



# ENE 101 – Introduction to Energy Engineering

## WEEK 9

### Energy Consumption and Conversion Continue:

- **Solar Energy Technology**

There are two main ways of generating energy from sun:

<b>Photovoltaic (PV)</b> Converts sunlight directly into electricity. 	<b>Concentrating Solar Thermal (CST)</b> Generate electricity indirectly 
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Solar thermal power generation systems use mirrors to collect sunlight and produce steam by solar heat to drive turbines for generating power. This system generates power by rotating turbines like thermal and nuclear power plants, and therefore, is suitable for large-scale power generation.

- **Solar Thermal Energy Conversion**

- ✚ Solar thermal energy applications such as space and water heating have been known for a long time.

**Solar Water-Heating Systems** represent the most common application of solar energy at the present time. Small systems are used for domestic hot water applications while larger systems are used in industrial process heat applications.

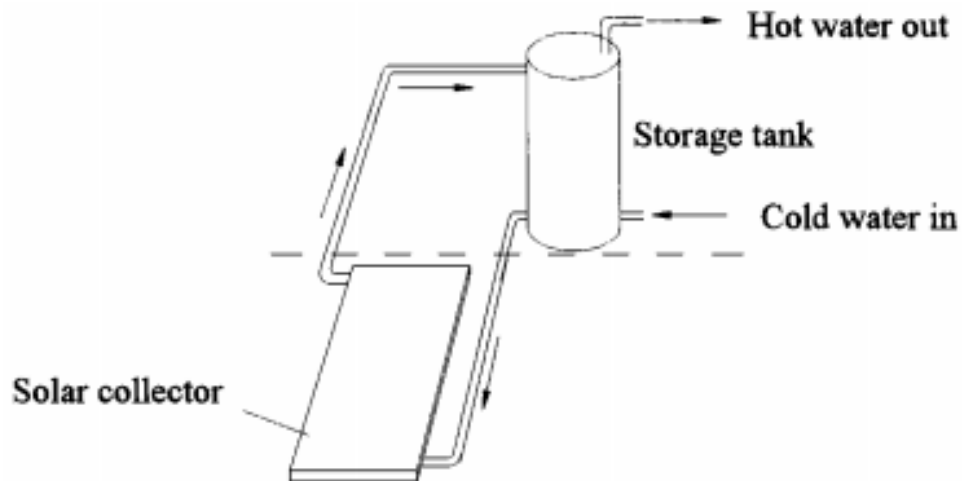
Researchers over the past few decades have developed a number of additional solar thermal applications, such as

- ✚ industrial process heat,
- ✚ refrigeration and air-conditioning,
- ✚ drying and curing of agricultural products,
- ✚ electric power production by solar thermal conversion.

Unlike photovoltaic technology, which converts solar radiation directly into electricity, the Ivanpah facility generates heat. More than 170,000 mirrors will gather tremendous amounts of sunlight and focus it on three towers filled with water, raising temperatures to more than 1,000 degrees Fahrenheit and producing steam that spins turbines that generate electricity.

There are basically two types of water-heating systems:

- ✚ **natural circulation or passive solar system** : A system requires no equipment, like when heat builds up inside your car when its left parked in the sun. For example; Thermal Chimneys, thermosiphon

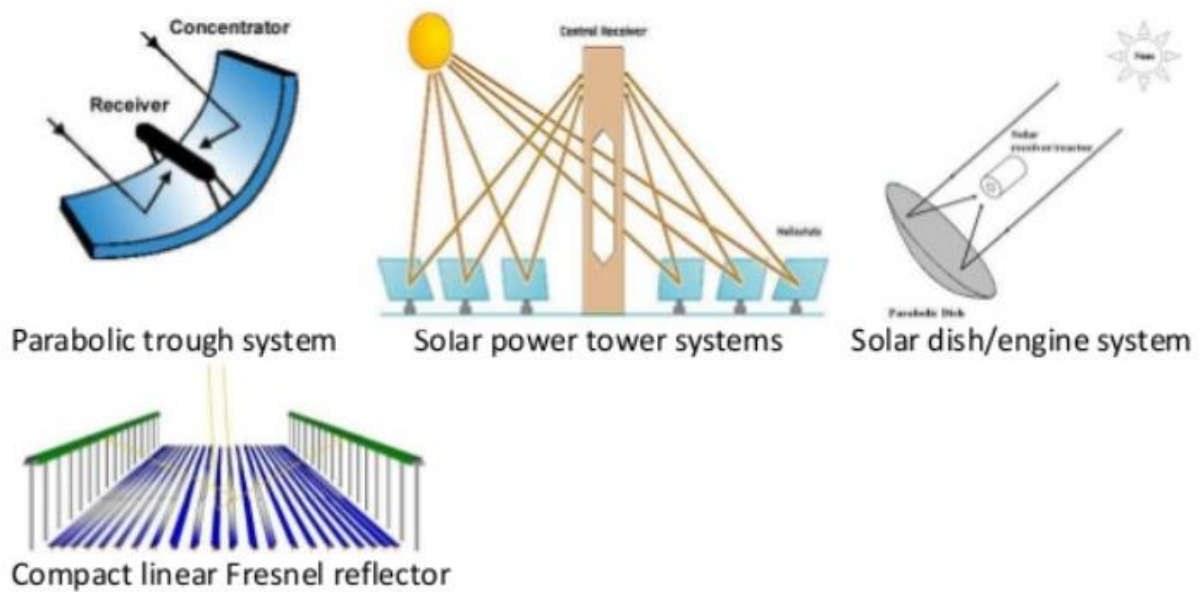


**Figure 1.** Schematic of a thermosiphon solar water-heating system.

It is also called a **thermosyphon** or **passive solar water heater** because it does not require a pump to circulate water. The storage tank is located above the collector. When the water in the collector gets heated, it rises into the tank, because of density change, setting up a circulation loop.

- ✚ **forced circulation or active solar system** : An active system requires some way to absorb and collect solar radiation and then store it. For example; solar power plants. Mirrors reflect and concentrated sunlight. Receivers collect that solar energy convert it into heat energy. A generator can then be used to produce electricity from this heat energy.

- **Types of Solar Thermal Power Plants**



The instantaneous efficiency of a collector is given by

$$\eta = \frac{\text{Useful energy collected}}{\text{Incident solar energy}} = \frac{Q_u/A}{I}$$

where

$$Q_u = mC_p(T_o - T_i)$$

$A$  = area of the collector,

$I$  = incident solar energy per unit area,

$m$ ,  $C_p$ ,  $T_i$ , and  $T_o$  are the mass flow rate, specific heat, and inlet and outlet temperatures of the heat-transfer fluid.

- **Pros and Cons of Thermal Energy**

### **Pros**

No Fuel cost

Predictable, 24/7 power

No pollution and Global Warming Effects

Using Existing Industrial Base

### **Cons**

High Cost

Future Technology has a high probability of making CSP Obsolete

Ecological and Cultural Issues

Limited Locations and Size Limitations

Long Gestation Time leading to cost overruns

### **Major challenges**

Installation cost and energy storage

The costs are still far higher than fossil fuel plants based on units of energy produced.

The hot water storage products are often stretched to their limits.

Alternatives could be phase change materials or thermochemical materials.

- **Defining Terms**

**Forced circulation or active solar system:** A solar thermal system that uses active means, such as pumps, for fluid flow and heat transfer.

**Glazing:** A material used in a solar collector that transmits short-wavelength solar radiation and blocks longer-wavelength reradiation from the absorber plate.

**Natural circulation passive solar system:** A solar thermal system that uses natural means, such as the thermosyphon effect, for fluid flow and heat transfer.

**Salt gradient solar pond:** A solar pond that uses high salt concentration in the lowest

layer and a concentration gradient in the middle layer to make those layers nonconvective.

**Selective surface:** A surface that has high absorptance in short wavelengths and low emittance in longer wavelengths.

**Solar hybrid combined cycle:** A hybrid of solar and natural gas turbine combined cycle.

**Solar thermal collector:** A solar collector that absorbs sunlight and converts it to heat.

- **Geothermal Energy Technology**

Geothermal power plants use hydrothermal resources that have both water (hydro) and heat (thermal).

Geothermal power plants require high-temperature (300°F to 700°F) hydrothermal resources that come from either dry steam wells or from hot water wells.

People use these resources by drilling wells into the earth and then piping steam or hot water to the surface.

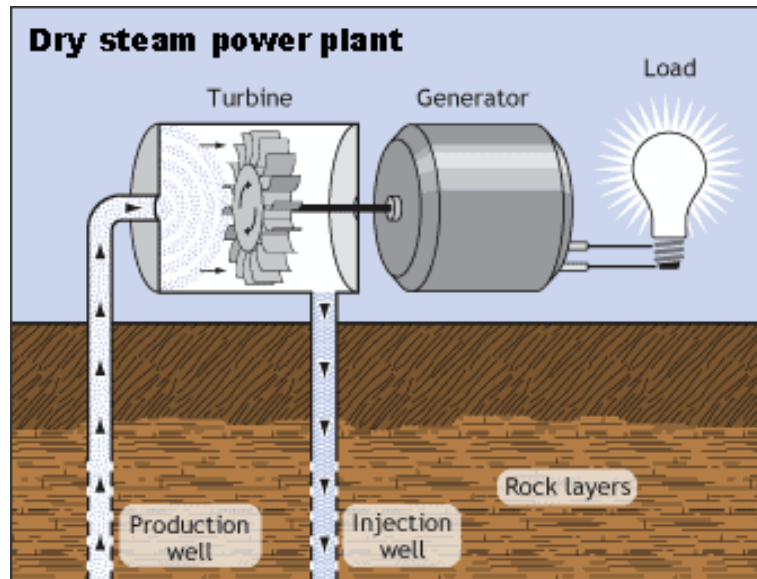
The hot water or steam powers a turbine that generates electricity. Some geothermal wells are up to two miles deep.

There are three basic types of geothermal power plants:

- ✚ **Dry steam plants**
- ✚ **Flash steam plants**
- ✚ **Binary cycle power plants**

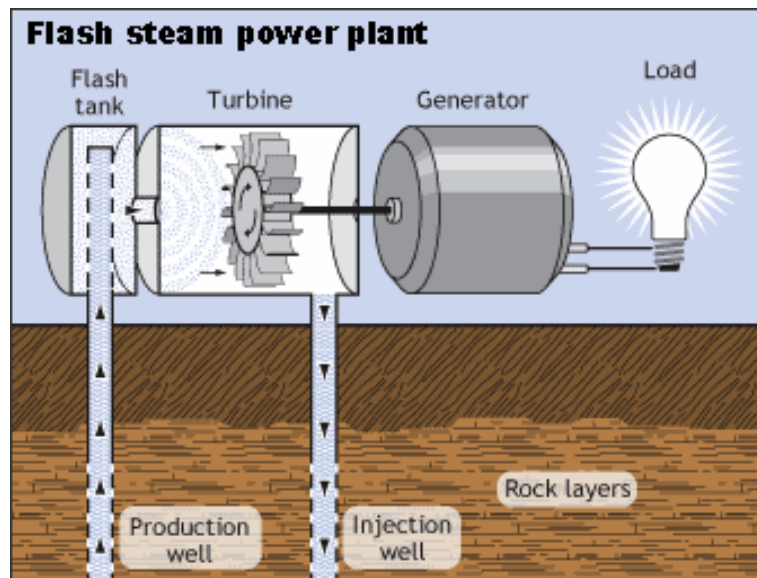
- **Dry Steam Plants**

Dry steam plants use steam directly from a geothermal reservoir to turn generator turbines. The first geothermal power plant was built in 1904 in Tuscany, Italy, where natural steam erupted from the earth.



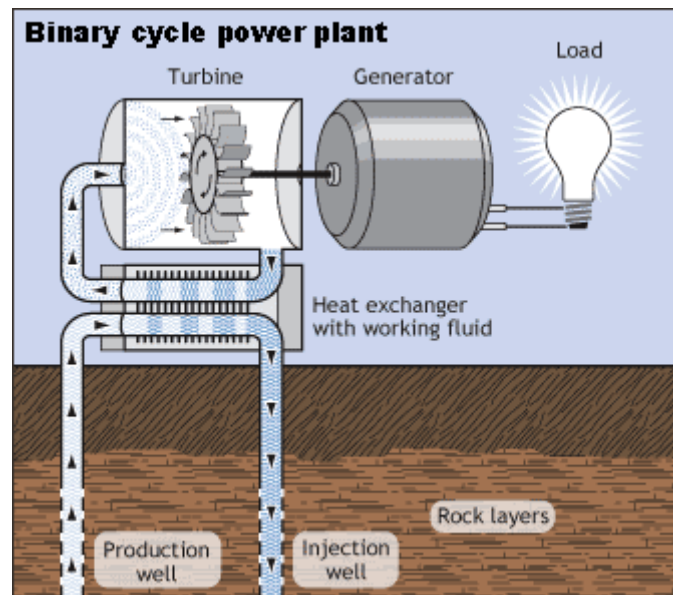
- **Flash steam plants**

Flash steam plants take high-pressure hot water from deep inside the earth and convert it to steam to drive generator turbines. When the steam cools, it condenses to water and is injected back into the ground to be used again. Most geothermal power plants are flash steam plants.



- **Binary cycle power plants**

**Binary cycle power plants** transfer the heat from geothermal hot water to another liquid. The heat causes the second liquid to turn to steam, which is used to drive a generator turbine.



**References:**

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