Viability Analysis of Solar thermal power plant using combined cycle system and Parabolic trough collector Technology for Chhattisgarh State

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Abstract- The Solar Power Technology requires the optimum intensity of solar potential for power generation. Losing the information about solar intensity on a certain area, availability of land and water sources may lead the Solar power generation system collapse. With the idea suggested in this paper, it is more likely to locate a state of India i.e. Chhattisgarh, as a Solar Power generation core by marking basic feasible parameters of this state on CSP technologies. The main aim of this paper is to boost up the Parabolic trough collector technology to reduce the dependency on conventional energy resources in a state of India.

Keywords – Parabolic trough collector Technology, Location of Chhattisgarh, 5 MW solar power plant

I. INTRODUCTION

As the population of the state is increasing, the power demand is also growing at very fast rate. The present scenario of the Chhattisgarh state is that almost 93% (CEA) of the electricity generated is through conventional fuel such as coal, as the state is enriched with this fossil fuel. The Coal as a fuel is a cheap source of electricity generation, while the other fuels like bio diesel, and solar are still at the beginning level in the state. Electricity generation from coal has great impact on the environment as well as the health of people. Considering the environmental concern of global warming and increasing pollution all over the world, the use of non-conventional source of energy is being promoted at very high rate throughout the world, and in India also it has also been started, though the rate of implementation is slow presently. As far as Chhattisgarh is considered for the renewable energy option, this state is blessed with sunshine of the order 5.35kWh/m^2/day (NREL) throughout the year and even if its few percent is harnessed, it may contribute sustainable amount of energy to our daily needs. Because the solar energy is free and abundantly available, thus there are large opportunities available to create good image in the society and the country, by promoting the state as renewable hub.

A. Objective Our aim in the present work is to analyze the feasibility, to establish a solar power plant of 5 MW capacity in the state, using parabolic trough collector technology operating on Integrated Solar Combined Cycle System (ISCCS) for the generation of electricity for the climatic condition of Chhattisgarh under the light of followings:

The factors that influences the size of the solar plant has been recognized which have decided the establishment of different capacity of the solar plants at different locations.

The Parabolic trough Collector based Solar thermal power plant will has been designed.

The cost of setting up of the plant will has been estimated for the 5MW capacity.

The reduction in the pollution in terms of the carbon dioxide produced will has been estimated in comparison with the coal based thermal power plant of the same capacity, to find out how environment friendly the proposed plant is.

Finally the payback period of the solar power plant will has been estimated.

B. Study Area

The study was carried out for Chhattisgarh state, India based on the data compiled for various locations. Chhattisgarh lies between $17^0$46’ to $24^0$50’ North and $80^0$15’ to $84^0$20’ East. It covers an area of 1,35,133 Sq. Kms. It accounts for 3.71 percent of the total area of the country i.e. 32.88 lakh sq. Km and ranks tenth among major States of the country in terms of size. For administrative purpose the state is divided into 27 districts.[8]

C. Scenario in Chhattisgarh

The Chhattisgarh state is emerging as industrial hub and the luxurious life style of people increasing the power demand. So it is important to note that the energy demands of people and the industries are also growing at very high rate. Presently the state has surplus energy to meet the needs of the people. However, it is the concern of the government that the energy demand is increasing very rapidly and time will come when this surplus energy will fall short .The power is mostly generated from fossil fuel coal, which is increasing the problem of pollution in the city. Recently Raipur has been declared as the third most polluted city of the country. To reduce the pollution level and promote the use of renewable energy sources CREDA (Chhattisgarh Renewable Energy Development Authority) is promoting the power generation from non renewable energy resources like using solar energy and from biomass etc. However the rate of deployment of such projects is very slow and we are not in a position to generate as per the norms of government of India, which states that every state should set a target for development of renewable energy resources (CREDA). The last year target set by Chhattisgarh state was 2.5 % of the total energy generated in the state out of which 0.25% should be by using solar energy and sadly, that has not been achieved (CREDA).

The present work proposes one such method of using solar energy for the power generation in the state, In regions with good solar resources within the state where coal plants are currently used, parabolic trough plants can be integrated into the coal plant to reduce coal consumption, much like the ISCCS configuration.

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II. Literature Review

As per Belen Gallego; Founder & Director; CSP Today (2013), Hybridization is by far, the biggest opportunity for CSP technologies in India. There is a huge niche of opportunity right there and the MNRE have clocked onto it. Last year they released a program to target demonstration CSP hybrid plants ranging in size from 20-50 MW. The plants will each be located in different states (Rajasthan, Gujarat, Tamil Nadu, Andhra Pradesh and Chhattisgarh).

As per P.R. Arora (2013), CSP plant require about 3000 L/ MWh for parabolic trough and LFR plants where as in coal based plant the requirement of water is 2000 L/MWh and combined- cycle natural gas plants require 800 L/MWh. Land required for trough system without storage is 2 hectare/ MW, and for Fresnel with no storage 4 hectare /MW (10). Land required for thermal storage depends upon amount of thermal storage, i.e. operational hours after sunset.

As per JNNSM work draft (2013), Jawaharlal Nehru National Solar Mission was launched in January 2010.The objective of solar mission is to create conditions, through rapid scale –up of capacity and technological innovation to drive down the costs towards grid parity. The implementation of Jawaharlal Nehru Solar mission, with its ambitious target of 20 GW of installed solar energy plants by 2022, half is expected to CSP. Therefore, total 10 GW CSP plants shall be commissioned in India 10 GW by 2022.

As per Indian Chamber of Commerce (2012), Although India has the fifth largest reserves of coal in the world, it is not able to meet its domestic demand. Since FY 04, the country's coal import has grown at a CAGR of 15% (till 2010-11). During the same period the thermal coal import grew at a CAGR of ~25%. According to projections, India's coal import requirement will be more than 200 MT by the end of the 12th Five Year Plan.

As per Ali Rahoma (2001) analyzed global index and diffuse fraction for clear-sky conditions usingdirect, global, and diffuse solar radiations (cloudless) taken over a one year period atHelwan. The results highlight the need for routine instantaneous surface meteorologicaldata to compute global and diffuse radiations on a horizontal surface in the absence of any other radiation measurements. The spectral composition of the global solar-radiation was found to be 4.3% UV band, 32.5% band range 250–630 nm, 13.74% red band, 52.75% infrared band and 29.7% diffuse solar-radiation The spectral distribution of direct solarradiation ratio of the extraterrestrial solar radiation was found to be: 0.69% green and blue band, 47.5% yellow and orange band 45% red band, and 52.7% infra-red band.

III. Proposed Methodology

CSP plants can be broken down into two groups, based on whether the solar collectors concentrate the sun rays along a focal line or on a single focal point (with much higher concentration factors) to concentrate the power the sun.[3]

Line-focusing systems include parabolic trough and linear Fresnel plants and Single –axis tracking systems.

Point-focusing systems include solar dish systems and solar power plants and include two axis tracking systems.

Parabolic Trough Collector Technology

The parabolic trough collectors (PTC) consist of solar collectors (mirrors), heat receivers and support structures. The parabolic-shaped mirrors are constructed by forming a sheet of reflective material into a parabolic shape that

concentrates incoming sunlight onto a central receiver tube at the focal line of the collector. The arrays of mirrors can be 100 meters (m) long or more, with the curved aperture of 5 m to 6 m. A single-axis tracking mechanism is used to orient both solar collectors and heat receivers toward the sun (A.T. Kearney and ESTELA, 2010). PTC are usually aligned North-South and track the sun as it moves from East to West to maximize the collection of energy.

The receiver comprises the absorber tube (usually metal) inside an evacuated glass envelope. The absorber tube is generally a coated stainless steel tube, with a spectrally selective coating that absorbs the solar (short wave) irradiation well, but emits very little infrared (long wave) radiation. This helps to reduce heat loss. Evacuated glass tubes are used because they help to reduce heat losses.

A heat transfer fluid (HTF) is circulated through the absorber tubes to collect the solar energy and transfer it to the steam generator or to the heat storage system, if any. Most existing parabolic troughs use synthetic oils as the heat transfer fluid, which are stable up to 400°C.New plants under demonstration use molten salt at 540°C either for heat transfer and/or as the thermal storage medium. High temperature molten salt may considerably improve the thermal storage performance.

IV.CONCLUSION

In Chhattisgarh state the direct solar radiations available is of the order 5.35kWhr/m^2/day for an average of 22 years as per NREL and 5.08 kWh/m^2/day for an average of 1 year as per data retrieved by RET Screen software. This shows that the climatic condition of the state is favorable for establishing solar power plant in the state with parabolic trough collector. The data retrieved also shows that the availability water resources and land resources, which will not put any hindrance in the working and operation of the solar power plant.

There are four technologies, which are primarily used for generation of electricity throughout the world i.e. photovoltaic cell, parabolic trough, dish Stirling, and central receiver system. Our present work is based on the parabolic trough collector system. The advantages of the system are high solar efficiencies, high steam temperature, high power availability and simple operation. Moreover, the cost of generation is cheaper than photo voltaic cell.

The solar thermal power plant using parabolic trough collector technology is a new concept in our country. The best thing with these solar plant using parabolic trough collector technology is that, it can be established at any location and of any generating capacity where the intensity of solar radiation is above 1600 kWh/m^2/year and the Chhattisgarh state has favorable climatic conditions for such projects.

The operation problems associated with the plant has to be studied in the state environment if any.

The components of the plant at present are imported from other countries. So the technology based on the requirement of these plants can be promoted in the country, which will help to combat the prices of these equipments and the process of installation. The manufacturing of component of parabolic trough collector technology can be promoted in the Chhattisgarh state also. So the indignation of the technology has high scope in country and as well as in the state.

To compare CSP's generating costs in relation to alternative technologies, and the values of CO2 mitigation.

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