Lecture Notes

Selected Topics in Power Engineering

Code: CECE455

Level: Four

Points: 100 = 25+15+60

COURSE OUTLINE

Course consists mainly of two main parts:

Part 1: Solar Energy

Part 2: Wind Energy

Part One: Solar Energy

1- Introduction to Solar Energy
2- What is a Solar Thermal System?
3- What is a Solar Photovoltaic (PV) System?
4- How does a Solar PV System Work?
5- Types of Solar PV System
6- What are the benefits of PV System?
7- Components of Solar PV System
8- Solar Panel Types
9- Solar Characteristics
10- Charger Controller
11- Battery
12- Inverter
13- Off-Grid PV System Design
14- Design and Sizing of PV System
15- Applications of PV System

Fig. : Home PV System (see video 1.MP4 … 10MB)

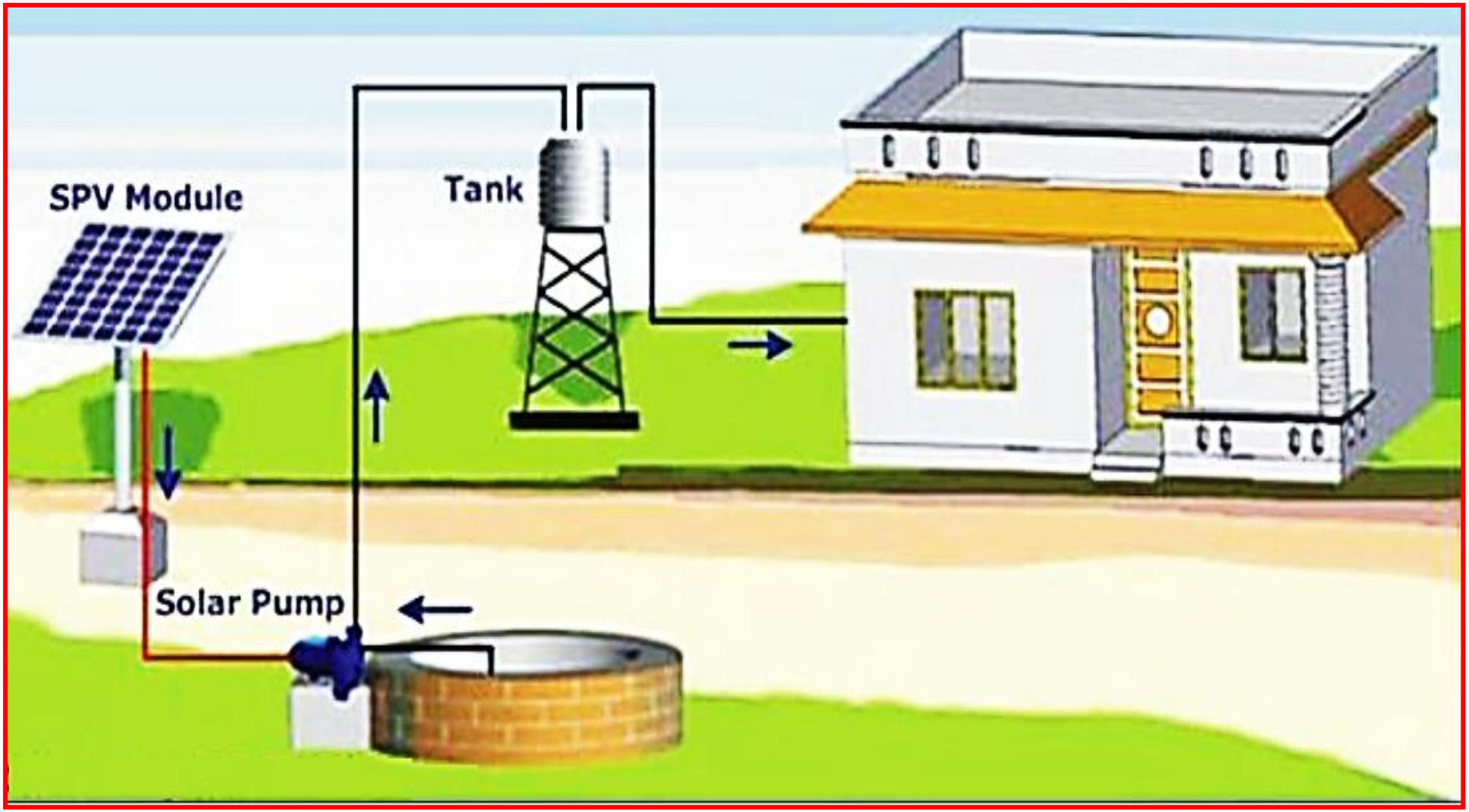


Fig. : Solar Pumping System

The Energy in the Universe

- The total amount of energy in the universe is constant. Energy can neither be created nor destroyed; it can only be transformed from one state to another.
- Indeed, the sustainable economic growth of a country may be possible only by the well-planned and efficient use of fossil fuel and locally available natural resources such as solar energy, wind, hydro, and biomass. This improves the quality of everyone's lives on planet Earth.
- Energy, the environment, and economic development of a country are closely related.

Renewable Energy Sources

Table 1.2 Renewable forms of energy

Energy	Percent of renewable resources	Product
Bio mass	Burning of plant materials and animal wastes	Heat and gas
Hydro power	Water flowing from higher to lower elevations through dams	Electricity
Wind	Capture of wind by turbines	Electricity
Geothermal	Tapping steam and hot water from the Earth's mantle	Heat and electricity
Solar	Absorbing and storing heat from the Sun	Heat and electricity
Emerging technologies		
Hydrogen fuels	Burning hydrogen gas	Power for movement
Nanotechnology	Using the unique properties of materials on the size scale of molecules or atoms	Electricity
Ancient technologies		
Wind	Water wheels, dams, weight	Power motion
Water	Windmills, sails	Power motion
Movement(kinetic energy)	Animals, human exertion	Power motion

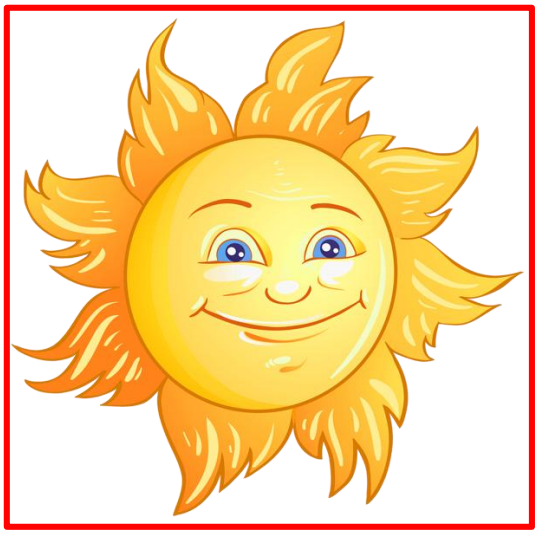
Traditional Sources of Energy

1- Natural Gas	2- Crude oil	3- Coal
		

All these energy sources that we use in our industrial age are exhaustible.

Solar Energy

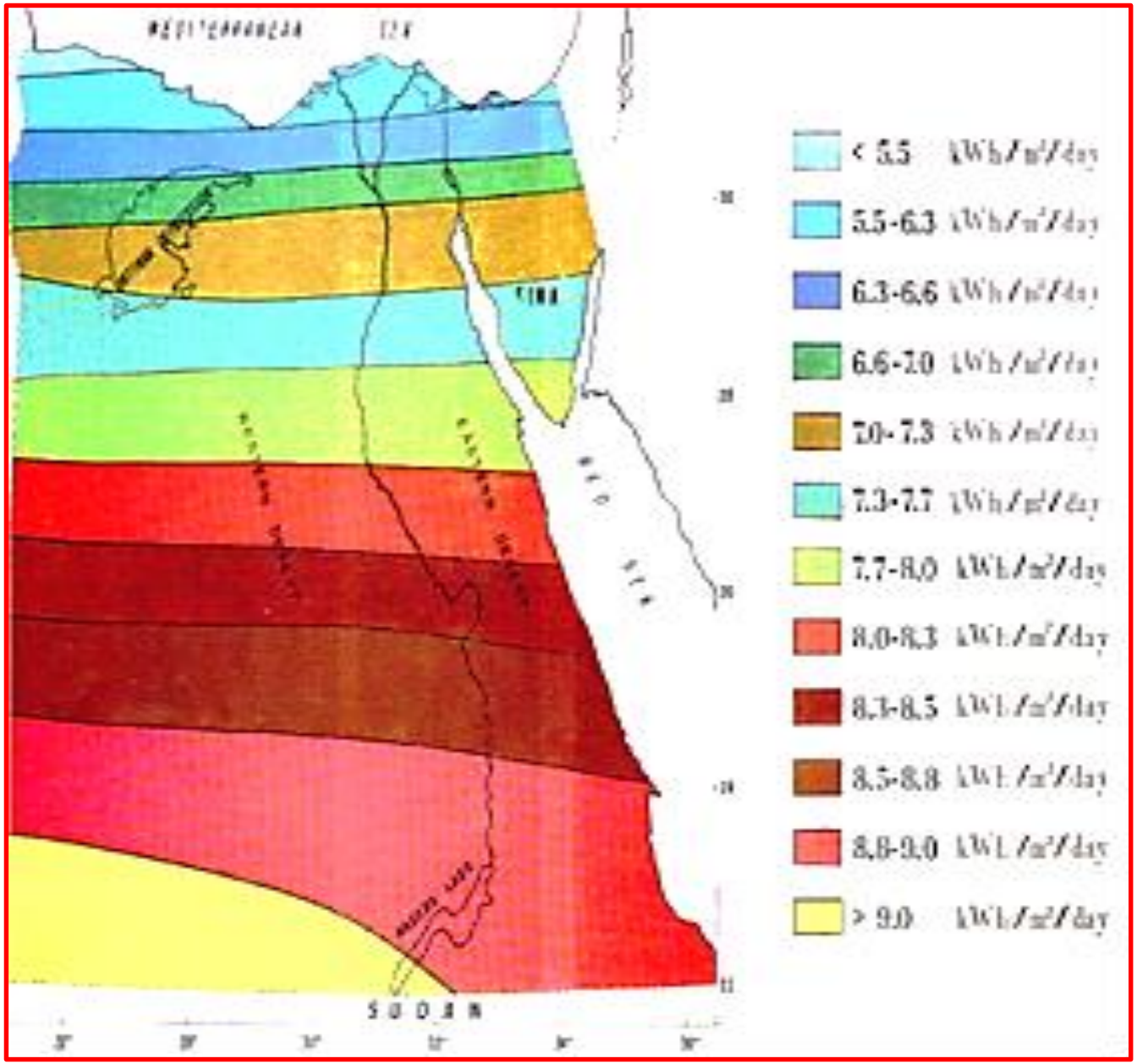
- The Sun is an energy source.
- The sun supplies energy in the form of radiation, which without the life on the earth is not exist.
- The sun is an enormous nuclear fusion reactor.
- The amount of energy in the sunlight reaching the Earth's surface is equivalent to around 10,000 times the world's energy requirements.
- Consequently, only 0.01% of the energy in sunlight would need to be used to cover mankind total energy needs.



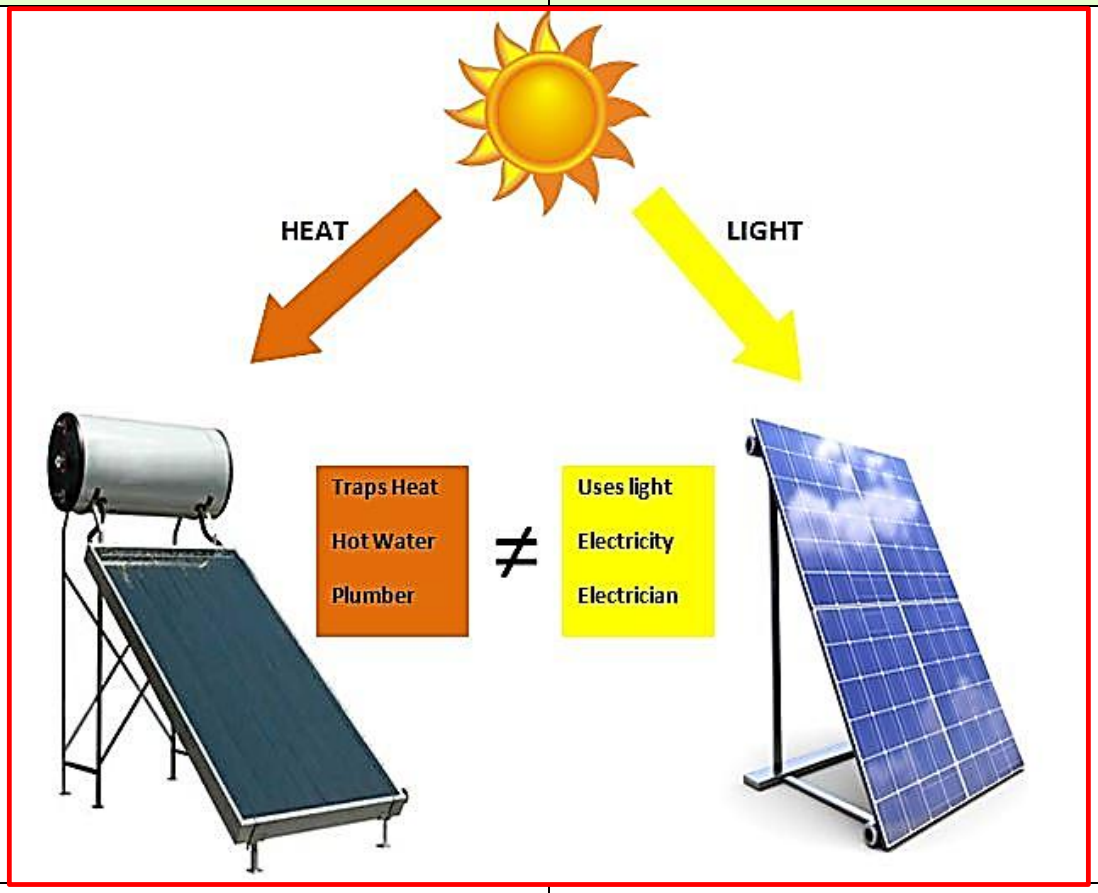
Distribution of Solar Radiation

- The intensity of solar radiation outside of the Earth's atmosphere depends upon the distance between the Sun and the earth.
- In the course of a year this varies between $1.47x10^8$ km and $1.52x10^8$ km.
- As a result, the irradiance fluctuates between $1325W/m^2$ and $1412W/m^2$.
- The average value is referred to as the solar constant: ***Solar constant***: EQ = $1367W/m^2$
- ***Solar constant***: is the total radiation energy received from the Sun per unit of time per unit of area on a theoretical surface perpendicular to the Sun's rays and at Earth's mean distance from the Sun.

Solar Radiation in Egypt

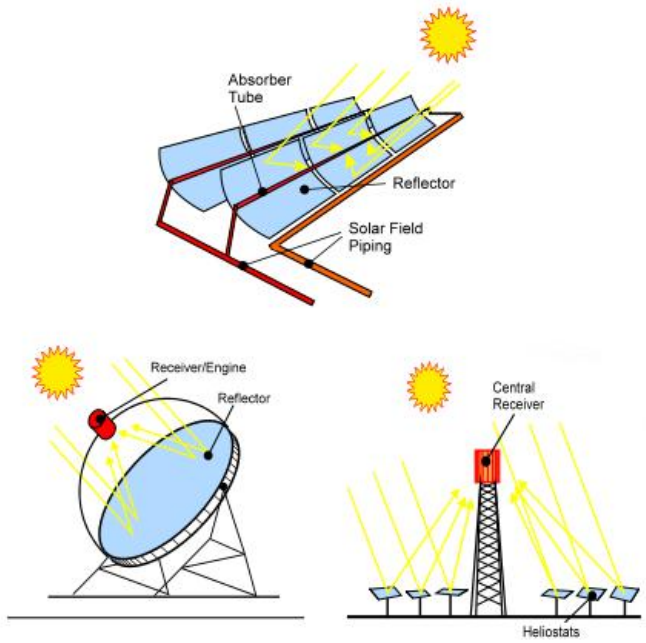


Solar Thermal versus Solar Photovoltaic

Solar Thermal	Solar Photovoltaic
	
• Heats the water instead of creating electricity • Slightly thicker panels than PV panels	• Converts sunlight into electricity

Solar Thermal System

- It is a form of energy and a technology for harnessing solar energy to generate thermal energy or electrical energy for use in industry, and in the residential and commercial sectors.
- In this type as shown in the figure, we can generate electricity via the concentration of sunlight radiations to create heat, and then this heat is used to run a heat engine which turns the generator to produce electricity, one main advantage of solar thermal power plants over other renewable power technologies, is the option of energy storage.



- **In this plant, the solar energy is collected by thousands of Sun-tracking mirrors, called *heliostats*, which reflect the Sun's energy to a single receiver at the top of a centrally located tower. The enormous amount of energy focused on the receiver is used to generate high temperature to melt a salt. The hot molten salt is stored in a storage tank, and is used, when needed, to generate steam and drive the turbine generator. After generating the steam, the used molten salt at low temperature is returned to the cold salt storage tank. From here it is pumped to the receiver tower to get heated again for the next thermal cycle. The usable energy extracted during such a thermal cycle depends on the working temperatures. The thermal energy is more economic than the solar photovoltaic because it eliminates the costly semiconductor cells.** Watch … 2.mp4 & 3.MP4

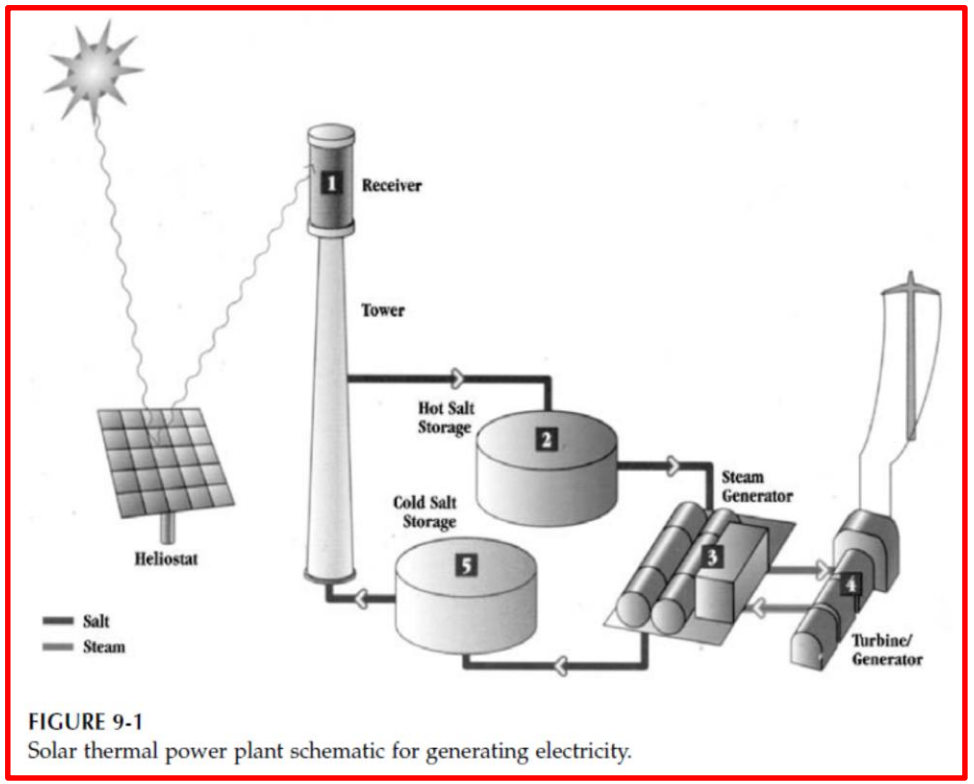


FIGURE 9-1
Solar thermal power plant schematic for generating electricity.

Table 1.1 A list of operating CSP plants around the world.

Project	Country	Output(MW)	Technology	Completed
Andasol-1 (AS-1)	Spain	49.9	Parabolic trough	2008
Andasol-2 (AS-2)	Spain	49.9	Parabolic trough	2009
Andasol-3 (AS-3)	Spain	50	Parabolic trough	2011
Arcosol 50 (Valle 1)	Spain	49.9	Parabolic trough	2011
Aste 1A	Spain	50	Parabolic trough	2012

Table 1.2 A list of CSP plants under construction all over the world.

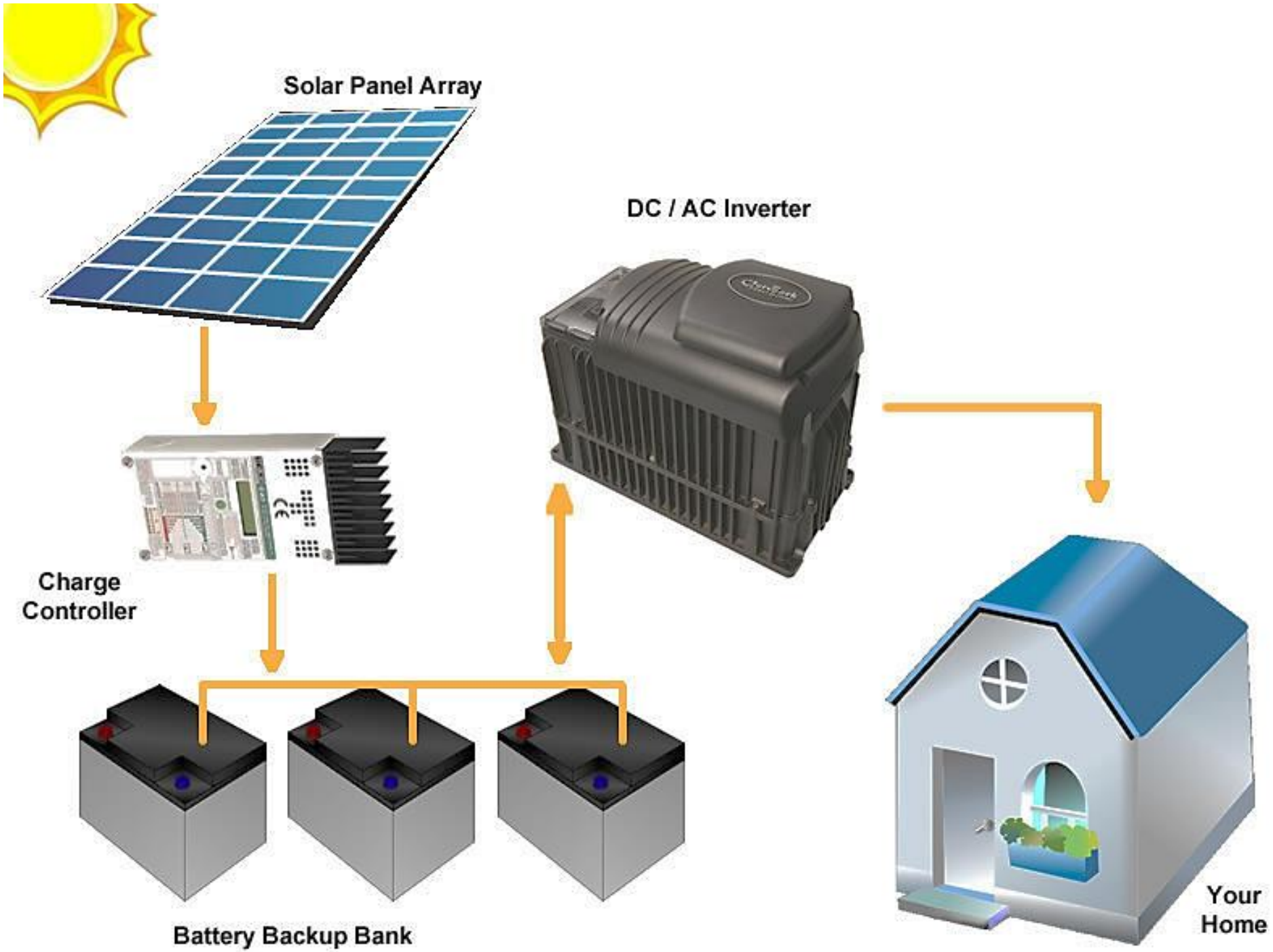
Project	Country	Output(MW)	Technology	Expected completion
Arenales	Spain	50	Parabolic trough	2013
Godawari Solar Project	India	50	Parabolic trough	2013
Kogan Creek Solar Boost (Kogan Creek)	Australia	44	Fresnel	2013
Solaben 2	Spain	50	Parabolic	2013
Termosol 1	Spain	50	Parabolic	2013
Termosol 2	Spain	50	Parabolic	2013
Crescent Dunes Solar	United stated	110	Tower	October 2013
Rice Solar Energy Project	United states	150	Tower	October 1, 2013
Victorville 2 Hybrid Power Plant	United states	50	Parabolic trough	2013

Table 1.3 A list of CSP plants that will be constructed

Project	**Country**	**Output(MW)**	**Technology**	**Expected completion**
Gaskell Sun Tower (Gaskell)	United states	105	Tower	Not determined yet
Ashalim power station	Israel	121	Tower	2017
Genesis Solar Energy Project	United states	250	Parabolic trough	January 1, 2014
KaXu Solar One	South Africa	100	Parabolic trough	2014
NextEra Beacon Solar Energy Project (Beacon)	United states	250	Parabolic trough	2014
Palen Solar Power Project[	United states	500	Parabolic trough	January 1, 2014
Pedro de Valdivia	Chile	360	Parabolic trough	2015

What is a Solar Photovoltaic (PV) System?

- PV cells consists of semiconductor materials that convert sunlight into electrical energy through the photovoltaic process.
- When the panels of PV system is exposed to the sunlight, the valence electrons in the semiconductor materials of PV panel acquire heat energy then they become free to move through the PV panel. This means that the panel produces direct current (DC) which is converted to an alternating current (AC) by an inverter so it can be used by appliances in the home.
- These systems can either be connected to a battery system or to the national electricity grid.


Solar Panel Array
DC / AC Inverter
Charge Controller
Battery Backup Bank
Your Home

How Does a PV System Work?

- **PV cells convert incident sunlight into electricity; light falling onto a PV cell imparts energy to electrons, freeing them from their valence shells of their atoms, then these electrons are free to move to electrical contacts of the PV module creating an electrical current. Each cell provides 0.55V and 4.7A (=2.59Watt). When many cells are connected together to form module (i.e., PV panels) more DC electrical energy can be produced.**

How PV module be installed In the Home?

- PV modules can be installed in the home in a variety of ways. All that is needed in a site of little or no shading for most days of the year.
- See the figure; how the PV installed. This is important to consider when siting and positioning a PV array.

Watch Video: 4.mp4