Power Plant Engineering
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Lecture - 38
Economic of Power Generation

Hello, I welcome you all in this course on Power Plant Engineering. And today we will discuss Economics of Power Generation.

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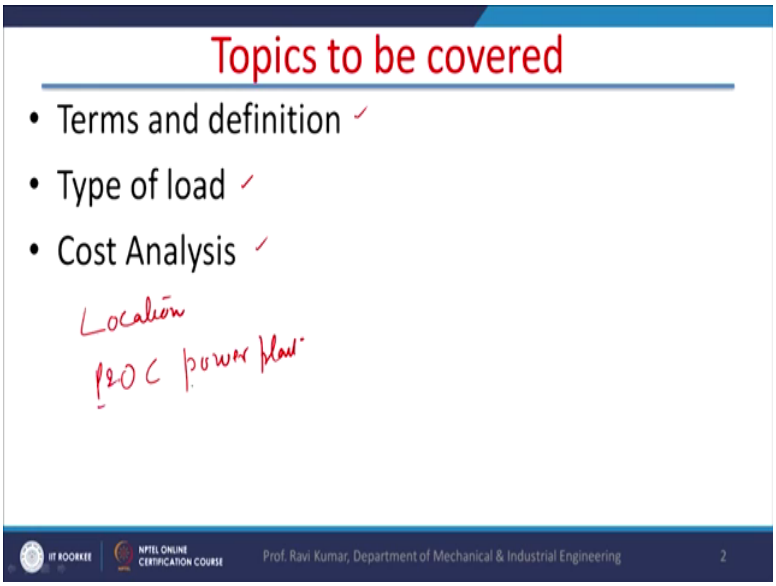

Today we will discuss some terms and definitions related with the power generation, type of load, cost analysis. We will also discuss the location of power plant, we will also discuss operating characteristics and of power plant operating characteristics of power plant, right. So, performance and operating characteristics of the power plant we will also discuss in this lecture; first of all terms and definitions.

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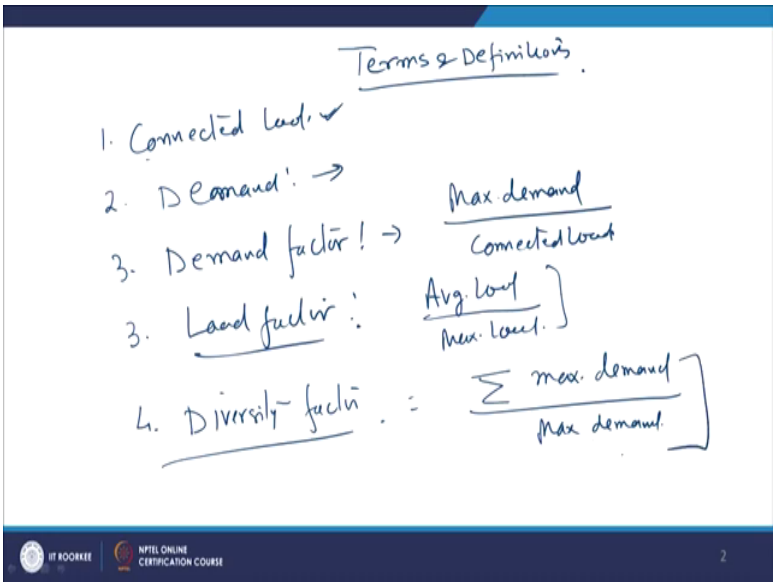

First is connected load right. So, all the load which is operative and it is connected to the mains is known as the connected load right. Now, second is demand. So, average of the load drawn from the source is known as demand. So, if demand may vary, but when we express demand what is the demand? The demand is the average load which is drawn from the source right.

So, connected load will is the load active load which is connected to the mains, demand is the average of the load which is connected to the mains that is known as demand. Third is demand factor; so demand factor is a ratio between these two maximum demand and connected load right. So this is known as demand factor.

Another is load factor; the load factor is average load divided maximum load. So, load factor has to be as high as possible. So, the average load becomes close to the maximum it means

variations are less. Fourth is diversity factor, it is some of the individual maximum load, diversity factor maximum demand divided by the maximum demand. I will give you an example suppose in a hotel there are 4 wings right, some of the time 2 wings are operative some of the time 3 wings are operative right.

So, we fight that what is the maximum demand for a particular period; for a particular period right. And total though maximum that is maximum demand is the demand of the 4 wings. So, ratio of these two; these two is known as the diversity factor ok.

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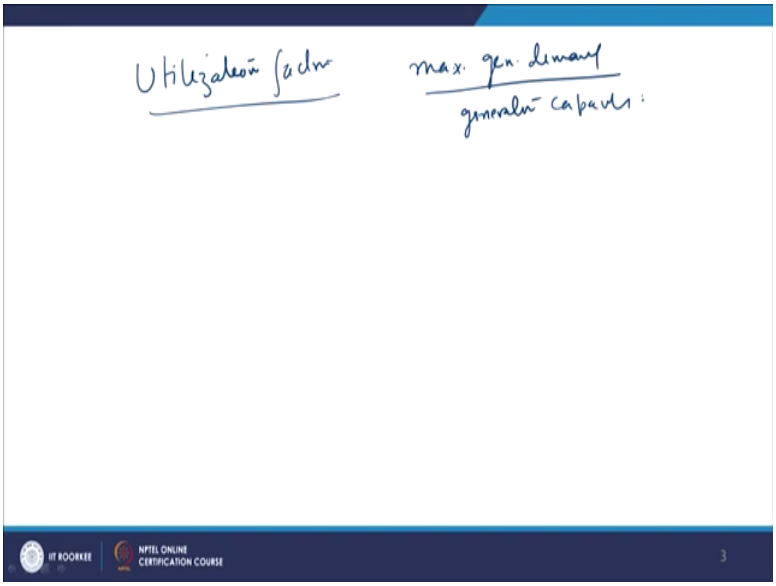

Third is utilization factor. Utilization factor is related with the generation capacity how much energy we are generating and how much capacity we are utilizing. So, it is maximum generator demand divided by generator capacity. This is known as utilization factor, there are two things diversity and utilization.

Diversity reflects the pattern of uses of energy right in ideal case it has to be 1. In ideal case utilization factor has to be 1, but it gives how much what is the generation capacity and what is the maximum generation demand relation ratio between these two that is a difference between utilization factor and plant chemistry factor. So, it is expressed in terms of energy kilo Watt hours, right.

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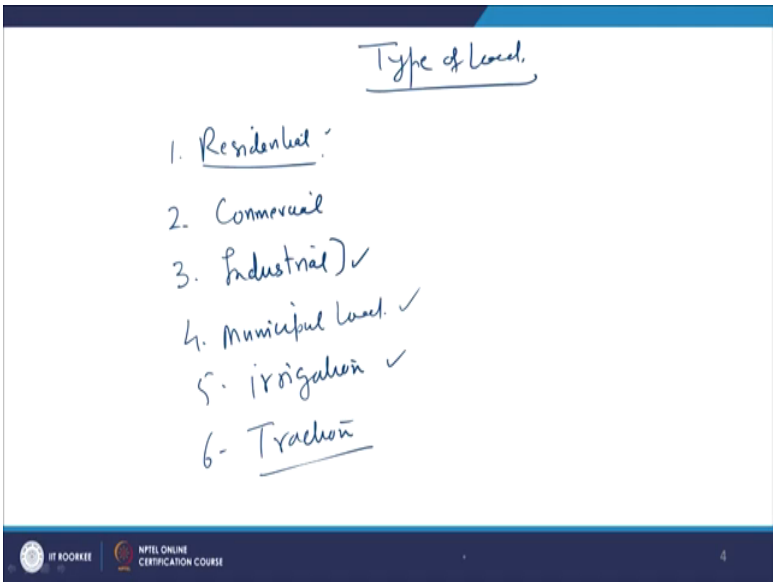

Now, type of load, there are different types of loads as you know one is residential load; residential load; residential load consists of the load by the light lighting load. And, this we have to operate fan lights like television refrigerator all this load comes under residential load nowadays AC is also included. Now, second is commercial load; commercial load maybe also as a residential like load in the shops right. So, the electricity when electricity is used for the commercial purpose it is known as a commercial load.

Third is industrial load, when electricity is used for the production or in the industry or industrial estate or running an industry that is known as industrial load. Municipal load; municipal load is lightening the street or operating machines where maintaining for the maintenance of the city. So, that is known as municipality load municipality load. Irrigation, the electricity is also used for the irrigation purposes to run the tube well right.

So, for the irrigation purpose when the electricity is used that is known as irrigation loads. And last is traction; traction means running the railways or the trains that comes under traction load. So, these are the different type of loads and tariff are also decided depending upon the type of the load.

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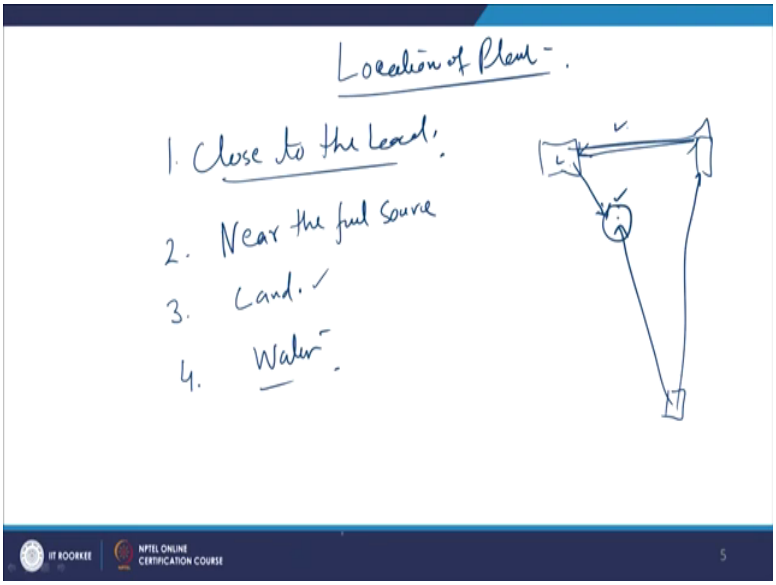

Now, location of the plant; location of the plant means site selection, the site selection of the plant first of all it should be closed to the load. Because if the load and the generation they are

close to each other then transmission losses are reduced right, otherwise transmission loss because the loss of energy in transmission is quite high. In India it goes up to 30, 35, 40000. So, I mean the transmission losses has to be have to be restricted ok.

And for the restriction of the transmission loss the load has to be very close to the plant, but what happens sometimes the source of the fuel is quite far, nature of the fuel source or it should be near the fuel source also. Because otherwise if the fuel source is quite far then transportation of fuel will also cost it will add cost to the generation of electricity. So, some optimum location has to be identified, your plant can be located, which is optimum distance from the load and optimum distance from the fuel source. So, this is an optimization factor ok.

Third thing is cost of the land, right because we cannot make power plant in herd of a multiple density a part from the other environmental issue the cost of the land is very high. So, power plant has to be installed, where the land of the cost of the land is not too high also. So, this is also one of the criteria because otherwise it will add to the fixed cost of the plant.

And the most important thing is availability of water, because if it is a know the thermal plant you need or it is a nuclear plant this availability of water is very important because they require a lot of water. If it is the hydro plant in that case itself water is a working fluid. So, availability of water is required. So, a costs analysis of any power plant is done.

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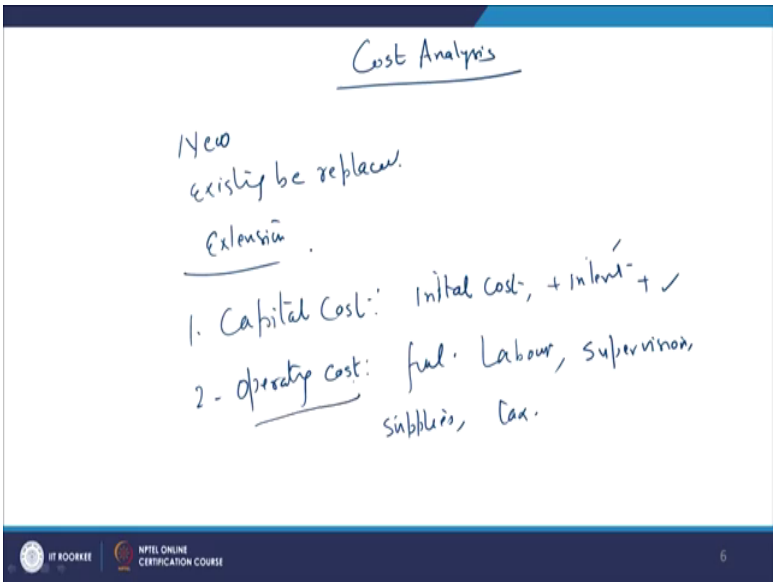

Now, cost analysis first of all we choose whether it is a new system or existing be replaced or extension right. There three things which are to be taken into the consideration and according to them the cost is decided; first is capital cost. Now, what is capital cost? It is the fixed cost, it is initial cost plus interest, was if you initially you need certain money certain amount of money to install the power plant right.

And definitely when you take the money from money lender or from a bank, interest has to be paid, then the moment you purchase the machinery depreciation starts. So, depreciation will also be counted here and taxes and insurance because the moment the equipment is procured you have to pay certain taxes. So, that is also a capital cost insurance part has to be borrowed by you that is also a capital cost.

Now, second is operating cost which brings the recurring expenses. So, first operating cost is the fuel except hydropower plants. So, fuel you always required if you want to generate the power. Labour, working forces, that is the operating cost maintenance periodic maintenance has to be done. So, it is also counted against the this operating cost supervision, supplies and taxes. When you operate the plant, then you may attract so, then taxes, so those taxes you have to paid and this is known as operating cost. And there is one initial cost also there initial cost.

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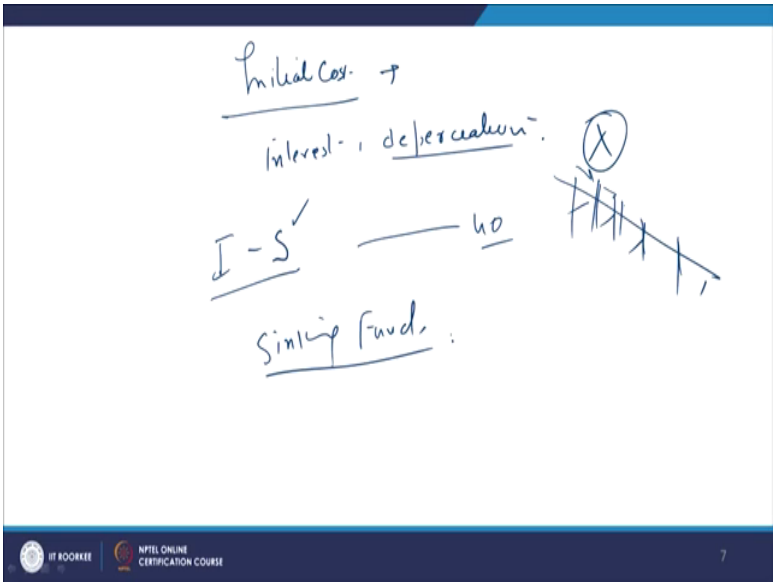

And initial cost depends upon the location of the plant, you will you will go and go for the site selection and purchase the land that is the first investment we are going to make if you want to make a power plant right. Time of construction; time of construction also incurs the cost, if

you want to make a plan in a very short duration you have to increase the number of labour or it has to be labour intensive ok.

If you do not put the labour or you do not collect the material, then it would spread over a time and then the cost of the plant will also increase. So, it is always suggested that whenever the idea of a power plant is considered it should be made in the minimum possible time. Because cost of the power plant will be recovered for the traffic when the electricity will be sold and investment has been done initially. So, gestation period of the power plant as to be minimum that is way thermal power plants are very popular because their gestation period is less.

If you go for the hydro big hydropower plants, the big hydro power plant they take a lot of time for construction and cost escalation is also there, but at the same time you can generate a lot of energy there is a lot of. It depends on many factors; I mean location of the country and where location where you are going to put the power plant, if inside the location only hydro is possible there is abundance of water. So, definitely one should go for the hydropower plant, but the gestation period should be should be the edginess should try to execute the project in such a way that the gestation period is minimum.

Now, interest and depreciation; depreciation is I mean very important part how the whatever you purchase suppose you purchase a car, depreciation it depreciates very fast the moment it comes out of the showroom the price will go down by 10 percent or 25 percent, it is the fast selling commodity right. So, there is a depreciation for it because every product has life, power plant cannot run forever it has life it may have life for 30 years 40 years or 100 years.

So, after 100 years it will have certain value, but that is salvage value we call the scrap value. So, tariff have to be decided in such a manner or you have to operate plant in such a manner that initial cost minus depreciation value is the earning from the tariff. So, that the entire project does not run in the loss right.

Now, collection of because we may not know I do not know of my suppose I install a power plant right now or suppose I purchased the commodity forget about the power plant. I

purchase a computer right now, what is going to be the salvage value of computer after 500 sorry 5 years right. Similarly, if I install a power plant here what is going to be scrap value of the power plant after 40 years? Right.

So, this predictions have to be made and for predictions there are certain methods right. So, once we know the last I mean salvage value and the initial cost then we can decide every year how much money we should recover right. So, initial cost and this is salvage cost and initial cost, if you take the difference suppose if life is 40 years you divide 40 parts and each year you recover the 1 by 40th part, then this is a straight line method; I mean we have just connected the straight line divided it to 40 parts and start collecting the money that is it that is one way of doing it.

Another is instead of dividing it number of parts you just go by percentage each year we will be recovering this much of percentage or this much of percentage does plus every year you have to calculate the depreciation. So, depreciation you can calculate percentage wise also. So, plant will depreciate there will be a depreciation of 5 percent every year that way you can calculate the depreciation or I mean a fixed value. It will depreciate by let us say 400 or 500 units or whatever it is the x amount per year ok.

And third one is sinking fund method. Now, sinking fund method gives you the idea that how much fixed amount you should extract to for the returns to beat the difference between initial cost and the salvage value like EMI it is something like EMI.

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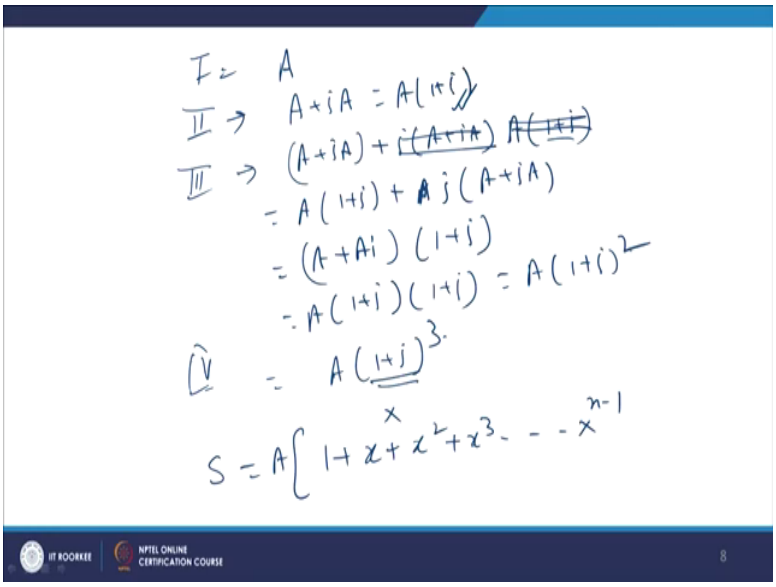

Now, in sinking fund method suppose A amount we extract every year I will say that I will extract the this concept gives the concept of EMI also, A amount I will extract from the running of the plant. So, next year this is first year first year you extracted A amount, second year A amount will be there and you will get interest also. Suppose you first year you take 100 rupees, the next year you will get 100 rupees plus interest on those 100 rupees that is earning of next year.

Earning of third year interest plus interest of sorry, interest A 1 plus i or A 1 plus i plus sorry i A plus i A; it will be A plus A i A will be common then 1 plus i. A 1 plus i 1 plus i A 1 plus i square this is third year. Now, fourth year again you will get A 1 plus i cube. If I take 1 plus i as X so, there is series. If I take the sum and the sum is A we will take out, 1 plus x plus x

square plus x cube and so on x to the power n minus because forth it is third, third powers 2, second power 1 this is also A 1 plus i right.

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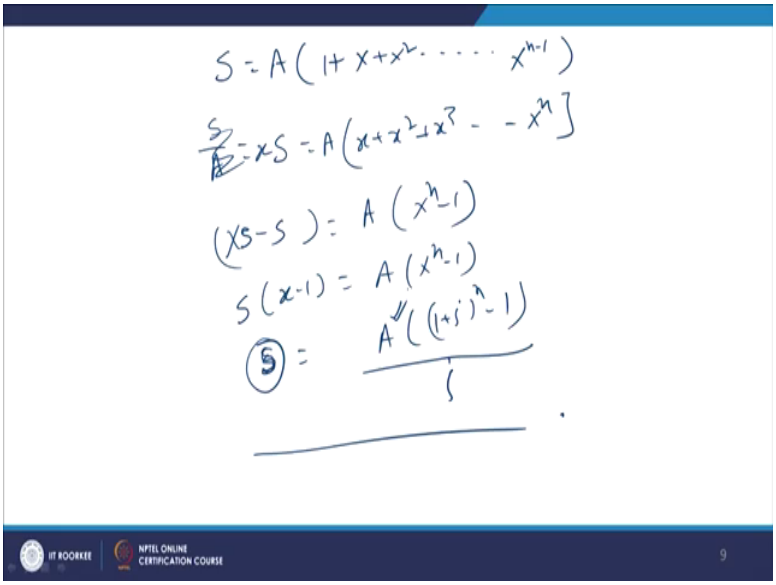

Now, we have series S is equal to A 1 plus X plus X square and so on X to the power n minus 1. Now, we can simply take S by A as sorry let us take S only S is equal to we multiply this by x. So, we will get A x plus x square plus x cube X to the power n that is it right. Now, we take difference of these two ok. So, if you take difference of these two, then X S minus S is equal to A X to the power n minus 1 or S x minus 1 is equal to a X to the power n minus 1. So, S is equal to A x is 1 plus i raised to the power n minus 1 divided x minus 1 is i.

So, this is how we get, we have now we have the value salvage value, then we can find the value of A. This much amount has to be extracted every year so, that we can meet the depreciation in the power plant ok. There is another method which is one is unit method.

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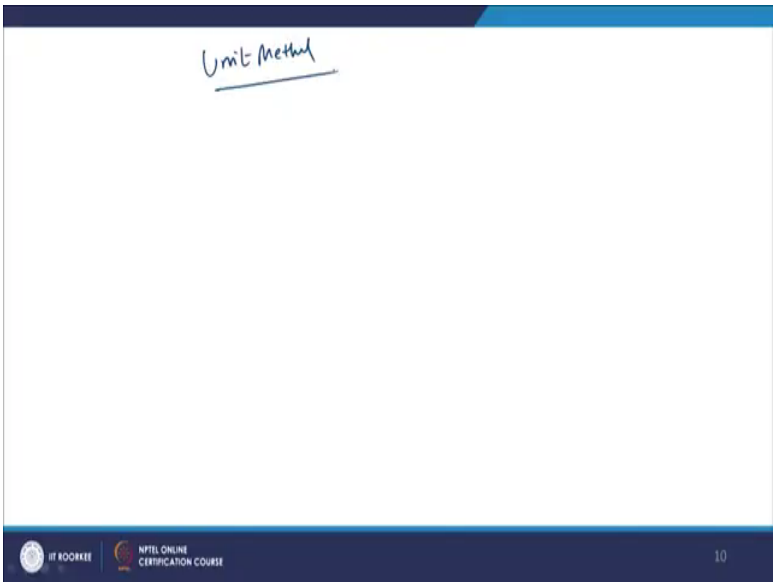

In unit method hourly consumption of power is taken. Suppose the capacity of the planet is thousand units and 1 hour we have used and how many hours we have used the power plant? We have used power plant for 500 hours.

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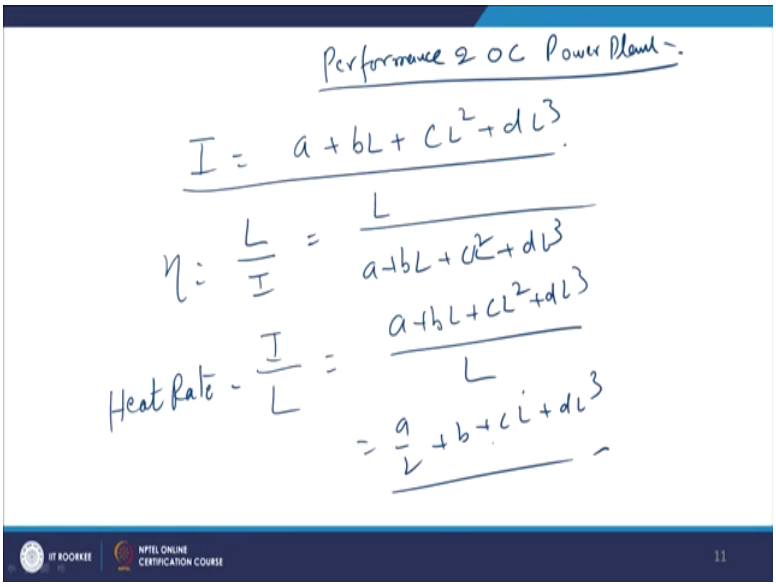

So, for that period we will take out the money and that is known as unit method; performance and operating characteristics of power plant right. Every power plant has input, input in terms of the cost of the fuel and it gives the output and input output relation output we express it terms of load L ok. So, input is equal to always there is a relationship between input and output.

And efficiency of the plant is output by input it is obvious, but whatever output we are getting and whatever input we are giving will give the efficiency of the plant. So, L is equal to a plus b L plus c square plus d L cube right. And another term is heat rate; heat rate is about the inverse of the efficiency that is input by output. So, here it comes a plus b L plus c L square plus d L cube divided by L or a by L plus b plus c L plus d L cube something like that. Now, if you draw the operation characteristic curve of any power plant this is b by L c.

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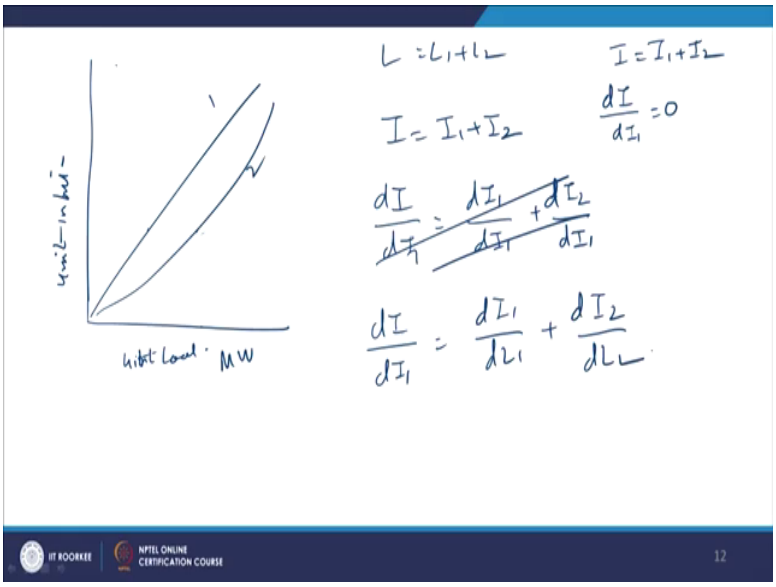

Now, if we take the input and output characteristics of a plant, there is a unit load and power plant has units right. Suppose this has two units let us start with the two units and each unit is taking certain input I 1 and I 2 and each unit is giving certain output L 1 and L 2 right. Now, we have to make the combination of these two plants so that, the net output which you are getting power plant is has the minimum cost.

So, this is unit input and this is unit load in it is mega Watt and input will have certain unit kilo Watt hours per into something ok. So, unit input is in kilo Watt hours and that is how we have some load in mega Watts the two plants; let us say one in the straight and another is curved characteristics. So, if you take second one, the second one require I mean it is producing more or it is giving more output with the same input. So, the same input first one is giving less output right.

And now I want to have; I want to run this plant and where L is equal to L 1 plus L 2 right and definitely I is equal to I 1 plus I 2 right. But if you want to have minimum input any in that case d I by d I 1 has to be 0, right. Now, as you know I is equal to I 1 plus I 2 we take d I by d I 1 is equal to d I 1 by d I 1, plus d I 2 by d I 1 sorry, this is not d I by d I 1 which is equal to d I 1 by d L 1 plus d I 2 is equal to d L 2.

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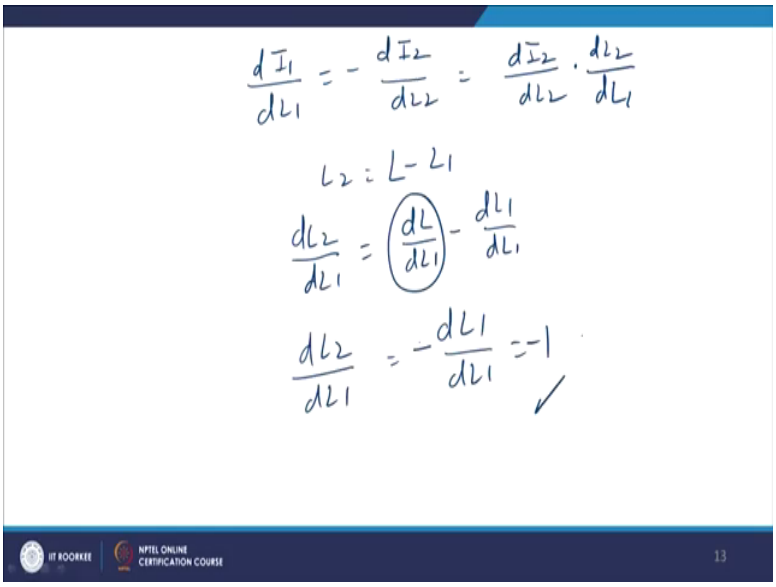

Now, after having this since I is equal to constant, then d I 1 divide by d L 1 is equal to d I 2 by d L 2. And we can further write d I 2 by d L 2 into d L 2 by d L 1. Now, here L 2 equal to L minus L 1 d L 2 by d L 1 is equal to d L by d L 1 minus d L 1 by d L 1 this is going to be equal to 1. So, d L by d L 1 is equal to 0. Now, in this case d L 2 by d L 1 is equal to minus d L 1 by d L 1 and is equal to minus 1 it is obvious right.

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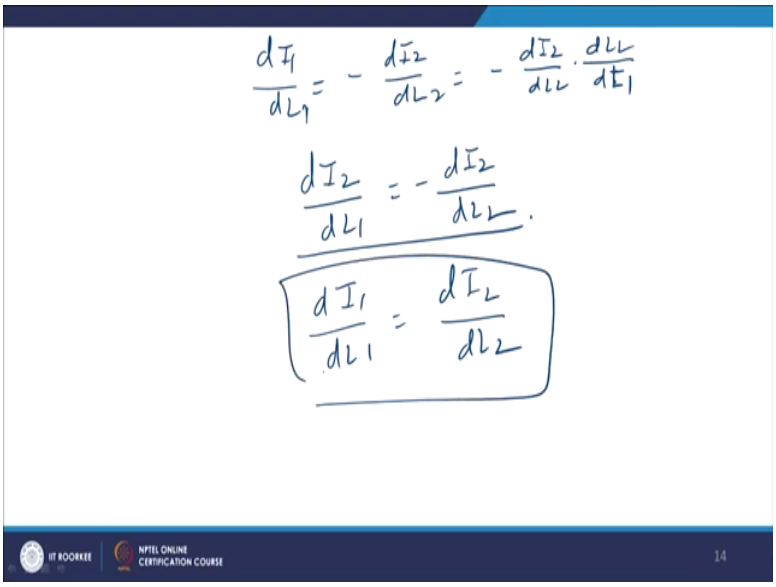

And substituting this value now, we have previously we had equation d I 1 by d L 1 is equal to minus d I 2 by d L 2 is equal to minus d I 2 by d L 2 into d L 2 by d L 1 right. Now, substituting this value, in this equation we get d I 2 by d L 1 is equal to minus d I 2 by d L 2. Now, as we know this as we know this is equal to this one. then we can find the d I 1 by d L 1 is equal to d I 2 by d L 2.

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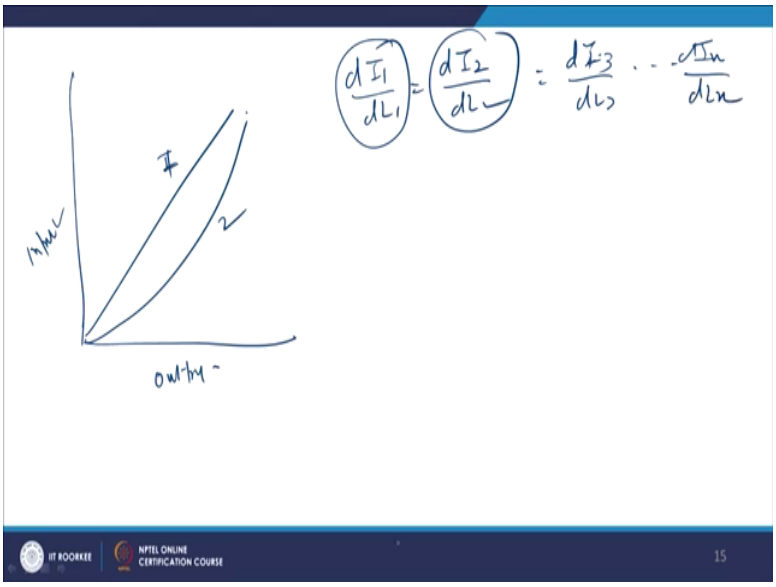

Now, if we go back to the this graph, we have drawn that there is a input and here is output the 2 plants and now 1 and 2; 1 and 2 and if we say d I 1 by d L 1 is equal to d I 2 by d L 2 right. If we compare if you look at this it means the slope of these two curves have to be same, if you want to have the maximum output right because this is d I by d L this is also d I by d L.

So, at any point if you want to have maximum output or minimum inputs or moreover same thing if you say for a given input maximum output or for a given output minimum input. These two all the tangential of the if you have there combination of n. So, d I 3 by d L 3 and it can go up to d I n by d L n ok.

Now, after this we will go for the tariff how the tariff are decided now this is important once you have generated the power how to sell that power? So, objective of the tariff is I need not

explain, it is just to generate the money to meet the expenses or the recurring in the fixed cost of the plant right. So, for the tariff a good tariff plan is that which I mean which brings back the money and it also promotes the consumer to use power in a delicious manner I mean right.

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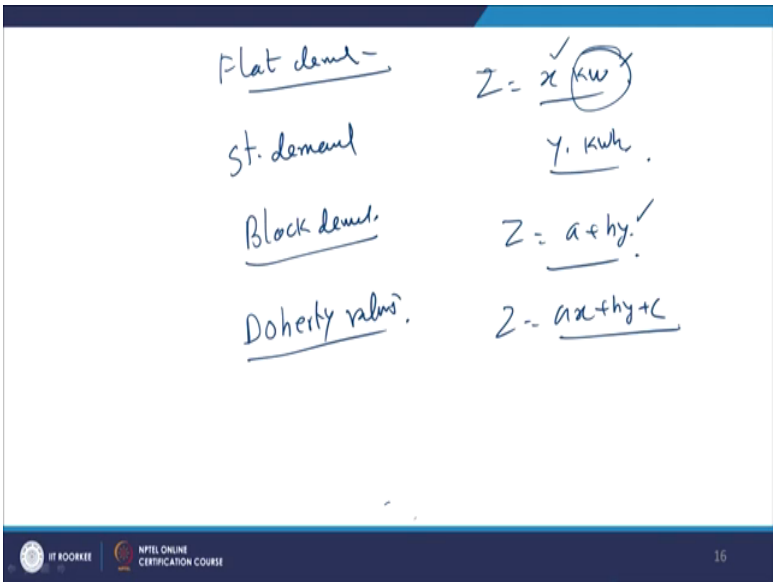

So, there is a flat demand rate, in this case flat demand type of rate Z is equal to x kilo Watt. If you have taken 5 kilo Watt load it will give you multiplying factor and that is your power traffic that is it energy whatever amount of energy you use so, this is not a very good plant in nowadays.

So, whatever amount of energy what is the fixed load in your building that will be multiplied by some constant and that is that is known as flat demand. Another is straight demand; in a straight demand Y kilo Watt hour, how much energy you have used? In this case is what

happens if you are not using energy you will not pay anything. So this is also not a very good plant.

Another is block Z is equal to a plus b y right. So, here you can have blocks also this is the fixed cost this is the cost related with the energy consumption. And if you use this much of energy beyond this the rates will change the rates may increase or decrease. Say in India I want to save energy we will say that up to 1000 unit the rate is let us say 5 rupees, if you consume more than 5 rupees then sorry more than 1000 rupees the rates should be 7 or 8 rupees. So, that is also known as block demand rates.

Now, another Doherty rates, here Z is equal to a x plus b y plus c here you take fix amount, then the amount is charged for the energy consumption. And there several other methods of also fixing the tariff, it depends upon the energy situation in the country.

If energy is in abundance the government will promote the energy consumption. So, if you use more energy, then the tariff will be less but if the our country where the scarcity of the energy. Normally the tariff plan is made in such a way if you are more consuming more energy then you have to pay more. And normally in our country the domestic rates are quite less than the commercial or industrial rates right. So, there are many governing factors for deciding the rates for it and any power generations unit, that is all for today.

Thank you very much.