Study of Optimization Techniques of Renewable Energy Resources to Increase the Efficiency of Smart Grid for Power Sector in India

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Abstract— Power sector plays an important role in any nation's development. The improved and advanced technology is always required in production of goods, services in the industrial, health, education and agriculture sector. Therefore, introduction of smart grid technology is an essential requirement that reduces the overall greenhouse gas emission with demand management. This paper discusses the benefits and features of all the renewable energy sources especially solar energy for smart grid technology in terms of challenge, cost effectiveness and efficiency in conversion. The paper also shows the improvement in the integration of smart grid technology into the national grid using solar renewable energy.

Keywords: Grid, Energy, Technology

I. INTRODUCTION

In India, electricity is the pillar of its growth and development. Innovation and modernization with new trends is being introduced in almost every field of science and technology. To the exception the power grid management in India is not updated with the technology enhancement.

Today's most of the grids are designed and installed before the era of microprocessor and suffering from reliability issues. Second thing, existing power system can be considered as a major reason for greenhouse or global warming that cause environmental impact due to use of fossil fuels, especially coal. In contrast to fossil fuel, renewable energy offers alternative sources of energy which are in general pollution free, technologically effective and environmentally sustainable. The existing electricity grid has no potential to offer adequate services addressing energy efficiency, reliability and security or the integration of renewable energy at the scale needed to meet the clean-energy demand for the future.

Therefore, introduction of smart grid technology is an essential requirement that reduce greenhouse gas emissions and encourage energy efficiency, improves reliability and manages power more efficiently and effectively.

II. SMART GRID

A smart grid can be defined as a upgraded electricity grid network enabling two way information and power exchange between suppliers and consumers due to the prevalent incorporation of intelligent communication monitoring and management systems. The US Department of energy defined smart grid as a system that will incorporate digital technology to improve reliability, efficiency and security of the electric system.

According to the International Energy Agency Technology Roadmap, a smart grid is an electricity network that uses digital and other advance technologies to monitor and manage the transportation of electricity from all generation sources to meet the varying electricity demand of end-users. The smart grid will organize various capabilities and needs of the grid operators, generations, end-users and electricity market stakeholders to operate all the parts of the system as efficiently as possible and it also reduce environmental impacts and cost while improving system reliability and stability. Besides the smart grid being able to match supply with demand, it will also reduce the emission of greenhouse gases by reducing the heavy dependence on fossil fuel plants through the integration of renewable energy which will make the system flexible and also electricity use will be more efficiently utilized.

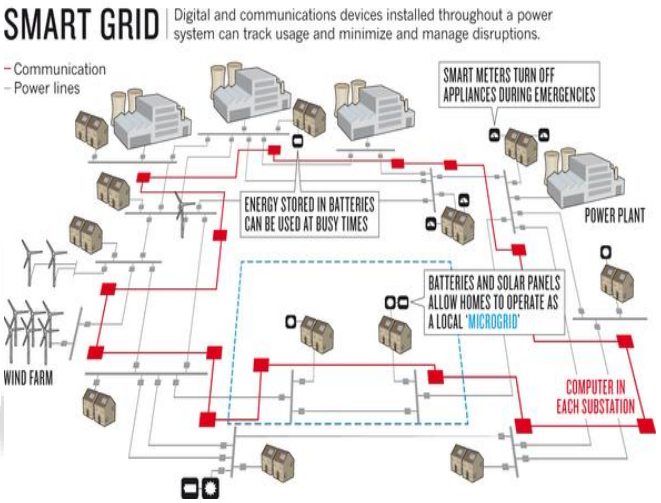


Fig. 1: Block Diagram of Smart Grid

A. *Features of Smart Grid:*

- Intelligent Metering and better reliability.
- Improved interoperability of appliances and equipment connected along with the infrastructure serving the grid.
- Better demand and response control deployment.
- Active consumer participation by enabling control over consumption and associated costs over a wide network.
- Distributed power generation and grid interaction from all sources of energy like wind turbines, solar panels and so on.
- Consumer engagement with resources to solve power crisis.
- Environmentally friendly by maintaining the ratio of renewable generation to total generation and emission control.

Renewable energy is increasingly becoming a solution, to some extent, for the nation's large energy demands. In all renewable energy aspects, India is currently positioned at the 5th rank in the world. With a total capacity from renewable sources being about 30 GW, mostly obtained through Wind (18.3 GW), small hydro (3.4 GW), biomass(1.2 GW) and solar(1 GW).

According to the renewable energy index, India is among top five countries worldwide for solar energy development.

The main renewable energy sources in India are wind energy, solar energy, biomass and waste energy and small hydro energy. Since this paper is devoted to the study of integration of solar energy with smart grid that is major player of India's renewable energy it has been studied deeply.

B. Biomass Energy

India's biomass energy resources can be identified as wood fuel with capacity of about 13million hectares of forest and wood land, animal waste is about 61 tons/year and crop residue is currently limited to thermal application as fuel for cooking. However, these biomass resources could be utilized as fuel for small scale industries to support electricity in national grid.

C. Wind Energy:

The wind power program in India was initiated in 1983-84 with the goal of speeding up the commercialization of wind power in the country and it has progressed rapidly in the last few years. The relatively short period required for the installation of wind turbines and the constant advancements made in the wind turbine technology leading to higher reliability.

The performance of the turbines has made wind power the preferred choice for energy capacity additions in the country. The latest calculations indicate the total potential of wind energy in the country to be at 45,000 MW. Presently, India, with 15,700 MW of wind energy, is at the fifth position with China (44,733 MW), the US(40,180 MW), Germany(27,215MW) and Spain (20,676 MW) leading in development.

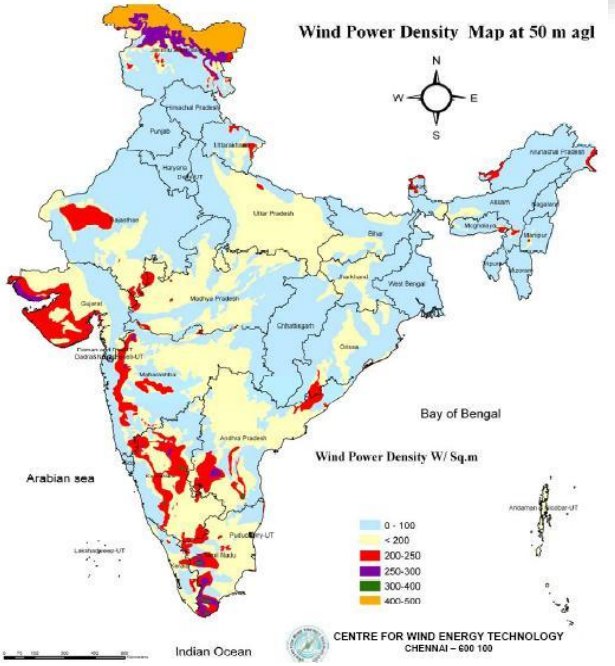


Fig. 2: Wind Energy Map of India

III. SOLAR POWER

Solar power takes the prominent position among all other sources due to its continuous availability and cost effectiveness. Solar energy is available in abundance in India. In recent days, the solar photo voltaic cell manufacturing costs have come down due to the encouragement from government in the form of subsidy; this in two reduces the cost of solar power generation. Because of the promotion and go green initiatives, the number of solar power is on the raise and hence the total installed capacity of solar power plants. The integration of solar power generation with smart grid will allow higher flexibility to have localized and right sized power plant with reduced transmission loss, less complexity, zero environmental concerns and higher efficiency.

A. Challenges Related to Solar Power Generation Are:

- High initial cost.
- More dependent on sunny weather.
- Occupies more space for per unit panel installation.
- Less efficiency in energy conversion.

At the heart of the blooming solar power industry is the semiconductor material, like silicon or gallium arsenide.

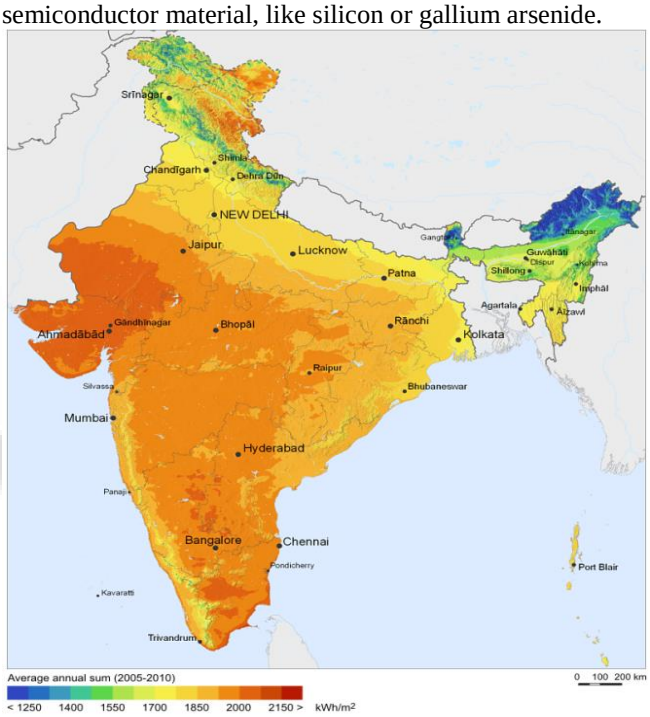


Fig. 3: India's Solar Resources

arsenide which absorbs sunlight and forms the basics of solar panels. It converts electromagnetic energy in the form of sunlight to electrical energy. Now a new techniques have demonstrated to increase the amount of electrical current produced by a solar panel simply by augmenting its light facing surface with aluminium nanostructures.

When the photon, particle of light are absorbed by the semiconductor, they knock out electrons, which are passed through a circuit and then to a battery for storage as electricity.

By studying the light receiving surface of gallium Arsenide devices with aluminium nano cylinders, like the ridge on Lego blocks, the researchers were able to advance the scattering of light in the visible part of the spectrum which dominates the energy in sunlight. The scattering of light then travels a longer path inside the semiconductor, meaning that more photons can be absorbed and converted into current. It is important that the nano cylinders do not

absorb the light themselves, as that would prevent it from reaching the panel. Higher efficiency device could play a significant role in perceiving energy goals in India, making them more cost- effective. Already according to industry trackers, the price of solar power in India has come from Rs 18/kWh to Rs 7/kWh in 2013 and Rs 3.5 /kWh in 2014 while the price of thermal power is pushing Rs 4/kWh with subsidies.

IV. SMART GRID INTEGRATION INTO THE INDIAN GRID NETWORK:

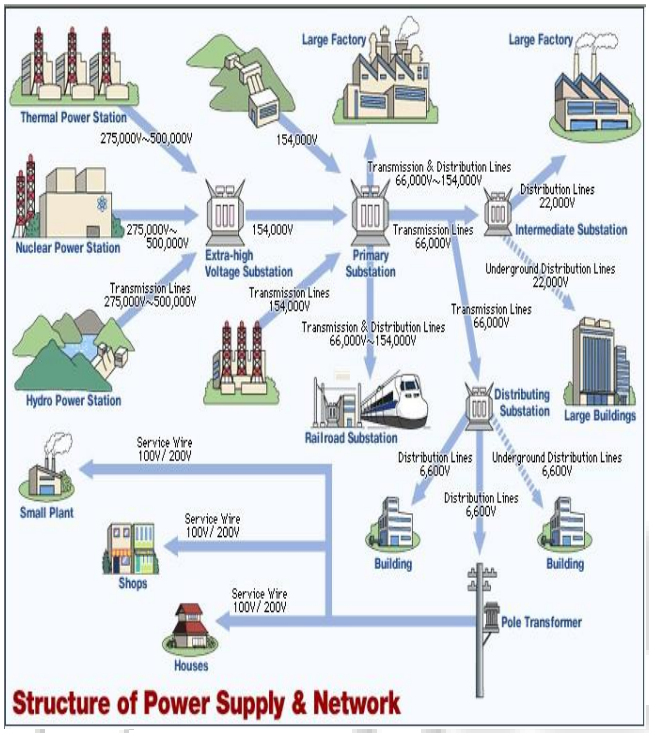


Fig. 4: Structure of Power Supply & Network

A. *Contradiction Between Two Grid System:*

1) *Traditional Power System:*

Traditional power systems provide less information to utility operators and less control as one move away from generation source.

The limited metering and communications from substations and points on hired hands provide limited visibility into the current operating status of the distribution system and consequently provide only limited information on transformer loading, line losses, voltage sags and swells and other distribution system characteristics such as outage detail.

Traditional power systems face challenges integrating distributed energy resources including solar, wind and combined heat and power.

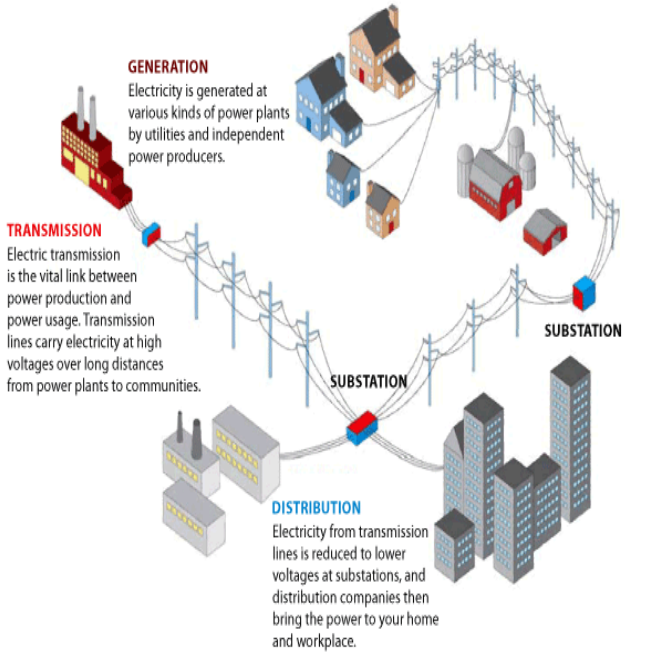


Fig. 5: Traditional Power System

Difficulty in monitoring and controlling distributed electricity generated from these sources and their intermittent nature can destabilize the grid. Increasing use of electric vehicles also contributes to concerns over the ability of traditional power systems to adapt to future electricity demands.

Most traditional power systems use electromechanical meters collecting readings manually once a month providing utility customers with little detail on how or when they use electricity.

B. *The New Smart Grid Power System Model:*

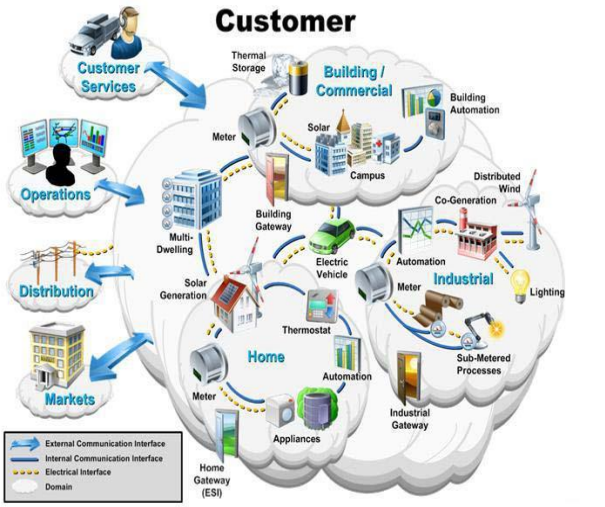
The characteristics of the new smart grid power system are:

Extensive metering and communication throughout the distribution system- smart grids meter individual customers and individual grid equipment throughout the distribution system including transformers, switches, capacitor banks, voltage regulators and other equipment. This information is relayed back to the utility typically through a combination of communications systems.

Two way communication and power flows- Instead of a traditional system that sends power in one direction(to the customers) and returns information in the opposite direction (back to the utility) at monthly intervals, the smart grid accommodates frequent and on demand two way information and power delivery.

Utility Customer participation- This is one of the most important smart grid system characteristics. Not only do customers provide electric production with solar but also provide combined heat and power and other technologies, they can actively respond to signals from the utility to reduce electricity use during peak period times or during situations where the power system is stressed.

Increased control- Smart grids increase utility control of distribution system equipment and operating characteristics and increase control of customer demand response.



Coordination and integration- Smart grids coordinate and integrate new metering, communication, control and customer engagement technologies and strategies, leveraging technologies and programs to achieve objectives across the entire utility system.

V. Conclusion:

In this paper we have discussed about smart grid and various renewable energy sources in India which includes solar energy, wind energy, biomass energy which can be utilized to increase the efficiency of smart grid for power sector in India. Also we have discussed about challenges which India is facing to generate these renewable energies and ways to improve these. Also a comparison between traditional power system and the smart grid power system is done. So at last we conclude that conversion of traditional grid into smart grid is a very beneficial step to improve the power efficiency of India and renewable energy plays a vital role in this.

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