**Subject Name: RENEWABLE ENERGY SOURCES (EEI)**

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**UNIT – I: GLOBAL AND NATIONAL ENERGY SCENARIO**

**Important Points / Definitions:**

* Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever increasing energy needs requiring huge investments to meet them
* Energy can be classified into several types based on the following criteria:
* Primary and Secondary energy
* Commercial and Non commercial energy
* Renewable and Non-Renewable energy
* Conventional and Non-conventional energy
* The energy sources that are available in the market for a definite price are known as commercial energy. Examples: Electricity, lignite, coal, oil, natural gas etc.
* The energy sources that are not available in the commercial market for a price are classified as non-commercial energy. Non-commercial energy sources include fuels such as firewood, cattle dung and agricultural wastes, which are traditionally gathered, and not bought at a price used especially in rural households. These are also called traditional fuels. Non-commercial energy is often ignored in energy accounting.
* Conventional energy resources which are being traditionally used for many decades and were incommon use around oil crisis of 1973 are called conventional energy resources, e.g., fossil fuel,nuclear and hydro resources.
* The energy consumption of a nation can be broadly divided into the following areas or sectors depending on energy-related activities. These can be further subdivided into subsectors
* Domestic sector (houses and offices including commercial buildings)
* Transportation sector
* Agriculture sector
* The proven global coal reserve was estimated to be 9,84,453 million tonnes by end of 2003. The USA had the largest share of the global reserve (25.4%) followed by Russia (15.9%), China (11.6%). India was 4th in the list with 8.6%.

**Questions**

**2 Marks**

1. Explain clearly the term ‘Renewable Energy Sources’
2. Explain the prospects of renewable energy sources with reference to Indian context
3. What is beam and diffused radiation
4. Classify methods of solar energy storage
5. Describe thermal energy storage in detail

**3 Marks**

1. What is solar radiation data?
2. Define Hour angle, Altitude angle, Solar Azhimuth angle, Declination angle?
3. What is a solar constant.
4. Briefly describe the impact of solar power on environment?
5. Briefly explain the role and potential of Renewable Energy Sources

**5 Marks**

1. Explain Extraterrestrial and terrestrial solar radiation
2. What is the difference between pyrheliometer and pyranometer?
3. Explain any one instrument for measuring solar radiation?
4. Explain the working of sun shine recorder with a neat sketch
5. Classify methods of solar energy storage

**Fill in the blanks :**

1. The predominant source of energy on earth is **The Sun**
2. Solar energy travels through space by the process of **Radiation**
3. Solar radiation that has not been absorbed or scattered and reaches the earth surface directly is called **Beam radiation**
4. At the time of sunset to sunrise the Zenith angle **90**
5. The value of solar constant is approximately **1.36 kW/m2**
6. Pyranometer is an instrument used for measuring the **Solar irradiance of a solar photovoltaic cell**
7. Satellites in space are provided power with the help of **Solar photovoltaic cells**
8. The total solar radiation received at any point on the earth's surface is termed as **Insolation**
9. Photovoltaic energy is the conversion of sunlight into: **Electricity**
10. Lignite, bituminous and anthracite are different ranks of **Coal**

**Choose the best:**

1. In what form can solar energy be used? [ d ]

[a] Thermal energy [b] Electrical energy

[c] Mechanical Energy [d] All of above

2. Which of the following sources of energy does not get depleted? [ d ]

[a] Natural gas [b] Coal

[c] Petroleum [d] Wind

3. Harmful radiation emitted from the sun is [ c ]

[a] Visible radiation [b] Infrared radiation

[c] Ultraviolet radiation [d] None of the above

4. Which of the following is a disadvantage of most of the renewable energy sources? [ c ]

[a] Highly polluting [b] High waste disposal cost

[c] Unreliable supply [d] High running cost

5. The energy which is not derived from the sun is \_\_\_\_\_\_ [ c ]

[a] bio-mass [b] fossil fuels

[c] nuclear energy [d] geo-thermal energy

6. A substance which produces a lot of heat on burning is called \_\_\_\_\_\_. [ d ]

[a] oxidizing agent [b] biogas

[c] biomass [d] fuel

7. Fuel formed under the earth's surface by the decomposition of organic matter is called [ c ]

[a] organic fuel [b] biogas

[c] fossil fuel [d] under ground fuel

8. The main constituent of LPG is \_\_\_\_\_\_ [ b]

[a] methane [b] butane

[c] hydrogen [d] propane

9. The radiations absorbed by ozone layer are \_\_\_\_\_\_. [ b ]

[a] infra-red [b] ultra-violet

[c] visible [d] gamma rays

10. The radiations emitted by the sun and responsible for the cause of skin cancer are [ d ]

[a] infra-red [b] X-rays

[c] micro-waves [d] ultra-violet

**UNIT-II- SOLAR ENERGY**

**Important Points / Definitions:**

* The sun is a sphere consisting of intensively hot ionized gaseous matter, called plasma. In fact the sun is a large nuclear reactor where thermo-nuclear fusion reactions take place continuously generating huge amounts of energy. The energy radiated into the surrounding space
* The incident spectral solar radiation outside the earth's atmosphere is called "extraterrestrial", Go, or, air-mass zero (AMO) solar radiation. Its instantaneous power the "irradiance" or, solar flux density is measured in W per square meter (W m-2) and is considered as a constant, although there exist some fluctuations due to solar activities. At the top of the atmosphere and at a mean earth-sun distance ro, the intensity of this radiation is termed as the "Solar Constant", Gsc, which is defined as: "the perpendicular radiation that receives a surface of one square meter, at the earth's mean distance from the sun per unit of time". Many scientists give in their studies values of the Solar Constant, calculated from terrestrial measurements.
* Declination is the angular distance from the sun north or south to the earth’s equator
* Hour Angle (ω) The concept of hour angle is used for describing the rotation of the earth around its polar axis which is equivalent to +15◦ per hour during the morning and −15◦ in the afternoon. It is the angular distance between the observer’s meridian and the meridian whose plane contains the sun
* Solar Azimuth Angle (γ) The angular displacement from the south of the beam radiation projection on the horizontal plane is defined as the solar azimuth angle
* Latitude (φ) The latitude of an area is the position with relevance north or south of the Equator. The variation of the latitude is from 0◦ to ±90◦ (positive for northern and negative for the southern hemisphere), 0◦ at the Equator and ±90◦ at the Poles.
* Hourly Extraterrestrial Radiation (Io) Extraterrestrial radiation is defined as the incidence of solar radiation outside the earth’s atmosphere and is computed with the following equation: Io = 12 × 3.6 π IscE0 × (sin ϕ cos δ) × (sin ω2 − sin ω1) + π(ω2 − ω1) 180 (sin ϕ sin δ) where Isc is a solar constant (1367 W/m2 ); E0 is the eccentricity correction factor; δ is the declination angle; ϕ is the latitude of location; ω1 and ω2 are the hour angle at the beginning and end of the time interval, where all angles are given in degrees. The eccentricity correction factor E0 can be calculated according to Spencer
* Hourly Global Solar Radiation on Horizontal Surfaces (IH) Global solar radiation on horizontal surfaces can be measured with a pyranometer, which is an instrument that measures global solar radiation from all directions. The global solar radiation on horizontal surfaces can be categorized as follows:
  + Diffuse solar radiation (Ib )
  + Direct beam solar radiation (Id )
* Solar radiation on a horizontal surface is the sum of the horizontal direct and diffuse radiation. IH = Id + Ib
* Systems for utilizing low-temperature solar thermal energy include means for heat collection; usually heat storage, either short-term or interseasonal; and distribution within a structure or a district heating network. In some cases more than one of these functions is inherent to a single feature of the system
* **Interseasonal storage.** Solar heat (or heat from other sources) can be effectively stored between opposing seasons in aquifers, underground geological strata, large specially constructed pits, and large tanks that are insulated and covered with earth
* **Solar-driven cooling**

Worldwide, by 2011 there were about 750 cooling systems with solar-driven heat pumps, and annual market growth was 40 to 70% over the prior seven years. It is a niche market because the economics are challenging, with the annual number of cooling hours a limiting factor

* **Solar process heating** systems are designed to provide large quantities of hot water or space heating for nonresidential buildings
* Solar thermal energy can be useful for drying wood for construction and wood fuels such as wood chips for combustion. Solar is also used for food products such as fruits, grains, and fish. Crop drying by solar means is environmentally friendly as well as cost effective while improving the quality
* Solar cookers use sunlight for cooking, drying and pasteurization. Solar cooking offsets fuel costs, reduces demand for fuel or firewood, and improves air quality by reducing or removing a source of smoke.
* Solar stills can be used to make drinking water in areas where clean water is not common. Solar distillation is necessary in these situations to provide people with purified water. Solar energy heats up the water in the still. The water then evaporates and condenses on the bottom of the covering glass

**Questions**

**2 Marks**

1. Describe thermal energy storage in detail
2. What is the principle of solar photovoltaic power generation
3. With the aid of neat sketch classify flat plate collectors for water/air heating
4. Explain different types of concentrating collectors
5. Differentiate between flat plate and concentrating collectors

**3 Marks**

1. What is the principle of solar photovoltaic power
2. Explain the construction and working of a solar pond with neat sketch.
3. Draw and discuss the IV Characteristics of single crystalline solar cell
4. Discuss in detail the various parameters to be considered in detail for the design of
5. Solar water heating systems and its efficiency

**5 Marks**

1. Derive an expression for daily yield that can be obtained in a solar still
2. Explain principle and operation of non convective solar pond in
3. Explain the process of solar distillation
4. Explain Solar production of hydrogen
5. Explain the working of a solar furnace
6. Explain the working of a solar pump

**Fill in the blanks :**

1. The outermost layer of the earth is: **Crust**
2. Greenhouse effect refers to increase in **Global temperature**
3. A solar cell is made up of **silicon**
4. In a solar panel, the metal used is **silver**
5. The energy radiated by sun on a bright sunny day is about **1.0 KW/m2**
6. Thermo - chemical process is known as **Pyrolysis**
7. The minerals present on the inner core of the earth **Magnesium**
8. **Nickel, silicon and magnesium**
9. The vacuum between absorber and glass cover can be maintained only in **Tubular collector**
10. A solar cell converts **solar energy into electrical energy**

**Choose the best:**

1. In solar power plants the solar heat is transferred to [ d ]

[a] Liquid metals [b] Water steam

[c] Molten salt [d] Any of above

2. Solar energy cannot be stored in which of the following mediums? [ d]

[a] Water [b] Iron

[c] Gas [d] Wood

3. Which of the following appliances use solar photovoltaic technology? [ a ]

[a] Solar lantern [b] Biogas plant

[c] Solar water heater [d] Solar air heater

4. The magma (molten mass) in the temperature range. [ a ]

[a] 1250 degree centigrade to 1550 degree centigrade

[b] 2000 degree centigrade to 2250 degree centigrade

[c] 1525 degree centigrade to 1550 degree centigrade

[d] 1750 degree centigrade to 2000 degree centigrade

5. The radiation in the sunlight that gives us the feeling of hotness is \_\_\_\_\_\_. [ b ]

[a] visible radiation [b] infra-red

[c] red [d] ultra-violet

6. Which power plant has the high efficiency? [ b ]

[a] Thermal [b] Diesel

[c] Hydel [d] Gas

7. In green plants which process occurs during the day? [ b ]

[a] Photosynthesis [b] Photosynthesis and respiration

[c] Respiration [d] Temperature control

8. Which country is the largest producer of sugar cane? [ c ]

[a]usa [b]india

[c]brazil [d]uk

9. The commercial sources of energy are [ a ]

[a] fossile fuels and radioactive substances. [b] solar, wind, biomass

[c] wood, animal wastes and agricultural wastes [d] none of above.

10. Rotameter is used for measuring [ b ]

[a]fluid fdensity [b]fluid discharge

[c]fluid viscosity [d]none of the above

**UNIT-III- WIND ENERGY**

**Important Points / Definitions:**

* Power available in wind (in Watts) = ½ \* air density \* swept area \* wind velocity Pa=1/2 \*P\*A\*V or Pa=1/8 \*P\* D \*V
* Where air density P = 1.23 kg per cubic meter at sea level, and swept area is in square meters and wind velocity is in meters per second.
* A ―perfect turbine‖ would work right at the Betz limit, the blades and the alternator would match perfectly at all wind speeds, and the alternator would have no internal magnetic or electrical losses. This is also known as coefficient of power Cp. Power co-efficient (Cp), describes that fraction of the power in the wind that may converted by the wind turbine in to mechanical work It is the fraction of power in a wind stream that can be extracted. It has a theoretical maximum value of:
* Cp (max) = 0.593 (popularly known as Betz co-efficient)
* The actual power output of a wind turbine is given by
* 3 P = 0.5 x P x A x Cp x V x x g b Where:
* P = Power in watts (746 watts = 1 hp) (1,000 watts = 1 kilowatt)
* P = Air density (about 1.225 kg/m3 at sea level, less high up)
* 2 A = Rotor swept area, exposed to the wind (m )
* Cp = Power Coefficient [0.59 {Betz limit}is the maximum theoretically possible, .35 for a good design]
* V = Wind speed in meters/sec (20 mph = 9 m/s) = Generator efficiency (80% or possibly more for a permanent magnet g Generator or grid-connected induction generator)
* The major components of modern wind energy systems typically consist of the following:
* Rotor, with 2 or 3 blades, which converts the energy in the wind into mechanical energy onto the rotor shaft;
* Gearbox to match the slowly turning rotor shaft to the electric generator;
* Wind turbine generator
* Tall tower which supports the rotor high above the ground to capture the higher wind speeds;
* Solid foundation to prevent the wind turbine from blowing over in high winds and/or icing conditions;
* Control system to start and stop the wind turbine and to monitor proper operation of the machinery.

**Questions**

**2 Marks**

1. Discuss about the performance characteristics of wind turbines.
2. Discuss about different configurations of wind turbines
3. List out the differences between horizontal and vertical wind mills
4. Derive an expression for axial force on the turbine blade
5. What is Betz limit? Derive an expression for it

**3 Marks**

1. Prove that in case of horizontal axis wind turbine, maximum power can be obtained
2. When Exit Velocity = 1/3 wind velocity and Pmax = 8/27 pAV3
3. Explain the importance of torque coefficient of a wind turbine
4. Describe the potential for wind power in India

**5 Marks**

1. Explain the phenomenon of dynamic matching
2. Explain savonius Rotor
3. Explain the working principle of Darrius Rotor
4. What are the applications of wind energy

**Fill in the blanks :**

1. A wind turbine use **Kinetic energy**
2. The maximum energy conversion efficiency of a wind turbine for a given swept area is **59.3%**
3. If the velocity of wind is doubled, then the power output will increase by **8 times**
4. The term Darrious & Savonius rotor are related to **Wind energy**
5. Power output from a wind energy electric generator is directly proportional to **Cube of wind velocity**
6. Another name for a windmill is **Propeller**
7. A place where many wind turbines are nstalled together to produce electricity is called as **Wind farm**
8. Wind blows because of a difference in **Temperature**
9. An anemometer is an instrument used for Measurement of **Wind speed**
10. The relationship between power available from wind 'P' and wind velocity 'v' is **P ά v 3**

**Choose the best:**

1. Which of the following states in India ranks first in the installation of wind power [ d ]

[a] Gujarat [b] Andhra Pradesh

[c] Maharashtra [d] Tamil Nadu

2. What type of energy is associated with wind? [ c ]

[a] Potential energy [b] Chemical energy

[c] Kinetic energy [d] Rotational energy

3. Lower speed wind turbines are mainly driven by [ a ]

[a] Drag forces [b] Lift forces

[c] Push forces [d] None of the above

4. Which source of renewable energy is caused by uneven heating of earth's surface? [ b ]

[a] Solar [b] Wind

[c] Geothermal [d] Biomass

5. With increase in height, wind speed [ a ]

[a] Increases [b] Decreases

[c] Remains the same [d] None of the above

6. Which of the following forces act on the blades of wind Turbine rotor? [ c ]

[a] Lift force [b] Drag force

[c] Both (a) & (b [d] None of the above

7. Wind machine with Darrious type of rotor is a [ a ]

[a] Vertical axis machine [b] Horizontal axis machine

[c] Machine that can spin in one direction only

[d] None of the above

8. During the day, the surface wind flows [ a ]

[a] From sea to land [b] From land to sea

[c] On the surface of the sea [d] On the surface of land

9. Air density at standard conditions is about [ c ]

[a] 1.885 kg/m3 [b] 2.55 kg/m3

[c] 1.226 kg/m3 [d] 3.267 kg/m3

10. Betz law finds application in [ d]

[a] MHD systems [b] Solar cells

[c] Geothermal power plants [d] Wind mills