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Smart Grid a Revolution in Power Sector

Raghib Ahmed[1], Shadab Siddique[2]

B.Tech Student, Department of Electrical Engineering, NIT Raipur, Raipur, India

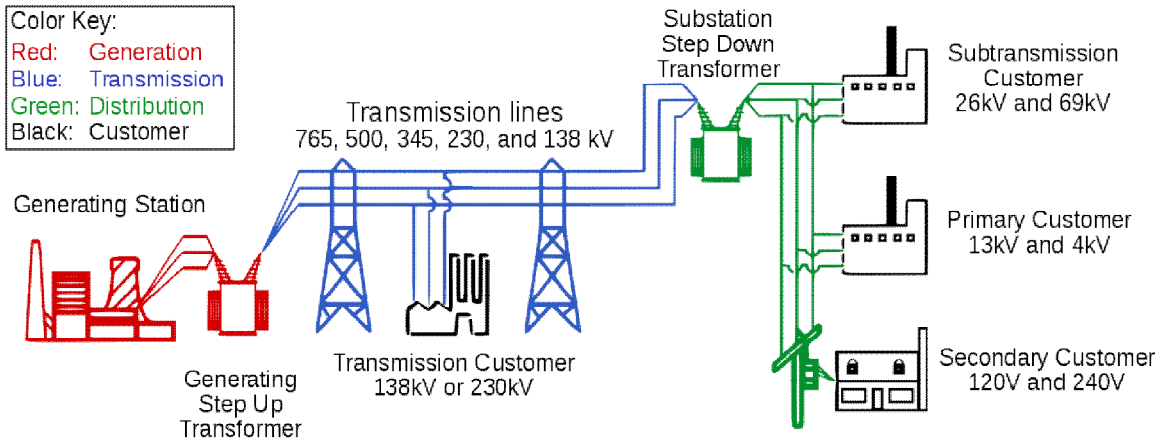
B.Tech Student, Department of Electrical Engineering, Jamia Milia Islamia, New Delhi, India

ABSTRACT: With 215 GW of installed capacity, the potential demand of electricity in India is estimated to be as high as 900GW. It is expected that demand for electric energy will triple by 2050 all around the globe. Rolling power outages in developing countries, previously just an unwelcome fact of life, have escalated to the level of national emergency. This paper explores about the idea behind Smart Grid and the immense opportunities that lies within the Smart Grid. This paper gives an overview how Smart Grid technology can offer a country the tools needed to engage and overcome the challenges faced by current Grids.

KEYWORDS: Smart grid, AMI, Automation, Demand Response, ISGF, SGTF

I.INTRODUCTION

According to an article published in New-York Times, the country with the most powerful clean technology industry in the 21st century will have the most energy security, economic security, healthy environment, innovative companies and global respect.



Source: Smart grid solutions Fig.1: A simple Grid Network

Fig. 1 shows a typical generation, transmission, and distribution grid network. This electric value chain has six stages .First stage is generation and trading. The next stage is the generation substation where voltage is increased to transmission levels, third stage is long distance transmission of electricity. After that there is distribution substation where the voltage is decreased to distribution levels, then next stage is transportation of electricity at lower levels of voltages to customers and the last stage is consumption of electricity by customer .According to department of energy in the United States when electricity is generated from coal, there is about 65% in losses. A further 4.8% of loss is incurred during transmission process and another 5% in distribution process, resulting in a mere 30% or lesser that reaches the customer's premises. It can be seen that for every unit of energy that actually reaches the end user, roughly 4 unit of energy are input into generation process and the remaining three are lost.

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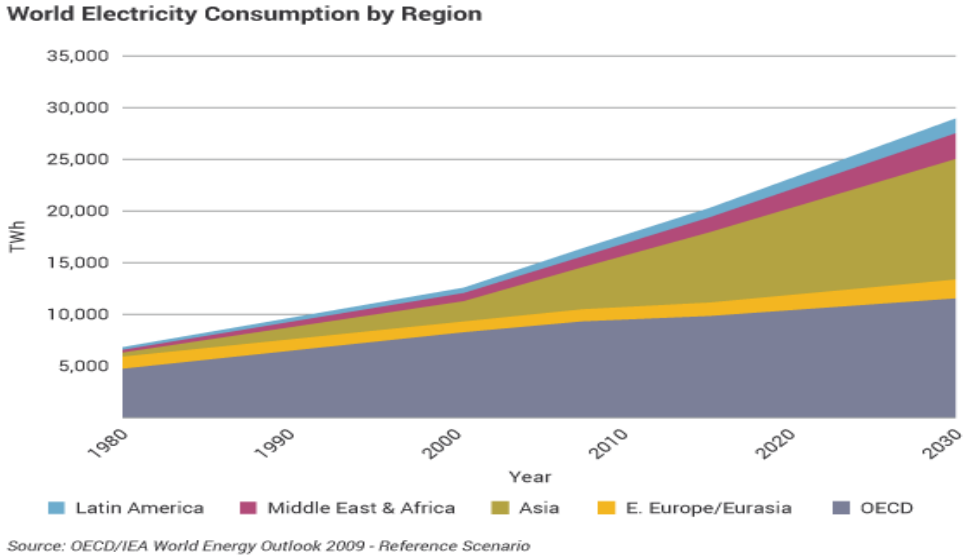

Fig.2: World energy consumption

The fig.2 depicts the world energy consumption by region from 1980 to 1930.It can be concluded from figure that there is constant demand of electricity in each region and this consumption trend is going to increase sharply in upcoming years. The majority of electric grids was built when energy was reasonably low cost while minor upgrading has been made to meet the rising demand, the grid still operates the way it did almost 100 years ago. The old age grids are incompetent and environmentally extravagant system that is a foremost emitter of green house gases ,consumer of fossil fuels and not well suited to distributed renewable energy sources like wind and solar. Man-made green house gases are leading to dangerous climate change, hence ways of using energy more effectively must be found. Smart Grid is a host of solutions in meeting the increasing energy demand of the country and supplying 24×7 power to all its citizen. Smart Grids are also in keeping with the ambitious climate change and for large scale deployment of intermittent renewable energy generation. Smart Grids can brought down aggregate technical and commercial losses from 30% to 18%.Since they constantly monitor usage, pin point losses and collate the relevant data. Smart Grid is the integration of communication networks with the power grid in order to create a super highway electricity communication capable of monitoring its own health all the time, alerting officials immediately when problems arise and taking corrective actions. In India there is establishment of NSGM which will have its own resources, independence, and statutory authority to plan and monitor smart grid implementation in India.

II. DEFINITION OF SMART GRID

Smart Grid is a nebulous term spanning various functionalities geared towards modernizing the electricity grid. Smart Grid is a modernized electrical grid ,a transmission and distribution infrastructure that is reliable and secure, that can meet the future demand growth ,delivering power in a reliable ,efficient ,economic and sustainable manner .According to the definition by NIST (national institute of standards and technology),it is a modernized grid that enables bi-directional flow of energy and uses two way communication and control capabilities that will lead to an array of new functionalities and applications.

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III. COMPARISON BETWEEN MODERN GRID AND SMART GRID

Current 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

From India's perspective smart grid technologies are vital to meeting India's vast and growing electricity needs. We need an Indian smart grid model that can engage our country's particular operating and address her priority challenges curbing power loss and enhancing access to reliable ,quality power for all.

IV. SMART GRID TECHNOLOGIES

Use of computers for power applications in early 1970's was a major breakthrough in grid monitoring .As the speed of data communication improved it was possible to monitor transient grid condition rather than its steady state condition. An electrical disturbance can result into shutdown to a large area in less than a second .It is impossible to take decisions manually in such a short time , it needs to be done automatically. Phasor measurement technique is used for transmission network monitoring and it is very useful to analyze grid failures. SCADA has made it easy to monitor the power grid from a remote location. Similarly many smart grid technologies areas each consisting of sets of individual technologies span the entire from generation through transmission and distribution to various types of electricity consumers.

TECHNOLOGIES

TECHNOLOGY AREA	HARDWARE	SYSTEMS AND SOFTWARE	IMPLEMENATION AREA
Wide area monitoring and control	Phasor measurement units and sensor equipments	SCADA,WAMS,WAAPCA,WASA	Generation and transmission
Information and communication technology integration	Routers, relays ,switches, gateway	ERP, customer information system	Generation, transmission, distribution ,residential, industrial
Renewable and distributed generation integration	Power conditioning equipment, control hardware	EMS,SCADA,DMS,GIS	Generation, transmission, distribution, service
Transmission enhancement	Superconductors, HVDC, FACTS	Network stability analysis, automatic recovery system	Transmission
Advanced metering infrastructure	Smart meter , in-home displays , servers, relays	Meter data management system	Distribution , industrial, residential service
Customer side system	Smart house appliance, ,in-home displays	Energy dashboards, EMS	Industrial ,service ,residential

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Some of these technologies are actively being deployed and are considered mature in both their application and development phase while others require further development and demonstration.

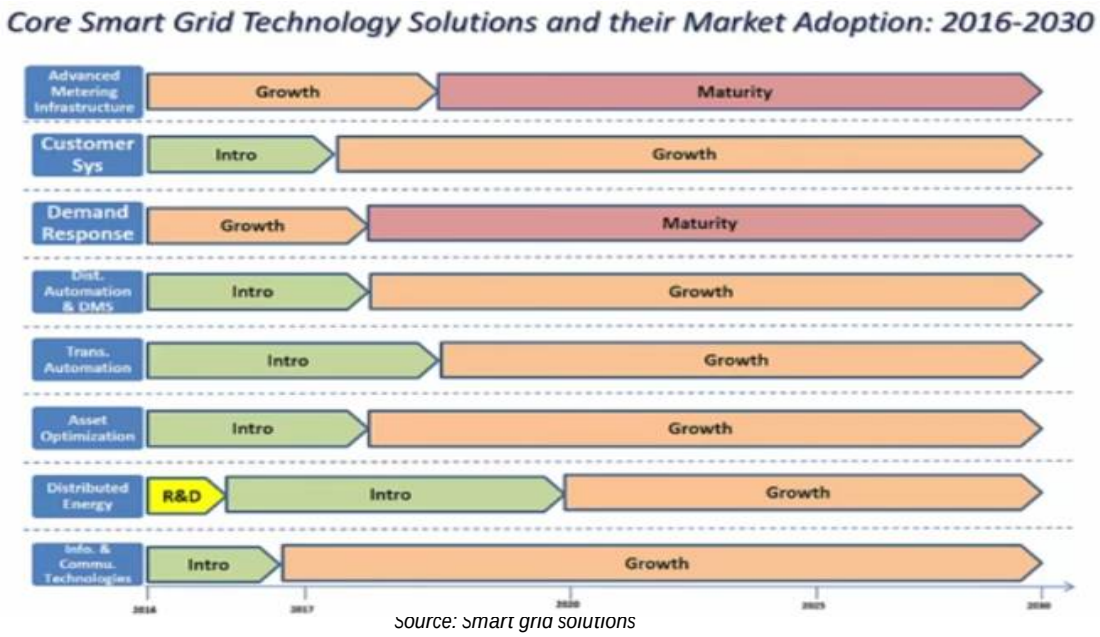

Fig.3 Market adoption worldwide

The fig.3 shows that Smart Grid marketplace will evolve into full adoption based on changing market drivers and availability of cost justified at scale technology. All these adoptions will happen in waves .The first wave consists of smart grid early adopters which are those utilities who are willing to try new technologies and see if they provide any benefits at all. The next wave focuses on optimizing the grid and sweating it's assets. Technologies like AMI and Demand Response comes under first wave whereas customer system, asset optimization, distribution and transmission automation comes under second wave. The third wave will focus on integrating distributed energy. Smart grid might be defined by its capabilities and operational characteristics rather than by the use of any particular technology. Deployment of smart grid technologies will occur over a long period of time, adding successive layers of functionality and capability onto existing equipment and systems. In short, a smart grid employs innovative products, and services together with intelligent monitoring, control, communication and self healing technologies.

V. CHARECTIRISTICS OF SMART GRID

• **Self healing and resilient**: Smart grid system performs real time self-assessment to detect, analyze and respond to subnormal grid conditions.

• **Asset optimization and operational efficiency**: A smart grid will enable better asset utilization from generation to the consumer end points.

•**Enabled demand response**: Extending the smart grid within the home, consumer appliances and devices can be controlled remotely, allowing for demand response.

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•**Integration of advanced and low carbon technologies**: A smart grid will exhibit "plug and play" scalable and interoperable capabilities. It permits a higher transmission and distribution system penetration of renewable generation, distributed generation and energy storage.
•**Improved power quality**: A smart grid will have high quality of power and reduces the occurrence of distortions of power supply.

•**Market empowerment**: A smart grid will provide greater transparency and availability of energy market information. It will enable more efficient, automated management of market parameters.

•**Customer inclusion**: A smart grid involves consumers by engaging them as active participants in the electricity market.

•**Clean and green energy**: The energy conservation and improvements in end-use efficiency enabled by the smart grid reduce half of the emissions.

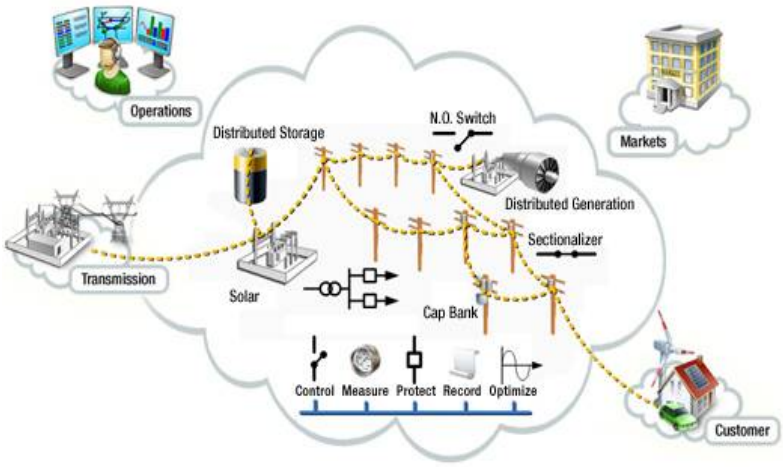

Fig.4: A complete smart grid

VI .SMART GRID ADOPTION WORLDWIDE

Smart Grid Modernization is an evolutionary process that will probably span a period of somewhere between 2-3 decades. Every analysis indicates that an investment of somewhere between 17$ to 24$ billion dollars would be needed every years for the next 20 years to fully achieve the smart grid. But the benefits from this benefit would far exceed the cost by almost 6 times. In US major smart grid investment started with the American Recovery and Reinvestment Act of 2009.InIndia it started with the formation of Indian Smart Grid Task Force(SGTF) and Indian Smart Grid Forum(ISGF) in 2010. In US smart grid implementation began with the deployment of smart meters. China is heavily focused on transmission grid upgrades. In India the main focus is on transmission and distribution upgrades, mainly through digital substations and efficient meters. In Australia the focus is on AMI implementation. New zealand has mainly focused on integration of renewable with current grid. In Europe the focus is mainly on transmission grid upgrades and integration of renewable. In Brazil the focus is on grid reliability and reduction of energy theft through the deployment of smart meters. In Africa specifically South Africa, the focus is on demand side management, community micro grids and improvements to the communication infrastructure.

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CHALLENGES TO IMPEMENTATION OF SMART GRIDS:

- Political and regulatory framework: There is lack of clarity over project funding and Government's uncertainty regarding where to raise the money from and what kind of instruments to use.
- Cyber security: Digital communication network and more granular frequent consumption on consumption patterns raise concerns for misuse of private data.
- Lack of awareness : There is lack of awareness among stakeholders about the role of smart grids in enabling a low carbon future
- Skills and knowledge: In longer term a shortfall is expected in critical skills that will be required to architect and build a smart grid.
- Integration of renewable: There will be very much difficulty in integration of renewable as they vary in type and scalability.
- Communication: Delivering the communication infrastructure to allow potentially million of partners to operate and trade in a single market.

VII.SMART GRID SCENARIO IN INDIA

India's increasing electricity demand especially during peak hours continue to out space India's power supply. According to ministry of power, India's transmission and distribution losses are amongst the highest in world. India losses money for every unit of electricity sold as it has very poor grid network. With a vision and roadmap India is trying to transform its power into a secure, adaptive and digitally enabled ecosystem by 2027 that provides quality energy for all with active participation of all stakeholders. In this regard government of India has taken many initiatives. It formed Indian Smart Grid Task Force in 2010 which is primarily meant for understanding and advocating policies in smart grid technologies. Government of India also formulated Indian Smart Grid Forum in 2010 as a non-profit, voluntarily consortium of public and private stake holders with the primary objective of accelerating development of smart grid technologies in the Indian power sector. India is also steadily venturing into renewable energy resources, a good electricity supply is one of the key infrastructure development. With this envision, the ministry of power has allocated 14 smart grid pilot projects that will be implemented by various state owned distribution utilities in India.

VIII. CONCLUSION

As by definition smart grid is the integration o communication network and IT infrastructure with the power and energy layer. But in reality a smart grid concept is still not defined .Every country has its own implementation model and definition. As we have seen in this paper smart grid is powerful and dangerous at the same time. Regulation is required to harness the power of smart grid while limiting its danger. Huge investments are required on studies, research, technology, education and participation initiatives worldwide. Despite the challenges in the implementation of smart grids, there is a hope of a more robust grid that will offer multiple benefits in future.

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