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Survey on Smart Grid from Traditional grid

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***Abstract*: Power grid required to become smarter in order to provide an affordable, reliable, and sustainable supply of electricity. India is world's sixth largest energy consumer. To serve the energy needs of the country in a better way, the utilities have been working on interconnecting the different regional power grids into a unified national grid. The developments in the area of smart grid provide an opportunity to address issues. The need of adopting developments to make the power infrastructure robust, self-healing, adaptive, interactive and cost-effective. This paper investigates the growth and present status of the Indian power grid and provides unique vision for the future smart transmission grid initiating to make the grid smart.**

***Keywords:* Smart Grid, Intelligent Grid, Self Healing Grid, Indian Power Grid, Indian Smart Grid**

I.INTRODUCTION

Republic of India is the seventh largest country by geographical area and the second largest by population. India is world's sixth largest energy consumer, accounting for 3.4% of global energy consumption. The country has recently experienced an impressive rate of growth and the demand for energy has grown at an average of 3.6% per annum over the past 30 years. According to the Central Electricity Authority[1], at the end of April 2011, the installed power generation capacity of India was 74361.40MW, while the per capita energy consumption was 733.54 KWh. While the capacity is high the demand is far higher (Fig. 1)[2]. The Indian government has set an ambitious target to add approximately 78,000 MW of installed generation capacity by 2012. The total demand for electricity in India is expected to cross 950,000 MW by 2030[1]. However this increase in reliability comes at a price of increased risk associated with the possibility of blackouts, experienced quite regularly in the Indian grid. Apart from blackouts there are other factors like; huge gap between demand and supply, extremely high line losses and lack of automation and use of ICT in the grid which needs to be addressed.

India's power grid is in need of a major overhaul because of several factors:

- Huge gap in supply and demand
- Very high transmission and distribution losses
- Predominantly manual operation of the grid
- Poor utilization of enormous renewable energy potential
- Low metering efficiency and minimum consumer Participation
- Lack of utilization of advancements in information technology in the power grid.

This paper investigates the growth and present status of the Indian power grid, identifies the drivers for a smart grid and provides an account of the initiatives taken to make this grid smart.

The growth and present status of the Indian power grid is explained in section II of the paper. The need for transition from dumb grid to smart grid and the features of a smart grid are briefly explained in section III and IV. Section V provides the details of smart grid initiatives taken in India while section VI discusses the methods which may be utilized for evaluating the progress. The conclusions drawn are presented in section VII.

II. TRANSMISSION POWER GRID

Electricity supply in India commenced in the year 1897 with the commissioning of a 130 kW hydro-electric station near Darjeeling. The first thermal power plant in India was installed by the Calcutta Electric supply corporation in 1899. In the initial phase of its origin the Indian power sector grew at a very slow pace. The aggregate installed capacity in the country by the end of 1920 amounted to 130MW only. However with increased industrialization the power sector got a real boost during the period 1920-1940 and the total installed capacity at the end of 1940 reached to 1250MW[3].

The first interconnected grid system to come into existence in India was the Ganga Canal Grid in U. P. in between the years 1930-1934. In 1937 the power plant erected at mettur dam was interconnected with the thermal station with the pykara hydroelectric station in Madras. In 1945 papanasam hydroelectric station was also connected with this system. The subject of interconnection of power systems gained importance just after independence [4]. It was envisaged that there is a sufficient scope for justification for the establishment of super-grids from transmitting power from large power stations to distant load centers. The incentive on offer was the resulting economic power generation and distribution[5]. However during those years the interconnected operation was restricted to similar types of power plant and usually administered by a single authority. Even when there were different parties involved e.g. in the case of interconnection between Madras and Kerala, there was a prior agreement for transfer of a block of power. So the exchange of power, an essential feature of interconnected grid system, was missing. In this scenario the interconnection between Hirakud hydro-electric system and the Rourkela thermal power station was path breaking development. This interconnection involved two different agencies of which one was hydro and the other was thermal to get the maximum dividend out of both[6].

Power Grid is now working on the planned set up of a national power grid to facilitate transfer of power within the different regions in India

III. TRADITIONAL GRID TO SMART GRID

Interconnected power systems span large geographical areas and virtually work as a single machine. This interconnected nature of the power system make economical use of the power generated and generally improve overall reliability as every part of the system has more generation and transmission options to fall back to in case of an emergency. However this increase in reliability comes at a price of increased risk associated with the possibility of a minor disturbance propagating and resulting in complete shutdown of the whole system[1].

It has been observed that with the increase in interconnectedness of power systems the number of blackouts has been increasing. The Indian grid has also been experiencing blackouts regularly[4]. The fundamental cause of a blackout in a highly reliable meshed network is the limit imposed by line impedance. In such a network the first line which becomes overloaded limits the capacity of network. Under such condition trying to force more power may trip the line leading to cascading failure[5].

Analysis has shown that most of the large scale blackouts shared a common thread and could have been prevented or at least there effect could have been mitigated. Leaving aside the natural causes of blackouts in a number of cases the blackout condition was precipitated because of some controllable events. Some of these events are; lack of reactive power support, ageing equipment, lack of coordination in preventive measures, inadequate monitoring and communication equipments, and human error involved because of lack of automation [6]. Another thing usually overlooked by the utilities is that the present age is of digital economy and to computer and communications equipment, voltage variations are as perilous as complete outages[20].

It requires a power grid which is more aware of its operating states and should be able to "self-heal" in case of a failure. Such a power grid was coined as "smart Grid"[2].

IV. SMART GRID

This vision of the smart transmission networks builds on the existing electric transmission infrastructure. However, the emergence of new technologies, including advanced materials, power electronics, sensing, communication, signal processing, and computing, etc., will increase the utilization, efficiency, quality, and security of existing systems and enable the development of a new architecture for transmission networks.

Although there is no formal definition of a smart grid but based on its features proposed in the literature the smart grid may be considered as a power grid in which modern sensors, communication links, and computational power are used to improve efficiency, stability, and flexibility of the system[2-6]. The Electric Power Research Institute(EPRI), the U. S. National Technology Laboratory and the Smart Grids European Technology platform have defined seven principal characterstics of a smart grid; self-healing, resilient to threats, involve active consumer participation, provides quality power, incorporates distributed generation, interactive with market, and optimize the assets and provides a conceptual model of smart grid incorporating these features as shown in fig 1.

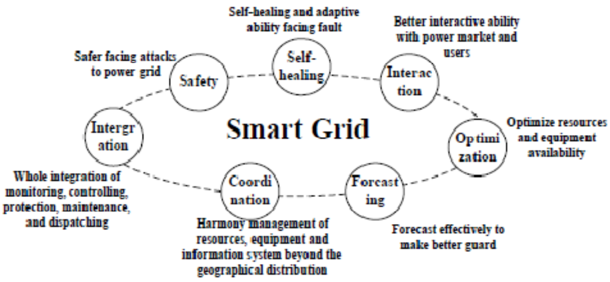

Fig. 1: Smart grid definition

The smart grid offers a whole array of benefits as compared to the conventional power grid as given in table I[1].

Table I: Comparison of Traditional and Smart Grids

Characterstic	Traditional Grid	Smart Grid
Self Healing Capability	Absent	Self-healing nature
Consumer participation	Uninformed and non participative consumer	Active consumers
Power Quality	Poor	High
Communication	Communication Absent or one way	Two way

V. SMART GRID INITIATIVES IN INDIA

In order to address, the Indian power grid has been facing a number of challenges; inefficient structure, inadequate generation, frequent outages, poor power quality. These problems the Indian government initiated various reforms with the Indian Electricity Act 2003[3] and programmes like accelerated power development and reforms programme(APDRP) and later its restructured version RAPDRP[34]. However these programmes were primarily intended towards distribution side management. Consequent upon the development of smart grid technology, the Indian government has identified the need of adopting these developments to make the power infrastructure robust, self healing, adaptive, interactive and cost-effective. Efforts are directed towards incorporating modern technologies at all the levels of power grid for achieving a seamless integration and high degree of automation. Ref [35] identifies the principal areas to make indian power grid smart; distribution automation, integration of distributed energy resources, enhancing system reliability, defining and implementing standards for better interoperability, and substation automation.

- *Peak reduction and time-of-use pricing for load adjustment*
- *Power quality improvement and grid self-healing*
- *Integration of renewable and captive generation*
- *Providing a variety of Tariff options to consumers*
- *Reducing technical and commercial losses to an acceptable level*

VI. EVALUATING THE PROGRESS

The smart grid maturity model (SGMM) proposed by IBM presents a relatively complete concept for smart grid[48]. The SGMM may be used by any utility/organization to test where they stand on the road to smart grid.

The SGMM proposed five levels; level 1 through level-5 as given in table II.

Table II: The Five Levels of SGMM

Level	*Description*
Level1	*Contemplating Smart Grid transformation. May have vision, but no strategy yet. Exploring options. Evaluating business cases, technologies.*
Level2	*Making decisions, at least at functional level. Business cases in place, investments being made. One or more functional deployments under way with value being realized. Strategy in place.*
Level3	*Smart Grid spreads. Operational linkages established between two or more functional areas. Management ensures decisions span functional interests, resulting in cross functional benefits.*
Level4	*Smart Grid functionality and benefits realized. Management and operational systems rely on and take full advantage of observability and integrated control across and between enterprise functions.*
Level5	*New business, operational, environmental and societal opportunities present themselves, and the capability exists to take advantage of them.*

VII. CONCLUSION

Given the scale of the effort required and the enormity of the challenges ahead, collaboration among different sectors is essential and should be developed through various channels in order to ensure and accelerate the success of realizing the smart transmission grid. The smart grid and its allied developments offer a unique opportunity to develop a vastly improved electricity environment. This new environment implies that the nation's electric system will move from a centralized, producer-controlled network to a less centralized, more consumer-interactive, more environmentally responsive model. To develop and implement the next-generation electric grid ensuring economic prosperity and environmental health, the government officials, utility executives, energy policy makers, and technology providers must agree on a common vision and take action to accelerate the process towards final deployment.

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