Chapter 4.12: Application of Non-Conventional and Renewable Energy Sources

Short type questions

1.	What do you mean by solar window? **Ans.** The period four to five hours in late morning and early afternoon (between 9 am. To 3 p.m.) is commonly called the *solar window*. During this time, 80% of the total collectable energy for the day falls on a solar collector.
2.	How photovoltaic (PV) modules are rated and what is the efficiency of commercial solar cell? **Ans.** PV modules are rated by their peak watt output at solar noon on a clear day. A typical commercial solar cell has an efficiency of 15%.
3.	Using biomass as fuel, how much carbon dioxide will be released? **Ans.** Biomass does not add carbon-dioxide to the atmosphere as it absorbs the same amount of carbon is growing as it releases when consumed as fuel.
4.	Write short note on biogas? **Ans.** Biogas is a clean and efficient fuel, generated from cow-dung, human waste or any kind of biological materials derived through anaerobic fermentation process. The biogas consists of 60% methane with rest mainly carbon-di-oxide. Biogas is a safe fuel for cooking and lighting. By-product is usable as high grade manure.
5.	Mention various forms of renewable energy? **Ans.** Various forms of renewable energy are i) Solar energy, ii) Wind energy, iii) Bio energy, iv) Hydro energy, v) Geothermal energy and vi) Wave and tidal energy
6.	What is the approximate quantum of solar energy (in kWh/m^2) received by India? **Ans.** India receives solar energy in the range of 5 to 7 kWh/m^2 for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plant per square kilometre land area.
7.	What is the average wind speed (Km/h) considered as *Good* for operation of wind mill. **Ans.** Wind speed of 25 Kmh or 15.5 Mph is considered to be Good for power generation.
8.	What is the Capacity Factor (CF) of wind Turbine? **Ans.** The Capacity Factor (CF) is simply the wind turbine's "*actual energy output for the year divided by the energy output if the machine is operated at its rated power output for the entire year*". A reasonable capacity factor would be 0.25 to 0.30 and a very good capacity factor would be around 0.40.
9.	What is methane content (in %) of bio gas. **Ans.** The biogas consists of 60% methane with rest mainly carbon-di-oxide. Biogas is a safe fuel for

	cooking and lighting. By-product is usable as high-grade manure.
10.	Mention various types of Biomass or bio power? **Ans.** Biopower, or biomass power, is the use of biomass to generate electricity. There are six major types of biopower systems: *direct-fired*, *cofiring*, *gasification*, *anaerobic digestion*, *pyrolysis*, and *small - modular*.

Long type questions

1.	Explain renewable energy, mention various forms of the same and elaborate on its potential in Indian Scenario. **Ans.** Renewable energy sources are sources that are continuously replenished by natural processes. For example, solar energy, wind energy, bio-energy - bio-fuels grown sustainably, hydropower etc., are some of the examples of renewable energy sources. A renewable energy system converts the energy found in sunlight, wind, falling-water, sea-waves, geothermal heat, or biomass into a form, we can use such as heat or electricity. Most of the renewable energy comes either directly or indirectly from sun and wind and can never be exhausted, and therefore they are called renewable. Solar: India receives solar energy in the region of 5 to 7 kWh/m^2 for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plant per square kilometre land area. Wind Energy : India has been rated as one of the most promising countries for wind power development, with an estimated potential of 20,000 MW. Biomass fuels account for about one-third of the total fuel used in the country. It is the most important fuel used in over 90% of the rural households and about 15% of the urban households. Using only local resources, namely cattle waste and other organic wastes, energy and manure are derived. Thus the biogas plants are the cheap sources of energy in rural areas Cogeneration : Cogeneration improves viability and profitability of sugar industries. Indian sugar mills are rapidly turning to bagasse, the leftover of cane after it is crushed and its juice extracted, to generate electricity. This is mainly being done to clean up the environment, cut down power costs and earn additional revenue. According to current estimates, about 3500 MW of power can be generated from bagasse in the existing 430 sugar mills in the country. Around 270 MW of power has already been commissioned and more is under construction.
2.	(i) Explain about various components and operation of typical biogas plant (ii) what is fuel cell and establish link between Biogas plant and Fuel cell. **Ans.** (i) A typical biogas plant has the following components: A digester in which the slurry (dung mixed with water) is fermented, an inlet tank - for mixing the feed and letting it into the digester, gas holder/dome in which the generated gas is collected, outlet tank to remove the spent slurry, distribution pipeline(s) to transport the gas into the kitchen, and a manure pit, where the spent slurry is stored. (ii) Fuel cells work much like batteries, but never need recharging, producing electricity as long as there is fuel. Methane produced from the Biogas plant can also be used as the "fuel" in a fuel cell.
3.	Mention various energy efficient and conservation projects financed by IREDA. **Ans.** India has the World's largest programmes for renewable energy. Several renewable energy technologies have been developed and deployed in villages and cities of India. A Ministry of Non-Conventional Energy Sources (MNES) created in 1992 for all matters relating to Non-

	Conventional / Renewable Energy. Government of India also created Renewable Energy Development Agency Limited (IREDA) to assist and provide financial assistance in the form of subsidy and low interest loan for renewable energy projects. IREDA's covers a wide spectrum of financing activities including those that are connected to energy conservation and energy efficiency. At present, IREDA's lending is mainly in the following areas: - • Solar energy technologies, utilization of solar thermal and solar photo voltaic systems • Wind energy setting up grid connected Wind farm projects • Small hydro setting up small, mini and micro hydel projects • Bio-energy technologies, biomass based co-generation projects, biomass gasification, energy from waste and briquetting projects • Hybrid systems • Energy efficiency and conservation

4.	Write short note on the following: a) Hydro energy b) Tidal and Ocean Energy c) Biomass Gasifiers and its application. **Ans.** a) The potential energy of falling water, captured and converted to mechanical energy by waterwheels/turbine. Water under pressure flows through a turbine causing it to spin. The Turbine is connected to a generator, which produces electricity. A small and micro Hydro Power unit are reliable and has mature and proven technology. It is non-polluting, and does not involve setting up of large dams or problems of deforestation, submergence and rehabilitation. Micro (upto 100kW) mini hydro (101-1000 kW) schemes can provide power for farms, hotels, schools and rural communities, and help create local industry. In India the potential of small hydro power is estimated about 10,000 MW. A total of 183.45 MW small Hydro projects have been installed in India by the end of March 1999. Small Hydro Power projects of 3 MW capacity have been also installed individually and 148 MW project is under construction. b) Tidal Energy : Tidal electricity generation involves the construction of a barrage across an estuary to block the incoming and outgoing tide. The head of water is then used to drive turbines to generate electricity from the elevated water in the basin as in hydroelectric dams. Barrages can be designed to generate electricity on the ebb side, or flood side, or both. Tidal range may vary over a wide range (4.5-12.4 m) from site to site. A tidal range of at least 7 m is required for economical operation and for sufficient head of water for the turbines. Ocean Energy: The Ocean contains two types of energy: Thermal energy from the sun's heat, and mechanical energy from the tides and waves. Ocean thermal energy is used for many applications, including electricity generation. In this system, ocean's warm surface water is used to vaporize a working fluid, which has a low boiling point, such as ammonia. The vapour expands and turns a turbine. The turbine then activates a generator to produce electricity. Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. A barrage (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator. c) Biomass gasifiers convert the solid biomass (basically wood waste, agricultural residues etc.) into a combustible gas mixture normally called as producer gas. The conversion efficiency of the gasification process is in the range of 60%–70%. The producer gas consists of mainly carbon-monoxide, hydrogen nitrogen gas and methane, and has a lower calorific value (1000–1200 kcal/Nm^3). Gasification of biomass and using it in place of conventional direct burning devices will result in savings of at least 50% in fuel consumption. The gas has been found suitable for combustion in the internal combustion engines for the production of power. Using biomass gas, it is possible to operate a diesel engine on dual fuel mode-part diesel and part biomass gas. A few of the devices, to which gasifiers could be retrofitted, are dryers- for drying tea, flower, spices, kilns for baking tiles or potteries, furnaces for melting non-ferrous metals, boilers for process steam, etc.
5.	Explain about wind energy potential in India and Central govt Assistance and incentives **Ans.** India has been rated as one of the most promising countries for wind power development, with an estimated potential of 20,000 MW. Total installed capacity of wind electric generators in the world as on Sept. 2001 is 23270 MW. Germany 8100 MW, Spain- 3175 MW, USA 4240 MW, Denmark 2417 MW, and India - 1426 MW top the list of countries. Thus, India ranks fourth in the world in Wind power generation. There are 39 wind potential stations in Tamil Nadu, 36 in Gujarat, 30 in Andhra Pradesh, 27 in Maharashtra, 26 in Karnataka, 16 in Kerala, 8 in Lakshadweep, 8 Rajasthan, 7 in Madhya Pradesh, 7 in Orissa, 2 in West Bengal, 1 in Andaman Nicobar and 1 in Uttar Pradesh. Out of

	208 suitable stations 7 stations have shown wind power density more than 500 Watts/ m^2. The following financial and technical assistance are provided to promote, support and accelerate the development of wind energy in India: • Five years tax holiday • 100% depreciation in the first year • Facilities by SEB's for grid connection • Energy banking and wheeling and energy buy back • Industry status and capital subsidy • Electricity tax exemption Sales tax exemption

Numerical type questions

1.	In a village power supply to drinking water pumps is connected with 7.5 kVA DG set using HSD, which operates for 2 hours in a day. The specific energy generation ratio (SEGR) consumption of the DG set is 3.0 units per litre and pump consumes 4.0 kW. Villagers decided to use rape seed oil for the DG set. It is found that 4 kg of rape seed gives 1 litre of oil and 3 kg of bio fertiliser which can be sold at Rs 5 per kg. Using bio-fuel like rape seed SEGR consumption of DG set will fall by 10% (as per manufacturer). Cost of rape seed is Rs 7 per kg, where as HSD landed cost is Rs 24 per litre. Evaluate the cost difference per day between bio-fuel and HSD. **Ans.** Evaluation of fuel cost per day: HSD as fuel: Power consumption of pumps : 4.0 kW Pumps operating hours : 2 h/ day Electricity to be generated from DG set : 8 kWh / day Specific Energy generation ratio : 3 kWh / litre Fuel (HSD) consumption : 2.66 litre / day Cost of fuel per day : 2.66 x 24 = Rs 63.84/- Rape seed oil: Specific Energy generation ratio : 2.7 kWh / litre (10% less than HSD) Rape seed oil consumption for same electricity generation: 8/2.7 = 2.96 litre of oil /day Rape seed requirement for 2.96 litre oil : 2.96 x 4 = 11.84 kg of seed Bio fertilizer production by processing 11.84 kg seed : 8.88 kg (75% of seed) Cost of bio fertilizer (Rs 5/kg) : Rs 44.4 Cost of rape seed (Rs 7/kg) : Rs 82.9 Cost of rape seed oil after selling bio fertilizer : 82.9 – 44.4 = Rs 38.48 By using rape seed oil in DG set (instead of HSD) cost of fuel will come down by Rs 25.3 / day.

2.	A Plant has 4 electroplating process tanks of total capacity of 2000 litres, where hot water at 75 °C is used for process. Make-up water requirement for four tanks is around 1000 litres per day. During the year week-ends tanks will be cleaned and it will be toped up with fresh water (25 °C) of 2000 litres. Plant has planned to switch over from electrical heating to solar water heating for make-up water requirement. Cost of electricity for the plant is Rs 5.15 per kWh. Solar water heating supplier guaranteed make-up can be heated up to 75 °C. If the cost of solar water heater Rs 2,50,000 for 1000 litre capacity evaluate the simple pay back period taking 300 days process operation. **Ans.** Per day make-up water (for 4 water tanks) : 1000 litre Heat energy (electricity) use for heating tank make-up water: Water tanks : 1000 x 1 x (75-25) : 50,000 kcal Total heat required for preheating : 50,000 kcal After installing solar water heating system, make-up water temperature 75 °C (around) Reduction in heat energy (from electricity) : 50,000 kcal per day : (50,000/860) : 58 kWh per day Heat requirement during weekend (from one tank) : 2000 litres Reduction in heat energy for heating : 2000 x 1 x (75-25) : 1,00,000 kcal EQ. kWh savings = 116 kWh Annual savings from 4 tanks (320 days) : 58 x 300 = 17,400 kWh Annual savings from one tank (52 weekend process) : 116 x 52 = 6032 kWh Total annual savings : 17400 + 6032 = 23432 kWh Annual cost savings : Rs. 1,20,675/- (Unit cost @ Rs 5.15 per kWh) Investment for (1000 litres size) Piping net work : Rs 2,50,000/- Simple pay back period : $\frac{250000}{120675}$ = 2.07 years