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A Study on Power System: Smart Grid

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ABSTRACT: An electric power system is a network of components used to supply, transmit, distribute and use electrical power. Smart grid is a new power system developed which intelligently increases the efficiency in terms of power consumption. This paper presents the structure and components of the smart grid. The characteristics of the smart grid and its benefits over the present grid have also been explained. It presents the advantages of using smart technologies in homes, appliances, meters and vehicles, leading to greater efficiency and a decrease in carbon emissions. The concept of using consumer interaction through information and communication technology (ICT) to reduce the consumption of electricity has been explained. The difficulties in the implementation of the grid have been discussed. Future scope of the smart gird in India has also been mentioned.

KEYWORDS: Smart Grid; Stability; Reliability; Efficiency; Prosumers.

I.INTRODUCTION

Today we see many smart appliances being used. The term 'smart' indicates a better and more efficient way of handling and processing. A smart grid is an electricity network based on digital technology that is used to supply electricity to consumers via a two-way digital communication. This system allows for monitoring, analysis, control and communication within the supply chain to help improve efficiency, reduce the energy consumption and cost, and maximize the transparency and reliability of the energy supply chain. Power is generated at power stations, which are generally far away from the consumers. Then, they are transmitted at high voltages in order to reduce the transmission losses. Further, they are stepped down to a low voltage and distributed to the consumers. The concept of smart grid is to enhance the performance of the present grid and make it more intelligent and energy efficient. It leads to utilization of power in a smarter and efficient way in order to meet the growing energy demands. It also further contributes to energy saving by reducing losses.

II.REQUIREMENT

The first a.c. power grid system was installed in 1886. At that time, the grid was a centralized unidirectional system of power transmission, electricity distribution, and demand driven control. Since then the same grid is being used for transmission and distribution. But now the need for a new improved grid is being felt the reasons for which are as follows:

1) Continuous increase in demand of energy: Energy consumption is increasing day by day and it is not possible to increase the power generation in proportion to the increase in demand. Thus, it is required to use the available amount of energy more efficiently and judiciously.

2) Old and weak infrastructure: The old infrastructure needs repairing and management quite frequently, which makes it unreliable and requires a lot of capital investment.

3) A way of increasing consumer participation in using energy efficiently: The earlier grid had only one-way communication between the utility and the consumer. The consumer did not participate in the consumption pattern at all. Whereas, smart grid provides a two-way communication in which the consumer actively participates

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and takes decisions according to his requirements. This also leads to an increase in transparency and trust on the utility.

4) Increased reliability: The smart grid uses techniques to detect areas, which are likely to break down, and schedule maintenance of those areas. This preemptive measure prevents grid failures and thus increasing reliability.

5) Reduction in carbon emissions: Implementing the smart grid will lead to reduction of the peak loads and consumption will be near the average demand. Thus, fluctuations in load requirements will reduce. Therefore, production of large amount of energy at peak load time will be avoided which will reduce the carbon emissions at the power generating stations.

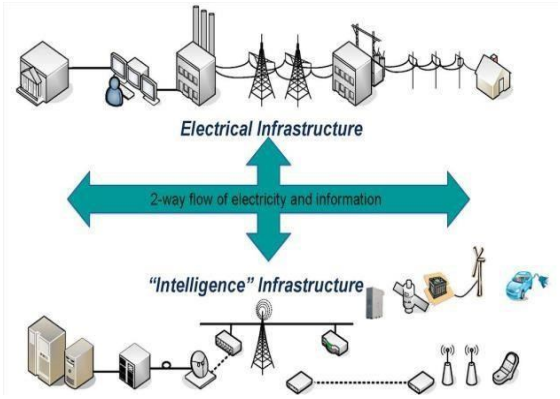

Figure 1: Comparison of infrastructures (courtesy of cnx.org) [1]

III. ADVANTAGES OF SMART GRID

The characteristics of smart grid, which make it a better option than the existing grid, are:

1) Energy efficiency: Power saved in generation, transmission and consumption can be utilized in other areas.
2) Demand and response: It tries to adjust the requirement so as to reduce variations and bring the demand near the average demand.
3) Revenue reduction: The consumer becomes aware of the rates of energy at different times and can accordingly use energy.

4) Operational efficiency: Smart grid leads to use of the same amount of energy in a more efficient way.

5) Customer satisfaction: The customer gets good quality power all the time. He can choose the time of using any appliance according to the rates of energy at that time.

IV. COMPONENTS OF SMART GRID:

The major areas of implementation of the Smart grid are:

1) Advanced Metering Infrastructure (AMI): AMI is the infrastructure of an advanced two-way communication between the utility and the consumer [2]. The aim of the API is to provide the utility with data about power consumption and allow the consumers to make informed choices about energy usage depending on the price at the time of use. Every consumer is provided with a smart meter which records the power consumed by the consumer and displays the variations in the rates of power at different times of the day. Thus, a consumer can make an informed choice about the use of appliances according the time and the rates of electricity at that time. Thus, the peak loads will reduce and energy will be available at cheaper rates.

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2) Distribution automation system (DA): The distribution and automation system aims at providing the best quality of power, improving the management and thus increasing the efficiency. It manages the power grid monitoring, failure management and power balance. Expensive power outages can be avoided if proper action is taken immediately to isolate the cause of the outage. Utility companies install sensors to monitor and control the electrical grid within seconds to detect faults and respond to them. Grid performance information is integrated into supervisory control and data acquisition (SCADA) systems to provide automatic, near-real time electronic control of the grid. Sensors are also used to control the bidirectional flow of energy. This will improve the stability and reliability of the grid.

3) Personal energy management (PEM): PEM is the most important feature of the smart grid. It enables the utility to control peak load and support sources of generation and new uses of electricity. A smart distribution grid captures information, monitors performance and executes commands that enable energy efficiency and reliability.

PEM includes:

a) Smart meter and variable pricing: In smart meter on an average off peak price at night is fifty percent less than during the day. Prices may be very high during demand peak. This new device allows utility companies to monitor consumer usage frequently and allow the consumers to choose the time of consumption according to the variable rates provided.

b) Distributed electricity generation: Some homes and commercial places are provided with microgeneration devices for smaller scale generation of electricity. Thus, they produce some or all of the energy they use. They can sell surplus energy back to the company for a profit, which makes them “prosumers” who not only consume but also produce energy.

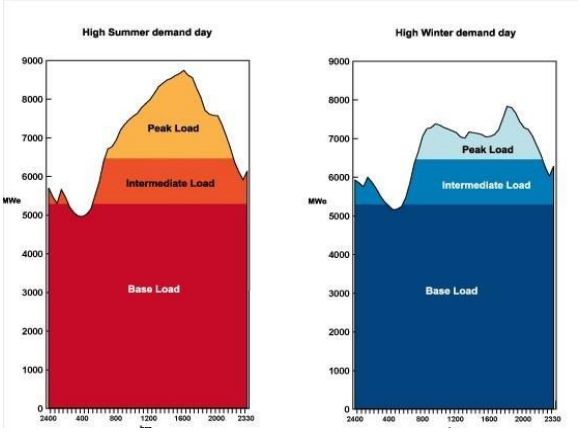

Figure 2: Load curve (courtesy of alfin2300.blogspot.com) [3]

c) Storage and PHEV (plug-in hybrid electric vehicle): The new PHEVs and electric cars can be used to further increase energy efficiency. These vehicles charge at off-peak times. Vehicle to grid (V2G) system describes a process through which a PHEV communicates with the power grid. Since most vehicles are parked ninety-five percent of the time their batteries could be used to let electricity flow from the car to the power lines and back. This could generate value to the utilities of up to 4000$ per year.

d) Reduction in green house gas emissions: The electric energy demand worldwide is expected to rise by 82% and the resulting carbon dioxide emissions would rise by 52% by 2030 [4]. Thus, carbon dioxide emission needs to be curbed by adopting greener methods of energy generation and consumption. Adoption of the smart grid would reduce the peak demands and thus the stress on the power stations. This would reduce carbon dioxide emissions by 15% globally. This is equivalent to 7.8 billion tones of carbon dioxide.

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V. CHALLENGES IN THE IMPLEMENTATION OF SMART GRID

The smart grid is a very good way of improving energy efficiency. But the implementation of any new idea always

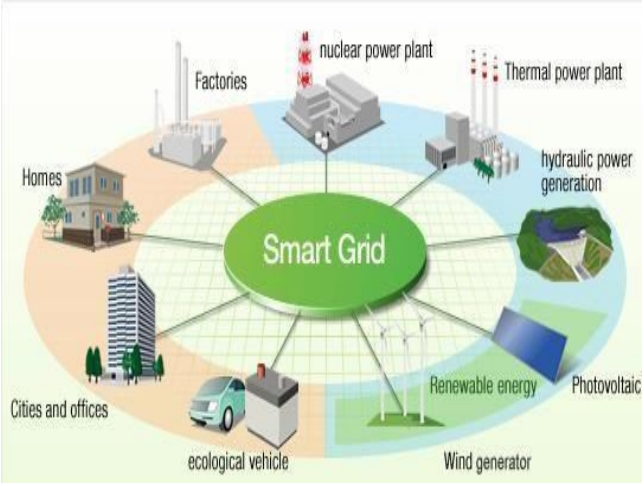

Figure 3: Areas affected by smart grid (courtesy of hitachi.com)[5]

leads to some problems and difficulties, which need to be resolved. The challenges in the implementation of the smart grid are as follows:

1. Grid Stability: Grid stability issues arises due to the variable nature of output characteristic of photovoltaic production. Spikes and dips are produced due to change in the voltage and current caused by varying insulation. They last for a few milliseconds. Bidirectional current flow is also a problem and is compounded by the lack of grid monitoring equipment. Power that is sent back to the grid from houses cannot be handled by the transformers and current lines. To provide necessary control at all times, utilities need to know the power flow structure of such areas accurately. Sensors are provided to tackle this type of contingencies.

2. Variable Renewable Energy Sources: Renewable energy sources are not consistent and reliable. There may be variations during different times and seasons, thus they are unpredictable. Thus their needs to be a backup power source to supply power when these are in sufficient.

3. Improved infrastructure: In order to manage the significant number of generation sources, and distribution between them, the grid needs improved monitoring and communications infrastructure.

4. Quality: The quality of power (i.e. voltage and frequency) delivered to consumers must be consistent.

5. Meeting the needs of consumers: Utilities are unable to strategically and precisely direct power to meet individual users' needs.

6. New Hardware: Incorporating new hardware including improved transformers and inverters is required.

7. Overcoming incompatibility: In order to interface renewable energy sources and storage technologies with the grid, the incompatibility between alternating and direct current needs to be resolved.

VI. SOLUTIONS

We need to take certain steps in order to implement the smart grid. The solutions to the challenges listed above are as follows:

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1. Invertors: Commercially available inverters solve this issue of compatibility between alternating and direct current. This allows the DC power generated by solar panels to interface with the AC power needed for homes and to transmit on the grid. Installing inverters at each household has the additional benefit of improving the quality of power that is transmitted to the grid.

2. Bi-directional transformers: As the penetration of renewable energy increases, however, more and more individual users' generated energy will be transmitted back to the grid. This reverse power flow would cause traditional grid components (especially transformers and voltage regulators) to fail. Therefore, bi-directional transformers and voltage regulators would need to be installed throughout the grid, at both the distribution and substation level. Since the majority of grid components need to be replaced to install a smart grid.

3. Sensors and computation methods: Additionally, sensors would need to be installed (monitoring voltage and power quality) at many intermediate points within the grid. Also, computation and control centers would need to be constructed and the models needed to run them would need to be developed and implemented.

4. Micro-network: A micro_network is a neighbourhood size group of individual power producer_consumers who are connected with each other and share communal power and centralized storage. Advantages of this type of network includes- improved reliability and cost effectiveness. If micro-network is implemented, no individual household or commercial energy storage is required, instead, excess power generated is passed onto the micro_network, which is used by others on the network or stored at the centralized storage facility. Bi _directional power flow is an important factor of the micro _network.

VII. AREAS WHERE SMART GRID HAS BEEN IMPLEMENTED

There are various examples of areas where the smart grid has been implemented successfully. Its use has lead to remarkable results and a large amount of savings. Two examples of such areas have been stated below:

1. The oldest and the largest, example of a smart grid is the Italian system installed by Enel S.p.A. of Italy. Completed in 2005, the Telegestore project was highly unusual in the utility world because the company designed and manufactured the meters, acted as their own system integrator, and developed their own system software. The Telegestore project is widely regarded as the first commercial scale use of smart grid technology to the home, and delivers annual savings of 500 million euro at a project cost of 2.1 billion euro [6].

2. In the US, the city of Austin, Texas has been working on building its smart grid since 2003, when its utility first replaced 1/3 of its manual meters with smart meters that communicate via a wireless mesh network. It currently manages 200,000 devices real-time (smart meters, smart thermostats, and sensors across its service area), and expects to be supporting 500,000 devices real-time in 2009 servicing 1 million consumers and 43,000 businesses.

VIII. FUTURE IN INDIA

India is a developing country and energy production and distribution are one of the most important aspects for the growth of the country. There are many areas where load shedding occurs; people face 50% power cuts and some places are still deprived of electricity. India's load demands too are high on account of the large population. Thus, there is a dearth of power in India on a large scale. Considering all these aspects implementation of the smart grid will prove beneficial in many ways and would accelerate India's progress. However implementation of the smart grid in India will poses challenges such as:

1. Lack of awareness: People do not have much knowledge about the smart grid and appliances. They need to act on the basis of the requirement and electricity rates at that particular time.

2. Poverty: Implementation of the grid will require installation of smart meters, which the poor people will not be able to afford.

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3. Inadequate grid infrastructure: The present infrastructure in India is not adequate enough and requires replacement with a more efficient one.

4. Large initial investment: Setting up the grid requires a large initial investment, which might be difficult for the government to fund.

In order to overcome these impediments the government will have to invest large amount of capital for the infrastructure. Further programs will be required for spreading awareness among the people about this new technology. Various social and ecological issues will also have to be solved. The smart grid has been proposed at various places in India, such as:

1. Panipat, Haryana
2. Mysore, Karnataka
3. Kerala
4. Tripura

IX.CONCLUSION

Considering the fast depleting natural resources and the increasing demand for power, the need for improving the power generation system is inevitable. Due to ever increasing demands it is not possible to increase the generation in proportion to the increase in demand. Thus, efforts have to be made to exploit the power generated completely in order to meet the increasing demands. The smart grid is a very effective way of improving the energy efficiency and can be used to bridge the gap between production and demand. This would lead to a tremendous increase in the global development and the capital savings can be used for the development of other areas.

REFERENCES

1. Electricity, (http://cnx.org/content/m41728/latest/) [Accessed on 17th March, 2014].
2. Gurlin Singh Lamba, "Smart Grid and its development Prospects in the Asia-Pacific region", Journal of Emerging Trends in Computing and Information Sciences, Volume 2, No.
3. 1 ISSN 2079-8407.Al Fin Energy, (
4. http://alfin2300.blogspot.in/2012/05/intermittent-windcannotreplace.html) [Accessed on: 17th March,2014].
5. Dr. S.L. Nalbalwar, Jayesh D.Ruikar, Shailesh R.
6. Sakpalk, "Smart Grid: A modernization of existing power grid ", International Journal of Advanced Engineering Research and Studies, E-ISSN2249–8974.
7. Smart grid: Environmental Activities,
8. (http://www.hitachi.com/environment/showcase/solution/ener gy/smartgrid.html) [Accessed on: 17th March, 2014].
9. Smart grid (http://en.wikipedia.org/wiki/Smart_grid) [Accessed on: 17th March, 2014].