Energy Resources, Economics, and Sustainability

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Week – 04

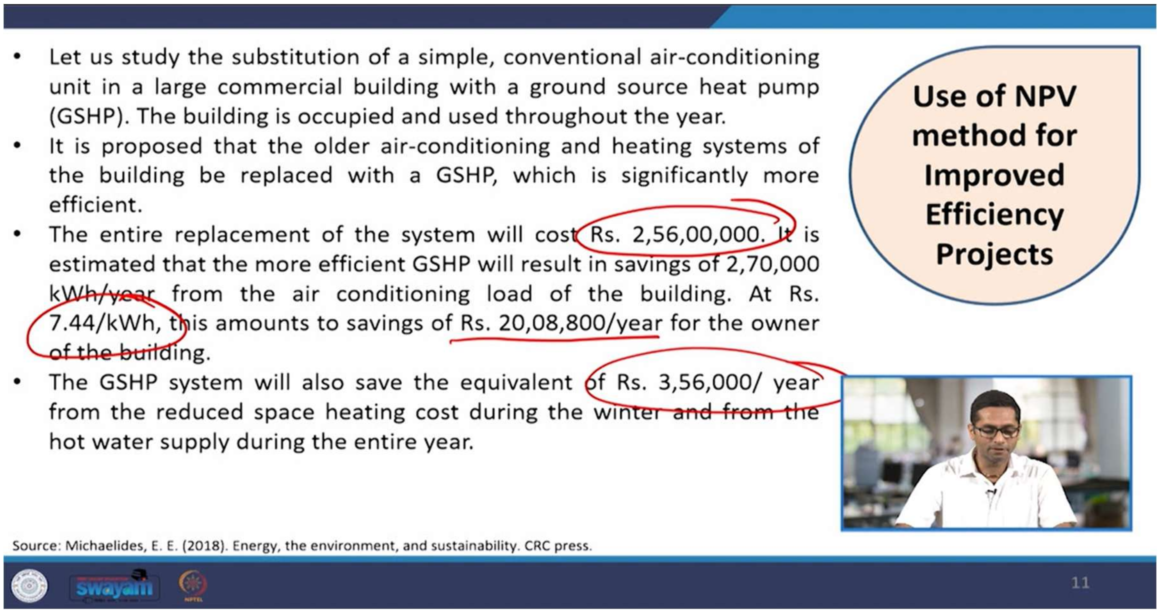
Lecture – 01

Lecture 17 - Economic Decision Making

Hello everyone. Welcome back to the course Energy Resources, Economics and Sustainability. In today's class, we'll try to understand the application of the net present value method in some of the economic making decisions. In the previous few classes, we have tried to understand the application of the NPV method in estimating the profitability of a hypothetical wind energy firm. We tried to understand how the cash flows would look like based upon some assumptions and what could be the different incentives, disincentives, policy measures that could be taken up for inducing profitability in a renewable energy plant. Now, we will extend our discussion to some of the energy efficiency plants as well as for installation of plants in a more decentralized setting like a solar rooftop PV system.

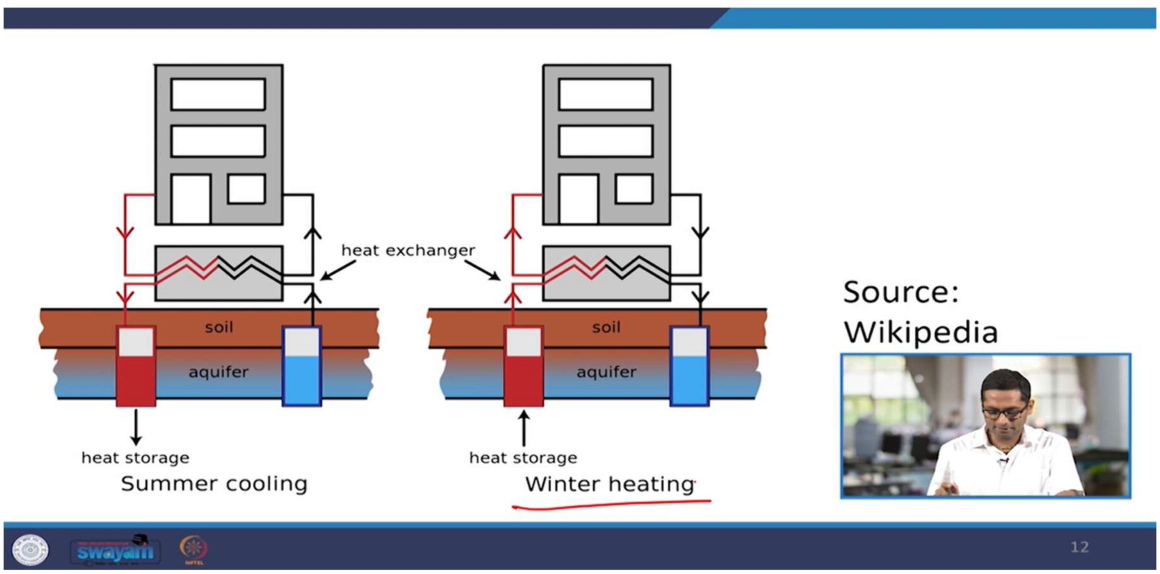
So again, we are going to use the NPV methodology, but the applications will be somewhat different so as to understand the applications of the same methodology in different scenarios. So, in the first case that we'll undertake today, we'll try to understand what if we are undertaking an energy efficiency process. So, we are inducing a technology that would help make the already established system to be much more efficient. And as a result, there will be a net saving in electricity.

But for putting up this new system, we would also have to put in capex and upfront capex. Does that make sense to put in an upfront capex and will that be able to realize that capex in terms of the efficiency increase and further the cost reduction that happens in the future years? So let us take an example of a ground source heat pump.

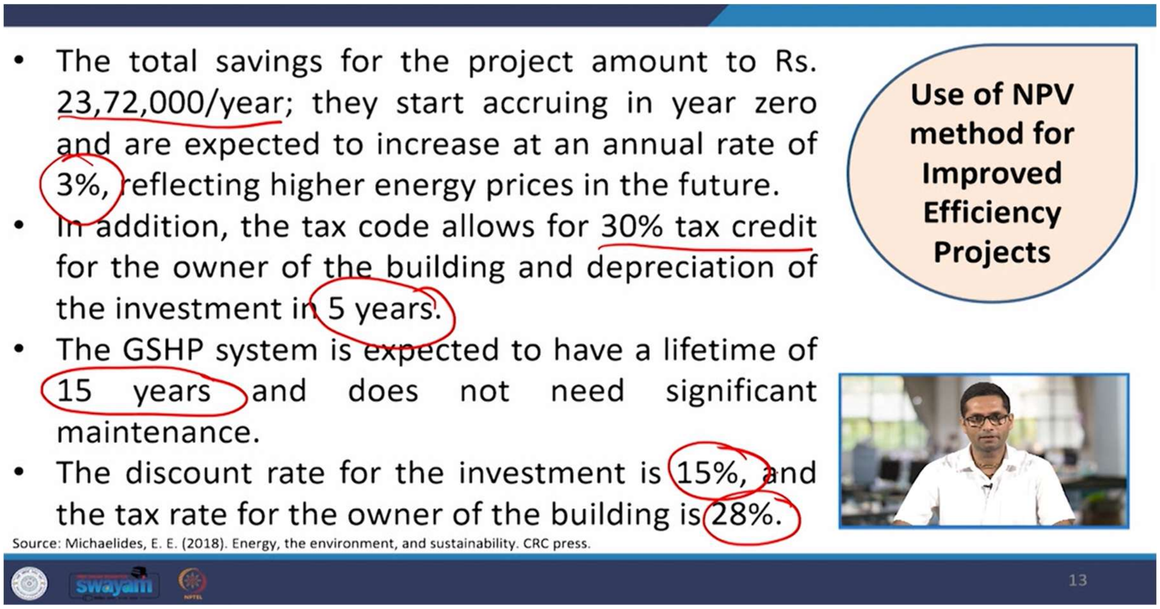


Now ground source heat pump is basically a technology that is widely used in the developed world in the sense that it is one of the technologies that makes use of the fact that the aquifers that are below the ground are at fairly equal temperature throughout the different seasons. So during the hot summer seasons, they would be operating at around ambient temperature of 20 degrees Celsius or lesser. And something similar could also be said to be around in the harsh winter seasons.

So now these kinds of countries normally would have good air conditioning as well as the heating requirements during the summer and the winter seasons. For which they would have a specific air conditioners and heaters or centralized heating installed. What if we were to replace that with a ground source heat pump? That would entail that we would have to put in extra capex in terms of rupees of around 2.56 CR and it is also estimated that because this kind of process is like much more efficient and it would help in saving of around 270000 units of electricity in a year for the cooling requirements specifically. If I am taking an electricity rate of around 7.44 kilowatt hour which I have taken from an industrial unit, so I am thinking about a service sector, a business office which is operating for business purposes and they would normally be paying a high price of electricity that then the homes would be paying. So this is taking them into the scenario. So the electricity price that is taken is slightly on a higher end. So the total savings that can occur in that sense would be around 20 lakh rupees and few thousand rupees per year. Further because this ground source heat pump also helps in the building heating during the winter time, it can also help some of the heating load and which could be of the tune of around 3.5 lakhs an year that could be saving. So what is happening here is like a business entity which has a huge office wants to update its cooling and heating setup which was earlier coming from traditional air conditioners and heaters and it is now going for a ground source heat pump and that would entail that it would have to put in a new system and the ducting and the air conditioning vents can remain the same but it would still need an initial investment of 2.56 crores and because of this investment it is also expected to lower its electricity bill in the future and it is estimated that it will be saving around 20 lakh rupees an year just because of the cooling needs and around 3.5 lakhs, sorry it would be 20 lakhs an year for the cooling needs and around 3.5 lakhs for the heating needs.



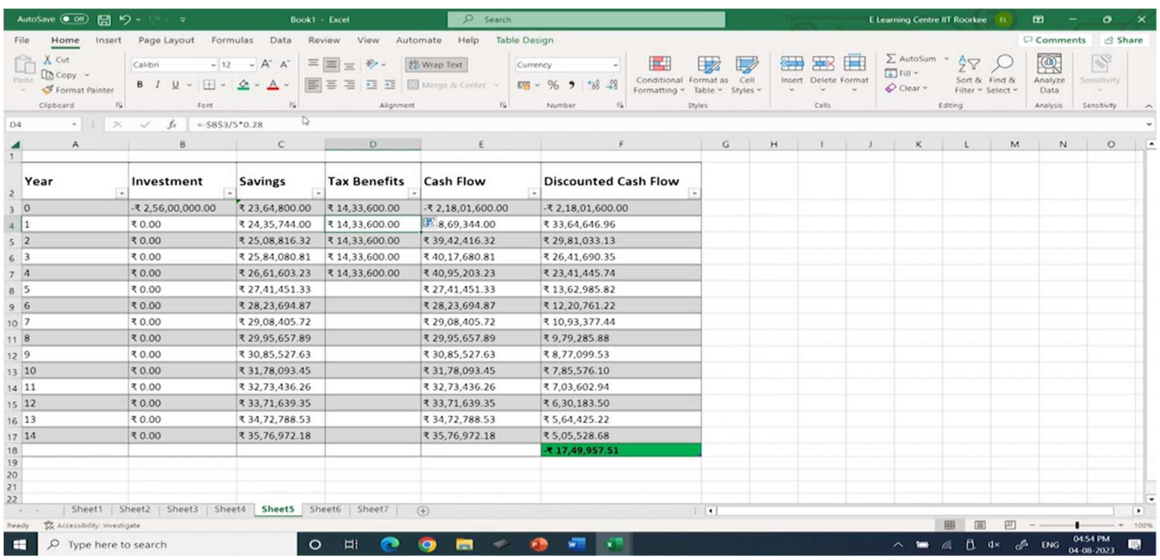
So this is a simple diagram to show how a ground source heat pump would be working. So during the summer times you would see that the ground is normally at a much lesser temperature so this could be used with the help of heat exchanger and supply of or like exchanging the hot air and cooling it down and supplying it back to the building and the opposite would be happening in the winter where the ground would be at a slightly higher temperature as compared to the ambient temperature in the atmosphere and this heat could be again be used for heating up the air which could be supplied to the indoors to maintain a warm and cozy environment.



Again some other assumption that we might want to take place or we might to understand is like the total savings of the project would be a total of both the summer air conditioning needs as well as the winter heating needs and they would come at to a total of around 23 lakhs 72 thousand per year and they start from the year zero so we are assuming that this kind of process is quite easy to install and would start quite early and we are also expecting because the electricity prices are increased at a general rate so these kind of savings which are coming from the reduction in the electricity payment would also increase at the rate of 3%. So, the assumption is that because electricity prices are normally varying at around 3% on an yearly basis we can also expect the profit that we are deriving because of this particular technology intervention to also increase at the rate of 3% so the revenue that we are saving in terms of the reduced bill is also increasing. Further because of the country's policy it also allows a 30% tax credit on a technology update like this because this helps in bringing down the electricity consumption and brings down the overall load on the power plant that are there.

So, the government has a policy that it will give a 30% tax credit on any investment like this. A further credit is given by the government in the form of an accelerated depreciation which can happen over the span of 5 years. Again I would like to point out like for making use of these kinds of incentives the corporate is expected to have a profit making business where it can avoid or where it can decrease the tax that it is supposed to pay. In this case we are assuming that this kind of updation or the ground source heat pump would have lifetime of around 15 years and this would not require any significant maintenance. So, we can assume that the operation and maintenance cost to be negligible in this case.

The discount rate for an investment like this for the corporate is assumed to be around 15% and the tax rate for the owner of the building is around 28%. So, this is the normal rate at which the tax would be paid. So, in this case again we are taking the simplistic assumption that the tax rate is constant whereas the tax codes are generally very complicated. They would change from country to country and normally you would have a couple of chartered accountants or tax consultants who would be guiding you how to calculate the tax, how to make the maximum out of the schemes of the government. So, let us go with this simple case and let us try to understand this with the help of an excel sheet.



Year	Investment	Savings	Tax Benefits	Cash Flow	Discounted Cash Flow
0	-₹ 2,56,00,000.00	₹ 23,64,800.00	₹ 14,33,600.00	-₹ 2,18,01,600.00	-₹ 2,18,01,600.00
1	₹ 0.00	₹ 24,35,744.00	₹ 14,33,600.00	8,69,344.00	₹ 33,64,646.96
2	₹ 0.00	₹ 25,08,816.32	₹ 14,33,600.00	₹ 39,42,416.32	₹ 29,81,033.13
3	₹ 0.00	₹ 25,84,080.81	₹ 14,33,600.00	₹ 40,17,680.81	₹ 26,41,690.35
4	₹ 0.00	₹ 26,61,603.23	₹ 14,33,600.00	₹ 40,95,203.23	₹ 23,41,445.74
5	₹ 0.00	₹ 27,41,451.33		₹ 27,41,451.33	₹ 13,62,985.82
6	₹ 0.00	₹ 28,23,694.87		₹ 28,23,694.87	₹ 12,20,761.22
7	₹ 0.00	₹ 29,08,405.72		₹ 29,08,405.72	₹ 10,93,377.44
8	₹ 0.00	₹ 29,95,657.89		₹ 29,95,657.89	₹ 9,79,285.88
9	₹ 0.00	₹ 30,85,527.63		₹ 30,85,527.63	₹ 8,77,099.53
10	₹ 0.00	₹ 31,78,093.45		₹ 31,78,093.45	₹ 7,85,576.10
11	₹ 0.00	₹ 32,73,436.26		₹ 32,73,436.26	₹ 7,03,602.94
12	₹ 0.00	₹ 33,71,639.35		₹ 33,71,639.35	₹ 6,30,183.50
13	₹ 0.00	₹ 34,72,788.53		₹ 34,72,788.53	₹ 5,64,425.22
14	₹ 0.00	₹ 35,76,972.18		₹ 35,76,972.18	₹ 5,05,528.68
					-₹ 17,49,957.51

So, what you see in front of you is a simple excel sheet that basically reflects the different kinds of cash flow that we have discussed. So, the building owner is going to invest around 2 crores, 56 lakhs in the first year and then there will be no more investment. In terms of savings it will be making savings in terms of the cooling needs as well as the winter needs. So, it would be saving around 270,000 units and one unit is charged at around 7.44 rupees and plus an additional saving of around 3,56,000 in terms of the winter heating needs and this is what is happening in the first year and then this would be increasing at the rate of 3% every year.

So, the underlying assumption is that the electricity price would be increasing at 3% and so the savings would also increase and this will keep on till the year 14th. So, the savings would keep on increasing till the 14th year and so the overall life of the plant is 15 years and since we are denoting first year as 0, the 15th year is denoted as 14th year. Further, because of the incentives given by the government, we have two kinds of incentives. One is the credit in terms of the tax credit which is 30% of the investment. So, we have around 30% of the cell B3 which is basically the investment made in the year 0.

So, that is given back to the corporate in form of tax credit and further we would have an accelerated depreciation. So, the investment that I have made around 2,56,000 lakhs has been divided by 5 because it is an accelerated depreciation of 5 years and that I have multiplied by 28%. This is the rate at which the building owner is paying the tax. In reality, this would be much more complicated. It would not be a standard number but for the case of simplicity, I have assumed it to be 28%.

So because of this depreciation, this is the total cost on which the tax is saved and the tax is around 28%. So, I have taken 28% of the amount that is depreciated as the amount that I have saved. So, this is the total tax saving in the year 0. In the second year, I do not have any tax credit which was the percentage of the CAPEX investment. It was just the accelerated depreciation that is happening for the investment that took place in year 0 and then multiplied by 28% which is the rate at which the tax is being paid. And I will be having that for the next 4 years or so because the accelerated depreciation would be taking place for the 5 years. So, all the investment that I have made would be depreciating in the first 5 years. The only addition is that in the first year, I also have the advantage of a tax credit. Now comes the cash flow. The cash flow would be an addition of the investment plus the savings and the tax benefits, an addition of the 3 and this is what I have been taking down. So, you would have a big investment happening in the first year and then the savings accrue in the following years. We also need to take into account the time value of money and in this case, we have assumed around 15% of the discount rate. So, I have discounted all the cash flows at the rate of 15% and this is raised to the number of years that have passed. So, the amount is as such in the year 0 whereas there is a substantial reduction in terms of the amount that or the savings that is made in the year 14th. I add all of these to get the final NPV which comes around to be around 59 lakh rupees and overall we can see that the corporate would be quite happy in investing in a project like this which would have a total NPV which is positive.

But in this case, we also need to understand the effect by the tax credit and the appreciated depreciation that is happening. In case I am not having the tax credit taking place, I just remove the tax credit, we can see the NPV is now negative and the building owner might not want to put money in a technology like this. Further, if the accelerated depreciation was not to happen and it would be a regular depreciation happening in 10 years, you might again end up with not such a profitable business and this is something that you can try at your own end. So, the underlying learning from this particular example could be, sometimes it could be very important to have some kind of policies by the government to help people come up or take up or readily accept technology which is clean and green in nature which could help make it profitable for the entities which might not be profitable at the first instance.

Year	Investment	Savings	Tax Benefits	Cash Flow	Discounted Cash Flow
0	-25,600	2,364.80	9,113.60	-14,121.60	-14,121.60
1	0	2,435.76	1,433.60	3,869.60	3,364.80
2	0	2,508.80	1,433.60	3,942.40	2,980.80
3	0	2,584.08	1,433.60	4,017.60	2,641.60
4	0	2,661.60	1,433.60	4,095.20	2,341.60
5	0	2,741.44		2,741.60	1,363.20
6	0	2,823.68		2,824.00	1,220.80
7	0	2,908.40		2,908.80	1,093.60
8	0	2,995.68		2,996.00	979.20
9	0	3,085.52		3,085.60	876.80
10	0	3,178.08		3,178.40	785.60
11	0	3,273.44		3,273.60	704.00
12	0	3,371.60		3,372.00	630.40
13	0	3,472.80		3,472.80	564.80
14	0	3,576.96		3,576.80	505.60

NPV Calculation of the GSHP Project

NPV = 5,930.40

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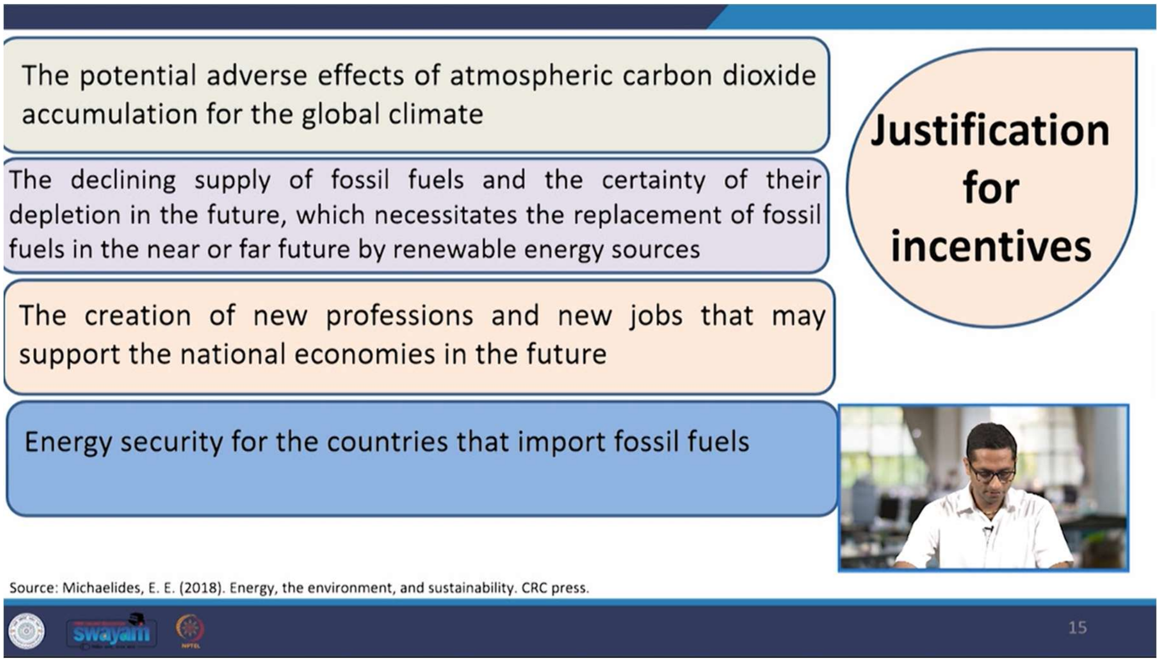
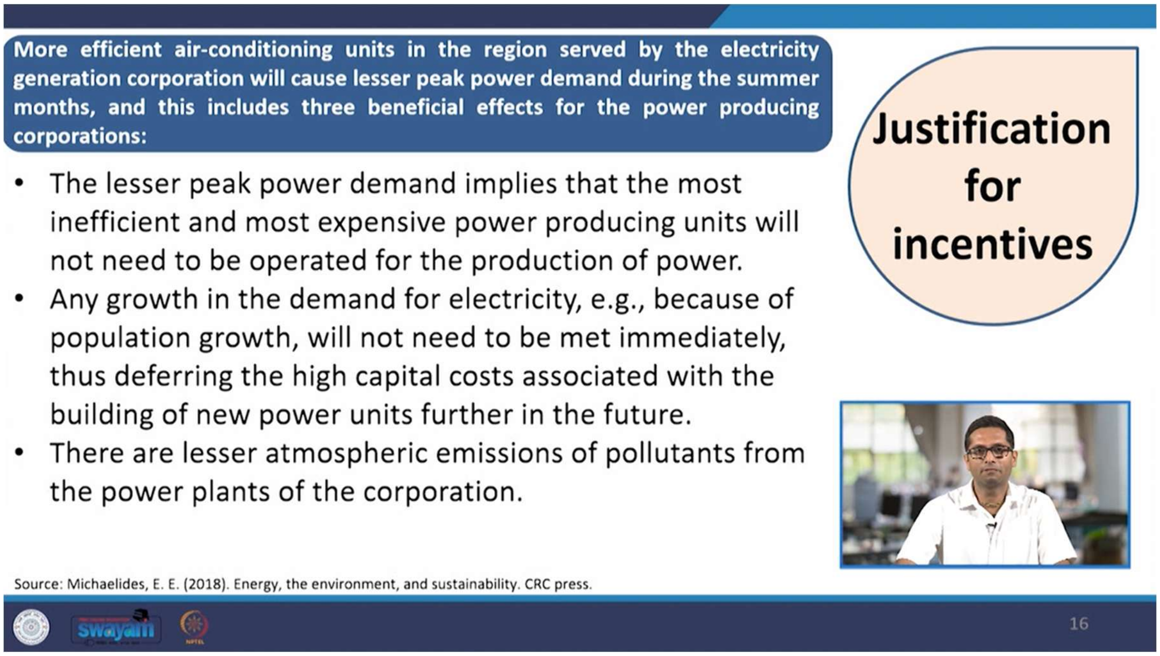
Now, some of you might argue like why would the government want to do away with the taxpayers money for setting up a plant because anyway someone would have to bear the cost for which the advantage is given to the plant owners which are setting up a green plant.



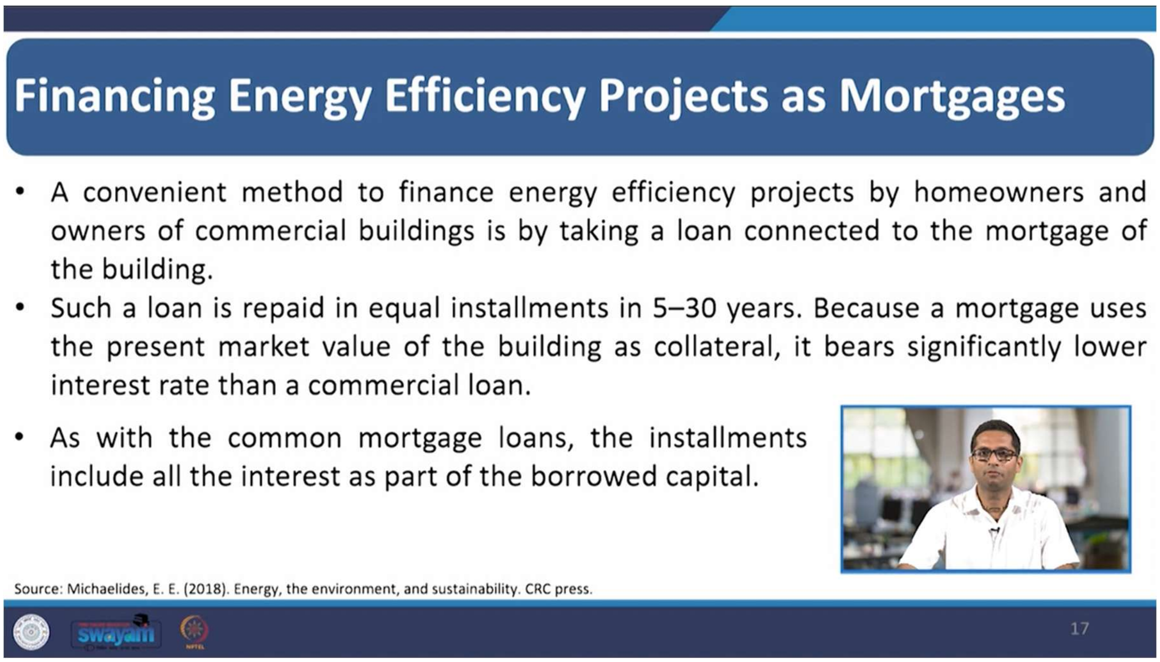
So, are these incentives justified? So, there are the following arguments that are put in the favours of like putting up incentives like this. The first thing is of course this effects in bringing down the atmospheric CO2 levels which are increasing at an alarming rate and which basically endanger a lot of our life in terms of the effect of global warming. So, we are delaying that. Then the declining supply of fossil fuels and a reliance on the foreign nations for its supplies is another thing that we would want to reduce as much as possible. So, if we are able to just incentivise some of the energy efficiency processes that might call for reduction in the import that we are making.

Further, it is also important that a labour force is created in the new domain of renewable energy or green energy and for the creation of the labour force there needs to be certain place where they would be employed and where they can learn the traits and for that the plants need to be set up. So, that is another argument. Further, again like as already mentioned energy security is a big aspect like where we would want to be having energy independent as far as possible. Then there are some other justifications that are given. One is that if we are taking this case for example where we are bringing down the air conditioning and the heating load, this also helps us bring down the peak power.

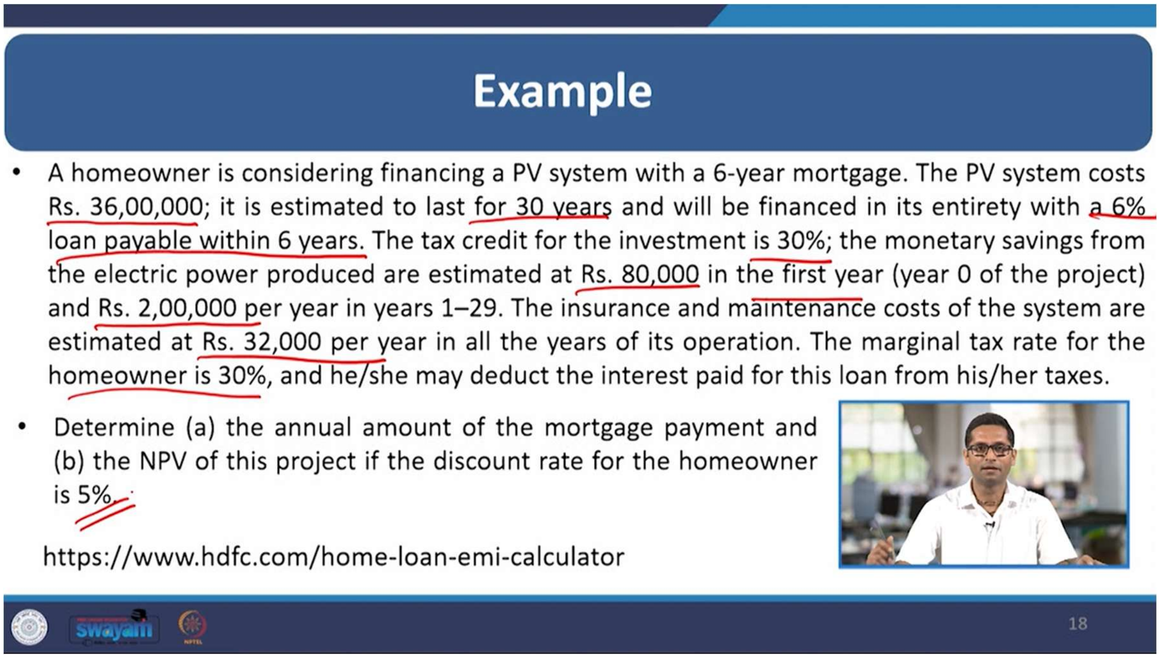


So, the production of electricity as you would understand is not at a constant rate throughout the day. There are certain parts of the day when the electricity consumption is much more than the other parts of the day which means that we would have to ramp up or ramp down the capacity or the operating capacity of the power production plants. Certain plants would have to be operated just to meet the peak power and normally the running or the operation of these plants are the most costliest and these are also the plants which are not the most efficient ones. So, let me repeat again most of the time when we are going for peak powers the plants that would be additionally operated are not very efficient and it is very expensive to produce that power. So, in case we are able to reduce the peak consumption we are doing away with the production of the expensive power that was being taken place and further we are also reducing the inefficiency in the system that is induced because of the running of the plants for few moments.

Further, any increase in the efficiency also delays down the setting of new facilities because as we are growing in population naturally we would need more and more power plants to come up in the future so as to justify the electricity needs of the growing population. By increasing in efficiency we are also delaying the setting up of new plants because that calls for a lot of capital. It also wants a lot of facilities to be set up because as we have seen these kinds of plants can take anywhere from 3 to 5 years to set up so we can delay the setting up of these plants. And another incentive that we have already discussed is we are delaying the atmospheric emissions of pollutants like CO_2 which have a major effect and these are some of the effects that we will be discussing in the next section of the course in detail where we will discuss what are the major aspects with respect to the electricity production from different kinds of pathways. Let us try to understand another example where we are taking in the application of projects which are related to energy efficiency but more on a decentralized fashion.



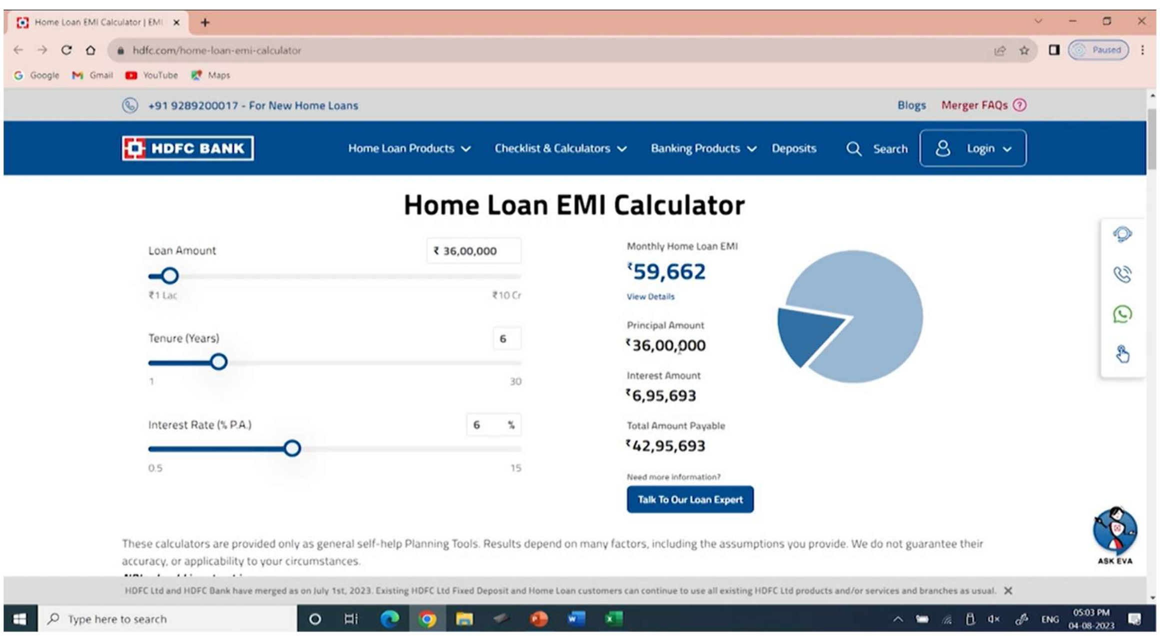
So one of the ways in which it is accomplished is in the form of the mortgage. What happens in this is that if the homeowner takes a loan with respect to the building for setting up of a decentralized plant maybe solar or might be some other technology and because the loan is paid with the building as the collateral the interest rates are significantly lesser that would be charged in market for other kinds of loans. So what is happening here is like if I am owning a house I would take a loan for setting up a power plant and I will put my home as collateral and I know it is a pretty safe investment which I will be able to recover in the future and because the banks know that they have a good thing, the loan is safe and they would also want to charge me a lesser interest rate. So it is a sort of win-win situation for both the entities and the banks are able to offer the loans and the loan helps in setting up of plants which are much more energy efficient to a conventional homeowner. So let us try to understand this example.



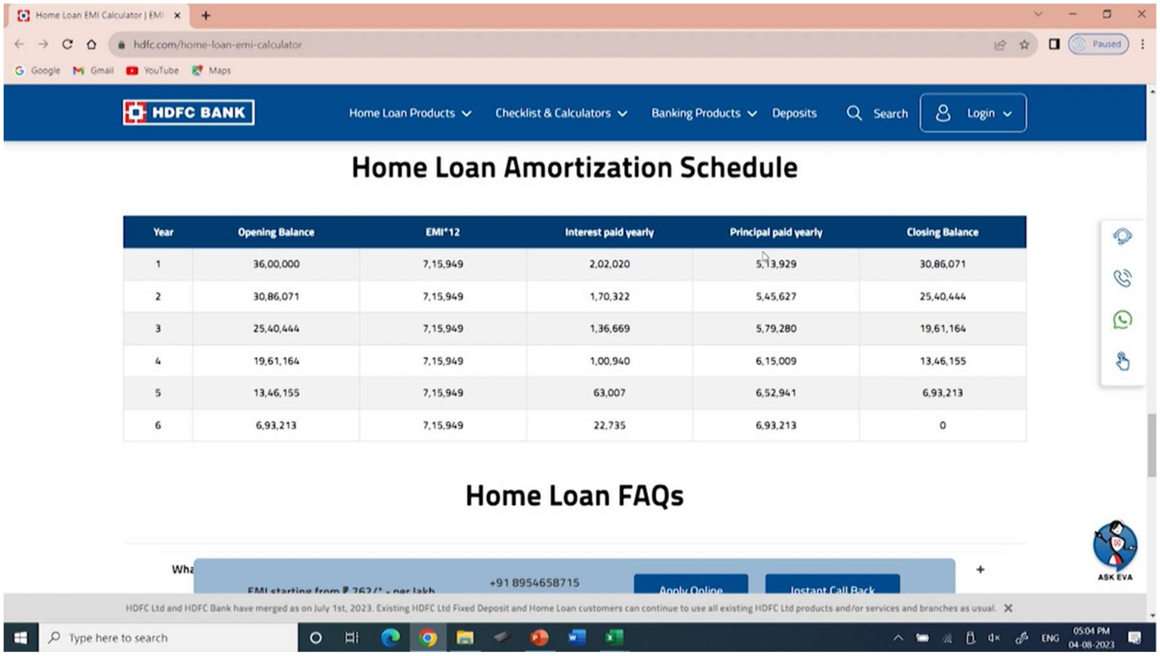
So suppose a typical homeowner is considering a setting up of a PV system using a 6 year loan and the PV system is expected to cost around 36 lakh rupees. So I am talking about a pretty decent system and again the life is estimated to be around 30 years. The homeowner is thinking about financing the project entirely with the help of a 6% loan that is payable in 6 years. The tax credit for the investment which is coming from the government incentives is around 30% of the capex. The monetary saving from the electricity power produced is estimated to be around 80,000 in the first year because the plant is just setting up and for the next 29 years it is expected that the plant owner will save around 2 lakh rupees per year.

The underlying assumption is the electricity produced by the solar plant would be comparatively cheaper and you would be saving from the high rate of electricity that is coming from the grid. The insurance and the maintenance costs for the system are assumed to be around 32,000 rupees per year and this stays constant throughout the operation. And the tax or the marginal tax for the homeowner is assumed to be 30%. So this is I am expecting the homeowner will be paying tax at and he or she may deduct the interest paid on the loan for his or her taxes. So this is again a government policy wherein if you are putting in an investment or taking in a loan for a green energy project, the interest that you pay for that particular loan might not be chargeable. And this is also a normal policy in the Indian tax system for a home loan. So what we would have to do is let us try to determine the annual amount in terms of the payment that we make and the NPV of the project if the discount rate for the homeowner in this case is 5%. So in this case because it is a pretty safe investment and the homeowner is pretty confident to recover this kind of investment, I have assumed a very small discount rate of 5%. So let us try to understand this. For calculating the EMI for this particular case, I have just used an open tool by the HDFC bank.

You just Google it and you will find many tools that are available. I have just chosen one of it from an Indian bank. So let us open that tool and try to estimate the EMI that I would be supposed to pay for a loan like this. So this is a simple tool which is put up by different banks for you. Any possible bank who gives a home loan in any country would have this kind of calculator and you can explore that.



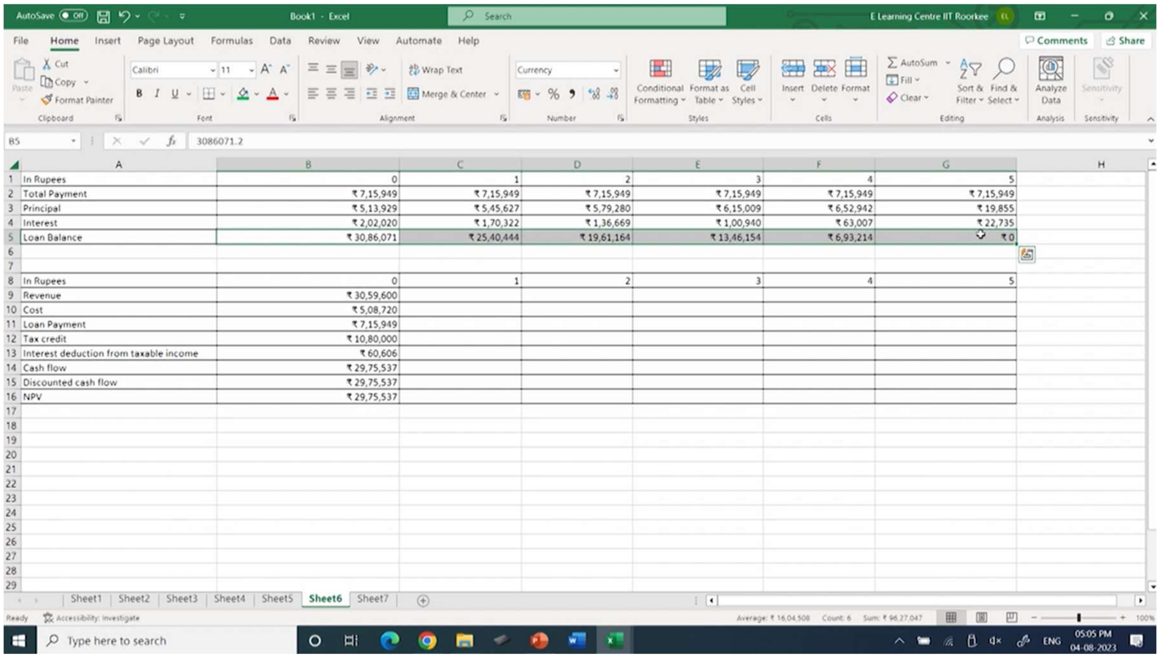
So if I am taking in a loan of say 36 lakh rupees which I am putting in here and the tenure of the loan is around 6 years and the interest rate that is charged is again I am assuming that to be 6%. So it has calculated that if that was the case, the EMI that I would be paying is around Rs. 59,662 per month and if I go with the cash flows, this is how the cash flows would look like.



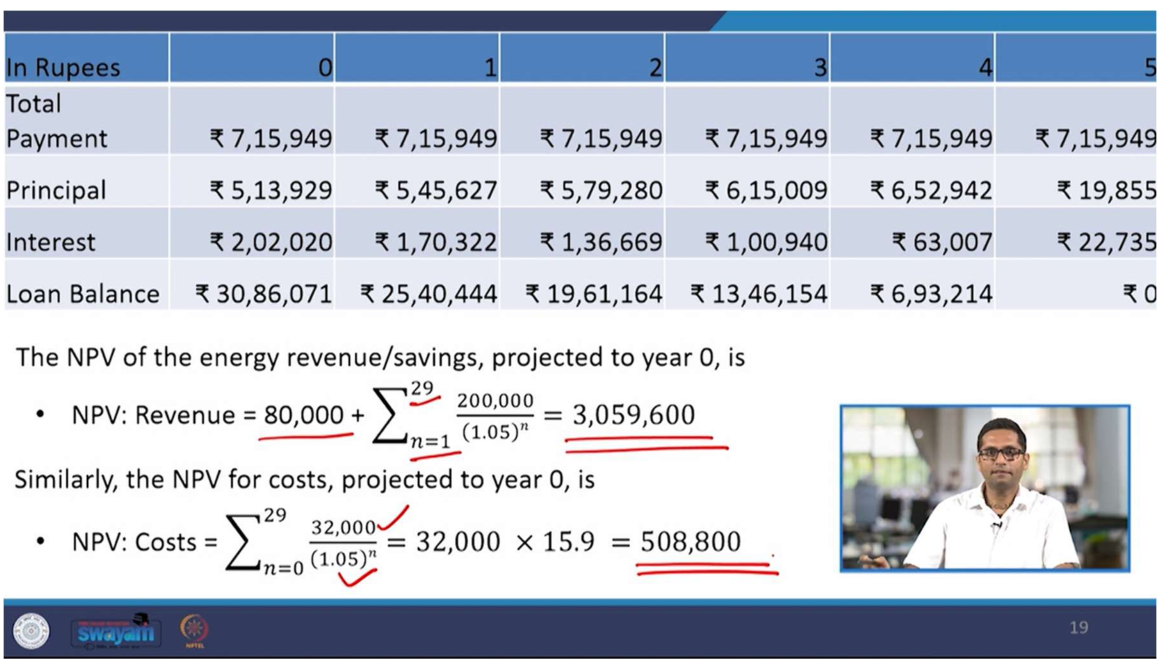
Year	Opening Balance	EMI*12	Interest paid yearly	Principal paid yearly	Closing Balance
1	36,00,000	7,15,949	2,02,020	5,13,929	30,86,071
2	30,86,071	7,15,949	1,70,322	5,45,627	25,40,444
3	25,40,444	7,15,949	1,36,669	5,79,280	19,61,164
4	19,61,164	7,15,949	1,00,940	6,15,009	13,46,155
5	13,46,155	7,15,949	63,007	6,52,941	6,93,213
6	6,93,213	7,15,949	22,735	6,93,213	0

The initial investment was 36 lakhs. The annual EMI that I would be paying would be around Rs. 7,15,949 and out of this in the initial few years, I would be paying a good amount of interest. So out of this 7 lakh that I pay, the interest would account for around 2 lakh rupees and 5 lakh rupees would be the interest payment and this interest would keep on reducing in the future years and whereas the principal payment keeps on increasing in the future years. So this is the normal way in which loans are offered. So the initial few investments or initial few payments that you would pay in the form of EMI would have a significant quantity of interest which keeps on reducing and at the same level the principal will keep on increasing in the future years. So the banks would naturally would want to recover as much as interest in the as soon as possible again bringing in the discounting principal any payment that is made now would be worth more than in the future.

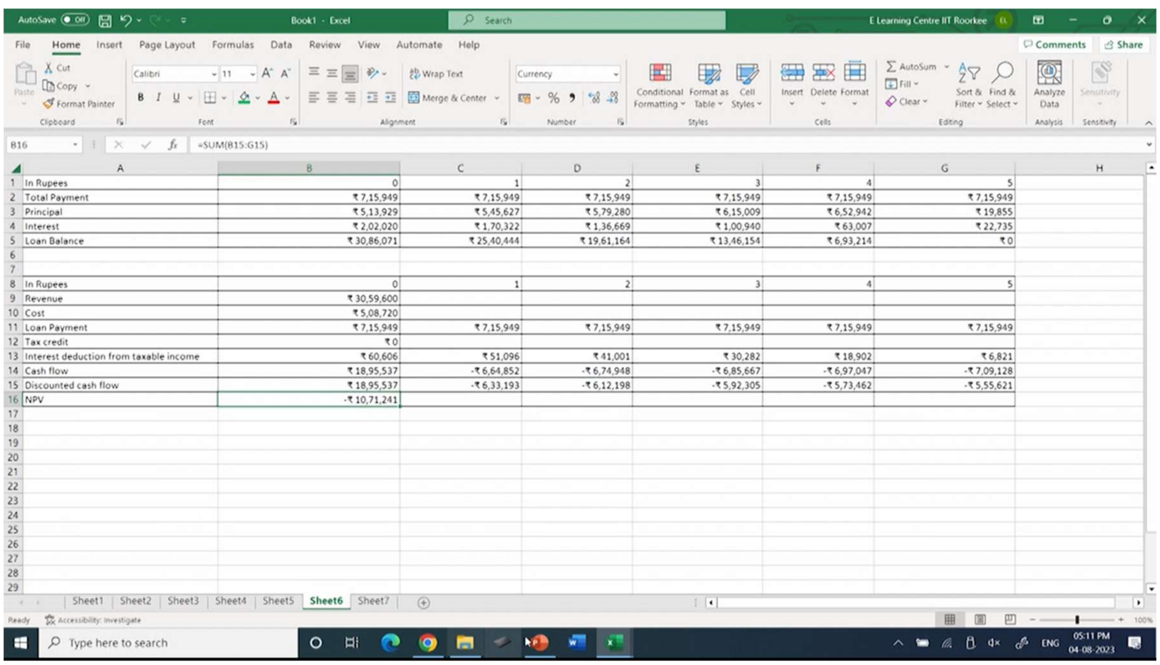
So they would want to recover much of the interest in the present few years rather than recovering in the future and the principal is normally delayed in the future years. So these are the values that are coming and you can use any calculator that is available online for these kinds of calculations. So let us take these values in an excel sheet.



So this is the excel sheet that is taking those values. So we have the total payment that is being made and this is the principal and that is being returned every year and the same level this is the interest and this is how the loan balance would be reducing over the years.



Let us go back to the slides to take care of the other calculations as well. So these are the values that would be coming from the calculator that you see in the top. Further we also need to take in the net present value of the different revenue saving that is going to happen and that let us project that to the year 0. So what we have assumed that in the first year we would have been saving of around 80,000 and for the next 29 years a saving of around 2 lakhs per year. Taking that into account so I can write it simply like the NPV would be 80,000 that happens in the year 0 and then I am having a saving around 2 lakh rupees per year and I am discounting that to 5% every year and this summation varies from year 1 to 29 and if I total everything and this gives me a total of around 30 lakh rupees 59 thousand 6 hundreds. So this would be the NPV of the revenue that I am generating. If I talk about the cost that I would have to incur in terms of the maintenance cost and insurance cost I have made an assumption that these cost would be roughly 32,000 throughout the life which starts from the year 0 and continue till the year 29. So overall 30 years of life 32,000 is something that I am paying every year discounted at the rate of 5%. So I would have a rate of 1.5 raised to power n and the summation of the whole and this gives me a total cost of around 5,88,800 again taken as the present value or the present cost.



In Rupees	0	1	2	3	4	5
Total Payment	₹7,15,949	₹7,15,949	₹7,15,949	₹7,15,949	₹7,15,949	₹7,15,949
Principal	₹5,13,929	₹5,45,627	₹5,79,280	₹6,15,009	₹6,52,942	₹19,855
Interest	₹2,02,020	₹1,70,322	₹1,36,669	₹1,00,940	₹63,007	₹22,735
Loan Balance	₹30,86,071	₹25,40,444	₹19,61,164	₹13,46,154	₹6,93,214	₹0

In Rupees	0	1	2	3	4	5
Revenue	₹30,59,600					
Cost	₹5,08,720					
Loan Payment	₹7,15,949	₹7,15,949	₹7,15,949	₹7,15,949	₹7,15,949	₹7,15,949
Tax credit	₹0					
Interest deduction from taxable income	₹60,606	₹51,096	₹41,001	₹30,282	₹18,902	₹6,821
Cash flow	₹18,95,537	-₹6,64,852	-₹6,74,948	-₹6,85,667	-₹6,97,047	-₹7,09,128
Discounted cash flow	₹18,95,537	-₹6,33,193	-₹6,12,198	-₹5,92,305	-₹5,73,462	-₹5,55,621
NPV	-₹10,71,241					

So let us go back to the excel sheet now. So in the excel sheet what you see here is the revenue that you would be coming in the form of the cost savings in terms of the lowering of the electricity bill. The cost in terms of the increased cost because of the maintenance and insurance of the solar plant that you would have. Further you would have a loan payment that would be for the next 6 years.

So I am just putting in here. So this remains the same. Further the tax code allows you a tax credit of around 30% of the total investment. So we have made an investment of around 36 lakh rupees in the year 0 and 30% of that would be around 10,80,000 rupees and that is what the tax credit I have assumed. Further you can also have a reduction on the interest that you pay on the loan that you have taken. So the interest that I would be paying is given in this column which starts at around 2 lakh rupees reduced to 1.7 lakhs and the tax that I would have to pay on that particular amount is around 30%. So 30% was the marginal tax for the homeowner that I have charged.

So, I am just taking a tax saving of 30% of the interest. So this is the interest on which I would have to pay the tax initially but because of the tax loss I have been given the liberty of avoiding that tax and this comes at around 30% of the cost and this tax saving would also happen for the next 5 years or so. So the cash loss if I would have to assume would be a total of the revenues subtracting the cost then the loan payment which I would be making is also a cost for me. The tax credit is an advantage that I accrue just in the first year which is 30% of the investment that I am making and further I am also saving the tax that I would have to pay because any interest on the loan that I have taken is not taxable. So I add all these entities and this gives me the cash flow and I do this for the next 5 years and I would also want to repeat that this calculation I have made it a bit simple. Originally the life of the plant is 30 years but because I have taken the revenue and the cost remains almost constant for the 30 years I have just taken the NPV in the first year to simplify the calculation and because the taxation would change only for the first 6 years I am just in the calculation I am just assuming the first 6 years.

Whereas if you see the cash flows you might would want to do the cash flows for the exact 30 years but the results more or less remain the same. Now I would also want to discount this cash flows and the discounted that I would have chosen is around 5% and this is raised to the year so I am just increasing that and this are my discounted cash flows and finally I add them all of them and this gives me the NPV and it comes out to be positive which means as a homeowner it would be profitable for me to take up this kind of investment and I would love to take this investment but again we need to understand that in this case again we are relying a lot on tax credits. In case the tax credit that was offered by the government was to be 0 and we can see the NPV comes out to be negative and I as a homeowner might not want to adopt this kind of investment. So with this example and the previous example we have tried to understand the application of different kinds of government incentives and the effect that it would have on the picking up of renewable energy plants.

In Rupees	0	1	2	3	4	5
Revenue	₹ 30,59,600					
Cost	₹ 5,08,720					
Loan Payment	₹ 7,15,949	₹ 7,15,949	₹ 7,15,949	₹ 7,15,949	₹ 7,15,949	₹ 7,15,949
Tax credit	₹ 10,80,000					
Interest deduction from taxable income	₹ 60,606	₹ 51,096	₹ 41,001	₹ 30,282	₹ 18,902	₹ 6,821
Cash flow	₹ 29,75,537	-₹ 6,64,852	-₹ 6,74,948	-₹ 6,85,667	-₹ 6,97,047	-₹ 7,09,128
Discounted cash flow	₹ 29,75,537	-₹ 6,33,193	-₹ 6,12,198	-₹ 5,92,305	-₹ 5,73,462	-₹ 5,55,621
NPV	₹ 8,759					

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So here you have again the cash flows and we try to understand like these kinds of projects could be taken up or could be avoided based upon the government incentives so it becomes really important to form the government to come up with policies that encourage more and more renewable energy projects to be taken up and we have already tried to understand the justification for these kinds of incentives. With this we would like to end today's class and in the future classes we will take a few more case studies to try to understand the economics of renewable energy project. Thank you.