

Smart Grids Implementation: An International Overview

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ABSTRACT: Developments in the field of Information technology have revolutionized human life. Almost all sectors such as finance, banking, trading, telecommunication, railway, airplane ticket booking, etc are completely revolutionized due to the application of information technology. The power distribution sector is also changing and experiencing the benefits of information technology through a new concept of smart grids. With the continuous rise in electricity consumption, without the implementation of modern IT technologies, it may not be possible to manage the power distribution sector effectively. Smart grids are interactive grids in which communication is established between the grid and the intended user for effective utilization of all the resources and offer many advantages over traditional non-interactive grids. This paper covers a broad review of smart grid technologies and their applications in different developed and developing nations.

KEYWORDS: Smart Grids, Smart Grid Architecture, Smart Grid Applications.

I. INTRODUCTION

In the recent past many nations have shown huge interest in ground-level deployment of smart grid technology especially in the area of management of power demand, integration of renewable energy sources, and advancements in metering [1]. Smart grid projects are undertaken to achieve green growth and are being accepted by electricity consumers. It is important to minimize the gap between consumer's expectations and their satisfaction [2]. Due to the continuous increase in the electricity demand, it is important to integrate renewable sources to reduce the use of fossil fuels, by installing smart grid technology in consumer's homes. Studies based on the Technology Acceptance Model and supported by the Norm Activation Model reveal that there is an increase in variance in the acceptance level of smart grids due to the addition of personal norms to independent variables of the Technology Acceptance Model [3]. Even if smart grid technology is widely accepted, experiments conducted on end users' perceptions based on signal detection theory (SDT), fuzzy detection theory, and fuzzy detection theory show that end users have a conservative approach towards the same due to lack of confidence in the intelligent technology used in the smart grid [4]. With the application of smart grid technology modern electricity grids are shaped and evolved continuously to strengthen their role in the better management of demand and supply of electricity [5]. With combination of the Internet of Things (IoT) with smart grids offers multiple advantages in energy management like virtual control of everything in various fields [6]. Various factors like awareness of energy efficiency, the latest trends in electricity markets, the obsolescence of traditional electricity distribution models, and climatic changes are the main driving forces for the smart grid paradigm. With the integration of multiple distributed generation and storage sources, control of these distributed generation sources necessitates smart metering systems also [7]. Smart grids are enabled with intelligent devices to monitor and control for efficient use of electricity for demand response. They are located at appropriate locations to make appropriate decisions and act with flexibility and autonomy [8]. With the integration of renewable energy sources, smart grids are confronted with new opportunities and challenges that can be analyzed from the point of view of planning, stability, protection, and control using suitable modeling and simulations [9]. The analogy of "electric springs" applies to smart grids which have their power demand profile following the power generation profile [10].

II. SMART GRID ARCHITECTURE

Fig. A shows the difference between Traditional and Smart grids. In traditional power supply grids, a top-down layer approach is followed in which the communication is achieved in only one direction i.e. from the utility to the

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consumers, however, in smart grids, a two-way communication is established between utility and consumer. The advantage of this is the optimum utilization of grid resources [11].



(A) DIFFERENCE BETWEEN TRADITIONAL AND SMART GRIDS

The communication between various sections of the power distribution system is established by placing different intelligent electronic devices (IED) located at suitable locations as shown in Fig.B. These IEDs are then connected with a central controlling facility through suitable communication networks for effective controlling,

(B) COMMUNICATION WITH IEDS IN SMART GRIDS



2.1 Major advantages offered by smart grids over traditional grids are described as follows:

1. Self-healing: The smart grids are self-healing in nature to the disturbances occurring on the system as they can rapidly detect, analyze, respond, and restore from the disturbances.
2. Tolerance to attack: The smart grids should be resilient to physical and cyber security attacks on IT and communication infrastructure.
3. The smart grids can provide the quality power required by users due to continuous monitoring and automated corrective actions.
4. It can integrate distributed generation sources including solar power generation, and wind power generation.
5. Allows competitive electricity markets.
6. The use of Information Technology for monitoring the system minimizes Operation & Maintenance costs for the utility.
7. Empower the consumer and incorporate consumer equipment and behavior in the operation and design of the grid.

2.2 Various domains in which smart grid technology can be implemented are as follows:

Smart grid technologies can be implemented in different sections of power distribution networks such as • Bulk power generation • Power Transmission and Distribution networks Electricity consumer Markets with smart metering technology • Operations and maintenance of utility • Service provider • Participative involvement of electricity customers [12].

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III. INTERNATIONAL PREVIEW

In this section, a scenario of the implementation of smart grid technologies is presented. Some developed countries like Australia, and New Zealand have set a good example in the implementation of smart grid technologies. While some countries like China, India, and Brazil have proper planning and development in this technology. The progress of smart grid technology in China, India, and Brazil, can be considered as a pattern of reference for other developing nations. In China, the efforts are comparable with developed nations like the U.S. [13].

3.1 The scenario in Australia: The major international programs include the European Union Smart Grid Technology Platform and the US 2030 Smart Grid vision to deliver an electricity network that is flexible, accessible, reliable, and economical. A smart grid facilitates the desired actions of its users and these may include distributed generation, the deployment of demand management and energy storage systems, or the optimal expansion and management of grid assets [14].

3.2 The Scenario in New Zealand: The country has already achieved 80% renewable generation and 62 % advanced metering infrastructure for household consumers. It primarily focuses on challenges to achieve a greener and smarter grid identified in the GREEN Grid research program with the growing use of wind and solar generation. It also focuses on power quality and congestion issues arising out of high levels of small-scale distributed generation such as the requirement of increased supply frequency, readiness of instantaneous reserves due to variations in demand, and relatively low level of consumer engagement in demand response [15].

3.3 The Scenario in China: In China, smart grid technologies are widely experimented with for forecasting of new energy, storage of energy, development of smart substations; prevention of disasters and reduction for power transmission lines; flexible DC transmission; distribution automation; distributed generation access and micro grid; smart power consumption; the comprehensive demonstration of power distribution and utilization; smart power dispatching and control systems; and the communication networks and information platforms [16].

3.4 The scenario in India: The Ministry of Power, Government of India on the recommendation of the India Smart Grid Task Force (ISGTF) has shortlisted fourteen (14 Nos.) Smart Grid pilot projects that are planned to be executed in the power distribution sector in India showcase the relevance of Smart Grid on different aspects such as Advanced Metering Infrastructure (AMI), Outage Management System (OMS), Peak Load Management System (PLMS), Renewable Energy (RE) Integration, etc [17].

3.5 The Scenario in Brazil: Decarbonization, Digitalization, and Decentralization are the main key drivers for the implementation of smart grid technologies in Brazil. Distributed Generation (DG), Demand-Side Management (DSM), and new tariff schemes are on a path of accelerated deployment in the country. The deployment of storage technologies, however, is at a slow pace of growth [18]. In Brazil, the conception of the smart grid is aligned with sustainability and accounts for a pattern for smart grid development based on demand-side response and active demand-side management. It is being done with two major objectives. The first objective is the validation and replicability of the pilot project implemented from the point of view of the location of the pilot project comparable with the sample of the utility's energy market or a particular area of interest with frequent power failures due to high environmental constraints. The second major objective is to develop a model of a sustainable smart grid with national visibility after the location of the pilot project is finalized [19].

3.6 The Scenario in UAE and GCC: In the United Arab Emirates (UAE) is considered among the highest energy consumers in the world. To reduce dependency on fossil fuels UAE is focusing on the use of additional sustainable and renewable energy sources like photovoltaic energy, concentrated solar power, wave energy fuel cell energy, etc. [20]. The member countries of the Gulf Cooperation Council (GCC), like Qatar, Bahrain, Saudi Arabia, Kuwait, Oman, and the United Arab Emirates (UAE), are emphasizing on need for the development of smart power grids, as the development of smart grids can reduce the stress on the existing grid, defer the investments for technical up gradation of existing grids, increase the efficiency of power distribution system, and effectively reduce carbon emissions. They have come up with three objectives (i) trading and exchange of energy exchange through GCC interconnection; (ii) renewable generation resources integration; and (iii) deployment of demand side management

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technologies to effectively handle the continuously increasing electricity demand along with a reduction in the carbon emissions [21].

3.7 The scenario in Pakistan: Current energy crises are being handled by converting the current power management system to a smart automatic system through Information and Communication Technologies (ICT) in smart grids. A major transformation in electricity infrastructure is needed at the time so as to meet the increasing demands for electricity. It focuses on the promotion of the use of alternative energy sources such as solar, wind, hydro, and biogas/biomass to offer environment-friendly energy solutions [22].

IV. CONCLUSION

From the above discussion, it can be concluded that many developed and developing countries are consistently implementing smart grid technologies for effective management and upgrading their existing power distribution grids on a pilot project basis. With continuous advances in instrumentation technology, communication networks, and computational algorithms, the scalable use of smart technology has great potential and will soon become a reality.

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