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A Review on Development of Initiative Smart Grid Technology in India and Its Future Perspectives

Manan Y Pathak
Department of Electrical Engineering, School of Technology, Pandit Deendayal Petroleum University, Raisan Village, Gandhinagar, Gujarat, India

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Abstract

Indian power sector is growing at an enormous Space. Building and operating such a power system is a challenging problem. The power network which carries the MWs across large distances is analogous to a "muscle system" of human body. Likewise, the entire range of associated monitoring and control network is analogous to a "nervous system". While strengthening the muscles is important in order to fully realize the potential, they also have to be complemented by an intelligent nervous system. India is truculent to meet the electric power demands of a fast expanding economy. Restructuring of the power industry has only increased several challenges for the power system engineers. The proposed vision of introducing viable Smart Grid (SG) at various levels in the Indian power systems has recommended that an advanced automation mechanism needs to be adapted. Smart Grids are introduced to make the grid operation smarter and intelligent. Smart grid operations, upon appropriate deployment can open up new avenues and opportunities with significant financial implications. Smart Grids can continue towards enhancement of power market. The current status of the power market as well as initiations of Smart Grids in India is studied to scrutinize the potential power market enhancement with the advent of Smart Grids. This paper presents various Smart Grid initiatives and implications in the context of power market evolution in India.

1. Introduction

The economic growth of developing countries like India depends heavily on reliability and eminence of its electric power supply. Indian economy is anticipated to grow at 8 to 9% in 2010- 2011 fiscal year, which in the impending years is set to reach double digit growth (10%+) [1]. But India suffers from serious power shortage which is likely to worsen over the next few decades. India has a power sector characterized by deficient generation and high distribution losses. In addition to that, abhorrent geological and environmental factors have encouraged carbon footprints since its grass roots level of CO_2 emissions, greenhouse effect and the adverse effect of globalization in the country [2].

This may cause instability in the power system and problems like brownout and blackout might arise. In order to prevent the occurrence of instability, it is essential to upgrade the prevailing power systems. One of such incipient technology, Smart Grid (SG) plays a very vital role in achieving the key technical benefits like power loss reduction; refining quality of supply, peak reduction, economic load dispatch etc. Smart Grid technology has been a high priority topic of research and development in many developing as well as developed countries. This technology also has a dynamic role in remodeling the energy scenario of the global market. Factors like policies, regulation, efficiency of market, costs and benefits and services normalizes the marketing strategy of the Smart Grid technology. Other concerns like secure communication, standard protocol, advance database management and efficient architecture with ethical data exchange add to its essentials [3]. Such technology has a potential to prolific other

Corresponding Author,
E-mail address: manan.pmt13@sot.pdpu.ac.in

technologies like Flexible AC Transmission System (FACTS) and Wide Area Monitoring (WAM) to redefine the capability of power system engineering and unite the necessity of the rural, suburban and urban regions across the globe under single roof [4]. In addition, the technology employs the reduction of carbon footprints and foot-dragging the greenhouse gas emission. This paper designates about the Smart Grid initiatives along with various examples of existing structures of automation in India. It also reviews the encroachment made in Smart Grid technology in R&D, initiated by various public and private sector organizations supported by prominent institutions across the globe. Limelight on the current and future issues involved for the development of Smart Grid technology for future demands has also been debated.

2. Brief Outline of the Indian Power System

The Indian power system is operated as five Regional grids viz., Northern Regional grid (NR), Western Regional grid (WR), Eastern Regional grid (ER), Southern Regional grid (SR) and North Eastern Regional grid (NER) [4]. Three of the regions, viz. NR, WR and SR suffer from severe deficits while ER is having surplus generation of about 2500 MW and NER is having marginal surplus based on hydro reservoir levels. The regions are connected to each other either through asynchronous links (HVDC back-to-back) or AC links to enable exchange as and when available surpluses. The objectives of interconnecting the five regional grids in the country through synchronous and asynchronous links are to enable transfer of power from surplus regions to deficit regions, to enable optimal development and utilization of coal, gas and hydro resources in the overall interest of the nation and to improve economy, reliability and quality of power supply. Since the advent of the current century, the focus of planning the generation and the transmission system in the country has shifted from the orientation of regional self-sufficiency to the concept of optimal utilization of resources on an all India basis [5]. The national grid now operating at present has two synchronous grids, viz. NR-WR-ER-NER (Central grid) and SR (Southern grid) as shown in Fig. 1. In 2007, the national grid meets a peak demand of 90 GW, with installed capacity of 132 GW. Power flowing from ER/NER to NR/WR/SR is of the order of 5,000 to 6,000 MW. Inter regional transmission capacity of 18,400 MW is available. The majority of inter regional power transfer takes place over 400kV Network. However, introduction of 765KV EHVAC Lines and 800KV HVDC lines is being planned [6]. Table I shows the projected growth of the National Grid.

Fig: 1. Regions of Indian Power Grid

2.1 National Load Dispatch Centre (NLDC)

The Electricity Act 2003 has provided for constitution of the National Load Dispatch Centre for optimum scheduling and dispatch of electricity among the RLDCs. As of now the NLDC for India is not yet commissioned for operation. As per policy, it is envisaged that in future all RLDCs shall report to proposed NLDC for Unified Grid Operation at National level. At present the national grid is operated by mutual coordination of RLDCs.

Role of NLDC: The NLDC shall be an apex body to ensure integrated operation of the national power system and discharge the following functions:

- Supervision over the RLDCs.
- Scheduling and dispatch of electricity over inter-regional links in accordance with Grid standards specified by the authority and Grid code specified by the Central Commission in coordination with RLDCs.
- Coordination with RLDCs for achieving maximum economy and efficiency in operation of National Grid.
- Monitoring of operations and grid security of the National Grid.
- Supervision and control over inter regional links as may be required for ensuring stability of the power system under its control.
- Coordination for restoration of synchronous operation of National Grid with RLDCs.

2.2 Regional Load Dispatch Centers (RLDC)

The Electricity Act 2003 requires the Central Government to make regional demarcation of the country for efficient, economical and integrated transmission and supply of electricity. In particular this demarcation would facilitate voluntarily inter-connection and co-ordination of facilities among the inter-state, regional and inter-regional generation and transmission of electricity. To ensure integrated operation of power system in each such region, the RLDC has been envisaged as an apex body. The directions given by the RLDC for ensuring grid stability etc. are to be complied with by the licensees, generating company, generating stations, sub-stations and any other person connected with the operation of the power system.

Role of RLDC: The RLDC is the apex body to ensure integrated operation of the power system in the Region.

- Monitoring regional grid security parameters in Real time for integrated operation of power system.
- Daily scheduling and operational planning.
- Facilitating interstate / inter regional exchanges.
- Analysis of power system disturbance in the region and facilitating immediate preventive measures.
- Computation of energy dispatch and drawal values as per Special Energy Meter (SEM).
- Operational system studies and contingency analysis.
- Augmentation of SCADA, Telemetry and Communication facilities.
- System studies, planning and contingency analysis.

2.3 State Load Dispatch Centers (SLDC)

Corresponding to the RLDC which operates at the regional level, the SLDCs have been envisaged at the State level with the responsibility of ensuring integrated operations of the power system in State.

Role of SLDC• To be responsible for optimum scheduling and dispatch of electricity within a State in accordance with the contracts entered into with the licensees or the generating companies operating in that State.

- Monitor grid operation.
- Keep accounts of the quantity of electricity transmitted through the state grid.
- Exercise supervision and control over the inter-State transmission system.
- Be responsible for carrying out real time operation for grid control and dispatch of electricity within the State through secure and economic operation of the State Grid.

3. Towards Smart Grids

A “Smart Grid” is a concept for transforming an electric power grid by using advanced communications, automated controls and other forms of information technology. It integrates new innovative tools and technologies from generation, transmission and distribution all the way to consumer appliances and equipment [7]. This concept, or vision, integrates energy infrastructure, processes, devices, information and *markets* into a coordinated and collaborative process that allows energy to be generated, distributed and consumed more effectively and efficiently. Though the deployment strategy for Smart Grid encapsulates all stages of the electric power life cycle (generation, transmission, distribution, metering, customer), it should initially focus on sustainable options for customers at the distribution, meter and customer phases. Hence, a “Smart Grid” enables devices at all levels within the grid (from utility to customer) to independently sense, anticipate and respond to real-time conditions by accessing, sharing and acting on real-time information. Simply stated, Smart Grid is the convergence of information and operational technology applied to the electric grid, allowing sustainable options to customers and improved security, reliability and efficiency to utilities. A modernized grid would create a digital energy system that will:

- Detect and address emerging problems on the system before they affect service,
- Respond to local and system-wide inputs and have much more information about broader system problems,
- Incorporate extensive measurements, rapid communications, centralized advanced diagnostics, and feedback control that quickly return the system to a stable state after interruptions or disturbances,
- Provide to consumers with timely information and control options,
- Deploy and integrate distributed resources and generation, including renewable resources,
- Integrate “smart” appliances and consumer devices like hybrid cars, electric vehicles, etc.

For example, the combination of three emerging technologies i.e., advanced metering infrastructure, distribution automation; along with integration of distributed energy resources would constitute a *Distribution Smart Grid*. It is identified that one of the ways to succeed in implementing a Smart Grid that can enable a wide range of intelligent applications well into the future is the usage of "standards based approach" and the focus on dual interoperability of technologies.

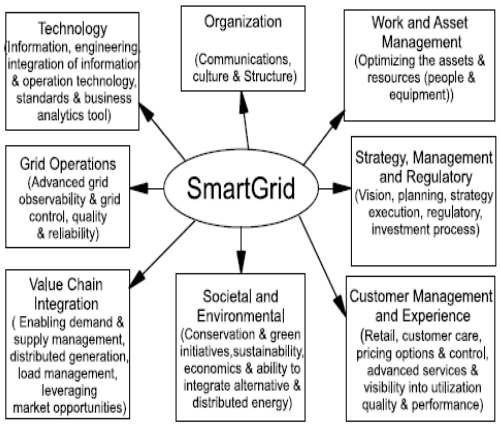

Fig: 2. Eight Smart Grid logical domains and important element

4. Smart Grid Initiatives in India

As it has been acknowledged earlier that, Smart Grid Technology has a widespread overview of transforming the Indian power grid from technology based standard to performance based standard. The Ministry of Power (Mop) participated in the SMART 2020 event with "The Climate Group" and "The Global e-Sustainability Initiative (GeSI)" in October 2008 which aimed to highlight the reports relevant to key stakeholders in India. Unfortunately, the possible "way forward" has not yet been drilled out and is still a question mark for the Government. But to facilitate demand side management distribution networks has been fully augmented and upgraded for IT enabling, which has enhanced the grid network with amended customer service. Table-1 provides a brief analysis of some of the initiative which has been taken under the supervision of many government and private bodies and allies. In the view of multitude that could be accrued, it is suggested that there should be ample Government regulatory support and policy initiatives to move towards Smart Grids. India is in its nascent stage of implementing various other controls and monitoring technology, one of such is ADA. Further researches are being carried out in some of the elite institutes in the country in collaboration with some of the various multinational companies and power sectors across the nation.

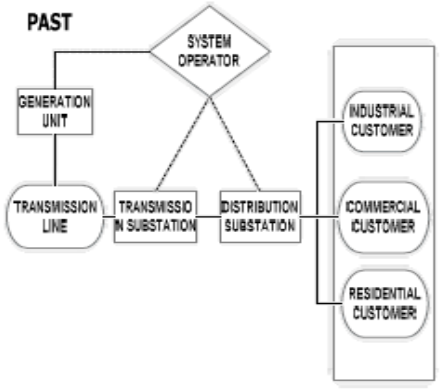

Fig: 3.1

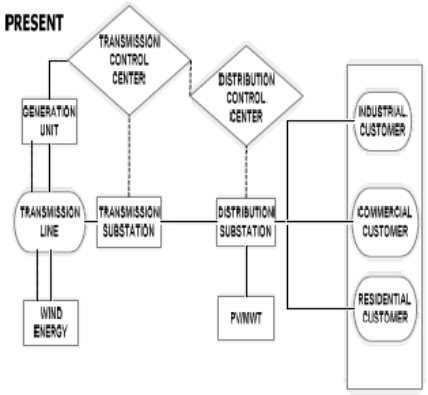

Fig: 3.2

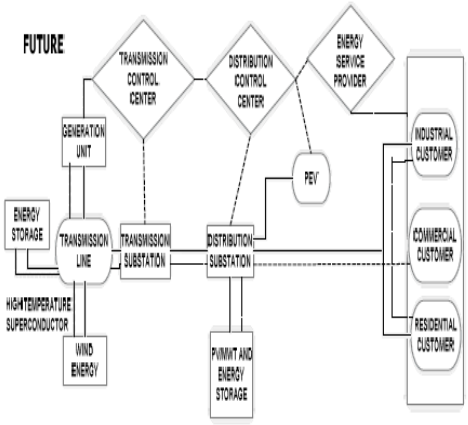

Fig: 3.3

Fig: 3. Smarter electricity systems

5. Micro Grid

The renewable resources in absolutely stand-alone mode do not perform reasonable due to reliability issues subjected to asymmetrical behavior and disturbance in weather conditions. As in such cases, the generators are supported by another generating technology and/or storage devices consist of two or more distributed generation system like; wind-PV, Wind-diesel etc., to supply a common load. Such a technology is called Hybrid energy [34]. Hybrid connection of different resources and/or storage devices improves the reliability of the system, as well as is technically and economically sustainable more ethical approach is to congregate all such technology into Micro Grid. There are some similarities between Smart Grid and Micro Grids or smart Micro Grids. But, the scale, the type of decision makers involved and the impending rate of growth are different for both.

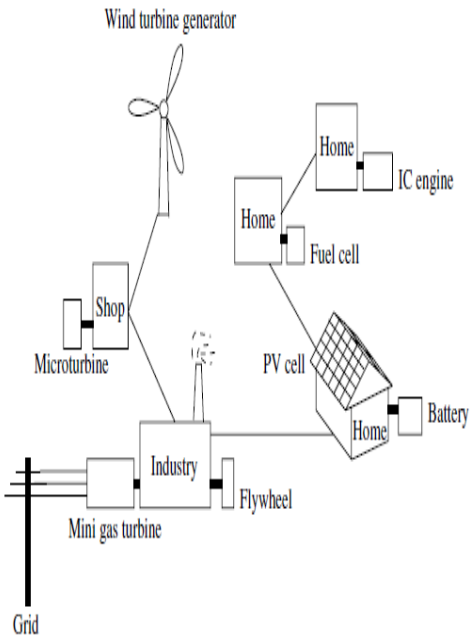

Fig: 4. Micro Grid architecture.

Smart Grid are realized at the utility and national grid level, concerning large transmission and distribution lines, while the smart Micro Grid integrates various DG technologies into electricity distribution networks and have faster implementation [25], [34]. Smart Micro Grid are to create perfect power system with smart technology, redundancy, distributed generation and storage, cogeneration or combines heat and power, improve voltage profile, cost reduction, reduction in carbon credits, smart regulation of appliances and load etc.. The Fig. 4 gives an overview of Smart Micro grid architecture with several different AEDGs split DC and AC buses with centralized and de-centralized control system.

6. Conclusions

The paper presents a discussion on Indian Power Strategy along with its pitfalls in various technical and non-technical themes, with an organized approach to evolve the conceptualization of Smart Grid. An overview of Indian Power Market along with brief analysis about the power system units is described. Power market in India is generally characterized by the poor demand side management and response for lack of proper infrastructure and awareness. Smart Grid Technology can intuitively overcome these issues. In addition to that, it can acknowledge reduction in line losses to overcome prevailing power shortages, improve the reliability of supply, power quality improvement and its management, safeguarding revenues, preventing theft etc.. Model architecture as well as India's Smart Grid initiatives taken by the government and many private bodies, are presented in the paper. Further, various prospects of sustainable energy and off-grid solutions, Rural Electrification (RE) and evolution of Micro Grid along with various policies and regulatory affairs of India is also presented here. In this connection, the paper should act as advocate to bring forth the significance and fortification of Smart Grid philosophy and implanting it on the basis of proposed ideology in Indian subcontinent.

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