Energy Resources, Economics, and Sustainability

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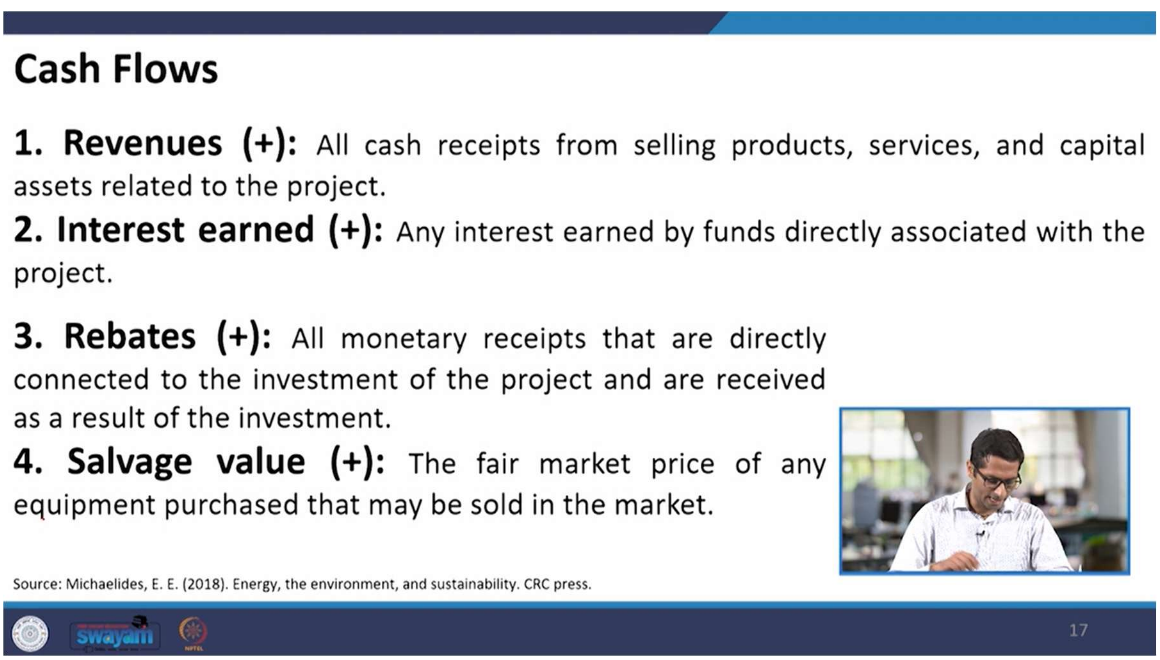
Week – 03

Lecture – 02

Lecture 12 - Energy Economics-II

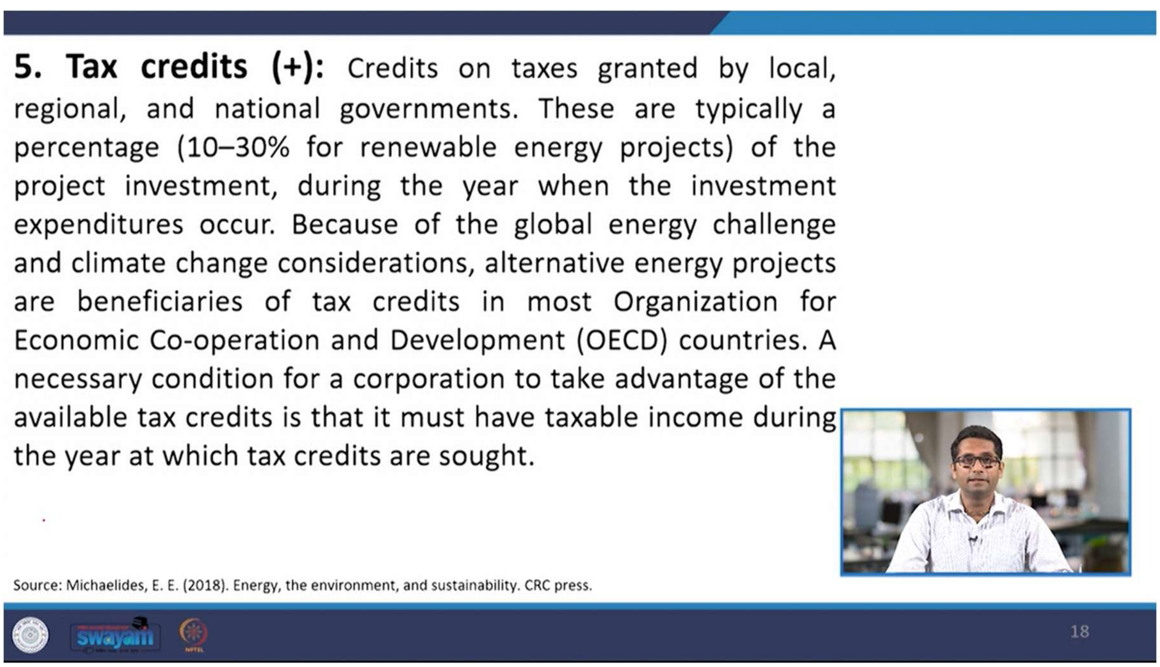
Hello everyone. Welcome back to the course. And this week we have been discussing the different basics of energy economics. So we will continue with the same. So we have been discussing the basic concepts of time value of money and what are the different problems that one would encounter in an energy related project. One of the major issues for an energy related project would be that of cash flows. So you would have the capital investment being invested in the first few years. Then you would have the revenue being generated for the next 15, 20, 30, 40 years. And in between you can also have ups and downs in terms of the replacement at the end maybe the salvage value or in between the payment of the interest. And all these aspects make it too difficult to understand like will the plant be profitable on an overall basis or not. Because you would have the revenues being generated at a very different time from which the costs are associated. And let us try to understand some things on that particular front. So let us try to understand some more basic concepts.



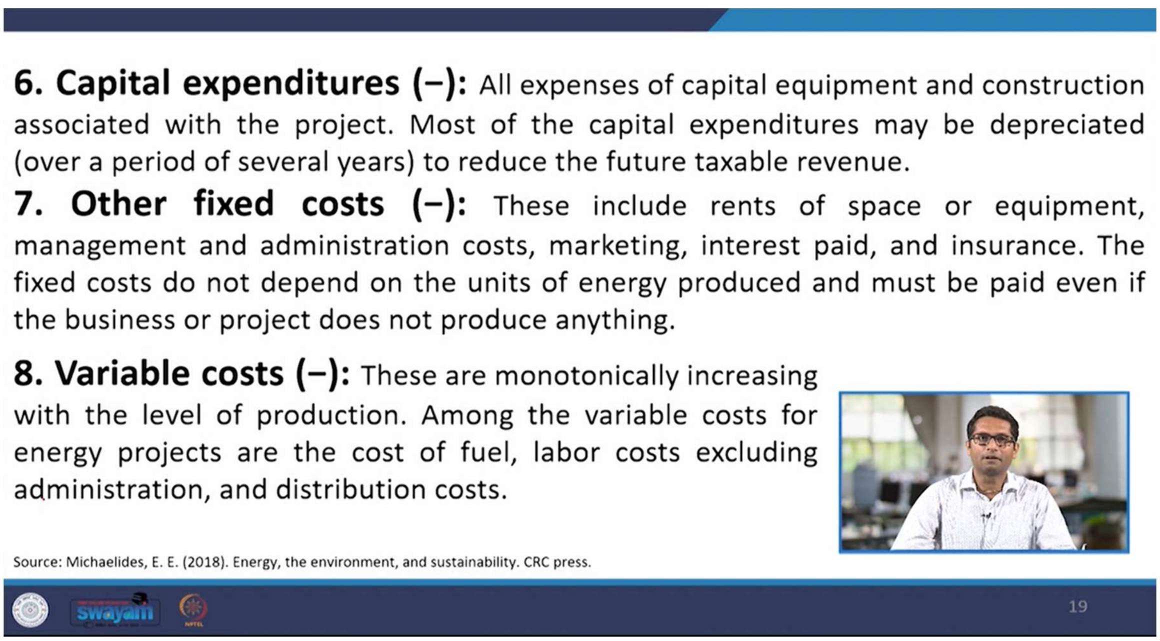
So I am going to basically like take you through the different aspects which could be either the addition of funds or the subtraction of funds. So wherever you can see a plus sign which means there is some kinds of funds that are being added to your account.

And when there is a negative you can see there is a cost being incurred. So the basic place how or the basic way in which the funds will be added to your account will be revenues. This would be the revenues from the selling of the different products, services or the capital assets that can happen at different time frames. But basically it will be selling of the energy that you generate. Then the revenue could also be generated from the interest that is earned on the basis of if you have given any funds to as loan to some entity.

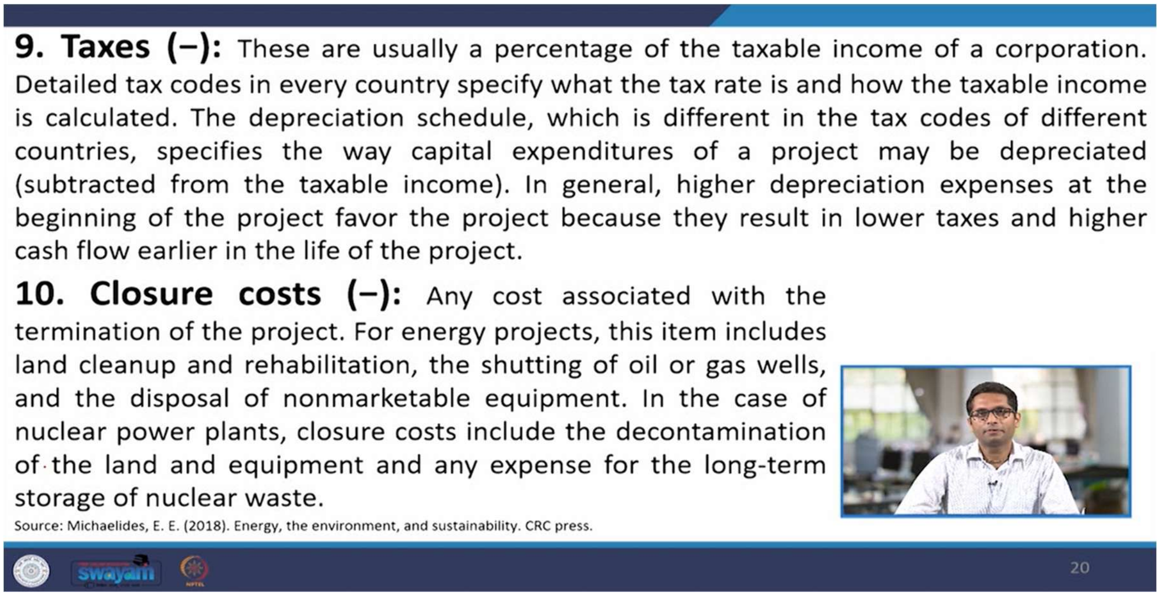
There could be some kind of rebates that are given to you in terms like you are a green manufacturing company or the green energy production company and the government gives you some rebates. So that is a value addition. Further there could be a value addition in terms of the salvage value which is selling of the products after their useful life is over. Again this is like this could be negative also in some cases as we have discussed in the case of nuclear energy there could be some additional cost at the end of the plant as well. Then there could be significant tax credits.



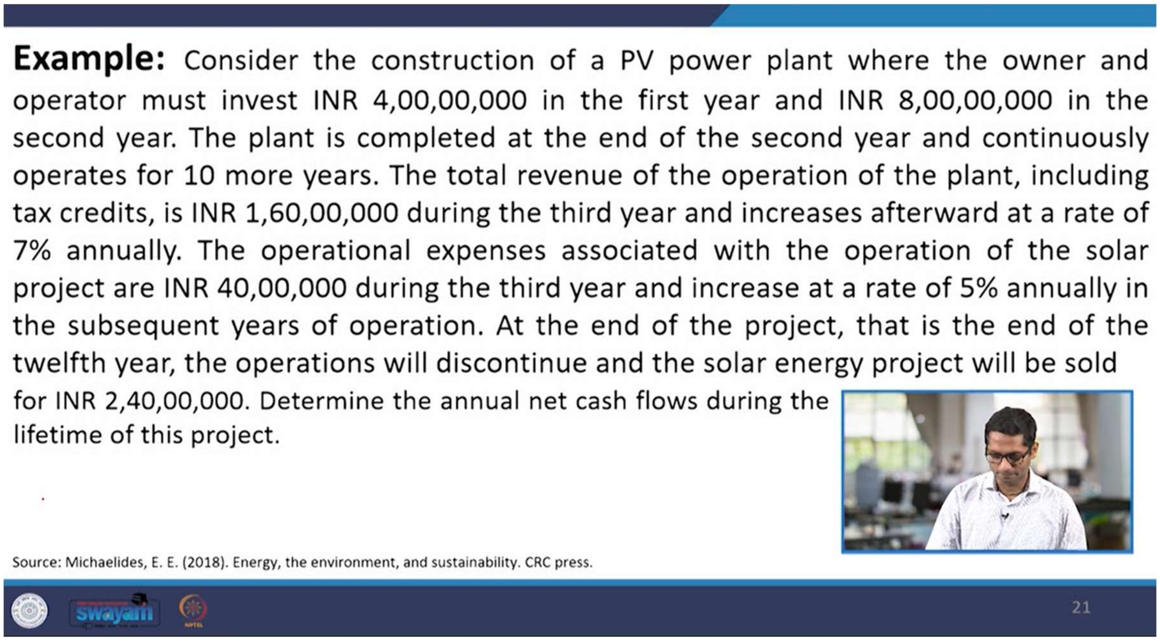
So the governments around the world would want more and more green energy projects to come up. And as an incentive for the different types of corporates or industries to set up some plant the government is like trying to come up with policies where it provides certain kind of tax rebates to the company so that they have an impetus to invest money into these kinds of projects. And this is specifically true for countries in the OECD which is the organization of economic cooperation and development. But these kinds of tax credits is basically given in terms of during the initial few years when the investment is occurring. So your overall cash flow is negative so the government would want to give you some further tax credits to make you help or to help you invest money. But to make use of these tax credits you also need to have a few operations that are profitable wherein you could you should be able to utilize the credits that are generated from this particular project. So overall it is an incentive that the government would like to provide to encourage the companies to put or invest money into energy projects for the future.



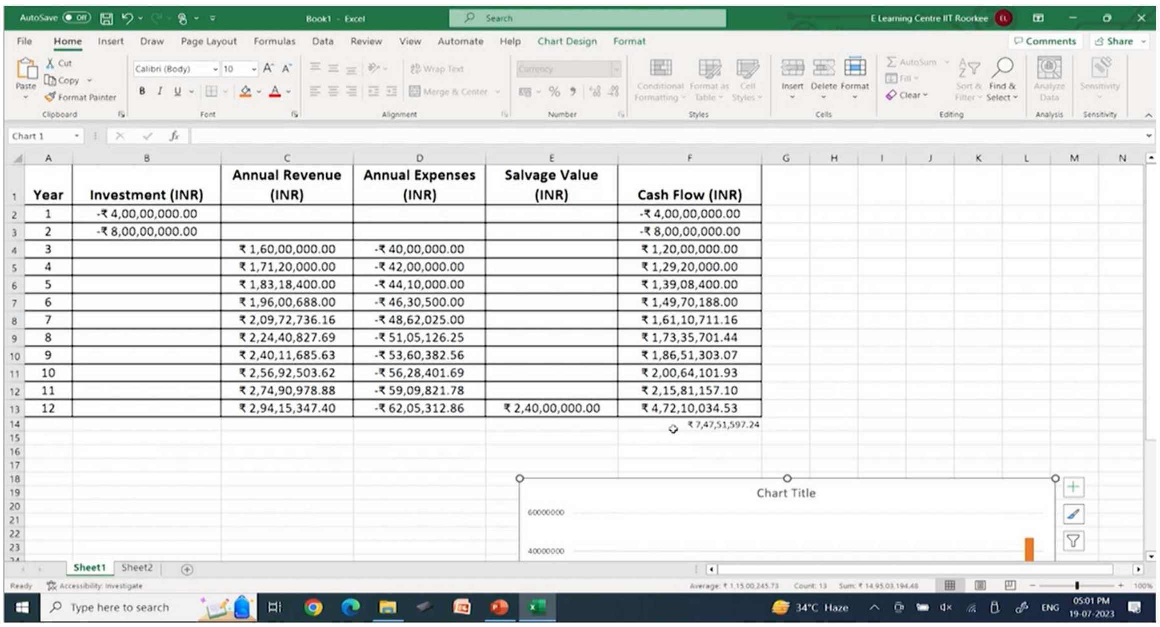
If I talk about the different kinds of like places where the funds are deducted the first thing would be the capital expenditures which means putting up the capital equipment which is a significant cost during the initial few years of the operations of the plant or setting of the plant. Then there would be other fixed costs like the maintenance cost, the equipment cost, the salaries, the interest, the insurance that would have the that should be paid irrespective whether the plant is operating or not. Then there is a whole lot of variable cost which are basically linked to the production capacity of the plant more the production more the fuel cost can be expected and lesser the production less could be the sales or the distribution cost.



Then nonetheless you would also have the taxes the different government would want to tax on the profit that you would generate. Of course there would be different countries like would be given different kinds of tax credits or incentives so as to help the different kinds of industry being set up. And also like the taxes would depend upon the individual tax codes of the different countries so the tax codes are not uniform throughout the world there is a huge variation and there are a lot of integrities that are involved like what is to be taxed and what rate it is to be taxed and it is beyond like the scope of the current cost to go into this but again there could be different kinds of taxes that would apply. And then there could be a closure cost the closer cost could be again be positive or negative so when it is positive it will normally be called a salvage value else it would be called a closure cost and it might like typical example could be a nuclear power plant then few other examples could be like shutting down an oil or gas well which would also mean the disposal of the non-marketable equipment. So if you have taken some equipment to the far off field but no one would want to buy the equipment now so you would have to dispose it off to a safe location that would incur some of the transportation and the dismantling cost so these are some of the cost that you would incur again.



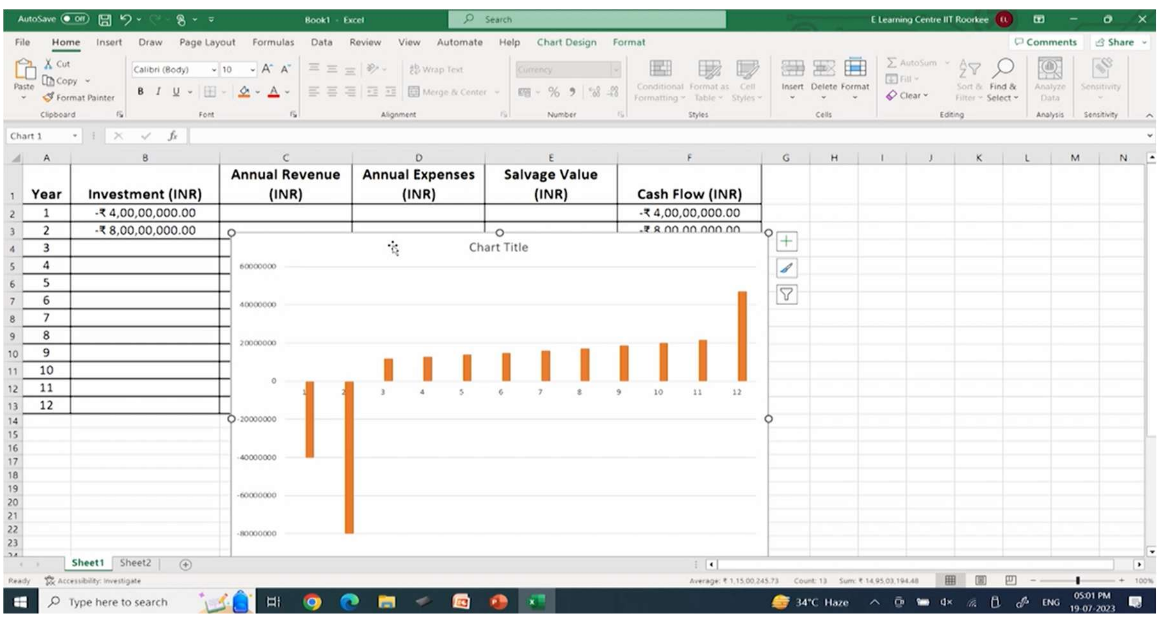
So let us try to understand how this cost would be affected in the life of a plant through the help of a simple example. Let us consider the construction of a simple PV power plant where the operator is planning to invest around 4 crore rupees in the first year and 8 crore rupees in the second year so that brings the total plant cost to be around 12 crores and the plant is expected to be completed by the end of 2 years after 2 years or like the onset of the third year it is expected that it will generate some revenue and that revenue including the different incentives that you will be getting is expected to be around 1 crore 60 lakhs per year and this is expected to increase at a rate of 7% annually which means every year there is going to be 7% increment. So one can expect that you are charging or you are increasing the charge from the consumers so today if you are selling the electricity for rupee 4 rupees I would increase that by 7% and sell it at a slightly higher price next year. Further there would be an increase in the operational expenses as well so this is also expected like every year you would want the salaries of your like people or the employees to be rising and also there could be an inflation which affects the rise of the price rise of certain equipments or as well as the raw materials. So it has been assumed that the operational expenses are almost 40 lakhs per year and they rise at the level of 5% annually. Further at the end of the project there would be some material that would be left and there it is expected that it could be sold for some kind of recovery and it has been like approximated that around 2 crores 40 lakhs is something that you can fetch by selling of the old plants like which could have metals or there could be some silica that might be recoverable from the PV power plant. If these are the types of cash flows like how are the total net cash flows for the project going to look like. So we will try to do this calculation with the help of MS Excel which I believe is a common tool to which most of you would have access to or you could use a similar spreadsheet type of software to do this calculation. So let me now try to go to MS Excel and try to share like how this kind of calculation would appear. So this is a typical Excel that I have already prepared to start with for the convenience of all of us.



Year	Investment (INR)	Annual Revenue (INR)	Annual Expenses (INR)	Salvage Value (INR)	Cash Flow (INR)
1	-₹ 4,00,00,000.00				-₹ 4,00,00,000.00
2	-₹ 8,00,00,000.00				-₹ 8,00,00,000.00
3		₹ 1,60,00,000.00	-₹ 40,00,000.00		₹ 1,20,00,000.00
4		₹ 1,71,20,000.00	-₹ 42,00,000.00		₹ 1,29,20,000.00
5		₹ 1,83,18,400.00	-₹ 44,10,000.00		₹ 1,39,08,400.00
6		₹ 1,96,00,688.00	-₹ 46,30,500.00		₹ 1,49,70,188.00
7		₹ 2,09,72,736.16	-₹ 48,62,025.00		₹ 1,61,10,711.16
8		₹ 2,24,40,827.69	-₹ 51,05,126.25		₹ 1,73,35,701.44
9		₹ 2,40,11,685.63	-₹ 53,60,382.56		₹ 1,86,51,303.07
10		₹ 2,56,92,503.62	-₹ 56,28,401.69		₹ 2,00,64,101.93
11		₹ 2,74,90,978.88	-₹ 59,09,821.78		₹ 2,15,81,157.10
12		₹ 2,94,15,347.40	-₹ 62,05,312.86	₹ 2,40,00,000.00	₹ 4,72,10,034.53
					₹ 7,47,51,597.24

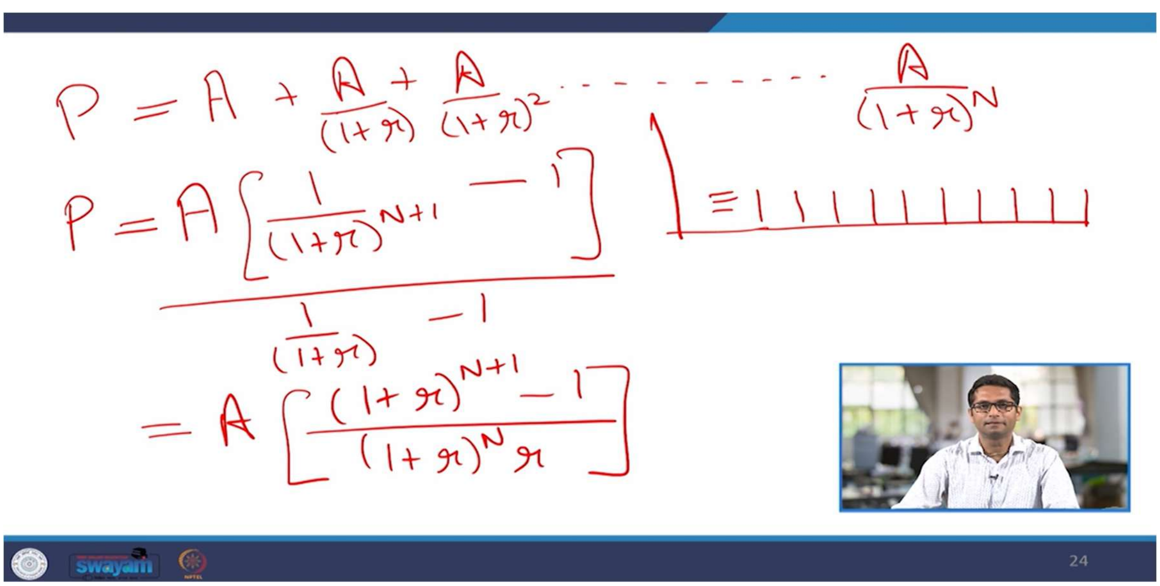
So as have been told in the question that in the first year there is going to be an expense of 4 crores and this would be followed by an expense of 8 crores in the second year and in these two years it is basically the construction of plant that is happening which means there would not be an annual revenue or expenses or salvage value that would be happening. The revenue starts from the year 3 which would be around 1 crores 60 lakhs and expenses would be almost 40 lakhs per year. Also we have thought that or we have envisaged that the revenue would be increasing at the rate of 7% per year. So what I will do is like I will just mark an increase of 7% from the previous year and scroll it down until the useful life of the plant which is 10 years from the beginning of the plant. So third year happens to be the first year and it is going till the 12th year which makes it a total of 10 years and every year the revenue is expected to increase at a rate of 7% and we can also see in the span of 20 sorry the 10 years the revenue has almost doubled.

It started from around 1 crores 60 lakhs and it has now reached around 2 crores 94 lakhs. So at the same time we can also expect the expenses to rise and the expense rise I have taken to be rising at a slightly slower rate. So it starts with 40 lakhs and increase at the rate of 5% from the previous year and if I scroll this down the expenses might increase up till 62 lakhs at the end of 12 years. Also at the 12th year or the end of the 12th year we would have a salvage value that would be taking place. So this is how the cash flow would take place and the total cash flow would be an addition of these four aspects which is the investment plus the revenue plus the expenses and the salvage value. So if I scroll this down and this is how my expenses would look like. There would be negative in the first two years and there would be positive in the next few years and would be continuously increasing. I can also try to analyse these kinds of expenses with the help of a simple bar graph. So let me try to make a simple bar graph in here. So what you can see here are the expenses in terms of a simple bar graph.



So what you see on the x axis is the year. So you would have the negative expenses happening in the first two years 4 crores and 8 crores respectively and for the future you would have a net income that is being generated so that is steadily rising and there is an increase in last year and that is basically attributed to the selling of the remaining material that you have as salvage value. So you can see there is a drastic increase. So if I add the whole thing, all the net flows and do a sum it might come to be positive and you might say that the plant is profitable as a whole. But there is a catch here. We have not taken into account the time value of money. Is the revenue or the total cash flow that we have taken at the end of the plant that is 4 crores 72 lakhs is that greater than a cash flow of around 1 crores 20 lakhs at the third year? This is something we cannot say as of now. It might happen to be greater, it might happen to be lesser because as we move in the future we would have an depreciation in the value of money as we have discussed in the time value of money. So something that is like if I have 100 rupees today in my pocket this is worth more than 100 rupees at the end of the year or after two years. So this is something that also needs to be taken into account and that makes the whole thing very interesting.

So let us now continue with these types of analysis and let us try to understand more on this particular aspect. Another thing that we would want to learn in the future or like another thing that we would want to learn is many times it happens that the income that is generated throughout the life of a plant stays constant. The only thing that changes is the year of that income and in that in such a case the income could be estimated or the time value of money could be applied to it with the help of an annuity. So suppose I have like an income generating say A at year 0 and this A at the end of year 1 then another A at the end of year 2. If I have to take the present value this would be A, this is the income at the present year.



Then for the second year it would be divided by 1 plus R, 1 plus R square and this goes on till the year N and it could be 1 plus R raised to power N. So it looks very similar or it is exactly a geometric series in action and we can estimate the sum of this geometric series by the simple formula. So the present value of an annuity or such kind of expenses are called an annuity what can be calculated with the help of a simple calculation. I am just taking the first term outside and then this would be 1 plus R raise to power N plus 1 because there are N plus 1 terms in total. I divide that with 1 plus R minus 1.

You do a few arrangements I would want you to do that and finally what you would come up with the value is the annuity which is the exactly same expense that you are making into 1 plus R N plus 1 minus 1 divided by 1 plus R raise to power N into R. Where A is the exactly same payment or like if you are dividing a principle into the same payment throughout the life of maybe N years and R is the interest rate that have been put into action. So what I am exactly trying to say here is if I have same payments being received at different years and if I would want to say an equivalent of those payments I can have a payment like this and this is the formula that could be utilized. The inverse of this formula could also be utilized for calculating of the EMIs. So many of you might have an experience of taking a product from the market and you would want to pay back the principle amount along with the interest in the form of equally monthly installments.

$$M = \frac{rP(1+r)^N}{(1+r)^{N+1} - 1}$$

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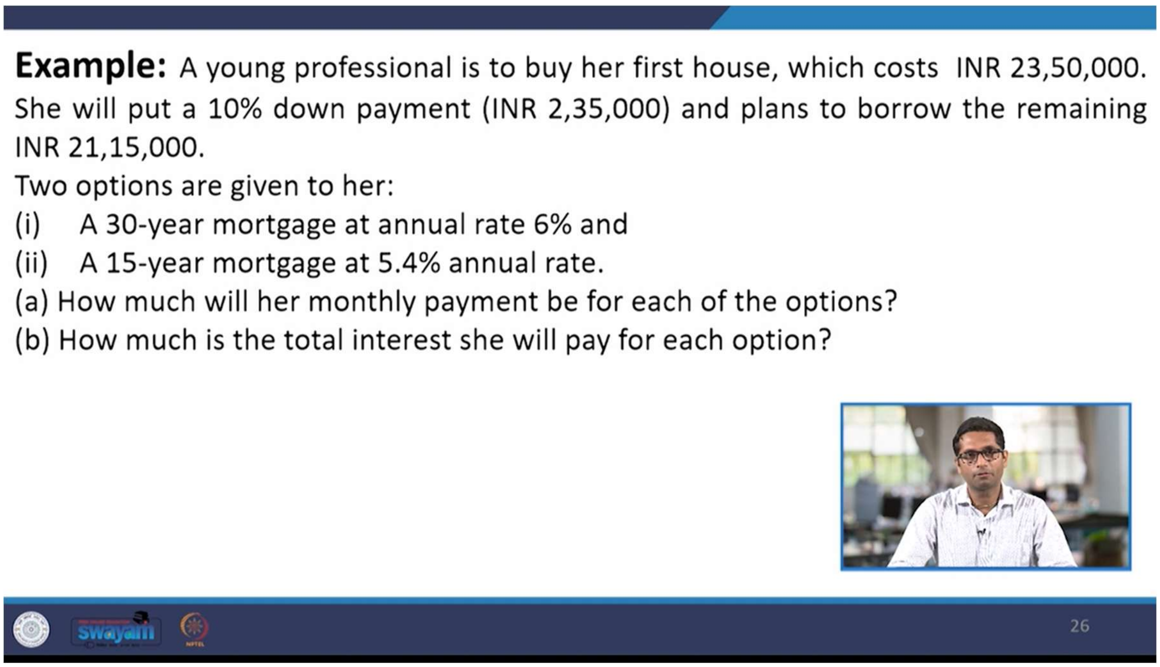
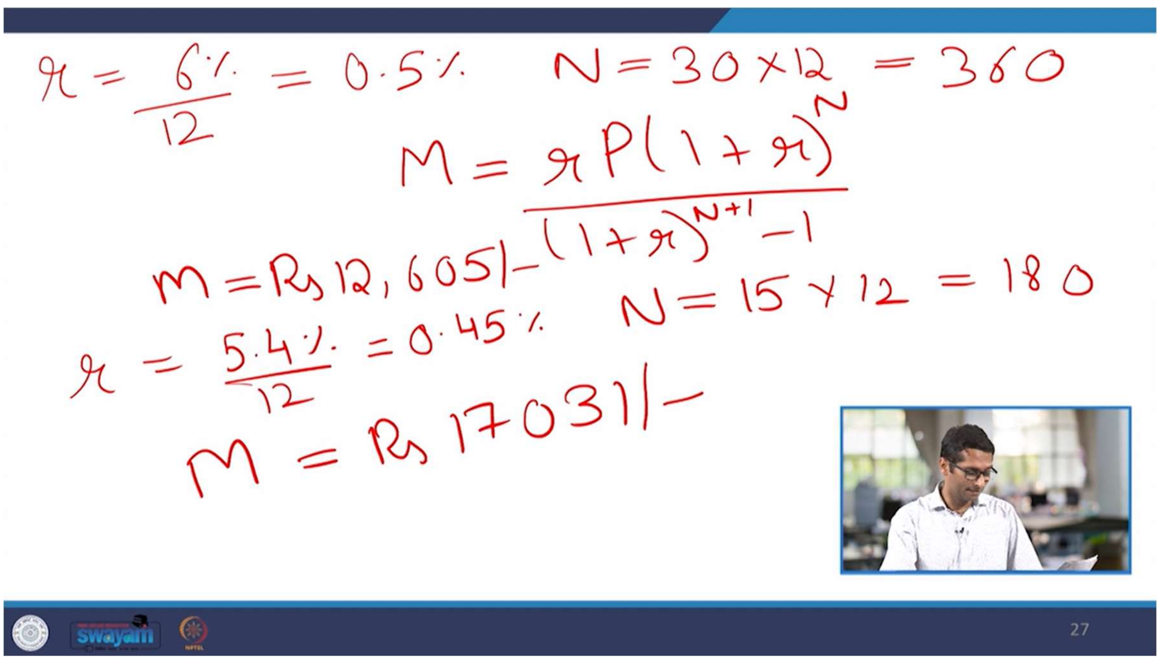
And you could do a similar thing and you can just reverse the formula in which your monthly installment or the yearly installment if I say M would be nothing but the R into the principle amount 1 plus R raise to power N where N is the length total length of the time span and 1 plus R raise to power N plus 1 minus 1. So this is exactly and the same formula I am just rearranging the terms and this is a similar calculation in which you are just paying back the monthly installments in for a principle amount that you would have taken. So let us again try to understand this with the help of a simple example.



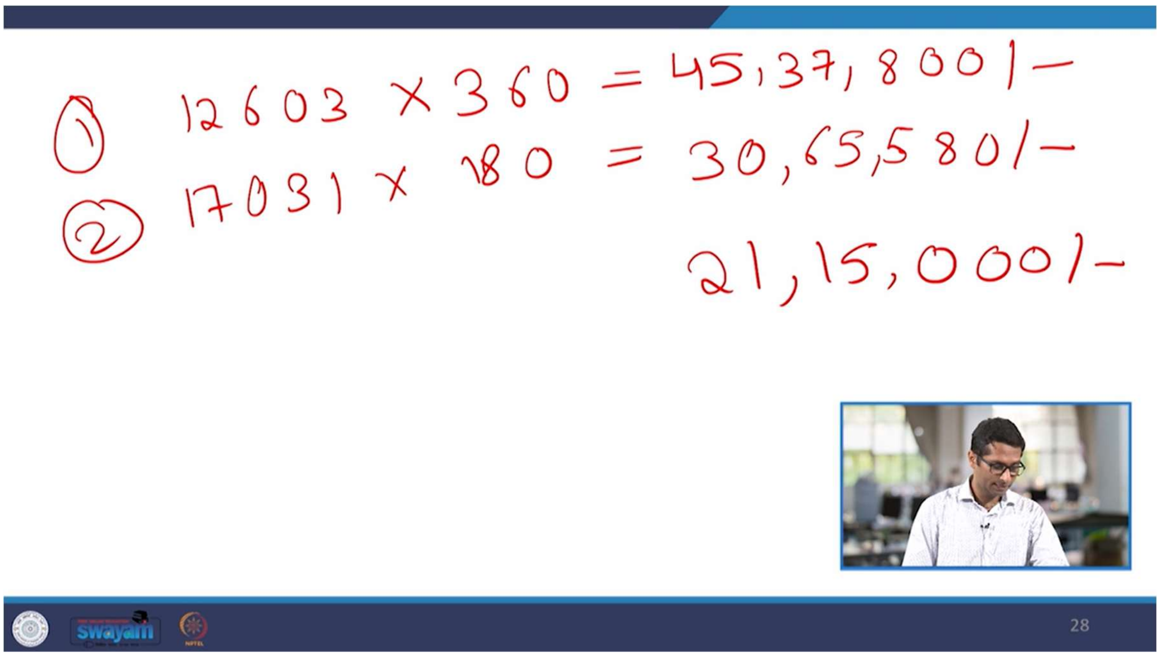
Suppose I am talking about a young professional like some of you who would want to buy her first flat and the cost of the flat would be around 23 lakhs 50,000 rupees like the person already has some money at her disposal and she would want to put a 10% down payment that would come around 235,000 and plans to borrow the remaining 21 lakhs 15,000. Now there are 2 options that are given to her either she can go for a 30 year loan at an annual rate of 6% or a 15 years loan at a slightly lesser interest rate.

So what you would have to calculate is how much would be the monthly payment for each of the options and what is the total interest that she would have to pay for each option. So we will be using the formula we just derived for the EMIs and try to come up with the answers. So let us try to do that together. Let us try to evaluate these both options which is like 30 years loan at the rate of 6% and 15 years loan at the rate of 5.4%.

So intuitively like it is very difficult to say which is going to be better or not so we would have to do this calculation. So if I go with 6% loan so in that case the R would be 6% and divide that with 12 because it will be compounded on a monthly basis that is where the monthly installments are going in and the final interest rate would turn out to be around 0.5% per month and at the same time the time period N would be 30 which is the 30 years into 12 and finally this would be 360 months. If I put all of these values in the formula that we did okay we just calculated which comes out as so the formula let me repeat it again for you it is the EMI M is equal to the rate of interest into the principle 1 plus R raise to power N again 1 plus R raise to power N plus 1 minus 1. If I plug in all the values into this formula and the interest rate or the total value or the installment for the monthly installment M and that I would have to pay would be roughly around rupees 12,605.

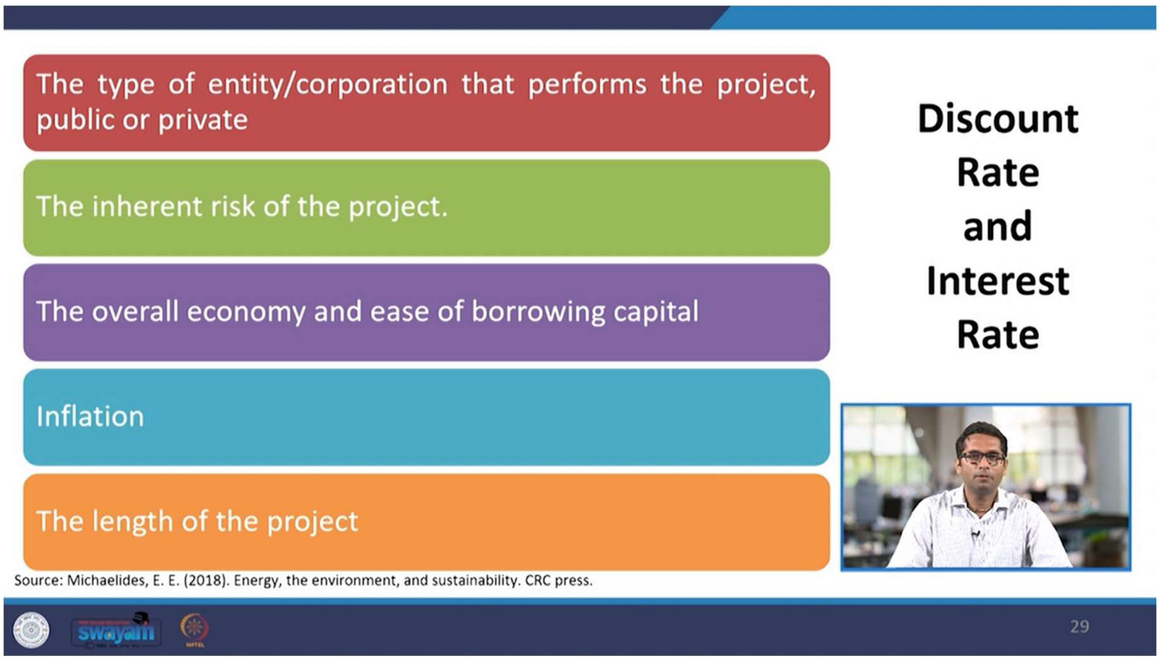


So let me compare this value with the type of EMI that would be paying for the second case. So in the second case I have an interest rate of 5.4% and a duration of around 15 years. So in this case this would be 5.4% divide by 12 and the interest rate would come out to be 0.45% and the number of installments would be 15 years into 12 and this would be roughly 180 installments and if I put these values in the above formula in which I am taking a loan of around 21,15,000 rupees the value of M or the EMI would come around to be 17,031 rupees. So it appears that there is an increase in the amount of the total amount of the EMI that I would be paying but is it worth it to pay 12,000 for 30 years or 17,000 for 15 years. Some of you might have guessed it right but for the benefit of others let us do a total calculation. So if I multiply 12,603 into 360 which is the total number of installments that would be going it would come around to be around 45,37,800 rupees. So this will be the total amount that I will be paying back.



So just remember that I had initially taken a loan of 21,15,000. So this is the case 1 and if I see the case 2 which was in which the EMI was around 17,000 so I will put that value so the value was around 17,031 into 180 and the total value for this particular amount would be roughly 30,65,580 rupees. So you can see there is a drastic difference between the amount total amount that you will be paying back for the two kinds of loan that you will be taking. Although the interest rate appears to be very similar there is a change in the lifespan of the project and you can see if you see the present value of all the value that you will be paying back there is a drastic difference. So this is a major reason why we need to understand the time value of money and the time for which I have taken the loan or I have given something for credit and again like what is the rate at which the interest is being charged because that can have a drastic effect on the total amount that you are generating or paying back.

And again I would like to reiterate that in this case the loan that was taken had a initial amount of 21,15,000 rupees or so and based upon the type of loan that you would take you might end up either paying 30,65,000 or 45,37,000. So let us proceed with this and by this point of time you might be also be interested like how would one come up with this rate of interest or the discount rate are this interrelated or how would like this interest be chosen at all.



So for understanding like interest rate is something that is basically chosen by the different government entities and discount rate is basically something that is charged over the interest rate and this discount rate that normally the corporations would be using for their different evaluations like would be something that would be related to the type of corporation it is like normally if I am talking about a non-profit organization or a public sector organization they would have a lesser discount rate whereas a corporate would want to have a greater discount rate. Then what is the inherent risk of the project as the saying is like the higher the risk higher the like higher the payment so if people are investing in a higher risk like project they would also want it to have a higher discount rate they would want to recover the money back as soon as possible. Then it also depends upon how the overall economy or the world economy is behaving is the is the capital available easily or and there is a death of capital in the market.

Further if there is a high inflation this also is linked to a high amount like high percentage of the discount rate if the inflation is smaller so it affects the discounted in a similar way and further another major aspect and that effects in the discounted is the length of the project. Again as I have reiterated earlier like the higher the length of the project more is the risk involved and higher would be the discount rate charged because no one knows how the policies are going to look like maybe 15 years 20 years down the line if there is a war like the project stop stops what happens. Take the example or the case of Germany like there was the Fukushima disaster in Japan and all of a sudden the country decides to close most of its nuclear power plants. So all the investment that had been going into the nuclear power plant becomes a difficult thing to recover and people who are investing in the energy field would want to take such investment with a lot of caution.

Interest Rate

The interest rate, to which the discount rate may be tied, is usually one of the following:

1. The interbank discount rate, which is the rate banks charge each other for borrowing funds.
2. The short-term interest rate pertains to government securities.
3. The intermediate term interest rate is the interest rate of 10-year treasury bonds.
4. The long-term interest rate of government securities is typically the interest rate on 20-year or 30-year treasury bonds. The long-term interest rate is pertinent to most energy projects that typically last more than 30 years.

Source: Michaelides, E. E. (2018). Energy, the environment, and sustainability. CRC press.

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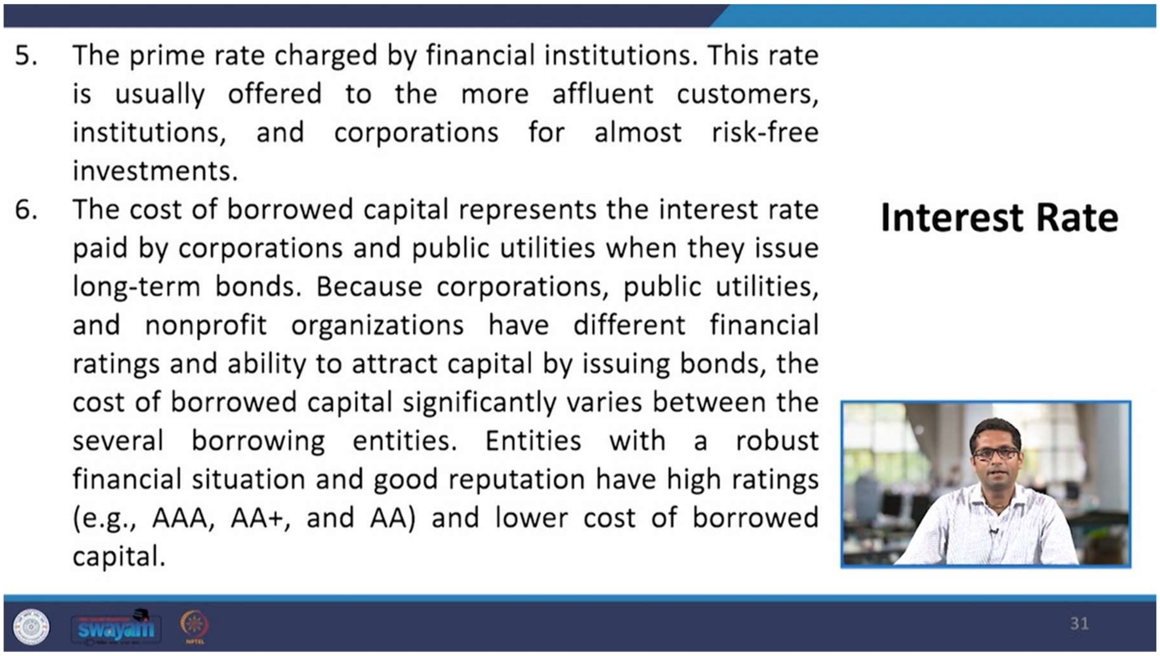
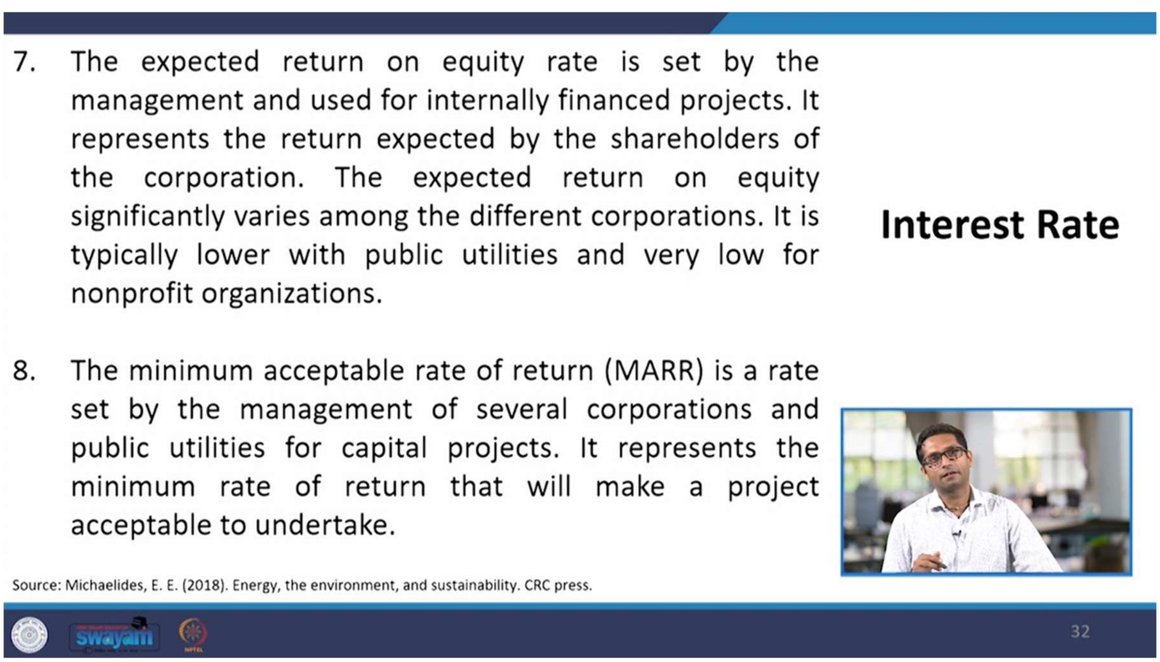
And again the interest rate to which this discount rate is normally tied could be coming from the different sources it could either be the interbank discount rate like or the rate that which the banks charge one another it could be the short term interest rate based on the government securities or the government bonds. This could like example could be the 10 year treasury bonds in the case of the US it could also be linked to the long term interest rate of the government for 20 years or 30 years treasury bonds. So these are some of the examples to which companies would want to link their discount rates and each corporate would have its own discount rate.



Further this could also be the interest rate that is charged by the different financial institutions as banks to for the different loans it gives. It could also be the cost of the borrowed capital like to give an example there are different rating agencies like the standards and poor's or the moody’s is which would want to rate the companies or the corporates on the different grading and there is capital that is given to these companies on a different interest rate.



Further companies could have their own discount rates which is based which could be based upon like what is the percentage of return they would want to give to its shareholder. So that is again dependent upon a company policy and many of the corporates or the management teams of the corporates also have a minimum acceptable rate of return like this is the minimum rate they would want to gain for their projects and the discount rate for the projects is linked to that particular rate of return. Again the first few that we have discovered that we have discussed are known to us like they are normally given like they are available like if we find them but if we talk about these two rates of return this is something that is specific to the organisation and it is specific to the management team and might not be available to the public. So in today's particular class we have tried to understand how the cash flows look like for a typical project and why the time value of money is important to be accounted for. In the following classes we will try to focus on the decision making process and what are the different types of matrices that would be used to ascertain whether a project is profitable or not. With this we end today's class. Thank you.