Challenges of solar energy in Indian power sector

Vidya Sagar

Abstract
The solar energy vitality advancements has encountered amazing development. The acknowledgment of mechanical upgrades, developing open consciousness of ecological issues, the financial atmosphere and number of strategy instruments have encouraged and supported this solid enthusiasm for these advancements. Since the expense of power produced from solar energy is as yet costly and furthermore the force from inexhaustible assets including solar power is weak force, enormous scope advancement of sustainable assets didn't occur and dissemination utilities are likewise least intrigued to buy power from inexhaustible sources.

Keywords: Solar Energy and Indian Power Sector

Introduction
The Indian force area is prevalently founded on non-renewable energy sources, with around three-fifths of the nation's capacity age limit being reliant on immense indigenous stores of coal. In any case, in scarcely any last decades Indian government has found a way to diminish the utilization of petroleum derivatives based vitality while advancing inexhaustible age. Sun powered vitality establishes the most bountiful sustainable power source asset accessible and in many locales of the world even its in fact accessible potential is far in abundance of the current all-out essential vitality gracefully. As such sunlight based vitality innovations are a key instrument to bring down overall carbon discharges. The wide scope of innovations accessible today, to bridle the sun’s vitality, is arranged into latent and dynamic advancements. The dynamic advancements, which framed the substance of this paper, are comprehensively partitioned into photovoltaic and sunlight based warm, where solar energy warm can be additionally arranged into solar power warm electric and non-electric applications.

The market for many of the solar energy technologies has seen dramatic expansion over the past decade in particular the expansion of the market for grid-connected PV systems and solar hot water systems have been remarkable. At present India is fifth largest country in the world of electricity generation, having presently installed capacity of 243 GWs out of which 69.5% is from thermal, 16.5% from hydro, 2% from nuclear and rest about 12% from renewable energy sources. Although Indian power sector has experienced a seven times increased in its installed capacity a jump from 30,000 MW in 1981 to over 243028 MW by March, 2014 but still there is a huge gap in generation and demand in India hence need to be established more generation plants preferable to come from renewable sources by governmental as well as various private participation. As per the load generation balance report for FY2013-14 issued by CEA, the anticipated peak shortage in the country during FY2013-14 works out to 6.2% based on the anticipated demand and availability of power. Solar energy has emerged as a viable, cost-effective and commercial option for grid connected power generation. During the past few years, a significant trust has been given to the development and induction of solar energy technology for use in different sectors.

India is the main nation on the planet with a selective Ministry to advance the sustainable power sources. By and by the introduced limit of solar energy vitality ventures in India is around 3000 MW. India intend to create 20 GW of sun powered force by 2020. While the expense of vitality from numerous sun powered vitality advances stays high contrasted with traditional vitality advances, the cost pattern of solar power vitality advances exhibits fast decreases in the ongoing past and the potential for noteworthy decreases sooner rather than later.
Notwithstanding cost, it is discovered that various obstructions that seem to confine the quick development of such advancements. These incorporate specialized obstructions, for example, low-efficiencies, challenges with vitality stockpiling, dependability of parity of framework segments; and institutional boundaries, for example, absence of data, outreach and administrative structure. Accordingly, various profoundly compelling strategy instruments have met up in the absolute best markets for sunlight based vitality. These incorporate monetary and market based budgetary motivations (for example feed-in-tax, refunds, charge credits), guidelines (for example inexhaustible portfolio norms, solar energy vitality commands) just as various pilot exhibit ventures. While the proceeded with activity of such activities is basic for the future development of these business sectors it is additionally turning out to be obvious that inventive approaches to diminish the financial weight of strategy motivating forces are required. All things considered, there is directly developing enthusiasm for advertise based components to supplement existing financial strategy impetuses.

Solar energy has experienced phenomenal growth in recent years due to both technological Improvements resulting in cost reductions and government policies supportive of renewable energy development and utilization. This paper analyzes the technical, economic and policy aspects of solar energy development and deployment. While the cost of solar energy has declined rapidly in the recent past, it still remains much higher than the cost of conventional energy technologies. Like other renewable energy technologies, solar energy benefits from fiscal and regulatory incentives and mandates, including tax credits and exemptions, feed-in-tariff, preferential interest rates, renewable portfolio standards and voluntary green power programs in many countries. Potential expansion of carbon credit markets also would provide additional incentives to solar energy deployment; however, the scale of incentives provided by the existing carbon market instruments, such as the Clean Development Mechanism of the Kyoto Protocol, is limited. Despite the huge technical potential, development and large-scale, market-driven deployment of solar energy technologies world-wide still has to overcome a number of technical and financial barriers. Unless these barriers are overcome, maintaining and increasing electricity supplies from solar energy will require continuation of potentially costly policy supports.

Drives moving toward decrease of capital expense of sunlight based vitality through mechanical turn of events and increment in Plant Utilization Factor with by and large improvement in effectiveness. Drives are additionally moving toward creating storerooms for vitality from solar energy to make them firm and helpful type of vitality. Rebuilding of intensity segment has changed the conventional strategic commands of utilities in complex manner, and had enormous effect on ecological, social and political conditions for a specific nation. Simultaneously, new administrative methodologies are being found for lessening natural effects in rebuilt power area. Establishment of the Electricity Act 2003 (the Act) has offered further help to sustainable power source by specifying acquisition of a level of the force obtainment by dispersion utilities from sustainable power sources. The inexhaustible buy commitment just as particular duty for obtainment of such force has been indicated by different State Electricity Regulatory Commissions (SERCs). Notwithstanding all key arrangements set up, acquisition of Renewable Energy Certificate (REC) has not been exceptionally promising and offer of now sunlight based REC is at a low cost. SERCs must sway Discoms to meet them RPO commitment. Cost of vitality produced from sun powered can likewise be diminished by advancing rivalry inside such ventures. Simultaneously, satisfactory special measures would likewise must be taken for improvement of advances.

While the Electricity Act, 2003, the policies framed under the Act, and also the National Action Plan for Climate Change (NAPCC) provide for a roadmap for increasing the share of renewable in the total generation capacity in the country, there are constraints in terms of availability of RE sources evenly across different parts of the country. This inhibits the State Commissions, especially in those states where the potential of RE sources is not that significant, from specifying higher renewable purchase obligation. The latest technological development in the field of solar energy and its storage facilities. This would help to minimize cost of power procurement, and lead to efficient resource utilization across the country and provide incentive for investment in appropriate technologies. The paper also highlights salient features, technological development, potential and achievement, advantages and key barriers in development of solar energy projects in India.

**Basic concept of solar energy**

Solar energy can be produced by two methods. One is Solar PV i.e. through photovoltaic cells and other is Solar Thermal i.e. through concentrated solar power.

**Solar photovoltaic (PV)**

**Historical development:** Solar Photo-voltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. It is a device that directly converts solar energy into electricity by photovoltaic effect. Photoelectric effect was first time recognized in 1839 by F.C. Becquerel. In this Phenomenon the electrons are emitted from matter after absorption of energy from radiation. In 1883 – First solar cell was built by coating Selenium with extremely thin layer of gold. In 1958 – Bell laboratories found that Silicon (Si) doped with certain impurities was very sensitive to light. This finding resulted in the production of first practical solar cell with sunlight conversion efficiency ~6% made from materials that emit electrons when exposed to EM radiation. Mainstream materials presently used for photovoltaic include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Due to the increased demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years. The amount of power available from a solar cell depends on - Type and area of material - Intensity of sunlight - Wavelength of sunlight.

**Working principle:** Sunlight is made out of tiny energy pockets called photons and that each individual solar cell is designed with a positive and negative layer thus being able
to create an electric field (similar to the one in batteries). As photons are absorbed in the cell their energy causes electrons to get free, and they move to the bottom of the cell, and exit through the connecting wire which creates flow of electrons thus generate electricity. The bigger amount of the available sunlight the greater the flow of electrons and the more electricity gets produced in the process. It is a form of photovoltaic cell (in that its electrical characteristics e.g. current, voltage, or resistance vary when light is incident upon it) which, when exposed to light, can generate and support an electric current without being attached to any external voltage source, but do require an external load for power consumption. Pure Si is a poor conductor of electricity. Doping – introducing impurities into an intrinsic (pure) semiconductor to change its electrical properties. Examples of n-type dopants – Phosphorus (Ph), Arsenic (As), Antimony (Sb). Examples of p-type dopants – Boron (B), Aluminium (Al). Doping provides with charge carriers (holes and electrons) that can carry electrical current. Electric field to force electrons to flow in a certain direction. This electric field is achieved by bringing together p-type and n-type semiconductors together to make a diode. Holes and electrons from p-region and n-region respectively recombine, creating a depletion region and an electric field. The movement of holes and electrons are represented below. Depletion region continues to grow till the electric field becomes large enough to prevent the flow of charge carriers from one side to the other. Now, if the diode is exposed to light, it frees the electrons in n-region and these electrons, repelled by the electric field, flow through the load to p-region. These electrons constitute current. The flow of electrons and hole can be represented as follows:

The movement of hole and electrons resulting flow of electricity across the cell represented as given below:

Several solar cells are connected together, encapsulated in a glass covered frame to form a module. A solar cell made from a mono-crystalline silicon wafer with its contact grid made from bus bars (the larger strips) and fingers (the smaller ones) as light hits the solar panels, the solar radiation is converted into direct current electricity (DC). The direct current flows from the panels and is converted into alternating current (AC) used by local electric utilities. Finally, the electricity travels through transformers, and the voltage is boosted for delivery onto the transmission lines so local electric utilities can distribute the electricity to homes and businesses.

Essential requirements for solar energy generation are as follows:
1. High solar radiation at that particular site.
2. Adequate land availability.
3. Suitable terrain and good soil condition.
4. Proper approach to site.
5. Suitable power grid nearby.
7. Scientifically prepared layout.

Solar thermal

Concentrated solar power: This systems use mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy, onto a small area. Electrical power is produced when the concentrated light is converted to heat, which drives a heat engine (usually a steam turbine) connected to an electrical power generator or powers a thermo chemical reaction. Solar thermal power technologies are of three types namely Parabolic trough, Dish engine and Power tower.
Working principle: The common basic principle of solar thermal power plants is the use of concentrating parabolic dish systems in large-scale solar fields that concentrate the solar radiation onto a receiver. All systems must track the sun in order to be able to concentrate the direct radiation. This radiation is first converted into thermal energy at temperatures in the range of about 200 to over 1,000 °C (depending on the system). The thermal energy can then be converted to power, as in a conventional power plant, using steam or gas turbines; if needed, it can also be used in other industrial processes, for example, water desalination, cooling or — in the near future — for hydrogen production. Power plants based on concentrated solar power use the sun's energy to generate electricity on an industrial scale. Solar radiation is optically concentrated, thus generating very high temperatures for the power plant process. This high-temperature heat can be stored, thus allowing electricity to be generated on demand an important advantage of this technology.

Components of Solar thermal: High-temperature collectors: During the day the sun has different positions. For low concentration systems (and low temperatures) tracking can be avoided (or limited to a few positions per year) if non-imaging optics are used. For higher concentrations, however, if the mirrors or lenses do not move, then the focus of the mirrors or lenses changes (but also in these cases non-imaging optics provides the widest acceptance angles for a given concentration). Therefore it seems unavoidable that there needs to be a tracking system that follows the position of the sun (for solar photovoltaic a solar tracker is only optional). The tracking system increases the cost and complexity. With this in mind, different designs can be distinguished in how they concentrate the light and track the position of the sun.

Power tower designs: Power towers (also known as ‘central tower’ power plants or ‘heliostat’ power plants) capture and focus the sun’s thermal energy with thousands of tracking mirrors (called heliostats) in roughly a two square mile field. A tower resides in the center of the heliostat field. The heliostats focus concentrated sunlight on a receiver which sits on top of the tower. Within the receiver the concentrated sunlight heats molten salt to over 1,000 °F (538 °C). The heated molten salt then flows into a thermal storage tank where it is stored, maintaining 98% thermal efficiency, and eventually pumped to a steam generator. The steam drives a standard turbine to generate electricity. This process, also known as the “Rankine cycle” is similar to a standard coal-fired power plant, except it is fueled by clean and free solar energy. The advantage of this design above the parabolic trough design is the higher temperature. Thermal energy at higher temperatures can be converted to electricity more efficiently and can be more cheaply stored for later use. Furthermore, there is less need to flatten the ground area. In principle a power tower can be built on the side of a hill. Mirrors can be flat and plumbing is concentrated in the tower. The disadvantage of this system is that each mirror must have its own dual-axis control, while in the parabolic trough design single axis tracking can be shared for a large array of mirrors.

Working of Solar Thermal: A solar thermal power plant in principle works no differently than a conventional Steam power plant. However, there is one important difference. No harm is done to the environment by burning coal, oil, natural gas or by splitting uranium to produce steam. It is produced solely by the energy that comes from the sun. In order to achieve the high temperatures required, solar radiation must be concentrated. Parabolic trough collectors represent the most advanced technology for use in doing this. These troughs are more than 1, 300 feet (400 meters) in length and are made up of parabolically shaped mirror segments. The troughs track the sun over the course of the day and focus the resulting radiation along the caustic line of the mirrors onto specially coated, evacuated absorber tube receivers. Solar radiation heats up the thermo-oil that flows through the receiver to a temperature of 400 °Celsius so that a downstream heat exchanger is able to generate steam. As in a conventional power plant, the steam is pressurized inside the turbine that drives the generator. Heat storage systems can allow electricity output even if the sun isn't shining.

Benefits of Solar power
a) Solar energy is a clean, renewable resource that is continuously supplied to the earth by the sun.
b) Solar resources are available everywhere in the world. It gives out no emissions i.e. environmentally safe.
c) Energy security to the country. No dependency on foreign resources for electricity generation.
d) Can be permitted and installed faster than other traditional or renewable power plants.
e) Produces local, on-site energy, which reduces the need for extensive high-voltage transmission lines or a complex infrastructure.
f) Reliable over the long term. With no moving parts, fixed photovoltaic systems last longer than other energy sources.
g) Clean, quiet and visually unobtrusive in nature. Solar energy plants do not have any polluting emissions, do not make any sound, and are not considered to be an "eyesore."

Conclusion
Solar power force is decrepit force and endeavors are required to be made it firm force by creating fitting storerooms. The solar energy force can likewise make a feasible wellspring of vitality by reporting the appropriate strategies motivators. Re-driving must be a piece of any methodology to scale-up sunlight based force limit as it is fundamental to ideally use high sun powered radiation locales that stay unused because of less exertion by the administration and contributing organizations and to retrofit or supplant the old boards with present day, enormous and higher, progressively proficient ones. This should come side endeavors to create and encourage presentation of another age of sunlight based boards that can tackle the potential from continued low to medium sun powered radiation systems accessible in bountiful measure in huge pieces of the nation.

References
2. A market for renewable energy credits in the Indian power sector, by Anoop Singh. In Science Direct

4. LOLE. Best Practices Working Group Andrew P. Ford, Sr. Member, Brandon Heath, Member, IEEE 978-1-4673-2729-9/122012 IEEE.