Electrical Power Engineering

Solar Power:

This power is based on the ability of certain materials to convert the radiant energy of the sun into electrical energy. The total amount of solar energy that lights a given area is known as ***irradiance*** (***G***) and it is measured in ***watts per square meter*** (***W/m***2). The instantaneous values are normally averaged over a period of time, so it is common to talk about total irradiance per hour, day or month. Solar Power is characterized by:

- The fuel is free.
- There are no moving parts to wear out, break down or replace.
- Only minimal maintenance is required to keep the system running.
- The systems are modular and can be quickly installed anywhere.
- It produces no noise, harmful emissions or polluting gases.

Solar Power can be classified into two groups:

(i) Photovoltaic Energy (PV).

(ii) Solar Thermal Power.

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i) Photovoltaic Energy (PV):

Photovoltaic is a marriage of two words: “photo”, meaning light, and “voltaic”, meaning electricity. Photovoltaic technology, the scientific term used to describe what we use to convert solar energy into electricity, generates electricity from light. We use a semi-conductor material which can be adapted to release electrons, the negatively charged particles that form the basis of electricity. The most common semi-conductor material used in photovoltaic (PV) cells is silicon, an element most commonly found in sand.

All PV cells have at least two layers of such semi-conductors, one positively charged and one negatively charged. When light shines on the semi-conductor, the electric field across the junction between these two layers causes electricity to flow, generates DC current. The greater the intensity of the light, the greater the flow of electricity. A photovoltaic system therefore does not need bright sunlight in order to operate. It also generates electricity on cloudy days by a rationing of the energy output that depends on the density of the clouds. Due to the reflection of sunlight, days with slight cloud can even result in higher energy yields than days with a completely cloudless sky. Two types of PV technology are currently available in the market:

(a) crystalline silicon-based PV cells and (b) thin film technologies made out of a range of different semi-conductor materials

Photovoltaic system components

A basic photovoltaic system consists of four main components: the ***solar panel***, the ***batteries***, the ***regulator***, and the ***load***. The panels are responsible for collecting the energy of the sun and generating electricity. The battery stores the electrical energy for later use. The regulator ensures that panel and battery are working together in an optimal fashion. The load refers to any device that requires electrical power. See Figure 4.

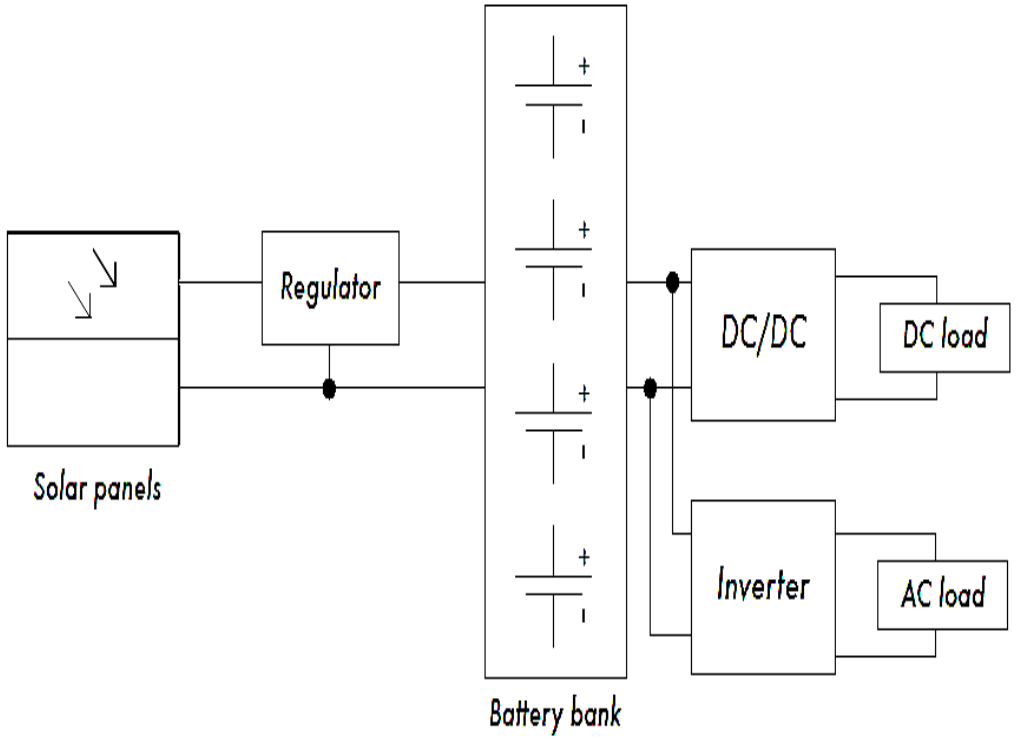
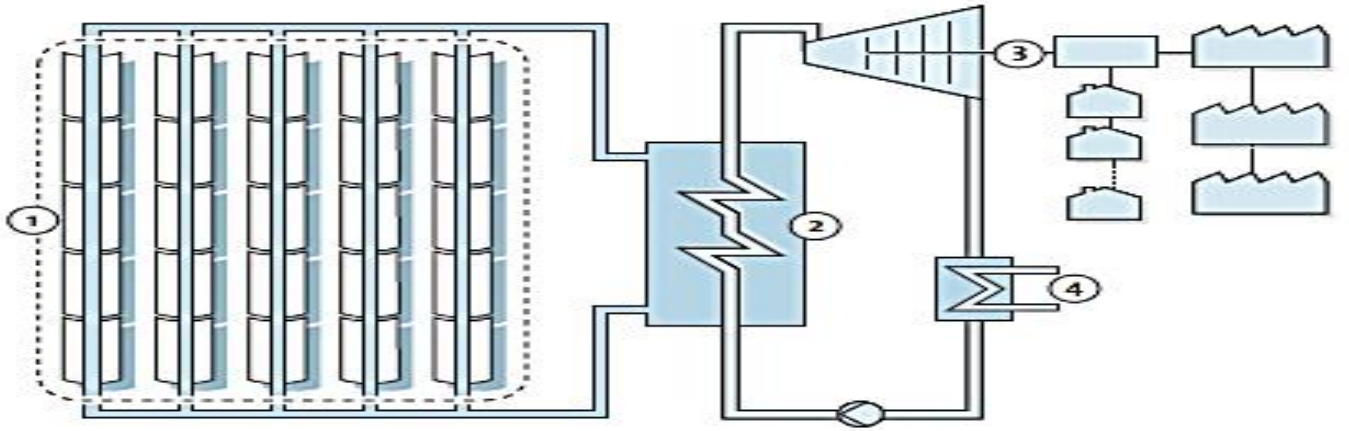


Figure (4)

ii) Solar Thermal Power:

Solar thermal technology uses solar heat, which can be used directly for either thermal or heating application or electricity generation. Accordingly, it can be divided into two categories: (i) solar thermal non-electric and (ii) solar thermal electric. The former includes applications as agricultural drying, solar water heaters, solar air heaters, solar cooling systems and solar cookers, the latter refers to use of solar heat to produce steam for electricity generation, also known as concentrated solar power (CSP). Four types of CSP technologies are currently available in the market: Parabolic Trough, Fresnel Mirror, Power Tower and Solar Dish collector.

Parabolic Trough Power Plant



1. Solar field, 2. Heat exchanger,
3. Steam turbine and generator,
4. Condenser

Figure (5)

1- Troughs or parabolic cylinders concentrate the solar rays on long heat collector pipes (moving with the troughs). Current plants use some synthetic oil as heat transfer fluid. Alternative concepts include direct steam generation, and the use of molten salts as transfer fluid. Troughs represent the most mature technology and the bulk of current projects; some have significant storage capacities. Their solar to electricity conversion can reach than 15% (annual mean value).

2- Linear Fresnel Reflectors (LFR) use slightly curved mirrors reflecting the solar rays on a long, fixed receiver. Investment costs per mirror area are lower but the annual efficiency remains below 10%. Saturated steam is directly generated in the receiver tubes.

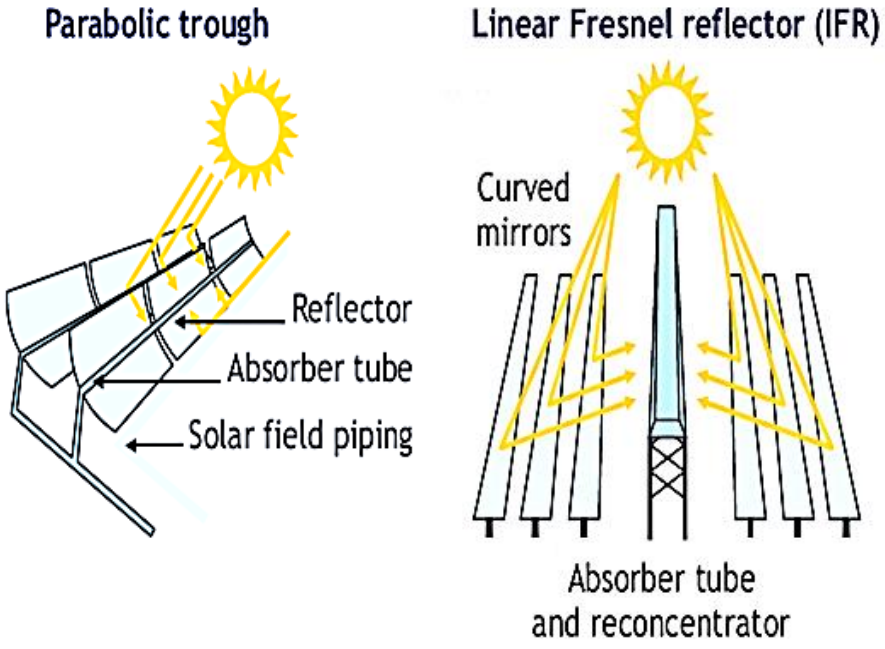


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Figure (8)

3- Towers or Central Receiver Systems (CRS), concentrate the sunrays on top of a fixed tower. This allows for higher temperatures and efficiencies than linear systems. Towers can generate saturated or superheated steam directly, or use molten salts, air or other media as heat transfer fluids. Solar fields of thousands of small heliostats are proposed as a cheap alternative to state-of-the-art field design.

4- Parabolic Dishes concentrate the sunrays on a focal point that is moving together with the dish tracking the sun, offering the highest optical efficiency on much smaller capacities (typically tens of kW). Mass production may allow them to compete with the larger systems, which benefit from economies of scale. Dish systems are less compatible with thermal storage than other CSP technologies, but require no cooling water.

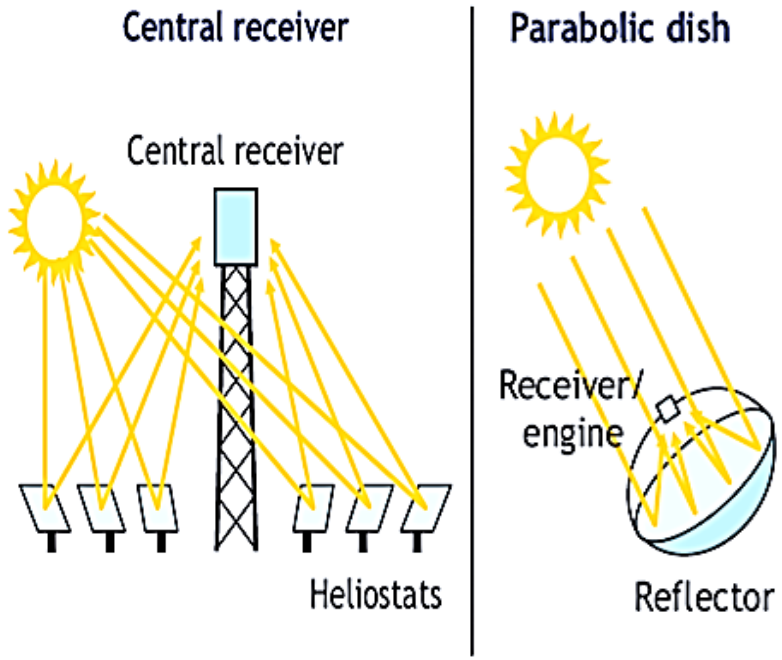

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Figure (9)

Thanks