CMR INSTITUTE OF TECHNOLOGY, BENGALURU

(Approved by AICTE, New Delhi, Accredited by NAAC with A+ and Affiliated to VTU)

Department of Electrical and Electronics Engineering

15EE563 - Renewable Energy Sources (V Semester - Open Elective)

Academic year 2018-19

Solutions to IAT-I

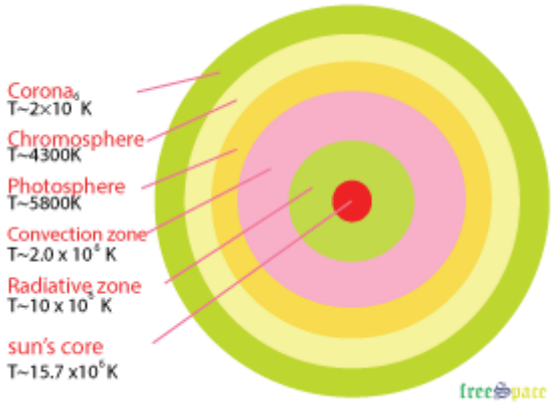
1 Compare the renewable energy potential and installed capacity of renewable energy sources in Indian scenario with worldwide context.

Ans: **Indian scenario (As on 31 March 2018):**

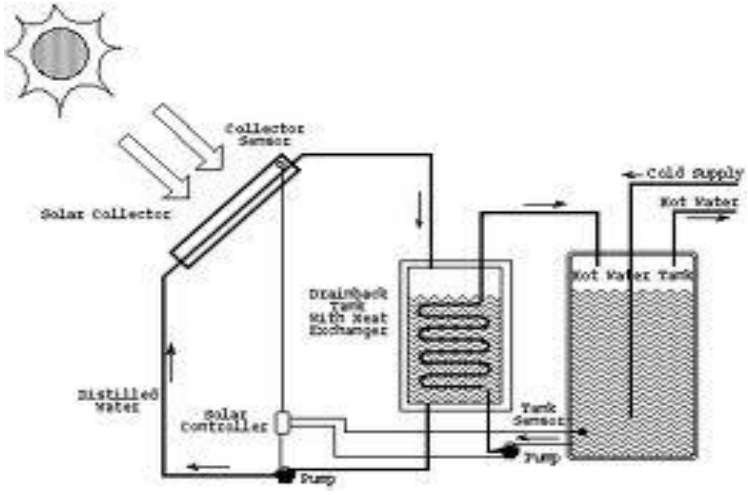
Rnewable Energy Potential	Installed capacity (MW)
Wind power	34,046
Solar power	21,651
Biomass power (Biomass & Gasification and Bagasse Cogeneration)	8,701
Waste-to-Power	138
Small hydropower	4,486
TOTAL	69,022

World context (At the end of 2017):

Renewable Energy Potential	Installed capacity (GW)
Wind power	514
Solar power	397
Biomass power	109
Geo-thermal	13
Hydro power	1152
Marine Energy (Tidal, Wave, Ocean Energy)	0.5
TOTAL	2,179

2(a)	Explain about different layers of sun.
Ans:	**Layers of Sun:**  The Sun can be divided into six layers. From the center out, the layers of the Sun are as follows: 1. The innermost quarter of the Sun's radius, called **core** 2. the **radiative zone** 3. and the **convective zone** 4. then there is the visible surface known as the **photosphere** 5. the **chromosphere** 6. and the outermost layer, called the **corona** **Core:** The energy produced through fusion in the Sun's core powers the Sun and produces all of the heat and light that we receive here on Earth. The process by which energy escapes from the Sun is very complex. Since we can't see inside the Sun, most of what astronomers know about this subject comes from combining theoretical models of the Sun's interior with observational facts such as the Sun's mass, surface temperature, and luminosity (total amount of energy output from the surface). **Radiative zone:** Above this core, energy is carried outwards by radiation. This "radiative zone" extends about three-quarters of the way to the surface. The radiation does not travel directly outwards – in this part of the Sun's interior, the plasma density is very high, and the radiation gets bounced around countless numbers of times, following a zig-zag path outward. It takes several hundred thousand years for radiation to make its way from the core to the top of the radiative zone. **Convective zone:** Compared to the amount of time it takes to get through the radiative zone, energy is transported very quickly through the outer convective zone. Energy begins to move by convection in huge cells of circulating gas with several hundred kilometers in diameter. **Photosphere:** The lowest layer of the sun's atmosphere is the **photosphere**. It is about 300 miles (500 kilometers) thick. This layer is where the sun's energy is released as light. Because of the distance from the sun to Earth, light reaches our planet in about eight minutes.

	Chromosphere: The next layer is the **chromosphere**. The chromosphere emits a reddish glow as super-heated hydrogen burns off. But the red rim can only be seen during a total solar eclipse. At other times, light from the chromosphere is usually too weak to be seen against the brighter photosphere. **Corona:** The third layer of the sun's atmosphere is the **corona**. It can only be seen during a total solar eclipse as well. It appears as white streamers or plumes of ionized gas that flow outward into space. Temperatures in the sun's corona can get as high as 3.5 million degrees Fahrenheit (2 million degrees Celsius). As the gases cool, they become the solar wind.
2(b)	Analyze various causes of energy scarcity and their probable solutions.
Ans:	The following are the causes of energy scarcity. 1. Increasing population 2. Increasing energy usage or consumption 3. Uneven distribution of energy resources 4. Lacks of technical knowhow **Solutions for Energy scarcity:** 1. Minimizing the population growth 2. Development of energy conversion techniques to convert basic energy available from energy reservoirs to usable form of energy 3. Keep the new energy system pollution free as far as possible, thereby environmentally acceptable to human beings 4. Development of cheap and reliable energy storage systems 5. Energy management
3	Illustrate the following terms related to solar radiation geometry. (i) Declination angle (ii) Hour angle Also analyze the reasons why the solar radiation reaching the earth is lesser than that at the atmosphere.
Ans:	**Declination angle:** It is nothing but the angle between the rays of the sun and the plane of the earth's equator. The earth's axial tilt is the angle between the earth's axis and a line perpendicular to the earth's orbit. It can be approximated as, $\sin(\delta) \approx 0.39795 * \cos[(0.98563 * (n - 173)$

	Hour angle: It is the angular distance between the meridian of the observer and the meridian whose plane contains the sun. Hour angle is mainly used to describe the earth's rotation about its polar axis. It can be calculated from solar time, $$\omega = 15 * (t_s - 12) \text{ (Degrees)}$$ Where, t_s – Solar time in hours Otherwise, it can be found from time after local solar noon t_m as follows. $$\omega = \frac{1}{4} * (t_m) \text{ (Degrees)}$$
4	With a neat schematic diagram, explain the working principle of solar water heating system.
Ans:	**Principle:** Solar water heating is the conversion of sunlight into heat for water heating using a solar thermal collector. A variety of configurations are available at varying cost to provide solutions in different climates and latitudes. These water heaters are widely used for residential and some industrial applications. There are two modes of water heaters namely, Active solar heater and passive solar heater. Active solar water heaters rely on electric pumps, and controllers to circulate water. It can further be classified as Direct-circulation systems and Indirect-circulation systems. Passive solar water heaters are of two types viz., Thermosyphon systems and Integrated solar collectors. **Schematic Diagram:**  **Parts of water heating system:** 1. Collector 2. Circulating system to move a fluid between the collectors to a storage tank 3. Storage tank 4. Backup heating system 5. Control system to regulate the overall system operation

5 Distinguish between Flat plate collectors and Concentrating collectors in solar thermal energy conversion system.

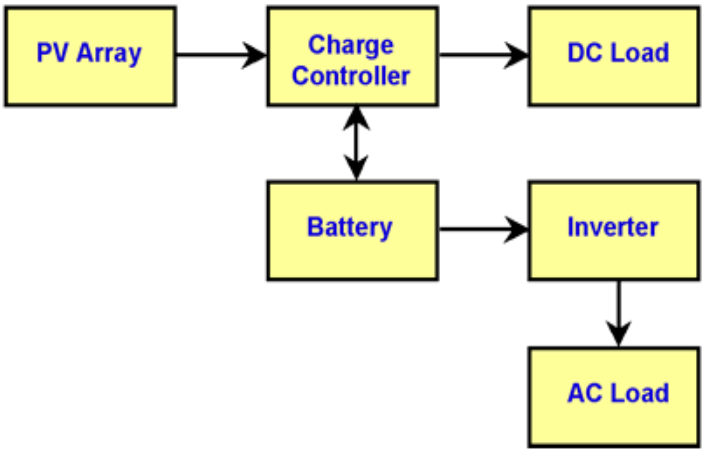
Ans:

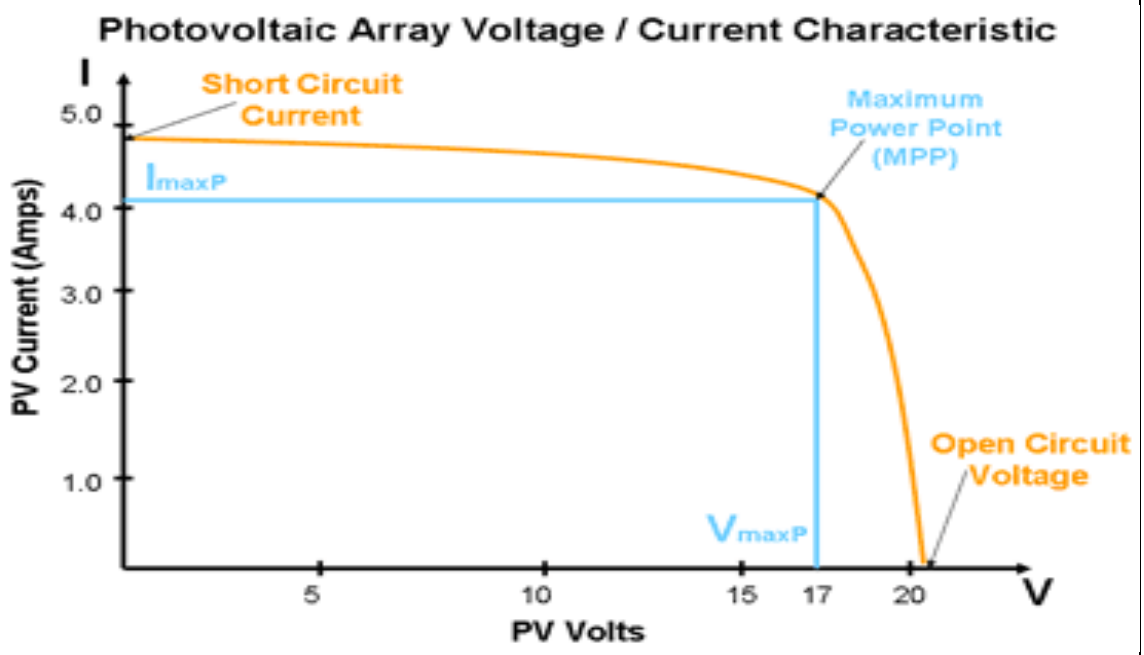
Flat plate collectors	Concentrating collector
Not much maintenance is required	Additional requirement for maintenance is required
Initial cost is cheaper	High initial cost is there for concentrating collectors
Additional optical losses are less	Additional optical losses occur in concentrating collectors
Uniform flux on absorber is there in Flat plate collectors	Non uniform flux on absorber is there in concentrating collectors
both diffused & beam radiations are collected	Only beam component is collected
Absorber need not track the sun	It is necessary to have an absorber
Reflecting surfaces require more material	Reflecting surfaces require less material
Absorber area is larger	Absorber area is smaller
More antifreeze is required	Little or no antifreeze is required
Only less temperature is attainable with flat plate collector	Temperature attainable with concentrator collector is high
Flat plate collector cannot be used for power generation	Concentrating collector is used for power generation

6 Explain the principle of solar PV power generation system and describe about the main elements of solar PV system.

Ans: **Main elements of solar PV system:**

- **Modules** – solar electric collectors. 3 basic types in the marketplace: Mono crystalline, poly crystalline, thin film.
- **Array** – modules connected together into a system.
- **Inverter** – converts the DC power produced by the modules to A/C.
- **Grid Tie Inverter** – converts DC to AC and feeds the utility grid with the A/C power.
- **Charge Controller** – regulates the power going to the batteries.
- **Batteries** – stores DC power.

	Block diagram of Solar PV Power generation system 
7(a)	Classify the solar PV cell and analyze the impact of solar radiation using I-V characteristics of Solar PV cell.
Ans:	**<u>Classification of Solar PV cell:</u>** 1. Monocrystalline • Made using saw-cut from single cylindrical crystal of Silicon. • Operating efficiency up to 15% 2. Monocrystalline • Caste from ingot of melted and recrystallised silicon • Cell efficiency ~12% 3. Thin-film • Silicon deposited in a continuous on a base material such as glass, metal or polymers. • Thin-film crystalline solar cell consists of layers about 10μm thick compared with 200-300μm layers for crystalline silicon cells **I-V characteristic of a solar cell:** The well-known characteristic of an ordinary silicon p-n junction with the junction not illuminated mathematically given by $I=Io\{\exp(V/Vt)-1\}$ Where Io is the reverse saturation current, Vt is known as the voltage equivalent of temperature and at room temp.(20 degree Celsius), its approximate value is 26mV. When pn junction illuminated: (When photon generated component is added with reverse leakage current) **$I=-Isc+Io\{\exp(V/Vt)-1\}$**

	Voc=Vt ln{(Isc/Io)+1} (When I=O) For Isc=2A ,Io=1nA; Voc is found to be **0.55V.**  The Fill Factor, FF which indicates the quality of the cell, is defined as the ratio of the peak power to the product of open-circuit voltage and short circuit current, i.e FF=(Vm Im)/(Voc Isc) Ideal cell will have a fill factor of unity.(An ideal cell would have a perfect rectangular characteristic). For maximize FF, The ratio of photocurrent to reverse saturation current should be maximized while minimizing internal series resistance and maximizing the shunt resistance. Typically, its value for a commercial silicon cell is in the range of 0.5 to 0.83. Conversion efficiency of a solar cell is given by, η = Vm Im /solar power = (FF Voc Isc)/solar power
7(b)	Illustrate about the efficiency of solar cell and the factors affecting the efficiency of the solar cell.
Ans:	**Efficiency of the Solar cell:** It is defined as the ration of power output of cell at its maximum power point and the product of input light power and the surface area of the solar cell under standard conditions. It is given by, η = Maximum output power /(irradiance * area) = $P_{max}/(E * S)$

	Factors affecting the efficiency of solar cell: 1. Wavelength of solar spectrum: 2. Temperature 3. Mounting of the cells 4. Arrangement and maintenance of solar cell 5. Position of cell

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