Technologies for Clean and Renewable Energy Production
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Lecture - 29
Wind Energy 2

Hi friends, now we will start discussion on the topic wind energy that is the second part of wind energy.

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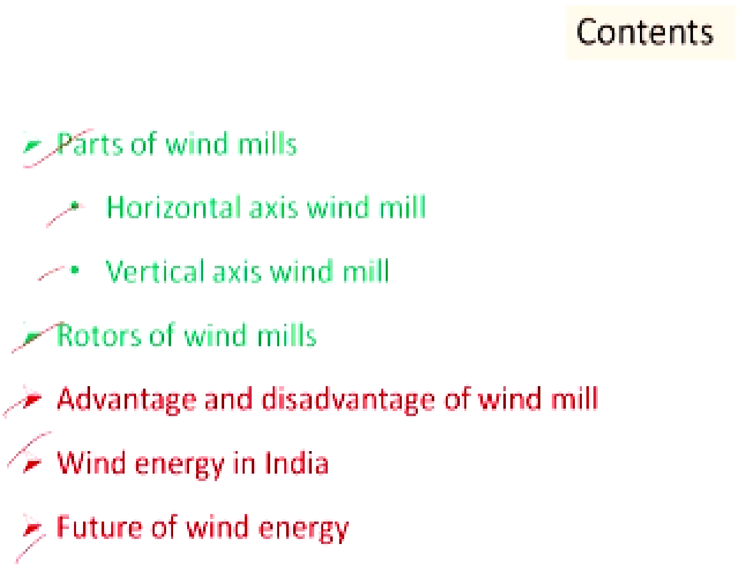

The content of today's class is parts of windmills, the horizontal axis windmill and vertical axis windmill, rotors of windmills, advantage and disadvantage of windmill, wind energy in India and future of wind energy.

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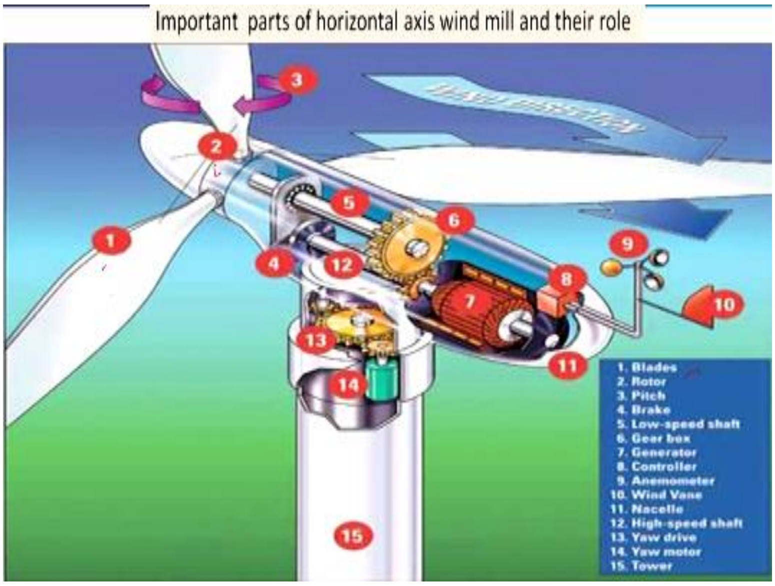

Now we will see the important parts of horizontal axis windmill and their role. So this slide shows us some example of horizontal axis windmill and different parts. We see here 1 that is blades, 2 is our rotor, 3 is the pitch, 4 is our brake, 5 we have shaft that is your low speed shaft, this 6 is our gearbox, 7 is our generator, then we have 8 is control unit and controller, 9 is your anemometer, 10 is your wind vane, then 11 is your nacelle, then 12 is our another shaft that is high speed shaft, then 13 is our yaw drive, 14 yaw motor, and 15 our tower.

This figure shows us different important parts of the horizontal axis windmill. Now we will see the role of these parts.

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Important parts of horizontal axis wind mill and their role

Blade (rotor blade): Helps to trap the kinetic energy of air/wind. The blades are basically the sails of the system; in their simplest form, they act as barriers to the wind (more modern blade designs go beyond the barrier method). When the wind forces the blades to move, it has transferred some of its energy to the rotor.

Rotor: The **rotor** is connected to the main shaft, which spins a generator to create electricity.

Pitch: Blade **pitch** or simply **pitch** refers to turning the angle of attack of the blades of a propeller or helicopter rotor into or out of the **wind** to control the production or absorption of power.
Pitch controls adjust the blades in wind turbines by rotating them so that they use the right fraction of the available wind energy to get the most power output, all the while ensuring the turbine does not exceed its maximum rotational speed.

Rotor brakes control over speed, and provide parking and emergency **braking**. These **brakes** can be mounted on the rotor or low-speed shaft, on the **generator** (high-speed shaft), and in some cases on both shafts.

Shaft - The wind-turbine shaft is connected to the center of the rotor. When the rotor spins, the shaft spins as well. In this way, the rotor transfers its mechanical, rotational energy to the shaft, which enters an electrical generator on the other end.

So let us see the blades number 1. So blade is the sails basically, it captures the kinetic energy of the wind and then it moves. Then 2 is rotor, rotor fixes the blades with it and also it is attached with the central shaft. This shaft is attached with one generator, so this socket arrangement is there. This 3 is pitch. The pitch is used to direct the blades in such a way that it will get maximum amount of wind. So we see the rotor brakes, we have some rotor brakes here, so this 4 the rotor brakes, the role is to prevent it from very high speed of the axis.

So rotor brakes control over speed and provide parking and emergency braking. So these brakes can be mounted on the rotor or low speed shaft on the generator that is high speed shaft. So this is our low speed shaft or it may be high speed shaft or may be in both, so that way the brakes can work. Then we see low-speed shaft. So low-speed shaft here it is attached with the rotor and then other side it is getting connected to one generator, but generator will be of high speed.

So this shaft connected to generator will be getting more speed because the diameter has been reduced here in the socket, the diameter has been reduced here, so the generator shaft gets more rpm, so more electricity can be produced. Then the wind turbine shaft is connected to the center of the rotor, when the rotor spins, the shaft spins as well, in this way the rotor transfers its mechanical rotational energy to the shaft which enters an electrical generator on the other end.

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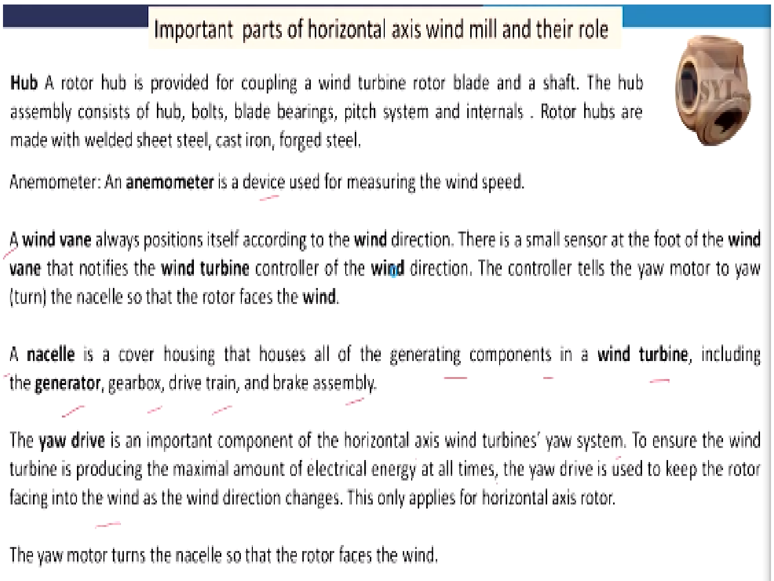

Then hub, the hub is important because it gives connection to low-speed shaft as well as the blades of the rotor, so rotor blades and shaft gets connected with the hub. Then anemometer is a device used for measuring the wind speed. Wind vane, wind vane that we are talking about this always gives the direction of wind and this at the bottom is attached to it this control unit that control unit gives the signal to the nacelle to move it according to the wind speed, so the total arrangement moves in such a way that maximum wind can be can be used.

Then the nacelle is a cover housing that houses all the generating components in a wind turbine including the generator, gearbox, drive train and brake assembly. The yaw drive, this yaw drive is an important component of the horizontal axis wind turbines' yaw system and the to ensure the wind turbine is producing the maximal amount of electrical energy at all times, the yaw drive is used to keep the rotor facing into the wind as the wind direction changes.

So when the wind direction changes, so this according to direction of the wind, the total nacelle will move in that direction and this yaw drive will help for this movement. So these are the different parts of the horizontal axis windmills. So this yaw drive helps to move the blade and then this controller this wind vane helps to decide in which directions this movement should be and this control unit perform this job by its control mechanism.

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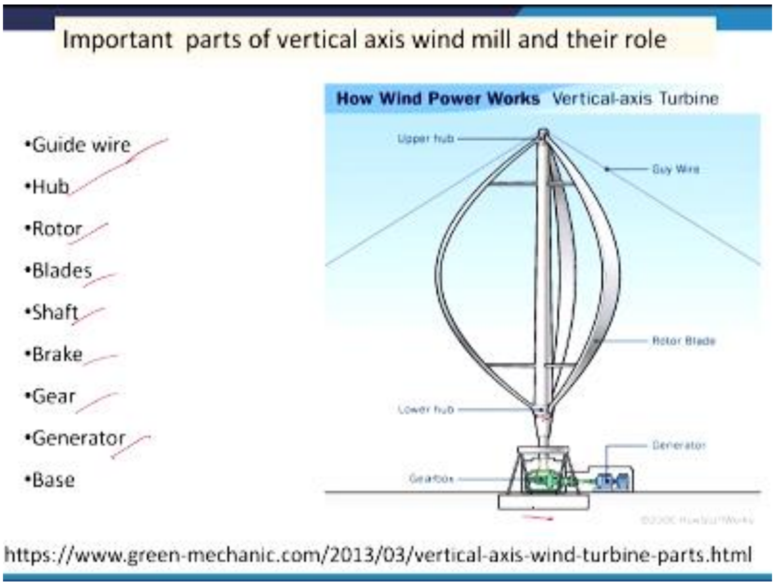

Now we will see important parts of vertical axis windmill and their role. So this figure shows a vertical axis windmill. So here our one shaft and then here we have 2 hubs, lower hub and upper hub. So in this hub, the shaft is attached and the blades are also attached. So both side we have hub to attach the blades unlike in a horizontal axis one side we had hub. So then we have guide wire, so guide wire, we have hub, we have rotor, we have rotor here, we have blades these are the blades, we have shaft.

Then we have brake arrangement here, and we have gear and generator and base, this is our base. So these are the different parts of the vertical axis windmill.

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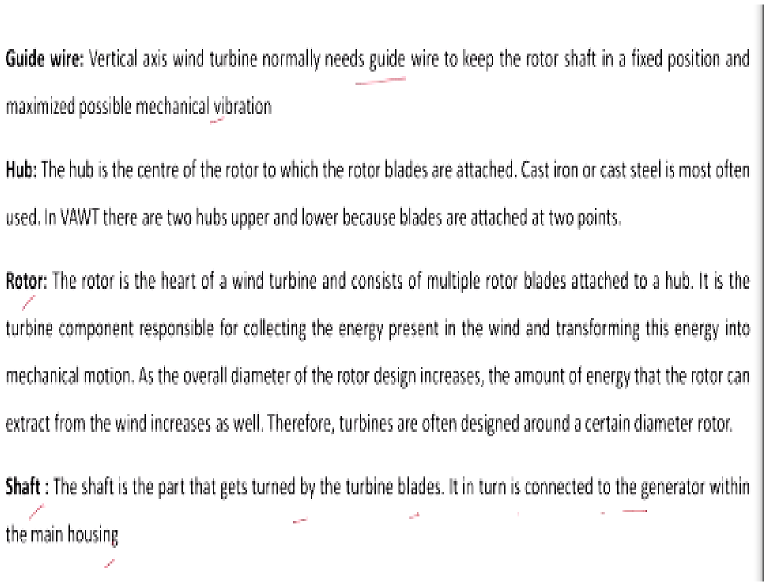

We see the guide wire. The vertical axis wind turbine normally needs guide wire to keep the rotor shaft in a fixed position and maximized possible mechanical vibration. Hub already we have discussed. Rotor also we have discussed. The shaft it is connected to the turbine one end and other end it is to the rotor. So the shaft is the part that gets turned by the turbine blades. It in turn is connected to a generator within the main housing.

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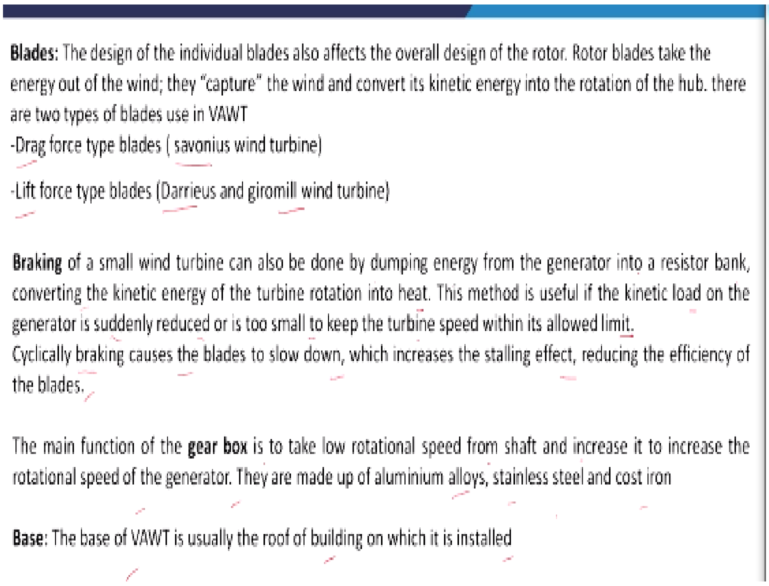

Then the blades, as you have seen the blades are like this, it is not similar to that of the horizontal axis turbines. So these blades may be of 2 types, one is may be of savonius wind turbine and that is drag force type blade and another is lift force type blades that is called

Darrieus and giromill wind turbine. Braking, already we have discussed that it can reduce the high speed of the shaft as well as it can also stop when there is no wind.

So the breaking of a small wind turbine can also be done by dumping energy from the generator into resistor bank and converting the kinetic energy of the turbine rotation into heat. So this method is useful if the kinetic load on the generator is suddenly reduced or is too small to keep the turbine speed within this allowed limit, just we are talking about. Then cyclically braking causes the blades to slow down, so which increases the stalling effect reducing the efficiency of the blades.

So this is the role of the braking, so cyclic braking is also not desirable. The gearbox we know that to control the speed of the shaft. The main function of the gearbox is to take low rotational speed from shaft and increase the rotational speed of the generator. They are made up of aluminum alloys, stainless steel, and cast iron. Base, the base is the roof or building on which it is installed. As you know, the height required for these machines is less than that of the horizontal axis machines.

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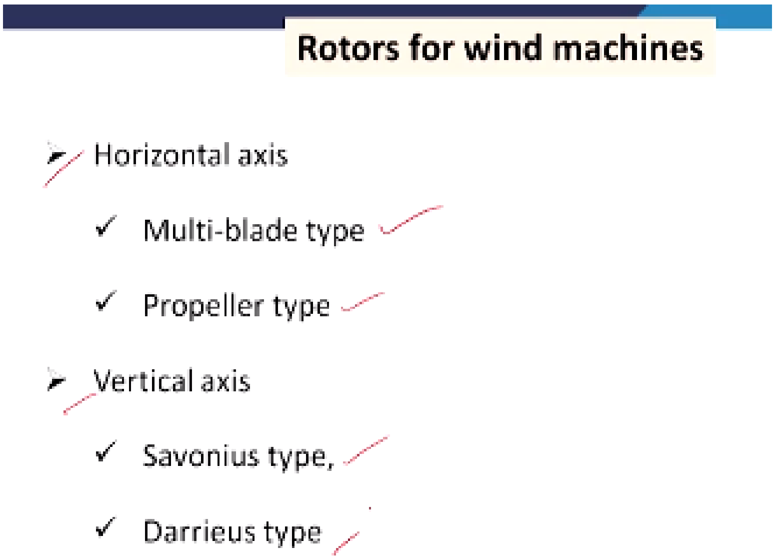

Now we will see the rotor part. So rotor of wind machines, so horizontal axis and vertical axis. If we see the rotor of these, basically the blades which are attached to these 2 types of machines are different, in case of horizontal we will get multi-blade and we can get propeller type and vertical axis we can get savonius type or Darrieus type.

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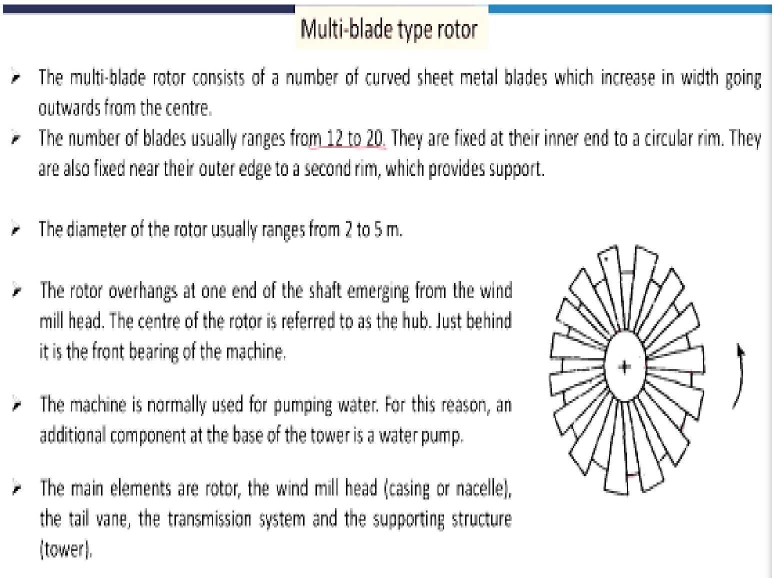

So this is one example of multi-blade type rotor. You see this is our rotor hub and the blades are connected here. So blade if you see the number of blades are connected in the hub around 12 to 20 number of blades are attached and other part is also connected with a circular rim. So this is our circular rim connected, and the blade if we see the width also increases as you go outside. So this is the structure of the multi-blade type rotor and this rotor was previously used in ancient mills and basically that mills are used for the pumping purpose.

So in this type of rotor when we are having these shafts there and then at the bottom of this mill, it is also having one water pump.

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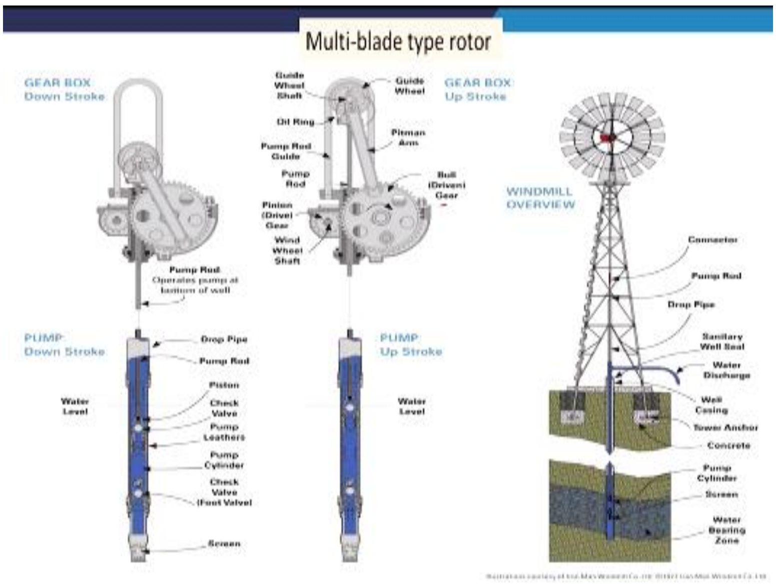

So we will see this is the case, so we have some multi-blade type rotor here and the multi blades and we see at the bottom it is connected with the pump. So this pump how it is working if we see, so this energy is coming from this machine, so this is lower socket to we are having in a gearbox so we are having the gear, so this gear diameter is more, and so rpm will be less here, and this is connected with your crankshaft, so that this crankshaft arrangement will help to give some vertical movement of the pump rod.

So that way it helps, it will helps to get the water out from these and for pumping purpose. So that was the initial application of this multiple blade type rotor.

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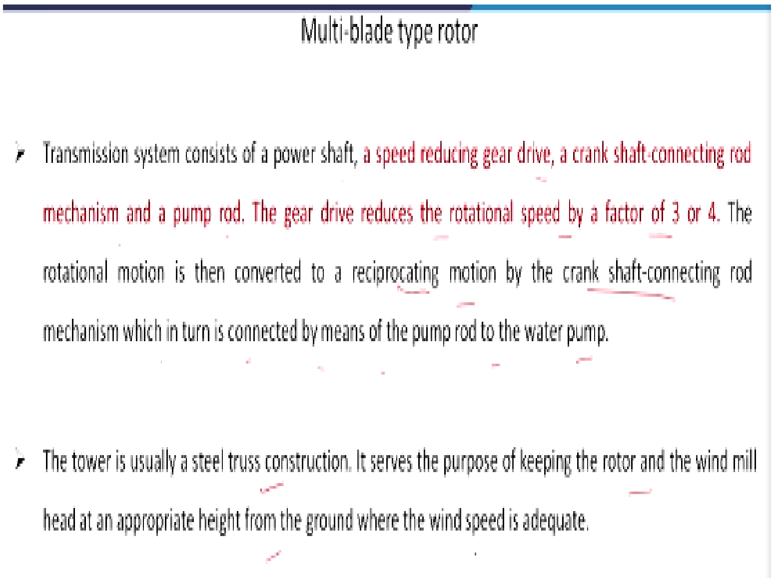

As you see the transmission system consists of a power shaft, a speed reducing gear drive, a crank shaft connecting rod mechanism and a pump rod. So the gear drive reduces the horizontal speed by a factor of 3 to 4. So this the gear drive, this is the gear which reduces the speed by 3 to 4 times reduction, by a factor of 3 or 4. The rotational motion is then converted into reciprocating motion. The rotational motion is converted to reciprocating motion by the use of this crankshaft, that we have discussed now, this mechanism which is connected this shaft.

It is helping to give the reciprocating motion and also which in turn connected by means of the pump rod to the water pump. So pump rod is used to connect the water pump. So this is the mechanism and that was used in the previous days. This tower is usually steel truss construction. It serves the purpose of keeping the rotor and the windmill head at an appropriate height from the ground where the wind speed is adequate.

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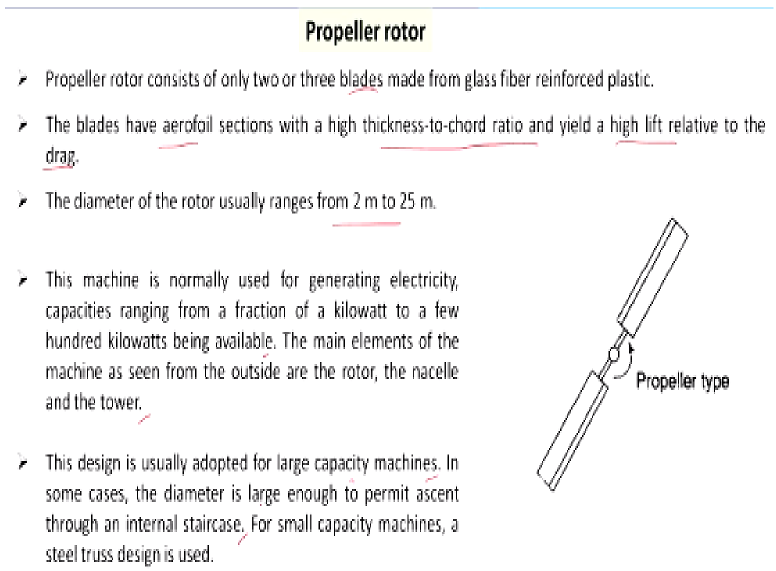

Now propeller type of rotor came later and these are more suitable for the production of electricity. So in this case, we get 2 or 1 or 3 blades made from glass fiber, reinforced plastic, and the blades have aerofoil sections with a high thickness-to-chord ratio and yield a high lift relative to the drag. So it gives high lift and gives more rpm. The diameter of the rotor usually ranges from 2 meter to 25 meter. The machine is normally used for generating electricity and then capacity is ranging from a fraction of kilowatt to a few hundred kilowatts being available.

The main elements of the machine as seen from the outside are the rotor, the nacelle and the tower. This is basically suitable for obviously the horizontal axis type of turbines, so this design is usually adapted for large capacity machines. In some cases, the diameter is large enough to permit ascent through an internal staircase.

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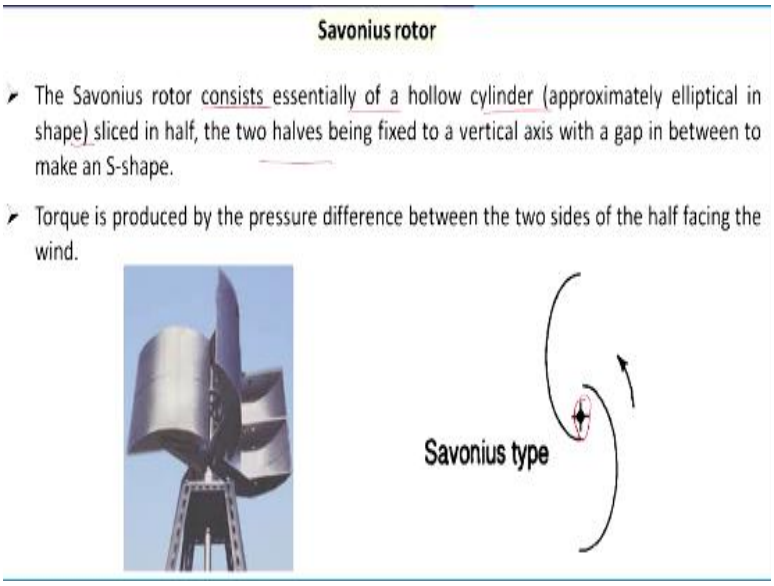

This is our for vertical axis type of machines, this type of rotor is used, savonius rotor. So we see here one S type of structure is formed. So it consists essentially of a hollow cylinder approximately elliptical in shape sliced in half. The two halves being fixed, so this is one half of hollow cylinder two part, so one connected here, this is our rotor, and so these are the blades, so as a whole it is called savonius rotor. So the torque is produced by the pressure difference between the two sides of the hub facing the wind. So here the drag force helps to rotate the rotor blades.

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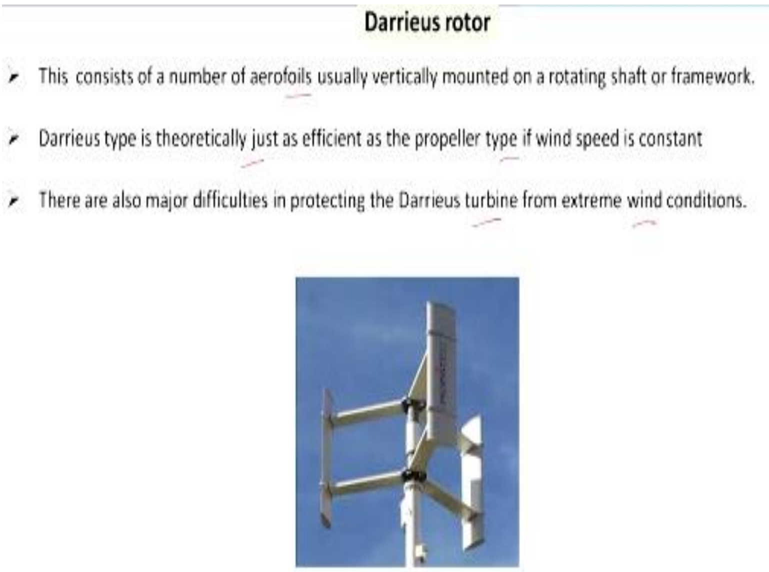

But in case of Darrieus rotor, this consists of a number of aerofoil, so this one, this one, this one so when the air is coming here, so there will be some lift, so lift will help to move the rotor and the blades. So Darrieus type is theoretically just as efficient as the propeller type if wind speed is constant, so its efficiency is better with respect to savonius type and there are few major difficulties in protecting the Darrieus turbine from extreme wind conditions.

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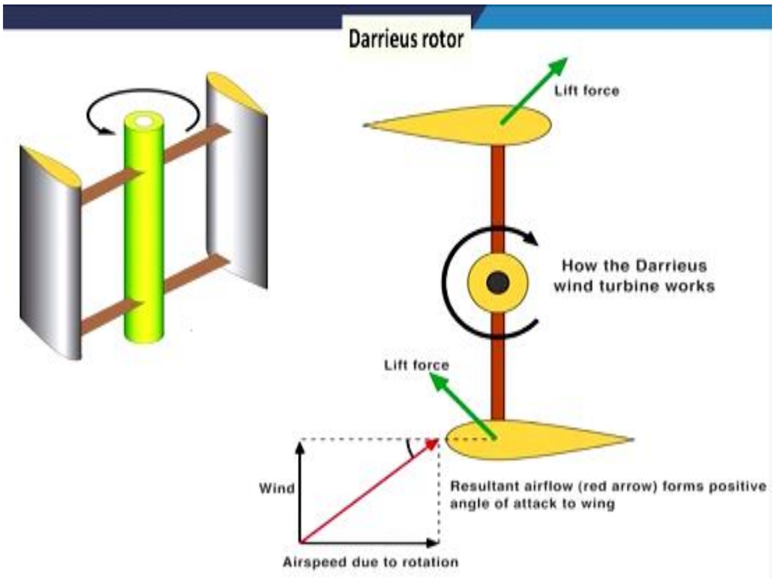

This is the mechanism you see here. So this will move this direction. So the lift will work in these directions and it will give some movement.

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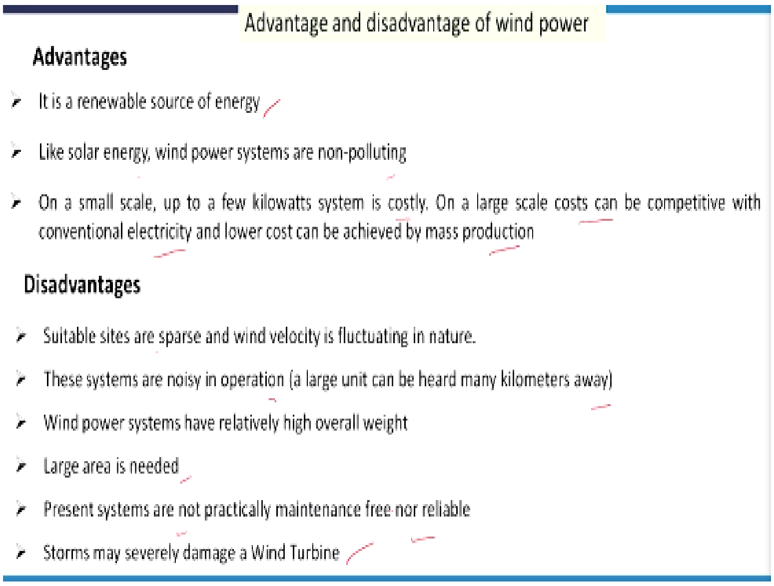

Now advantage and disadvantage of the wind power if we see. So it is a renewable source of energy, this is advantage one. Like solar energy wind power systems are non-polluting, no pollution from the wind power. On a small scale, up to few kilowatt system is costly, but on a large scale, cost can be competitive with other type of energy available, particularly the conventional electricity and lower cost can be achieved by mass production. So these are the advantage of wind, basically it is pollution free.

On that that way it is pollution free, but it also creates some noise pollution because these systems are noisy in operation, a large unit can be heard many kilometers away and suitable sites are sparse. Wind velocity is fluctuating in nature, so every time we may not get wind. It requires very large land area, so it has to be available, wind speed has to be available, then only these machines can be applicable for that area.

Then wind power systems have relatively high overall weight, obviously the weight is high and then the large area is needed. The present systems are not practically maintenance free or nor reliable. Storms may extremely damage the wind turbine, so we have to take some action for this.

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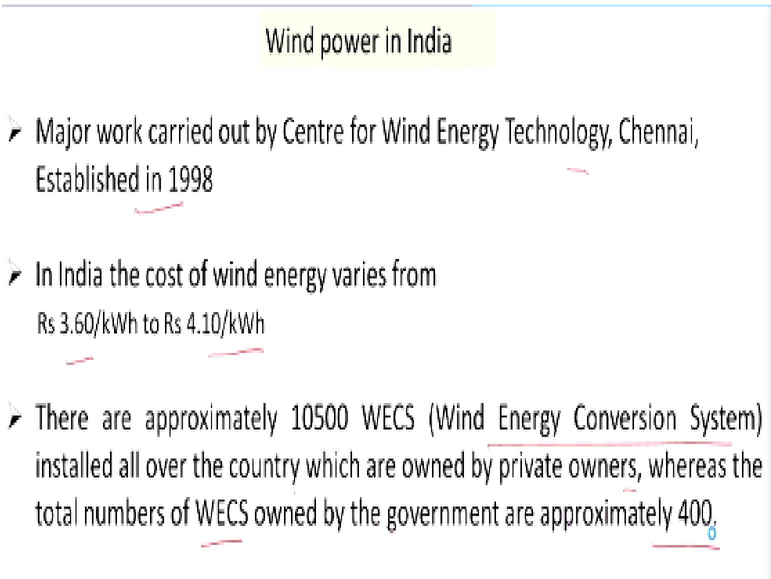

Now we see the wind power in India. So, major work carried out by the Centre for Wind Energy Technology, Chennai, established in 1998. In India the cost of wind energy varies from 3.6 to 4.10 that is slightly higher than that of the conventional energy, the coal waste energy or very competitive. There are approximately 10,500 WECS that is wind energy conversion system installed all over the country which are owned by private owners whereas the total numbers of WECS that is wind energy conversion system owned by the government is approximately 400.

So maximum private players are taking role for the development of this wind technology in the country.

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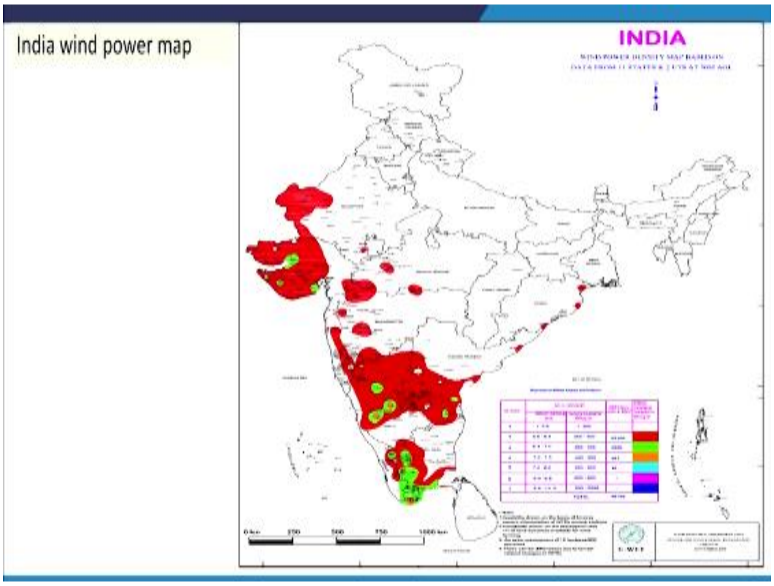

This is the wind map. You see all the coastal areas are having the potential to have the wind power harnessing.

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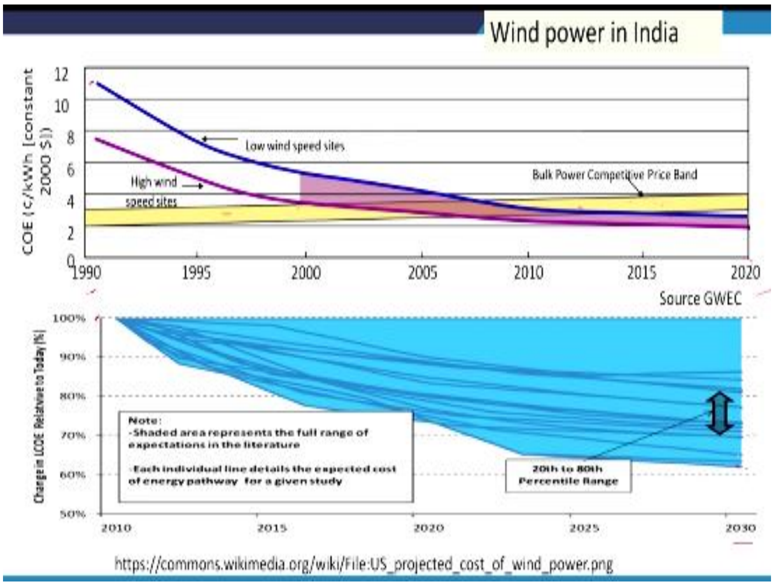

If we see the energy cost, the cost is also reducing. In 1990, what was the cost here and now it is expected to reduce here at 2020, and this is our bulk power competitive price band. So this is our competitive price, in this early stage, the wind energy was costlier, but here now it is very competitive and it is expected to be lower in near future. Here also the US prediction of the cost that is, it is expected to reduce by 2030, it is expected to reduce.

When it is at 2010 the price is 100%, it is expected to be around say 60 or 65% at 2030. So this is the wind energy cost reduction prediction in future.

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Future of wind energy

Potential state-wise break-up of renewable energy target of 60,000 MW by 2022

State/union territories	Wind installation (MW)
Northern region	
Rajasthan	8,600
Western region	
Gujarat	8,800
Madhya Pradesh	6,200
Maharashtra	7,600
Southern region	
Andhra Pradesh	8,100
Telangana	2000
Karnataka	6,200
Tamil Nadu	11,900
Other	
(New States)	600
Total	**60,000**

Source: MNRE http://mnre.gov.in/file-manager/UserFiles/Tentative-State-wise-break-up-of-Renewable-Power-by-2022.pdf

These are the future energy expansion, wind energy expansion in India. So northern region, western region, then southern region and others total 60,000 megawatt electricity production is expected by 2022. This is the future of wind energy in the country. So, up to this on this subject. Thank you for your patience.