

Scope and Application of Solar Thermal Energy in India-A Review

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Abstract

Energy is available in two different alternatives, non renewable (coal, petroleum, natural gas) and renewable (solar, wind, small hydro) sources. In recent years solar energy has received great deal of attention as an easily utilizable source of renewable energy for providing electricity. Renewable energy sources like solar is indigenous and can help in reducing the dependency on fossil fuels. Solar energy provides a variable and environmental friendly option and national energy security at a time when decreasing global reserves of fossil fuels threatens the long-term sustainability of global economy. The solar energy can be utilized in two ways one is solar photovoltaic and other is solar thermal. This paper describe the generation of electricity through solar thermal energy in Indian perspective.

1. Introduction

Energy is considered a prime agent in the generation of wealth and a significant factor in economic development. Limited fossil resources and environmental problems associated with them have emphasized the need for new sustainable energy supply options that use renewable energies. Solar thermal power generation systems also known as Solar Thermal Electricity (STE) generating systems are emerging renewable energy technologies and can be developed as viable option for electricity generation in future. This paper discusses the technology options, their current status and

opportunities and challenges in developing solar thermal power plants in the context of India.

2. Solar Energy Potential

India is located in the equatorial sun belt of the earth, thereby receiving abundant radiant energy from the sun. The India Meteorological Department maintains a nationwide network of radiation stations, which measure solar radiation, and also the daily duration of sunshine. In most parts of India, clear sunny weather is experienced 250 to 300 days a year. The annual global radiation varies from 1600 to 2200 kWh/m², which is comparable with radiation received in the tropical and sub-tropical regions. The equivalent energy potential is about 6,000 million GWh of energy per year. The solar radiation levels are different in various parts of the country. It can be observed that although the highest annual global radiation is received in Rajasthan, northern Gujarat and parts of Ladakh region, the parts of Andhra Pradesh, Maharashtra, and Madhya Pradesh also receive fairly large amount of radiation as compared to many parts of the world especially Japan, Europe and the US where development and deployment of solar technologies is maximum. (Amita and Soni, 2010)

3. Solar Thermal Power Generation Program of India

In India the first Solar Thermal Power Plant of 50kW capacity has been installed by MNRE following the parabolic trough collector technology (line focusing) at Gwalpahari, Gurgaon, which was commissioned in 1989 and operated till 1990, after which the plant was shut down due to lack of spares. The plant is being revived with development of components such as mirrors, tracking system etc. A Solar Thermal Power Plant of 140MW at Mathania in Rajasthan, has been proposed and sanctioned by the Government in Rajasthan. The project configuration of 140MW Integrated Solar Combined Cycle Power Plant involves a 35MW solar power generating system and a 105MW conventional power component and the GEF has approved a grant of US\$ 40 million for the project. The Government of Germany has agreed to provide a soft loan of DM 116.8 million and a commercial loan of DM 133.2 million for the project. In addition a commercial power plant based on Solar Chimney technology was also studied in North-Western part of Rajasthan. The project was to be implemented in five stages. In the 1st stage the power output shall be 1.75MW, which shall be enhanced to 35MW, 70MW, 126.3MW and 200MW in subsequent stages. The height of the solar chimney, which would initially be 300m, shall be increased gradually to 1000m. Cost of electricity through this plant is expected to be Rs. 2.25 / kWh. However, due to security and other reasons the project was dropped. BHEL limited, an Indian company in power equipments manufacturing, had built a solar dish based power plant in 1990's as a part of research and development program of then the Ministry of Non-conventional Energy Sources. The project was partly funded by the US Government. Six dishes were used in this plant. (Ishan and Pallav, 2011)

4. Opportunities for Solar Thermal Power Generation in India

Solar thermal power generation can play a significant important role in meeting the demand supply gap for electricity. Three types of applications are possible

1. Rural electrification using solar dish collector technology.
2. Typically these dishes care of 10 to 25 kW capacity each and use striling engine for power generation. These can be developed for village level distributed generation by hybridizing them with biomass gasifier for hot air generation.
3. Integration of solar thermal power plants with existing industries such as paper, dairy or sugar industry, which has cogeneration units Many industries have steam turbine sets for cogeneration. These can be coupled with solar thermal power plants. Typically these units are of 5 to 250 MW capacities and can be coupled with solar thermal power plants. This approach will reduce the capital investment on steam turbines and associated power-house infrastructure thus reducing the cost of generation of solar electricity.
4. Integration of solar thermal power generation unit with existing coal thermal power plants. The study shows that savings of up to 24% is possible during periods of high insolation for feed water heating to 241°C.

5. Advantages of Solar Energy

It is an abundant Renewable Energy This technology is Omnipresent and it can be captured for conversion on a daily basis It is a Non-polluting technology, which means that it does not release green house gases It is a Noiseless technology as there are no moving parts involved in energy generation. This technology requires Low-maintenance because of lack of moving parts it can be installed on modular basis and expanded over a period of time most viable alternative for providing electricity in remote rural areas as it can be installed where the energy demand is high and can be expanded on modular basis.

6. Limitations of Solar Energy

As the technology is in an evolving stage, the efficiency levels of conversion from light to electricity is in the range of 10 to 17%, depending on the technology used. The initial investment cost of this technology is high. At present the technology is basically surviving because of subsidy schemes available by the government. Solar energy is available only during daytime. Most load profiles indicate peak load in the evening/night time. This necessitates expensive storage devices like battery, which need to be replaced every 3 to 5 years. Generally, the cost of the Battery is 30 to 40% of the system cost. As the efficiency levels are low, the space required is relatively high. For instance, with the existing levels of technologies, the land required for putting up a 1 MW solar PV power plant is between 6 to 9 acres. However, research is going on to increase the efficiency levels of the cell. Solar energy is heavily dependent

on atmospheric conditions .Solar insolation varies from location to location, so there are certain geographic limitations ingenerating solar powers. (Nixon et al. 2010)

7. Concentrating Solar Power Technology

Concentrating solar power (CSP) plants produce electricity by converting the infrared part of solar radiation into high temperature heat using various mirror/reflector and receiver configurations. The heat is then channeled through a conventional generator. The plants consist of two parts: one that collects solar energy and converts it to heat, commonly known as ‘solar field’ and another that converts heat energy to electricity, known as ‘power block’. CSP plants use the high-temperature heat from concentrating solar collectors to drive conventional types of engines turbines. (Ramchandra and Jain, 2011) All CSP are based on four basic essential sub systems namely collector, receiver (absorber), transport/ storage and power conversion. Following four CSP technologies have either reached commercialization stage or are near it:

- Parabolic Trough
- Power towers
- Parabolic Dishes (Dish-Sterling)
- Compound Linear Fresnel Reflectors (CLFR)

Table 1: Comparison of Various CSP Technologies.

	Parabolic trough	Central receiver	Parabolic Dish	Fresnel linear reflector
Applications	Grid-connected plants, midium to high-process heat (Highest single unit solar capacity to date: 80 MWe. Total capacity built: over 500 MW and more than 10 GW under construction or proposed)	Grid-connected plants, high temperature process heat (Highest single unit solar capacity to date: 20 MWe under construction, Total capacity ~50MW with at least 100MW under development)	Stand-alone, small off-grid power systems or clustered to larger grid connected dish parks (Highest single unit solar capacity to date: 100 kWe, Proposals for 100MW and 500 MW in Australia and US)	Grid connected plants, or steam generation to be used in conventional thermal power plants. (Highest single unit solar capacity to date is 5MW in US, with 177 MW installation under development)

<p>Advantages</p>	<p>Commercially available over 16 billion kWh of operational experience; operating temperature potential up to 500°C (400°C commercially proven)</p> <ul style="list-style-type: none"> • Commercially proven annual net plant efficiency of 14% (solar radiation to net electric output) • Commercially proven investment and operating costs <ul style="list-style-type: none"> • Modularity • Good land-use factor <ul style="list-style-type: none"> • Lowest materials demand • Hybrid concept proven <ul style="list-style-type: none"> • Storage capability 	<ul style="list-style-type: none"> • Good mid-term prospects for high conversion efficiencies, operating temperature potential beyond 1,000°C (565°C proven at 10 MW scale) • Storage at high temperatures • Hybrid operation possible • Better suited for dry cooling concepts than troughs and Fresnel • Better options to use non-flat sites 	<ul style="list-style-type: none"> • Very high conversion efficiencies – peak solar to net electric conversion over 30% • Modularity <ul style="list-style-type: none"> • Most effectively integrate thermal storage a large plant • Operational experience of first demonstration projects <ul style="list-style-type: none"> • Easily manufactured and mass-produced from available parts • No water requirements for cooling the cycle 	<ul style="list-style-type: none"> • Readily available • Flat mirrors can be purchased and bent on site, lower manufacturing costs <ul style="list-style-type: none"> • Hybrid operation possible • Very high space efficiency around solar noon.
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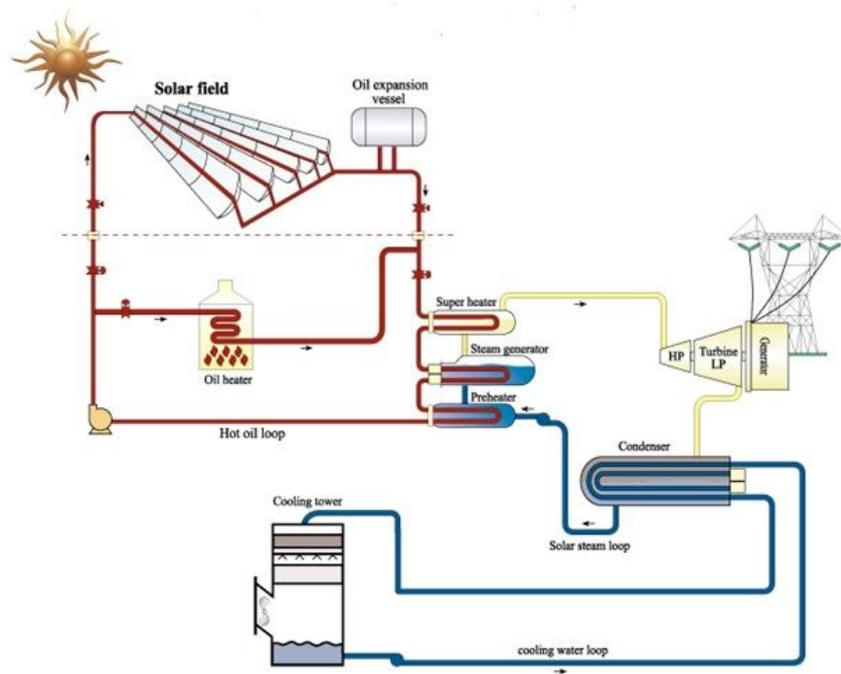


Fig. 1: Working of Solar Thermal Power Plant.

8. Working of Concentrating Solar Thermal System

Solar energy collectors are special kind of heat exchangers that transform solar radiation energy to internal energy of the transport medium. The major component of any solar system is the solar collector. This is a device which absorbs the incoming solar radiation, converts into heat, and transfers this heat to a fluid (usually air, water, or oil) flowing through the collector. The solar energy thus collected is carried from the circulating fluid either directly to the hot water or space conditioning equipment or to a thermal energy storage tank from which can be drawn for use at night and/or cloudy days. (Beerbauma and Weinrebe, 2000) There are basically two types of solar collectors: Non concentrating or stationary and concentrating. A nonconcentrating collector has the same area for intercepting and for absorbing solar radiation, whereas a sun-tracking concentrating solar collector usually has concave reflecting surfaces to intercept and focus the sun's beam radiation to a smaller receiving area, thereby increasing the radiation flux.

9. Conclusion

Concentrating solar thermal is considered as one of the main options for renewable bulk electricity production. It is expected for the next years a concentrating solar thermal development similar in potential and magnitude to the wind power take-off

recently experienced. Recent economic support measures that have been considered in countries like Spain are going to make possible the first steps for this concentrating solar thermal emerging business.

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