Course: Sustainable Energy Technology 1
12110598

Title: PV TECHNOLOGY –L13

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Concentrating Solar Power Systems (CSP)

Concentrating solar power (**CSP**) plants use mirrors to **concentrate** the sun's **energy** to drive traditional steam turbines or engines that create **electricity**.

The **thermal energy concentrated** in a **CSP plant** can be stored and used to produce **electricity** when it is needed, day or night.

Parabolic Trough

Parabolic trough systems use curved mirrors to focus the sun's energy onto a receiver tube that runs down the center of a trough. In the receiver tube, a high-temperature heat transfer fluid (such as a **synthetic oil**) absorbs the sun's energy, reaching temperatures of about **400°C or higher**, and passes through a heat exchanger to heat water and produce steam. The steam drives a conventional steam turbine power system to generate electricity. A typical solar collector field contains hundreds of parallel rows of troughs connected as a series of loops, which are placed on a north-south axis so the troughs can track the sun from east to west. Individual collector modules are typically 5-7 m tall **and 100-150 m long**.

Concentrating Solar Power Systems (CSP)

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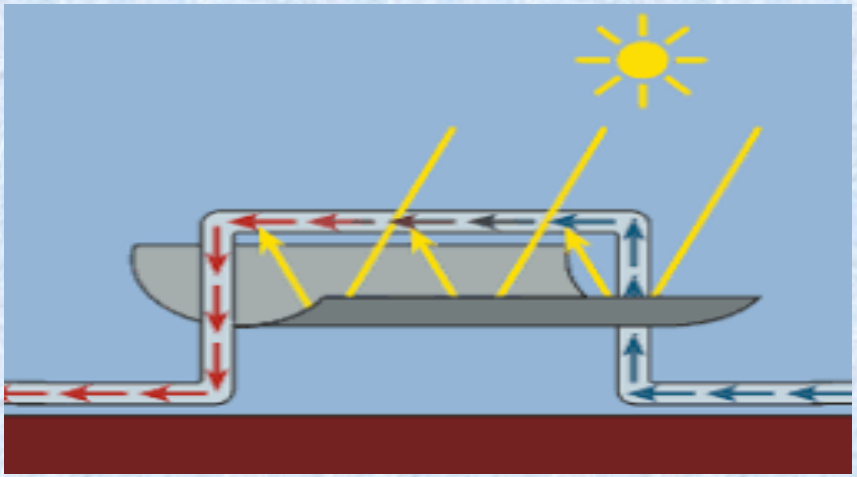
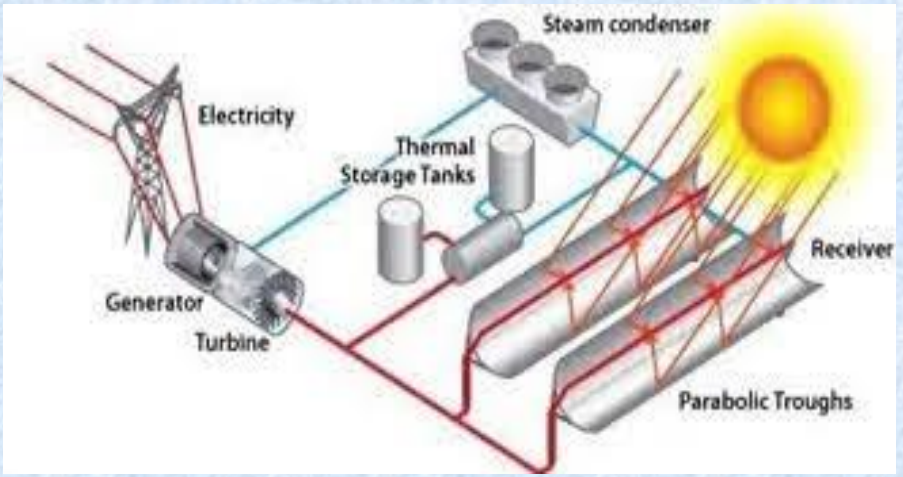
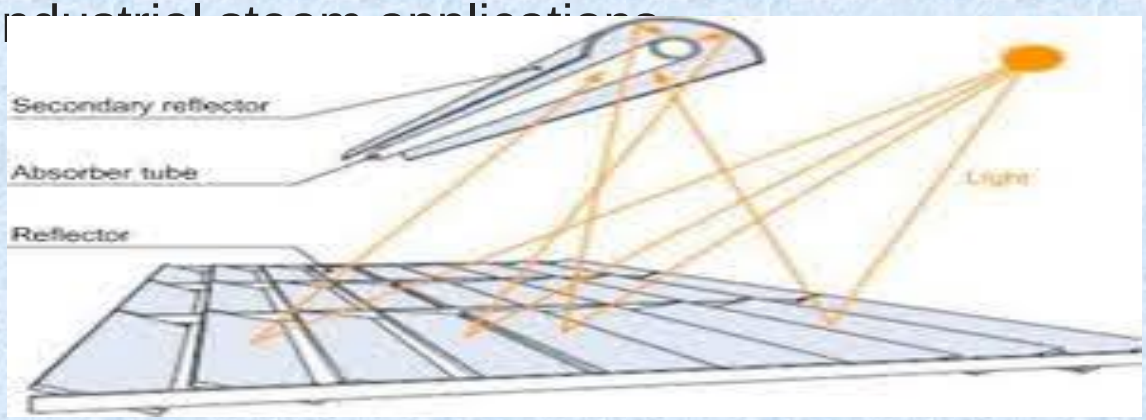


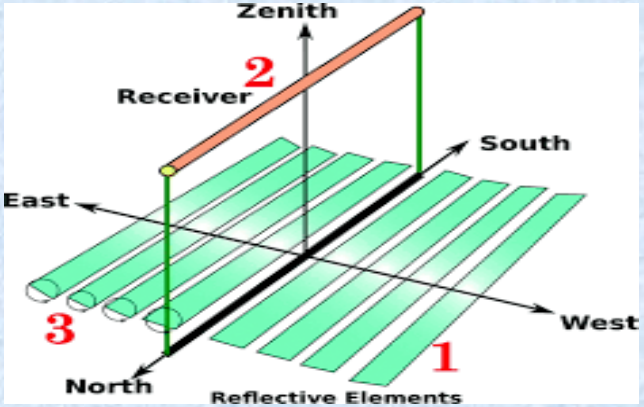


Concentrating Solar Power Systems (CSP)

Compact Linear Fresnel Reflector

CLFR uses the principles of **curved-mirror trough systems**, but with long parallel rows of **lower-cost flat mirrors**. These modular reflectors focus the sun's energy onto elevated receivers, which consist of a system of tubes through which water flows. The concentrated sunlight boils the water, generating high-pressure steam for direct use in power generation and industrial steam applications.





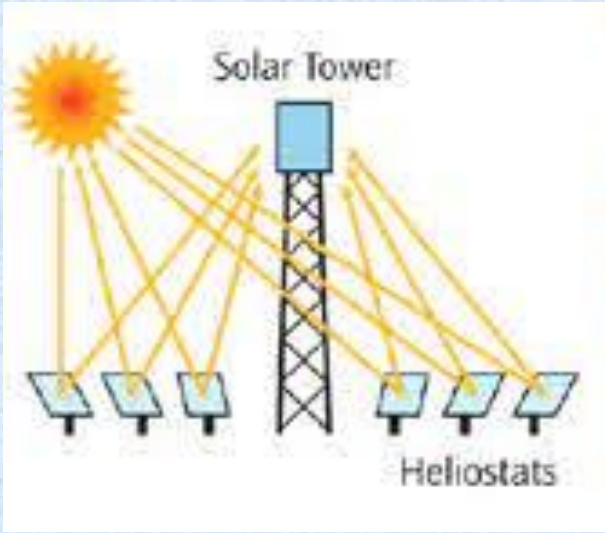
Concentrating Solar Power Systems (CSP)

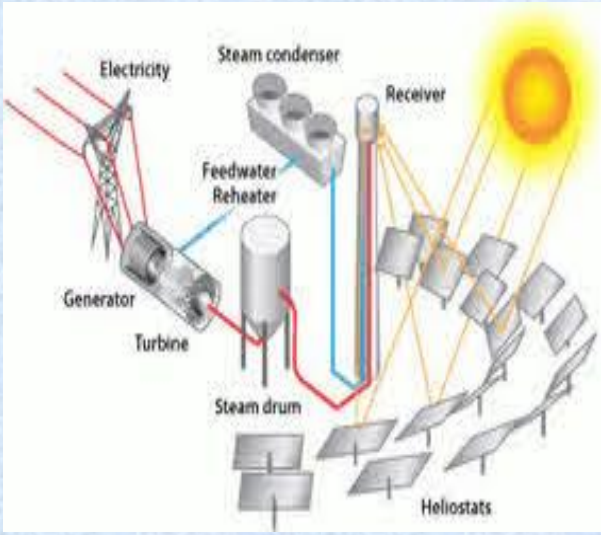
Power Tower

Power tower systems use a central receiver system, which allows for higher operating temperatures and thus greater efficiencies.

Computer-controlled mirrors (called heliostats) track the sun along two axes and focus solar energy on a receiver at the top of a high tower. The focused energy is used to heat a transfer fluid (over 500° C) to produce steam and run a central power generator.

Energy storage can be easily and efficiently incorporated into these projects, allowing for 24 hour power generation.





Concentrating Solar Power Systems (CSP)

Dish-Engine

Mirrors are distributed over a parabolic dish surface to concentrate sunlight on a receiver fixed at the focal point. In contrast to other CSP technologies that employ steam to create electricity via a turbine, a dish-engine system uses a working fluid such as hydrogen that is heated up to 650° C in the receiver to drive a engine. Each dish rotates along two axes to track the sun..

Concentrating Solar Power Systems (CSP)

EXAMPLE:

A station using solar power towers over an area of 14.2 km2 generates about 392 MW. It consists of 173,500 heliostats (mirror) and three power towers.

It supplies about 100,000 home.

It uses molten Salt Power Tower facility with energy storage.

Solar Inverters

The importance of inverters in solar installations

Inverters are an important part of any solar installation; they are the brains of the system.

The main job is to convert DC power produced by the solar array into usable AC power.

Inverters enable monitoring so installers and owners can see how a system is performing.

Inverters can also provide diagnostic information to help O&M crews identify and fix system issues.

These important components are increasingly taking on decision-making and control functions to help improve grid stability and efficiency.

With the growth of solar and storage, inverters are also taking on responsibility for battery management. Here is a look at some different types of solar inverters.

Solar Inverters

Types of solar inverters

1- String inverters

Solar panels are installed in rows, each on forms a string.

Multiple strings are connected to one string inverter.

Each string carries the DC power generated from the solar panels to the string inverter where it is converted into usable AC power consumed as electricity.

Depending on the size of the installation, one may have several string inverters each receiving DC power from number of strings.

They are good for installations without shading issues and in which panels are positioned on a single plane so do not face different directions.

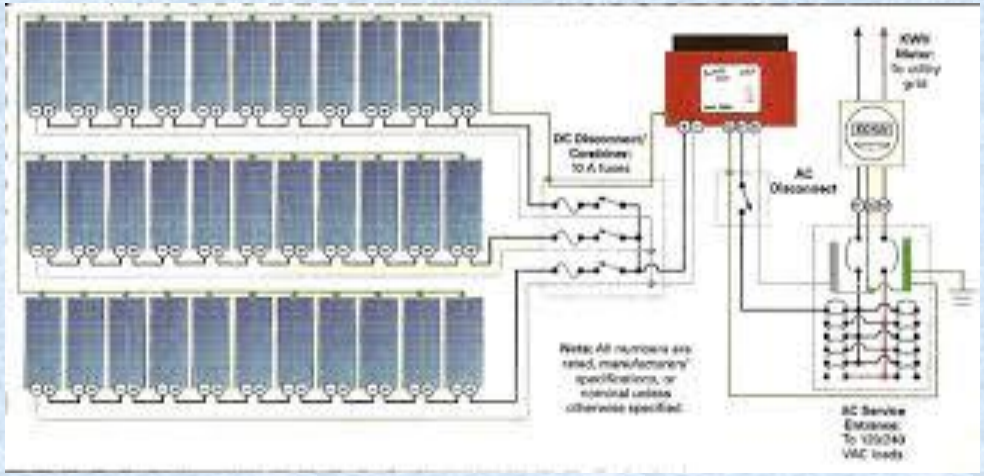
If an installation uses string inverters and even one panel is shaded for a portion of the day reducing its performance, the output of every panel on the string is reduced to the struggling panels' level.

String inverters are commonly used in residential and commercial applications

Solar Inverters

Types of solar inverters

1- String inverters



Solar Inverters

Types of solar inverters

2- Power optimizers integrated with string inverters

Power optimizers are module-level power electronics meaning they are installed at the module level, so each solar panel has one.

Some panel manufacturers integrate their products with power optimizers and sell them as one solution known as a **Smart Module**.

Power optimizers are able to mitigate effects of shading that string inverters alone cannot.

They condition the DC electricity before sending it to the inverter, which results in a higher overall efficiency than using a string inverter alone.

Power optimizers offer similar benefits as **microinverters**, but tend to be less expensive and so can be a good option between using strictly string inverters or microinverters.

Solar Inverters

Types of solar inverters

3- Central inverters

Central inverters are similar to string inverters but they are much larger and can support more strings of panels.

Instead of strings running directly to the inverter, as with string models, the strings are connected together in a common combiner box that runs the DC power to the central inverter where it is converted to AC power.

Central inverters require fewer component connections, but require a pad and combiner box.

They are best suited for large installations with consistent production across the array.

Solar Inverters

Types of solar inverters

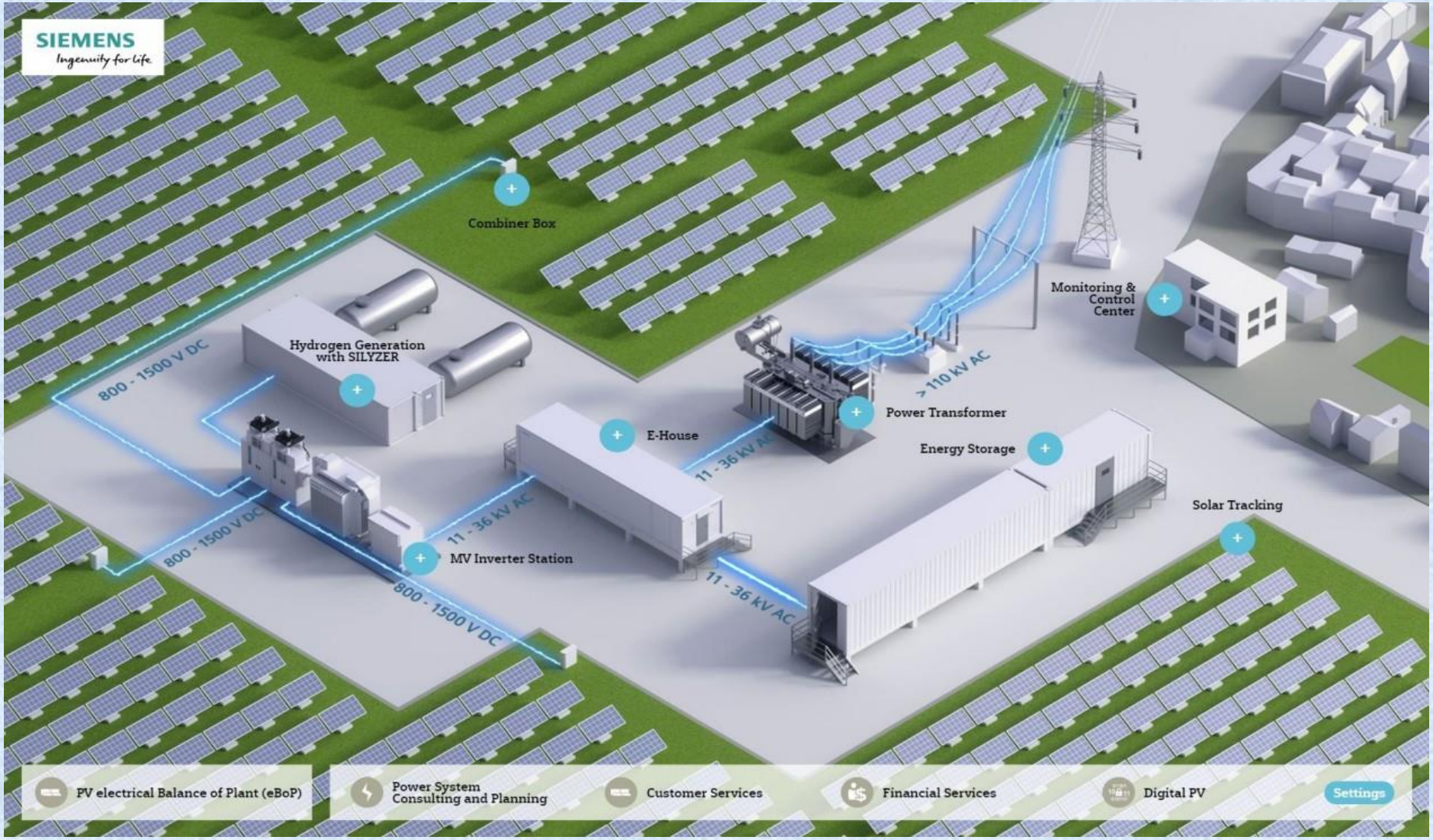
Central inverters

The 5MVA, MV-inverter station is a comprehensive plug-and-play solution with highest power density for extra-large PV plants.

Solar Inverters

Types of solar inverters

Central inverters



Solar Inverters

Types of solar inverters

4- Microinverters

Microinverters are also becoming a popular choice for residential and commercial installations. Like power optimizers, microinverters are module-level electronics so one is installed on each panel.

However, unlike power optimizers which do no conversion, microinverters convert DC power to AC right at the panel and so don't require a string inverter.

Also, because of the panel-level conversion, if one or more panels are shaded or are performing on a lower level than the others, the performance of the remaining panels will not be jeopardized.

Microinverters also monitor the performance of each individual panel, while string inverters show the performance of each string.

This makes microinverters good for installations with shading issues or with panels on multiple planes facing various directions.

Systems with microinverters can be more efficient, but these often cost more than string inverters.

Microinverters can also be sold through panel manufacturers already integrated into the panel, similar to Smart Modules but instead known as an **AC Module**. This makes installation easier and cheaper.

Solar Inverters

Types of solar inverters

Microinverter

Microinverters and power optimizers are two inverter technologies that allow the PV array to better deal with system shading. Both will help maximize the system power output, with the tradeoff of higher cost.