UNIT 15 HYDROPOWER AND WIND ENERGY

Structure

15.1 INTRODUCTION

Along with solar energy and biomass resources, water and wind are abundantly available energy resources. Many regions across the world have enormous supplies of water mainly in the form of rivers, streams, waterfalls, etc. You know that the water in rivers and streams can be used to produce electricity, also termed hydropower. The most common form of hydropower uses dams on rivers to create large reservoirs of water. In Unit 3, you have learnt how electricity is produced in hydropower plants. The focus in this unit is on **small hydropower** that produces electricity without disturbing the ecological and social conditions of a place. Small to medium sized local water resources can be tapped to fulfil the electricity demands of remotely located areas. Small hydropower has proved to be a cost competitive source of electricity.

In this unit, we also acquaint you with the working of **wind energy systems**. You have learnt about **wind energy** in Unit 3. In view of its economic success, wind power is playing a leading role in the development of renewable energy technologies. The technological progress made in wind turbines over the last few years has been tremendous. The next generation of turbines are expected to generate 3 to 5 MW power. The idea is that if you know the potential of these technologies, you can influence decisions about their use and take advantage of their applications in your own context.

Objectives

After studying this unit, you should be able to:

- explain the working of a small hydropower plant and a wind turbine;
- discuss the advantages and limitations of these technologies; and
- evaluate the potential of small hydropower and wind energy in India.

15.2 HYDROPOWER

You have studied about the ecological impact of hydropower in Unit 4. Although hydropower is inexpensive and does not produce air pollution, damming water bodies can change the ecology of the region. For example, the water below the dam is often colder than what would normally flow down the river, so fish sometimes die. The water level of the river below the dam can be higher or lower than its natural state, which affects the plants that grow along the riverbanks. Mega hydropower projects also have major social costs. In developed and many developing countries, such huge projects are being phased out slowly. The share of hydropower generation in India has shown a downward slide in spite of its large scale potential.

With the growing environmental consciousness, the stage is well set for large scale exploitation of **small hydropower** (SHP), which if used with care, can leave the ecology of a place undisturbed. Moreover, it is the highest density energy resource amongst all renewable sources of energy. The small hydropower route of power generation is well-established technologically across the globe under a diverse range of geo-physical conditions. Small and medium hydropower stations are now major sources of power supply in many countries of Europe and South East Asia, Canada, the USA and Brazil. Governments worldwide have formed a wide range of attractive policy initiatives coupled with financial and fiscal incentives to boost the growth of SHP.

Increasing numbers of small hydro systems are being installed in remote sites across the globe. There is a growing market for small hydropower systems especially in the developing countries as it also decreases the power demand and supply reliance on the conventional power grid. Therefore, you should know about it.

15.2.1 Small Hydropower

A hydropower plant producing less than 10 MW of useful electric energy is said to be a small hydropower plant. It can meet the captive power needs of closely located communities. With SHP, the transmission and distribution (T&D) losses are much lower as the power generated is close to the point of use. The small scale hydro is the cheapest way to power a house located away from the main grid. The price per kilowatt-hour is far cheaper than photovoltaics (PV) and even less than wind. We now explain the working of a small hydropower plant.

15.2.2 Working of Small Hydropower Plant

You know that in hydropower plants, the energy of **falling** water is captured to generate electricity (see Fig. 15.1). The falling water moves a turbine, which runs the generator to produce electricity.

Small hydro systems have the following components:

- a water turbine that converts the energy of flowing or falling water into mechanical energy that drives a generator, which generates electrical power;
- a control mechanism to provide stable electrical power; and
- electrical transmission lines to deliver the power to its destination.

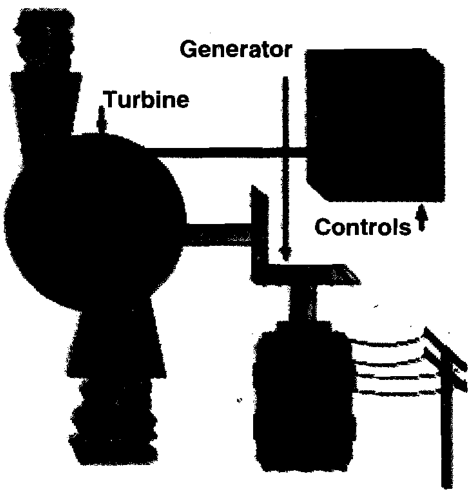

Fig.15.1: Schematics of hydropower generation

The amount of power that can be produced in a hydropower plant depends on two factors:

1. **Flow rate**, i.e., the amount of water flowing per unit time, and
2. **Head**, i.e., the height from which the water falls.

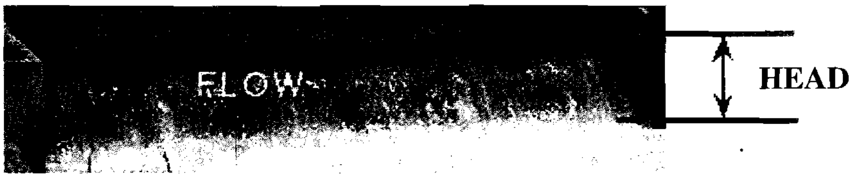

Fig.15.2: Flow rate and head determine the power capacity of a hydropower plant

See Fig. 15.3. Depending on the site, the following may need to be put in place to produce power from a small hydropower system:

- an intake to divert stream flow from the water course. The intake is usually placed off to the side of the main water flow to protect it from the direct force of the water and debris during high flow,
- a canal/pipeline to carry the water flow to the fore bay from the intake,
- a fore bay tank and trash rack to filter debris and prevent it from being drawn into the turbine at the penstock pipe intake,
- a penstock pipe to convey the water to the powerhouse,
- a powerhouse, in which the turbine and generator convert the power of the water into electricity, and
- a tailrace through which the water is released back to the river or stream.

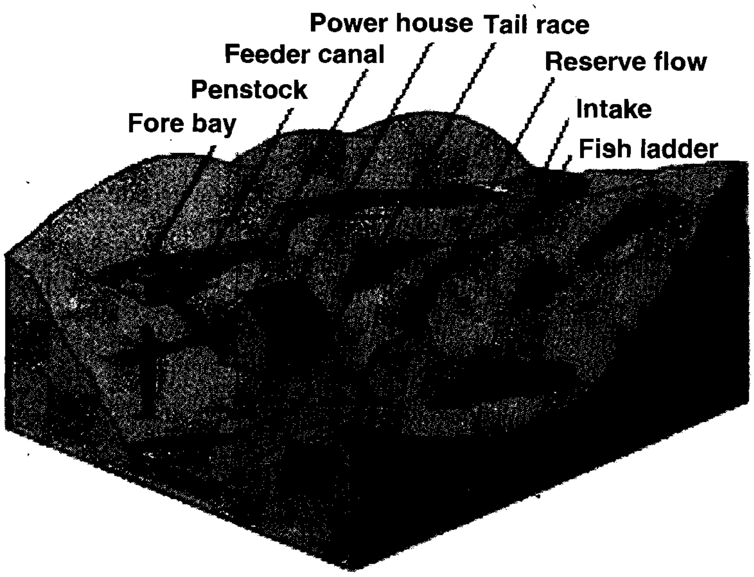

Fig.15.3: Schematic diagram of a small hydropower plant

If a pipeline is used, it should be of sufficiently large diameter to minimise friction losses from moving water. If possible, the pipeline should be buried in the ground. This stabilises the pipe and prevents animals from chewing it. Pipelines are usually made from PVC although metal or concrete pipes can also be used.

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Most SHP systems are of the "run-of-river" type. This means that neither a large dam nor water storage reservoir is built nor is land flooded. Only a fraction of the available stream flow at a given time is used to generate power, and this has little environmental impact. Additionally, fish ladders can be created to prevent fish from being harmed. Power is generated at a constant rate in an SHP system. However, if it is not used, it can be stored in batteries or sent to a shunt load.

However, these systems produce electricity only when water is available; generation ceases when it dries-up and the flow falls below a predetermined amount. Therefore, there is much less regulatory complication.

Power can be supplied by a small hydropower plant in two ways:

- In a **battery-based system**, power is generated at a level equal to the average demand and stored in batteries. Batteries can supply power as needed at levels much higher than that generated and during times of low demand, the excess can be stored. The input voltage to the batteries in a battery-based system commonly ranges from 12 to 48 volts DC. If the transmission distance is not large, then 12 volts is often high enough.

  Lead-acid deep-cycle batteries are usually used in hydro systems. Deep-cycle batteries are designed to withstand repeated charge and discharge cycles typical in renewable energy systems. Usually, a small hydro system needs just one to two days storage. In contrast, PV or wind systems may require many days' storage capacity because the Sun or wind may be unavailable for extended periods. This is typically known as system autonomy.

- If enough energy is available, an **alternating current (AC) system** can generate power. This system typically requires much higher power level than the battery-based system. In an AC system, there is no battery storage. This means that the generator must be capable of supplying the instantaneous demand, including the peak load.

  The most difficult load is the short-duration power surge drawn by an induction motor found in refrigerators, freezers, washing machines, some power tools and other appliances. Since other appliances may also be operating at the same time, a minimum power level of 2 to 3 kilowatts may be required for an AC system, depending on the nature of the loads. In a typical AC system, an electronic controller keeps voltage and frequency within certain limits. The system's output is monitored and any unused power is transferred to a "shunt" load, such as a hot water heater.

Battery-based systems usually need far less water than AC systems and are cheaply available. One of the advantages of a battery system is that the generator can be shut down for servicing without interrupting the power delivered to the loads. Since only the average load needs to be generated in this type of system, the pipeline, turbine, generator other components can be much smaller as compared to an AC system. Very reliable inverters are available to convert battery power into AC output. These are used to power almost all home appliances.

Small hydropower in developing countries implies decentralisation. Energy produced is usually supplied to relatively few consumers nearby, mostly with a low-tension distribution network. With energy efficient appliances and lights and careful end-use management, it is possible to reduce the average demand to about 200 watts of continuous supply.

Small hydropower system is not a complicated system. However, it needs to be designed with an utmost care keeping in view its operation at remotely located sites.

Before ending this discussion, let us look at the advantages and limitations of this technology.

Key Advantages of Small Hydropower

- SHP is a reliable, mature and proven technology. It can be exploited wherever sufficient water flows in streams, small and medium rivers, waterfalls, irrigation dams and canal drop sites.
- SHP does not involve setting up of large scale dams or problems of deforestation, submergence or rehabilitation of displaced population.
- It is a decentralised and environmentally benign source of power, which can be harnessed cheaply.
- It is non-polluting, entails no wastes or production of toxic gases and is thus quite safe to use.
- It is ideally suited for power fulfilment needs of small areas and village clusters and is an ideal substitute for diesel generators run at high cost of power generation.
- It has minimal operation and maintenance costs and can be maintained even by semi-skilled local people.

Limitations

- Hydropower systems can be difficult to install.
- Site topography is usually complex and logistics during the period of system installation become somewhat difficult.
- SHP systems require a diversion from the water body, pipelines from the diversion to the turbine, and a place to put the turbine above the high-water level of the stream. Building a diversion and intake that effectively screens out debris and can stand up to high seasonal flows is particularly challenging.
- Many a times, the turbine site is far enough away from the home and requires long runs of electrical cable.
- Most hydro systems are limited in output capacity by stream conditions. That is, they cannot be expanded indefinitely like a wind or PV system. The sizing procedure needs to be based on site conditions rather than power needs. Thus, the size and/or type of system components may vary appreciably from site to site.
- System capacity may be governed by specific circumstances (e.g., water drying up in the summer). A hydropower system is much more site-specific than a wind or photovoltaic system since a sufficient quantity of falling water should always be available.
- In case insufficient potential is available to generate the power necessary to operate the average load, more energy efficient appliances need to be used. Or other forms of generation equipment have to be added to the system. Hybrid wind/PV/hydro systems are very successful and the energy sources complement each other.

But if these limitations are overcome, we are rewarded with a constant, inexpensive, and low-maintenance source of energy.

15.2.3 Small Hydropower Development in India

India is bestowed with large resources of water bodies in the form of large rivers, waterfalls and streams. There exists an estimated potential of about 15,000 MW of small hydropower projects in India. In India, successful execution of smaller hydro capacities has been demonstrated under the UNDP-GEF hilly hydro programme and also by successful Independent Power Producers (IPPs). There are a sizable number of small hydropower development projects with the potential to generate 25 MW each.

Thirteen States in India (Himachal Pradesh, Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Karnataka, Kerala, Andhra Pradesh, Tamil Nadu, Orissa, West Bengal, Maharashtra and Rajasthan) have announced their policies for private sector participation in SHP sector. Core activities identified under the renewed focus on SHP include the following:

- nation-wise resource assessment,
- setting up of commercial SHP projects,
- renovation and modernisation of old SHP projects,
- development and up-gradation of water mills, and
- industry based research and development.

The facilities available include wheeling of power produced and banking, attractive buy-back rate, and facility for third party sale.

More than 760 sites of about 2000 MW capacity have already been offered/allotted in these States. Indian Renewable Energy Development Agency (IREDA) provides soft loans for setting up SHP projects up to 25 MW capacity in the commercial sector. UNDP/GEF Hilly Hydro project is also being implemented actively.

There are more than eight manufacturers in the country in the field of small hydropower manufacturing various types of turbines, generators and control equipment etc.

However, to date, only about 15% of the projects sanctioned have been implemented or are under various stages of implementation. The reasons for such a massive shortfall may be enumerated as follows:

- The existing mode of project allotment via open bids does not differentiate between bidders who are keen to actually implement the project and those who bid and hold on to the allotment indefinitely.
- The entry cost of Rs. 5-10 lakhs per MW is rather low. This allows bidders with minimal financial means to enter the fray, particularly in the 1-3 MW range. More often than not, such bidders are always on the lookout to sell the allotted project in lieu of some quick cash gains.
- Occasionally, the bidding company does have not the proper capability to execute the project. This may be in the form of inadequate knowledge and experience of executing such a project.
- In some cases, the project may have been taken up under the business diversification plan of the company. The remoteness of the project site and the distance from the usual place of business turn out to be the major handicaps.
- At some sites where the actual generation potential was found to be lower than estimated, the project has been abandoned.
- The high project cost and water royalty levied as free power deliverable to the SEB at 12-18 percent of generation also hinder the projects.
- The state governments have not instituted any scheme to encourage timely completion of the projects.

Due to these reasons, the actual power generated from the small hydro projects remains insignificant and much of the realisable potential remains untapped.

Incentives available for SHP Development

The Ministry of Non-Conventional Energy Sources (MNES) offers substantial cash subsidy for hydropower projects up to 25 MW capacity. The Project income is exempt from tax for ten years. No less important is the fact that hydro projects automatically qualify for carbon credits under the Clean Development Mechanism (CDM) supported by the Kyoto Protocol and similar Emission Reduction Funds. In addition, such projects provide a perennial stream of revenue to the investors. Besides, with the allowable provision to trade power, the entry of the private sector may push up the demand for hydropower generation because of its cost advantage. Let us look at some examples of SHP use in India.

Small Hydropower Utilisation in Uttaranchal

The water mills of Uttaranchal are in the process of receiving a technology refit at the hands of non-governmental organisations and the concerned government agencies. These water mills are known as *gharats* in the local parlance. The *gharats* are typically used for grinding wheat, rice and maize and also to extract oil. Such *gharats* are now getting technology attached to their slow moving wheels.

As per rough estimates, about half-a-million water mills exist in the entire Himalayan region from the North Eastern states to Jammu and Kashmir. It is possible to produce about 2500 MW of power from these mills at an average generation of 5 kW per unit. Uttaranchal alone has over 70,000 water mills. Around 150 such water mills have been turned around with bare minimum changes since 1989 to produce power in the Garhwal region of Uttaranchal through the painstaking efforts of local NGOs.

Today, in Lachiwala near Dehradun (in Uttaranchal) one such water mill produces enough electricity to light homes and run appliances along with grinding grains. The proud owner of the house has upgraded his *gharat* to power light bulbs, fans, TV, refrigerator and cooler too.

In Rudraprayag, another house owner designed his own turbine, which is no mean accomplishment. Today, each one of the 51 houses in the village cluster has a light connection at the nominal charge of Rs. 10 per month.

Small Hydropower Projects in Uttaranchal

S. No.	Name of Project	Capacity (MW)	District
1.	Tankul	7.80	Pithoragarh
2.	Kaliganga-I	4.60	Rudraprayag
3.	Kaliganga-II	6.00	Rudraprayag
4.	Painagad	4.00	Pithoragarh
5.	Supin	11.20	Uttarkashi
6.	Urgam-II	3.80	Chamoli
7.	Alaknanda-I	15.00	Chamoli
8.	Alaknanda-II	10.00	Chamoli
9.	Madhyamaheshwar	5.60	Rudraprayag
	Total	**68.00**	

Here are a few more inspiring stories sourced from www.indiatogether.org.

In the village of Dogwala up in the mountains, just 12 km from Dehradun, the capital of Uttaranchal, there are no roads, water supply, and telephone lines. The village houses about 12 families living below the poverty line. Homes are located roughly around a small canal that runs right through the middle. A few families, own traditional water mills or *gharats*. Until some time ago, there was no electricity in the village.

When the story of a faster *gharat* model that increased the output of flour grinding reached this village, three water millers in the village installed this new system. This turbine was so fast that their grain grinding output nearly tripled to 40 kg per hour and they could also produce their own electricity. Each water mill started generating 1 KW (kilowatt) of power. The children of Dogwala no longer had to study by the light of kerosene lamps. The run down water mills of the mountains were beginning to light up homes here.

Village youth were trained in operating and maintaining the system. They not only understood the working of the system they could also trouble shoot. These *gharats* have turned into a small industry. The miller usually employs two others to thus ensuring employment opportunities for the village youth. Sometimes a third person is employed as an electrician to check the lines and ensure that the power supply is uninterrupted.

(a) (b)

Fig.15.4: a) A traditional gharat; b) Ramgopal with his lathe machine
(Source: www.indiatogether.org/)

Wedged deep in the Himalayan Mountains are springs and glaciers that ensure steady flow of water perennially. The rivulet that runs through Ramgopal's field is a forceful one, and it hosts three turbines. Once his mill used to grind grains, today it is being used almost exclusively to operate a lathe machine. His turbines not only produce 5 KW of electricity but also run a lathe machine. The workshop is lined with metal wheels at all stages of development. Turbines are being fabricated here. His unit also doubles up as a training centre for aspiring *gharatis* – from government officials to army men who want to use this technique in remote outposts on the mountains. His unit can be seen busy working on new turbines that need to be installed in more inaccessible parts of the mountains. They are happy, as all the villages they have visited are now producing 2 kW power.

Most homes have two to three lights – no one wants to use oil lamps any more. Ramgopal cannot believe the respect and admiration he has started getting! And that too for a home made product. He has found a novel way to share this prosperity with the rest of his village. With one more turbine he should be able to generate 10 KW power, he says, "...at night when my workshop is shut, the street lamps can be lit. Our village is near the highway, after nightfall the place is very dangerous for our children, so the street lamps would be really useful. I think the best service I can provide others is sharing my knowledge with them."

Ramgopal avers "I have seen that the government spends lakhs of Rupees and yet it cannot provide electricity to all the remotest of places. If it decides to spend small amounts like Rs. 1 to 1.5 lakh on newer and more efficient models like the *gharat*, our villages can produce their own electricity. Through simple technology and minimum investment, maximum benefit can be obtained."

These are some glimpses of how small hydropower is transforming the lives of people in remote areas.

So far, we have provided you a brief introduction to the working and the usefulness of small hydropower. You may like to evaluate your understanding before studying about wind energy in the next section.

SAQ 1

Explain the working of a small hydropower plant. Under what conditions would such an option be feasible for power generation?

15.3 WIND ENERGY

You know that wind is considered an indirect form of solar energy. This is because wind is driven by temperature differences on the surface of the Earth caused by sunshine. For centuries, wind has been used to sail ships, grind grain, and pump water. Now, people use it to generate electricity. The windmills built long ago had many blades, but modern wind turbines have two or three blades (Fig. 15.5). However, the blades on wind turbines are much longer than those you might see on a windmill. In fact, wind turbine blades can be up to 82 feet (25 metres) long.

Fig.15.5: Wind turbines

The blades drive a generator that produces electricity, much like steam turbines. The longer the blades and the faster the wind speed are, the more is the electricity generated by the turbine. Wind turbines are placed on towers because the wind blows harder and more steadily at these heights. A typical 600 kW turbine has a blade diameter of 35 metres and is mounted on a 50-metre concrete or steel tower.

To produce the maximum amount of electricity, wind turbines need to be located in areas where the wind blows at a constant speed. Wind speed is described by seven "classes." Class 7 winds are extremely strong, while Class 2 winds are mild breezes. Generally, Class 4 winds and above are considered adequate for a wind turbine to produce electricity. New turbine designs now take advantage of less windy areas by using better blades, more electronic controls, and other improvements. Some new turbines can also operate efficiently over a wide range of wind speeds.

Large groups of wind turbines, called **wind farms** or wind plants, are connected to electric utility power lines and provide electricity to many people. New wind farms can generate electricity at $0.04/kWh, a price competitive with many conventional technologies. Wind energy can be used for stand-alone systems or fed into the grid.

The immediate demand for rural energy supply in developing countries is for smaller machines in the 5-100 kW range. These can be connected to small, localised micro-grid systems and used in conjunction with diesel generating sets and/or solar photovoltaic systems. These types of hybrid systems are ideally suited both for energy resource optimisation as well as cost reduction measures. Battery power backup system may be needed in view of the intermittent nature of both solar and wind energy.

An advantage of wind turbines over some forms of renewable energy is that they can produce electricity whenever wind blows (at night and also during the day). In theory, wind systems can produce electricity 24 hours every day, unlike SPV systems that cannot produce power at night. Land around the turbines may still be used for agricultural production. There is no air/water pollution and wind farms are relatively cheap to build.

However, even in the windiest places, the wind does not blow all the time. So, even though wind farms do not need batteries for backup storage of electricity, small wind systems need backup batteries. Moreover, wind energy systems have relatively high initial costs. Complex rotating machinery requires regular servicing from trained personnel. Care must be taken to avoid noise from the turbines. There can be a danger to birds from the rotating blades. There may be a strong resistance from local groups objecting to the visual impact of turbines on the landscape.

You may be wondering if it is feasible to tap wind energy wherever it blows and in whatever measure. Practically, every such site is not wind potential worthy. Generation may be intermittent and is best suited to sites with regular and reliable wind patterns.

Criteria for Site Selection

The following considerations may be kept in mind for the purpose of evaluating windy sites:

- The ideal and best possible site for locating a wind energy system is at the top of a smooth well rounded hill having a gentle slope and open areas like the shorelines of sea or lake. Ideally, the average wind speed should vary from 6.5 to 8 m/s for useful power production. Prime wind sites have average wind speeds greater than 7.5 m/s (27 km/hour). Offshore sites provide excellent opportunities for wind turbines. Sites with wind speed varying between 3-4 m/s may also be feasible. The mountain coastal terrain offers some of the best wind power generation sites.

- The power that can be generated from a modern wind turbine is usually related to the square of the wind speed. This means that a site with twice the wind speed of another will generate four times as much energy.

- Good wind speed data is critical to determining the economic feasibility of a wind project.

Applications of Wind Energy

There are many applications of wind energy in

- **domestic use:** to provide power for homes in remote areas for lighting, and other appliances such as radios and televisions;
- **water pumping:** to provide clean water for drinking and washing, water for fish farming, animal farming and irrigation systems;
- **large-scale power generation:** by connecting wind farms to the national grid.

We now explain the working of wind energy systems.

15.3.1 Working of Wind Energy Systems

The **wind turbine** is the main component of a wind energy system. As it rotates, it drives a generator to produce electricity. A modern wind turbine (see Fig. 15.6) usually consists of the following components: **Blades, Rotor, Transmission, Generator,** and **Controls**.

Shaped like the wings of a plane, **blades** capture the wind. They are made of Fibre Reinforced Plastic (FRP). Most turbines have two or three blades. As the blades are moved by the wind, they turn a central hub.

All the blades of a turbine and the central hub to which the blades are attached make up the **rotor**. The rotor is connected through a series of gears (**transmission**) to an **electrical generator**. Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1200 to 1500 rpm, which is the rotational speed required by most generators to produce electricity.

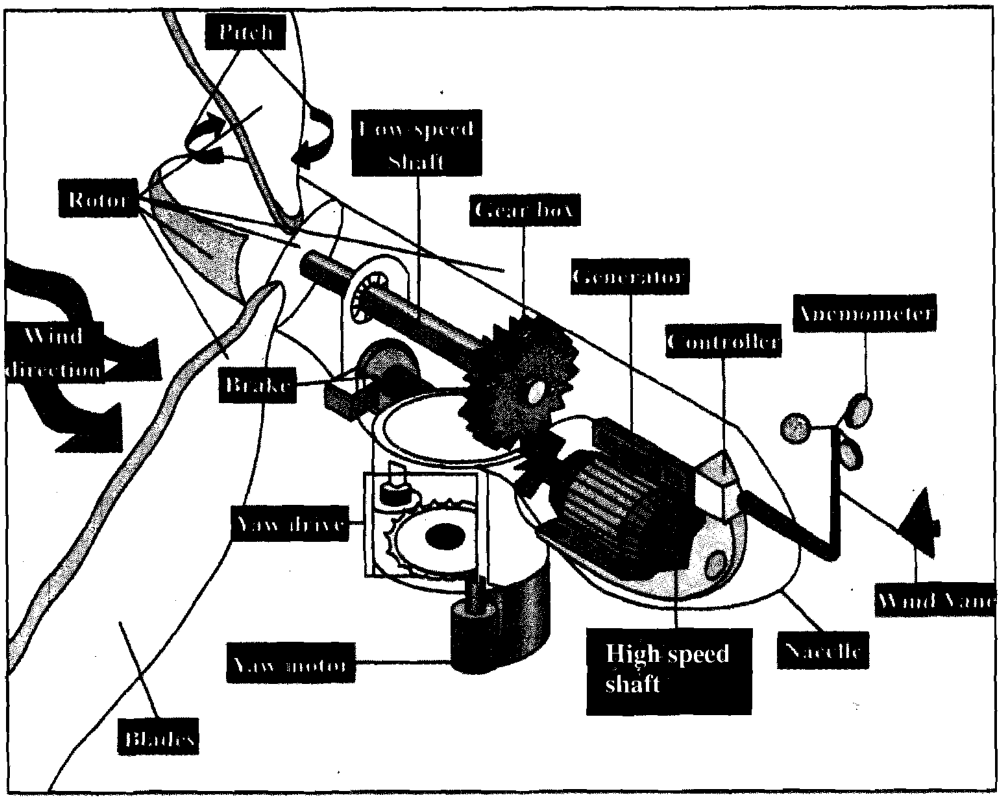

Fig.15.6: The schematic diagram of a wind turbine

The generator in wind energy systems is similar in construction to the generators used in thermal power plants. The **controls** start up the systems at wind speeds of about 8 to 16 miles per hour (mph) and shut them off at about 65 mph.

Turbines cannot operate at wind speeds above about 65 mph because their generators could overheat.

Wind turbines are rated by their maximum power output in kilowatts (kW) or in megawatts. For commercial utility-sized projects, the most common turbines sold are in the range of 600 kW-1000 kW (one megawatt) – large enough to supply electricity to 600-1000 homes. The newest commercial turbines are rated at 2 megawatts.

SAQ 2

Discuss the advantages and limitations of wind energy systems citing a few applications.

15.3.2 Wind Enrgy Applications in India

India's total wind power potential stands at around 45,000 MW. These figures were upgraded on the basis of a massive national wind resource assessment project. The wind machines deployed initially had a power generating capacity of just around 50 kW which has now been upgraded to about 750 kW and more.

Today several large scale wind farms operate in the southern region of the country. A National wind energy testing centre has been established in Chennai to maintain the standards as well as test the field performance reliability of the wide range of wind manufacturing equipment. Site-wise data pertaining to wind speed is now available for a large number of windysites. Using this data, the techno-economic feasibility of a site can be evaluated.

Wind farms are now adding nillions of units to the Indian power grid and several arrangements are now available for grid interfacing, third party sales and wheeling and banking facilities. We present here an example of wind energy use in India.

Wind Energy: An Exampl from Tamil Nadu

Wind energy has changed one of the most backward regions of Tamil Nadu, the Muppandal region, into an international model for social development. The giant fans atop the cluster of hills here are a standing testimony to the wind power development in this region. The region has close to 1500 giant windmill structures accounting for a whopping 460 MW of electricity generation.

Large sums of money invested in wind power have offered many direct and indirect job opportunities to the villagers In fact, Muppandal may be the only inhabited terrain in the world with a large concentration of wind mills. It may also go down as one of the first examples of renewable eergy having brought riches to an otherwise barren and drought prone area.

The land owners were the first to benefit from the wind farm development. Earlier, they had neither the means to cultivate their land nor were they in a position to sell it due to the lack of buyers. Their lot changed with the setting up of the National Centre for Wind Equipment Testing at Chennai. Availability of wind power helped them to irrigate their fields as they took advantage of 24 hour supply of quality power flowing through the newly set up electrical grid. Financial and technical support services related employment has found largetakers here. Young boys barely out of teens have been trained to check for defects on routine basis.

Having provided you a glimpse of the power of small hydro and wind energy in transforming the lives of people with readily accessible technology, we end this unit and present its summary.

15.4 SUMMARY

- **Small hydro** and **wind energy** are economical, non-polluting and environmentally benign renewable sources of energy. These are clean sources of energy and therefore effective.technologies for reducing carbon emissions.

- Water in the rivers, canals and streams can be captured and turned into hydro electric power. Small hydropower depends on two parameters: the **flow rate**, i.e., the amount of water flowing per second and the **head**, i.e., the vertical distance from which the water falls.

- A **small hydro system** consists mainly of **turbine**, **generator** and **pipeline** to carry water from the source to the turbine. In addition, it has an **intake to** divert stream flow from the water course, a **fore bay tank** and **trash rack** to filter debris and prevent it from being drawn into the turbine at the **penstock** pipe intake, and a **tailrace** through which the water is released back to the river or stream. It is easy to maintain and has long term operability.

- **Power produced** in a small hydro system **can either be stored in the batteries or fed directly to the grid**. Small hydro system can also be put in a hybrid combination either with Solar PV or wind energy dependingon the site specific conditions and parameters.

- Small hydro use is particularly well suited for developing countries like India, which has a large hydro resource and a large number of un-electrified villages. Small hydropower is a cheap source of power, which can meet the power needs of isolated village communities.

- **Wind** is an intermittent energy source and not availabe everywhere unlike solar energy. Wind energy output depends on a number of **site specific parameters** like the terrain, hour of the day and other topographical features.

- The machines which convert wind energy into electricalenergy are called **wind electric generators**. The **turbine** is the main component of a wind energy system.

- **Wind energy farms** use a large number of wind electric generators and are usually located away from the humdrum of noisy cities and towns. Wind energy can be fed to the utility power grid directly or used for captive power generation.

- Large scale wind energy programmes are in operation throughout the world. India, a SAARC member nation, is the fifth major producer of wind energy.

15.5 TERMINAL QUESTIONS

1. Discuss the advantages and limitations of small hyropower technology.
2. What are the criteria to tap small hydropower?
3. Discuss the advantages and limitations of wind energy technology.
4. Explain the criteria to set up wind energy system
5. How can the small hydropower and wind energy systems be used in the Indian context? Use the information given in Unit 8 while formulating your answer.