Energy Conservation and Waste Heat Recovery
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Lecture - 64
Energy Economics - III

Welcome back. So, in the last class, if you recall, we were talking about different metrics of energy economics and what we discussed where we so far, we have covered 3 such metrics.

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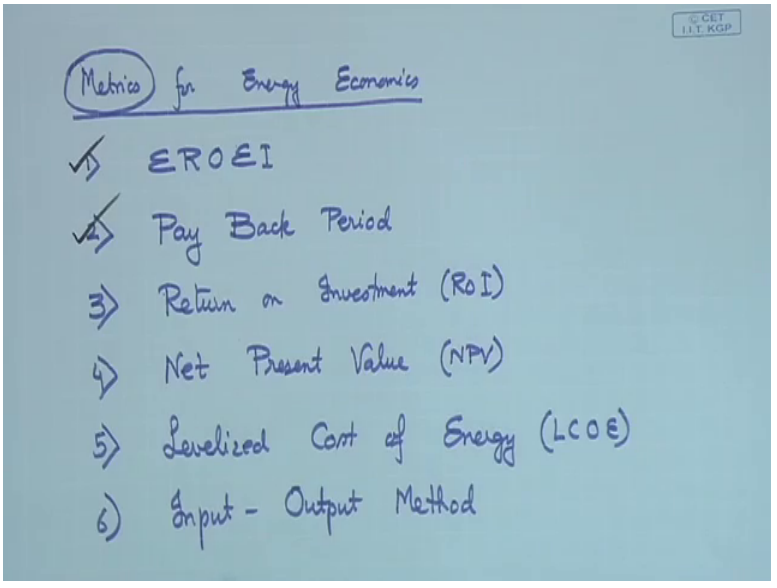

The first one is called EROEI, the second one is payback period and the third one; let us also write down this we denoted by N star and the third one this was N star; third one we discuss was return on investment.

So, today we will take up this fourth one which is net present value. Now what is the net present value recall that we first said when we were talking about payback period or even return on investment, we were just adding up the cash flows the net cash flows over the years and see when it totals or when it sums up to the initial investment, but what it did not take into account and which is one of the drawbacks as we state it is it did not take into account the time value of money.

So, 100 rupees next year or rather 100 rupees; today is worth much less next year because there is something called inflation what I get for 100 rupees today and what I will get for 100 rupees, let us say after 5 years are going to be very different, after 5 years the value of that 100 rupees will be much lesser clear. So, that is the crux of the problem and which is something that the net present value method tries to address.

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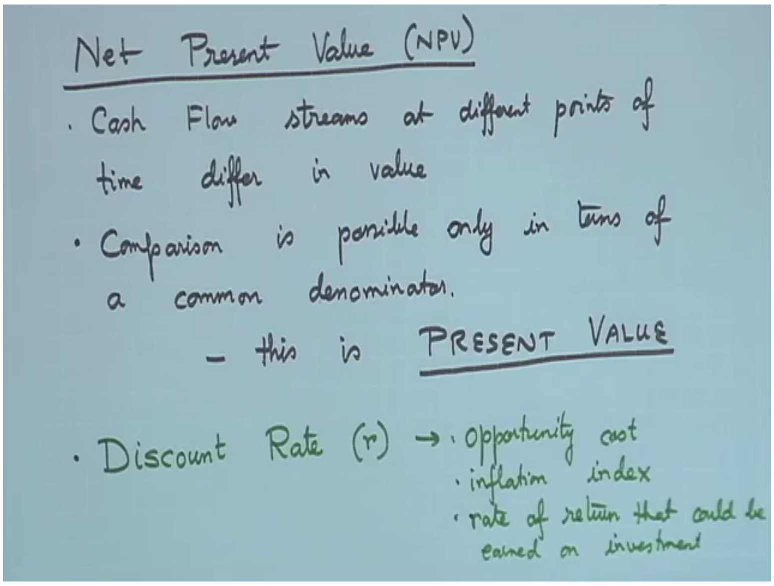

So, let us write that down first net present value or NPV. So, what I would say is cash flow streams at different points of time different value which is what we are talking about. So, we comparison is possible only, let us say in terms of a common denominator and this is the present value, all right.

So, I am sitting here today and trying to decide whether I want to put in some money to build a power plant and the person who has come to me with the proposal is saying that you know once this power plant is up power plant is up and running in the year 2025, you are going to make 20 crores. So, I would say 20 crores is a lot of money, but what I am going to say is wait a second you are saying 20 crores, but that is in 2025. So, what is it worth today and so, I am going to think about 20 crores in 2025 is not the same as 20 crores of today. So, what do I have to do?

So, that is where the present value concept come in. So, what I will do is I will introduce a term which I will refer to as r and I am going to talk about it, I will talk I will that is typically in or generally in economic jargon it is known as the discount rate r. So, it is also sometimes called opportunity cost some people also called it inflation index and whichever way you want to look at it some people also say that it is rate of return that could be earned on investment what I am trying to say is instead of putting this money in the power plant if I put it in the bank I would have earned some rate of return.

So, in the economic jargon when we are talking about present value that rate is called the discount rate or r, all right.

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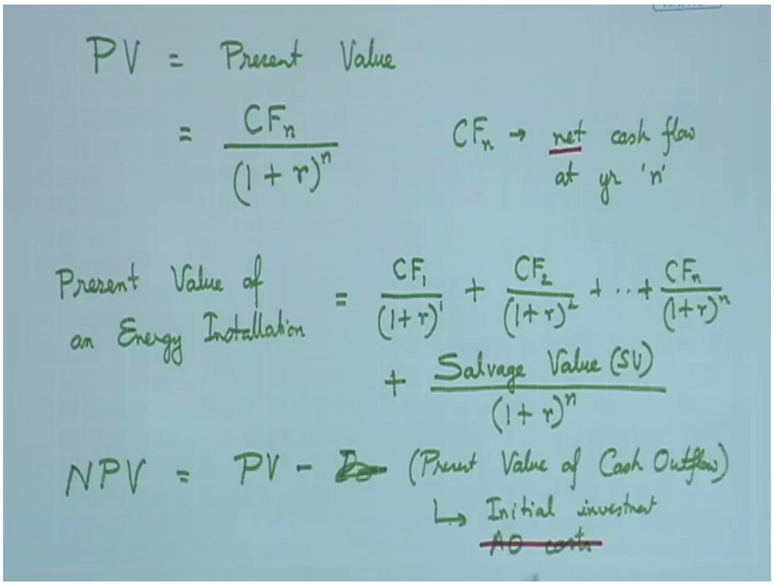

So, therefore, what is the present value I would say PV equal to present value, if I think about a cash flow net cash flow at the end of n years or the at the nth year I would say it is one plus r to the power n where CFn is the net cash flow at year n.

So, therefore, with this if I write present value of an energy installation I would write it as the following I would write it as CF of 1 divided by 1 plus r to the power 1 right plus this is all the cash flow that I am going to generate.

So, if you say what is the value of energy installation I would. So, you are going to make 10 crores in the first year, 10 crores in the second year, 10 crores or 5 crores in the third year and I can add up all that, but what I am going to where the investor is going to ask is well what is that 5 crores at the end of third year value; today what is the value of that 5 crores at the end of the third year if I look today? So, he is going to use this present value method. So, this is going to be CF 2 1 plus r to the power 2 plus bla-bla-bla and then CF n 1 plus r to the power n plus I would write something else which is called salvage value SV; what is salvage value if I have a plant whose life is n years and at the end of the n year the plant has to be stopped it will go out of production probably it will become obsolete or it will become worn it will degrade and no longer operational economically viable to operate and so on.

So, at that point what will I do I would like to sell off that plant. So, that is the salvage value for example, when we drive a car if I drive a car for 10 years the car is going to you know it is going to degrade with time to a point where I would say that you know just keeping this car itself is becoming a burden I want to get rid of this, but then when I take it to somebody they would say you know your car is hardly drivable anymore and therefore, you have not any way it has degraded badly it is no longer drivable. So, what are you going to get you will probably get in terms of the scrap metals in terms of parts and so on. So, that is the value I can salvage.

So, similarly for a plant for a factory let us say if that is goes out of production or that has reached its end of life you can take the equipment and sell it off you can even if nothing else has scrap value the metal is at least worth something. So, that is the salvage value salvage value is; what is the value of your plant of your installation at the end of its operating life.

So, this salvage value also this is a value at the end of its operating life at the end of n years. So, I have to do the discounting for this one as well and that is going to be one plus r to the power n. So, this is the present value of the installation. So, therefore, what is NPV or net present value net present value is present value minus the initial investment and also I would say minus the present or I would write it down as the following present value of cash outflow which includes initial investment it also includes annual operating costs.

So, this is present value of cash inflow and this is present value of cash outflow now sometimes we said that the cash flow is typically net cash flow therefore, I can remove this and say that it is already included in the CF one CF 2 which is because we are talking about it as net cash flow. So, the reason I wrote this and then struck it off is just to underline the point that you need to know while calculating NPV you need to know all this if somebody tells you a cash flow; I am going to give you the cash flow of this, this,

this, this you need to ask is this cash inflow or is this a net cash flow rather does it include the operational costs operational maintenance costs or the running costs.

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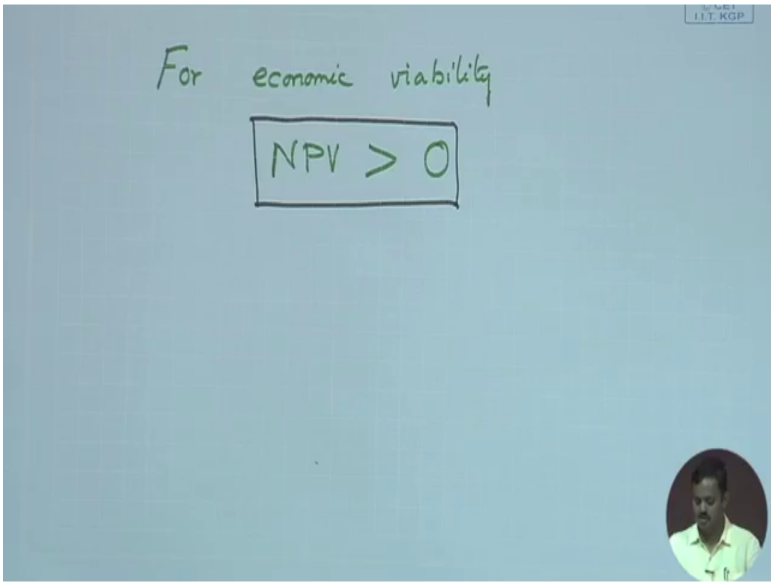

For economic viability it is very obvious that NPV must be greater than 0 right or much much greater than 0, I would say because if you are looking at it as an investment the net present value calculated in this manner should be much much bigger than 0, let us just spend a few more seconds on this look at each of this cash flow at the end of year one at the end of year 2, at the end of year n the present value of each of these cash flows is actually lower than the net cash flow because we have taken into account we have done the discounting and taken into account the time value of money the inflation, right.

So, if you are added just CF 1 CF 2; CF see the way we do it for calculation of payback period, then I would have thought that the payback period will be much much earlier or rather I would recover the cost much earlier, but if you put all these discounted discounting or if you apply the discount in and get the discounted values and then add up you will see that recovering the initial cost will take higher number of years. So, net present value kind of addresses the drawback of payback period which does not include or does not consider the time value of money.

So, we have now covered net present value also. So, let us take that we have already done that. So, these four we have covered the fifth one is probably the most widely used most relevant and important it is called levelized cost of energy or LCOE very interesting. So, let us write that down; what are we talking about here.

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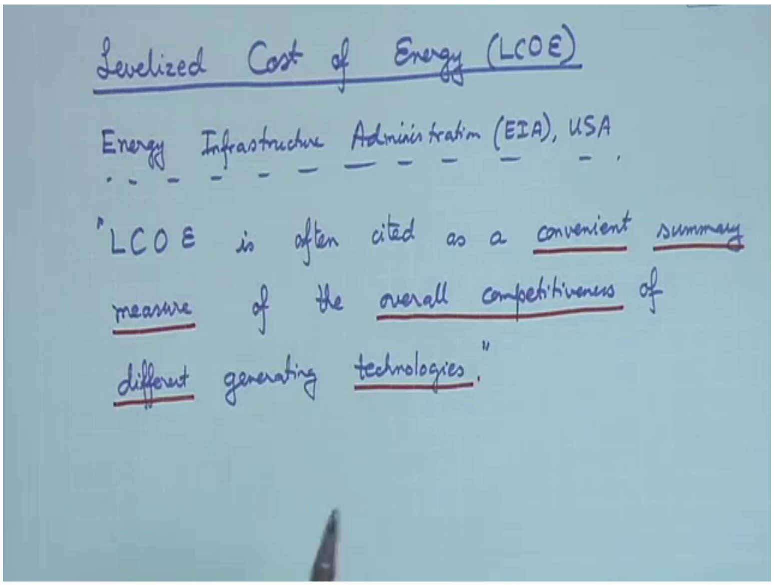

We are talking about levelized cost of energy LCOE; I will wrote down that this is the most widely used let me state this is the most widely used metric for an energy source.

So, let us say we are talking about different energy sources we are talking about coal we are talking about wind we are talking about solar we are talking about natural gas we are talking about oil biomass everything levelized cost of energy kind of it is suppose to give you a level playing field where you can compare different energy installations probably using different sources of energy and try to see that what is the cost of producing that energy. So, what is the cost of producing let us say and unit of energy let us say one kilowatt hour or one megawatt hour of energy.

So, what I will do first is I will write down a definition and this is from the energy infrastructure administration of USA energy infrastructure administration EIA from USA, what do they say it says that LCOE it is defined is this manner is often cited as a convenient summary measure convenient summary measure of the overall competitiveness of different generating technologies.

So, let me kind of underline convenient summary measure overall competitiveness different technologies . So, this is the definition. So, let me quote this let me put it in quotes this is from EIA; the EIA also say states that it presents a per kilowatt hour cost of building and operating a generating plant remember per kilowatt hour that is one unit of energy.

So, it represents the per kilowatt hour of building and operating a generating plant over an assumed life and duty cycles. So, there will be an operating life cycle and during the life cycle, there will be also be duty cycles of the power plant I am going to talk about what duty cycles are in a minute. So, we have to take all this into account and LCOE gives you a measure of the cost that is incurred to produce one unit of electricity let us say 1 kilowatt hour of electricity for both building and operating the plant mark my words building and operating the plant.

So, what is it? So, what I can see is this cost from what we just said the cost is levelized over this life. So, let me write that down.

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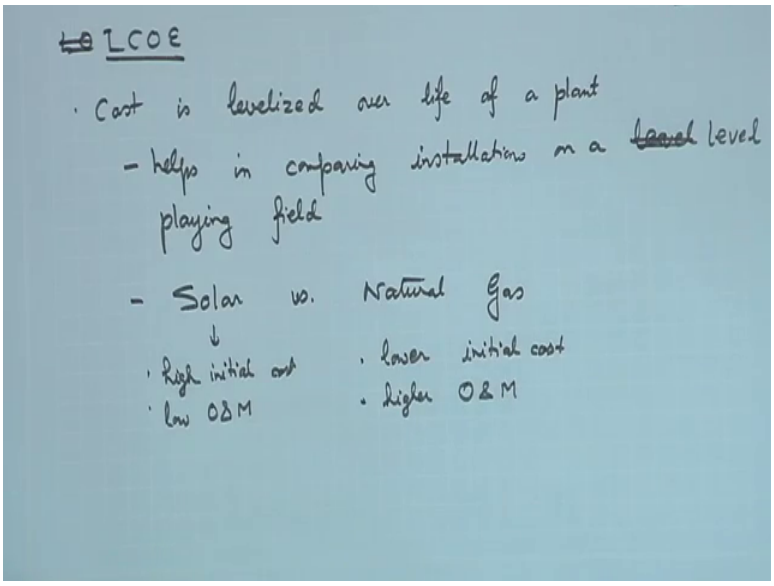

So, for LCOE; so, cost is levelized and what is levelized will talk about that over life of a plant; we also said that there is a life of the plant there is also life cycle and there is also a duty cycle. Now what is the duty cycle remember a plant may be rated as some megawatt hour or sorry some megawatts, but if we may not be running the plant all the time at that rating we may not be running a plant at its peak rating all the time.

It depends on the duty it depends on the load that we have we talked about that during off peak hours if we run at a peak load if during off peak hours we produce more electricity during which we say and we discussed that during energy storage technologies, but what we are trying to say is the duty cycle of a plant may vary from one period to another from one season to another from one part of the day to another part of the day and if we talk about let us say wind or solar it will depend from day to day depending on the conditions on a sunny day versus the cloudy day on a windy day versus on a still day all right. So, duty cycle does change and we have to consider that also when we talk about calculating LCOE.

So, this helps in comparing installations on a I would say level playing field right on a level playing field fair comparison for example, let us say I want to build a solar power plant or a wind power plant the initial cost of building the power plant is going to be large right the solar panels are expensive the PV cells are expensive, if you talk about solar photovoltaic.

But once it is installed the annual operating cost is going to be very low apart from manpower the operation and maintenance is not going to be that expensive we have to periodically clean the panels and that is about it all right no fuel compare that your natural gas plant the installation cost is going to be much lower compared to a solar plant, but then over the years the operating cost will be much higher especially because we will need fuel.

So, therefore, today if we talk about standing today and looking at 2 installations that are coming up I would say solar may appear or look to be much more expensive, but if we look at the expense over its entire life cycle then we do not know; what is going to be because its operating cost after installation is not going to be high whereas, a natural gas even though the installation is going to look cheap today, but over the period it is going to be much higher it is like; let us say a car running on gas or gasoline or petrol and an electric car electric cars are much more expensive, but when I have bought it and when I am using it the fuel costs are going to be much lower.

So, therefore, we do all these calculations and see that is it worth owning a worth buying an electric car today we are again not talking about the environmental impact and all those are also equally important, but only from cost point of view we do these calculations before making the decisions right . So, that is also I want to mention that it is important to note that final decision final or final comparison or final decision on which installation to go for if you are really making a choice does LCOE is not the only criterion there may be many other impact factors there may be environmental factors there may be social factors there may be political factors and so on.

So, LCOE is not the only criterion, but it is a important criterion. So, let me just write it down here what we talked about solar versus natural gas here this one is high initial cost low operation and maintenance and here lower, I wants a low lower initial cost or installation cost, but higher operation maintenance, all right.

So, we looked at the energy EIA of USA that definition I will just write down one more definition.

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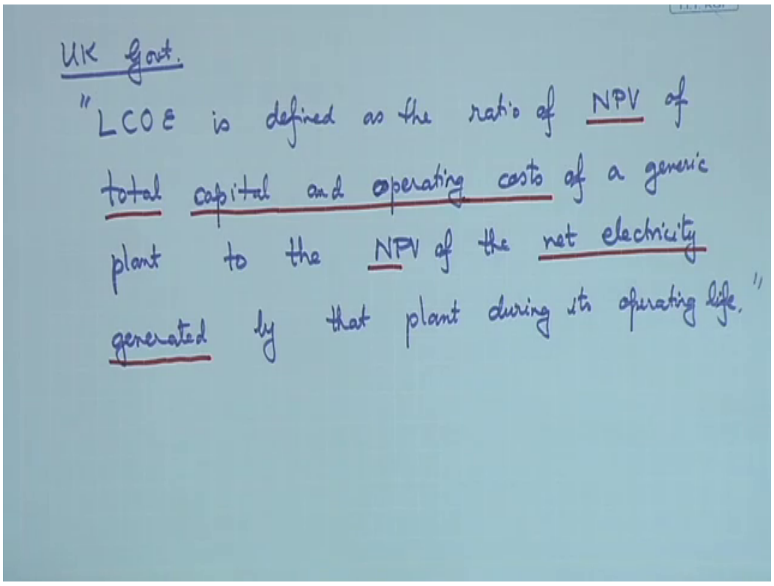

Because it is important to know these this is from the UK government and what it says is it again, it is not about that was energy EIA was energy infrastructure administration UK government, it is a generic one. So, it is not this definition is applicable not for this energy generating plants, but for any other thing.

So, I would say that LCOE is defined as the ratio of net present value of total capital and operating costs of a generic plant to the net present value of the net electricity generated by that plant during its operating life again this is also quotes and let me underline some of the good major points net present value we learnt net present value just before this as we will see here that discount rate is going to be used heavily when we look at the definition of LCOE total capital and operating costs and again NPV of the net electricity generated, all right.

So, this is important we have studied NPV we know how to operate how to apply discount rate. So, remember that discount rate has to applied both on the capital and operating costs as well as the energy that is generated. So, let us talk about discount rates discount rate as we recall it takes into account the money time value of money, if I talk about a nuclear power plant nuclear power plant we have mentioned this before also they have enormous decommissioning costs at the end of its life. So, that has to be taken into account when we calculate net present value, but it is going to definitely benefit from the discount rate right because it is a cost, but that cost is going to be incurred many years down the road. So, the value of that is much lower today.

On the other hand if we talk about the solar or wind installation where the initial cost is high we are not going to be benefit much in terms of the cost we are not going to benefit much due to discount rate, right. So, discounting does help in some cases discounting does not help in case of plants for the where the initial cost is high and the subsequent costs are lower, but anyway.

So, we will take all these into account and define; what is LCOE in the next class and see what all it encompasses due to which we say that it is one of the more fair metrics for comparing different energy installations or energy generating units.

Thank you very much. We will continue with LCOE in the next class.