Chapter 28
Utilization of Geo-Solar Hybrid System for Efficient Power Production in India

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Abstract Geothermal, Solar Energy combined can give a suitable working temperature for an Organic Rankine Cycle to be highly efficient. Solar energy is utilized to raise the temperature of the geothermal fluid (at 60–65 °C) up to 85 °C (minimum temperature for power generation through ORC). The paper focusses on major comparisons between combined Geothermal-solar energy source and conventional energy source. As CO_2 issues continue to degrade the environment and fossil fuels become more expensive, interest in low grade heat recovery has grown in the past few years. Hybrid Solar and Geothermal energy, as a clean, renewable, pollution-free and sustainable energy has great potential for the use of ORC systems.

28.1 Introduction

Numerous technical reasons are associated with a renewable geothermal-solar hybrid plant to make it a growing energy demand. The energy consumption in India is quite significant because of the resources consumption due to vast number of population for agriculture, residents, and industries purposes. Despite the increased power availability in India, the supply still continues to elude the demand [1].

The basis of writing this paper is the inability to produce power from the widely spread existence of low enthalpy geothermal reservoir in India. However, the utilization of low enthalpy geothermal resources in hybrid with the solar energy for electricity generation has not received sufficient attention so far [2]. Geothermal plants lose a lot of efficiency when operating in low temperatures where drilled holes yield steam at a temperature of around 100 °C [3]. Motivation to consider the hybrid power plants in geothermal power production is the decreasing production fluid temperature, flow rate, or both. Employing such carbon-free sources can help to combat climate change by lowering the extensity of fossil fuel combustion [4].

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28.2 Potential in India

Promising areas of geothermal energy are identified in Himalayan area, Puga, Manikaran, Chhumatang, Beas and Satlej field, Chamoli and Western India [5] as shown in Fig. 28.1. India has good potential for geothermal; the potential geothermal provinces can produce 10,600 MW of power [6].

Whereas, the installed capacity of solar energy projects in India is approximately 3000 MW [7] as shown in Fig. 28.2. Solar energy recently experienced a vast

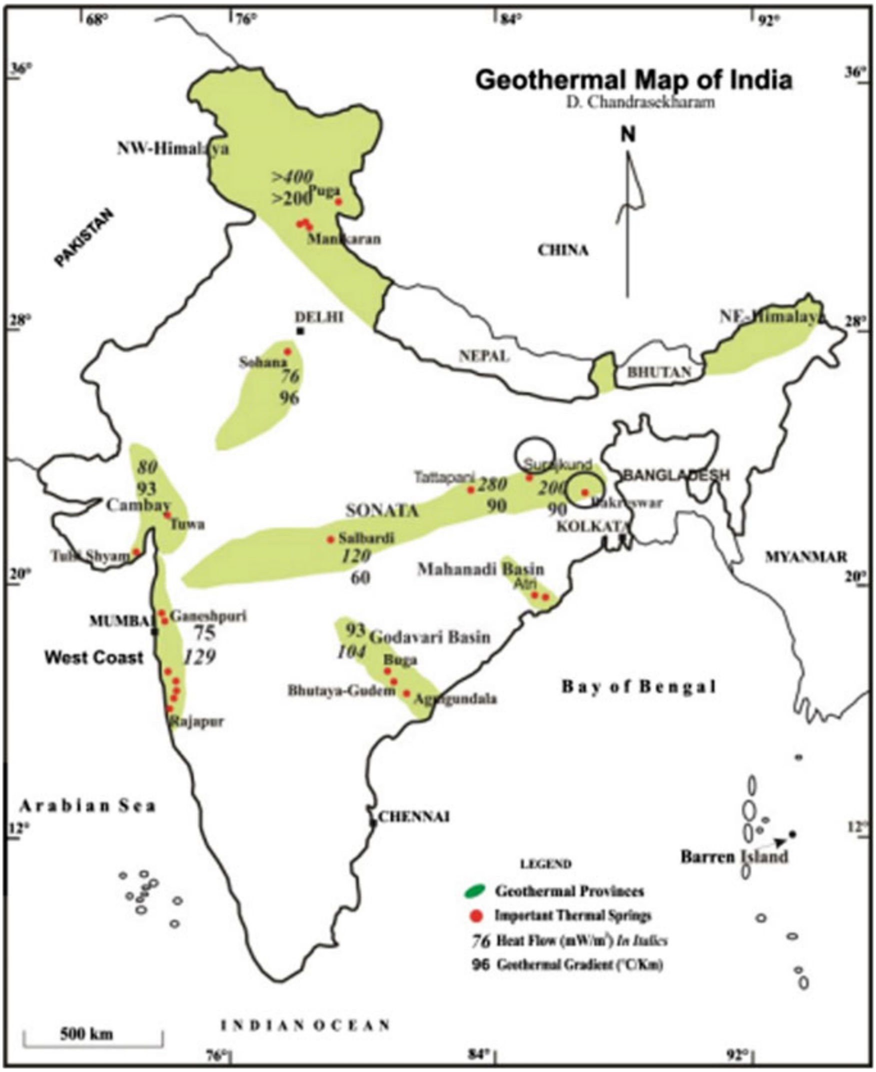

Fig. 28.1 Geothermal provinces in India (Chandrasekharam 2010)

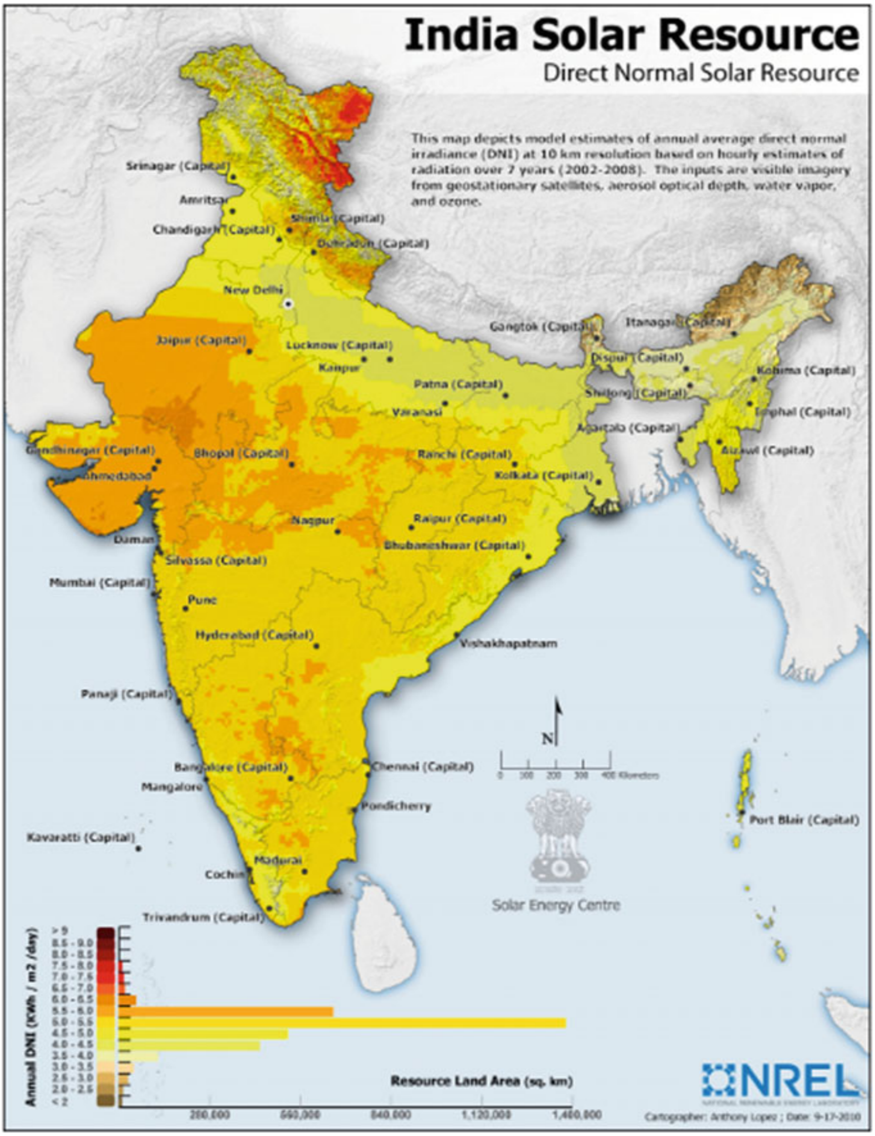

Fig. 28.2 Direct normal solar resource (National Renewable Energy Laboratory)

growth due to technological improvements resulting in cost reductions and government policies supportive of renewable energy development and utilization.

A low enthalpy geothermal resource means that the brine, or water from the Earth, comes out at a temperature between **100–150 °C**, which is considered too low for economic electricity production. By augmenting the thermodynamic quality of the brine with solar energy, higher performance should be possible. The goal is to find cost-effective hybrid power cycles that take advantage of the potential synergies of solar thermal and geothermal resources. There are certain areas in India like Tattapani, Cambay Basin, Mahanadi Basin, and Godavari Basin that have a geothermal reservoir and also get a good amount of sunlight. These are the areas where [8].

28.3 Methodology

The most popular configurations that have been analyzed are as follows [9]:

1. **Superheating the working fluid**: In order to achieve a greater exergy from working fluid and higher power generation, the heat from the sun is used to heat up the working fluid just before it enters the turbine.
2. **Brine recirculation**: a fraction of brine, coming from the heat exchangers, is heated using solar energy and then mixed again with the feed brine. The higher power generation is achieved with the reduction fresh brine requirement.
3. **Brine preheat**: this method results in increased brine enthalpy and higher power generation. Before entering the heat exchangers, the solar heat raises the geothermal brine temperature.
4. **Brine preheat/recirculation concept**: the temperature of both the geothermal brine entering the heat exchanger and the fraction of recirculating brine is raised. Hence the fresh brine requirement is reduced, the brine enthalpy increases and henceforth the power generated is higher.
5. **Brine cascade reheat concept**: the temperature of recirculating brine is raised at the exit of the heat exchanger. The temperature is raised up to original value and this is fed into the second heat exchanger. Hence, the same field produces the higher power.

The previous studies done indicate that the above different configurations are useful to enhance various parameters of the hybrid system. It was seen that in order to achieve the lowest per unit cost of electricity, the pre-heat and the superheat configurations are the most suited. Similarly, to achieve the highest maximum solar energy utilization, the cascade and reheat configuration are suitable.

28.4 Discussion

There are many common grounds on which one can point out the similarities between the geothermal and solar thermal systems. Some parameters on the basis of which the viability of both the systems can be analyzed are as follows [10].

- **Ability to Meet Demand Better**: Geothermal power plants, commonly use air-cooled condensers and hence there is a decrease in power produced during day. This is because of the increased ambient temperature. As a result the plant is not able to reject heat to the surroundings. The solar energy can be used to enhance the plant performance.

- **Boosting Power to Existing Plants**: solar thermal technology can take advantage of the existing infrastructure and hardware
- **Maximizing operational efficiency**: Higher renewable energy generation from the same geothermal technology.
- **Equipment Sharing**: Turbines, condenser and heat exchangers are common, hence can be jointly used
- **Financial preview**: Cost of electricity higher than geothermal plants but lower than solar thermal plants [11].
- **Incentives**: A hybrid system is qualified for more forms of economic support [11].

28.5 Conclusion

Geothermal energy is one of the emerging alternative for power generation as it can provide base load electricity [3]. Thermal efficiency of geothermal electric plants are in the range of 10–23% as heat or energy extraction limits the efficiency of the process [6]. Hybridizing a low enthalpy geothermal plant with a solar thermal energy conversion system increases the thermal efficiency; higher than the stand alone geothermal plant [12]. Thermal efficiency of the hybrid plant are always higher than the stand alone geothermal plant and less than the stand alone solar thermal plant. The cost of electricity generation from hybrid system is higher than geothermal plant but lower than the solar thermal plant [13].

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