12. APPLICATION OF NON-CONVENTIONAL & RENEWABLE ENERGY SOURCES

12.1 Concept of Renewable Energy

Renewable energy sources also called non-conventional energy, are sources that are continuously replenished by natural processes. For example, solar energy, wind energy, bio-energy - bio-fuels grown sustain ably), 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.

However, most of the world's energy sources are derived from conventional sources-fossil fuels such as coal, oil, and natural gases. These fuels are often termed **non-renewable** energy sources. Although, the available quantity of these fuels are extremely large, they are nevertheless finite and so will in principle 'run out' at some time in the future

Renewable energy sources are essentially *flows* of energy, whereas the fossil and nuclear fuels are, in essence, *stocks* of energy

Various forms of renewable energy

- Solar energy
- Wind energy
- Bio energy
- Hydro energy
- Geothermal energy
- Wave and tidal energy

This chapter focuses on application potential of commercially viable renewable energy sources such as solar, wind, bio and hydro energy in India.

12.2 Solar Energy

Solar energy is the most readily available and free source of energy since prehistoric times. It is estimated that solar energy equivalent to over 15,000 times the world's annual commercial energy consumption reaches the earth every year.

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.

Solar energy can be utilised through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials etc. Solar photovoltaic uses sun's heat to produce electricity for lighting home and building, running motors, pumps, electric appliances, and lighting.

Solar Thermal Energy Application

In solar thermal route, solar energy can be converted into thermal energy with the help of solar collectors and receivers known as solar thermal devices.

The Solar-Thermal devices can be classified into three categories:

- Low-Grade Heating Devices - up to the temperature of 100°C.
- Medium-Grade Heating Devices -up to the temperature of 100°-300°C
- High-Grade Heating Devices -above temperature of 300°C

Low-grade solar thermal devices are used in solar water heaters, air-heaters, solar cookers and solar dryers for domestic and industrial applications.

Solar water heaters

Most solar water heating systems have two main parts: a solar collector and a storage tank. The most common collector is called a *flat-plate collector (see Figure 12.1)*. It consists of a thin, flat, rectangular box with a transparent cover that faces the sun, mounted on the roof of building or home. Small tubes run through the box and carry the fluid - either water or other fluid, such as an antifreeze solution – to be heated. The tubes are attached to an absorber plate, which is painted with special coatings to absorb the heat. The heat builds up in the collector, which is passed to the fluid passing through the tubes.

Figure 12.1 Solar Flat plate collector

An insulated storage tank holds the hot water. It is similar to water heater, but larger is size. In case of systems that use fluids, heat is passed from hot fluid to the water stored in the tank through a coil of tubes.

Solar water heating systems can be either active or passive systems. The active system, which are most common, rely on pumps to move the liquid between the collector and the storage tank. The passive systems rely on gravity and the tendency for water to naturally circulate as it is heated. A few industrial application of solar water heaters are listed below:

- *Hotels*: Bathing, kitchen, washing, laundry applications
- *Dairies*: Ghee (clarified butter) production, cleaning and sterilizing, pasteurization
- *Textiles*: Bleaching, boiling, printing, dyeing, curing, ageing and finishing
- *Breweries & Distilleries*: Bottle washing, wort preparation, boiler feed heating
- *Chemical /Bulk drugs units*: Fermentation of mixes, boiler feed applications
- *Electroplating/galvanizing units*: Heating of plating baths, cleaning, degreasing applications
- *Pulp and paper industries*: Boiler feed applications, soaking of pulp.

Solar Cooker

Solar cooker is a device, which uses solar energy for cooking, and thus saving fossil fuels, fuel wood and electrical energy to a large extent. However, it can only supplement the cooking fuel, and not replace it totally. It is a simple cooking unit, ideal for domestic cooking during most of the year except during the monsoon season, cloudy days and winter months

Box type solar cookers: The box type solar cookers with a single reflecting mirror are the most popular in India. These cookers have proved immensely popular in rural areas where women spend considerable time for collecting firewood. A family size solar cooker is sufficient for 4 to 5 members and saves about 3 to 4 cylinders of LPG every year. The life of this cooker is upto 15 years. This cooker costs around Rs.1000 after allowing for subsidy. Solar cookers.(Figure 12.2) are widely available in the market.

Figure 12.2 Box Type Solar Collector

Parabolic concentrating solar cooker:

A parabolic solar concentrator comprises of sturdy Fibre Reinforced Plastic (FRP) shell lined with Stainless Steel (SS) reflector foil or aluminised polyester film. It can accommodate a cooking vessel at its focal point. This cooker is designed to direct the solar heat to a secondary reflector inside the kitchen, which focuses the heat to the bottom of a cooking pot. It is also possible to actually fry, bake and roast food. This system generates 500 kg of steam, which is enough to cook two meals for 500 people (see Figure 12.3). This cooker costs upward of Rs.50,000.

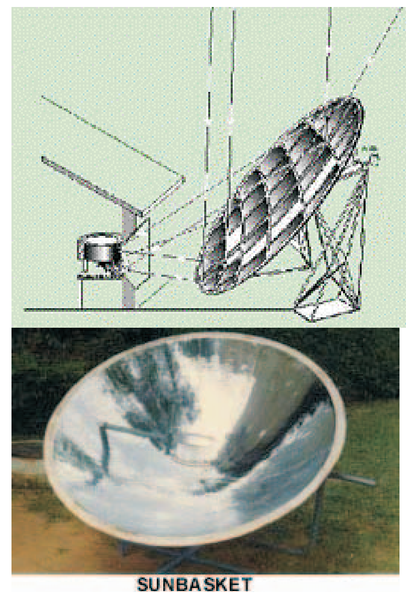


Figure 12.3 Parabolic Collector

Positioning of solar panels or collectors can greatly influence the system output, efficiency and payback. Tilting mechanisms provided to the collectors need to be adjusted according to seasons (summer and winter) to maximise the collector efficiency.

The period four to five hours in late morning and early afternoon (between 9 am to 3pm) is commonly called the "Solar Window". During this time, 80% of the total collectable energy for the day falls on a solar collector. Therefore, the collector should be free from shade during this solar window throughout the year - Shading, may arise from buildings or trees to the south of the location.

Solar Electricity Generation

Solar Photovoltaic (PV): Photovoltaic is the technical term for *solar electric*. Photo means "light" and voltaic means "electric". PV cells are usually made of silicon, an element that naturally releases electrons when exposed to light. Amount of electrons released from silicon cells depend upon intensity of light incident on it. The silicon cell is covered with a grid of metal that directs the electrons to flow in a path to create an electric current. This current is guided into a wire that is connected to a battery or DC appliance. Typically, one cell produces about 1.5 watts of power. Individual cells are connected together to form a

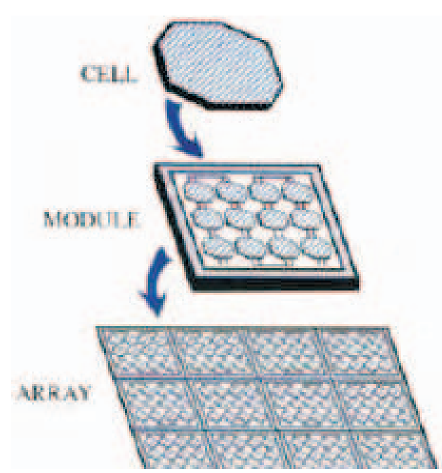


Figure 12.4 Solar Photovoltaic Array

solar *panel* or *module*, capable of producing 3 to 110 Watts power. Panels can be connected together in series and parallel to make a solar *array* (see Figure 12.4), which can produce any amount of Wattage as space will allow. Modules are usually designed to supply electricity at 12 Volts. PV modules are rated by their peak Watt output at solar noon on a clear day.

Some applications for PV systems are lighting for commercial buildings, outdoor (street) lighting (see Figure 12.5), rural and village lighting etc. Solar electric power systems can offer independence from the utility grid and offer protection during extended power failures. Solar PV systems are found to be economical especially in the hilly and far flung areas where conventional grid power supply will be expensive to reach.

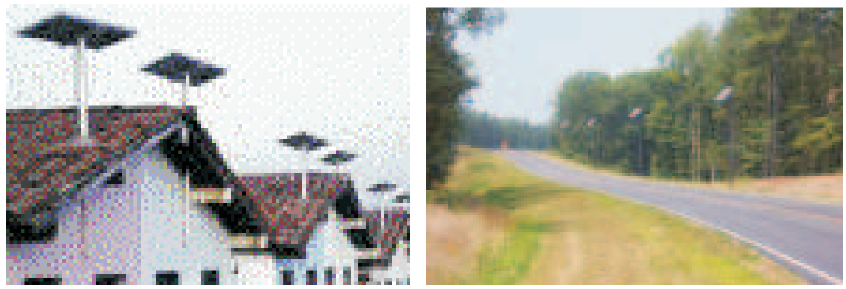


Figure 12.5 Photovoltaic Domestic and Streetlights

PV tracking systems is an alternative to the fixed, stationary PV panels. PV tracking systems are mounted and provided with tracking mechanisms to follow the sun as it moves through the sky. These tracking systems run entirely on their own power and can increase output by 40%.

Back-up systems are necessary since PV systems only generate electricity when the sun is shining. The two most common methods of backing up solar electric systems are connecting the system to the utility grid or storing excess electricity in batteries for use at night or on cloudy days.

Performance

The performance of a solar cell is measured in terms of its efficiency at converting sunlight into electricity. Only sunlight of certain energy will work efficiently to create electricity, and much of it is reflected or absorbed by the material that make up the cell. Because of this, a typical commercial solar cell has an efficiency of 15%—only about one-sixth of the sunlight striking the cell generates electricity. Low efficiencies mean that larger arrays are needed, and higher investment costs. It should be noted that the first solar cells, built in the 1950s, had efficiencies of less than 4%.

Solar Water Pumps

In solar water pumping system, the pump is driven by motor run by solar electricity instead of conventional electricity drawn from utility grid. A SPV water pumping system consists of a photovoltaic array mounted on a stand and a motor-pump set compatible with the photovoltaic array. It converts the solar energy into electricity, which is used for running the motor pump set. The pumping system draws water from the open well, bore well, stream, pond, canal etc

Case Example:

Figure 12.6 Photovoltaic Water Pumping

Under the Solar Photovolatic Water Pumping Programme of the Ministry of Non-conventional Energy Sources during 2000-01 the Punjab Energy Development Agency (PEDA) has completed installation of 500 solar pumps in Punjab for agricultural uses.

Under this project, 1800 watt PV array was coupled with a 2 HP DC motor pump set. The system is capable of delivering about 140,000 litres water every day from a depth of about 6 – 7 metres. This quantity of water is considered adequate for irrigating about 5 – 8 acres land holding for most of the crops. Refer Figure 12.6.

12.3 Wind Energy

Wind energy is basically harnessing of wind power to produce electricity. The kinetic energy of the wind is converted to electrical energy. When solar radiation enters the earth's atmosphere, different regions of the atmosphere are heated to different degrees because of earth curvature. This heating is higher at the equator and lowest at the poles. Since air tends to flow from warmer to cooler regions, this causes what we call winds, and it is these airflows that are harnessed in windmills and wind turbines to produce power.

Wind power is not a new development as this power, in the form of traditional windmills -for grinding corn, pumping water, sailing ships - have been used for centuries. Now wind power is harnessed to generate electricity in a larger scale with better technology.

Wind Energy Technology

The basic wind energy conversion device is the wind turbine. Although various designs and configurations exist, these turbines are generally grouped into two types:

1. **Vertical-axis wind turbines**, in which the axis of rotation is vertical with respect to the ground (and roughly perpendicular to the wind stream),
2. **Horizontal-axis turbines**, in which the axis of rotation is horizontal with respect to the ground (and roughly parallel to the wind stream.)

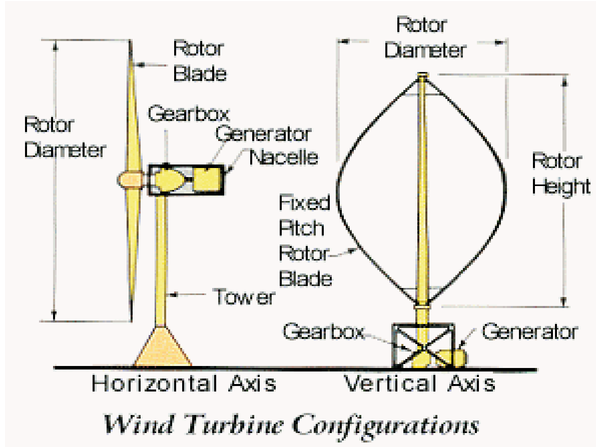


Figure 12.7 Wind Turbine Configuration

The Figure 12.7 illustrates the two types of turbines and typical subsystems for an electricity generation application. The subsystems include a blade or rotor, which converts the energy in the wind to rotational shaft energy; a drive train, usually including a gearbox and a generator, a tower that supports the rotor and drive train, and other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.

Wind electric generators (WEG)

Wind electric generator converts kinetic energy available in wind to electrical energy by using rotor, gear box and generator. There are a large number of manufacturers for wind electric generators in India who have foreign collaboration with different manufacturers of Denmark, Germany, Netherlands, Belgium, USA, Austria, Sweden, Spain, and U.K. etc. At present, WEGs of rating ranging from 225 kW to 1000 kW are being installed in our country.

Evaluating Wind Mill Performance

Wind turbines are rated at a certain wind speed and annual energy output

Annual Energy Output = Power x Time

Example: For a 100 kW turbine producing 20 kW at an average wind speed of 25 km/h, the calculation would be:

100 kW x 0.20 (CF) = 20 kW x 8760 hours = 175,200 kWh

The Capacity Factor (CF) is simply the wind turbine's actual energy output for the year divided by the energy output if the machine 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. It is important to select a site with good capacity factor, as economic viability of wind power projects is extremely sensitive to the capacity factor.

Wind Potential

In order for a wind energy system to be feasible there must be an adequate wind supply. A wind energy system usually requires an average annual wind speed of at least 15 km/h. The following table represents a guideline of different wind speeds and their potential in producing electricity.

Average Wind Speed km/h (mph)	Suitability
Up to 15 (9.5)	No good
18 (11.25)	Poor
22 (13.75)	Moderate
25 (15.5)	Good
29 (18)	Excellent

A wind generator will produce lesser power in summer than in winter at the same wind speed as air has lower density in summer than in winter.

Similarly, a wind generator will produce lesser power in higher altitudes - as air pressure as well as density is lower -than at lower altitudes.

The wind speed is the most important factor influencing the amount of energy a wind turbine can produce. Increasing wind velocity increases the amount of air passing the rotor, which increases the output of the wind system.

In order for a wind system to be effective, a relatively consistent wind flow is required. Obstructions such as trees or hills can interfere with the wind supply to the rotors. To avoid this, rotors are placed on top of towers to take advantage of the strong winds available high above the ground. The towers are generally placed 100 metres away from the nearest obstacle. The middle of the rotor is placed 10 metres above any obstacle that is within 100 metres.

Wind Energy in India

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 fifth 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.

Central Govt. Assistance and Incentives

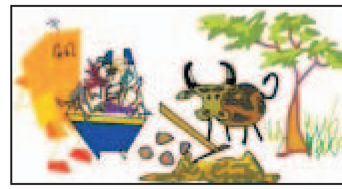
The following financial and technical assistance are provided to promote, support and accelerate the development of wind energy in India:

- 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

Applications

- Utility interconnected wind turbines generate power which is synchronous with the grid and are used to reduce utility bills by displacing the utility power used in the household and by selling the excess power back to the electric company.
- Wind turbines for remote homes (off the grid) generate DC current for battery charging.
- Wind turbines for remote water pumping generate 3 phase AC current suitable for driving an electrical submersible pump directly. Wind turbines suitable for residential or village scale wind power range from 500 Watts to 50 kilowatts.

12.4 Bio Energy



Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the wood industry, agricultural crops, raw material from the forest, household wastes etc.

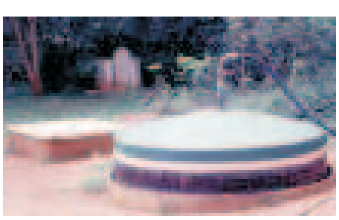
Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Its advantage is that it can be used to generate electricity with the same equipment that is now being used for burning fossil fuels. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas. Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development. Biomass offers higher energy efficiency through form of Biogas than by direct burning (see chart below).

Application

Bio energy is being used for: Cooking, mechanical applications, pumping, power generation
Some of the devices : Biogas plant/ gasifier/burner, gasifier engine pump sets, stirling engine pump sets, producer gas/ biogas based engine generator sets

Direct Burning	25 kg Fresh Dung	Biogas
5 kg dry dung	Product	1 cu m biogas
10460 kCal	Gross energy	4713 kCal
10%	Device efficiency	55%
1046 kCal	Useful energgy	2592 kCal
None	Manure	10kg air dried manure

Biogas Plants



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.

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.

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. The types of biogas plant designs popular are: floating drum type, fixed dome-type and bag-type portable digester.

Biomass Briquetting

The process of densifying loose agro-waste into a solidified biomass of high density, which can be conveniently used as a fuel, is called Biomass Briquetting (see Figure 12.8). Briquette is also termed as "Bio-coal". It is pollution free and eco-friendly. Some of the agricultural and forestry residues can be briquetted after suitable pre-treatment. A list of commonly used biomass materials that can be briquetted are given below:

Figure 12.8 Biomass Briquetting

CornCob, JuteStick, Sawdust, PineNeedle, Bagasse, CoffeeSpent, Tamarind, CoffeeHusk, AlmondShell, Groundnutshells, CoirPith, BagaseePith, Barleystraw, Tobaccodust, RiceHusk, Deoiled Bran

Advantages

Some of advantages of biomass briquetting are high calorific value with low ash content, absence of polluting gases like sulphur, phosphorus fumes and fly ash- which eliminate the need for pollution control equipment, complete combustion, ease of handling, transportation & storage - because of uniform size and convenient lengths.

Application

Biomass briquettes can replace almost all conventional fuels like coal, firewood and lignite in almost all general applications like heating, steam generation etc. It can be used directly as fuel instead of coal in the traditional chulhas and furnaces or in the gasifier. Gasifier converts solid fuel into a more convenient-to-use gaseous form of fuel called producer gas.

Biomass Gasifiers

Biomass gasifiers (see Figure 12.9) 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).

Figure 12.9 Biomass Gasifiers

Gasification of biomass and using it in place of conventional direct burning devices will result in savings of atleast 50% in fuel consumption. The gas has been found suitable for combustion in the internal combustion engines for the production of power.

Applications:

Water pumping and Electricity generation: Using biomass gas, it possible to operate a diesel engine on dual fuel mode-part diesel and part biomass gas. Diesel substitution of the order of 75 to 80% can be obtained at nominal loads. The mechanical energy thus derived can be used either for energizing a water pump set for irrigational purpose or for coupling with an alternator for electrical power generation - 3.5 KW - 10 MW

Heat generation: A few of the devices, to which gasifier 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.

Direct combustion of biomass has been recognized as an important route for generation of power by utilization of vast amounts of agricultural residues, agro-industrial residues and forest wastes. Gasifiers can be used for power generation and available up to a capacity 500 kW. The Government of India through MNES and IREDA is implementing power-generating system based on biomass combustion as well as biomass gasification

High Efficiency Wood Burning Stoves

These stoves save more than 50% fuel wood consumption. They reduce drudgery of women saving time in cooking and fuel collection and consequent health hazards. They also help in saving firewood leading to conservation of forests. They also create employment opportunities for people in the rural areas.

Bio fuels

Unlike other renewable energy sources, biomass can be converted directly into liquid fuels— biofuels— for our transportation needs (cars, trucks, buses, airplanes, and trains). The two most common types of biofuels are *ethanol* and *biodiesel*. See Figure 12.10.

Figure 12.10 Biodiesel Driven Bus

Ethanol is an alcohol, similar to that used in beer and wine. It is made by fermenting any biomass high in carbohydrates (starches, sugars, or celluloses) through a process similar to brewing beer. Ethanol is mostly used as a fuel additive to cut down a vehicle's carbon monoxide and other smog-causing emissions. Flexible-fuel vehicles, which run on mixtures of gasoline and up to 85% ethanol, are now available.

Biodiesel, produced by plants such as rapeseed (canola), sunflowers and soybeans, can be extracted and refined into fuel, which can be burned in diesel engines and buses. Biodiesel can also made by combining alcohol with vegetable oil, or recycled cooking greases. It can be used as an additive to reduce vehicle emissions (typically 20%) or in its pure form as a renewable alternative fuel for diesel engines.

Biopower

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*.

Most of the biopower plants in the world use direct-fired systems. They burn bioenergy feedstocks directly in boiler to produce steam. This steam drives the turbo-generator. In some industries, the steam is also used in manufacturing processes or to heat buildings. These are known as combined heat and power facilities. For example, wood waste is often used to produce both electricity and steam at paper mills.

Many coal-fired power plants use cofiring systems to significantly reduce emissions, especially sulfur dioxide emissions. Cofiring involves using bio energy feedstock as a supplementary fuel source in high efficiency boilers.

Gasification systems use high temperatures and an oxygen-starved environment to convert biomass into a gas (a mixture of hydrogen, carbon monoxide, and methane). The gas fuels a gas turbine, which runs an electric generator for producing power.

The decay of biomass produces methane gas, which can be used as an energy source. Methane can be produced from biomass through a process called anaerobic digestion. Anaerobic digestion involves using bacteria to decompose organic matter in the absence of oxygen. In landfills -scientific waste disposal site - wells can be drilled to release the methane from the decaying organic matter. The pipes from each well carry the gas to a central point where it is filtered and cleaned before burning. Methane can be used as an energy source in many ways. Most facilities burn it in a boiler to produce steam for electricity generation or for industrial processes. Two new ways include the use of microturbines and fuel cells. Microturbines have outputs of 25 to 500 kilowatts. About the size of a refrigerator, they can be used where there are space limitations for power production. Methane can also be used as the "fuel" in a fuel cell. Fuel cells work much like batteries, but never need recharging, producing electricity as long as there is fuel.

In addition to gas, liquid fuels can be produced from biomass through a process called pyrolysis. Pyrolysis occurs when biomass is heated in the absence of oxygen. The biomass then turns into liquid called pyrolysis oil, which can be burned like petroleum to generate electricity. A biopower system that uses pyrolysis oil is being commercialized.

Several biopower technologies can be used in small, modular systems. A small, modular system generates electricity at a capacity of 5 megawatts or less. This system is designed for use at the small town level or even at the consumer level. For example, some farmers use the waste from their livestock to provide their farms with electricity. Not only do these systems provide renewable energy, they also help farmers meet environmental regulations.

Biomass 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.

12.5 Hydro Energy

The potential energy of falling water, captured and converted to mechanical energy by waterwheels, powered the start of the industrial revolution.

Wherever sufficient head, or change in elevation, could be found, rivers and streams were dammed and mills were built. Water under pressure flows through a turbine causing it to spin. The Turbine is connected to a generator, which produces electricity (see Figure 12.11). In order to produce enough electricity, a hydroelectric system requires a location with the following features:

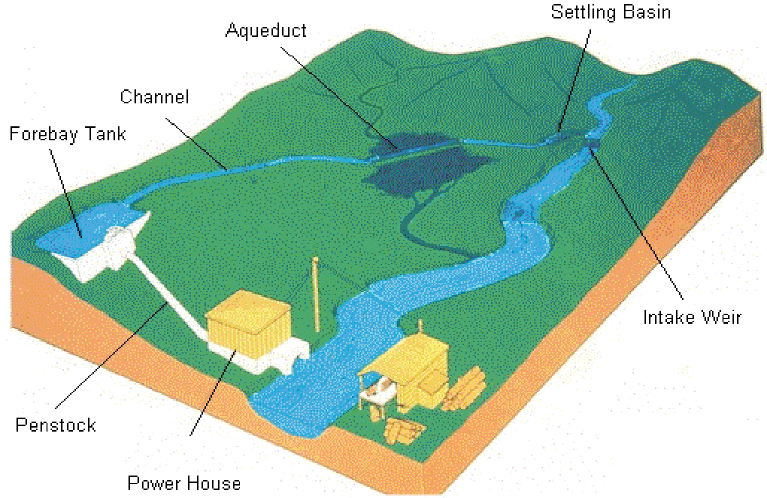
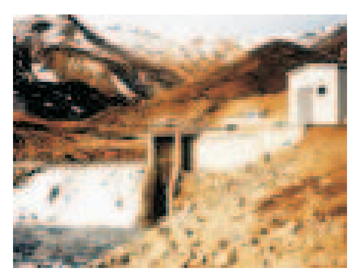


Figure 12.11 Hydro Power Plant

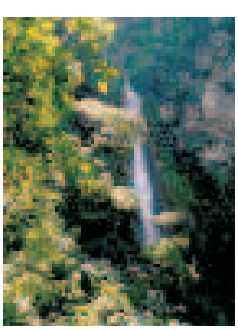
Change in elevation or head: 20 feet @ 100 gal/min = 200 Watts.
100 feet head @ 20 gal/min gives the same output.

In India the potential of small hydro power is estimated about 10,000 MW. A total of 183.45 MW small Hydro project 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.

Small Hydro



Small Hydro Power is a reliable, mature and proven technology. It is non-polluting, and does not involve setting up of large dams or problems of deforestation, submergence and rehabilitation. India has an estimated potential of 10,000 MW

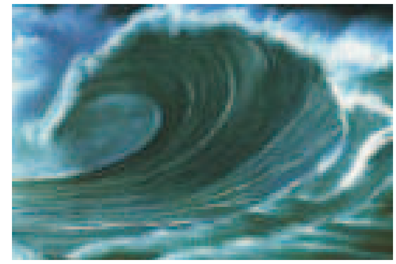


Micro Hydel

Hilly regions of India, particularly the Himalayan belts, are endowed with rich hydel resources with tremendous potential. The MNES has launched a promotional scheme for portable micro hydel sets for these areas. These sets are small, compact and light weight. They have almost zero maintenance cost and can provide electricity/power to small cluster of villages. They are ideal substitutes for diesel sets run in those areas at high generation cost.

Micro (upto 100kW) mini hydro (101-1000 kW) schemes can provide power for farms, hotels, schools and rural communities, and help create local industry.

12.6 Tidal and Ocean Energy



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

Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. Ocean energy draws on the energy of ocean waves, tides, or on the thermal energy (heat) stored in the ocean. The sun warms the surface water a lot more than the deep ocean water, and this temperature difference stores thermal 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. There are three types of electricity conversion systems: closed-cycle, open cycle, and hybrid. Closed cycle systems use the ocean's warm surface water 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. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine / generator. The hybrid systems combine both closed-cycle and open-cycle systems.

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.

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 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

The estimated potential of various Renewable Energy technologies in India by IREDA are given below.

Energy source estimated potential

Solar Energy	20 MW / sq. km
Wind Energy	20,000 MW
Small Hydro	10,000 MW
Ocean Thermal Power	50,000 MW
Sea Wave Power	20,000 MW
Tidal Power	10,000 MW
Bio energy	17,000 MW
Draught Animal Power	30,000 MW
Energy from MSW	1,000 MW
Biogas Plants	12 Million Plants
Improved Wood Burning Stoves	120 Million Stoves
Bagasse-based cogeneration	3500 MW

Cumulative achievements in renewable energy sector (As on 31.03.2000)

Sources / Technologies	Unit Upto31.03.2000
Wind Power	MW 1167
Small Hydro	MW 217
Biomass Power & Co-generation	MW 222
Solar PV Power	MW / Sq. km 42
Urban & MSW	MW 15.21
Solar Heater	m^2. Area 480000
Solar Cookers	No. 481112
Biogas Plants	Nos. in Million 2.95
Biomas Gasifier	MW 34
Improved Chulhas	Nos. in Million 31.9

QUESTIONS	
1	What do you mean by renewable energy
2	Why is solar energy potential high in India?
3.	Explain working of solar water heater?
4.	List few applications of low temperature water heaters in domestic and industrial use
5.	What are the two methods by which energy can be recovered from solar radiation
6.	How can the performance of solar collectors be improved?
7.	Explain any two applications of concentrated solar energy?
8.	What do you mean by photovoltaic?
9.	Explain the terms cell, module and array as applicable to photovoltaic.
10.	What are the typical applications of photovoltaic power?
11.	Name the few states with high wind energy potential in India.
12.	What are the criteria for selection of wind mill installation?
13.	What ere the incentives available for wind mill installation?
14.	Explain the bio-energy potential in India and its applications.
15.	What are the various methods by which power can be generated from biomass?
16.	What is the role of IREDA in renewable energy sector
17.	India has recorded good growth in wind energy sector. Do you agree? What are the factors responsible for such a high growth?

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