Smart Grid: New dimension for conventional grid

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ABSTRACT
The traditional electrical grid is steadily being replaced with the technologically advanced Smart Grid. Some of the key factors contributing to the paradigm shift toward smart grids include the steadily rising cost of electricity, the lack of proper infrastructure, intermittent losses of electricity, the carbon footprint, and climate change. The next generation grid network, known as the smart grid, offers advantages including digitalization, decentralized control, intelligence, adaptability, resilience, sustainability, and customization. This article outlines some of the innovative developments and difficulties encountered in the context of smart grids. The development of smart grids is also covered in this article from an Indian perspective.
Keywords: Carbon Footprint, Commercial Aspects, Smart Grid, SGTF (Smart Grid Task Force)

Introduction

The traditional electrical grid is neither designed or built with variable scenarios and future uncertainties in mind. Consequently, the greatest power transmission line collapse in global history occurred in India on July 31, 2012, and August 1, 2012, affecting over 600 million people in 21 states [1]. From a global standpoint, another significant blackout occurred in 2009 when a natural disaster destroyed a hydroelectric project near the Paraguayan border, cutting out power to over 60 million people.. Around 4 million people in China were left without energy in the early months of 2008 due to another significant power outage. In 2005, there was another significant power outage in Indonesia caused by a power system issue, affecting a minimum of 100 million people. Over 55 million people were impacted by the 2003 US northeast blackout, which was a widespread power outage in the northeastern United States and central Canada [1, 2]. These are a few prominent instances of grid failure worldwide, which are brought on by the technical and artificial issues with the traditional grid.. The power outage or grid failure can be prevented using advanced technologies of electronics, computer science and its allied fields. The *Smart Grid* is one of the prime solutions for such power outage or grid failure. The smart grid has great potential for driving innovation in the ways electricity is produced, managed and consumed [4]. The traditional power grids are generally used for carry power from a few central generators to a large number of users. In contrast with the *SmartGrid*, which uses two-way flows of electricity and information to create an automated and distributed advanced energy delivery network and produce computational intelligence in an integrated fashion across electricity generation, transmission, distribution and consumption. The fig. 1 depicts the basic smart grid infrastructure. The smart grid promises advantages of new technological advance in the field of communication, power electronics, supportive embedded system, IDAPS (Intelligent Distributed Autonomous Power System), improved interface and decision support, micro grid, smart equipment, smart sensor technology, smart homes etc. The conventional grid used in day to day practice may be malfunctioning in many areas such as production, transmission, distribution and consumption of Electricity. The losses of electric energy up to 20 % to 30% are due to the malfunctioning of the electric grid system and subsystem of electric grid [5].

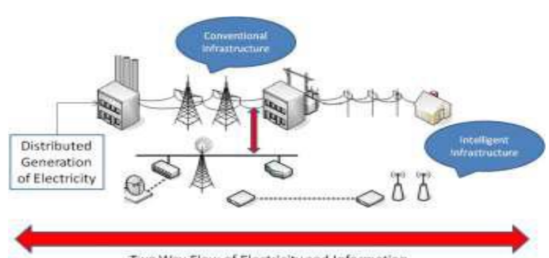

Fig.1. Smart Grid Infrastructure [Adopted From Ref. 3]

These losses of electric grid can be overcome by using smart architecture of electric grid system. According to IEEE, The smart grid is a next generation electrical power system that is typified by the increased use of communications and information technology in the generation, delivery and consumption of electrical energy‖. [6] According to IEA (International Energy Agency), "A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Smart grids co-ordinate the supply and reduce the electricity loss at various stages, such as production, distribution, transmission and consumption losses. Improved monitoring and networked IT systems can helps to limit losses of electricity along the way and thereby improve capacity utilization and avoid pollution; such losses represent on average 8% of production worldwide but over 15% in individual countries [4]. For such type of scenario, if an innovative architecture that includes minimum energy losses at various stages of distribution and consumption then such problems will not arrives. This makes total system smart enough to tactile future energy challenges. Considerable innovation is also occurring in the operations of the electrical sector's "Back-End." Modern technological advancements in sensing, communications, control, computing, and information technology are being used by the power industry to modernize and address difficulties more proactively [8–14]. The term "smart grid," along with a few other terms like Intelli Grid, Grid Wise, and Future Grid, have been used to summarize the change in transmission grid development toward increased intelligence [14]. Numerous other standardizations have been developed in various fields, nations, and commercial organizations. They are as follows, [15]

United States: NIST IOP Roadmap
European Union: Mandate CEN/CENELEC M/441
Germany: BMWi E-Energy Program
China: SGCC Framework
Japan: METI Smart Grid roadmap
Korea: Smart Grid Roadmap 2030
IEC SMB: SG 3 Roadmap
CIGRE: D2.24
Microsoft: SERA

Technological Trends of Smart Grid

In 2005 Amin and Wallenberg firstly focused on the smart grid on their article "Toward a Smart Grid" by IEEE P&E Magazine [16]. There is also some supporting technological activity is proceeding in some year back. The innovation of smart grid system is due to the advance technological attempt of smart electronic control, smart distributed sensor system, smart metering focused monitoring and demand on supply scenario. The first smart metering project was established in 2000 by the government of Italy. The name of project was Telegestore and MoMa project and this project connected over the 27 million people via low bandwidth power line communication [17]. The Wide Area Measurement System (WAMS) was adopted by China and this plan was completed in 2012 [18]. The similar project was developed by USA in Boulder, Colorado and Texas in the year 2008 [19, 20]. In Ontario (Canada) Hydro One is the Smart Grid project and the system will serve 1.3 million customers in the province of Ontario. The initiative won the Best AMR Initiative in North America‘ award from the Utility Planning Network [21]. Adelaide in Australia also plans to implement a localized green Smart Grid electricity network in the Tonsely Park redevelopment [22].

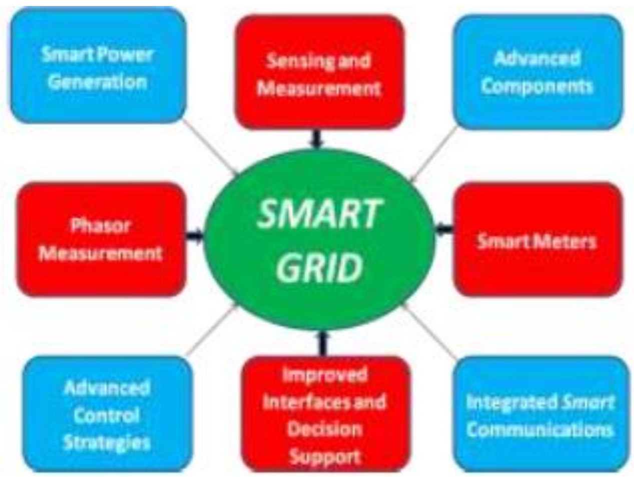

Fig.1. Key Research and Development Area of Smart Grid

These are some of the pioneer development in worldwide perspective but there are some other technological aspect still challenge the future of smart grid. The development and standardization of smart grid is one of the key research and development area of electric grid system. The development and deployment of new technologies in context with reduced carbon footprint is also a key aspect of research. The typical focused research and development area in smart grid platform is depicted in fig. 1 The scope for research and development in a smart grid is enormous. If we focused in transmission and distribution sector of smart grid then there are various challenges in front of us. In transmission and distribution sector, we have to develop communications protocols that promise the error free communication. For this communication there is need to develop smart sensor based cluster network system and supporting embedded system with integrated software systems and application programming interfaces (APIs). As the technical development is important, on the other hand the commercial aspect is also important. The commercial aspect such as, dynamic, real-time pricing for electricity consumption, distributed generation using smart metering, demand management and end user interface are to be look forward. The other key areas of research of smart power generation and its utilization for carbon foot print reduction is consumption of electricity using advanced low losses semiconductor devices, high efficient power converter technology, advanced storage system etc.

Characteristics of Smart Grid

The conventional transmission grids are in the heavy stress because of the environmental issues such as carbon foot print, water pollution etc. In technological point of view adaptation of new technologies and its safe use is also prime importance. The smart grid must hold on the smarter feature such as, digitalization, flexibility, intelligence, resilience, sustainability, and customization. With these smart features, the future transmission grid is expected to deal with the challenges in all identified areas. [23] For smarter use of smart grid the digital platform must be

provided for sensing, measurement, controlling of devices, communication and maintenance. The flexibility of smart grid is the expansion of grid for future development; it must be adaptable in various climates and also with dynamic market demands. The intelligence in all aspect of grid is the one of the prime feature of today's smart grid platform. The intelligence is with communication protocol handling, demand and user supply with intelligent loads etc. The other characteristic such as resilience, sustainability, and customization are also goes hands on hands in smart grid development and deployment.

Indian Context of Smart Grid

India is currently one of the fastest growing economies in the world. But still there are lots of Indian states facing the problem of blackouts due to incomplete infrastructure of conventional grid. The electricity generation in India is totally depends on thermal power plant, almost 60% electricity generation is due to thermal power plant of coal, oil and gas. Remaining electricity is generated by hydro (30%), nuclear (7%), and renewable energy sources (3%) [24] Apart from that the electricity capita of the country is 526 kWh only [24]. The losses and theft are the prime problem facing by Indian transmission and distribution sector. For this reason Indian government established the Smart Grid Task Force (SGTF) and India Smart Grid Forum for future perspective. The Smart Grid Task Force (SGTF) and India Smart Grid Forum are the pioneer of some the earlier project regarding with smart grid in India They developed some of the pilot project in India at various places such as, Smart Grid pilot project in Northern Region, Intelligent monitoring & control of the interconnected electric power grid using wide area measurements (WAM) for western region, PMUs (Phasor Measurement Units) with GPS system to be installed at four substations of Northern Region and PDC at NRLDC, Delhi. Bangalore Pilot Project for Bangalore city, Mangalore Pilot Project for Mangalore city. Distribution Reform, Upgrades and Management Projects for North Delhi, Bangalore, Gujarat, and Maharashtra states, Joint Clean Energy Research and Development Center in India, Smart Meter Installations at New Delhi and Kerala are some of the unique development by government of India [25]. Apart from this unique retransformation, the smart grid platform is facing some serious problem in India. The present infrastructure of conventional grid system is inadequate and requires expansion to support the growth, monitoring and control of smart grid. Hence the Indian policy makers and apex bodies are to consider this serious issue and planed next generation grid according to chaining scenario of smarter future.

Conclusion:

The electric power industry is changing quickly. In the near future, we will need to pay close attention to three main areas: climate change, grid security, and electricity generation prices. These significant issues are not met by the current grid network. Thus, it is impossible to avoid smart grid technologies. As a result, in the near future, we must concentrate on the research and development of next-generation smart grid technology.

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