Energy Resources and Technology
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Lecture - 26
Wind Energy - VI

In the last class we were learning about the, when we ended we were learning about the measuring instruments, anemometers.

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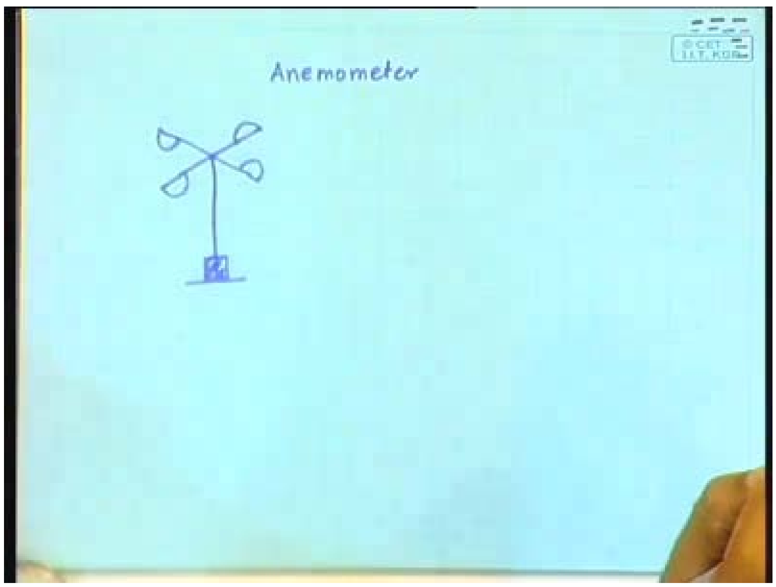

We have learnt about one specific type of anemometer, the Robinson cup anemometer in which there are cups like this at the end of rods, so that the whole thing would look something like this and it is a vertical axis device and here you have a measuring instrument. So, that is the essential structure of it and it is very simple. You can easily appreciate a couple of problems …. this one. If the speed, wind speed is too low, if the wind speed is too low, then obviously the speed of rotation will be small and then the torque produced will be, will have to overcome the frictional losses. If the frictional losses are much smaller, frictional, the torque due to friction is much smaller than the torque produced by the air, then it is working fine. But, if the torque due to friction becomes significant in comparison to the torque produced by the wind, then obviously it becomes somewhat inaccurate. That is one problem.

The second problem is the whole thing has some inertia, right, which means that if the wind speed changes fast, for example it was a very fast wind and then very swiftly the wind speed fell down. What will happen? It will continue to rotate because of its inertia and as a result, the fast drop in this wind speed will not be reflected by the speed of rotation of this fellow. So, fast changing wind speeds will not be properly reflected by the Robinson cup anemometer. So, these are the two major problems. One that it will not be able to measure wind speed accurately when wind speeds are say below 10 meters per second and secondly for fast changing wind speeds, it will not be very accurate.

The other problem is that here what kind of measuring or recording device you have? Here, it is by nature an electrical recording device. Because it is rotating, it will either be recorded as, as I told you in the last class as, a pulse signal whose frequency is recorded which is recorded by definition, by the essential nature as a recorded data in a computer, which means you have to have power supply and in most remote locations you may not have a power supply, right. So, that is a problem that this kind of devices may encounter.

One alternative may be that you have instead of a power supply operated thing you have a tachogenerator which means that it will generate its own voltage alright, but after that that voltage has to be recorded somehow. So, that poses a problem. So, these things are normally used where you have access to the power supply, but you can also imagine there are a large number of locations, for example the ones in Ladakh, up there in the hills, who will take power there. So, in this kind of remote locations you need to have some mechanically operated measuring and recording devices.

One mechanically operated measuring device I will describe now, it is called the pressure tube anemometer.

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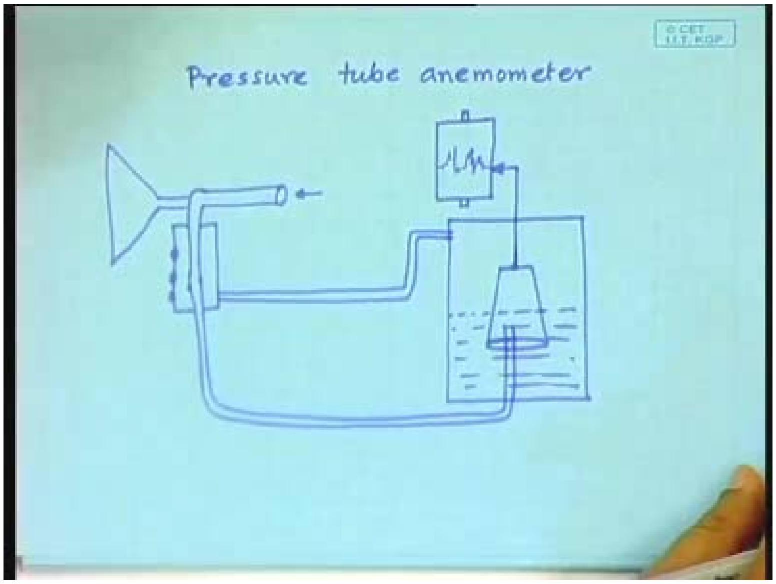

In the pressure tube anemometer, you have essentially a tube which is facing the wind and in order for it to face the wind, if the wind direction changes, it has to be reoriented and so, there has to be a tail vane. So, I will this one comes down and there will be a tail vane. So, this is the vane that orients it in the direction of the wind. So, the wind actually blows into the tube. If it blows into the tube what will happen? It will produce a larger pressure inside the tube. Now, that will be conveyed to another chamber. So, this fellow sits atop a poll at a height, always the wind speeds are measured at a height of 10 meters, so this will be, the whole thing will be atop a mast and then this will be brought down by means of a rubber tube to a place which I am showing now.

It will be a cylinder filled with, partially filled with water and there is a bucket like thing, a float which is inverted like this and this, this one actually is brought into, I will show it like this. So, what will happen? When wind blows, it will produce a pressure which will press it up. As a result, this float will rise and if the wind speed comes down, it will again sink and this is actually connected through a stiff rod to a pointer and at this point you have a strip chart recorder. So, what will happen? It will go up and down and if this cylinder with a paper on it rotates, then it will automatically record something like this. So, this is the essential structure of the pressure tube anemometer.

You might ask how does it rotate if you do not have an electrical power supply? This is often supplied by a spring operated device. So, there is a spring, there is a spring and somebody comes and winds the spring, like the olden days clocks you have to wind it up, right and the toys. So, there is a spring that is wound up once a day. So, it goes on rotating and it records without the intervention of anybody. In most designs, there is another ingenuity. Here, there is another outer sheath, outer casing of a cylinder and in the back side, this is the front side and in the back side there are series of holes.

What will happen? As the wind passes around that cylinder, it will, it will produce a suction effect, it will suck out air. So, here it produces a high pressure, in the outer cylinder it will produce a low pressure and that low pressure is then, with another flexible tube is, brought in here, so that this part, in this part you produce a low pressure, in this part you produce a high pressure. Thus the actual movement is further enhanced. So, this is the structure of the pressure tube anemometer normally used only in places where you do not have an electrical power supply.

If you do have electrical power supply, obviously the electrical recording has its advantage, because you can record it and take it for your later analysis, but ultimately here also you get a paper on which the wind speed variations are faithfully recorded. But, here also, as in the case of the Robinson cup anemometer, the low wind speed measurements will not be accurate. There it was not accurate because of the friction of the bearing. Here also, if the speed of the wind is low, obviously the pressure difference will be very small and that will not produce a sufficient amount of rise and fall, because there will be some amount of static friction in these joints. So, it will not be able to produce sufficient amount of force for the rise and fall. For low wind speeds therefore, a different type of measuring instrument is used. That is that depends on the character of the wind to cool anything, right.

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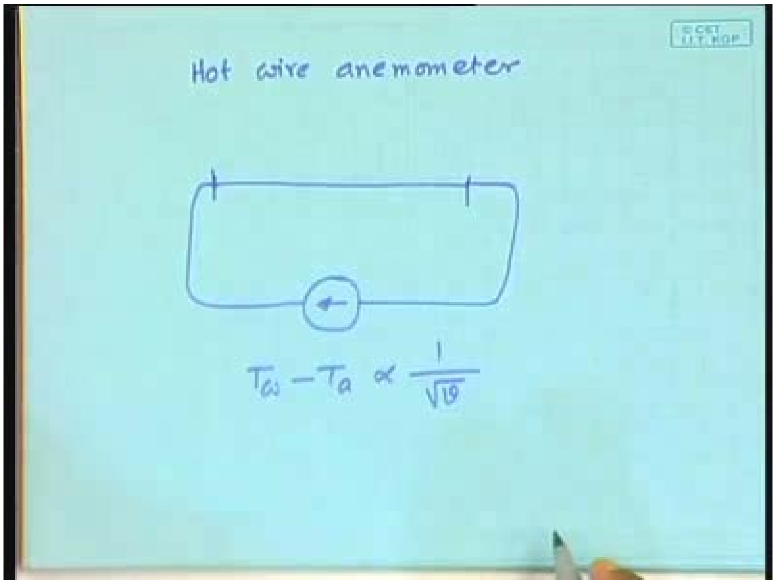

So, the name of that anemometer is the hot wire anemometer. The idea is simple. You pass a current through a wire, say here, this wire and you connect it to, what will you connect it to? A current source, not a voltage source, produce a specific current, specific amount of current say 1 ampere to flow through this wire, as a result of which there will be a heat produced. Heat produced means it will heat up, the temperature will be higher than that, higher than the normal temperature and at a higher temperature it will have a different resistance, right, so and then the wind blows and depending on the flow of the wind the temperature will be different even though the current is the same, because heat is dissipated away, it is taken away by the wind.

So, as the wind speed changes, the i square r law is the same; i square is the same, r is different. i square is the same, but the r is different, but that r will be continuously dependent on the wind speed. So, all you need to do is to measure the voltage, yeah, resistance, but the current is constant. So, measure the voltage that gives you the resistance and the resistance is a direct indication of the wind speed there, clear. In this case the advantage is that this can measure very low speeds quite efficiently, quite accurately. That is why for low speed measurements, the hot wire anemometer is better. The temperature of the wire minus the temperature of the ambient air will be proportional to 1 by root over the speed of wind and because of this relation, it becomes more accurate at very low wind speeds. So, these are the three types of anemometers in use and by far the largest number of anemometers are the Robinson cup anemometers.

So, let, when we, when we discuss from now onwards, we will assume that the measurement, initial measurement has come from a Robinson cup anemometer. What will the initial measurement be like? It could be that there is a microprocessor sitting there which is continuously taking the recording at constant intervals of time and it is recording as a data set. So, ultimately you have data set, time in the first column and the wind speed as the second column. It could, it could be that or it could be that you have already program in that microprocessor, so that it calculates the average value and ultimately, you come after some time and read off that average value from a display. Both are possible, both are actually done.

So, what will be the average value?

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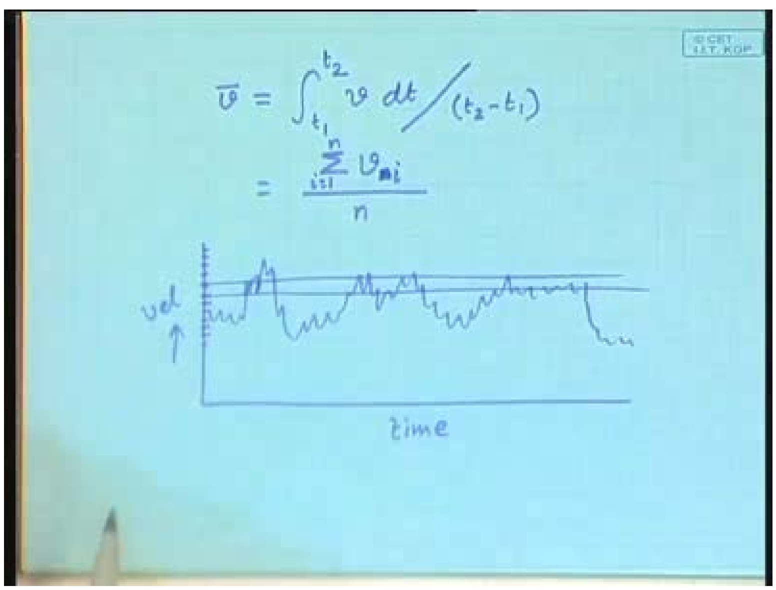

Average value will be, averages are normally denoted with a over bar, is from the starting time to ending time, t 1 to t 2 v dt, the whole thing will have to be divided by …, so that will be the average value. But, this is the average value if you know this as a continuous function of time, right. If you have this as a discrete function of time, then what will it be? Summation, yes. So, in that case, this is also the same as the summation over v n that means the different divided by … So, that will be the average value. No, I, I will write v i with i varies from 1 to n. So, essentially average, calculating the average is not a big deal. So, this is the average value. The reason I am describing this is that, in many cases it becomes somewhat difficult to get the actual indication of the continuous variation of the wind speed. People prefer to simply read off the average value and derive many conclusions out of that. How it is done, I will come to that later.

But supposing you have the continuous measurement available to you, you go after some time, bring back that hard disk or simply push in your USB drive, get the data and come back. What you have? After you have plotted it, you have a horribly messy curve, right. Here is the time and here is the velocity. What will be the curve like? A horrible messy curve, because it will be continuously varying. On the first go you will see that okay, I cannot derive anything out of it, because it is a horribly messy curve. All I can say is this, the average and that is why, yes, many people simply take the, obtain the average and that is what we use. But, let us see what we can make out of this? After all, from here we can derive the probability density distribution function. Can't we?

What is the probability density distribution function? If I ask you what the probability is that the wind speed will be something like 12 meters per second, you can obtain that. How? All you will have to do is to divide this axis into blocks like this and then find out for how much time was the wind speed within a specific block. For example, if you, if you take this block, you draw a horizontal line and measure off the times when this was inside this range and then what is the probability of us finding it in this block is that this time divided by the range. So, that is the definition of the probability density distribution and we can do that, can't we? What will you expect to see in that probability density distribution function?

First, what is the probability the wind speed will be zero? Zero. What is the probability that the wind speed will be infinity? Zero; so, obviously it will be a curve that starts off like this, builds up and then again goes down like that.

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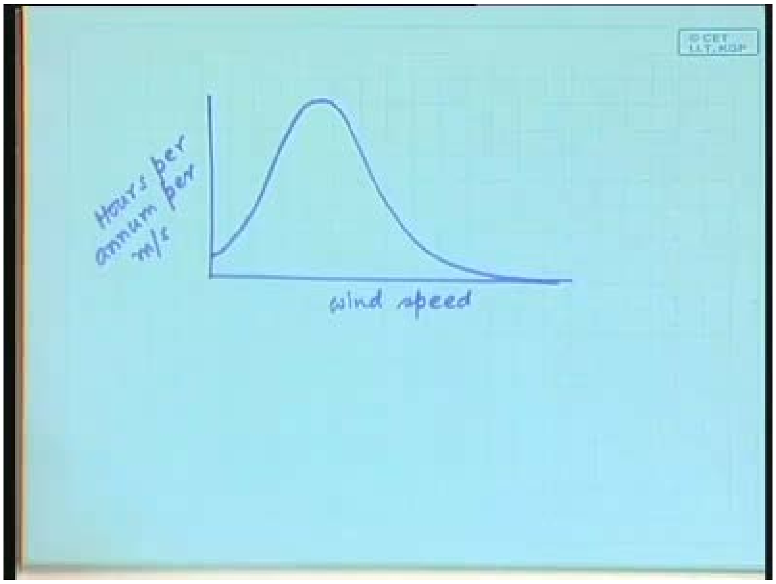

So, it will be logically something like this and here it is, there are two ways in which the y-axis can be drown. I will show for one. This is hours, hours per annum per meters per second. In that case it will be, well, in some sites, at this point when the wind speed is zero the hours per annum may not be zero. Why? Because, there could be some sites where it is actually zero; you have seen in Kharagpur, there are some days or days when not even the leaves move, horrible days, but there are such days, right. So, in practical measurement you might say that, theoretically it cannot be zero. Yes, theoretically it will start from here, but for practical purposes it could start also from there. So, it will be a curve that will go and finally it will fall like this.

The specialty of this unit is that, what will be the area under this curve? Will be the number of hours per year, 8760. You could also rescale this y-axis, so that the area of the curve, under the curve is 1. There are two ways. Area under the curve is 1 that is what gives you the probability or for our purpose, since we try to find out for how long will the wind speed be within a certain range in a particular year, most people prefer this hours per annum per meters per second. But, you can easily see that these are nothing but scaling.

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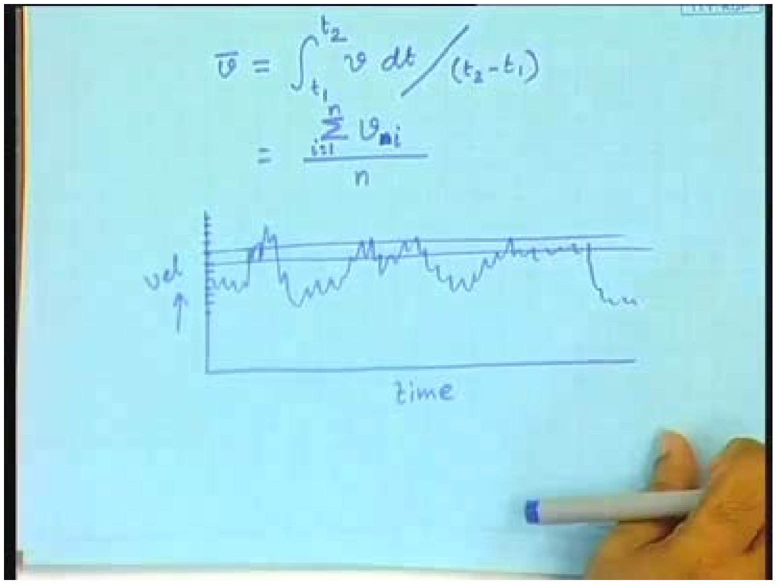

So, is it clear how you obtain this from this horrible graph and if this graph is available to you as a data set, then you can easily do that by writing a computer program. That will be trivial job, so you have this.

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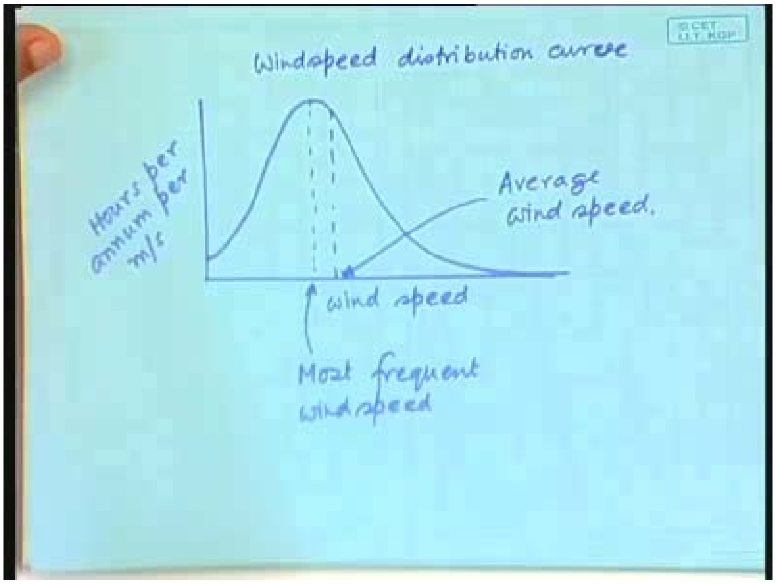

What does this point mean? This is the most frequent wind velocity, so this is the … But, this may not be the average, right and the average will be, in most cases somewhere beyond that, greater than that. So, say this is the average. The average will be the one where the area under the curve this side and that side is the same. So, this will be the average. So, this is … So, this is the probability density distribution function or this is the wind speed distribution function. This is the … It is important to note that this curve will be different for different sites.

In some sites you will find that for a short duration there is very high wind speed, but for the, for the other span of time it will be very low. So, in that case it will have a completely different distribution than the sites where it is a moderate wind speed for most of the time. In both cases, you will be able to obtain this, but they will be different. The curves will be different. That is why the wind energy harnessing is very, very location dependent; very location dependent. You have to obtain this curve for a specific site and on that basis you have to decide things.

What do you decide? For example, if you are trying to buy a wind turbine for a particular site, what will you first look for? Every wind turbine, as I told you, will have a rated wind speed it is designed to work. At that wind speed it works fine, with maximum efficiency at that wind speed. So, where will you rate it? Here, here, here, where? Average value? Most frequent, no, wrong. Wrong, because the most frequent wind speed may not be the one at which most power is available. Why? What is the, what is the expression for the power in energy, in wind? It is proportional to V cube, right. So, if this is the probability distribution function, what is the distribution function for something that depends on V cube? How will you obtain that?

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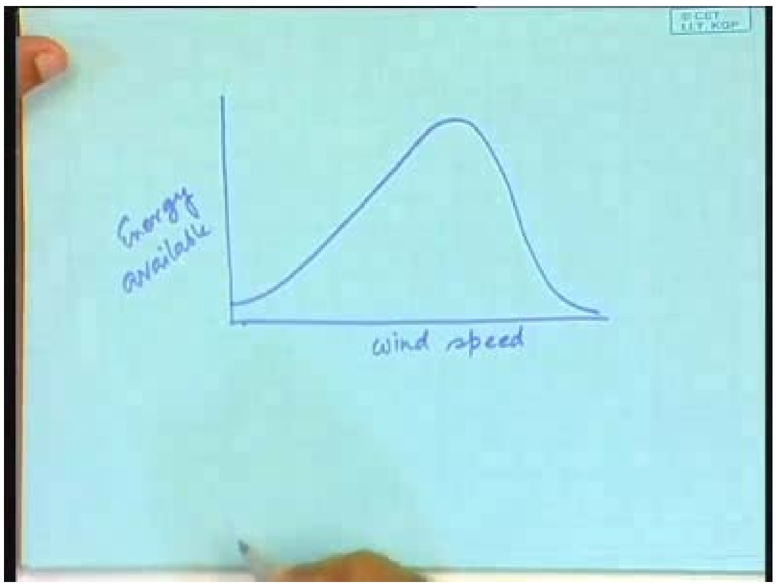

Suppose I want to say that now I want to plot here is the wind speed and here is the energy available, how will you plot that? Energy available is cubically proportional to the wind speed and the coefficient, constant coefficient does not matter, half rho A these things do not really matter. What is the variable? It is the V. So, what will you do? You will say that now I will plot a graph where at every value of wind speed V cube times this value is multiplied and plotted. You get it? So, you will get, by that way, the graph of the energy available versus wind speed and it will again be a curve like this, but it will have a peak at a higher wind speed. Why? Because, the more the wind speed, the energy available is cubically proportional to that and therefore even if at that wind speed the wind blows for a smaller amount of time, the total energy available at that wind speed is larger. You get the point?

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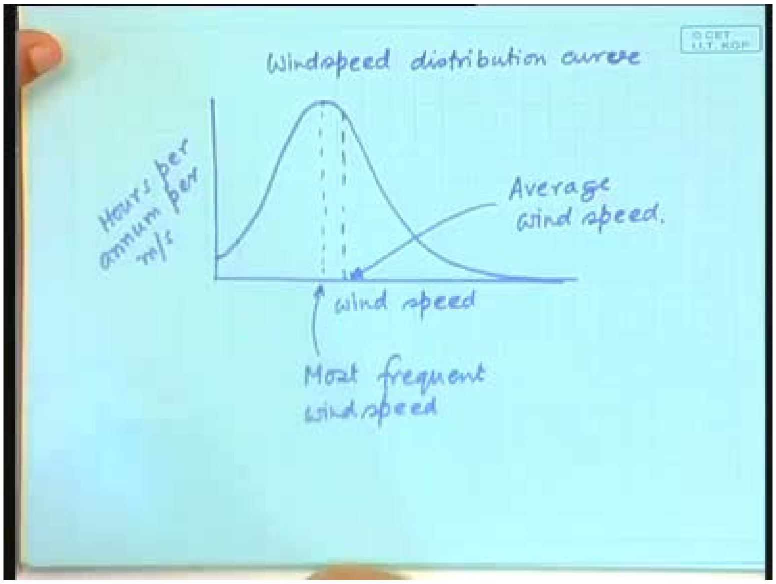

So, this curve will not give you the suitable rating of the wind turbine.

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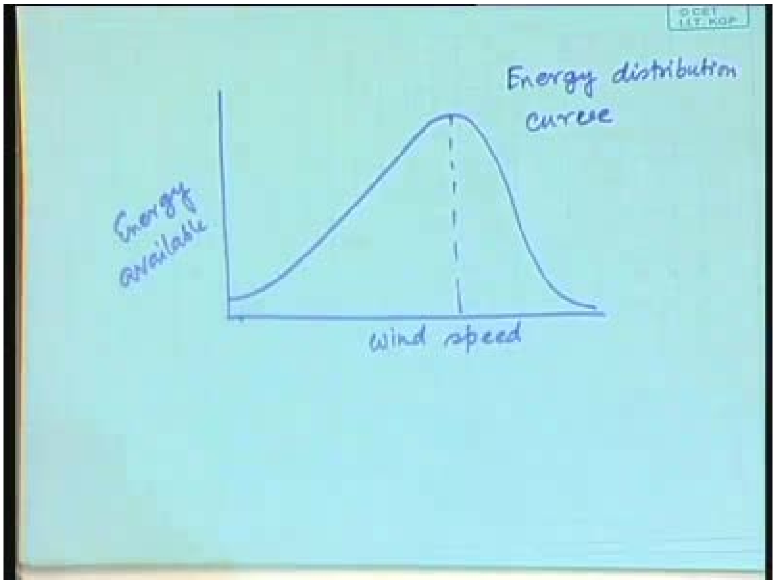

This curve will and this is the wind speed at which maximum energy is available, clear. So, this is the wind speed at which maximum energy is available and this is where the wind turbines should be rated, clear. So, many people commit this error that you measure the wind speed, obtain the average, this is my average wind speed and so, rate my wind turbine at that speed; no, it is not right. It should not also be the most required wind speed. It should be the wind speed at which the maximum energy is available, clear. Let us proceed. So, this is the energy distribution curve or power distribution curve.

Now, we come to the question that as I told you in most sites people prefer to just obtain the average wind speed and then if you have the whole graph available, you can do the exercise, write the computer program to obtain these and from there you obtain that, all that can be done.

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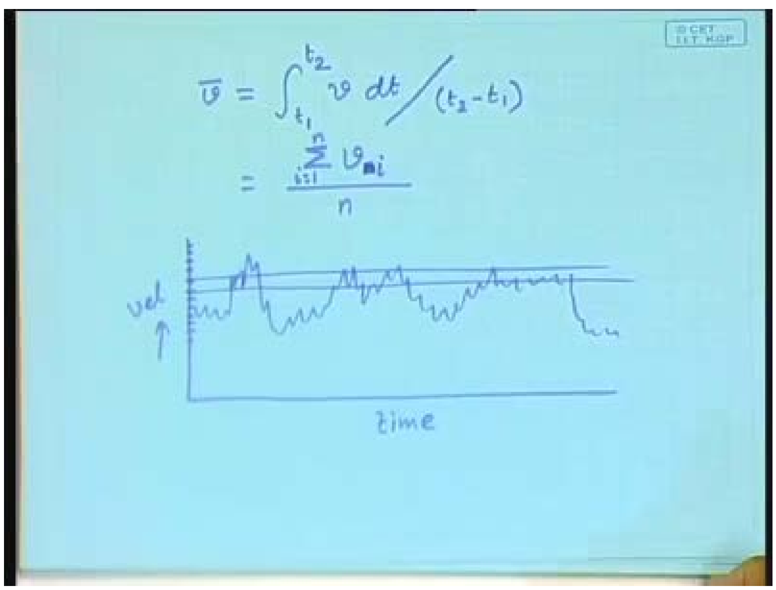

But supposing this is not available. You only have an indication of what the average wind speed is, can you obtain this?

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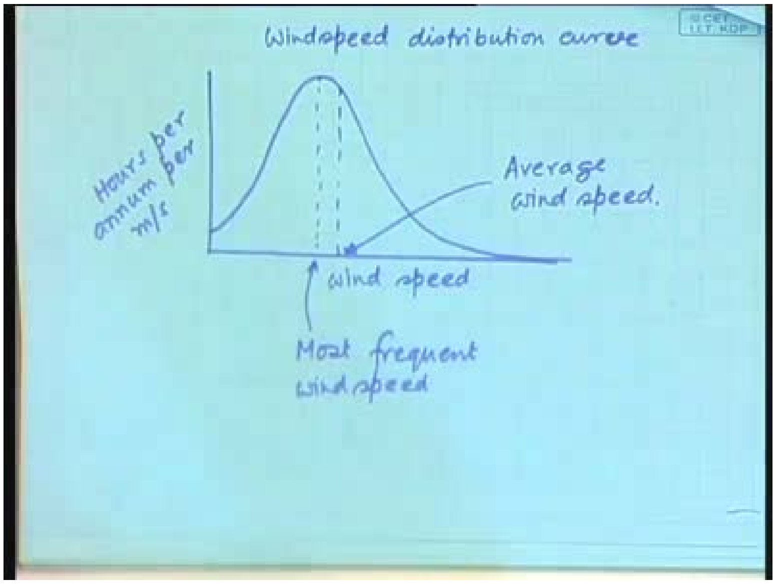

The logical line of thinking should be that, okay this graph after all follows some kind of a distribution and in your statistics courses you have learnt about certain distributions that normally represent this kind of bell curve, yes. That is what we do. From empirical observation from some sites, for example if there are sites close to the Eastern Ghats, then all the sites will have more or less the similar kind of distribution pattern, but the Western Ghat will be different. In Ladakh, it will be different, all right. But, if you have a range in Ladakh, then for every point you do not need to do all this exercise. If you do this exercise at one place, yes you can, you can use that as a reasonable, reasonable indication of what kind of statistics will be followed, right.

So, what kind of statistics is followed? These are normally found to satisfy the Rayleigh distribution function.

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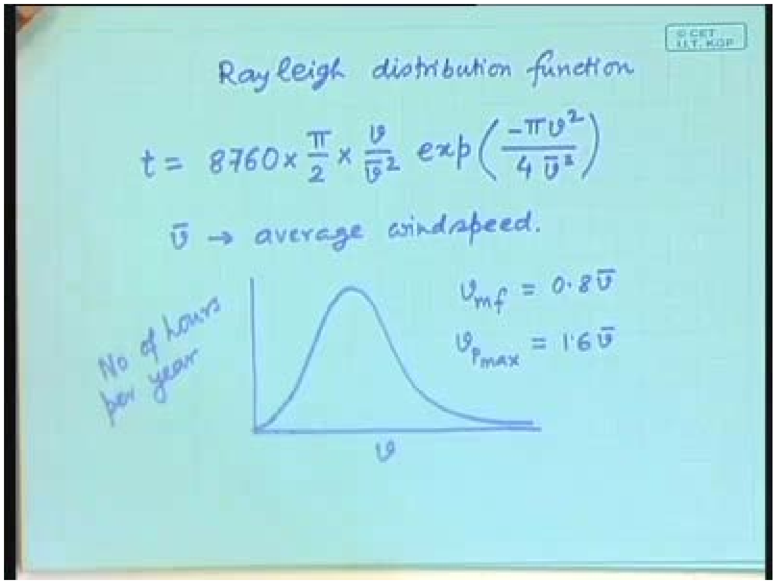

So, probably you have heard about this. The Rayleigh distribution function, if I write it in the form which will give you the number of hours per year, then it will be expressed as t is equal to 8760 times pi by 2 times v by average velocity square exponential minus pi v square divided by 4 v bar square, where v bar is the average. What does this distribution tell you? It tells you that if you know the average velocity, then if you substitute different values of v, then what will be the expected time for which this velocity will be effective? So, it will, you will get a curve like that. So, it will yield the curve something like this. Here is your v. So, what you do? In order to plot this curve, you choose a v, substitute it here. For a specific value of v bar, you obtain this number and that is what you plot here. Again, you take this v, obtain this number, you plot here and so on and so forth, you get this curve. Here what is the y-axis? For which this value is valid. You will have to pass in front of the camera, I do not know. So, this is the Rayleigh distribution function.

Now, it is known, since this is a closed form expression, since this is a closed form expression, you know that it is possible to obtain its average value, its most frequent wind speed and all that and in that case the v average, the most frequent wind speed, v average is this one, will be at 0.8 v average and the one at maximum power for p max, what is velocity at p max? It is this one (Refer Slide Time: 33:20), where the maximum energy is available and that happens around 1.6 of average. So, if you know that a particular site's characteristic satisfied their Rayleigh distribution, you have to know that first, remember you cannot apply that blindly, you have to know that first; if you know that it applies, then if you know the average velocity, you can immediately and just off the cuff say that the speed at which the maximum energy will be available is 1.6 of the average velocity. But for that, you have to know that it does satisfy.

In fact, there are most sites in which it has been found that it does satisfy, but there are also some which do not really very well satisfy. In that case, you will have to use some more general distribution function and that more general distribution function is the Weibull distribution.

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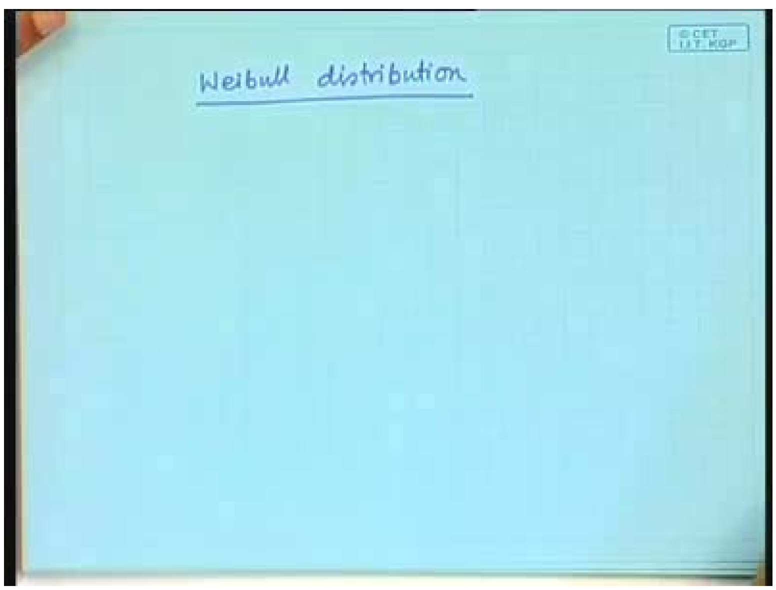

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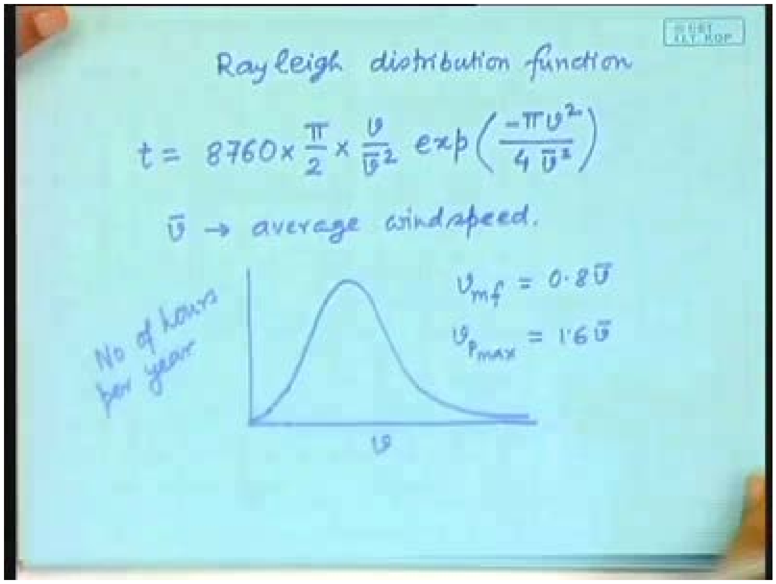

Here, there is only one unknown, the v bar. If you know v bar, everything is known. But in that case, there is no freedom of actually choosing the shape. In the Weibull distribution, in addition to this, you have a shape factor and the scale factor. So, it is given as, in this case I will write it as the probability distribution function, so that the area under the curve will be 1.

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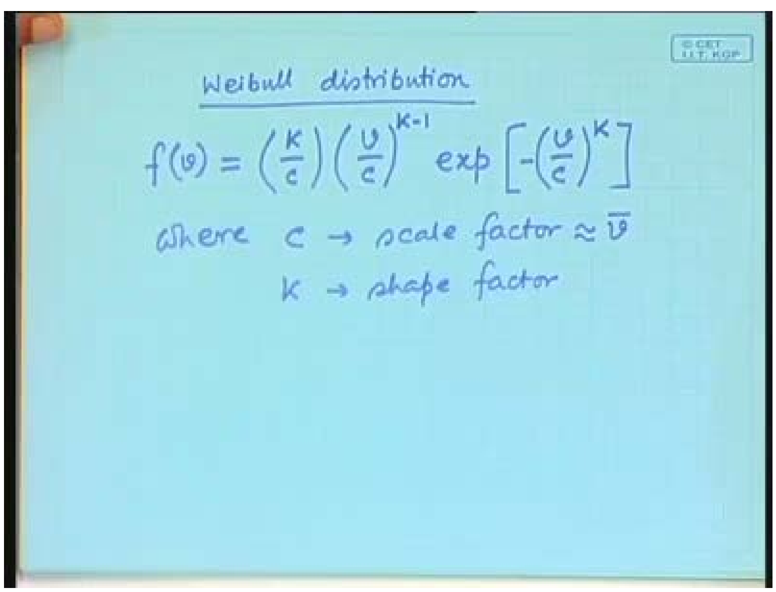

That will be f of v is equal to k by c v by c to the power k minus 1 exponential minus v by c whole to the power k, where c is scale factor and k is a shape factor. c pushes it up and down and k changes the shape. I will show you how it works, but normally people choose c as approximately the same as the average wind speed. You might of course change it. You might play with this value, say 1.1 to 0.9. You might play with this value to actually fit it properly into the curve and then say that if I do that for all the sites in this region, it will be more or less correct. You might ask what is the role of these two? These two guys have very important role to play in fitting into specific distribution functions.

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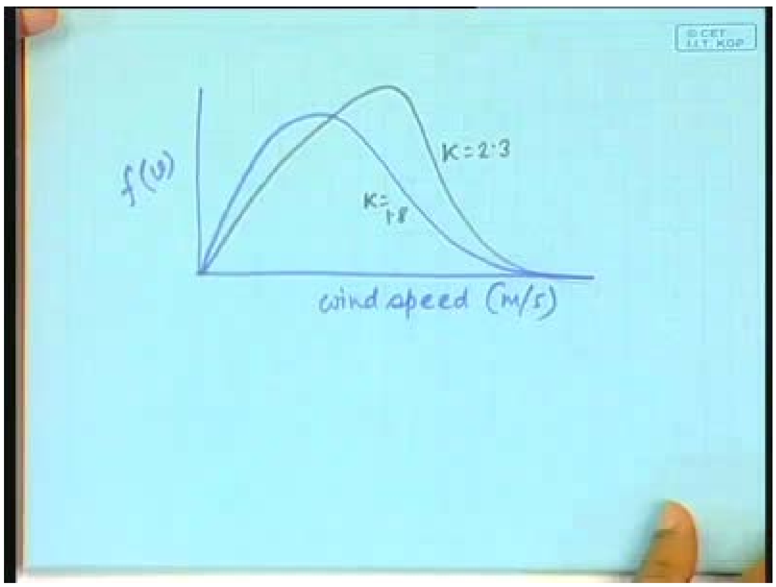

For example, if you have, by the way here also if you know the average wind speed of the site and if you decide that now I will fit average wind speed as c and if you choose the shape factor k, then you simply have, for different values of v you can plot the graph without any difficulty. So, what is the, what is the effect of c and what is the effect of k, that means, that is what we need to understand.

First let us understand the effect of k. This is wind speed. In one case it will be …, in the other case, it might also go off below that. So, what does it mean? It means that, here it this is for say k is equal to 1.8 and this is k is equal to 2.3. Normally, k's value varies between, varies in the neighborhood of 2. If it is 1.8, it means that it is sort of this side, this way and if it is larger, then it moves to the right side, which means its average moves to a higher value of wind speed.

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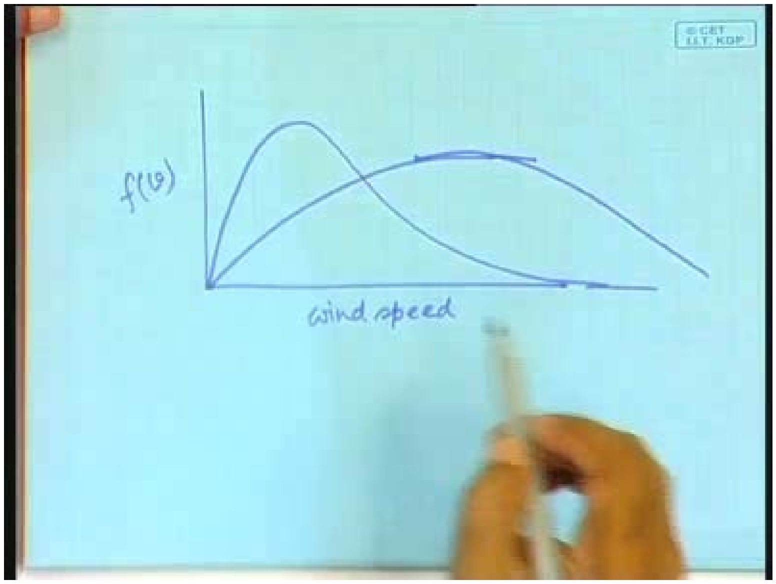

What is the effect of c? It will be in one case like this and other case is like, so it will go down again after some time. So, what does it mean? It means that the whole thing shifts like this.

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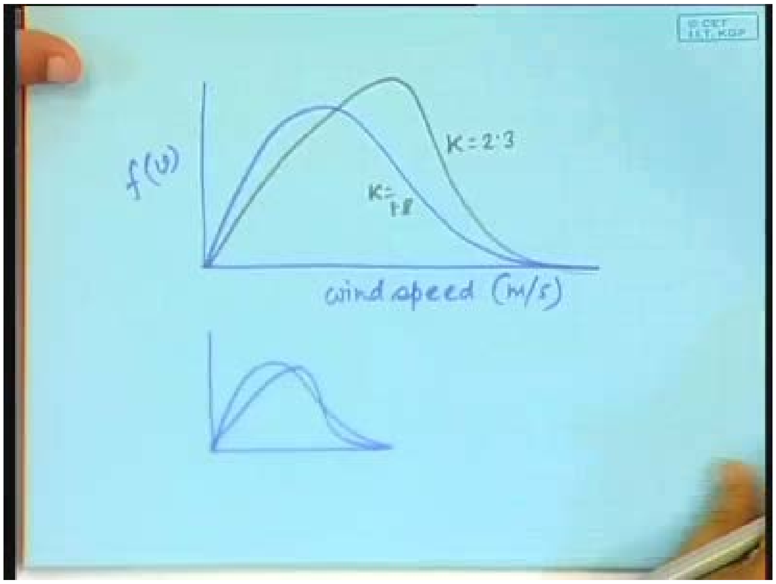

In one case it is the shape. For the k it will be, in one case like this and this case like that. So, it is the shape that matters.

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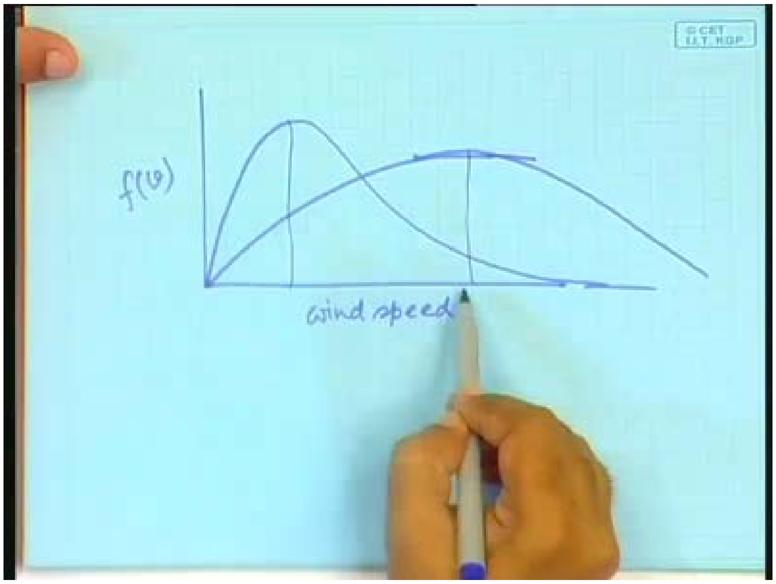

In this case the whole thing moves to the right side, right side means the average works at a higher value. That is what you expect, because that is why normally c is substituted by the average and notice these two functions, the Weibull distribution function.

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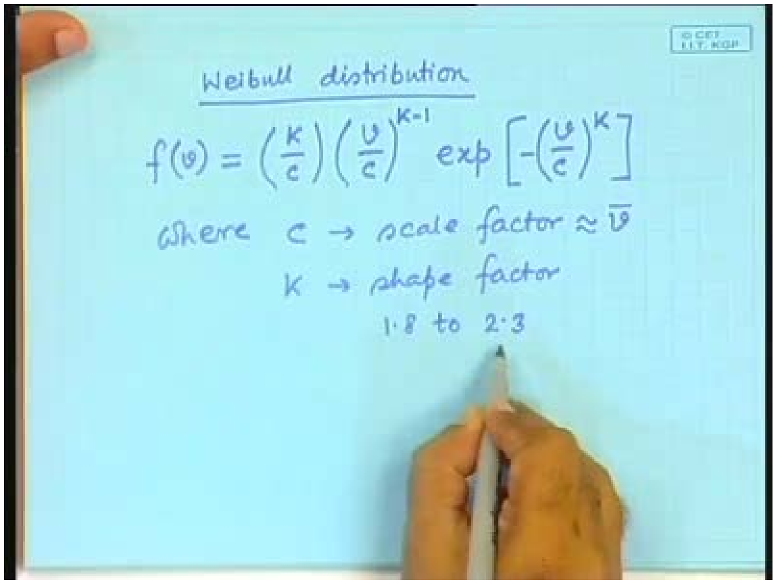

k, as I told you, is something between 1.8 to 2.3. This is the shape. The shape of the curve is fitted by choosing proper value of k and you would notice that 2 is somewhere in between them. So, what happens if you substitute 2 here? If you substitute 2 here, this becomes 1, this becomes 1 and then you will notice that this graph becomes same as or you know if you scale them, it will be the same as the Rayleigh distribution.

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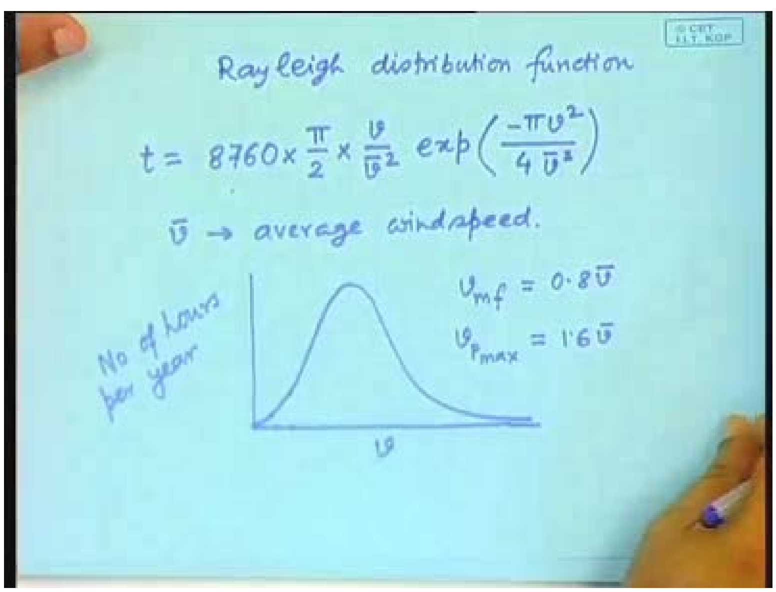

Why do I say you scale them? Because, the Rayleigh distribution function I drew for the number of hours per year, while this is actually the probability of finding the wind speed at a particular value. So, there has to be a scaling from this to that.

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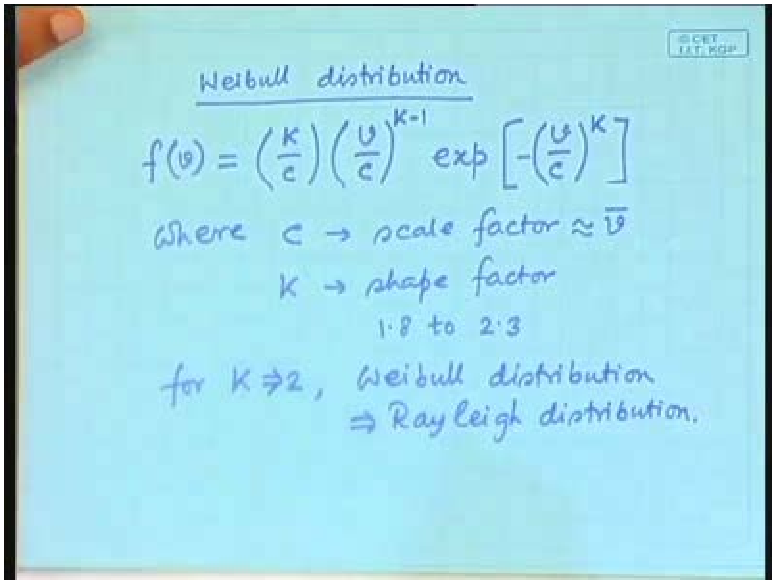

But, in general, if you put for k is equal to 2, for k tending to 2, Weibull distribution tends to …, clear. What is the use of all this? The use is that firstly, for a particular kind of site if you know which distribution it fits into, normally people actually fit into the Weibull distribution or find whether for which value of k you get the best fit, if it is close to 2, then you take the Rayleigh distribution, all right, else you take this, fine. But, with this you can plot the probability distribution function. With that you can plot the energy distribution function, with that you can obtain the, where you should rate the wind turbine. What is the, what is the desired, desirable value of the rated wind speed of the wind turbine? So, you can choose the wind turbine properly, clear. So, you we use this Weibull distribution and the Rayleigh distribution for that purpose, fine.

There is one indicator of this that is what is known as root mean cube wind velocity. We have heard of the root RMS value, right, where the power is proportional to the square, I square r, so you need to have RMS in case of electrical quantities. But here, it is proportional to the cube, power is proportional to the cube of the wind speed and so, you need to define the concept of root mean cube wind speed.

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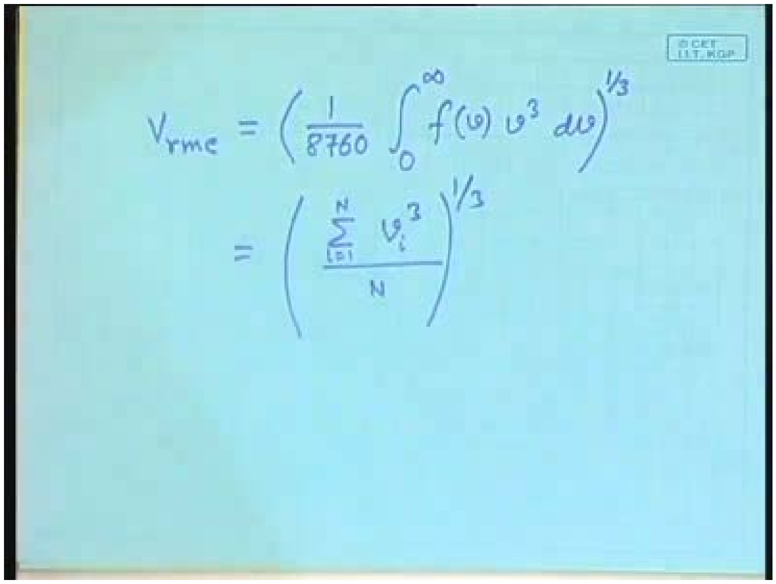

So, here the V rmc, remember rmc, not rms, is equal to 1 by 8760 0 to infinity f v times v cube dv, after you obtain that, to the power one third. So, that will be the root mean cube wind speed and that is what will decide the power that is available from a site. Notice, the power that is available from a site, the energy that is available from a site, how good a site is for the wind energy generation, you need to estimate. If I install a wind turbine here, how much is it going to generate ultimately? Obviously, it is not going to generate depending on its power rating. It is going to generate depending on the site's characteristics and that is given by this.

So, this rmc value gives, will give, I will show you how, will give how suitable is that, know how much will be the energy available, how much will be the power available. Before we go into that, suppose the data are available as discrete values at equal intervals as is done in any digital recording system, how will you, how will you write this? You will write that as, this is also same as, you will write it as i equal to 1 to N it is v i cube by N to the power one third. So, you will have to do it this way.

Now, the question is what will be the power, root mean cube power available at that site?

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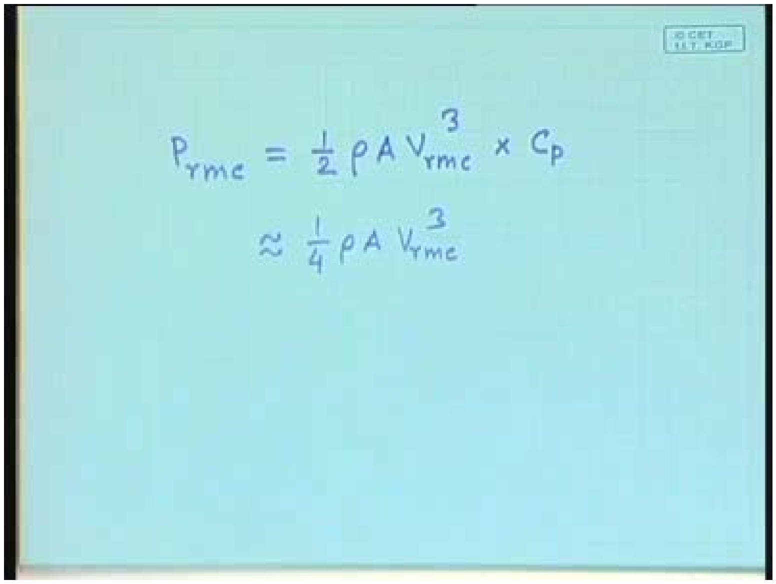

That is P rmc is equal to how will you obtain that? This was the root mean cube velocity. How much energy is available at that root mean cube velocity? So, that is half rho A V rmc cube times this is the energy contained in the wind times the power coefficient. This is the energy contained in the wind and how much will I actually get from here will depend on C p and the C p value you have already learnt that its maximum is 0.59, the Betz limit. So, a reasonably good estimate would be that it would be less than that, say 0.5. So, one often takes, if you know the V rmc, we can roughly, grossly estimate the power available at the site as …

So, you would notice that we started from where? We started from horrible graph and from there we are more or less being able to say if I install a wind turbine, how much energy I will get out of it, how much power will I get on an average and this is this value. This is a, there is a graphical way of obtaining it. The graphical way of obtaining that I will now describe. The reason that people apply the graphical way is that often, okay, how much energy will be available for a particular site, for a particular wind turbine. There two particularities is here, you have to understand that. Particularity of the site is given in terms of the distribution function, particularity of the wind turbine is given in terms of how much power is generated at which velocity, right. So, there are two things that come into the picture and we have to combine these two to obtain what will be the actual energy that can be obtained from a particular site for that wind turbine and then only we can decide which wind turbine is best for that site.

Now, in doing so, again remember we need to take into account two things: 1 - the characteristic of the site, 2 - the characteristics of the turbine. In obtaining that graphically, we prefer it graphically because the characteristic of the wind turbine is often available as graph.

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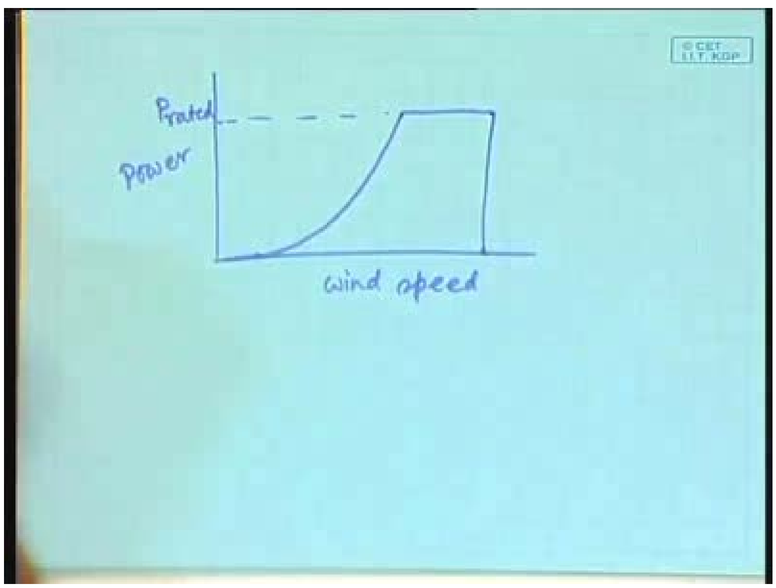

We have already shown that this graph is something like this, wind speed divided by power, against power. It starts from a specific value of wind speed, cut-in wind speed, it goes up like this and at a specific value it is flattened, where it reaches the rated power and then at specific value of the wind speed it is cut-out, shut down. So, this characteristic is given as graph. The wind turbines specification, when you ask for a wind turbine, the supplier will say that this is the characteristic of that wind turbine. So, this is how what has to be matched with the site. So, that is what we will do now and in doing so, the next step is what is known as the wind speed duration curve, the wind speed duration curve.

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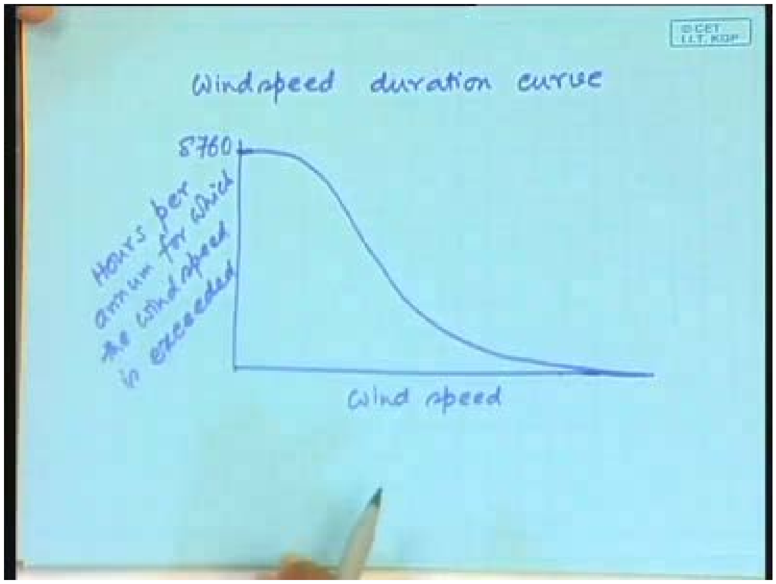

What is the wind speed duration curve? Here we plot, we plot the wind speed in the x-axis, in the y-axis, remember this is important, hours per annum for which the wind speed is exceeded. So, just try to argue out; wind speed zero, for how long is that wind speed exceeded? Always; so, what will be here? The full number of hours in year, 8760 and then, it will fall like this and ultimately when you, when you obtain, when you plot it for the highest speed that was obtained for that site, for how long was it exceeded? Zero. So, it should be a curve like this, clear. This curve is called the wind speed duration curve. The original data that was started with this horribly wavy curve, but this curve is a horribly smooth curve. It is a very well behaved smooth curve. So, this is called the wind speed duration curve, which is used at the next stage of graphical analysis.

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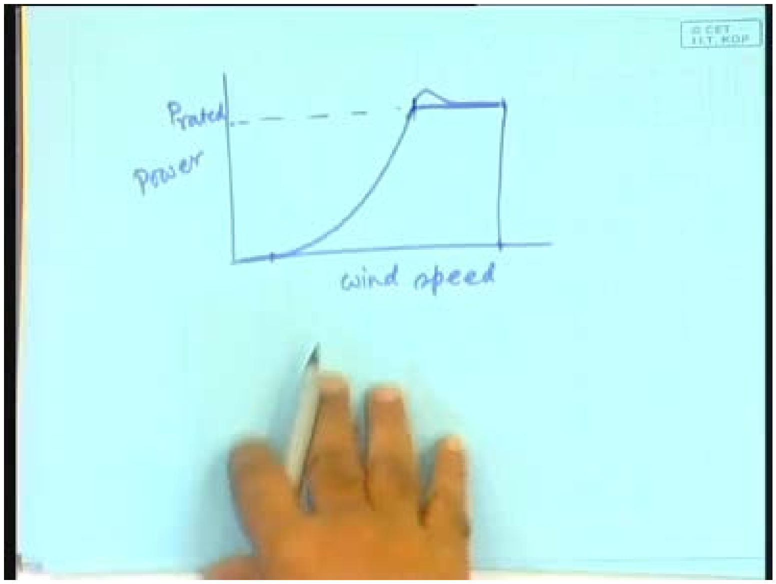

Now, this has to be combined with this and remember, different wind turbines will have different cut-in speed, different rated speed, different furling speed and different characteristics here and may be this will not be flat. This will be something like this, whatever, but it will be, it will be different characteristic for different wind turbines.

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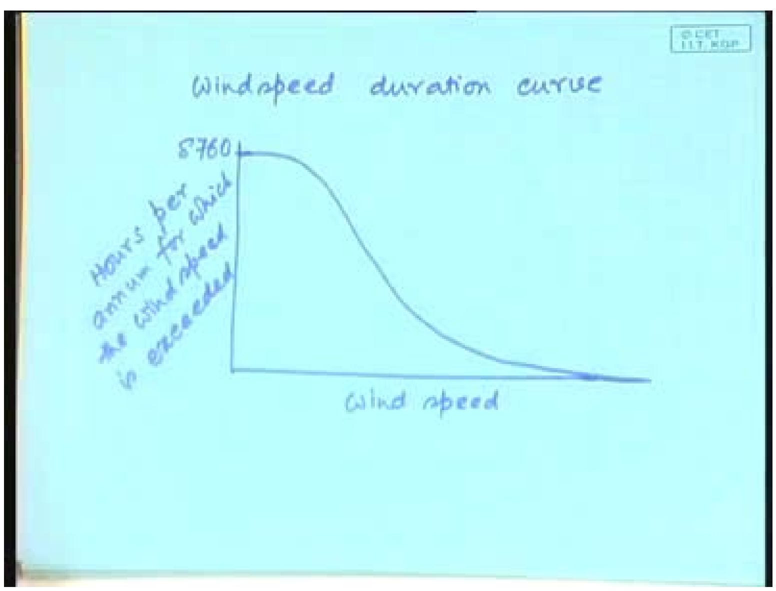

So, that characteristic has then to be matched with this.

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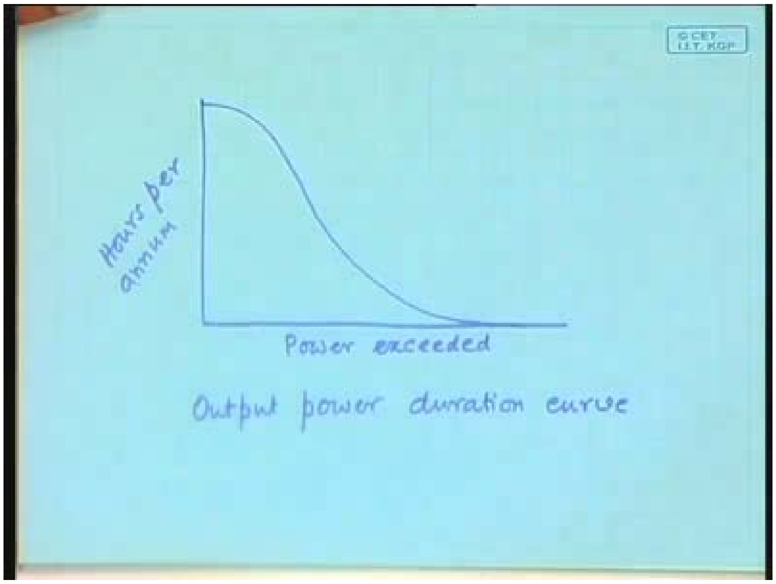

Now, it is done by plotting what is known as, known as the output power duration curve. So, what is the output power? Here it was the wind speed and here we were plotting the hours for which that wind speed was exceeded. Here, it will be power exceeded, right and here it will be hours per annum. Now, how will you obtain the basic curve? Supposing you are talking about how much power is available? Then, for each value of the wind speed, how much power is available? Cube of that; not only cube of that, so here whatever wind speed is available, cube of that will give you the power available. So, the power available curve will also be something like, something like this.

So, first draw the power available curve, but we will not be able to use the whole of this power. Why? Because, even when it is working at its maximum efficiency, there will be some inefficiency always there. That means even if you plot it for assuming, where is it, yeah, assuming this kind of character that means C p approximately 0.5, then you get a curve all right, but then you will not be able to utilize whole of it.

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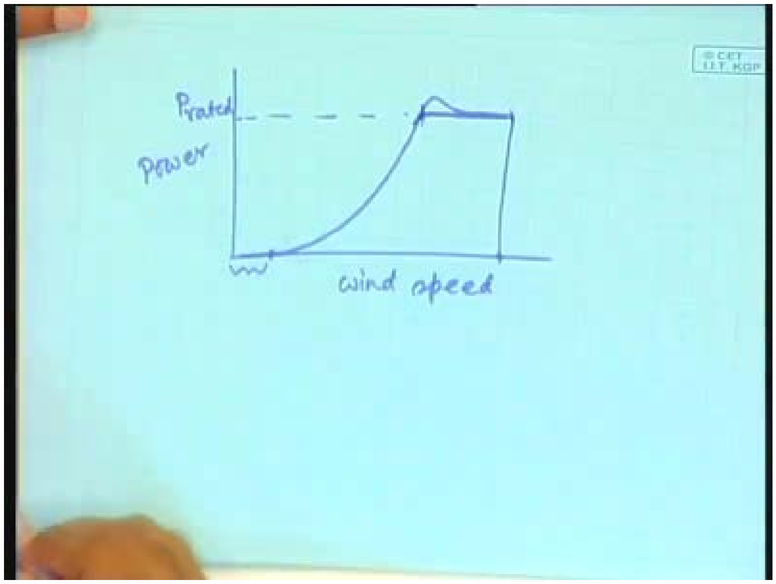

The three places where the inefficiency come will be first here. Below the cut-in speed it will not generate anything, which means that hours per annum for which this power is exceeded, it will not be 8760.

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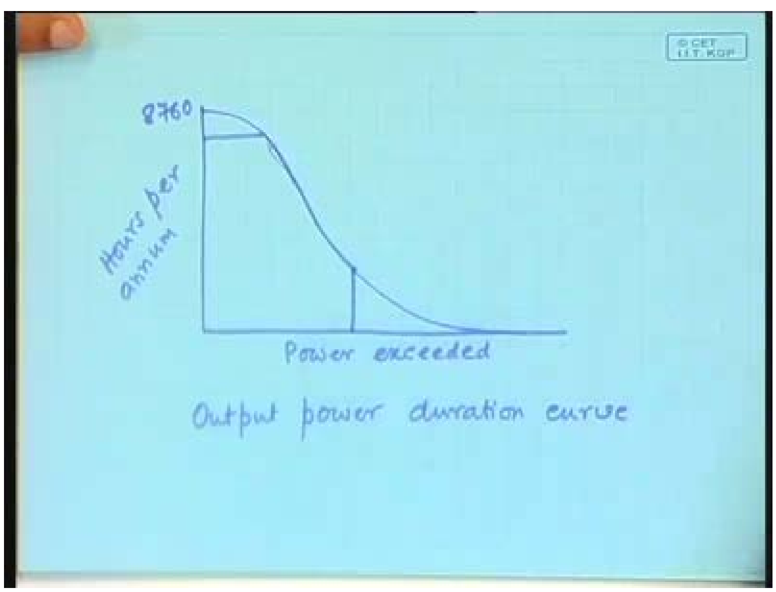

Here it is 8760. It will not be 8760, it will be chopped off somewhere here. That will not be available. In this part it is essentially the amount of power that could be maximally generated; yes, in this part you are trying to, as I already told, in this part you are trying to utilize the maximum power. So, it should really follow this curve may be with a bit of inefficiency. It might be slightly off, all right, but nevertheless let us plot it along ….. But, this power, this power can never be exceeded, because this is the rating of that generator. So, here it will be chopped off. It cannot be exceeded, clear.

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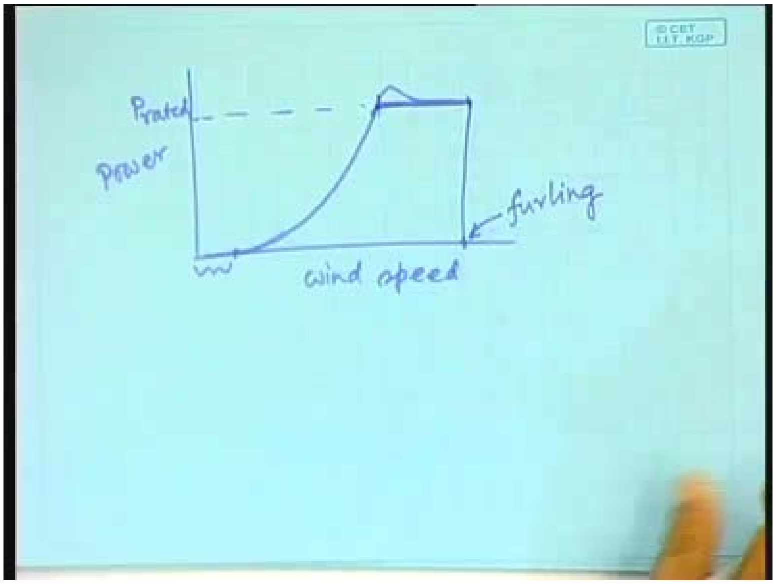

There will be another part, supposing here, beyond that whatever wind speed is available you cannot generate, because you have to shut off; you have to shut off the turbine. This is the furling, say the furling wind speed is related to here. How will it be reflected?

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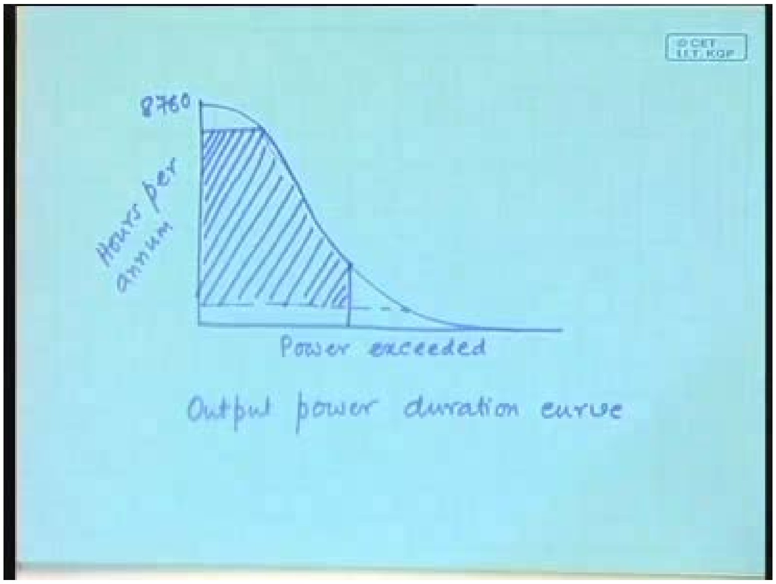

You will have to draw a horizontal line. This part will also be not available. So, ultimately the amount of energy that is available from that site is given by this area. So, this is how we match the character of the site with the character of the wind turbine. It will more or less be like this, more or less. Why? Because, how it will follow depends on the specifics of the wind turbine, where it will be chopped off depends on the specifics of the wind turbine. Where will it be chopped off, all this will be depending on the wind turbine characteristic. So, ultimately this much of energy is available. The area under this curve is what gives the energy that will be available, if this particular wind turbine is installed in this particular site.

So, if you are given the charge of choosing wind turbines for a specific site, what will you do? First, you will obtain the curve, the distribution curve for that site and then ask for vendors to give this curve for their own wind turbines. Then, you will have to do this exercise, find out which one has the maximum area under it. The one that has the maximum area under this will be the most suitable wind turbine for that specific site, clear, all right. We will continue with that in the next class.

Thank you!