decreased by a series of step-down transformers, which act as gates between high voltage power transmission and low voltage power distribution networks. In the Czech Republic the power transmission network consists of power plants, first-level substations and high voltage power lines. The first-level substations and power plants are connected using 400 kV and 220 kV lines. There is high flow of energy and therefore very high voltage is used to lower the electric current, which leads to lower losses during transmission. The first-level substations produce also 110 KV intended for power distributors. The Czech power distribution network consists of 110 kV lines, second-level substations transforming 110 kV to 22 kV or 35 kV for connected third-level substations. Multiple third level substations are situated in towns and produce well-known 230V/400V used by end customers. The current generation of power transmission and distribution network has been designed for centralized electricity generation in a small number of large power plants. Nowadays, this concept is being replaced with a more distributed electricity generation thanks to an increasing amount of predominantly renewable energy sources. European Union supports renewable energy sources in its Energy and Climate Change Policy with the goal to achieve 20% renewables share in the European energy mix until 2020. The new approach, however, brings up serious issues. Since the grid load changes along the day and since there is no efficient way to centrally store the surplus of generated electricity for later use or to rapidly increase the demand of electricity, power plants have to adjust their electricity production to meet the expected demand. Immediate production change is very complicated for most types of power plants, so both the consumption and the production of the renewable have to be predicted in advance, which brings additional risks to the whole process of electricity production and distribution.[4]

III. THE SMART GRID

In accordance with IEEE, the Smart Grid has come to describe a next generation electrical power system. It is typified by the increased use of communications and information technology in the generation, delivery and consumption of electrical energy. Another definition of Smart Grid can also be considered. According to Wikipedia it delivers electricity from suppliers to consumers using digital technology to control appliances at consumer's premises to save energy, reduce cost and increase reliability and transparency. As said by Green Energy Act (Canada) it is a nickname for an ever widening palette of utility applications that enhance and automate the monitoring and control of electrical distribution. DOE: The Smart Grid transforms the current grid to one that functions more cooperatively, responsively and organically. A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it - generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies. The smart grid is intelligent as it is capable of sensing system overloads and rerouting power to prevent or minimize a potential outage, of working autonomously when conditions require resolution faster than humans can respond and cooperatively in aligning the goals of utilities, consumers and regulators .It is capable of meeting increased consumer demand without adding infrastructure which shows its efficiency. Accepting energy from virtually any fuel source including solar and wind as easily and transparently as coal and natural gas; capable of integrating any and all better ideas and technologies energy storage technologies. This grid enables real-time communication between the consumer and utility so consumers can tailor their energy consumption based on individual preferences, like price and/or environmental concerns. This creates new opportunities and markets by means of its ability to capitalize on plug-and-play innovation wherever and whenever appropriate. Smart grid should be quality focused capable of delivering the power quality necessary free of sags, spikes, disturbances and interruptions to power our increasing digital economy and the data centers, computers and electronics necessary to make it run. It is increasingly resistant to attack and natural disasters as it becomes more decentralized and reinforced with Smart Grid security protocols. It shows the advance of global climate change and offering a genuine path toward significant environmental improvement. [1] Smart grid development tends to be driven by one of two principal visions for enhancing electric power interactions for both utilities and their customers: the European Union and U.S. models. The European Union vision seems to be
driven primarily by environmental concerns, whereas U.S. planning for the smart grid has been motivated primarily by a desire for reliability improvements. In the United States, desirable characteristics of the smart grid include self-healing transmission and distribution power architectures that will be resistant to intentional attacks and natural disasters and very high power quality levels along a broad range of metrics that go well beyond outage statistics. One of the key goals of model smart grids, such as the one being developed by the Pecan Street Project in Austin, Texas, is to

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promote active customer participation and decision making and thus to create a new grid operational environment in which both utilities and electricity users inflnuence each other.[5]

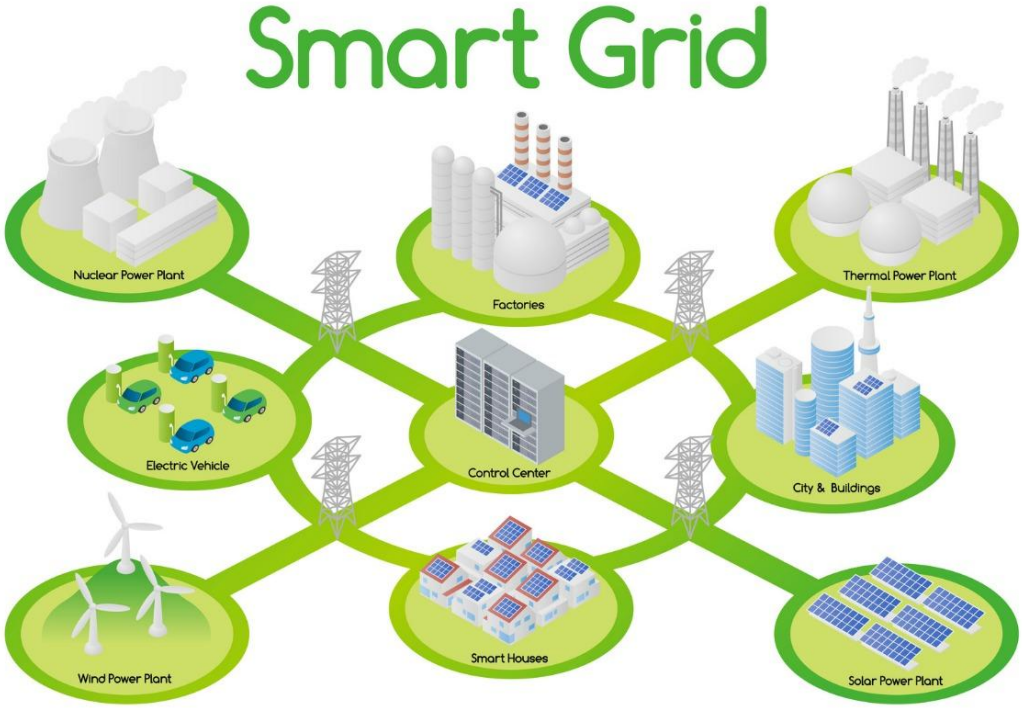

Fig 1. Illustration of smart grid.[11]

IV.SMART METERING SYSTEM

Availability Based Tariff (Advanced Metering system for digital grid)
What Is ABT**?**

- It is a performance-based tariff for the supply of electricity by generators owned and controlled by the central government
- It is also a new system of scheduling and dispatch, which requires both generators and beneficiaries to commit to day-ahead schedules.
- It is a system of rewards and penalties seeking to enforce day ahead pre-committed schedules, though variations are permitted if notified One and one half hours in advance.
- The order emphasizes prompt payment of dues. Non-payment of prescribed charges will be liable for appropriate action under sections 44 and 45 of the ERC Act.

Why ABT?

1. India plans to have an integrated National Grid. This will assist in meeting demand with the least cost supply. Five Regional grids already exist. Some linkages between Regions are also in place.

1. The five Regional grids work at vastly varying operational parameters today. Frequency level is one such operational parameter. The target frequency prescribed by the Indian Electricity Rules is 50 Hz
2. Integrated grid operations require the normalization of frequency across all five Regions. The alternative is to insulate each Regional Grid by Back to Back HVDC links. This is an expensive option. Normalization of frequency requires proactive load management by beneficiaries and dispatch discipline by generators.
3. There is currently no formal system of financial incentives to promote grid discipline.
4. The ABT provides this mechanism.

2. Chronic surpluses in the East and shortages in the South have resulted in sustained functioning of these grids at frequencies which are far beyond even the normal band, liberally defined by the IEGC as frequency variation within 49.5 to

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50.3 Hz.
1. Continued functioning at non-standard frequency results in long-term damages to both generation and end use equipment this is a “hidden cost” which is borne by the customer in the long term.
2. The ABT will induce corrections in the prevailing frequency to bring it within the permissible band.

3. Frequent fluctuations in frequency caused by short-term variations in the demand supply gap due to the tripping of load
or outage of a generator or a transmission line impose substantial costs on generators and consumers.
1. The ABT will address this problem by inducing grid discipline.[6]

Fig 3. Smart meter [12]

V.DIFFERENCE BETWEEN SMART GRID AND CONVENTIONAL GRID

COVENTIONAL GRID	SMART GRID
• Electromechanical • Centralized generation • Manual restoration • Check equipment manually • Estimated reliability • Blind • Non environment friendly • Unsafe	• Digital /microprocessors • Accommodates distributed generation • Self healing • Monitor equipment remotely • Predictive reliability • Intelligent • Environment friendly • Safe

Table 1. Difference between smart grid and conventional grid[7]

The above table shows that **smart grid** has more advantage an features compare to the conventional grid. And the increased cost of the smart grid than the conventional grid is neutralized by the fact that it provides the safety and saves more energy than conventional grid.

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VI.SMART GRID SECURITY

Upgrading the power grid will present many new security challenges that must be dealt with before extensive deployment of smart grid technologies can begin. The digitalization of the electric grid may enable remote attacks to increase rapidly, potentially spanning countries or even continents. Moreover, it is rapidly becoming easier to compromise computer systems due to the increased availability of hacker tools on the Internet and the decrease in technical knowledge required to use them to impose significant damage.

1. Vulnerabilities: In order to defend the smart grid, emphasizes three types of vulnerabilities that must be considered – physical, cyber, and open-source information.

Physical and cyber: While physical attacks – facility break-ins, weapon attacks, or explosives – are real and frightening possibilities, cyber attacks have the potential to be just as destructive and carry the added threats of stealth and long distance control . Attackers have the potential to initiate attacks from nearly any location in the world. Furthermore, currently more than 90% of successful cyber attacks take advantage of known vulnerabilities and misconfigured operating systems, servers, and network devices. In addition, the types of protocols and equipment used in the communication and control of power systems are numerous. The diversity and lack of interoperability in the communication protocols causes problems for anyone who tries to establish secure communication to and from a substation (or among substations in a network of heterogeneous protocols and devices). Within a substation control network, it is common to find media including commercial telephone lines, wireless, microwave, private fiber, and internet connections .
2. Security Needs: In order to protect electric infrastructure from the threats outlined above, several defense mechanisms are needed to minimize disruptions to system operations.

i. Layered Security: Layered security (or defense-in-depth as the Department of Defense (DOD) refers to it) involves strategically combining multiple security technologies at each layer of a computing system in order to reduce the risk of unauthorized access due to the failure of any single security technology. It exponentially increases the cost and difficulty for an attacker to compromise a system by creating a much stronger defense than the use of any individual component alone, thus, reducing the likelihood of an attack. Security features to be employed at each layer include examination, detection, prevention, and encryption.

ii. Deception: Deception consists of two possible techniques, dissimulation, hiding the real, and simulation, showing the false. McQueen and Boyer describe potential dissimulation and simulation techniques that can be used for control systems in. Deception defense mechanisms can greatly increase the difficulty of planning and conducting successful attacks upon the system, and can alert operators to possible threats before any systems are harmed.[2]

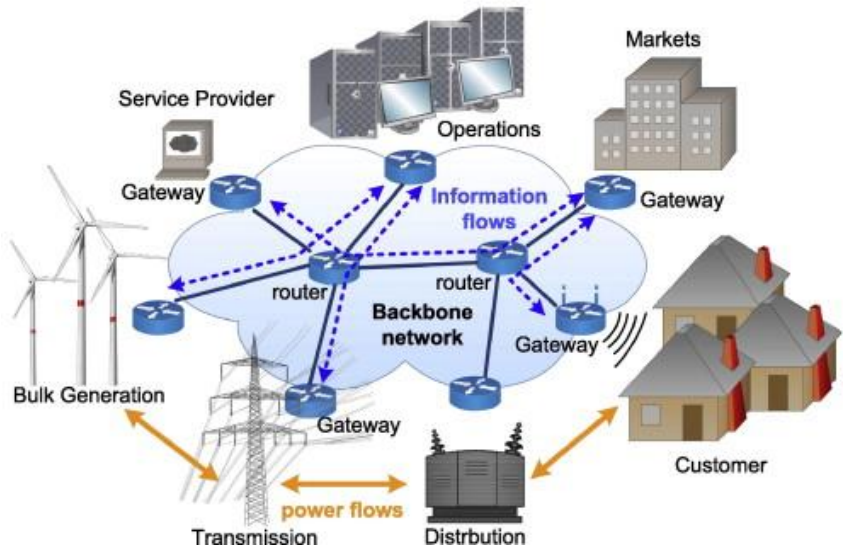

Fig 2. Cyber security in smart grid https://www.sciencedirect.com

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VII. CONCLUSION

In this paper review of smart grid terminologies has been done to understand the objective of smart grid technology. Load forecasting and demand side management help to predict for future planning of load and operation of the system. We have observed that smart grid is an emerging technology with its various applications to enhance electricity. Broad number of papers have been reviewed to know about smart grid with its components like demand side management, smart meters, demand response. So here this paper emphasizes the capabilities of smart grid.[8]

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