UNIT 5.Sustainable Energy Sources & Technology

Green energy Sources- Wind-water-solar– use of solar energy in space-Production of electricity using solar energy- Tidal, Biomass and geothermal energy

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Sources of Energy

Energy is the capacity to perform work. Energy exists in several forms such as heat, kinetic or mechanical energy, light, potential energy, electrical, or other forms. Energy sources could be classified in to two.

Renewable Energy: Renewable energy is derived from natural processes that are produced constantly such as solar, wind, ocean, hydropower, biomass etc.

Non Renewable energy: Coal, Oil and Natural gas are the non-renewable sources of energy. Known as fossil fuels.

Green energy is any energy that is generated from natural resources, such as sunlight, wind or water. It often comes from renewable energy sources.

The **most common forms** are as follows:

1. Wind Power

Wind power or **wind energy** is the use of wind turbines to generate electricity. Wind power is a popular, sustainable, renewable energy source that has a much smaller impact on the environment than burning fossil fuels. Wind farms consist of many individual wind turbines, which are connected to the electric power transmission network.

Onshore wind is an inexpensive source of electric power or cheaper than, coal or gas plants. Onshore wind farms have a greater visual impact on the landscape than other power stations, as they need to be spread over more land and need to be built in rural areas. Small onshore wind farms can feed some energy into the grid or provide power to isolated locations.

Offshore wind power is wind farms in large bodies of water, usually the sea. These installations can utilize the more frequent and powerful winds that are available in these locations and have less visual impact on the landscape than land-based projects. However, the construction and maintenance costs are considerably higher.

Demerits:

- Reducing demand when wind production is low.
- Variations in production of electricity.

2. Hydropower

Hydropower also known as **water power**, is the use of falling or fast-running water to produce electricity. Here water in rivers, streams, dams or elsewhere used to produce energy. Hydropower can even work on a small scale using the flow of water through pipes in the home or can come from evaporation, rainfall or the tides in the oceans. This is achieved by converting the gravitational, potential or kinetic energy of a water source to produce power. Hydropower is a method of sustainable energy production.

Since ancient times, hydropower from watermills has been used as a renewable energy source for irrigation and the operation of mechanical devices, such as gristmills, sawmills, textile mills, trip hammers, cranes, domestic lifts, and ore mills.

Hydropower is now used principally for hydroelectric power generation, and is also applied as one half of an energy storage system known as pumped-storage hydroelectricity.

Hydropower is an attractive to fossil fuels as it does not directly produce carbon dioxide or other atmospheric pollutants and it provides a relatively consistent source of power. It has economic, sociological, and environmental downsides and requires a sufficiently energetic source of water, such as a river or elevated lake.

3. Solar Power

This common renewable, green energy source is usually produced using photovoltaic cells that capture sunlight and turn it into electricity. Solar power is also used to heat buildings and for hot water as well as for cooking and lighting. Solar power has now become affordable enough to be used for domestic purposes including garden lighting, also on a larger scale to power entire neighborhoods.

Use of solar energy in space

Space-based solar power (**SBSP**) is the concept of collecting solar power in outer space and distributing it to Earth. Potential advantages of collecting solar energy in space include a higher collection rate and a longer collection period due to the lack of a diffusing atmosphere, and the possibility of placing a solar collector in an orbiting location where there is no night. A considerable fraction of incoming solar energy (55–60%) is lost on its way through the Earth's atmosphere by the effects of reflection and absorption. SBSP systems convert sunlight to microwaves outside the atmosphere, avoiding these losses and the downtime due to the Earth's rotation, but at great cost due to the expense of launching material into orbit. SBSP is considered a form of sustainable or green or renewable energy. It is attractive solution to fossil fuel depletion.

Besides the cost of implementing such a system, SBSP also introduces several technological hurdles, including the problem of transmitting energy from orbit to Earth's surface for use. SBSP designs generally include the use of some manner of wireless power transmission. The collecting satellite would convert solar energy into electrical energy on board, powering a microwave transmitter or laser emitter, and transmit this energy to a collector on Earth's surface.

SBSP is being actively pursued by Japan, China, Russia, India, the United Kingdom and the US.

2010: The Indian Space Research Organisation and US' National Space Society launched a joint forum to enhance partnership in harnessing solar energy through space-based solar collectors. Called the Kalam-NSS Initiative after the former Indian President Dr APJ Abdul Kalam.

2012: China proposed joint development between India and China towards developing a solar power satellite, during a visit by former Indian President Dr APJ Abdul Kalam

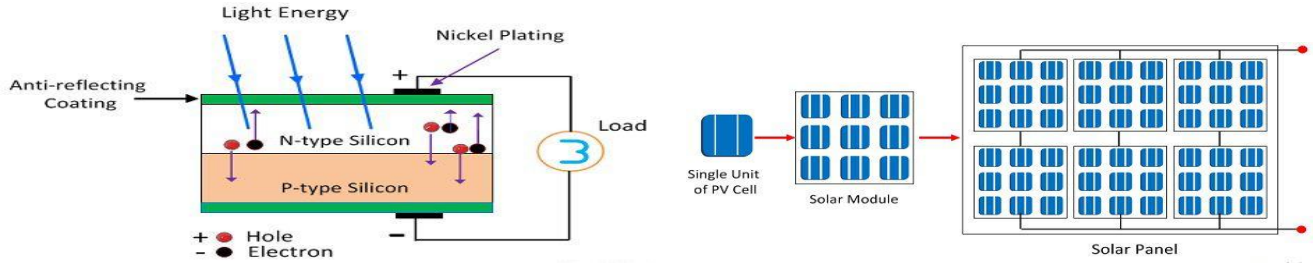
Electricity production: Sunlight can be converted into electricity, either directly using photovoltaics (PV), or indirectly using concentrated solar power (CSP). CSP systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. PV converts light into electric current using the photoelectric effect.

Photovoltaics or Solar Cell: It is a semiconductor device that converts the light into electrical energy. The voltage induces by the PV cell depends on the intensity of light incident on it. The name Photovoltaic is because of their voltage producing capability. The electromagnetic radiations are made of small energy particles called photons. When the photons are incident on the semiconductor material, then the electrons are emitted. The phenomenon of emission of electrons is known as the

photoelectric effect and the electrons are photoelectrons. The working of the Photovoltaic cell depends on the photoelectric effect.

Construction of Photovoltaic Cell: Mostly silicon and selenium are used for making the cell. Other than this materials like arsenide, indium, cadmium and gallium are also used.

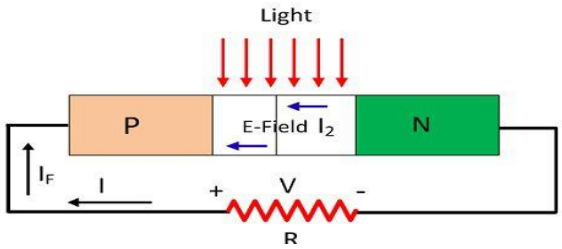
Consider the figure below shows the constructions of the silicon photovoltaic cell. The upper surface of the cell is made of the thin layer of the p-type material so that the light can easily enter into the material. The metal rings are placed around p-type and n-type material which acts as their positive and negative output terminals respectively.



The output voltage and current obtained from the single unit of the cell is very less. The magnitude of the output voltage is 0.6v, and that of the current is 0.8v. The different combinations of cells are used for increasing the output efficiency like Series Combination of PV Cells (voltage 1.2V), Parallel Combination of PV cells(current 1.6V), Series-Parallel Combination of PV cells(both current and voltage increases). The solar module is constructed by connecting the single solar cells. And the combination of the solar modules together is known as the solar panel.

Working of PV cell: The light incident on the semiconductor material may pass or reflected through it. When the semiconductor material absorbs light, the electrons of the material starts emitting. When the electrons absorb the photons, they become energised and starts moving into the material. Because of the effect of an electric field, the particles move only in the one direction and develops current. The semiconductor materials have the metallic electrodes through which the current goes out of it.

In the above figure, the PV cell consists the P and N-type layer of semiconductor material. These layers are joined together to form the PN junction. The junction is the interface between the p-type and n-type material. When the light fall on the junction the electrons starts moving from one region to another.



Maximum power point tracker, inverter, charge controller and battery are the name of the apparatus used for converting the radiation into an electrical voltage. Maximum Power Point Tracker is a special kind of digital tracker that follows the location of the sun. The efficiency of the PV cell depends on the intensity of sunlight fall on it. The power of the sun varies with the time because of the movement of the earth. So for absorbing the maximum light, the panel needs to be moved along with the sun. Thereby the maximum power point tracker is used with the solar panel. The charge controller regulates the voltage drawn from the panel. It also protects the battery from the overcharging or overvoltage. The inverter converts the direct current into the alternating current and vice versa.

4. Tidal

Tidal power or **tidal energy** is converting energy from tides into useful forms of power, mainly electricity using various methods. Here water's kinetic energy is used for power generation. Tides are more predictable than the wind and the sun. Among sources of renewable energy, tidal energy has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges.

The process of using falling water and spinning turbines to create electricity was introduced in the U.S. and Europe in the 19th century. Tidal power is in small number of locations around the world. The world's first large-scale tidal power plant was the Rance Tidal Power Station in France, which became operational in 1966. It was the largest tidal power station in terms of output until Sihwa Lake Tidal Power Station opened in South Korea in August 2011. The Sihwa station uses sea wall defense barriers complete with 10 turbines generating 254 MW.

The Indian state of Gujarat was planning to host South Asia's first commercial-scale tidal power station. The company Atlantis Resources planned to install a 50 MW tidal farm in the Gulf of Kutch on India's west coast, with construction planned to start 2012, later withdrawn due to high costs.

5. Biomass Energy

Biomass is plant or animal material used as fuel to produce electricity or heat. Eg: wood, waste from forests, yards, or farms. It is a renewable form of energy.

Chlorophyll present in plants captures the sun’s energy by converting carbon dioxide and water into carbohydrates through the process of photosynthesis. When the plants are burned, the water and carbon dioxide is again released back into the atmosphere. Biomass energy is used for heating and cooking in homes and as a fuel in industrial production.

Sources: Wood, wood residues, corn, switch grass, miscanthus, bamboo etc.

The main waste energy sources are: wood waste, agricultural waste, municipal solid waste and manufacturing waste, Sewage sludge, algae or algae-derived biomass, enzymes or bacteria from various sources, grown in cell cultures or hydroponics.

Biofuel is a fuel that is produced through contemporary processes from biomass.eg: biodiesel. Biofuels are classified broadly into three major categories:

- First-generation biofuels are derived from food sources, such as sugarcane and corn starch - fermented to produce bioethanol- serves as an additive to gasoline, or in a fuel cell to produce electricity.
- Second-generation biofuels use non-food-based biomass sources such as perennial energy crops and agricultural/municipal waste.
- Third-generation biofuels refer to those derived from microalgae.

Disadvantages: This type of energy produces large amount of CO_2 greenhouse gas to the atmosphere, these emissions are still far lower than those from petroleum-based fuels.

6. Geothermal Energy

It is the thermal energy in the Earth's crust which originates from the formation of the planet and from radioactive decay of materials. The high temperature and pressure in Earth's interior cause some rock to melt and solid mantle to behave plastically, which is lighter than the surrounding rock and temperature will be up to 4000 °C.

The Earth's internal thermal energy flows to the surface by conduction at a rate of 44.2 terawatts (TW). Most of this energy flow is not recoverable. In addition to the internal heat flows, the top layer of the surface to a depth of 10 m is heated by solar energy during the summer. The heat energy can be collected by fluid circulation, either through magma conduits, hot springs, hydrothermal circulation or a combination of these. Worldwide, 13,900 megawatts (MW) of geothermal power was available in 2019.

Geothermal power is electrical power generated from geothermal energy. This type of green power uses thermal energy that has been stored just under the earth's crust. This resource can be used for steam to turn turbines and generate electricity. The thermal efficiency and profitability of electricity generation is particularly sensitive to temperature. Thus electricity generation from geothermal energy vary from 0.035 to 2 TW. Technologies in use include dry steam power stations, flash steam power stations and binary cycle power stations. Geothermal electricity generation is currently used in 26 countries, while geothermal heating is in use in 70 countries.

Geothermal power is considered to be a sustainable, renewable source of energy because the heat extraction is small compared with the Earth's heat content. The greenhouse gas emissions of geothermal electric stations are on average 45 grams of carbon dioxide per kilowatt-hour of electricity, or less than 5 percent of that of conventional coal-fired plants. As a source of renewable energy for both power and heating, geothermal has the potential to meet 3-5% of global demand by 2050.

Sources of energy in Kerala

Power sourse	**Name**	**Place**	**Units (mw)**
Gas	Kochi combined cycle power station	Kochi, Ernakulam	157
	Rajiv Gandhi CCPP	Kayamkulam, Alappuzha	359.58
Diesel	Kozhikode diesel power station	Kozhikode	96
	Brahmapuram diesel power plant	Brahmapuram, Ernakulam	64
Hydro	Idukki	**Idukki Dam** is a double curvature Arch dam constructed across the Periyar River between two granite hills locally known as *Kuravan* and *Kurathi* in Mariyapuram village in Idukki District	780
Solar	CIAL Solar Power Project	Kochi(first fully solar powered airport in the world)	40
Wind	Ramakkalmedu	Ramakkalmedu, Idukki	25