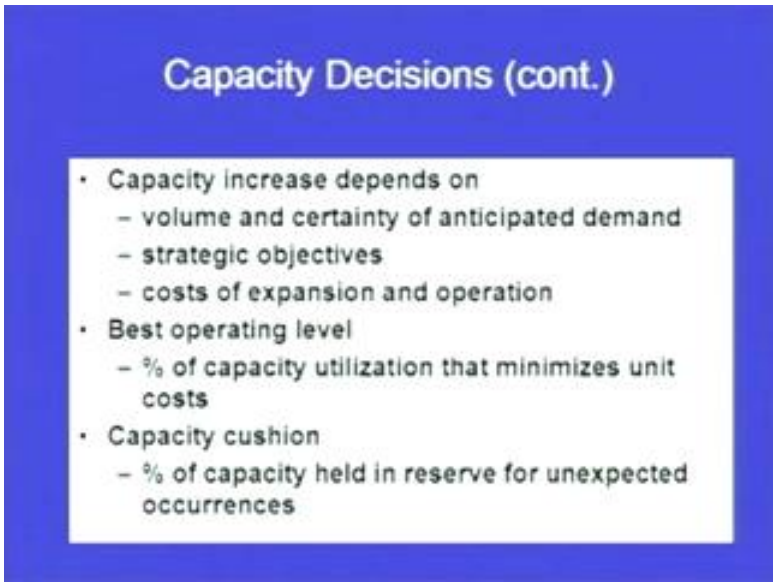
Industrial Engineering
Prof. Inderdeep Singh
Department of Mechanical and Industrial Engineering
Indian Institute of Technology, Roorkee

Module - 04
Lecture - 07
Capacity Planning – II

A very warm welcome to you, in this second lecture on Capacity Planning, in the first lecture we have seen what do we mean by capacity, what is productive capacity or producive capacity, what are various types of capacity, what are the different measures of capacity. We have seen that what is the economies soft scale, what is the diseconomies of scale and in the discussion on economies and diseconomies of scale, we have also seen that what is the best operating level.

We have also seen what are the measures of capacity, input measures of capacity, output measures of capacity. And we have seen that how capacity can be measured in different sectors, we have a taken examples of aviation industry, hospital, stadium, machines and other different types of systems in which the capacity is used. So, today we will discuss certain problems related to capacity planning, certain problems, certain tools which are used in order to take the capacity decisions, so let us first start with the capacity decisions.

(Refer Slide Time: 01:45)



Now, capacity increase depends on volume and certainty of anticipated demand, so volume and certainty of anticipated demand means, that I have given an example that most of the automobile companies, these days may be thinking that with the sixth pay commission coming into picture, the demand for the automobiles is going to increase in the financial year 2008, 2009. So, anticipated demand is more, so this would dictate the capacity requirements of the auto manufacturers in the country.

So, capacity increase depends on the volume and certainty of anticipated demand, so they are very, very set on the auto manufacturers are very, very certain that the demand is going to increase, in this particular financial year. So, certainty of demand is there and the volume also they can foresee because, most of the government employees are going to get their areas. So, they may think of buying the automobiles or the cars, so the demand or the volume is going to be more, as well as it is certain that the demand is going to increase.

So, the volume is going to increase and it is quite certain that the volume is going to increase. So, certainty of anticipated demand is also there and volume of demand is also there, so this is going to dictate the capacity decision, that most of the companies may take in order to enhance their manufacturing capability or in terms we can say manufacturing capacity. Second thing are the strategic objectives, strategic objectives means at the top level of the management, the planning is done for a long period of time, may be for another 5 years, another 10 years may be to the tune of another 20 years.

That where the company will stand after 20 years, so long range decisions are taken at the higher level of the management and these decisions are the strategic decision or the strategic planning of the company. So, certain strategic issues may be related to one particular item, which is going to be in the market in the next 5 years or the technology that is going to be develop in the next 5 years. So, in order to bring that technology in order to keep abreast with the competition that is being offered by the competitors, the strategic issues have to be taken into account.

That we should have the capacity to produce that particular item may be by 5 years or may be by 7 years. So, strategic issues are also equally important and these issues are the long term issues, which have to be addressed by the planners or by the high level managers of the organizations or the company. Then, the costs of expansion and

operations are also the capacity decisions that have to be taken, already I have told that if some new product is to be lost in the market, the decision has to be taken that what capacity we need to produce this product.

And what type of finances will be required to put this product into the market, so capacity increase depends on these three important parameter, volume and certainty of the anticipated demand, strategic objectives of the organization, as well as the costs of expansion and operation. So, these three things are going to result in an capacity increase of the organization, then the best operating level also has to be decided which is an important part of the capacity planning.

Percentage of capacity utilization that minimizes the unit costs, so in the last lecture we have seen. So, for those of you who have not gone through the last lecture, I would today also give a brief account of what is economies of scale, what is diseconomies of scale. So, those things we will discuss today also, but in a little bit more brief, so best operating level also has to be decided, so capacity decision related to the best operating level also has to be taken by the organization.

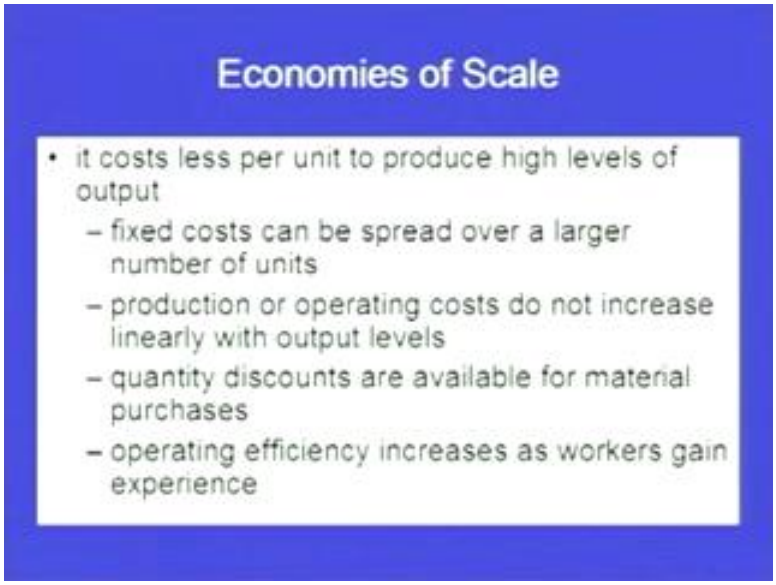
So, percentage of capacity utilization that minimizes the unit cost, so we have seen number of examples in the last lecture. Where, we have sent that there is a best operating level at which the average unit cost is minimum and beyond that the diseconomies of scale take place and the average unit cost starts to increase and this increase can be attributed to a large number of factors. So, we need to plan, we need to decide, we need to take a decision related to the best operating level of that particular machine or that particular plant or that particular capacity.

Third point is the capacity cushion, percentage of capacity held in reserve for unexpected occurrences I have already told, we have already studied the buffer stock in the inventory management to why buffer stock is kept, to this is certain capacity, which is held in reserve in order to meet certain dynamic scenario, certain dynamic changes in the demand. So, percentage capacity held in reserve, held in buffer for unexpected occurrences.

So, certain dynamic occurrences may take place there may be a sudden change in the demand, sudden abrupt increase in the demand, which we need to meet. So, certain

capacity will be kept in reserve, so that is the capacity cushion, now again revising what we have covered in the last class coming onto the economies of scale.

(Refer Slide Time: 07:43)



So, it costs less per unit to produce high levels of output, if you remember when on x axis, when we see output is there or the volume is there, on y axis we have the average per unit price, average per unit price or average per unit cost. So, we have seen that average per unit cost decreases as the volume increases, so why does that take place, fixed costs can be spread over a large number of units.

Now, we have spent certain amount of money in purchasing the raw materials, in purchasing the machines, in buying the land on which we have installed the factory. And there may be certain other infrastructural cost associated, which we can term collectively as the fixed cost. So, this fixed cost now which is excludes the may be the cost of raw material, the fixed cost in terms of machines, building, etcetera, now is spread over a number of products.

So, initially may be for 100 products this cost was added to the cost of 100 products as the volume is increasing now instead of 100 we are producing 500 units. So, this cost will now be spread on 500 units, so the total cost of the product is going to decrease. So, this is going to result in the average decrease or average per unit decrease in the cost of a product. So, the total cost is getting spread out, that is why the cost is average unit cost is decreasing.

So, fixed cost can be spread over a large number of units, which I have already explained, production or operating costs do not increase linearly with output levels. So, once the production facility is there, the cost of setting of the production as well as producing the particular component do not vary linearly with the output, so if the output is increasing the production and operating cost may not vary linearly.

So, it is it may, so happen that the unit cost is decreasing, as the volume of products is increasing. Because, the production and operating costs are not going to vary linearly, this may be increasing, but at a slightly slower rate, third is quantitative discounts are available for material purchase, if you remember the lecture on inventory management, in which we have discussed at length the quantitative discount. So, when large amount of material is being ordered, we get certain amount of quantity discounted and these quantity discounts reduce our raw material cost.

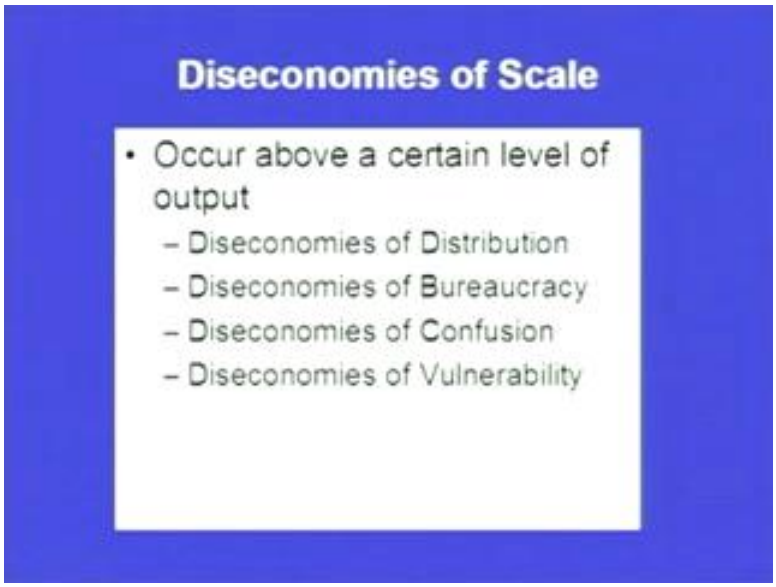
So, when we are buying more raw material and we are getting a discounted on that, so the per unit cost of the raw material is going to decrease. So, availing the quantity discounts and decreasing the cost of the raw material, that is going into the final product will also result in the decrease of unit cost of the product, when the volume of the product increases, moreover operating efficiency increases as workers gain experience.

So, as more and more products or more and more volume of products is being produced, the workers are gaining efficiency. The workers are getting more and more efficient, they are getting more and more use to the kind of work, so the rejections are less the rejection rate is less, more and more efficient production is taking place. And therefore, the unit cost of the product is decreasing, as the volume of the product is increasing or the number of products produced is increasing.

So, the unit cost is decreasing, so all these four points help us to understand that why the unit cost decreases, as the volume of production increases. Now, we can now come onto the diseconomies of scale, so this occur above a certain level of output, so that level of output usually we call as the best operating level. Now, beyond the best operating level diseconomies of scale take place, before that economies of scale take place, now diseconomies of scale, so why does this happen.

So, there are certain points that we need to address in order to understand that this economies of scale. So, this occur above a certain level of output that I have already told that is the best operating level.

(Refer Slide Time: 12:24)



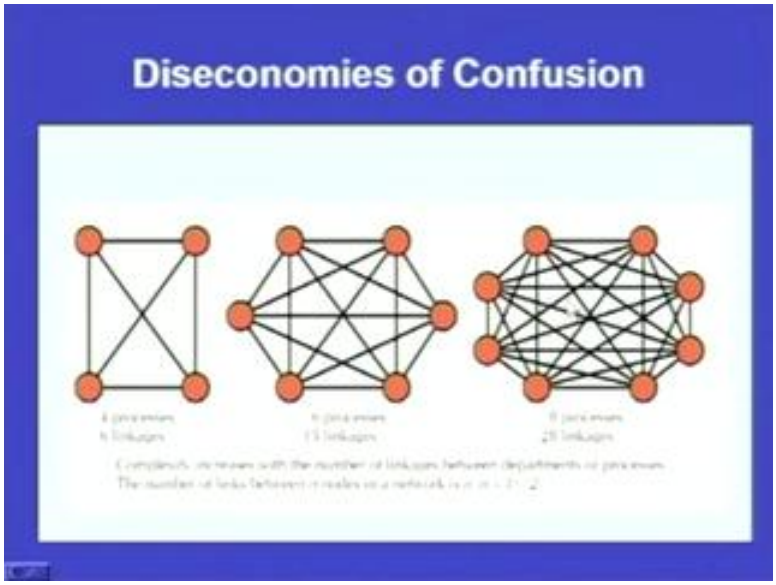
So, diseconomies of distribution, so distribution may not be appropriate, may not be optimal. So, if optimal distribution is not there, the cost is going to increase, this economies of bureaucracy which need not explain, the bureaucracy word itself tells that there may be certain official hassles, certain official problems, certain official paper work, which may lead to certain kind of discrepancies, which add to the cost of the product, then diseconomies of confusion, this I will explain with the help of another slide.

So, sometimes when the products are more there is a confusion, the scheduling may not be there and there may be certain other amount of haphazard type of planning, which may not result in lowering the cost of the product, but may result in increasing the cost of the product, then the diseconomies of vulnerability. So, when the product the volume of the product is more, it is more vulnerable two different kinds of breakdown, certain wear and tear may creep in and the system may fall down or may break, under the wear and excessive wear and tear.

So, these are certain points which results in the diseconomies of scale, that is distribution, bureaucracy, confusion and vulnerability. So, when all these points are

taken care off we may further see a decrease in the unit cost of the product, but because of these reasons sometime after a definite operating level diseconomies of scale set in.

(Refer Slide Time: 14:04)



Now, on your screen you can see diseconomies of confusion, now here very first diagram, you can see there are 4 processes and there are 6 linkages 1, 2, 3, 4, there are 4 processes and among these 4 processes there are only 6 linkages. But, when the number of processes increase, you can see 1, 2, 3, 4, 5, 6, so 6 processes there are 15 linkages. And you can see when the number of processes become even more, that is 8 processes then we have 28 linkages.

So, 4 processes, 6 processes and 8 processes, so when the number of processes are increasing, the intermingling or the we can say that the confusion generated is much more and the scheduling also becomes very, very complex. So, complexity increases with the number of linkages between departments or processes, the number of links between and nodes, suppose this end and this we call as the nodes. So, 1, 2, 3, 4 in this particular system there are 4 nodes, here there are 6 nodes, here there are 8 nodes.

So, if n is the number of nodes, then the number of links is given by n into n minus 1 divided by 2. So, we can see when n increases the number of linkages will also increase, which will further lead to complicate the whole management process, so we can say that in diseconomies of scale, when the number of products produced are more or the variety

of products are to be produced, the confusion the scheduling will be very, very difficult and that will lead to the increase in the per unit cost of the product.

Now, let us take an example of capacity utilization, so till now we have identified that there is a best operating level at which we should operate in order to take advantage of the economies of scale. If we are going beyond the best operating level, the diseconomies of scale would creep in and would lead to an increase in the per unit cost of the product or the per unit cost of the item, that we are manufacturing. Now, let us come to a problem on capacity utilization, so let us first read the statement of the problem.

(Refer Slide Time: 16:24)

During one week of production, a plant produced 83 units of a product, so per week what is the output 83 units per week, it is historic best utilization was 120 units per week. So, 120 units per week has been reported to be produced, but this time only 83 units or for one week 83 units of the product has been produced, what is the plant's capacity utilization rate. So, we have to find out what is the plant's capacity utilization rate 120 it has proved it has produced at certain moment of time may be in the may be in the history, but now per week it is producing 83 units.

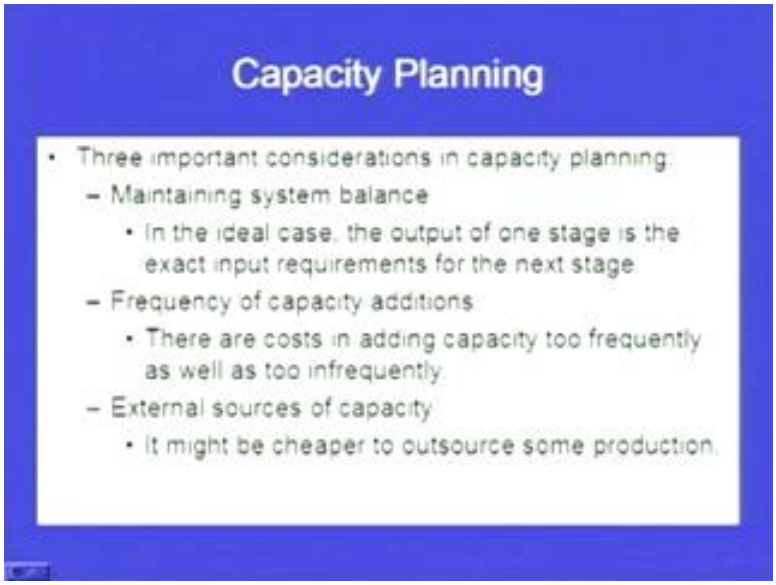
So, the capacity utilization rate on your screen, you can see is capacity used divided by the best operating level. So, 83 units per week is what is the capacity used and best operating level was 120 units per week which you has been effectively and efficiently

produced by this particular plant. So, we can say it is operating at 69 percent, so the capacity utilization rate comes out to be 69 percent.

So, it is a very simple mathematics nothing is difficult, but we such type of calculations we can think of finding out that how much is our process efficient, what is the efficiency of our process or how much is the capacity utilization are we working at a very high capacity utilization or are we under a utilizing our capacity. So, if we under utilizing our capacity, what we can do is that we can somehow think of out sourcing the capacity to some other player. So, that the capacity utilization increases and we are able to make more money out of the designated capacity, that we have developed at our premises.

So, this problem is a simple problem the problems will very, very complex a large number of other factors can also be incorporated into such type of simple problems. But, here we have found out that in a plant, which is producing 83 units of a product per week, it has shown the best operating level was 123 units per week, so we can find out that what is the capacity utilization rate.

(Refer Slide Time: 19:06)



Now, capacity planning this is the topic is capacity planning only, so the important considerations in capacity planning, now what type of considerations we have to make when we are doing the capacity planning. Three important considerations in capacity planning are, maintaining the system balance, in the ideal case the output of one stage is

exact input requirement for the next stage. So, ideal scenario is that the output of one particular shop or one particular machine becomes the input of the subsequent machine.

So, we have to maintain a balance in the capacity, it may not happen that one machine is working at a very fast pace and the subsequent machine is working at a very slow pace. So, the work in process will increase and that has to be managed and such type of imbalance will not result in a very good production rate, so we have to take care of the capacity in such a way, so that there is a system balance within the organization.

So, just to repeat the three important considerations that we have to take care in capacity planning are maintaining the system balance. In the ideal case, the output of one stage is the exact input requirement for the next stage, but in most of the companies this ideal scenario may not exist. There may be a little bit of ups and downs, like 100 components being produced on one machine and 80 components per hour being on the other machine.

So, this is working 100 components per hour, this is working as 80 components per hour, little bit of disbalance may be there. But, gross balance should not be there, misbalance should be there, so basically what do we need to understand is whenever we are doing the capacity planning, we have to maintain the system balance. Means, the output of one particular shop or machine should become the exact input to the other machine.

The second important consideration in capacitive planning is, the frequency of capacity additions, there are cost in adding capacity to frequently as well as to in frequently. So, we have to plan that at what moment of time and how much capacity is needed to be added. For example, we have seen with the change in the demand, the quantity of demand, quality of demand, timing of demand, how the capacity requirements change.

We have to take a decision, what type of capacity is required, what kind of capacity is required, how much capacity is required at what movement capacity is required and at what location capacity is required, all these points we have to bear in mind. So, we have to take a decision as a capacity planner, that when and at what moment of time the capacity has to be increased or we can say the capacity has to be decreased also. So, frequency of capacity additions, like there are costs in adding the capacity too frequently as well as too infrequently.

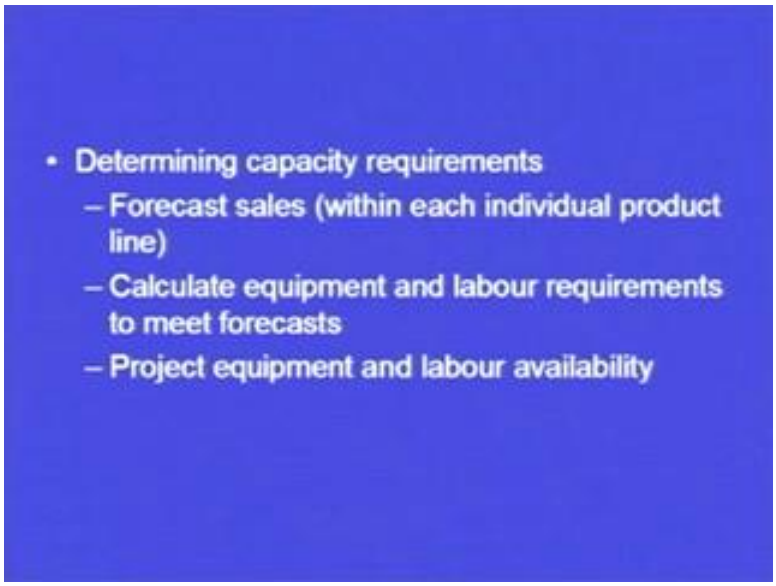
So, we have to take a judicious decision that is, if we are adding the capacity too frequently cause will be associated with it. If we are adding the capacity too infrequently, then also the cause will be associated with it, so we have to take a judicious decision that at what optimal movement of time the capacity should be adding to the plant or to the organization. So, the first point is maintaining the system balance and the second point is deciding the timing or the frequency of capacity addition.

Now, the third consideration in capacitive planning is external sources of capacity, so that is it might be cheaper to outsource some production. So, always we have to make a decision, whether to make or to buy, whether to do it ourselves or to get it done by some other sources or to outsource it to some other players. So, that kind of decision also has to be taken into account, so we have to take into account the outsourcing aspect also.

So, whenever we are taking the decision, whenever we are studying or whenever we are doing the capacitive planning, we have to take into account all these consideration. So, the first one being maintaining the system balance, second one being checking out the frequency at which the capacity additions have to take place and the third one being whether we should outsource some of our work, so that the system balance is maintained and we are not spending too much of money and time in building up the capacity.

Because, sometimes when we do the break even analysis, we find out that instead of adding onto the capacity, if we would have got this work done from some of the other players in the market, it would have been much cheaper, so those kind of decisions also have to be taken care of when we do the capacity planning.

(Refer Slide Time: 24:15)



Now, how we can determine the capacity requirements, now we have seen in the previous lecture also that it is the demand, which is going to act as one of the guidelines in taking a decision, that whether the capacity is needed to be added or not. So, when we take a decision regarding capacity requirement, the first point to be taken into account is the forecasting sale or forecasted sales within each individual product line, so there may be, so many different products there the company is manufacturing.

So, we have certain amount of forecast available for each and every product line, now depending upon the forecasts, the capacity requirements have to be seen whether the forecast is very, very positive. A large amount of products needs to be produced, if a large amount of products have to be produced, do we have the capacity to match that kind of forecast. If we do not have the capacity can we outsource it, if we are not able to outsource it can we build on our capacity, what type of capacity would be required, what quality of capacity is required, when the capacity would be required all these things will be dependent upon the forecasts, that we do for each and every product line.

So, whenever we think of determining the capacity requirement, the forecasts play a very, very important role, that is the thing that I already I have a addressed when we were studying sales forecasting. Although forecasting is the black art nobody can be very, very perfect in the forecasting, but we need to be very close to the actual demand whenever we do the forecast. If we are close to the actual demand, then our capacity

requirements, our planning will go very, very smoothly and we will be able to make a huge amount of money for our company.

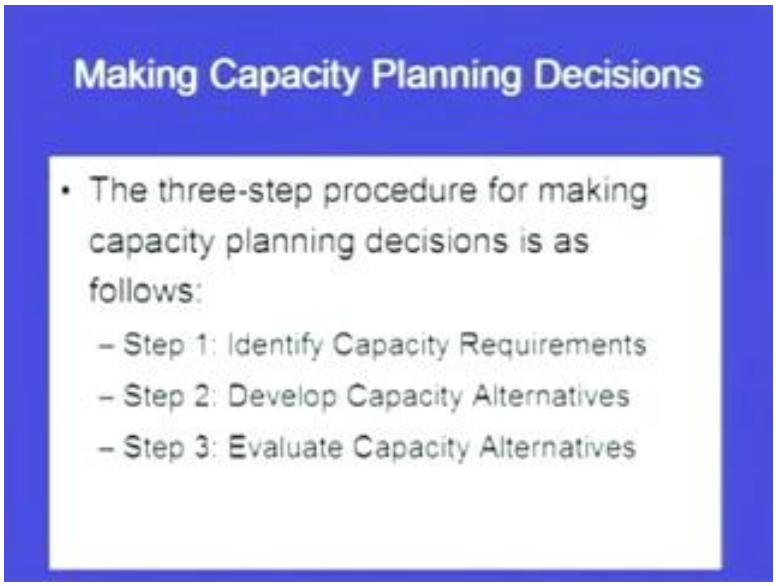
But, if the forecasts are not correct, the capacity suppose we say the forecast is for a particular segment of product, in the next year the sales are going to be too much or the sales are going to be exorbitantly high. And we take a capacity requirement decision, that we need to enhance the capacity, because the forecast says that the sales are going to be exorbitantly high. The capacity is purchased, the machines are purchased, the capacity is added and the forecast goes wrong.

So, if the forecast goes wrong the capacity that was have added is not going to be of any benefit to the organization plus a huge amount of capital will be tied up with at capacity, which would be of no use. So, the company may have to suffer, so the forecast sales or the forecasting of the sales will help us in order to take a decision, regarding the capacity requirements. But, we believe the forecasting would be very, very accurate and systematically done.

So, once we have accurate forecast available with us we can take a decision of enhancing the capacity or reducing the capacity what, so ever may be the case. Then, calculate the equipment at labour requirements to meet these forecast, so once the forecasts are ready we have to plan according to the labour requirements and the equipment that would be required, which I have already explained in the first point itself, project equipment and labour ability availability has to be seen then.

So, we have to see that what would be the equipment required in the project and what would be the labour required. So, basically capacitive requirement depends upon the forecast, once the forecasts are there then we can see that what would be the requirement in terms of machines, equipment and the labour. Now, making capacity planning decisions, so what type of decisions we make in capacity planning.

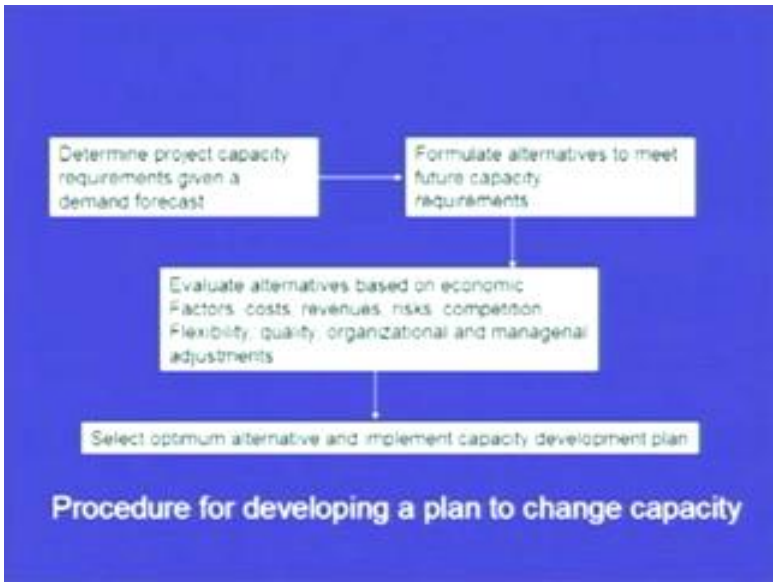
(Refer Slide Time: 28:29)



The three step procedure for making capacity planning decisions is as follows, so this is the very brief procedure I will explain another procedure, in which we plan to change the capacity, what are the various points, what are the various steps that we have to take whenever we plan to change the capacity. Now, this is the three step procedure for making a capacity planning decision it is as follows, identify capacity requirements.

So, capacity requirements from where this is going to come, this is going to come from the sales forecast. Then, develop capacity alternatives then we have to see that what are the alternatives available with us, and finally evaluate the capacity alternatives. So, when then finally, we have to evaluate, how we have to evaluate under which circumstances we have to evaluate, on which criteria we have to evaluate this alternatives, that we will be see in the subsequent slide.

(Refer Slide Time: 29:26)



Now, on your screen you can see this is the procedure for developing a plan to change the capacity, now basically we are manipulating the capacity. So, the very first point on your screen is determine the project capability requirements given a demand forecast, here also this is dependent on the demand forecast or the sales forecasting. We know that this is the demand forecast, this is the amount of sales or amount of product that will be sold in the market in the next financial year or in the next 5 financial years.

Now, we determine the project capacity, requirements given a demand forecast, so what would be the project capacity requirements, what kind of project has to be under taken in order to meet the demand or which has been forecasted using any of the sales forecasting methods. So, demand is playing a very important role here, then once we know the requirements that is the project capacity requirement, we formulate the alternatives to meet future capacity requirements.

So, large number of alternatives may be there, certain technological alternatives we will see we will figure out that this is thing that we want and this is the kind of demand that is to be generated. Then, depending upon this demand which type of technology would be best for us, we need to outsource certain things to certain other players in the market and all those types of alternatives would be formulated, then formulate alternatives to meet future capacity requirement. So, initially we know from the demand, what is going to be the project capacity requirements.

Then, we formulate the alternatives to meet the future capacity requirement and then comes the most important step that is the evaluation of the alternatives. Then, we evaluate the alternatives based on, now what is the criteria on the basis of which we are going to evaluate these alternatives. So, the criteria is the cost, revenues, risks, competition, flexibility, quality, organizational and managerial adjustments. So, there will be, so many alternatives available with us for the capacity enhancement or capacity reduction or capacity change.

And we will evaluate them on the bases of what would be the cost to the company, what would be the revenue generated if we plan this type of a change in the capacity. And what would be the competitors, view point in this particular change that we are doing, how the competitors are going to react to our capacity change or capacity enhancement. Then, we have to see what are the risks involved because, sometimes whenever we do a technological enhancement in terms of capacity, we have to invest a huge amount of money.

So, do we foresee that this particular capacity enhancement is going to result in a huge amount of profit for our company is the investment in increasing or enhancing the capacity, justified in terms of profit to the company. All these points or all these criterion have to be born in mind, when we have to take a decision and when we whenever we have to evaluate the alternatives. So, whichever alternatives gives us the best possible solution, those alternative would finally be selected.

So, just in order to summarize whatever I have already said, we will evaluate these alternatives based on economic factors, cost, revenue, risks, competition, flexibility, quality, organization and managerial adjustment. Now, flexibility I have not till now discuss, now flexibility in terms of capacity enhancement is also very, very important, why it is important is because, whenever we are enhancing the capacity if the capacity that we are adding is very, very flexible in nature. Flexible means, that instead of doing one particular task it can do a large number of a large spectrum of task.

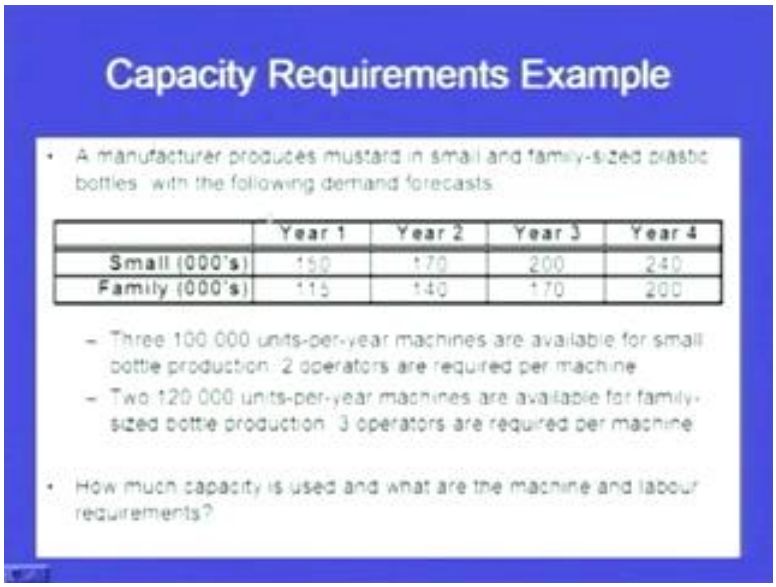
So, large spectrum of activities or large spectrum of operations, then by enhancing the capacity or enhancing such type of technological capacity, the risks involved are less. May be we are enhancing that capacity for one particular spectrum of products or one particular line of product, even though our forecast is wrong and that line of product is

not doing well in the market. But, the facility or the capability or the capacity, that we have added is very flexible in nature, this can be used for other line of products as well.

And this way this will be utilized and the risks involved in the failure of enhancing the capability or the capacity of the organization would be minimized. So, by purchasing or by enhancing a capacity, which is technologically well proven and which is very, very flexible in nature is going to be a low risk decision. Means, it is quite sure and it is quite certain that by adding a flexible capacity we are going to always be in profit. So, depending upon all these criteria we are going to appropriately select the most optimal alternative.

So, select the optimum alternative and implement capacity development plan, so on the bases of all these criterion, whenever we reach a particular solution. Whenever, we find a optimal solution we are going to select that particular alternative as that capacity, enhancement or capacity development plan. So, this is a procedure for developing a plan to change the capacity, now we would consider certain examples in which the capacity planning is actually being done, so let us first take a simple example, this is the capacity requirements example.

(Refer Slide Time: 35:50)



Let us first go through the problem, a manufacturer produces mustard in small and family size plastic bottles. So, mustard is being produced by a manufacturer in two types of bottle, small and family sized plastic bottles with the following demand forecast, so

the forecasting has been done and this is the demand forecast in the form of a table. So, for year 1 small this is in hundred thousand. So, hundred fifty thousand is the number which would be sold in the market or which is the demand forecast.

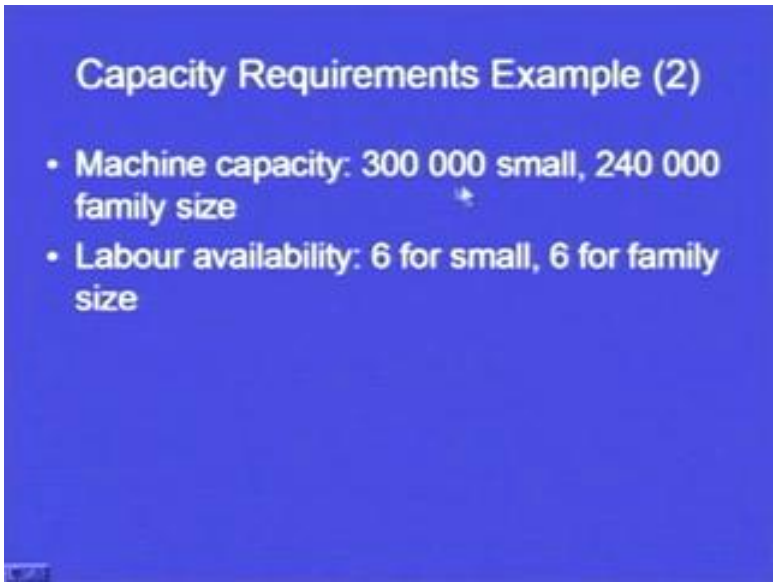
Then, year 2 for small is 170, year 3 200, year 4 240, similarly for family size bottles or the family size plastic bottles year 1 150 is the demand forecast, year 2 140 is the demand forecast, year 3 170 and likewise year 4 200 is the demand forecasts. So, till now we have seen that we have demand forecast for 4 years, and we have the values for the demand forecasts for both the type of products, that is the small size plastic bottle and the family sized plastic bottle of mustard.

Now, what we are required to do what is the other data that is available with us three hundred thousand units per year machines are available for small bottle production. So, there are three machines each having a capacity of hundred thousand units per year, machines are available for small bottle production and 2 operators are required per machine. So, how many total operators are required, 3 machines, 2 operators per machine means 6 operators per machine are required.

There are 3 machines which produce hundred thousand units per year, so per year the capacity is three hundred thousand, why because there are 3 machines available with us. Then, there are two hundred twenty thousand units per machines available for large or family sized bottle production and 3 operators are required per machine, so here also we have a requirement of 6 operators why, because three operators per machine are required and there are 2 machines.

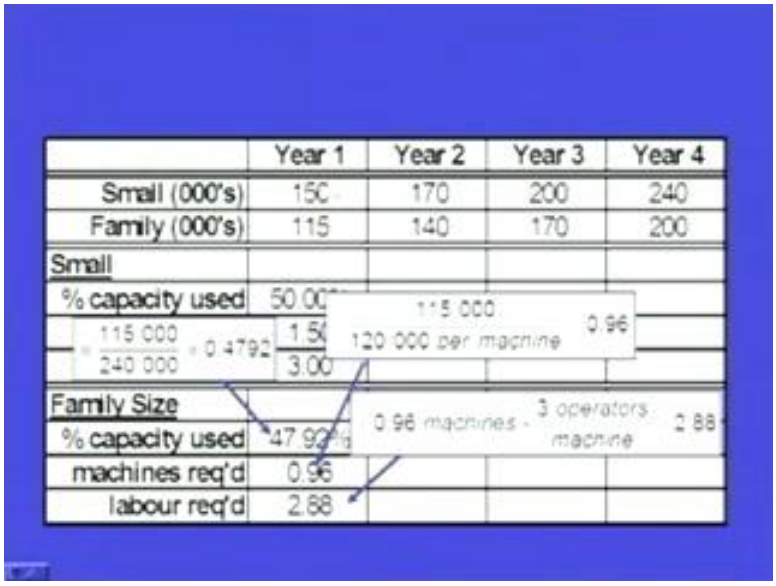
And what is the total capacity of large scale or bigger sized bottle or family sized plastic bottles that is hundred twenty thousand multiplied by 2 because, there are two machines available. So, we can say two forty thousand units per year can be produced of family sized bottles, so we have seen the problem now, now we can say how much capacity is used and what are the machine and labour requirements. So, we have to find out that we have certain capacity available with us and depending upon the demand forecast, what is needed in the market, we have to find out that what is the capacity utilization, how much capacity we are actually utilizing.

(Refer Slide Time: 38:57)



So, let us see now the capacity requirements the machine capacity is three hundred thousand for small. Because, one hundred thousand is the capacitive of 1 machine and there are 3 machines in all small machines, three hundred thousand is for small and two hundred forty thousand is for family size. Similarly, 6 operators are required for small machine and 6 operators are required for the family size plastic bottles manufacturing machine.

(Refer Slide Time: 39:23)



Now, we see year 1, year 2, year 3, year 4, so for smalls they we have give in hundred thousands we have the demand forecast, which was already given hundred fifty thousand, year 2 hundred seventy thousand. So, the important points to notice these three values like percentage of capacity used. Now, a capacity total capacity was two hundred and forty thousand units can be produced in a year and what is the requirement, that is hundred and fifteen thousand year this is hundred and fifteen thousand.

So, for year one hundred and fifteen thousand are actually to be produced, so what is the percentage capacity used. So, what is the actual that is demand forecast and what is the total capacity for family size and this gives out to be 47.92 percent. So, 47.92 percent is the percentage capacity used of the machines, then how many number of machines are required that is 0.96. Because, hundred fifteen thousand have to be produced and hundred twenty thousand per machine can be produced.

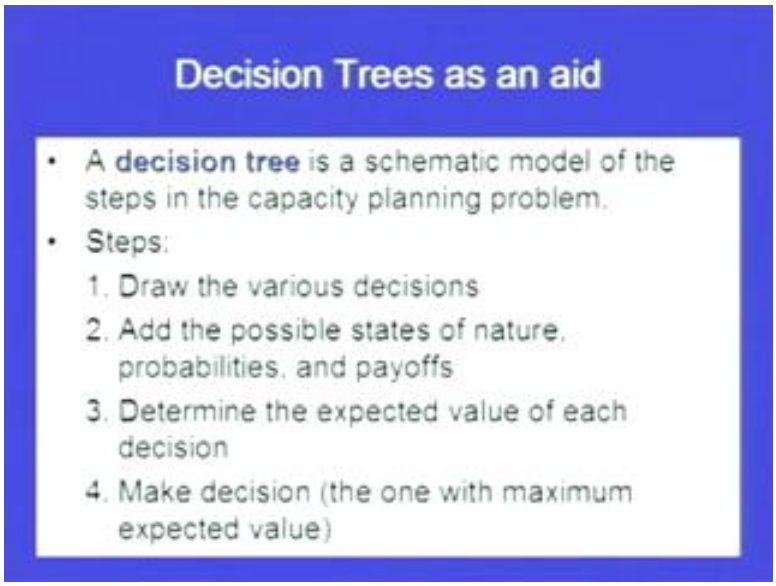
So, total machines required are 0.96 or we can say only one machine is sufficient to meet this demand forecast of 115. Similarly, how much labour is required, so labour required can be calculated as 0.96 number of machines which we have got from here multiplied by 3 operators per machine are required for family sized bottle machines. So, we can find out there it is 2.88 number of operators are required, so we can say 2.88 is not visible 3 operators are required and one machine is required for processing the demand forecast of one hundred and fifteen thousand bottles of family size.

(Refer Slide Time: 41:20)

	Year 1	Year 2	Year 3	Year 4
Small (000's)	150	170	200	240
Family (000's)	115	140	170	200
Small				
% capacity used	50.00%	56.67%	66.67%	80.00%
machines req'd	1.50	1.70	2.00	2.40
labour req'd	3.00	3.40	4.00	4.80
Family Size				
% capacity used	47.92%	58.33%	70.83%	83.33%
machines req'd	0.96	1.17	1.42	4.25
labour req'd	2.88	3.50	4.25	5.00

So, similarly if we do the calculations for each and every year we will be able to get a table of this form. And we would be able to find out that, what is the percentage utilization of the machine capacity of the labour required and how many machines would be required. So, once we know all this data, that how many machines would be required, how much labour will be required. We can do the capacity planning there do either we are required to add the capacity or we are surplus in capacity, and can be outsource this capacity to some of our friendly partners in business, who can use our capacity to the best possible manner and the optimal utilization of the capacity is taking place. Otherwise, the capacity is lying wasted and it is going to be of no use to us, so doing these type of simple exercises we can enhance the utilization of our capacity.

(Refer Slide Time: 42:16)



Now, decision tree is also an aid which helps us in making such types of decisions, a decision tree is a schematic model of the steps in the capacity planning problem. So, it is a schematic model of the step, what are the steps draw the various decisions that we will try to understand with the help of an example. So, here we draw the various decisions, then we add the possible states of nature probabilities and payoffs.

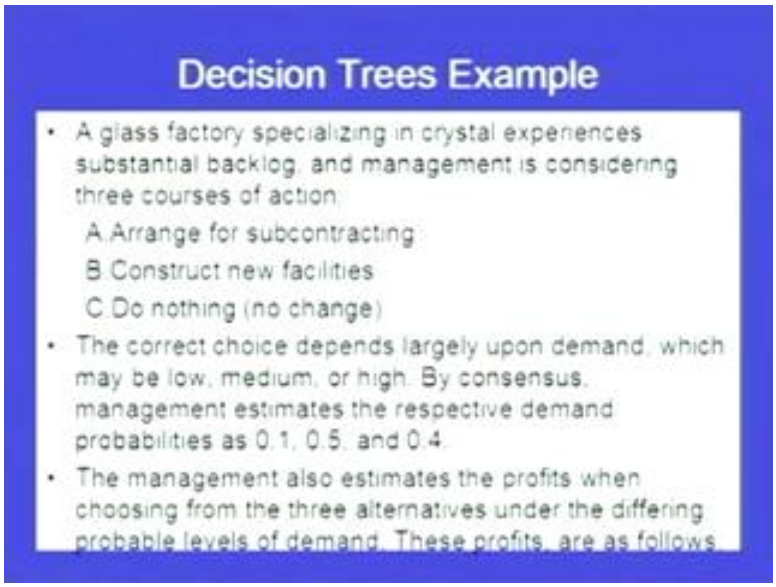
So, we see that what is the probability for example, decision tree problem can also be formulated as a manufacturing company is buying it is raw material from four different vendors. Now, all these four different vendors are supplying the raw material at particular rates and there are certain amount of risks involved in the timely delivery of these products or of these raw materials, which the vendors are supplying to this manufacturing company.

So, at decision tree analysis can be done in order to optimize that how much quantity should be ordered to a particular supplier. In order to overall optimize the total cost involved, but here also we will see a problem, in which the decision tree has been used as a tool to optimize or to find out the best possible alternative. So, at decision tree is a schematic model of the steps in the capacity planning problem, which already I have told the steps involved or draw the various decision.

Add the possible states of nature probabilities and payoffs with this can involve the risks also, determine the expected value of each decision and make the decision with the one

with maximum expected value. So, this is giving us one direction in which the decision trees can be used, now let us solve a problem using the decision trees, we will first go through the problem and then we will see the solution to this problem.

(Refer Slide Time: 44:26)



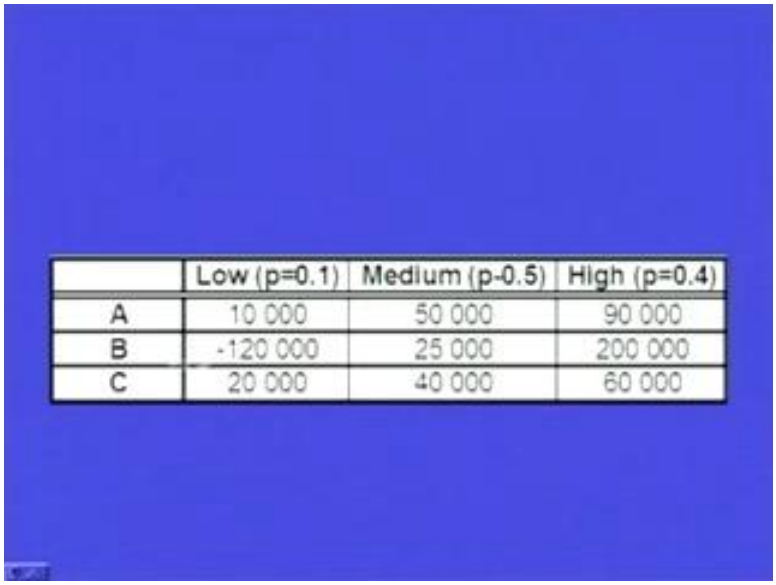
A glass factory specializing in crystal experiences, substantial backlog a glass factory which is specializing in crystal is experiencing substantial backlog. So, backlog of orders is there and management is considering three courses of action, now the management has three actions to take, it has to take a decision which action it should take. Now, first action is arrange for subcontracting, so it is going to subcontract to some other manufacturer or construct new facilities, which is the preview of this lecture which tells us regarding the capacity requirement.

So, construct new facilities means add the capacity and the third one is do nothing there is no change, the correct choice largely depends upon demand which may be low, medium or high. So, the demand can be low, medium or high by consensus the management estimates the respective demand probabilities as 0.1, 0.5 and 0.4. The management also estimates the profit when choosing from the three alternatives, under the differing probable levels of demand.

So, there a probable levels of demand already three different probabilities have been assign. And then the management estimates the profits also choosing from the three alternatives of three alternatives are already there on your screen, that is arrange for

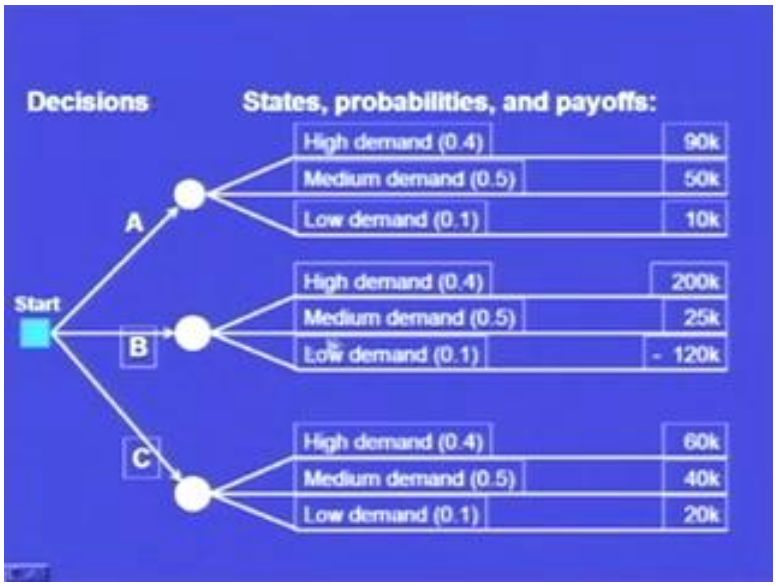
subcontracting, construct new facilities or do nothing, so what are the profits that management sees.

(Refer Slide Time: 46:11)



The profits are for low level of demand which was there in the screen ((Refer Time: 46:14)) you can say the demand can be low, medium or high. So, for low demand probability 0.1, alternative A will give this much of profit, alternative B will result in a loss and alternative C will give this much of profit. Similarly, for medium level of demand alternative A will result in 50,000 profit B and C ((Refer Time: 46:41)). Similarly, we can see that for low, medium or high demands the probabilities are fixed 0.1, 0.5 and 0.4, this is by general consciences. And the company has been able to find out that what is the profit, that they can foresee for by forecasting the demand and by a putting a profit value on the three alternatives.

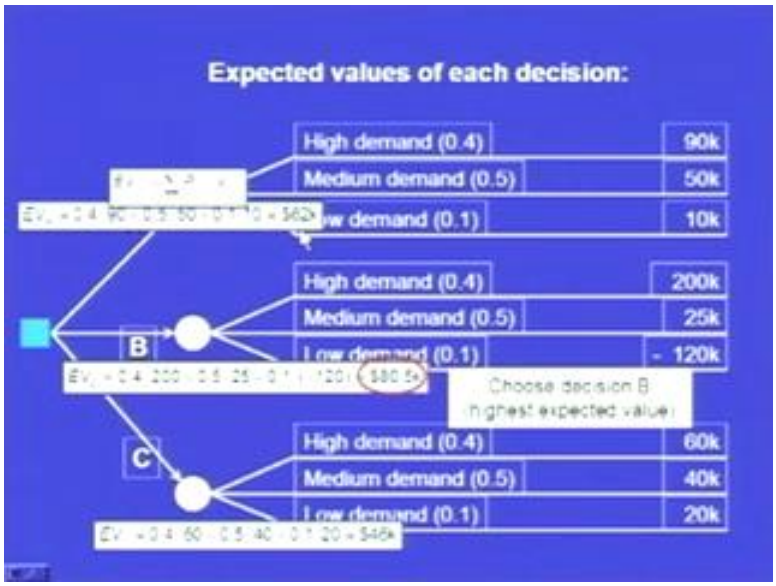
(Refer Slide Time: 47:04)



So, then we can see these are the decisions either the company can go for A or it can go for B or it can go for C. Now, what are the states or probabilities and payoff, if high demand is there 90k for 90,000 is the profit if medium demand is there, this is the profit, if low demand is there this is the profit. Similarly, if we go with alternative B high demand, medium demand, low demand and the profits have also been represented.

Similarly, when we do not do anything that is the alternative C, there is a high demand, medium demand and low demand and the profits have also been given. For example, let us check for C high demand 60 k ((Refer Time: 47:51)) C high demand 60 k, so this is the exact representation of the data, which was available in the previous slide in the form of a decision tree. Now, this is a decision tree we have to take a alternative that which particular alternative would we have to take a decision, which particular alternative would give us the maximum profit.

(Refer Slide Time: 48:23)



So, we would now calculate the expected value, now expected value we are finding out for alternative A, it comes out to be dollar 62,000 62 k and for alternative B we find out it is dollar 80.5 k it is mean dollar 80.5000. Similarly, for alternative C we find out the expected value for alternative C is dollar 46 k, how this is done you can see on your screen 0.4 multiplied by 90 plus 0.5 multiplied by 50 plus 0.1 multiplied by 10, this gives us dollar 62,000.

So, 0.4 multiplied by 90, 0.5 multiplied by 50, 0.1 multiplied by 10, 0.4 multiplied by 90 0.5 multiplied by 50 and 0.1 multiplied by 10 is going to yearly dollar 62 k. So, this is the expected value, so this expected value will be calculated for each and every alternative. And whichever alternative is going to give us the best possible value will be chosen as the best alternative for the company.

So, here choose decision B because, it is giving us the highest expected value to be dollar 80.5000. So, we can see that decision tree approach is a very, very important tool in making the decisions, so in this particular example we have seen that there were three different alternatives, whichever available with the company and the company has to take a decision, which alternative to adopt in order to maximize their profit.

So, we have use the decision tree approach in order to find out, which alternative should be used by the company or should be followed by the company. So, here alternative B has been selected on the basis of the decision tree analysis, which would give the

maximum profit to the organization or to the company. So, with this we come to the end of our lectures on capacity planning, we have had two lectures on capacity planning, capacity planning one we covered what do we understand by capacity, we have seen what is the best operating level, we have focused on diseconomies of scale, economies of scale.

Then, we have seen in the second lecture that what are the various types of tools and techniques, which help us to enhance the capacity and to evaluate the capacity. We have seen two types of problems, in one problem we have seen that how much machine utilization is taking place, how much labour utilization is taking place and how much all on and overall per view, if we say how much capacity utilization is taking place.

Then, we have used a decision tree analysis to find out that which alternative is best for the company, when it has to take a decision either to go for capacity enhancement or to leave it or to take another decision of outsource. So, in three different decisions where or alternatives over available with the company, which alternative would give the maximum profit has been found out using the decision tree analysis.

Thank you.