Chapter 03

TECHNOLOGY

3.1. Solar Thermal Power

The concentrating solar power (CSP) technologies can be divided into two general categories. The first is Concentrating Solar Thermal (CST), which includes those concentrating the sun's energy on a thermal conductor and then using that heat to move an engine or a turbine. These usually take the form of a large power plant and can concentrate using mirrors in a line or around a point. The mirror array can be concave or flat - concentrating from 80 suns for the linear arrays (including trough systems and Linear Fresnel Reflector systems (LFR)) to over 1500 suns on the point arrays (including tower and dish-engine systems), with corresponding temperatures and variations of technology components to convert the heat into useful electricity. Because they generate heat, CST systems have relatively more costs in the operation and maintenance versus PV systems, but create the advantage of potentially storing the heat or using it in a hybrid configuration to make the power dispatchable; a significant advantage in integrating the power into main electrical grid. Because trough and power tower systems collect heat to drive central turbine-generators, they are best suited for large-scale plants: 50 MW or larger. Trough and tower plants, with their large central turbine generators and balance of plant equipment, can take advantage of economics of scale for cost reduction, as cost per kW goes down with increased size [2].

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Alternatively, Concentrating Photovoltaic (CPV) technologies concentrate the sun's energy directly onto high efficiency PV materials to directly create electricity. These technologies use both mirrors and lenses and can be deployed in configurations that range from large systems to medium systems [2].

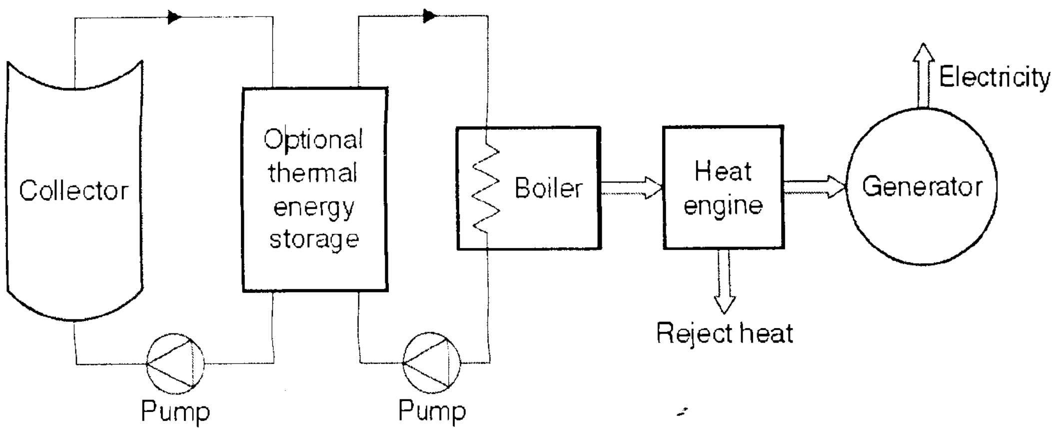

Figure 3.1: A schematic diagram of solar thermal power plant

3.1.1. Power Towers (Central Receiver Systems)

Power towers or central receiver systems use thousands of individual sun-tracking mirrors, called heliostats, to reflect solar energy onto a receiver located atop a tall tower. The receiver collects the sun's heat in a heat transfer fluid (eg. molten salt) that flows through the receiver. This is then passed optionally to storage and finally to a power conversion system, which converts the thermal energy into electricity and supplies it to the grid. Therefore, a central receiver system is composed of five main components: heliostats, including their tracking system; receiver; heat transport and exchange; thermal storage; and controls [3]. In many solar power studies, it has been observed that the collector represents the largest cost in the system; therefore, an efficient engine is justified to obtain maximum useful conversion of the collected energy. The power tower plants are quite large, generally 10 MWe or more, while the optimum sizes lie between 50–400 MW. It is estimated that power towers could generate electricity at around US$ 0.055/kWh by 2020 [4].

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The salt's heat energy is used to make steam to generate electricity in a conventional steam generator, located at the bottom of the tower. The storage system retains heat efficiently, so it can be stored for hours or even days before being used to generate electricity. The storage medium can be steam, molten salt, liquid sodium etc.

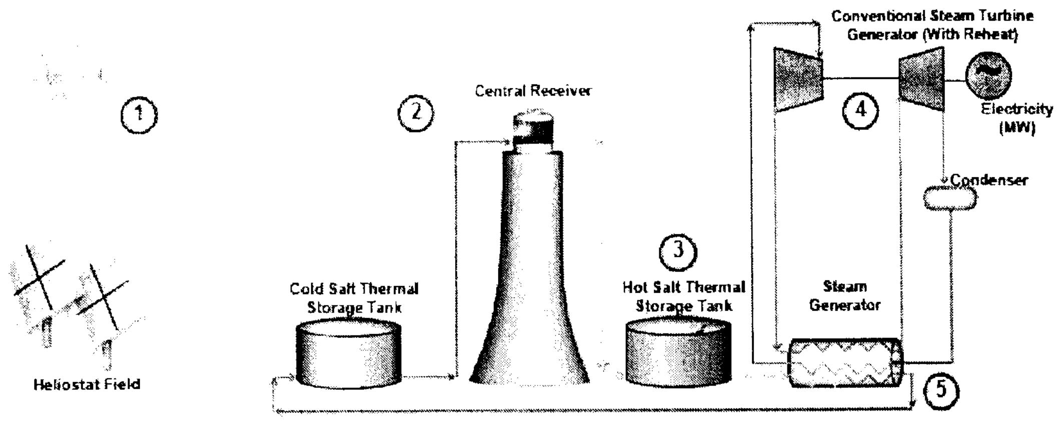

Figure 3.2: A simple diagram of a power tower

The heliostats reflect solar radiation to the receiver at the desired flux density at minimal cost. A variety of receiver shapes have been considered, including cylindrical receivers and cavity receivers. The optimum shape of the receiver is a function of radiation intercepted and absorbed thermal losses, cost, and design of the heliostat field. For a large heliostat field, a cylindrical receiver is best suited to be used with Rankine cycle engines. Another possibility is to use Brayton cycle turbines, which require higher temperatures (of about 1000°C) for their operation; in this case, cavity receivers with larger tower height to heliostat field area ratios are more suitable [5].

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3.1.2. Parabolic Troughs

A parabolic trough solar collector is designed to concentrate the sun's rays via parabolic curved solar reflectors onto a heat absorber element – a "receiver" – located in the optical focal line of the collector. The solar collectors track the sun continuously. The key components of a parabolic trough power plant are mirrors, receivers and turbine technology. The receiver consists of a specially coated absorber tube which is embedded in an evacuated glass envelope. The absorbed solar radiation warms up the heat transfer fluid flowing through the absorber tube to almost 400°C. This is conducted along a heat exchanger in which steam is produced, which then generates power in the turbines. The output of the power plant is between 25 MW and 200 MW of electricity, at its peak. Due to the presence of the storage systems, the plant can keep working at a constant load [5].

3.1.3. Dish/Engine Systems

In solar dish/engine systems, parabolic dishes capture the solar radiation and transfer it to a Stirling engine – an engine which uses external heat sources to expand and contract a fluid – placed in the focus of the parabolic dish. This approach is particularly suited for decentralized electricity generation [5].

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