**Energy Resources, Economics and Environment**
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**Lecture 17**
**Energy Projects Financing-Tutorial**

We have already looked at the basics of financing energy projects, we looked at the sources of funding the difference between debt and equity and now let us operationalize this in terms of understanding how much of debt and equity we should take and how do we configure in our calculations, the calculations of the loan repayments. So, we let us take a first a simple example.

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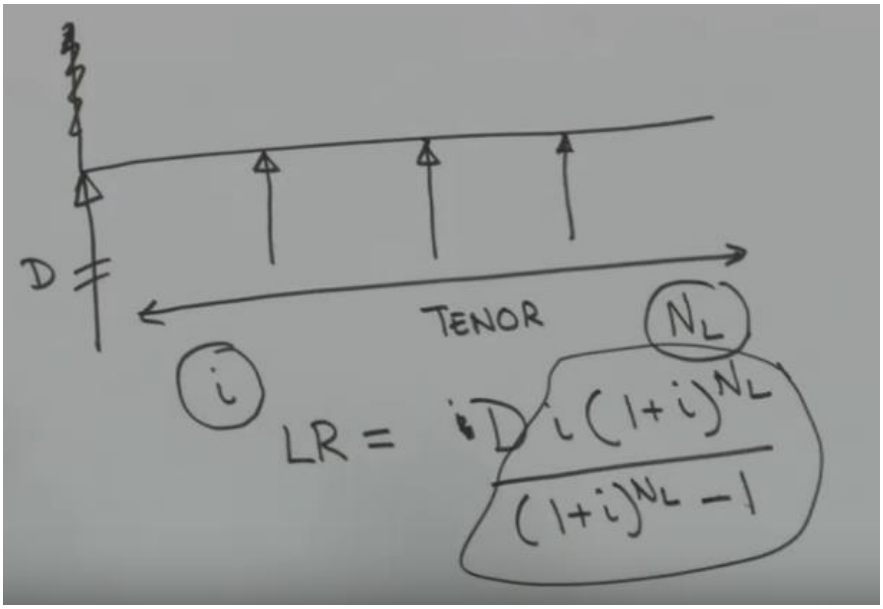


If we are taking a loan, a certain amount which is your initially we are looking at a debt which is being paid. So that means, this is the amount which is paid to us, this is the debt and then annually we are repaying, till what is known as the duration of the loan or the tenure of the loan, NL. So, what would happen is, suppose we have an interest rate which is i, we want to convert this into an equivalent amount which we are paying.

So, for a given interest rate i and a duration of loan NL, let us first see how we can annualize this into an equivalent amount that we have to pay. Let us take this as a equated annual payment which is a loan repayment in equated annual amounts of course, there could be loans where you could have different amounts being paid in different years, but it will be equivalent, we are converting it into an equivalent annual amount.

So, this will be very similar, it is similar to the formula that we had for the capital recovery factor and instead of d, now, we are going to use i, which is the interest rate. So, this will be the debt into i 1 plus i raised to NL divided by 1 plus i raised to NL minus 1. And this is the annualization factor that we will calculate, that will be multiplied by the debt to give annually how much we are repaying in the loan.

So, you will see for many of even the consumer durables and let us say a car or a high end phone it is possible either to pay for it upfront or you can also pay in equated monthly installments.

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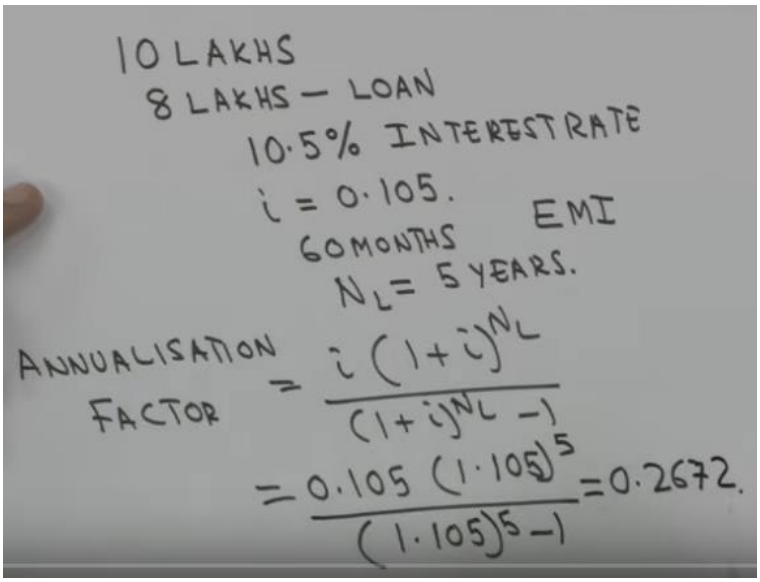


So, let us calculate, for instance I just looked at the web and I found that there is a car which whose price, overall price is 10 lakhs of rupees and for this, this is the price, there is an ex-showroom price plus there are some taxes and other payments that have to be made and it is possible to get a loan of 90 %of the X, you know the price, the original price that you are getting from the supplier.

So, that turns out to be, that does not include the taxes and other things for registration the payment which is made, so we can get a loan of that say 8 lakhs. So, let us just see, should the individual take the loan of 8 lakhs or should do to the individual pay the total 10 lakhs up front. Of course, in some cases you may not have 10 lakhs to pay and then you have no other option but to take the loan. We need to know what is the interest rate of the loan.

So, I just looked at a particular website. Today, it looks like for that car along the vendor itself is giving an option to have an equated monthly installment and the interest rate on the loan is

10.5 %. This is interest rate which means i is 0.105, this has to be repaid in a period of 60 months. So, we want to calculate how much will be the monthly EMI, equated monthly installment.

Also, this is NL then is 5 year. So, using a formula the annualization factor that substitute and get, annualization factor is i 1 plus i raised to NL 1 plus I raised to NL minus 1.105, 1.105 raised to 5. If you substitute this, you will find this is equal to just calculate it, you will find its 0.267, 0.2672.

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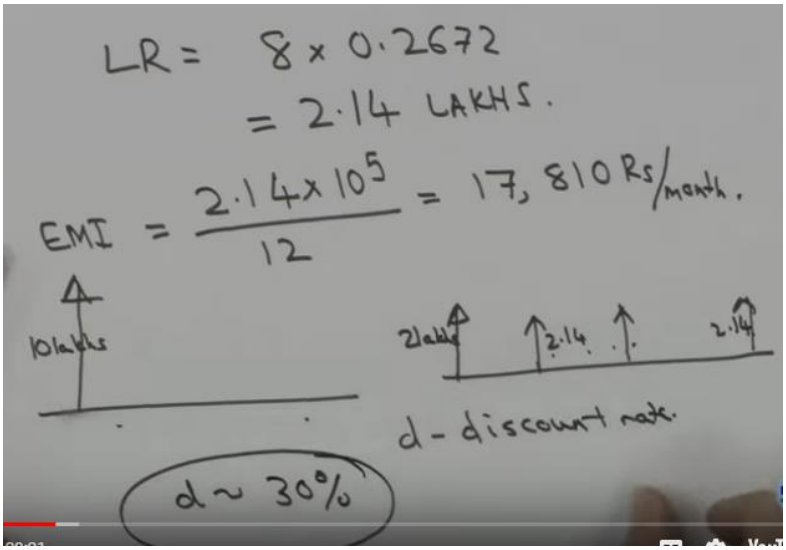


So, now, the loan repayment, annual loan repayment will be 8 lakhs into 0.2672 comes out to be 2.14 lakhs. So, on a monthly basis this will be 2.14 into 10 raised to 5 ₹ divided by 12. This is the equated monthly installment and if you work this out, this will turn out to be 17,810 rupees per month. So, what is happening is that you have an option which is you pay 10 lakhs here and nothing else or we pay 2 lakhs up front and then we end up paying 2.14 lakh each year for 5 years.

Now the question is which of this is preferable. It will of course depend on what is your discount rate and how much access to capital that you have. So, let us compare. Let us say that we are taking a discount rate. Suppose the individual has a discount rate of 30 %in which case what was the capital recovery factor?

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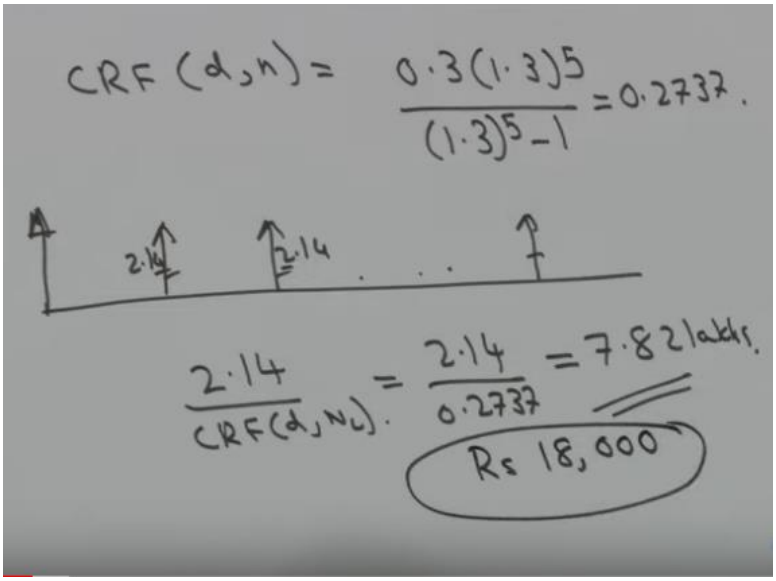


Capital recovery factor d, n will be 0.3. You remember we had done this in the energy economics portion, this turns out to be 0.2737. And what we are now doing is we are making these 2.14 lakh payments every year. We are discounting only at the end of the year, we are not doing it monthly basis, we could also compound it and discount it on a monthly basis.

We want to replace this by an equivalent upfront amount, which will be 2.14 divided by the capital recovery factor d, NL and this turns out to be 2.14 by 0.2737 which is 7.82 lakhs. Please note that this is less than the 8 lakhs that we are taking in the loan. So, with an effect we are getting a net benefit of 18,000 ₹ and hence we should go for the loan.

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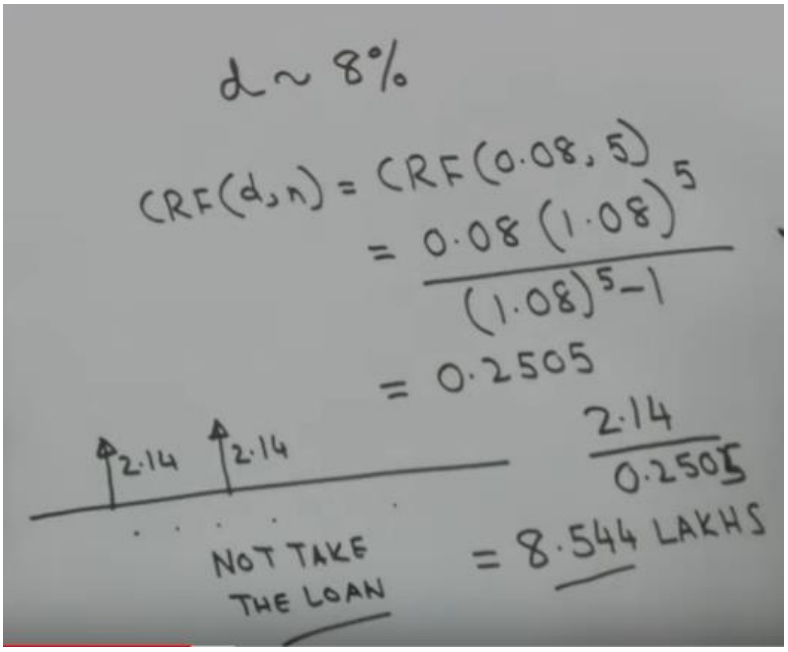


What if the discount rate is lower? Let us say the discount rate is 8 %. So let us recalculate. If discount rate is 8 %, then the CRF, 0.08, 5 years will be 0.08, 1.08 raised to 5, can calculate this and you will see that this comes out to be 0.2505. Now, when we look at the loan repayments, we are repaying 2.14 lakhs is the repayment which we are making each year. So, 2.14 for 5 year. So, that means, when we look at what is the net present value of all these repayments, that is going to be equal to the annual amount 2.14 divided by the capital recovery factor 0.2505.

And when you calculate this, this will come out to be, this is, the net present value you is 8.544 lakhs, please look at this. This now is more than the initial amount of the loan taken which was 8 lakhs. So, the net present value of the repayments is more than if it was a direct payment and hence, we should not take the loan. So, very clearly the decision on whether to take the loan or not will depend on the discount rate that the individual has and compare that with the rate at which we are getting the interest rate for the loan.

So, in this case since the discount rate for the individual is less than the interest rate of the loan, this turns out to be the loan is effectively much costlier than actually paying this from the own individuals funds.

Now, let us put this together in the form of let us look at a question where we talk about a company which wants to decide whether it should finance a particular energy project, either through its own funds, that is equity or through debt. So, let us look at there are two examples.

I will just read out both the examples explain them to you and then we will solve the first example, you can go ahead and solve the second one also.

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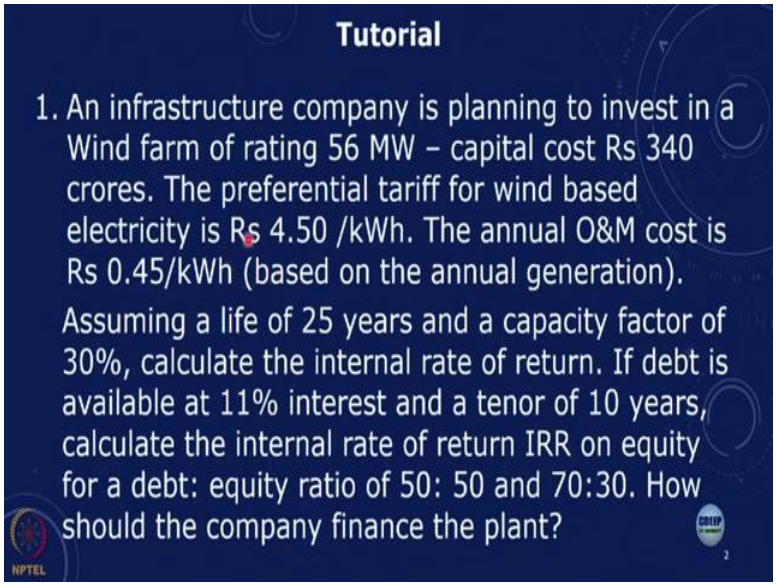


So, it is like a tutorial. The first one is there is an infrastructure company which is planning to invest in a wind farm of a rating of 56 megawatt. So, rating is 56 megawatt, we are given that the capital costs is of the order of 340 crores and this is a reasonable, this is typically the order of magnitude of the capital costs of wind machines, grid connected. The wind farm has a preferential tariff for wind based electricity at 4.5 rupees per kilo watt hour and then there is an annual operation and maintenance cost of 45 paisa per kilowatt hour.

So, this O&M cost will be multiplied by the annual generation. We are told that the life of the plant is 25 years, and the capacity factor is 30 %. So, we know how much generation. We want to calculate the internal rate of return. First if we just do this on our own, and then if debt is available at 11 %interest and a tenure of 10 years, calculate the internal rate of return, IRR on the equity for a debt equity ratio of 50-50 and 70-30 and the question is how should the company finance the land. So that is the, this is the first problem.

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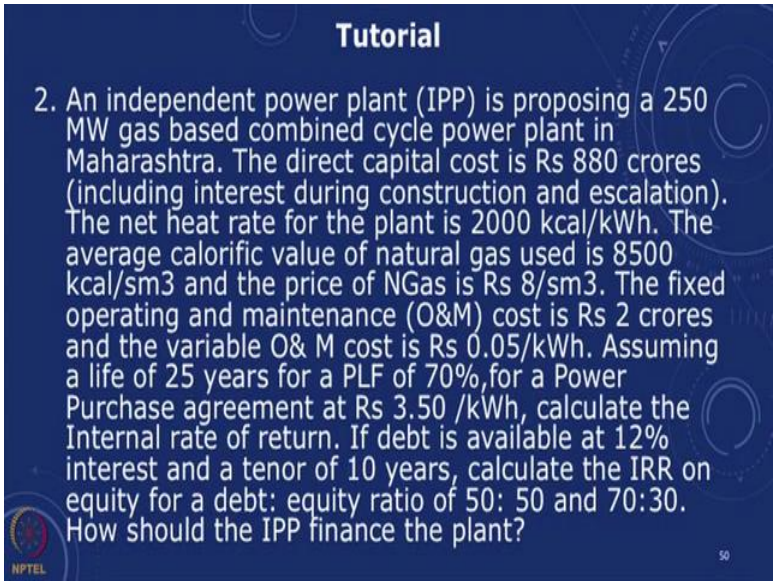


Second problem is now for a gas turbine based plant, an independent power plant proposing a 250 megawatt gas based combined cycle power plant in Maharashtra. Direct capital costs for the gas turbine is given to you, 880 crores, including all the, you know, during the construction there is some interest, during construction and escalation. So, it is a total overnight, it is called an overnight cost, which is as if you could build the plant overnight, then what would it cost you?

The heat rate is given. So, based on the heat rate we can calculate how much is the fuel which will be required, the heat rate should be, this should be to 2000 kcal/kWh and using that we should be able to calculate the calorific value of the natural gas which is, the calorific value is given and the price is given.

So, we can know how much natural gas is used for generation. The costs are shown as a fixed operation and maintenance costs and a variable operation maintenance costs. Life is given as 25 years, PLF is 70 % and the power purchase agreement has a purchase rate of 3.50 ₹, calculate the internal rate of return and if debt is available at 12 % and for 10 years, again to look at debt equity ratio, two debt equity ratios- 5050 and 7030. So, you can try both these problems.

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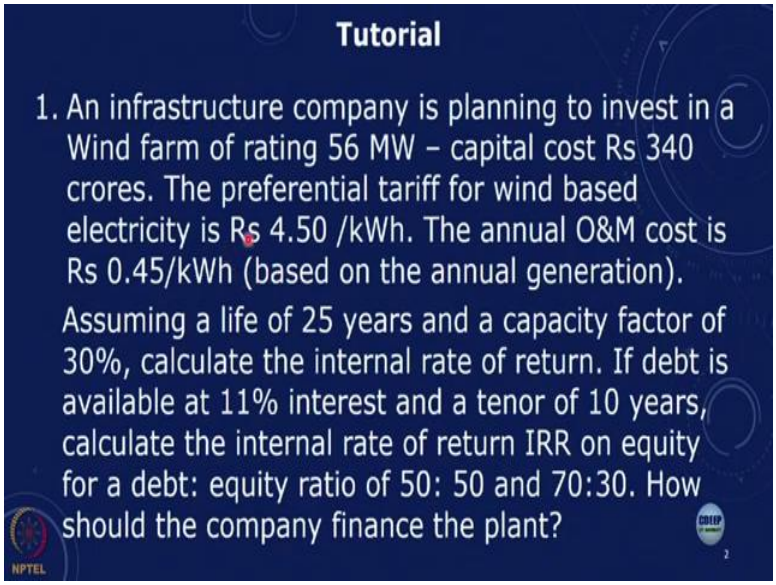


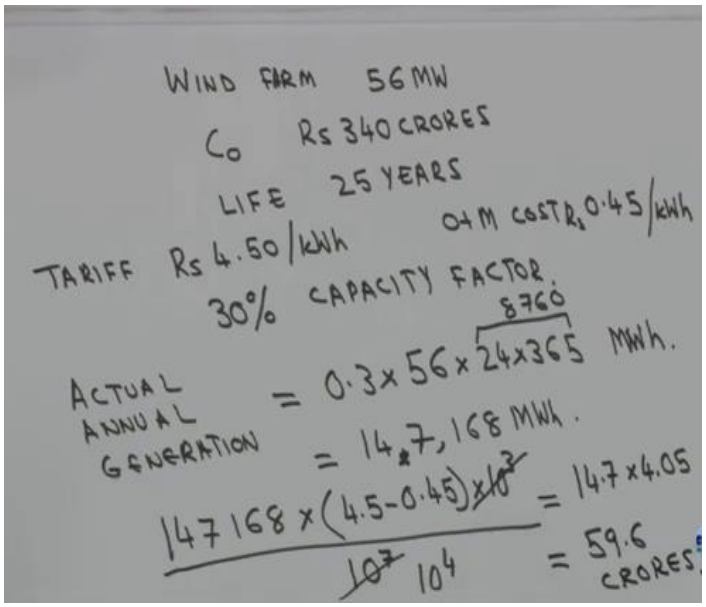


We will take a look at the first problem, which is we have a wind farm. If we write it down this is a wind farm rating is given to us as 56 megawatt and the capital cost or the C0 which we were talking off is ₹ 340 crores. We are also told that the life is 25 years and we have the preferential tariffs of rupees 4.50 per kilowatt hour.

We have this is the tariff, this is how much we will be paid and the capacity factor is 30 %, this is all the relevant data and then we have that annual O&M cost, is variable. It depends on the amount of generation and it is given to you as 45 ₹, 0.45 or 45 paisa per kilowatt hour of generation.

So, first of all, let us first calculate, this is all the data, let us first calculate how much is the generation from the wind turbine, wind plant. So, if we look at this, this is we are told that the capacity factor is 30 %. Capacity factor is the actual generation divided by the maximum possible generation. So, the actual generation, actual annual generation is going to be 0.3 into 56 megawatt into 24 into 365 or this is 8760 hours per year. This answer will be in megawatt hour.

So, if you look at, if you do this number you will find that we get a number which is, this comes out to be 14000, 147168 megawatt hours. So, what will be the total revenue each year? Net revenue will be the tariff which we are getting and we are subtracting from that whatever is the operation and maintenance costs. So, that means this will be 147168 megawatt hour into 4.5 minus 0.45 into, 1 megawatt hour is 10 raised to 3 kilowatt hour, this will be in rupees.

If we want to get this number, since we are talking in crores, let us get this in crores. So, 1 lakh is 10 raised to 5, 1 crore will be 10 raised to 7, we can divide this by 10 raised to 7 and this will become 3 raised to 4 and if you see this, 1234, it will be 14.7 into 4.05. Of course, we have rounded off some decimal places but you can look at this and you will get, this turns out to be 59.6 crores. So, you can check this and this is the amount that will be there.

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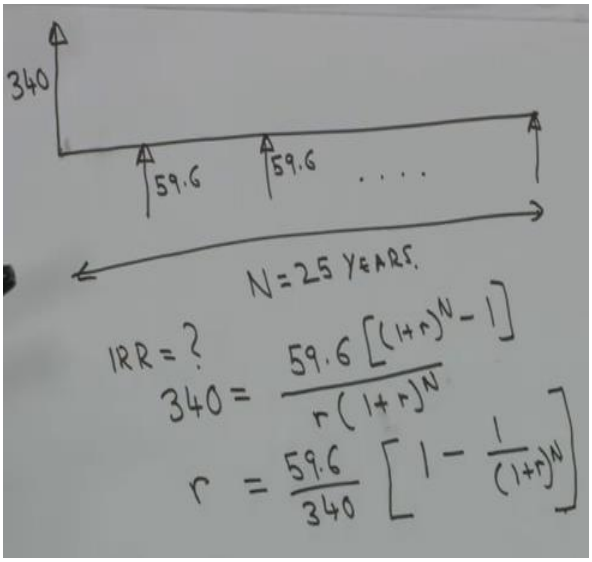


So, in the if we look at what happens here, we are paying 340 crores and we are getting 59.6 crores every year for a total life period, N is equal to 25 years. So, the question is, we want to calculate what is the internal rate of return, internal rate of return and we want to calculate that.

So this is going to be, this will be where we are putting the c 0 is 340, will be equal to 59.6 into, we was looking at this as r 1 plus r raised to N, 1 plus R raised to N minus 1. Look at the, so, this is r can be written as 59.6 by 340, 1 minus, so, we can take this and we can do the calculation, we can assume a certain value of r and then cross check and get what is the rate of return that we are getting.

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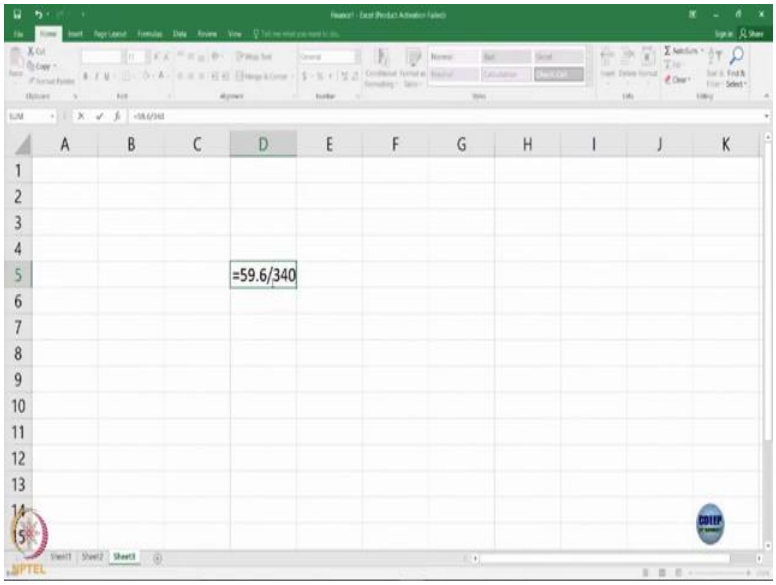


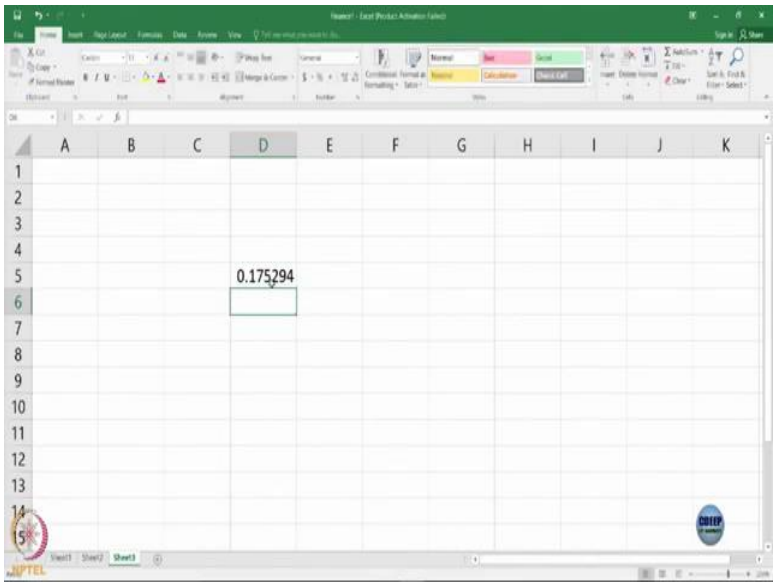

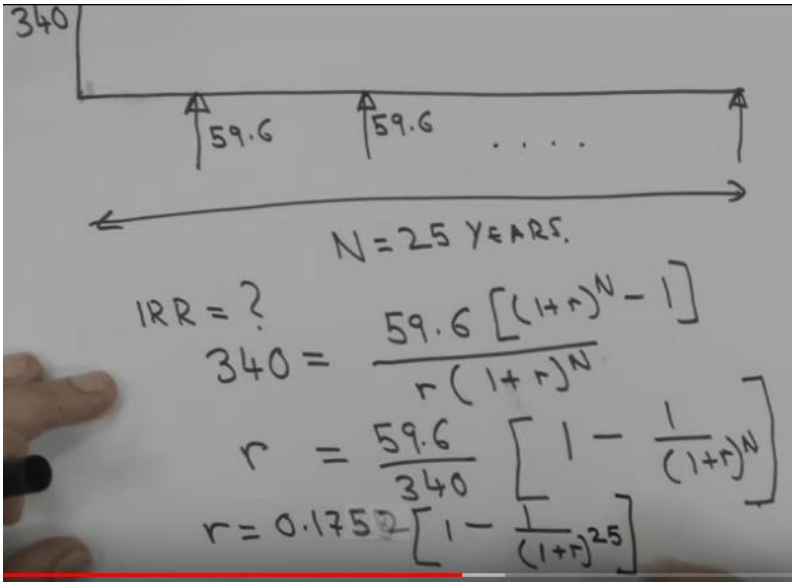


So let us see, let us just use a spreadsheet. If you are using an open office or you are using excel, we can, let us create a new sheet. So, let us see we are doing 59.66 divided by 340. And that is, that comes out to be 0.1752 into 1 minus 1 plus r raised to N where N is 25.

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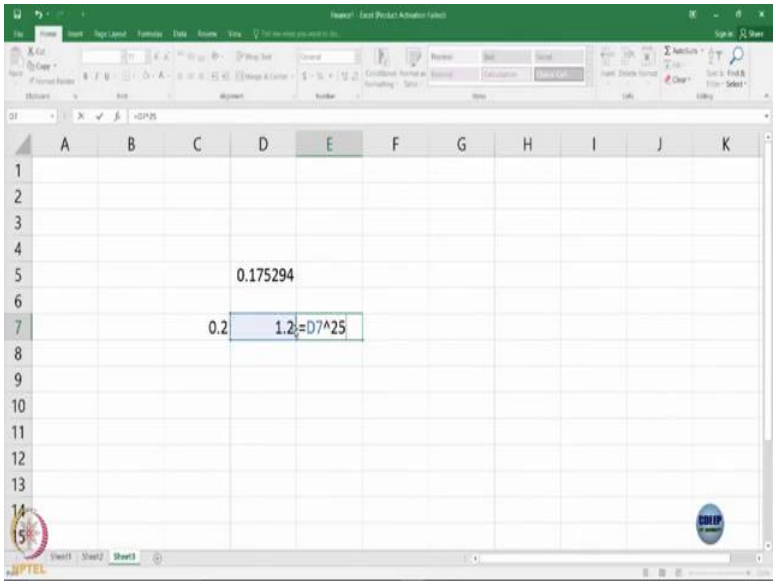

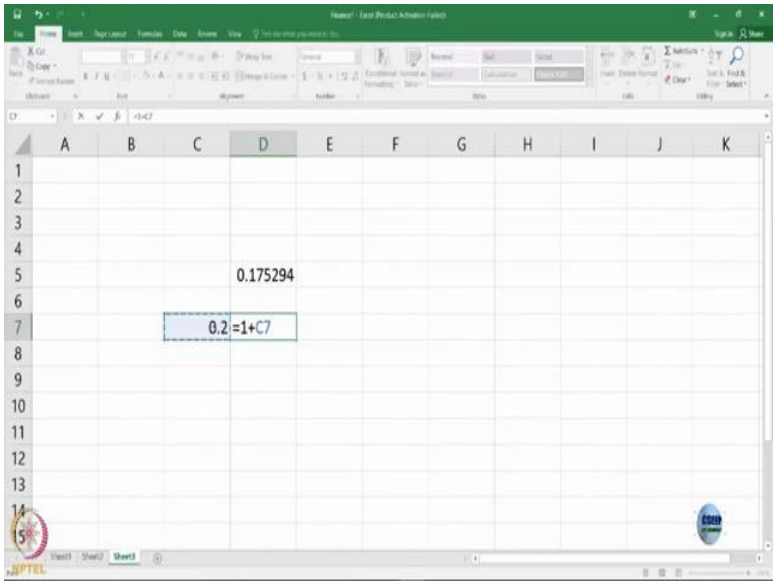


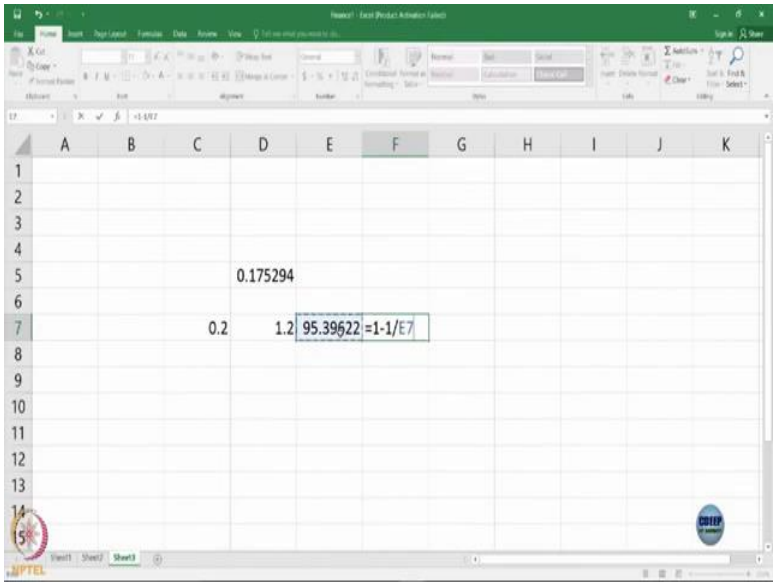


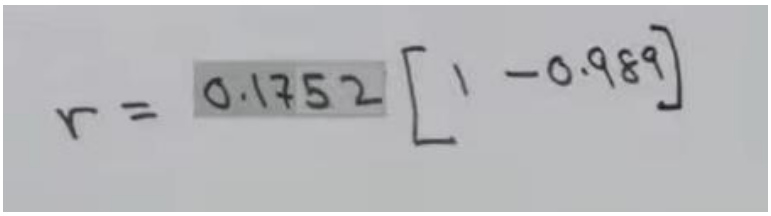


So let us put, let us calculate, let us take a value of, let us start with the starting value of 0.2. If r is 0.2, we are getting the 1 plus r is going to be 1.2 and we take, this one point, we take this and put 1.2 raised to 25 and that is 95.39. We can do 1 minus 1 by this. So, that is a bracketed term. That turns out to be, if we look at this, so r, if we start with r is equal to 0.2 we get r, the next value of r which we are getting is 0.175 and 2 1 minus 0.989.

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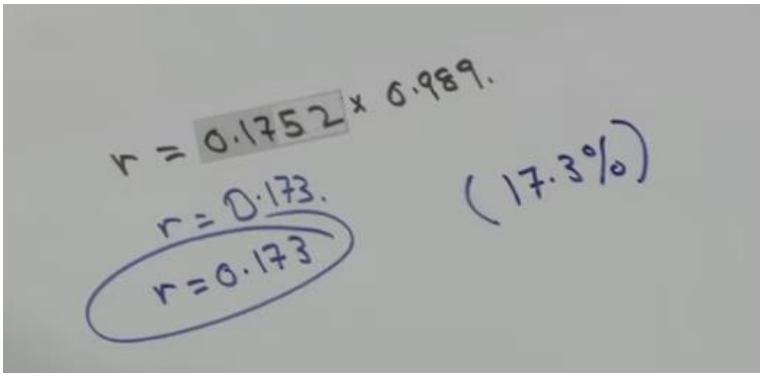


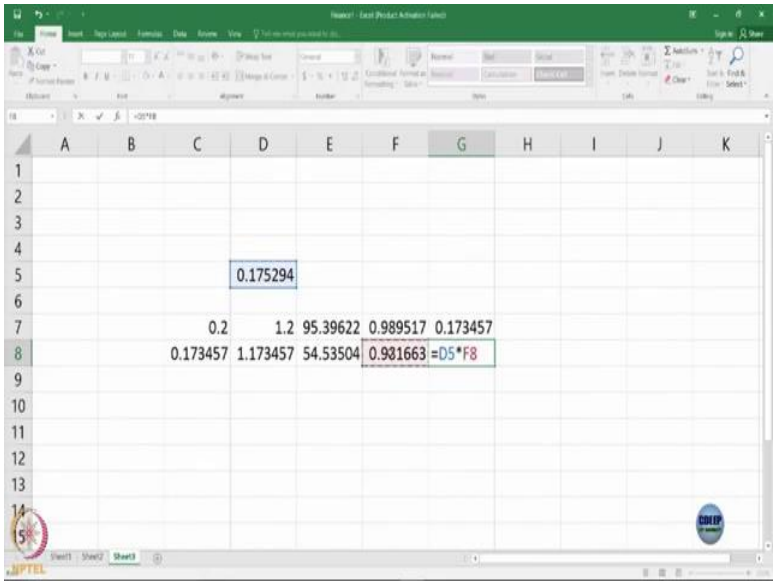


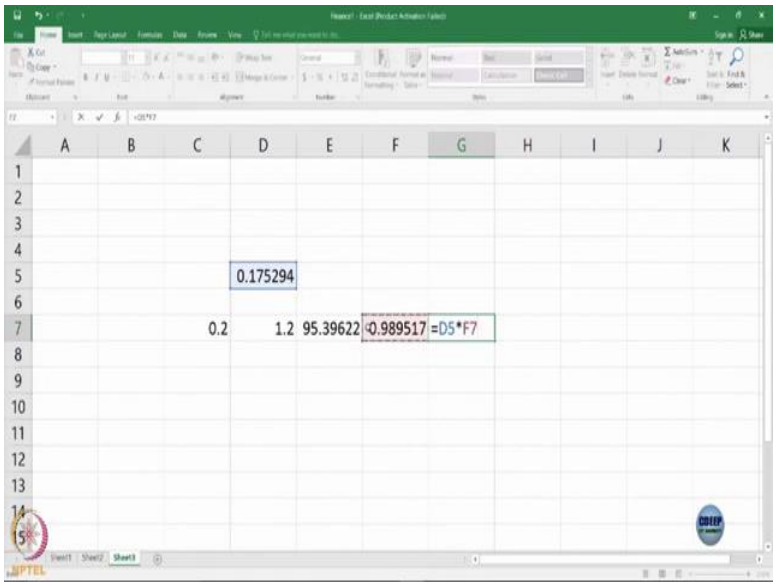

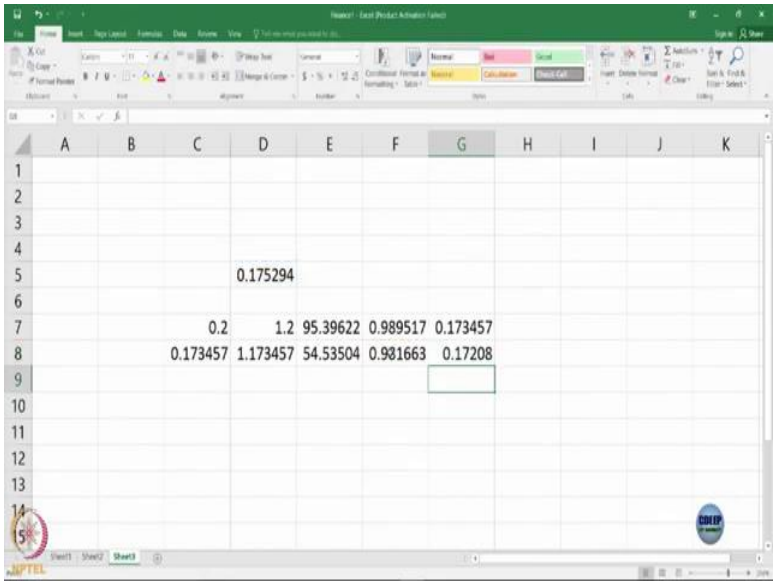


And, this is R is 0.175 into 0.989, that is what we have to do this is the bracketed term. So, we will get this as, now what we can do is we can convert, so this value now can be taken as, we can take this as 0.1735 as the new value of r, r is 0.173 and then we can multiply this is going to be now, we can copy these cells, we can just copy them and paste. So, we get this and then this is going to be this value into 0.98.

So, now this is coming to the next value of r, we get this as the new value of r comes out to be 0.173. So, it is fairly within so which basically we are getting a decent rate of internal rate of return of 17.3 % which is a reasonable amount that we are getting.

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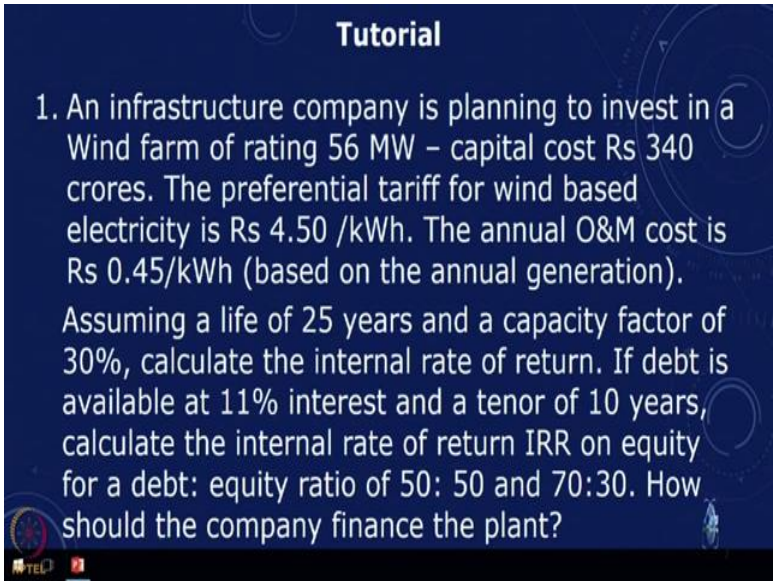


Now we go back to that question which we were trying to solve and if you see in this, the next question says that assuming a life of 25 calculate the internal rate of return, we have already

calculated that. If debt is available at 11 % interest and a tenure of 10 years, calculate the internal rate of return on the equity. So, now, what happens is that we are having a debt which is available to us at 11 %.

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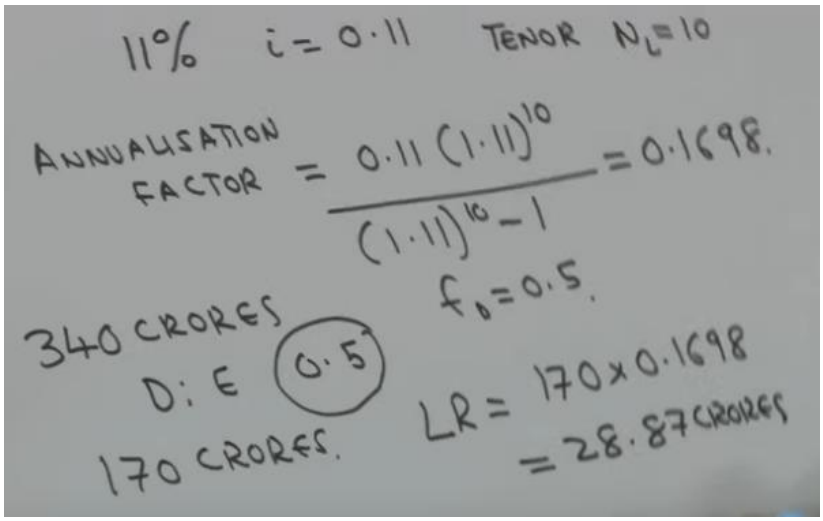


So, this is, i is 11 %. That means, i is 0.11, the tenure is 10 years, that means NL is 10. So, I can calculate the annualization factor as 0.11, 1.11 raised to 10, 1.11 raised to 10 minus 1 and if you substitute this, this comes out to be 0.1698. Now, we are let us look at the first case where we have 340 crores and we are saying debt equity ratio is 0.5. So, fraction of that is 0.5 which means, the total loan that we take is 170 crores.

If we are taking a loan of 170 crores how much will we be paying annually? Annual loan repayment 170 into 0.1698 and you can calculate this, this comes out to be 28.87 crores. So, now what happens to our stream of cash flows.

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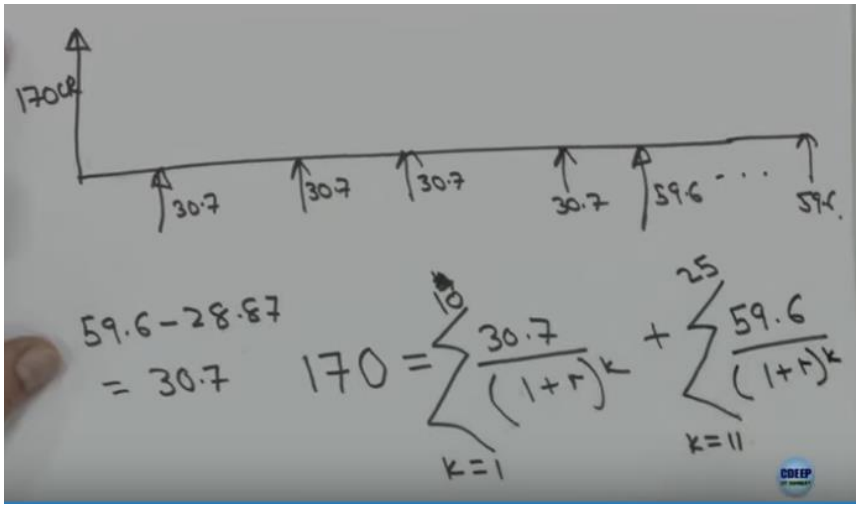


Now, we are only paying 170 crores of equity and in each year in the first 10 years we are getting the, you remember we were getting 59.6 crores each year. Now we have to pay from that revenue, the annual revenue of 59.6 we have to repay the loan. So, we have to do 59.6 minus 28.87 and this comes out to be 30.7 approximately. So, when we look at this situation, we will get now each year, first 7-10 years, we are getting 30.7 and then from the eleventh year onwards we are getting 59.6 till 25 years

So, when we write the internal rate of return, we on the equity, we are trying to balance it and get the rate of return where 170 is equal to we will get this as some of, in each case this will be 30.7 1 plus R raised to k, k is equal to 1 to 10. This is the first 10 years where we are paying the, we are repaying the loan and from the eleventh year onwards, k is equal to 11 to 25. This will be 59.6 divided by 1 plus r raised to k.

So, in the similar fashion that we had done the other calculation, we have to start with a trial value of r and find out what is the internal rate of return on the equity. Now, if this internal rate of return, we have to compare that with the return that we had got earlier, and if it is higher than that 17.3 %, I think we had got, if it is higher than that, it makes sense for us to go with the loan. If it is not then we should not hope for that.

Of course, it also depends on whether we have 340 crores to spend. If we do not, then as long as this is the rate of return on this is positive and is more than our minimum rate of return, then we should go for it. So, in order to calculate this let us again, let us just see a simple calculation with excel.

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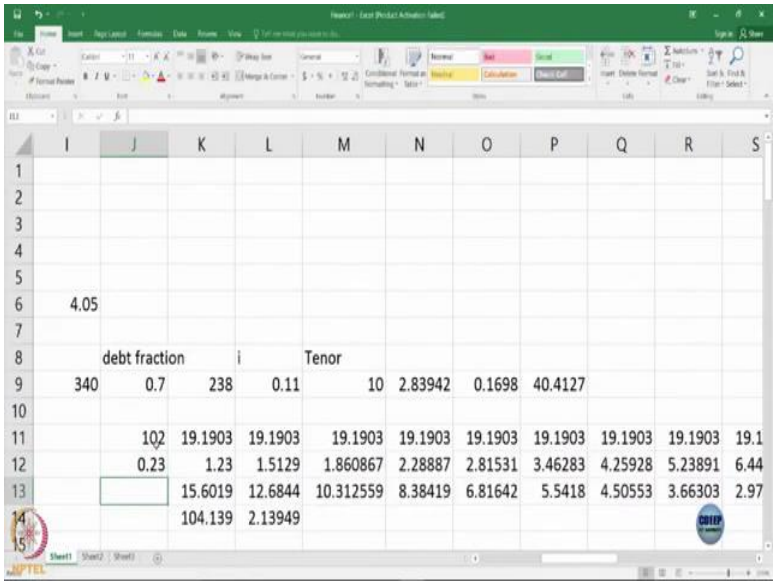

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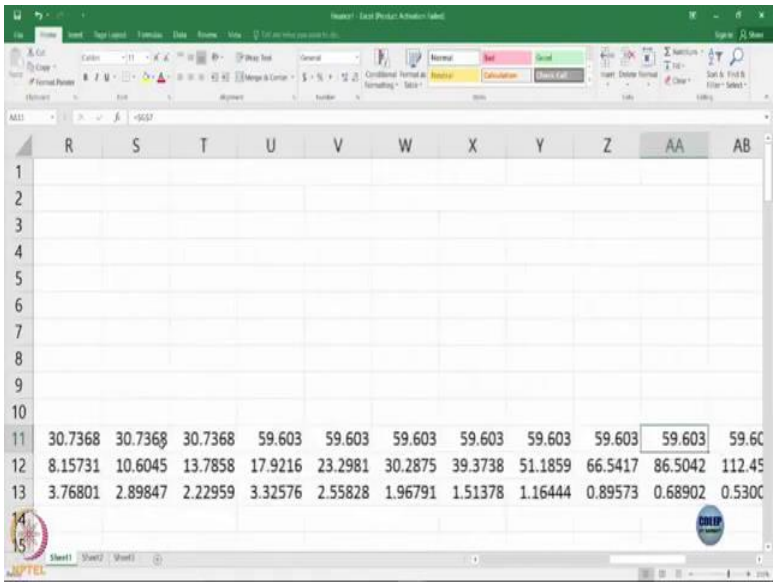

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| 10 | | | | | | | | | | | |
| 11 | 30.7368 | 30.7368 | 30.7368 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.6 |
| 12 | 8.15731 | 10.6045 | 13.7858 | 17.9216 | 23.2981 | 30.2875 | 39.3738 | 51.1859 | 66.5417 | 86.5042 | 112.45 |
| 13 | 3.76801 | 2.89847 | 2.22959 | 3.32576 | 2.55828 | 1.96791 | 1.51378 | 1.16444 | 0.89573 | 0.68902 | 0.5300 |
| 14 | | | | | | | | | | | |
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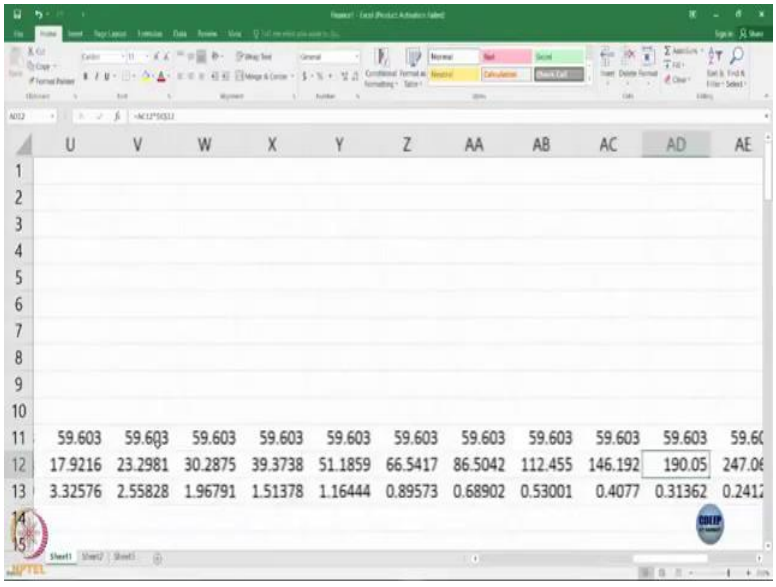

| | U | V | W | X | Y | Z | AA | AB | AC | AD | AE |
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| 11 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.6 |
| 12 | 17.9216 | 23.2981 | 30.2875 | 39.3738 | 51.1859 | 66.5417 | 86.5042 | 112.455 | 146.192 | 190.05 | 247.0 |
| 13 | 3.32576 | 2.55828 | 1.96791 | 1.51378 | 1.16444 | 0.89573 | 0.68902 | 0.53001 | 0.4077 | 0.31362 | 0.241 |
| 14 | | | | | | | | | | | |
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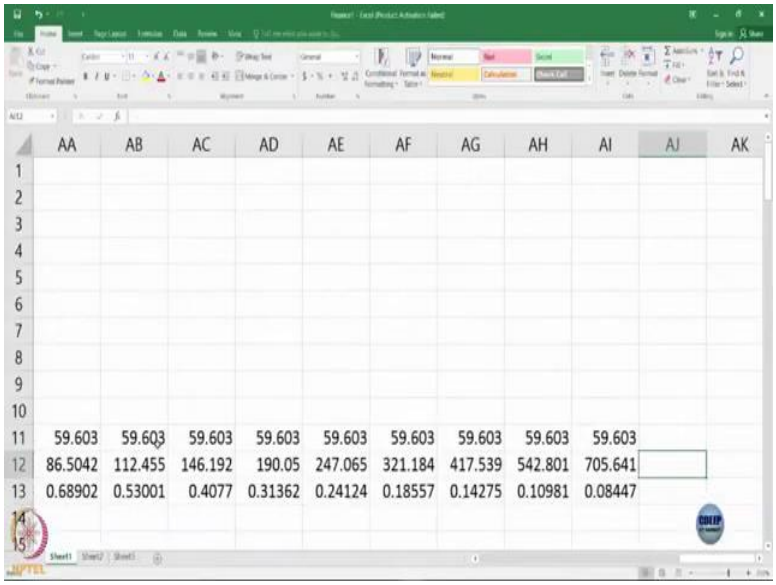
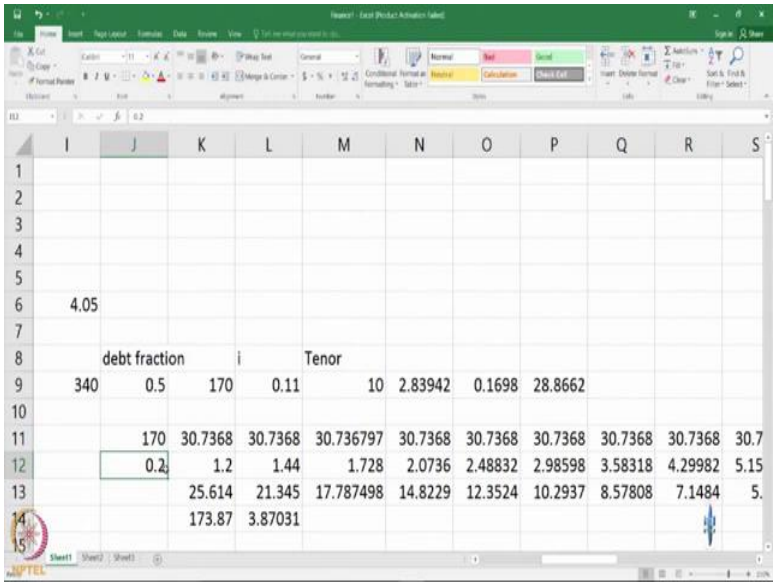
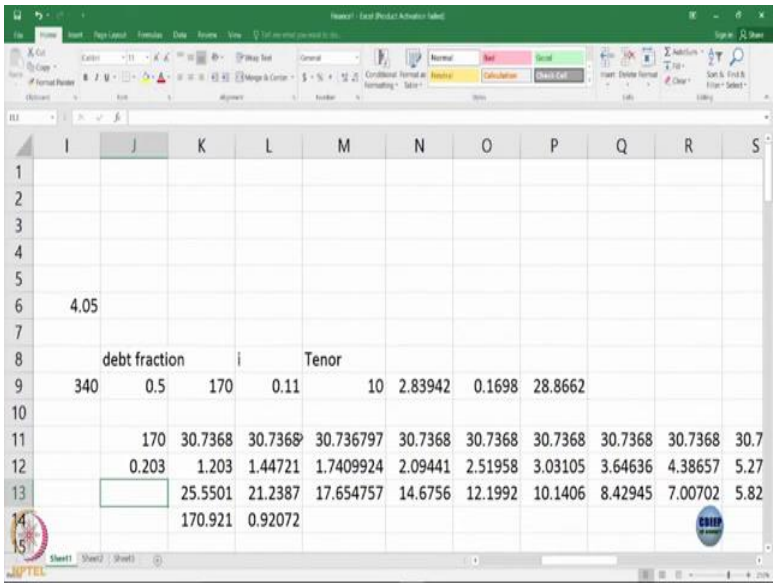


| | AA | AB | AC | AD | AE | AF | AG | AH | AI | AJ | AK |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | 59.603 | | |
| 12 | 86.5042 | 112.455 | 146.192 | 190.05 | 247.065 | 321.184 | 417.539 | 542.801 | 705.641 | | |
| 13 | 0.68902 | 0.53001 | 0.4077 | 0.31362 | 0.24124 | 0.18557 | 0.14275 | 0.10981 | 0.08447 | | |



| | I | J | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 4.05 | | | | | | | | | | |
| 8 | | debt fraction | | i | Tenor | | | | | | |
| 9 | 340 | 0.5 | 170 | 0.11 | 10 | 2.83942 | 0.1698 | 28.8662 | | | |
| 11 | | 170 | 30.7368 | 30.7368 | 30.736797 | 30.7368 | 30.7368 | 30.7368 | 30.7368 | 30.7368 | 30.7 |
| 12 | | 0.2 | 1.2 | 1.44 | 1.728 | 2.0736 | 2.48832 | 2.98598 | 3.58318 | 4.29982 | 5.15 |
| 13 | | | 25.614 | 21.345 | 17.787498 | 14.8229 | 12.3524 | 10.2937 | 8.57808 | 7.1484 | 5. |
| 14 | | | 173.87 | 3.87031 | | | | | | | |



| | I | J | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 4.05 | | | | | | | | | | |
| 8 | | debt fraction | | i | Tenor | | | | | | |
| 9 | 340 | 0.5 | 170 | 0.11 | 10 | 2.83942 | 0.1698 | 28.8662 | | | |
| 11 | | 170 | 30.7368 | 30.7368 | 30.736797 | 30.7368 | 30.7368 | 30.7368 | 30.7368 | 30.7368 | 30.7 |
| 12 | | 0.203 | 1.203 | 1.44721 | 1.7409924 | 2.09441 | 2.51958 | 3.03105 | 3.64636 | 4.38657 | 5.27 |
| 13 | | | 25.5501 | 21.2387 | 17.654757 | 14.6756 | 12.1992 | 10.1406 | 8.42945 | 7.00702 | 5.82 |
| 14 | | | 170.921 | 0.92072 | | | | | | | |

So, if you look at this we have already drawn this excel sheet. So, we are talking about a debt fraction of 0.5. So, 340 into 0.5 giving us 170 with the loan move at an interest rate of 11 % for 10 year. In the first year, we will have 30.7, 30.7 crores we said was the net input and this is, cash flow is there if you see 1, 2, 3, 4,5 6, 7, 8, 9, 10 years. After the tenth year, from the eleventh year onwards, it is 59.6 crores and this goes on till 25 year

Each year, what we have done is we have divided, we will take an assumed value of r. So let us say if we take 30 %, 0.3, then in the first year, we will just divide by 1 plus r which is 1.3, second year 1.3 squared, 1 plus r squared, 1 plus r cubed and so on and this is in the last year this will be 1 plus r raised to 25. So, if we look at this, this is what we have done. And then we have divided this number by the denominator and we have calculated it for each year. Then we have summed up all of this.

So, we sum up all the cash flows which are the benefit streams and then we subtract, this is the equity which we are paying minus 170 crores. So, we take the total sum of this and subtract from that the initial out payment and so, you see the net present value is negative. So, obviously we will not have a high debt, 30 % is too high a debt fraction. Let us reduce this and see, try it out with 20 % and see what happens.

You see now that we are getting something which is 174 crores, overall net present value, so it is positive. So, the fraction that we are getting is now we are getting the rate of return is going to be 20 % or more. We can try with, let us change this 0.22. Let us change it 0.22 and you see it 0.22, it is negative. We can bracket it even further. Let us take 0.21. 0.21 is also negative, so it is more like 0.205 negative.

So we can get it within an accuracy of 0.201 is positive, 0.202 is also positive. So 20.2, 0.203 and 20… So you see, it is between 20.3 and 20.4. We can just say that this is, it is 20.3 % is the rate of return and, of course, this is higher than the value that we got from the in the case where we are not taking the debt. We were getting 17.3 % return on our equity. So it is better that we take the loan. What if we increase the loan fraction and take it as 70-30?

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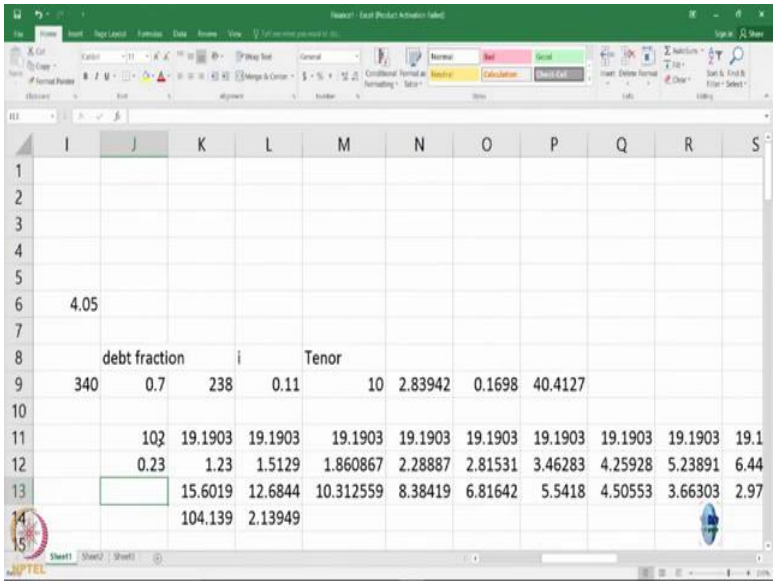

| | I | J | K | L | M | N | O | P | Q | R | S |
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| 6 | 4.05 | | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | debt fraction | | i | Tenor | | | | | | |
| 9 | 340 | 0.7 | 238 | 0.11 | 10 | 2.83942 | 0.1698 | 40.4127 | | | |
| 10 | | | | | | | | | | | |
| 11 | | 102 | 19.1903 | 19.1903 | 19.1903 | 19.1903 | 19.1903 | 19.1903 | 19.1903 | 19.1903 | 19.1 |
| 12 | | 0.23 | 1.23 | 1.5129 | 1.860867 | 2.28887 | 2.81531 | 3.46283 | 4.25928 | 5.23891 | 6.44 |
| 13 | | | 15.6019 | 12.6844 | 10.312559 | 8.38419 | 6.81642 | 5.5418 | 4.50553 | 3.66303 | 2.97 |
| 14 | | | 104.139 | 2.13949 | | | | | | | |
| 15 | | | | | | | | | | | |

When we take this as 70-30, what will happen is that the amount that we have to repay increases but the initial amount instead of 170 crores, now the equity is only 102 crores, but in the first 10 years, we are getting 19.19 crores instead of the earlier value that we had gotten 30.7 crores with the result that you can see now that actually the interest the rate of return will increase. Let us try with 0.3. 0.3 is negative. 0.25, 0.24. This is also negative.

So, you see it is now it has come to, earlier it was 20%. Now we are getting 23%. So, obviously from the point of view of the company, it is viable to go for a higher debt equity ratio. Of course, there will be a maximum debt equity ratio which the financing institution will give you. So, but if you can go up to 70 and 30 in this case, and that is the way in which we can calculate.

So please look at what we have done. We first calculated in case we did not take the loan, what will be our rate of return and the internal rate of return then we for the loan, based on the terms of the loan, we calculated how much will be the loan repayment, then adjusted in the years when we are repaying the loan, from the revenue stream we subtracted that amount and then build up the cash flow streams and then calculated the internal rate of return on the equity.

We tried with the two different debt fractions and the debt fraction that gives us a higher rate of return on the equity is the fraction that we would choose. In this particular case we can even without doing the numbers, we could have estimated what would happen because on the equity we are getting a rate of return of 17% and for the loan we are only paying 11%. So it would naturally make sense for us to maximize the equity.

There would be other situations where it will not be so obvious, and we would need to do the detailed calculation. With this we complete the portion that we have done on energy financing and I would suggest that you solve the second problem, which is given in the tutorial in a similar fashion and make sure that you yourself can do all these numbers