# MINERAL ECONOMICS AND BUSINESS

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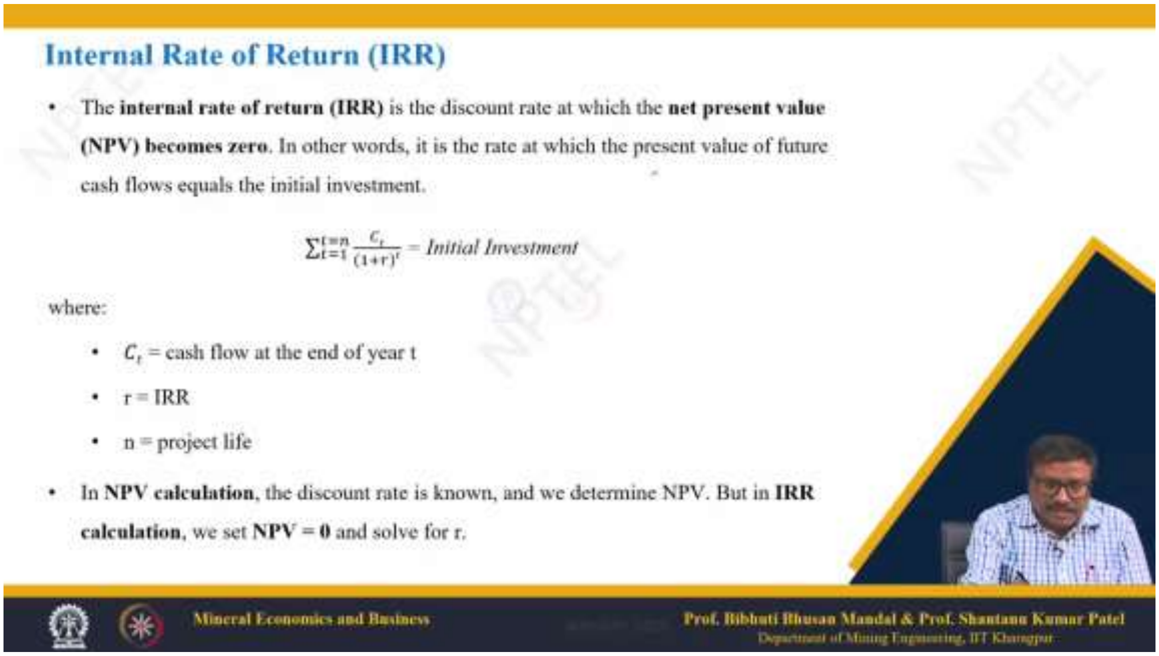
**Week 8**

## Lecture 38 : Modified Internal Rate of Return (MIRR)

Hello, I am Professor Mandal from the Department of Mining Engineering, IIT, Kharagpur. Today, I am going to talk about the modified internal rate of return. We have studied the internal rate of return or IRR, which is a key concept in economics, especially in mineral economics, but there were certain problems related to IRR. So, we are going to learn something that has been modified—a better approach known as the modified internal rate of return. So, the concepts that will be covered are a brief review at the beginning about the IRR or the internal rate of return, and then we will talk about the modified internal rate of return or MIRR.


Let us first review the IRR or the internal rate of return. The IRR is the discount rate at which the net present value becomes 0. That is the basic concept: we can test the equation, which we will recall now, and with different values of R, we can find out where the NPV becomes 0. So, in other words, it is the rate at which the present value of all future cash flows equals the initial investment.




These are the summation of all future cash flows, and this is the initial investment.

$$\sum_{t=1}^{t=n} \frac{Ct}{(1+r)^{\wedge}t} = Initial\ Investment$$

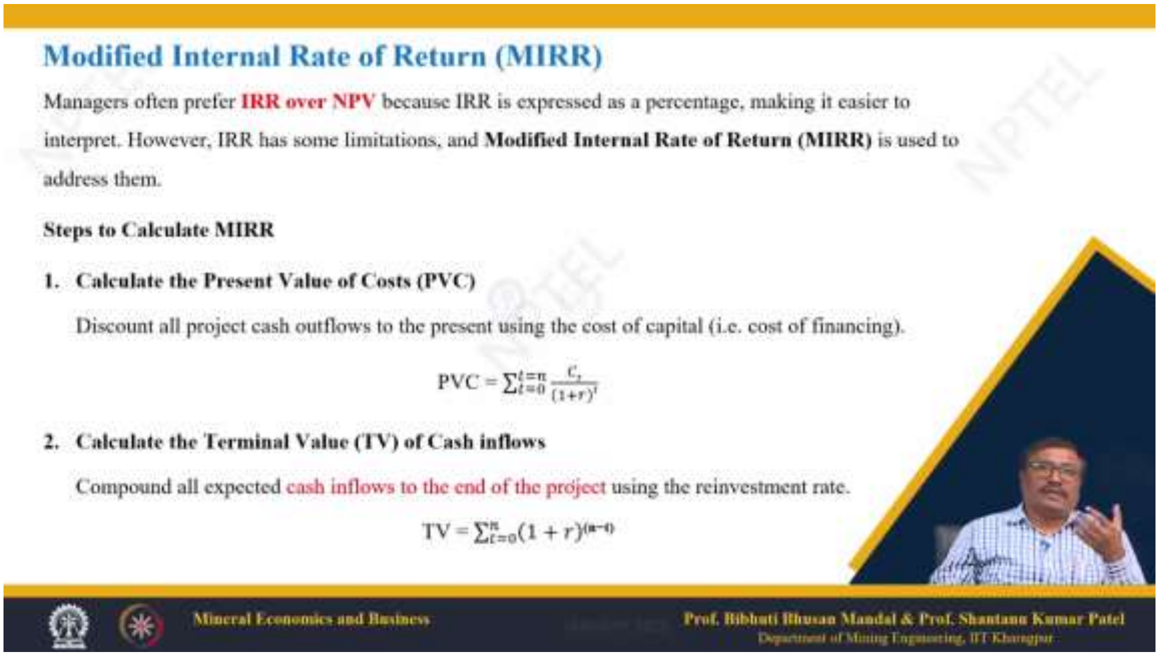
where:

- $Ct$ = cash flow at the end of year t
- r = IRR
- n = project life
- In **NPV calculation**, the discount rate is known, and we determine NPV. But in **IRR calculation**, we set **NPV = 0** and solve for r.

This is what I taught, what we learnt in the last lecture. Now this IRR is widely used for investment evaluation, but it has some limitations that can lead to misleading conclusions like this is where the MIRR comes into play. The key issues with IRR are number 1 unrealistic reinvestment assumption. We assume that all the project cash flows are reinvestment at the internal rate of return itself, which is often impractical. So, on the that basis IRR is calculated.

So, it is it has no absolutely practical basis, but of course, there are still relevance, but there is something related to the problems of assumption of all project cash flows being reinvested at the IRR itself. Secondly as we have seen in one of the problems that the when we solve the equation then we can we may find  ah multiple ah IRR. So, ah because of the switching between the positive and negative ah cash flows this can happen in the ah when when you try to find a solution for IRR. So, that makes the decision making difficult. you have one practical one is very unrealistic very high 400, 500 like that.


So, that we can take for assumption, but in practice when you have multiple IRR definitely you have the problem of taking a decision as to which value is correct. Secondly, ambiguity in the ranking of projects. When comparing mutually exclusive projects, IRR may not always select the most value adding project. This will give you two different IRRs, two different projects will give you two different IRRs, but it will not talk about the value addition to the project. So, it will give you only percentage.




So, this is giving you 10 percent, 12 percent IRR, and the other one is giving you 17 percent IRR, but the IRR itself does not give you anything that talks about the value addition to any project. But still, managers would prefer IRR over NPV because IRR gives a percentage value. So, you are getting something that makes it easier to interpret, but it has some limitations, and the modified IRR is used to address all these things. Now, let us calculate, let us write down the different steps to calculate the MIRR. First thing, this is one of the key aspects of the calculation of MIRR.

First thing is to find out the present value of costs, that means, the cost of financing or cost of capital:

- $PVC = \sum_{t=0}^{t=n} \frac{C_t}{(1+r)^t}$

So, discount all the project cash outflows in the beginning, the investment to the present, using the cost of capital. That means, all the cash outflows will be brought back to the present values using the cost of capital or, as it is, practically the cost of financing. Here, what we can see is the present value of all costs.

So, this is called the present value of cost or PVC. Now, for the cash inflows, that means, the revenue earnings, cash inflows. We compound all expected cash inflows to the end of the project. That means, say if it is here, so all these cash outflows generated are taken to the end of the year and then we sum them. So, it gives you the terminal value of the cash inflow.

Tterminal value of the cash inflows. So, now this is this can be expressed as TV (terminal value):

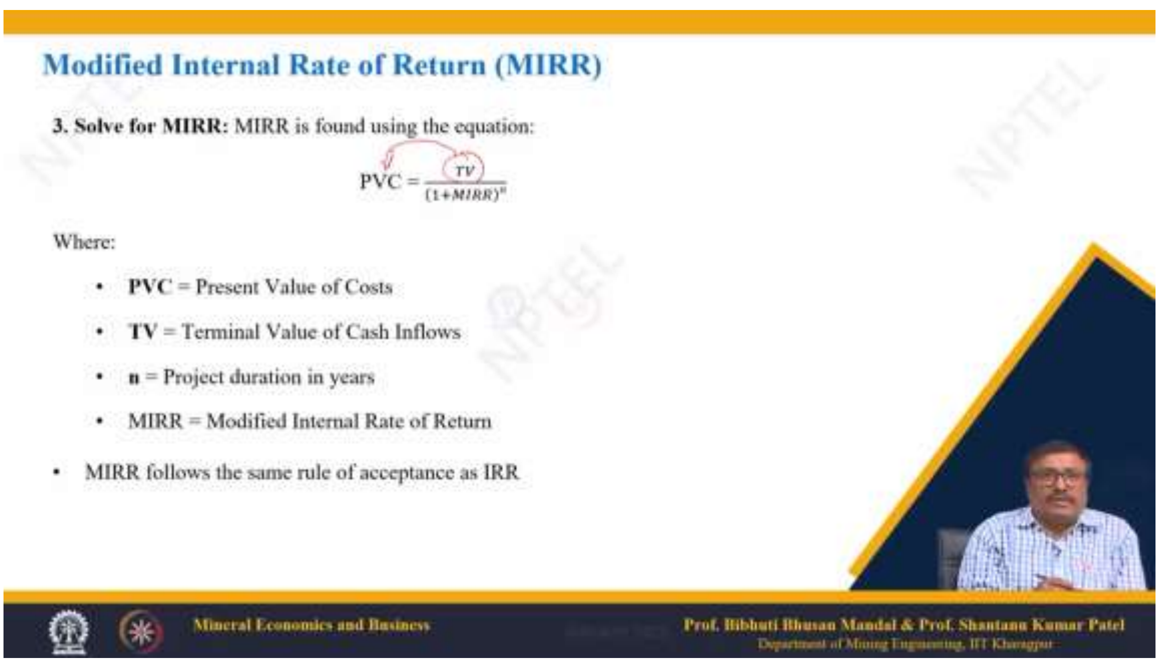
$$TV = \sum_{t=0}^{n}(1+r)^{(n-t)}$$

Where,

n = the life of the project life of the mine

t = the year where we are speaking now at the moment at any point of the calculation.

So, we got one is the present value of all cost and the other is the terminal value of all cash inflows. So, now what we use that what we do that all the terminal value is again brought to the present value with using the hypothetical MIRR as the rate of return. all the terminal values the total terminal value is brought to the present value using an imaginary MIRR which we will find out now.




So, what happens in this case the present value of the all cost is equating the present value of the terminal value of all cash inflows. So, this is the concept. So, see the PVC this one is the present value of all cost and again in the equation you see the TV is the terminal value of all cash inflows and now we are transforming this in the present value over a period of n years and at the rate of return which is now known as modified internal rate of return, this is not IRR:

$$PVC = \frac{TV}{(1+MIRR)^n}$$

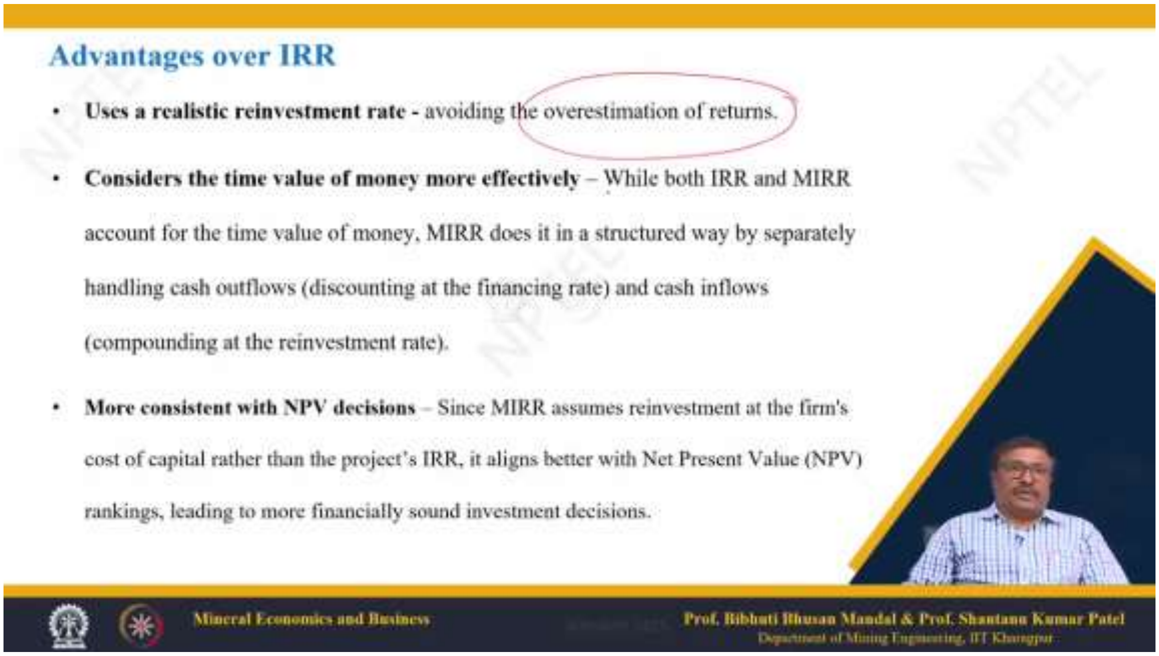
Where:

- **PVC** = Present Value of Costs
- **TV** = Terminal Value of Cash Inflows
- **n** = Project duration in years
- MIRR = Modified Internal Rate of Return

So, the when you get the value of MIRR, the acceptance that means, when you reject, when you accept, when you cannot take a proper decision, the rules are same as IRR.

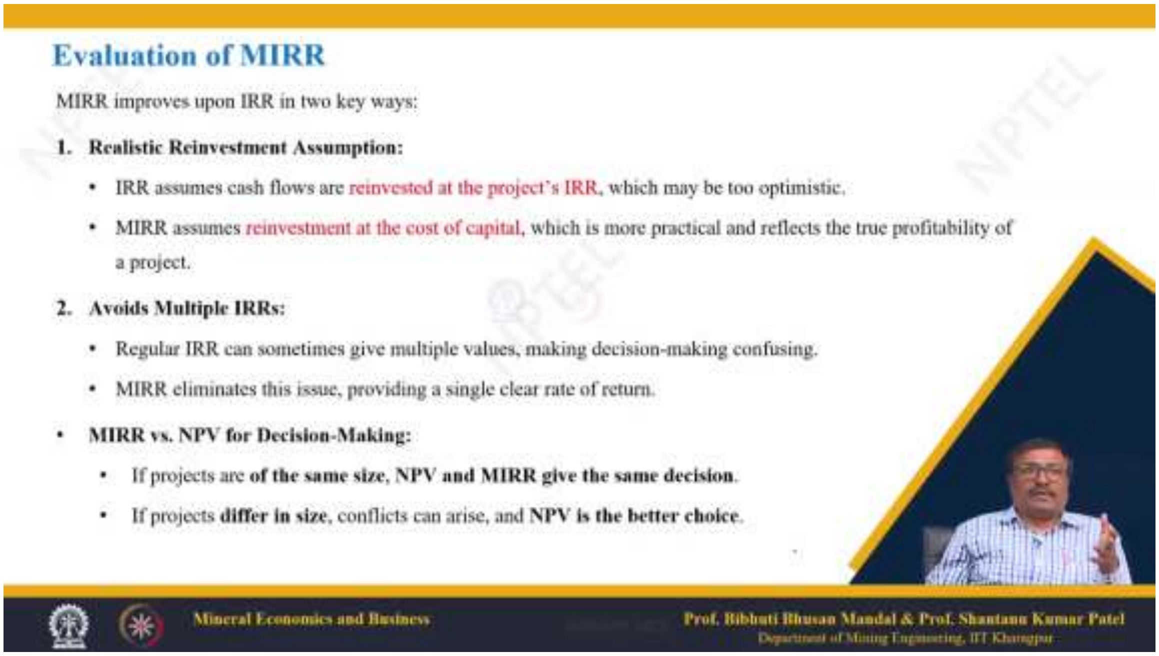
What are the advantages over of MIRR over the internal rate of return? First thing it uses a realistic reinvestment rate avoiding the over estimation of the returns where we say that they are reinvested at IRR which is not always true. It also considers the time value of money more effectively. While both so as as as as we are we are saying here that while both IRR and then MIRR account for the time value of money, MIRR is is doing it in a structured way by separately handling cash outflows first thing which we do by discounting at the financing rate that means cost of financing cost of capital rate and the cash flows cash inflows are dealt with using the compounding at the reinvestment rate, reinvestment rate.

So, we are dealing it separately. We are giving equal and importance of time value of money while calculating the PBC and the terminal value both. So, this is more consistent with NPV decisions. So, since MIRR assumes reinvestment at the firm's cost of capital. rather than the projects IRR.

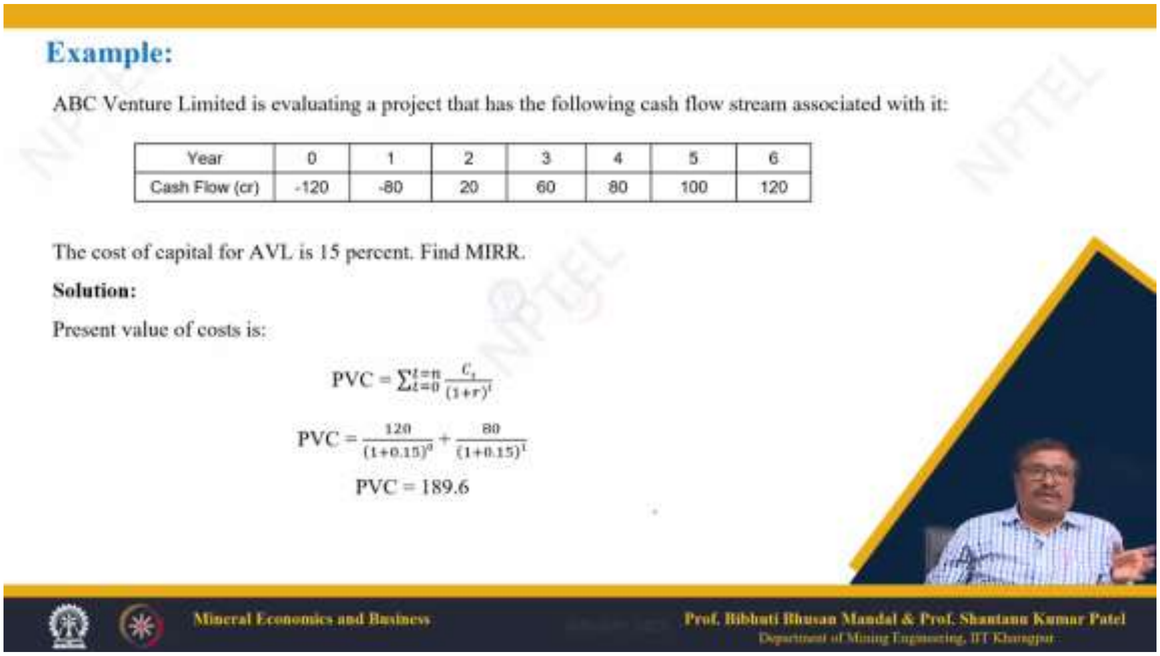



So, it aligns better with the net present value ranking and leading to more financially sound investment decision. So, it is since aligning more with the NPV. So, it is in a way it is a better tool for taking decisions as to whether to accept or reject and on what basis you are taking this decision. Now, the evaluation of MIRR just to understand the MIRR, MIRR over IRR. So, let there are at least 2 keys, 2 points, 2 important points

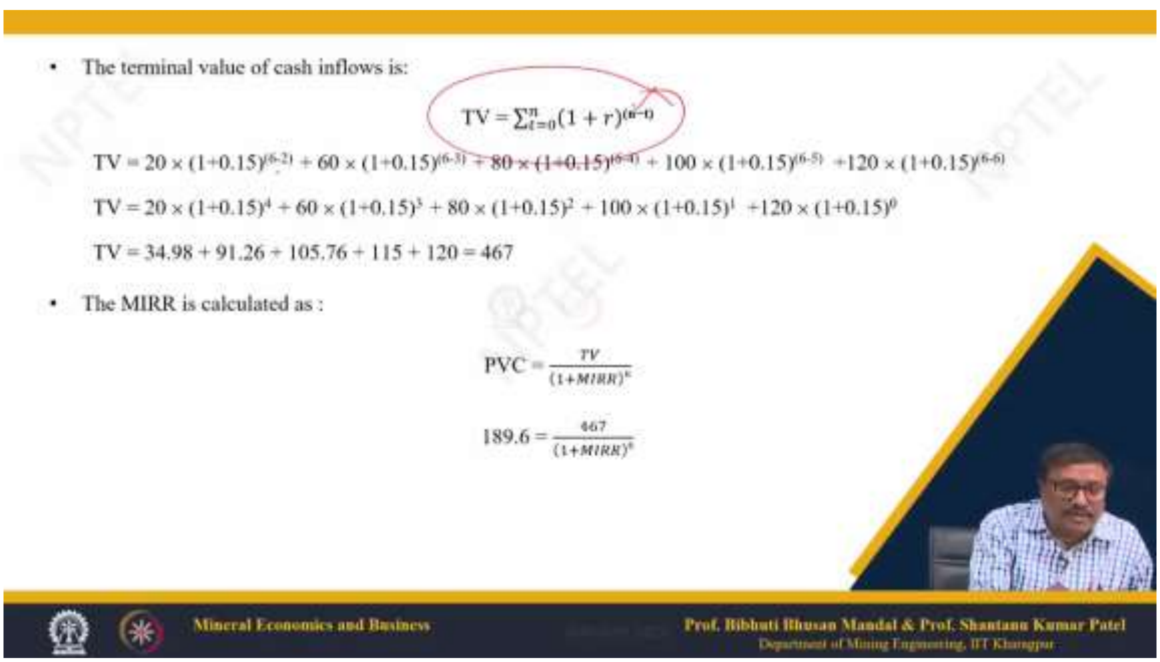
Remember, one is the as I said realistic reinvestment of assumption IRR assumes cash flows are reinvestment at the projects IRR which may be too optimistic as I said. Again, MIRR assumes the reinvestment at the cost of capital which is more practical and reflects the true profitability of the project. So, MIRR is more practical compared to IRR, it avoids multiple IRRs you get a single value. So, MIRR eliminates this issue and you get a single clear rate of return that is all. For MIRR and NPV for decision making, if the projects are of the same size, NPV and MIRR give the same decision.



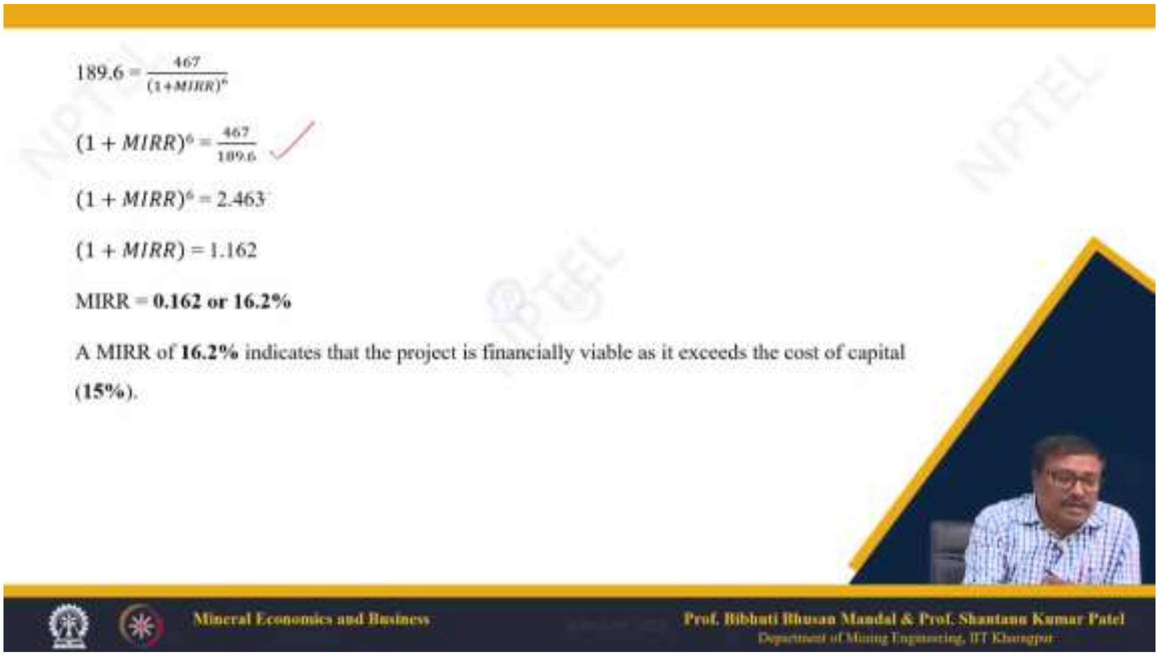

But if the projects differ in size, conflict can arise, and it is better to go by the NPV, that means the value addition, instead of going by simple return. Value addition is a better method here. We will take examples 1 and 1 or 2 and try to understand how to apply the concept of MIRR. Now, this ABC Venture Limited is trying to evaluate a project that has the following cash flow stream associated with it. We are not using any crores or lakhs here, just the conceptual thing. Year 0 we have a cash outflow of minus 120, then year-wise 1, 2, 3, 4, and 5. Year 6 is the life, and the cost of capital for AVL is about 15 percent. We have to find out the MIRR, modified internal rate of return. So, the present value of the cost is given by PVC, as we have seen in the beginning, and here we are trying to find out the value of PVC. So, the 120 is in the first year, there is a cash outflow; in the second year also, we have a cash outflow. So, these two we are bringing to the present value. At 15 percent is not the discounting rate truly; it is the cost of financing or cost of capital.




So, this is more realistic. So, here we are bringing down, bringing this 120 and 80 to the present value of cost, and we are getting the PVC as 189.6 here. In the next step, we talk about the terminal value. The terminal value of the cash inflow is given by this equation. Terminal value equals to t 0 to n 1 plus r raised to the power n minus t. So, here we have to think about all the cash inflows that we have: 20, 60, 80, 100, and 120.

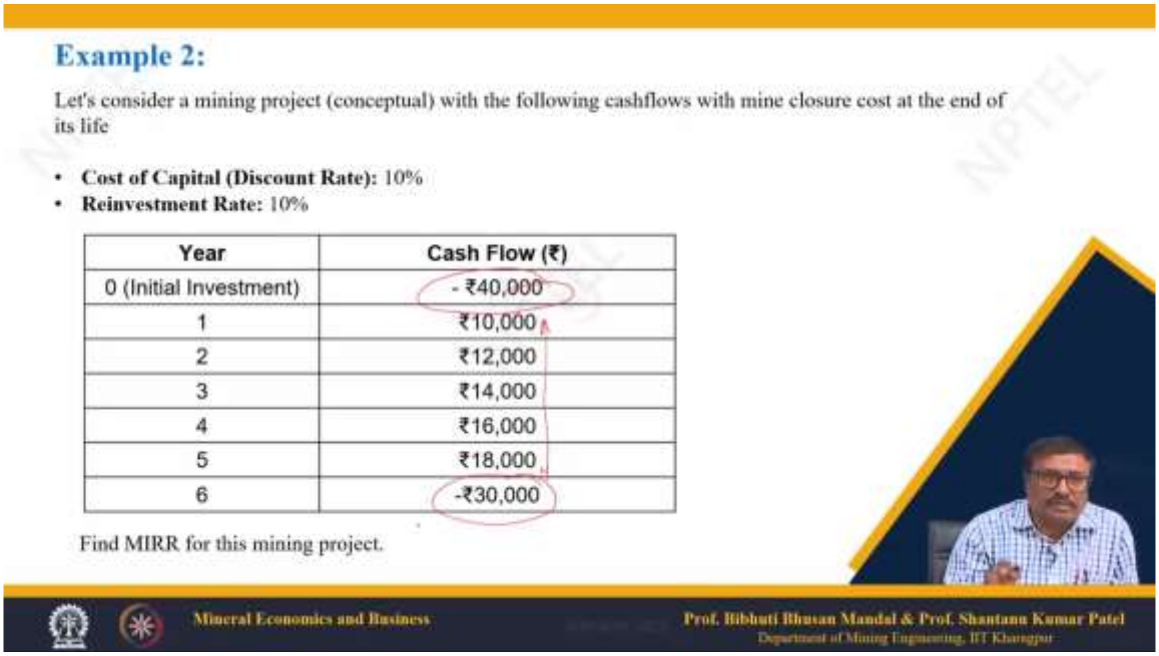


This we have to take it to the end stage that means the terminal value. So, as you can see that we are gradually reducing from here 6 minus 2, 6 minus 3, 6 minus 4, 6 minus 5 and 6 minus 3 this is the last one. So, this is how we are taking this all this present all this cash inflows to the terminal value end of the life of the project life of the project. we are simplifying all these calculations just by  the calculation is shown here and the terminal value is 467.




So, what we have to do now, this terminal value has to be transformed or rather converted to the present value. using or imagining the MIRR. So, what is that rate of return? That rate of return which makes this PVC and the terminal value equal provided that the terminal value is converted to the present value using this MIRR. So, now, we replace this 189.6 for PVC and 467 for the terminal value divided by 1 plus MIRR, rest to the power 6 is the life of the product.

Now solving this, we get that now just by  slightly manipulating 1 plus mi r r raise to the power 6 is this and from there we get 1 plus mi r r, the modified internal rate of return is 1.162 to minus 1 is 0.162. Or in terms of percentage, we get that MIRR equal to 16.2 percent. This MIRR of 16.2 percent indicates that the project is financially viable because the cost of capital or the cost of financing was 15 percent. our MIRR, MIRR is greater than cost of capital, cost of capital. So, we can accept the project as financially viable based on the MIRR.



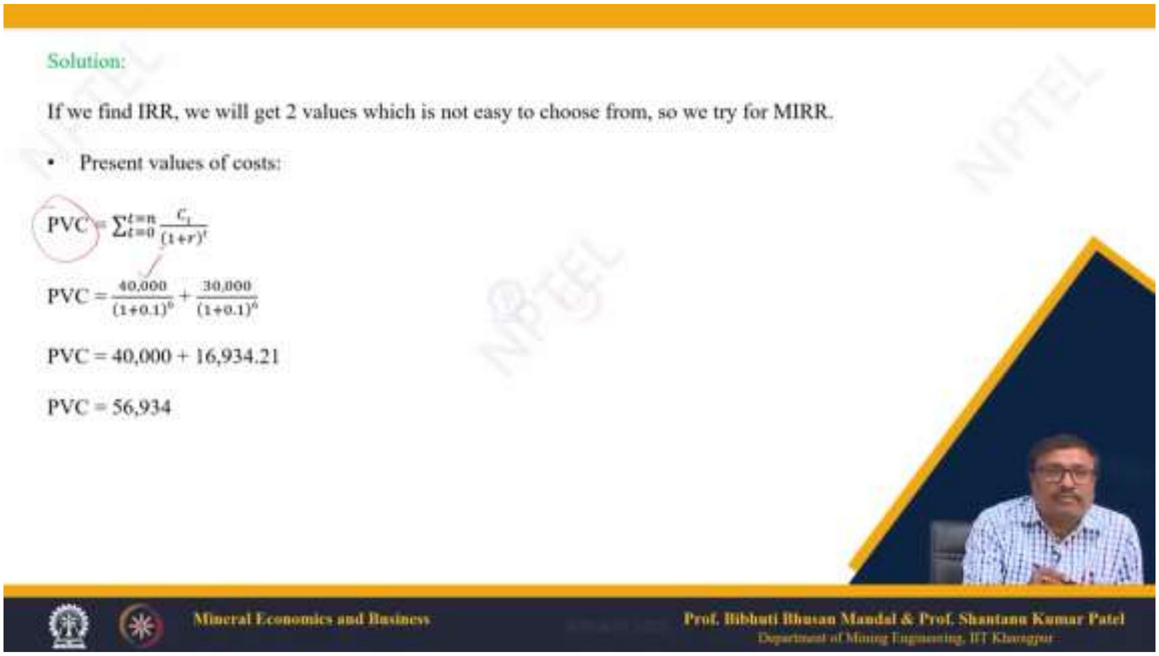

Let us take one more example. Here we have a mining project conceptual with the following say cash flows with mine closer cost at the end of its life figures are not absolute this is only to explain. Now In the initial year we have say 40,000 as cash outflow and in between we have the cash inflows 10,000, 12,000, 14, 16 and 18 and then it becomes 30,000 cash outflow for the closer cost. This is only conceptual again I am telling do not take these values as absolute value

we are finding out the MIRR for this mining project. For example, if we find IRR we will get two values, if you do it yourself you will find two values which is not easy to choose from. So, we try for say MIRR a better indicator. What are the present values of the cost? The PVC is:

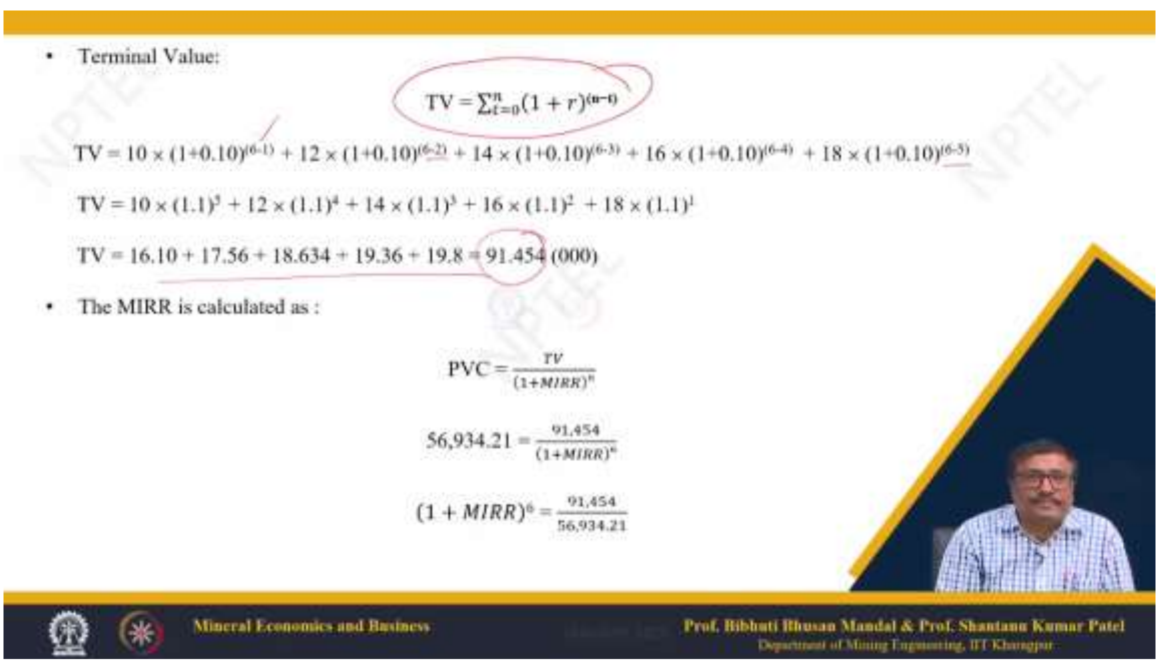
$$\text{PVC} = \frac{TV}{(1+MIRR)^{n}}$$

We have 40000 cash outflow and at the end we have 30000 cash outflow. So, we transform that to the bring it to the present value, bring it to the present value and we get 56934 as the present value of all cost, present value of cost. Now what is the terminal value? The terminal value is given by:

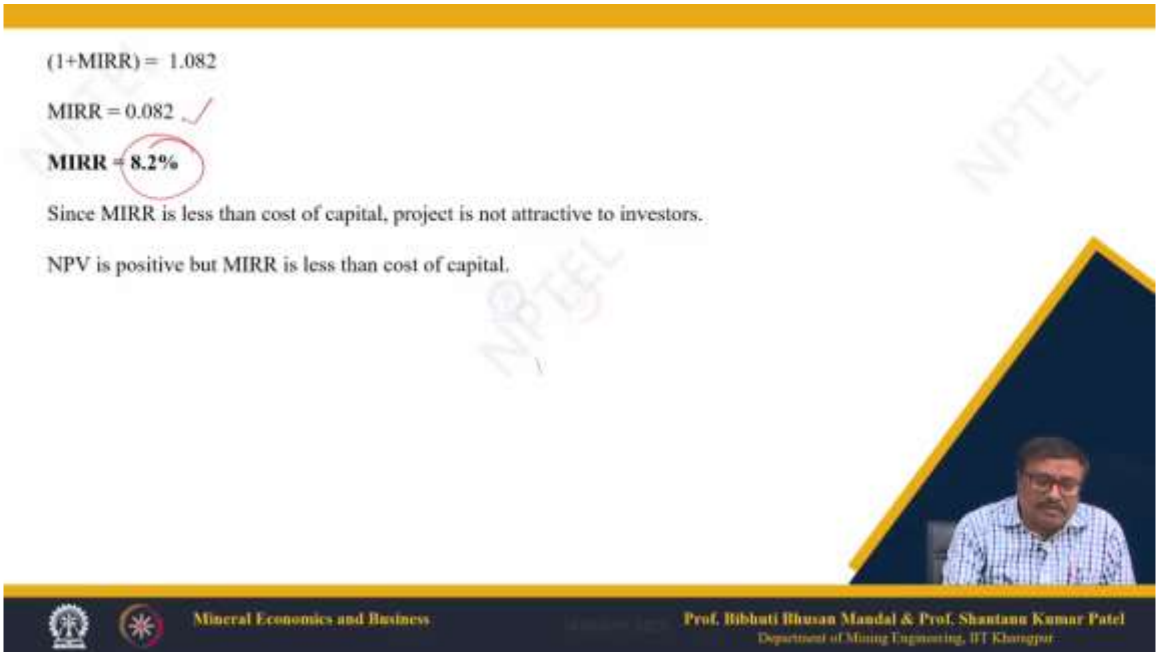
$$TV = \sum_{t=0}^{n}(1 + r)^{(n-t)}$$




Now for the first year we use 6 minus 1, then here for second year 6 minus 2 like that at the end we use 6 minus 5. So, here we get the terminal value, total terminal value just by calculation, we get 91454, 454 this is the terminal value. Now, what we do?



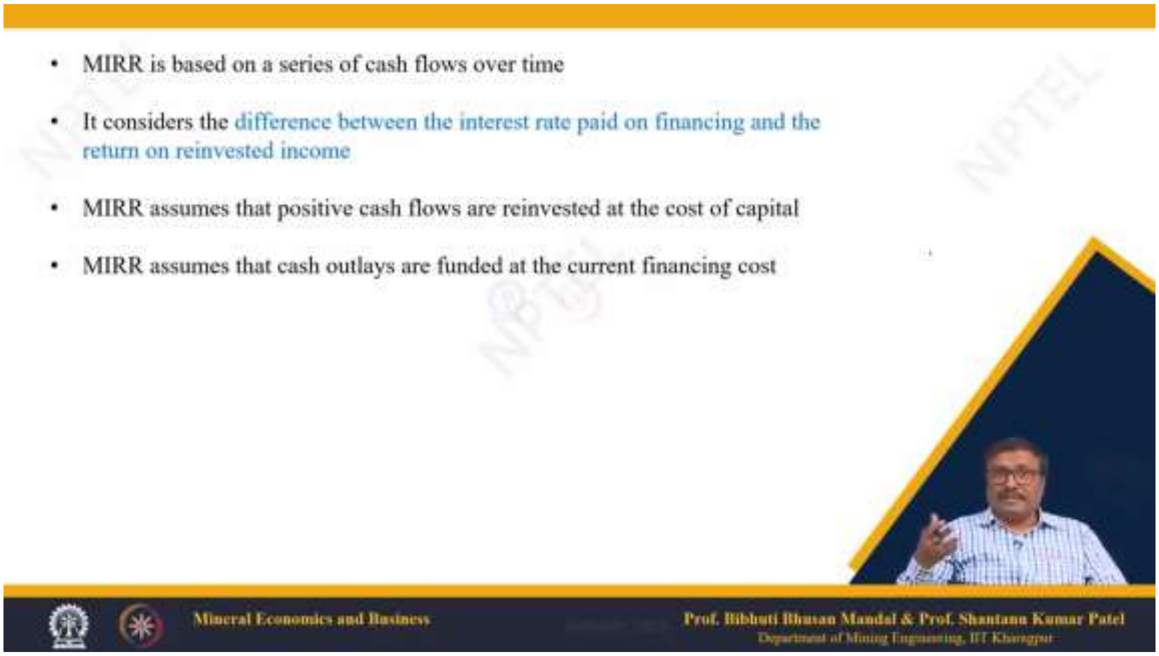

We take this terminal value and we assume that there is something MIRR. So, the PVC will be equal to the terminal value divided by 1 plus, say we take a big R as the MIRR raised to the power n. So, this is the typical formula where we see the present value of cost. So, the future cash inflows are here; the terminal value of all cash inflows is now converted to the present value over the period of n years, that is, we are equating it with the present value cost. If you do that, then and replace this value by, say, PVC with 56,934 and here 91,454 and solve this, you get the internal rate of return as 0.082, which is nothing but 8.2 percent.




Remember that the cost of capital, as we have seen before, the cost of capital as we have seen here is this, or the discount rate here is 10 percent. So, but our calculation shows that the internal rate of return, modified internal rate of return, is 8.2 percent. So, the MIRR, let us denote it as R, which is 8.2 percent, and the cost of capital was actually 10 percent. So, the MIRR is less than the cost of capital, which, in the beginning, we have written as 10 percent.

So, what do we do? We take a decision: the project is not attractive to the investors. Net present value is positive, but MIRR is less than the cost of capital. So, we take a decision on MIRR here. There is no confusion in this aspect.

We try to summarize what we learned: MIRR is based on a series of cash flows over time. It considers the difference between the interest rate paid on financing and the return on the invested income. Here, the difference between the interest rate paid on financing means the cost of capital or cost of financing, and the return on the reinvested income is again transformed to the last terminal value using that return rate. Then, we bring all the terminal values together to the present value and equate them. MIRR assumes that the positive cash flows are reinvested at the cost of capital.




It also assumes that the cash outlays are funded at the current financing cost, which is more practical compared to IRR. So, we consider MIRR as more practical. IRR is definitely widely used, but MIRR has better practical aspects in application. Often, we also get confused about which method to use—whether to use NPV or MIRR. The same problem was there with IRR as well.

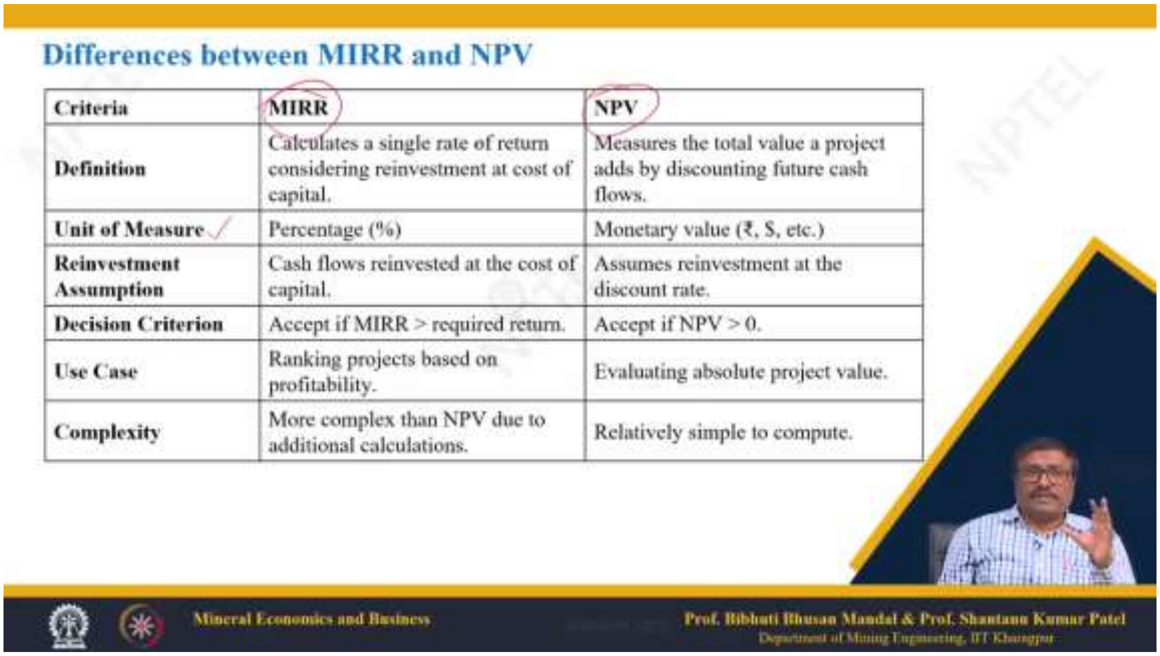
Here also, we have the same You can use MIRR when comparing multiple projects with different cash flow patterns and investment scales. So, you get only a percentage return from MIRR. In that case, it is easy to compare between different projects. So, this gives you a percentage, which is more useful.

So, that way you can make a decision. But, if you want to see if you want to maximize the firm value in absolute terms, that means, then not only does the MIRR have to be more than the cost of financing, maybe marginally, but we will see that the NPV is showing the addition of value to the firm. So, we will see where we can maximize the firm value. So, we should look at the NPV.

And what we say ultimately is that the best approach there for getting a complete financial picture and taking a more realistic, more dependable solution or decision is that you look at both the NPV and MIRR. If the two projects again have the same NPV but different MIRRs, the project with the higher MIRR is more efficient in capital utilization. But if a project has a high MIRR but a low NPV, it might not contribute much to the value, as I have explained earlier also. So, we can summarize in a tabular form the differences between MIRR and NPV, like criteria, definition, unit of measure, all these things. So, here we see MIRR and this side NPV.


So, MIRR calculates a single rate of return considering the reinvestment at the cost of capital. This we are seeing right from the beginning, which is totally different from the concept of IRR. NPV measures the total value of the project added by discounting future cash flows. And the unit of measure in MIRR is just like a percentage, like IRR, whereas this gives you a monetary value, dollars or rupees. So, what are the reinvestment assumptions here? MIRR gives you the cash flows, assuming that the cash flows are all reinvested at the cost of capital.

But, here it assumes reinvested at the discount rate these 2 are different in NPV and MIRR. The decision criteria we accept the if the MIRR is greater than the required return as we have seen through the examples. Here also we accept if NPV is greater than 0 that is positive value. Why do we utilize? Why do we prefer?




MIR is preferred when we try to rank projects, different projects based on the profitability, percentage data. Here, we are more interested in the value addition. So, we evaluate the absolute project value, how much it is adding to the firm value, NPV, not exactly how what percentage, what percentage, but the total amount that is being added. The complexity, it is more complex than NPV due to additional calculations of different discounting rate, cost of financing and again rate of return. These things are little complex, but more practical, this is relatively simple to compute

as compared to MIRR as we have seen. So, these are the basic differences or rather similarities between MIRR and NPV. We can conclude that in case of confusion, dilemmas you can look at both the matrix like the MIRR and NPV both when there is a confusion as to which one is to be believed. it is a very critical one you can go by in specific case when you need the percentage you go by MIRR when you need by value addition then you go by your NPV. So, in both the cases

We see that both can give you the decision-making strength. That means you calculate all these things and try to find out what the modified internal rate of return is. Also, you can see the NPV. So, depending on the criticality, you can choose either or both at the same time. Thank you very much.