Concentrating Solar Power and Its Prospects in India: Technological and Economic Requirements

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Abstract- *Concentrating solar power (CSP) is emerging has a viable alternative to fossil fuels in meeting the ever rising energy requirements of India. In addition to being renewable and environmentally safe CSP plants can produce concentrating solar fuels, thus giving an added advantage over other renewable energy sources. Though photovoltaic cells dominate the solar energy production industry, CSP when combined with thermal energy storage can operate even during sun down periods thus ensuring continuous supply. The major technological requirements for large scale energy generation using CSP's are abundant annual direct normal irradiation (DNI), a large area for the plant, water supply for the cooling of the plant and an optional storage mechanism. The economical requirements are initial installation costs, maintenance and operation costs. Though at present CSP plants are considered as costlier, considering the increase in conventional fuel prices and the increasing energy demands CSP's seem essential for self reliant, clean energy.*

Key words: **CSP, DNI, PV, FLW, FLC Thermal energy storage, solar power generation, technological issues, economic consideration.**

1. INTRODUCTION

Global energy consumption is growing at a rapid rate. It is predicted that the energy requirements of the developing countries will increase by 70% in the next 20 years. [1] The energy requirements of India are growing at an even higher rate. But still it is estimated that more than 30% of Indian population will not get access to electricity even by the year 2030. It is due to the over reliance of the Indian energy industry on fossil fuels. Fossil fuel prices keep on increasing everyday thus increasing the production costs. The scarcity of fuels increases their demand and never can fulfill India's energy needs. Thus it is long overdue for the industry to look for alternate energy sources. Solar energy seems to be an ideal option as most parts of India receive abundant sun light throughout the year. Solar energy is renewable, locally available and pollution free. So if provided with feasible technology and economics India can meet a major portion of its energy demands from solar power generation. [2] The storage and transportation costs will be also reduced while using this type of energy. [3]

There are basically two types of technologies available to convert solar energy into electrical energy. The first technique which utilizes photovoltic cells converts light energy directly into electrical energy. [4] Though this method has many advantages the major drawback is it cannot operate during sun down periods like cloudy, foggy conditions and during nights. Another approach utilizes thermal energy produced by the sun to generate electricity. [5] This method known as the concentrating solar power (CSP) can generate electricity during sun down periods also by storing the thermal energy in a storage medium. [6]

This paper discusses the technological and economical aspects of CSP based power generation in India considering various constraints. Both aspects can be predicted to a fair degree of accuracy by assuming a suitable model. Various models available for predicting the performance of CSP based power generation is also given in the later sections. [7]

The rest of the paper is organized as follows. The technological requirements for the CSP based energy generation is given in the following section. The economical considerations are given in the section which comes next. The fourth section gives

an overview about the existing performance analysis models and their suitability for predicting possible CSP power plant performances in India. The fifth section provides a comparative analysis of the results followed by conclusion.

II. TECHNOLOGICAL REQUIREMENTS

Unlike PV based power generation which can utilize scattered radiation also, CSP power plants require direct sunlight referred as direct normal irradiation (DNI) to produce sufficient thermal energy for power generation. This thermal energy is given to a turbine based power generation system to produce electricity. So in order to produce the high temperature required for producing electricity the CSP plant should be large enough to receive radiation in huge quantities and it should have a proper radiation capturing mechanism. But the major requirement is the plant should have been located at a place where there is sufficient DNI most of the time. It has been predicted that CSP plants in areas having an annual average DNI of 2000 or greater can operate at their full load potential for nearly 25% of the time. And that estimate is for plants without thermal storage. The operation hours can be extended even further by adding storage mechanisms. The following graph gives the distribution of DNI in India and indicates the total area that is available for CSP based power generation.

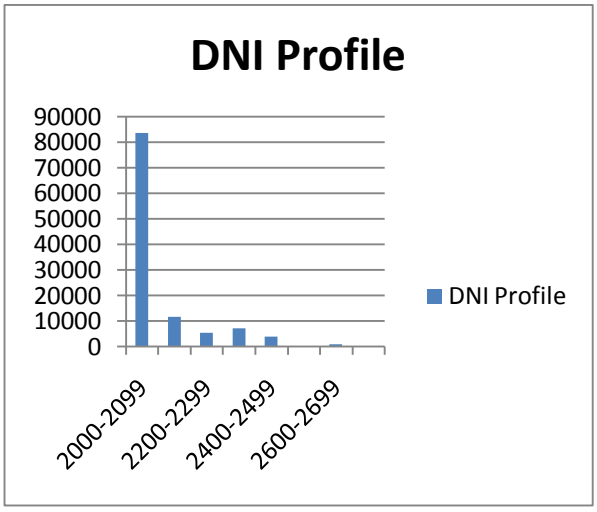

Fig 1: DNI Profile

There are four techniques available for the radiation gathering. Solar towers, Fresnel reflectors, parabolic towers and dishes. Another major problem is finding a suitable location for the plant. As it requires a vast area with proper sunlight, finding an appropriate place is a major issue in a vast country like India.

III. ECONOMICAL REQUIREMENTS

The economics of the plants should also be considered before its installation. As it requires a huge initial cost and considerable maintenance and operation costs proper planning is necessary before beginning any CSP based project. And hence it requires an accurate model for predicting the future generation capacity of a CSP plant based on the available present data. The model should take the annual DNI profile and the latitude and longitude positions as input and should predict the power generation capabilities for various types of receiver systems like parabolic reflector etc., Though various models have been already developed already they are generalized or specific to other regions than India. Hence it is necessary to develop a region specific analysis model for India with constraints and variables tuned to local needs. A brief account of the existing models and algorithms are given in the next section.

IV. CSP ANALYSIS MODELS

SAM model:

SAM model or solar advisor model is being developed by USA. It has a graphical user interface which enables easy analysis. It supports technological and economical analysis for both photovoltic and CSP based power generation. SAM model is based on a integer linear programming algorithm.

WITCH model:

WITCH model is being used by European countries. It is more complex than the SAM model and utilizes an heuristic approach for prediction

SOLAR MULTIPLE (SM) model:

This is one of the simplest model which can calculate the capacity of a plant just from the DNI and receiver details.

V. POTENTIAL IN INDIA BASED ON SM MODEL - RESULTS

Based on the DNI profile of India the following results were obtained using the SM model.

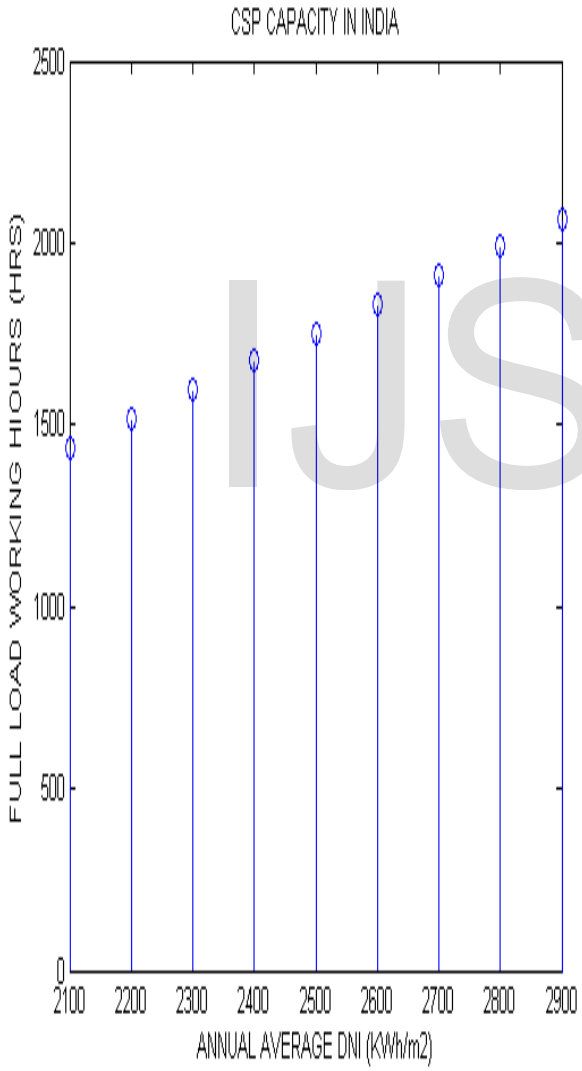

Fig.2 CSP Capacity in India

The above result indicate that there are places available in India where it is possible to construct CSP plants that can work in its full load capacity for more than 2000 hours a year. This estimate is for plants without storage facility.

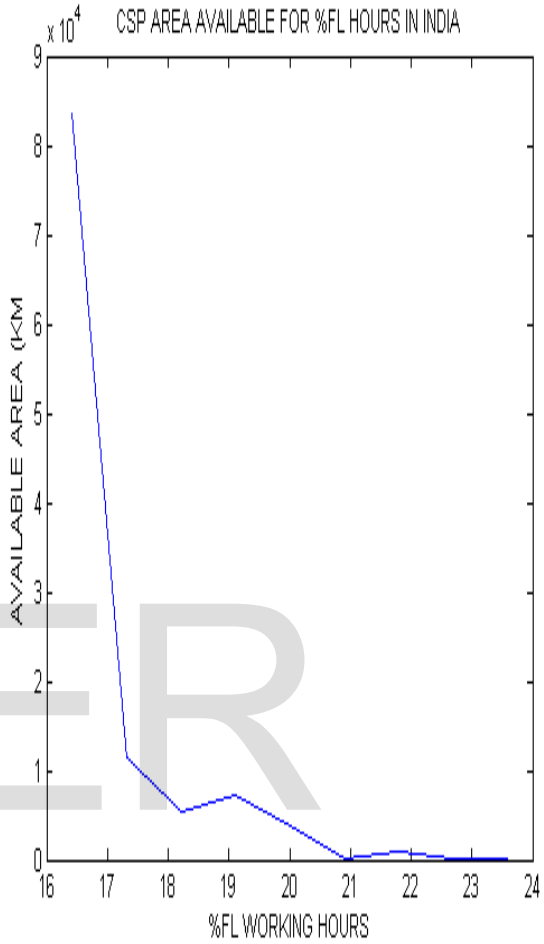

Fig.3. CSP Area available for %Full Load Hours in India

The above result indicates the potential to construct plants over a 10000 square kilometers landscape to work in its full load capacity for 20% of the time without storage.

VI. CONCLUSION

Though concentrating energy plants require high cost for their initial installation considering the energy requirement and sustain the development it is only appropriate for India to venture into CSP based power generation. It is possible both technically as well as economically to implement CSP plants that can produce considerable energy to partially fulfill India's energy needs.

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