Energy Resources and Technology
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Lecture - 11
Hydroelectric Power (Contd…)

We were dealing with hydroelectric power and we have seen that some of the basic steps in planning a hydroelectric power station will involve three stages of studies. The reconnaissance study, the feasibility study and finally making the ultimate plan and in these steps obviously you would need to make some measurements.

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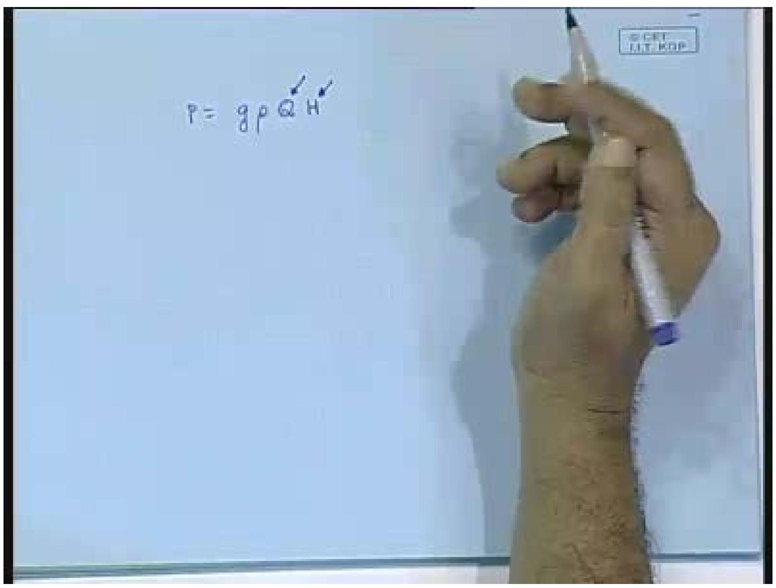

You have got a stream, you have got a river, so you need, in general, the data you would need would be as we have seen that the power output is what? g rho Q H, where g is the well known thing, rho is well known thing, so these two are not really varying, but these two are the varying quantities which we will need to measure. Now, H is essentially the head that you get, which means you need to look at the difference in levels at which you can create two reservoirs. So, whether it is possible to create a reservoir or not, that obviously depends on the geographical characteristics. So, once you look at this carefully, you get an estimate of H, but what about Q? Q is the flow rate, so how to measure at least approximately the flow rate of a river? So, we come across that particular problem. Now, measurement of the flow rate, as we have seen that, we have different stages of the study. At one stage you only make a very rough estimate whether you would really go for making a detailed study. So, at that stage, it is not necessary to make very accurate estimate of the flow rate, but it is necessary to have a, at least a rough estimate. So, how will you do that?

Supposing a flow is there, a river is there. A very simple technique is simply to drop a leaf on the surface. What will happen? It will get carried. So, if you now measure how long it gets carried in how much time with a stop watch, then obviously you can get, get what? You can get the surface velocity. Obviously, the velocity of the whole river will not be that, because in contact with the ground it will be zero velocity, right and then the velocity will grow to a point which is at the surface of the river.

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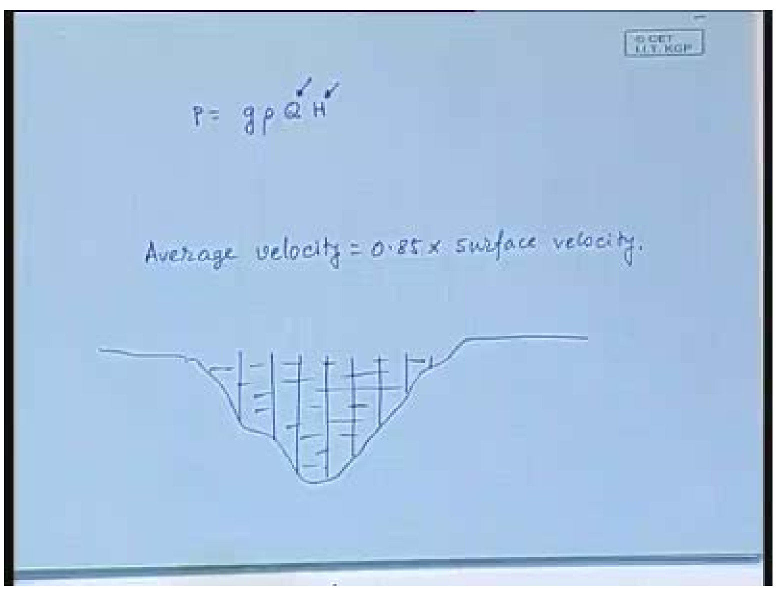

So, you obviously do expect that the average velocity will be less than the velocity that you have measured at the surface and in general you can, I mean you can assume for a very rough estimate that the average velocity is 0.85 times the surface velocity. So, once you use this relationship, it is not difficult to see that it is possible to obtain the average velocity at least as a matter of rough estimate. But, that is not Q, Q is a flow rate. So, in addition to that, you need what? The area, how do estimate the area? How do you estimate the area? It is after all a stream, how do estimate the area? Say, suppose you have got a stream, something like this. If you look at the cross section it is something like this. How do you estimate the area?

You have got the river. So, here is the water. The estimate, the method of estimation is very simple really. What you do is to take a big poll of bamboo and dip it at various places and find out to which depth it sinks. It can easily be done. If it is a fast river, then you have to station yourself somewhere and do the, you know, dipping. So, at this stage it goes to this level, at this stage it goes to this level, at this stage it goes to this level; so, you get an estimate. So, go to various distances from the shore, start from one side and dip the bamboo, assuming that the bamboo is greater in size, the length of the bamboo is greater than the maximum depth, assuming. Obviously, you cannot do that in Ganges, right. So, this method will be applicable only in relatively smaller rivers and then, you take a graph paper. On that graph paper, you put all these and then all these ends will then allow you to draw the contour and then you simply measure the area by counting the squares in the graph paper. Teek hai na?

So, it is possible to have a rough estimate of the area, it is possible to have the rough estimate of the flow rate, fine. Remember, this method is good, simple, but very rough. All you need is a scale, really, in this method and may be a stop watch, nothing more. But, at later stages, I mean this will allow you to at least go to the stage of the reconnaissance study, but after that you need a more accurate estimate of that and there are certain methods to get a relatively more accurate estimate. If the stream is not large, especially the streams that are there in the higher reaches of the Himalayas where the flow is not large, but the head is large, so there will be certain points when water is coming and then rushing down, but the quantity of water is not very large. In those cases the measurement of the quantity of water becomes very important there, because each cubic centimeter of water contains lot of energy, because of the large head.

There the method that is generally employed is something like this.

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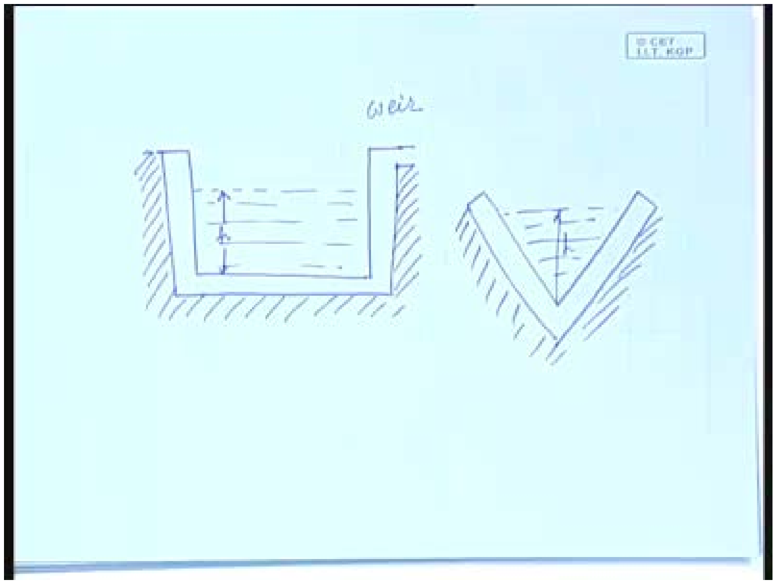

You produce an obstruction to the flow of water, but water obviously finds its way and there you make this kind of a cross section and force it to flow only through this channel. This is called weir. So, you make a channel like this, so here is your rest of the thing, the ground and you put the weir, so that water is forced to flow. Then, do you see that if the shape of the weir is known, then the amount of flow rate will be given just by this height, right. So, depending on the specific shape of that place, in some cases it may be convenient to put a, you know, rectangular weir, in some cases it may be convenient to put a triangular. But in both cases, you can derive relationship, so that the flow rate will depend on this, right and in civil engineering, in mechanical engineering, these relationships are easily available in those books. So, flows through weirs are very convenient way of measuring a flow rate of a river or a stream, but this is obviously applicable to small flows.

In a large river, relatively large river, for example of the size of, have you ever gone to the Kasai river that is between, that comes as you go to Minapur, a small river, but nevertheless it will be difficult to put such a thing there, right. So, in those cases or imagine when you go from here to Calcutta, you have to cross a river, close to Kolaghat, right. That is Rupnarayan, there the width is quite large. In such cases, it would be obviously difficult to put a thing like this; to force all the flow through this to measure it. So, in that case, what will you do? So, this is the method of measurement using weirs, quite accurate; quite accurate, but applicable to relatively smaller streams and this is, these are regularly used for streams in the upper reaches of Himalayas, where the quantity of water is small, but head is large. Where the river is relatively smooth flowing that means it does not have boulders and things like that, as it happens in the rivers that are there in the hilly regions, in hilly regions have you seen the rivers?

Always in the river there would be lot of boulders and stuff, so that the water flow will normally be turbulent. If the water flow is not turbulent like the flow of river in the Ganges, it is a nice flow, there you can simply use the turbine meter method. That means the turbine method is similar to a fan.

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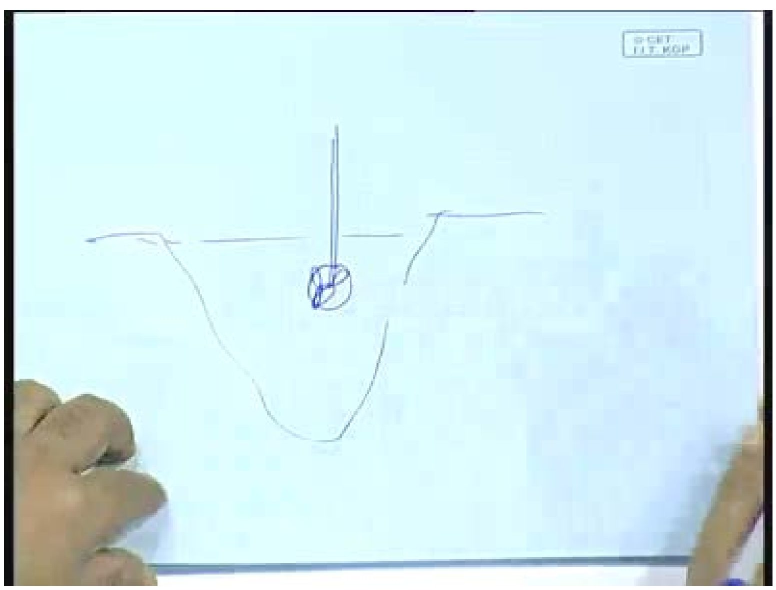

So, you have got a fan, a small turbine. So, you have got the river here. You can dip the small turbine, I drew it in a wrong direction, it should be in this direction, so that it flows like this. You are drawing the cross section, the water flows like this, so it should be like this. Let me draw it again.

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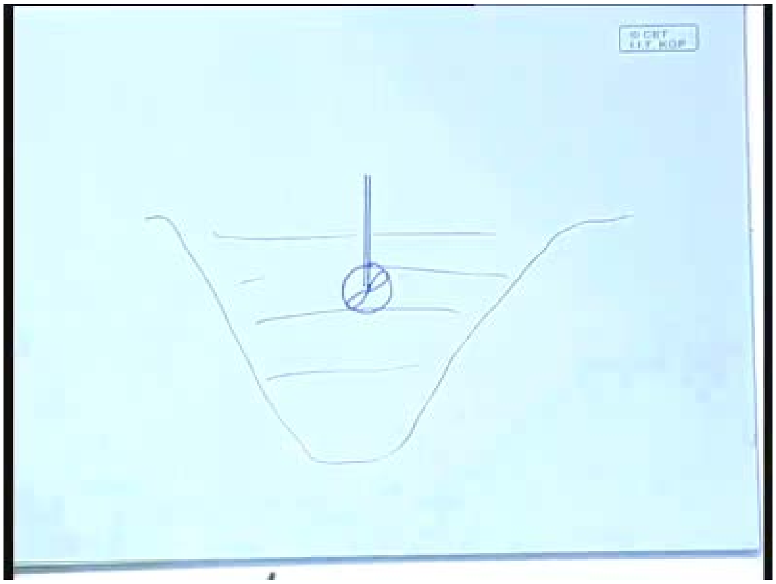

So, you have got the flow. Then, you can dip a small turbine, so that the rotation of the turbine will be proportional to the flow rate and since this does not produce much of an obstruction, it by itself will not create much of turbulence in that. So, you can measure; if you have simply a tachogenerator connected, you can measure the flow rate at different places by simply electrical measurement. This is called the turbine method. Now, the method is obviously to dip this to various levels and at various distances from the shore. That means here the velocity will be one, here the velocity will be another, here the velocity will be another and as you go from the surface, the velocity will increase and all that can then be measured. So, using this you can have an estimate of the average velocity. So, then you make a graph paper, make this contour and at every point there will be a different velocity and then you can make an average, clear.

This is more, obviously a more accurate method. But obviously, this will not be applicable to cases where there is turbulence in the stream itself. The turbulence will occur in, for example where there are bends. Even in relatively smoother river there are bends and in bends you should not do this, but the rivers that are there in the rocky regions, obviously this will not applicable. So, you need some other method for that. There the method that is used is something like this that somewhere, remember, this is applicable to turbulent flows; somewhere you drop a bit of concentrated solution of some salt and then what will happen? It will mix with that water and since it is turbulent, the mixing will be good and downstream at some length, so it should be say, this is the river, here you are dropping that solution.

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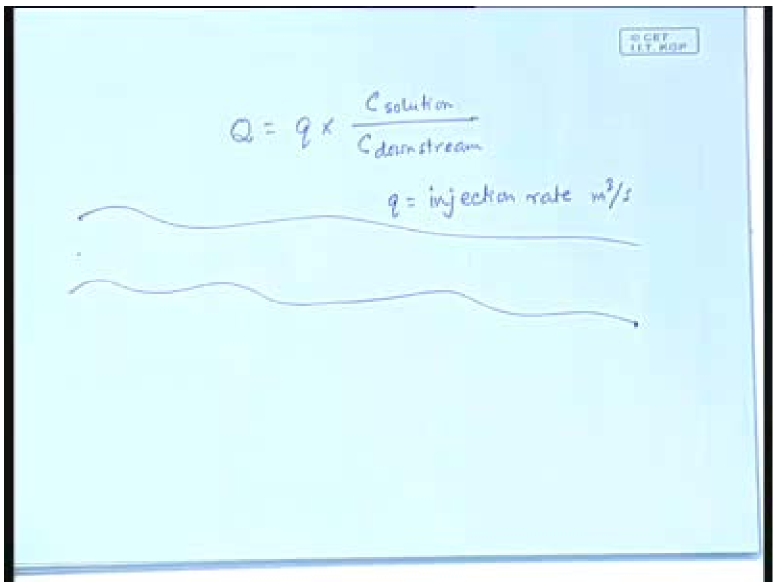

Then, you have to measure the concentration somewhere down stream. How much downstream? Obviously you have to wait till it is completely mixed with the rest of the water. In general, an estimate is that you have to go downstream to a length about 75 times the width of the river. So, say if the width of the river is something like the width is 10 meters, may be; so, you have to go to something like 750 meters there. So, at another point then, you pick up that water and measure the concentration, right. If you pick up the water and measure the concentration and if you know the concentration of the solution that you mixed here, then that will allow you to measure the flow rate, will it not?

What will be the concentration then? What will be the relationship then? Then your Q is q times C of solution by C downstream. Is it visible? Because these are subscripts, so I have to write it in smaller font, so where the q is the injection rate; so, small q is … So, concentration of the solution will be larger, concentration downstream will be smaller, so the injection rate, the rate at which we are injecting the fluid will be multiplied by this factor, which will be large, to get the actual flow rate, clear. There are some, issues here. Do you simply take a test tube of this and drop it; that is it? If you do so, what will happen?

Downstream there somebody is waiting, yeah; he will suddenly see the concentration appearing and then it will go up, after sometime it will go down. From this it is possible to measure the flow rate by just once mixing, but it will be relatively difficult thing to do. So, what is done is that it is a continuous stream that is put in at a certain point. So, there will be a flow rate here and there you measure the concentration that will give the flow rate. But for that, you will have to wait till the concentrations have stabilized. That means you are mixing that particular salt here. That means you have taken it in some kind of a jar and there is a tap and you have opened the taps, so that you can the measure the flow rate and that is dropping in. After you have started dropping in, the concentration will start building up there. After sometime it will reach stability. The rate of injection and the concentration at the downstream point will reach stability and then only you measure it. Then this, this relationship will be valid.

It is also true that in some cases people do measure by simply once dipping it. In some cases people do measure it that way. That means in downstream you will see a time variation of the concentration. So, you keep on taking it up, it will follow a graph and from there by integrating the area under the graph it is possible to measure, but it will be a crude and relatively inaccurate method. One thing you should remember that the thing that you mix, the thing that you are mixing should have some very specific characteristics.

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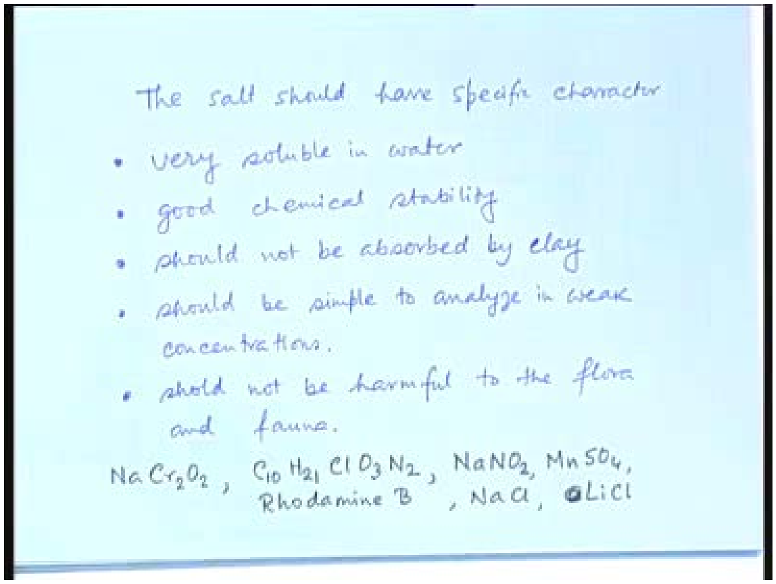

The salt … character. 1 - very soluble in water, 2 - good chemical stability that means it should not disintegrate or change into something else before reaching downstream; should not be absorbed by clay, because the stream normally contains clay particles and if that salt is absorbed by clay, you will get a wrong estimate there. Should be simple to analyze in weak concentrations, right, because ultimately at that length it will be very weak concentrations. So, you should be able to estimate the concentration at such weak concentration and most importantly should not be harmful; should not be harmful for the flora and fauna. So, these are the characteristics needed for the salt that you use.

Now, there have been a class of source that satisfy, that have been found to satisfy this. So, they have been in regular use for this purpose, for example is Na Cr 2 O 2, there has been C 10 H 21 Cl O 3 N 2, this is called Rhodamine B, NaNO 2, can you see? Yes; NaNO 2, MnSO 4. There is another characteristic needed that is it should not be already present in the stream. It has to be such a salt that is not already present in the stream. Now, sodium chloride is, may be present in the stream itself, though in some upper reaches it is not generally present, but it is a benign thing. So, you can also use NaCl and the lithium chloride. So, these are the substances that have been used for this purpose, clear.

So, you make, you do not really use this as the solid substance and put it into water, no; you mix it as a concentrated water, concentrated solution that will give you the q and then you have to drop that concentrated solution into the water. Is the method clear? This will allow you to measure the flow rate at a given time. Now, the flow rate varies with time, right, because of the season changes. Since the seasons change, the flow rate varies and if the flow rate varies you have to have an estimate of how the flow rate varies with time. So, if you do this measurement periodically, over a period of year or so, then you have say in the July August months rainy season, there is a high flow rate; in January there is very small flow rate, so you have, you need to have an estimate of that. So, you get an estimate of by measuring at different times, at different times you will get different estimates, right.

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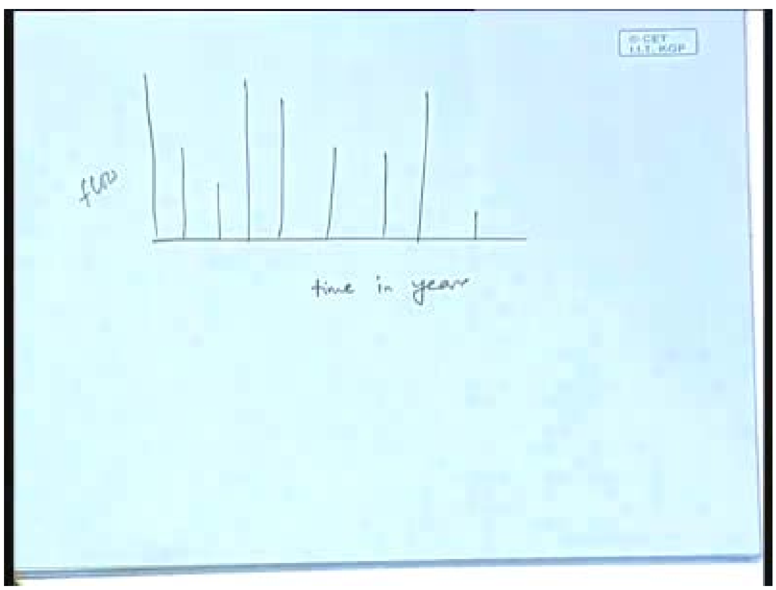

You will get a graph like this. You have made discrete measurements at different times and you have made a graph like this, clear. But, this graph is not all that useful for the purpose of design, because in the design, what is the purpose? I have got a flow. I need to decide how much energy can be extracted from it? What should be the size of the reservoir that I will create, what should be the rating of the turbine that I will buy? These are the design considerations. So, if you have a large reservoir, you will put in a lot of expenditure into it, right, because a dam has to be created, you will create a large reservoir. But, if the flow is not such that that kind of large reservoir is justified, then obviously that is a wrong engineering decision. So, you need to decide on this.

So, in the design process, what we are trying to do is we are trying to find out how much should be the rating of the turbine? How much should be the reservoir capacity? How much should be the spillway capacity? That means there will be a flat time. You will have to allow the water to flow without going through the turbine. So, what should be the size of the spillway capacity? So, all these designs have to, have to be done. Only this data will prove to be not very useful for this purpose. So, here is the time within the year and here the flow. Just this data is not very useful. So, what we do is we convert it to what is known as the flow duration curve.

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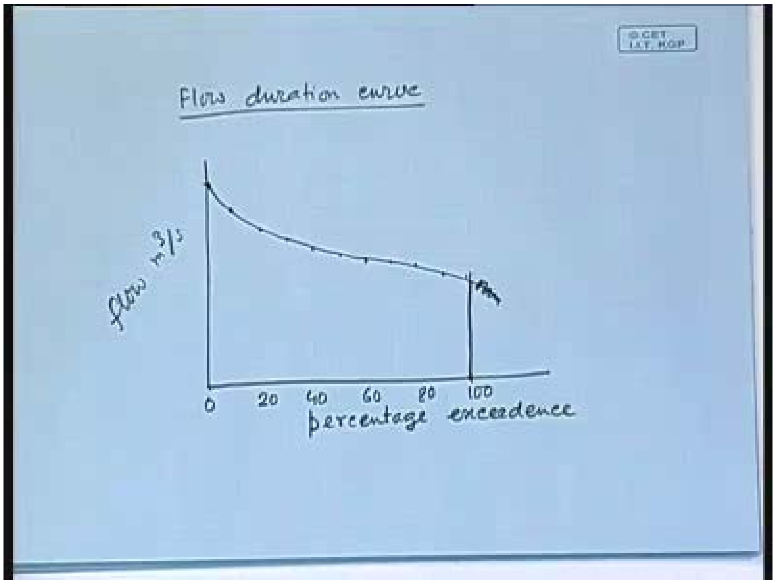

Now, what is the flow duration curve? You use the same data but convert it into a form that is more useful. So, in the flow duration curve you have, in the x-axis you have got percentage, percentage exceedence; I will explain what it is and here is flow. So, you are asking, you are asking for how much time a particular flow has been exceeded. Now, during the summer months you have measured and you have found that there is a, there is a peak flow rate, say the peak flow rate is here. For how much time did the flow exceed that rate? Actually zero; so, here again zero, it will be this point. Again you come to another value here. It will be, this particular flow will be exceeded for a small span of time. So, you get a point here.

Similarly, if you keep on asking this question for how long has this flow been exceeded, you will find that you will get a curve something like this. So, what is the meaning of this point? Meaning of this point is that this particular flow has been exceeded; here it will be percentage exceedence, so 0, 20, 40, 60, 80, 100, so it cannot go beyond that, of course, so I am talking about this much. So, this means that this flow was exceeded for 60 percentage of the time. So, here is the maximum flow and here is the minimum flow, right. So, there are, that is flow through. Then there are, of course, in many places stream that completely dried up during the, during the dry seasons. So, in that case this point would be zero, will come down to zero, fine. So, you have got a graph. It will be a graph like this. From here to here, this part will not be there, of course. This is called the flow duration curve.

Now, you would notice that when you plan to place the turbine, the turbine can have any of these ratings. How much flow do you allow through the turbine? It could be this much, it could be this much, it could be this much, it could be this much. Do you really rate the turbine? Should the rating of the turbine be this, for this value? No, definitely not. Why because, the turbine is then big, but you do not get as much flow for most of the time. So, it should be somewhere here, but where? That is the engineering decision. Is the point clear? What is engineering decision is that would you place it here, would you place it here, would you place it here, where? How much should be the flow that you allow through the turbine?

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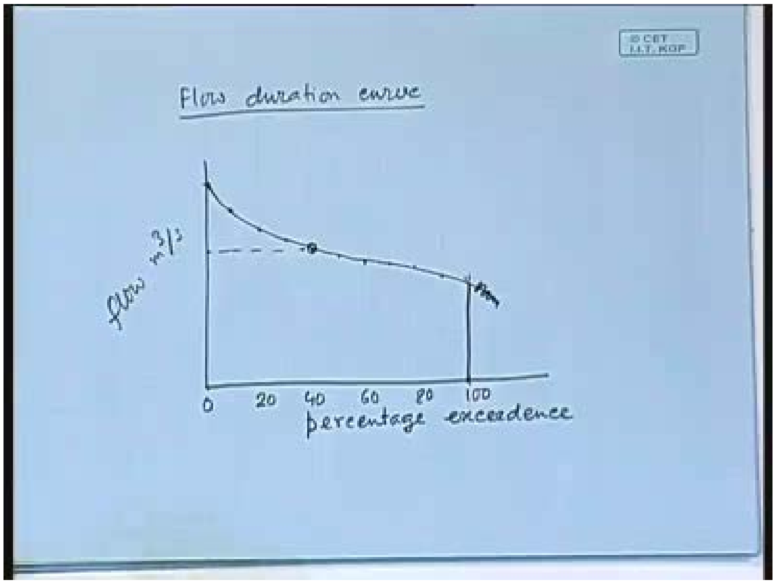

Now for that, supposing you have chosen this point. What does it mean? It means that this amount is the flow that you can allow through the turbine and this amount is the rating of the spillway there, right. So, this is the space that you have to allow in the spillway, so that this much of flow can be accommodated into the spillway, clear. So, you have, say you have decided this. On what basis you will decide that, I will come to that later. But for that flow, at different points of time when you are making the measurements, so this measurement has been made, this much of flow has been there at a particular time and at that time there has been a head also.

True, the head is essentially determined by the geographical considerations, but depending on the flow there will be head difference there, right and there will be a head difference here also. So, the head also depends on the flow rate, clear; the head also depends on the flow rate.

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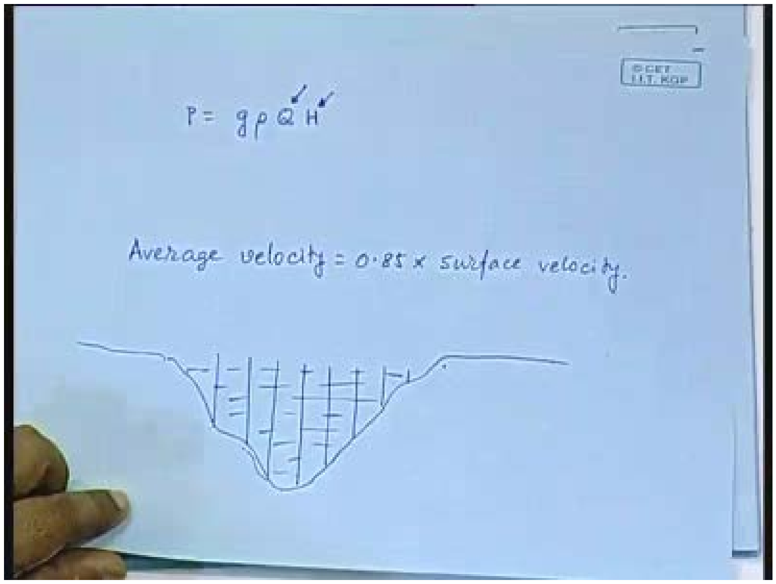

So, when I say this much of flow rate, this much of flow rate will have associated with it a specific head; it will have associated with it a specific head then, we can calculate the power from this relation, right. For every Q, for this Q, this is flowing through the turbine, so this is the amount of Q, not this. This is the amount of Q and for that, there will be a specific value of H, multiply this, you will get a certain amount of power that you can extract from the turbine.

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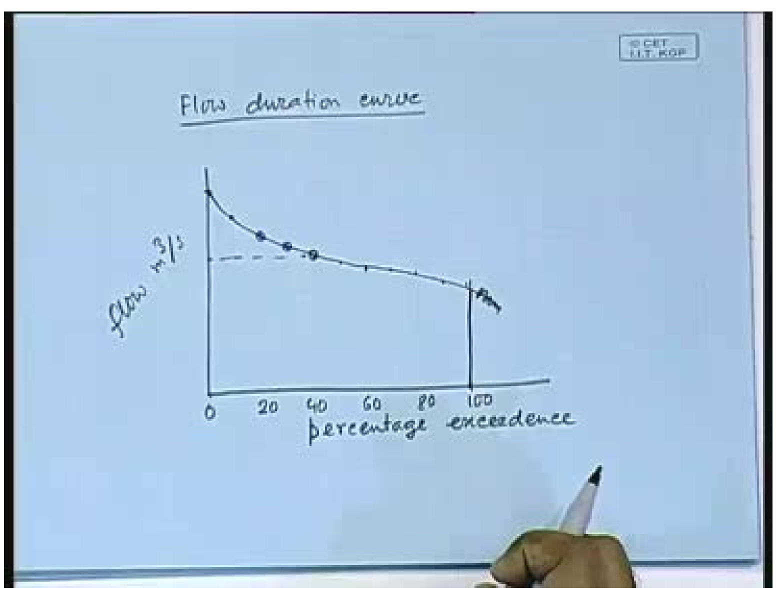

Then, instead if you had placed it here, you will get another point in the power curve. If you place it here, you will get another point, so on and so forth which will allow you to translate this into from a flow duration curve to a power duration curve. Now, since the head depends on the flow, at the same time you have to take into consideration another factor, that most of the turbines, as I told you in the last class, most of the turbines in the hilly regions where head is large, is of which type? Will be of the impulse turbine type; that means there will be a nozzle which makes the water come at a very high velocity which impinges on some surface, makes it rotate.

Now, a nozzle, you know that nozzle's character is that the more the flow rate, the more the head, it will sort of shrink there and then it will expand. Because of this effect, the amount of flow rate also depends on the head. So, if it is designed for a particular head, say 50 meters and now the head is 52 meters, then that will cause a difference in the flow. So, what you have drawn that the capacity of the flow is this much, it will be less slightly. So, how much less? It is something like this.

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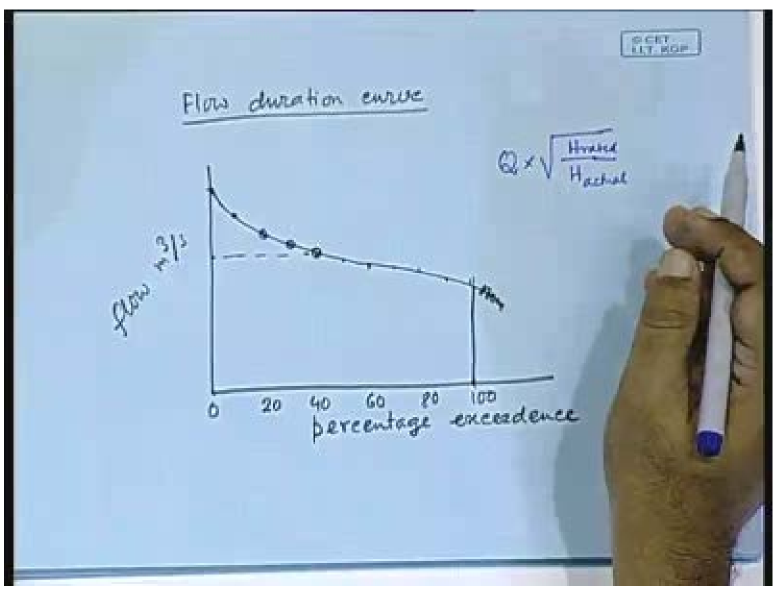

Normally it is given by the flow rate, flow rate Q times root over one head by the other head; this is the rated, actual. So, supposing the flow rate is something like 15 meter cube per second and the head for which the turbine has been designed is 50 meters and right now, the head is larger 52, 52 meters, then it will be 15 times root over 50 by 52. It will be slightly less, clear. So, these things need to be taken into account, but ultimately what you do is for every value of the flow, you can then calculate the power that will get out of it and even draw a power duration curve. So, it will look something like this.

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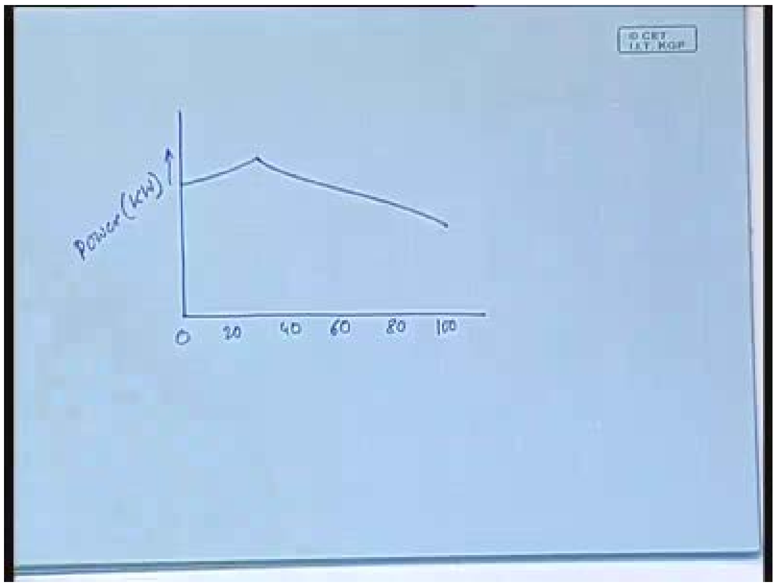

0, 20, 40, 60, 80 and 100; I have to drop up to this point and here is the power in kilowatt. Supposing I have placed the flow rate at a value that is corresponding to this point, so you will get a curve something like this. Now, if you had placed this point somewhere there, you will get a different curve, which will peak at this point and the power, total energy that you get out of it is the area under this curve.

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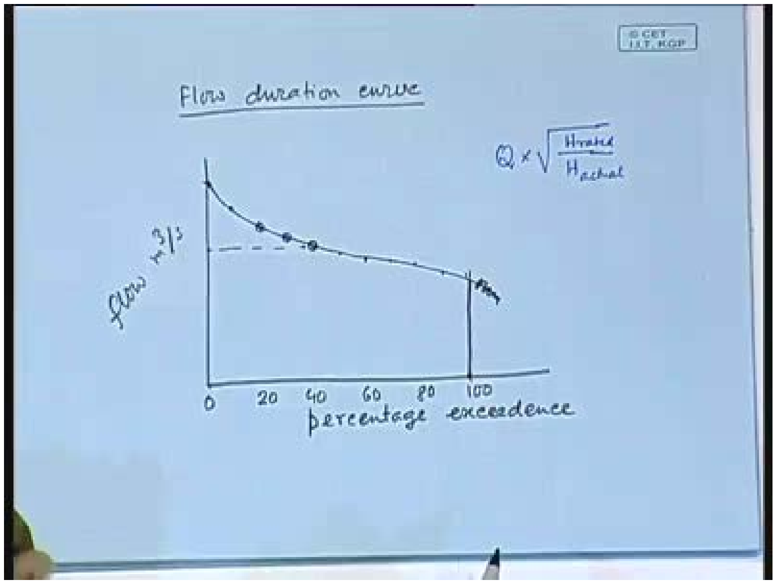

So, you have, if you place it at different points on this curve you will get different power duration curves with different areas under the curve. The one that gives you the maximum area under the curve will be a proper choice, clear. That will be the choice for the flow rate through the turbine. That is how you choose the rating of the turbine, clear.

Now, this is what should be done, but there are other considerations. For example, if the geographical structure of that place is such that you can create a small dam which will have a certain storage capacity. During the rainy season, you will allow as much as possible water to flow through, but during the dry season, it will be the stocked water that is there in the small dam. So, depending on the geographical characteristic and the desirability of creating a particular size of the dam that often dictates the choice. But nevertheless, in general, the scientific way of studying and finally deciding what should be the size of the turbine is to be done by this method.

So, we have come to a point where we have different types of turbines, we have different types of hydrolytic plants. We have learn that there can be small plants, run off the river without any storage, small plants but not exactly run off the river, you have got some storage and the big storage plants. The big storage plants obviously are created in relatively larger rivers. In India, though sites are relatively limited, relatively limited and the ones that were available more or less have been now exploited. There are problems which I will come to that later, but there is a huge resource right now available, which has not been tapped. That is the micro hydel power generation. That means very small of the order of say, 100 kilowatts to a megawatts size; these are small ones that use the streams in the upper reaches of the Himalayas. A huge amount of capacity is right now untapped, available in Assam, Meghalaya, Manipur, Mizoram, all these places in the eastern, north east India.

Similarly there are similar places in the upper West Bengal, in upper reaches of Bihar, in Uttaranchal, in all these places, in J and K, Jammu and Kashmir; so, there is a huge amount of untapped capacity right now. That should be actually tapped provided we have the access to those places. That is another consideration that I have already talked about. But, when you build a big tank, there are a few considerations that need to be kept in mind. The big dams are created with dual purpose of preventing floods, not dual, triple purpose; preventing floods, using the water for irrigation and also using the water for power generation. There are three purposes for that and one has to strike a balance between them. Why? Because you see, whenever you think of creating a dam, it is not like a reservoir, like you create a reservoir completely. It is already there. In most cases the geographical characteristic is such that the scope is there.

How?

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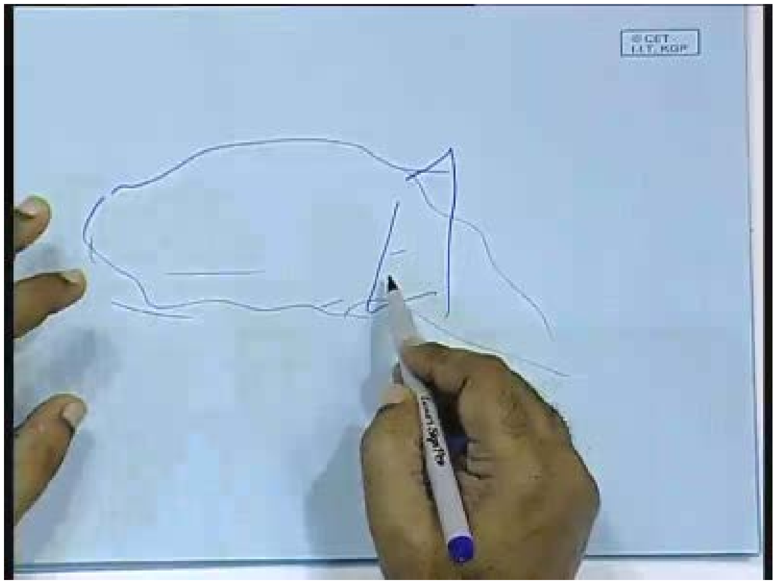

Suppose a place is covered from all the sides by some hilly terrain, only in one side it goes down, then in this place if you can build a dam, then it creates a reservoir and that is economical. But, it is not economical to have a completely surrounding, complete structure to make a reservoir. It is not done anywhere. So, never think that that is what is done. In all the sides it is open, in only one side you create a dam, thereby you obstruct the flow of the river. So, in one side you have created the dam, the other side is open.

Now, if the topography is such that the hills rise very fast, then if you create a dam, obviously you create a large body of water by inundating a small area. But, if the topography is such that it is almost flat, the gradient is small, what happens? In order to raise the height by just one foot, a larger area will have to be used and that is what happens in many of the places. For example that is the bone of contention in Narmada. Because, the dams if you raise the height by some level, it will inundate say, some hundreds of kilometer, square kilometers of area. Why? Because the topography is such that it is more or less flat; a slight raise of the height will have to use a larger area. So, in these, these places, in those places, it becomes more logical to have a relatively smaller height, because then you save more of land. In the places where you have a relatively steeper rise of the bank, there you can easily raise the height without creating much trouble. But, there are certain geological implications that you have to keep in mind.

The huge body of water in reservoir means there is huge weight. That weight was earlier not there. You have created that weight and in many cases, the geology of India is somewhat unstable. That means that the rocks are not yet stabilized, especially in Himalayas the rocks have not be stabilized, because Himalayas is a very recent, geologically very recent creation. They have not been stabilized. So, if you make a large body of water in that reaches, that might create, that might initiate earthquakes, reorientation of the rock structure. So, that is one problem. If there is an earthquake in a dam what happens? It is a disaster. An earthquake in a dam is a disaster, because, if the dam breaks, a huge quantity of water will suddenly flow out. It is not slow flow. It is like a flash flood, similar to what has now happened in Rajasthan, right. That is in a small quantity. That is in a small quantity; many people have died, but that is in a small quantity. If a dam bursts, it is a huge disaster. So, that is one problem one has to take into account.

The second problem is that in case of big dams there are many rivulets coming into the dam, depositing the water and all those rivulets bring in not only water, but also silt. Normally, if the dam were not there, that silt would be carried to the downstream, because there is a flow of water. But because there is stagnant water in the dam, the silt will precipitate, will drop there. As a result, the dam depth, the amount of water that can be stored in the dam, will keep on decreasing and that is exactly what has happened in Maithon and Panchet and the all the relatively older, say 30 years old dams in Bihar, West Bengal, Jharkhand, these areas. A large amount of slit has been deposited, as a result of which their water retention capacity is very low now. As a result, their ability to prevent floods is very little. If there is a sudden deposition of large amount of water, they cannot hold it. They have to release it and that is exactly what happened 4 years back, when there was a flood all over West Bengal, just because of this, the reservoirs could not hold it. So, that is another issue.

The third issue is human factor. That means if you inundate a large area, obviously a large number of people will be displaced and that human factor often takes toll. That is exactly what has happened in Narmada and there are many places where similar things will happen. So, that has to be taken into account. Often what happens is that since these people are marginal people, mostly tribals, so nobody really takes care of them; let them drown, let them go anywhere, let them secure ….. somewhere else. That is what generally happens and that is obviously what is not desirable. So, my point is that the direction of development of hydel power in India seriously demands attention, because there is a huge potential, but the potential has mostly been tapped in the form of large dams and large rivers, as a result of which this problem has been there.

There are far less problems created by run off the river plants and the plants that are small, relatively smaller capacity in the Himalayas which have largely been untapped as yet. So, in the future years the natural course of development should be to develop those sites mainly by the way of small dams and the run off the river hydroelectric plants, clear.

Before we end, let us again look at the structure of a normal power plant.

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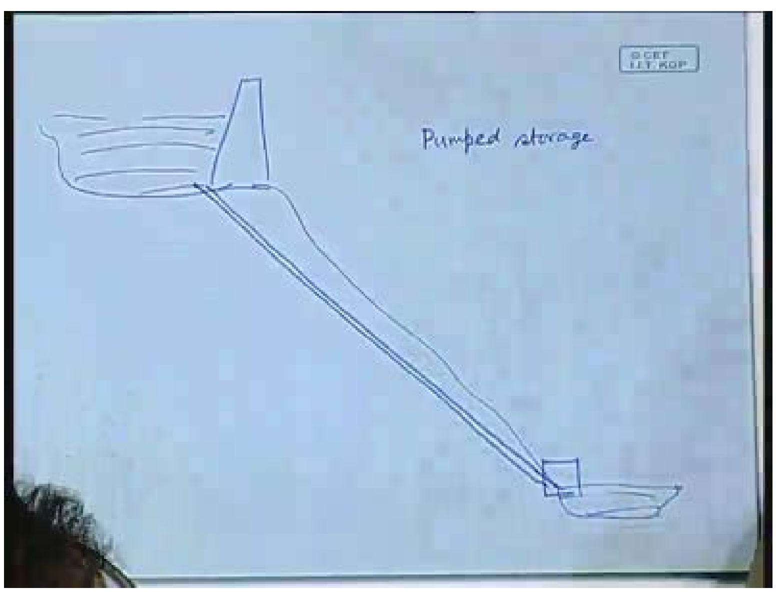

There would be, in the upper reaches there should be some kind of a reservoir. So, here you have the reservoir and there should be a downhill slope and here there will be another reservoir and there should be a penstock going through. In most cases in India, in medium sized power plants, the penstock goes through the hill. That means it is inside the hill. It is …. inside the hill. In some cases it is outside and here there should be the turbine. Now, you might argue that what is the necessity of the reservoir here? Actually there is no necessity; it is just a stream that goes through. But, if there is a reservoir here, you have an additional advantage.

What is it? The additional advantage is that as I told you, the thermal power plants operate well if they are allowed to operate at the same level of power generation. If you force them to have variation, what are you doing? You are varying the coal input all the time. When the coal input goes down, then obviously the power plant works relatively inefficiently. So, keep it at a certain level. If you keep it at a certain level, what is happening? The load curve is varying; load is going up and down. So, when in the middle of the night the load goes down, what do you do with the power? You can do nothing with it. So, you are normally forced to reduce the power generation in the power plant. That is why in many states where there is power shortage you still here cries that we have got power surplus, at 2 o’clock in the morning, right; you hear that.

Now, one of the nice things that one can do if there is a reservoir here is that during the, during the night time when there is surplus power, use that to pump water up there; so, use the surplus power to pump water up there, so that additional amount of water is available when you really need it and during peak hours allow that water to come down thereby, what you achieve is that on the thermal power plant the load is level. You have used that amount of power that was excess during the night to pump up water and this water is available to fill the gap during the peak hours. This is called pumped storage, pumped energy storage.

In many countries these systems are there. Especially where you have a hydrolytic power plant, it really takes very little in addition to create a pumped storage plant. Because, all that you need is that the same turbine should also be able to work as a pump and most turbines are of that type. So, a fan type turbine for example, just imagine a fan type turbine; you allow water through, it rotates and it generates power. If you put in the power and rotate it, it pushes water through and acts as a pump. So, turbines can also act as a pump and therefore, you really need very little extra in order to create a pumped storage plant and there are specific plants created for pumped storage purpose.

For example in Purulia now, Purulia means in West Bengal, now a pumped storage plant is being installed which is specifically for this purpose, because in this state we have very little hydroelectric power generation, most of the power is thermal power. The only hydroelectric power we get is from Chukha that is in Bhutan. Bhutan exports that power to us, so that is what hydroelectric power we get. So, in order to really satisfy the load, we need this pumped storage plant. That is why the pumped storage plant is being installed in Purulia. So, that is another thing that you have to keep in mind. In hydroelectric plants, with very little additional expenditure, it is possible to create a pumped storage plant, which over all helps the power system, because it can absorb the power when it is surplus and deliver the power when it is needed, clear.

So, it is about time; let us stop here. Only thing is that, there is another thing I need to mention here, before we change the subject. In the overall power system therefore, the whole load, load curve which goes at a peak during certain times, low at some other times, in order to satisfy that, as I told you the base load is satisfied by the very large thermal power plants. In India, they are called the super thermal power plants, mostly installed by NTPC. Then, intermediate load is satisfied by the medium sized power plants and the peak load is satisfied by, by what? By hydroelectric plants in general, but during the rainy season, the hydroelectric plant supplies the base. Where does the pumped storage thing go? Where does the pumped storage thing go? What is its role? It obviously supplies the peak power, it obviously supplies the, but also serves as a load during the off peak periods. That is fine. But in order to satisfy the load, you also need certain things. Supposing in an area, there is no hydroelectric power, but still you need to supply the load, supply the peak. What you can do? So, that is another thing we will need to consider later.

Where do the nuclear power plants come in? We also have nuclear power plants, right. Which part of the load that they supply? Basically, the base load; so, nuclear power plants are also of that type that cannot change it very fast. So, you have nuclear power plants also supplying the base load, base load again. Where do the run off the rivers power plants go? Do you understand my question? Run off the river power plants, where there is no storage, you obviously cannot time it, so that you will generate the power during the peak hours. So, it comes under …… it. So, where does it go? It goes to the base load again. So, run off the river power plants, power output goes to the base load again.

Wind energy, where does it go? These days, India has reasonable amount of wind power generation in Gujarat and in Tamil Nadu, in other places it is being installed. Where does it go? It also goes in the base load, because whenever it is available you generate it. So, with more and more of these coming in, the base load is being filled by such things that are not really constant and that is that additional load comes on the power station that can vary the power output, either the small power plants or the hydroelectric power plants that have some storage. Let us stop here.