Energy Economics and Policy

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Week – 4
Energy Supply – Part 1
Lecture – 1
Supply Behaviour of a Producer

Welcome back to the course Energy Economics and Policy. During this and the next week we are going to cover topics related to Energy Supply.

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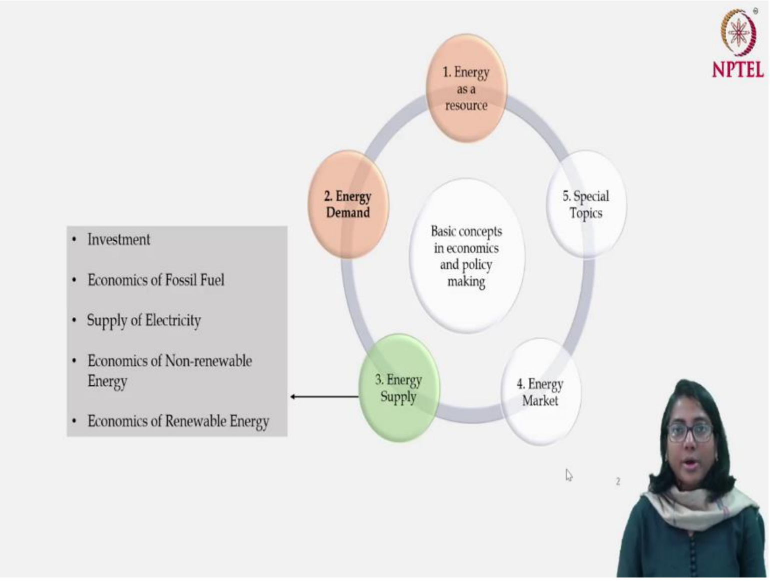

And specifically, we are going to cover 5 sub-topics namely, the investment in the energy sector, the economics of fossil fuel, the economics of supply of electricity, the economics of non-renewable as well as renewable energy. And for the section on energy supply, we are going to heavily rely on the book by Subhes Bhattacharyya which is called Energy Economics, Concepts, Issues and Markets and Governance. This was published by Springer in 2011. This is a very good material if you want to know more about economics of energy and the related policies.

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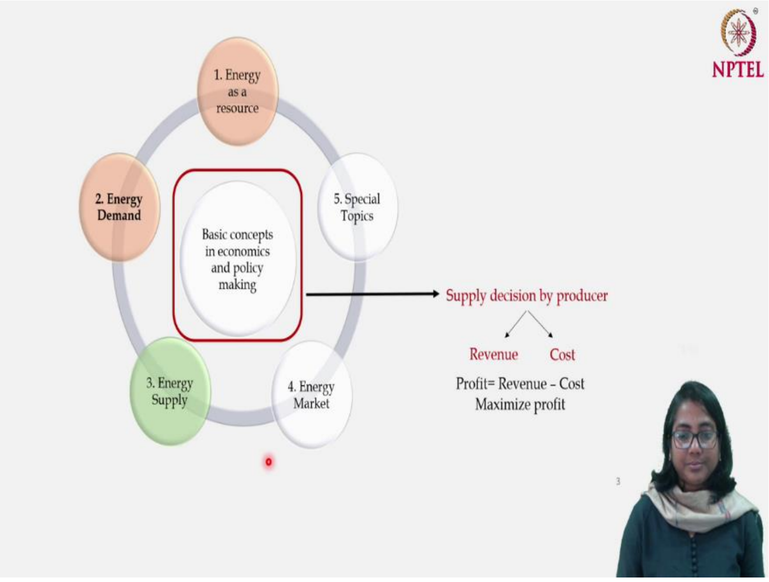

But before we enter into those 5 topics, our approach will be the same as we have done in the case of energy demand. First of all, we are going to explore the concepts and the mechanism of the supply in general. How supply can be conceptualized as an economic concept and what is the theory behind it? How does a supply curve of a producer look like and so on? It will be interesting if you carry these broad concepts with you as we dive into the detailed topics related to energy supply.

What are we going to look at when we are talking about the basic concepts in economics related to supply? Supply is the decision of the producer, how much the producer is going to supply to the market that can be bought by the consumers. It depends on two things; one is the revenue that the producer is expected to earn by selling those products, goods or services and the other is the cost of production of that particular amount of goods and services. It is the interaction of revenue and cost that determines the optimum amount, a supplier is willing to supply in the market at a particular price.

The objective of the producer is to maximize the profit which is total revenue minus total cost. Let us have a quick look at the detail of this profit maximizing behavior of a producer and explore how this behavior leads to a particular shape of the supply curve of the producer.

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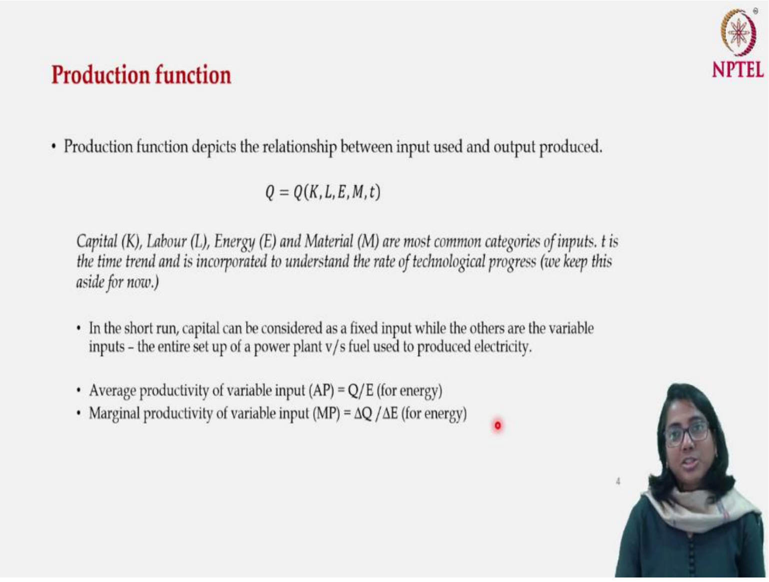

We start the discussion with Production Function. This is the fundamental concept of the production theory and the production function depicts the relationship between the inputs used and the output produced. In the functional form we can write it down as $Q = Q(K, L, E, M, t)$. Where Q stands for the quantity of output produced and is a function of K, which is capital (K is the short form of capital used in economics), L stands for the labor, E is energy, M is material and t is time. Some other inputs can also be incorporated that contribute to the production of a particular amount of output. In many cases service is being incorporated as one of the inputs in the production function. The functional relationship here is represented by Q, unlike using a function say f. In economics the standard way of representing is to use the left-hand side variable to represent the function itself. We have come across this while discussing consumers behavior also where we wrote $u = u(x_1\ x_2)$.

The variable t tries to capture the changing relationship between the inputs and outputs over time, the time trend and the technological progress. Technology is not conceptualized in the form of the machinery. Technology identifies the relationship between input and output, so t captures technological change as well. However, for the time being we are going to keep this t aside and we will deal only with inputs.

All the inputs; capital, labor, energy, material all of them are not similar in nature. How are they different? Let us have a quick look. If you think in the short run, suppose 2-3 years, once you make some investment in order to produce some goods and services, this investment will cater to the entire time period that is for the time period for which the production will go on.

The investment in capital is the amount of money that you are spending to come up with the complex or to buy the land in order to set up the machinery. This is called capital and it is a proxy for investment. The capital comes as a form of investment.

In the short run you can assume that capital is fixed. The amount of investment that you have made at the beginning of the production process is going to help the production for a particular range of years. Therefore, capital in the short run can be considered as a fixed input. On the other hand, if you look at labor, energy and material can be considered as the variable inputs. If we want to increase the production, we have to increase the quantity of these variable inputs.

Now, let us go back to the example that we were considering in the previous week in the context of load management. We have been emphasizing that it's very important to flatten the load curve. Because, if you can reduce the gap between the peak demand and off-peak demand, then the required capacity of power generation is going to be reduced. Among different competing investments, you don't have to put your money in a particular place where it is unproductive to invest or where there is no productivity for a particular duration of time.

Investment or the fixed input is something that once spent, stays there, it does not change with the change in the level of output. Fixed input is fixed at the beginning of the time period whereas, if you think about the quantity of coal or gas it would keep on changing as you change the quantity of power produced. That is what we said, during the off-peak period, even if you shut down a few units in the power plant that will save your cost on the fuel. The expenditure on coal will be saved, however, the expenditure that you have already made in order to come up with the power plant that is going to stay with you. The concept of variable input and the fixed input is very important whenever you think about any production process in the short run.

There are two related concepts that we are going to discuss, the first one is the average productivity of variable input. If you think of energy as the variable input then $\frac{Q}{E}$ is called the average productivity of the variable input. Here again, let me remind you that if you take the reciprocal of this average productivity that is $\frac{E}{Q}$, we arrive at the concept of energy intensity that we had been discussing during the first week of the lecture.

There is another concept related to the productivity of the variable input, that is the marginal productivity. The marginal productivity is defined as the increment in the quantity of output as you increase the quantity of input at a margin. This is incremental change in energy input. The change in output is the marginal productivity of variable input.

Later you will see that marginal productivity and average productivity of variable input is closely associated with the concept of average cost, average variable cost and marginal variable cost.

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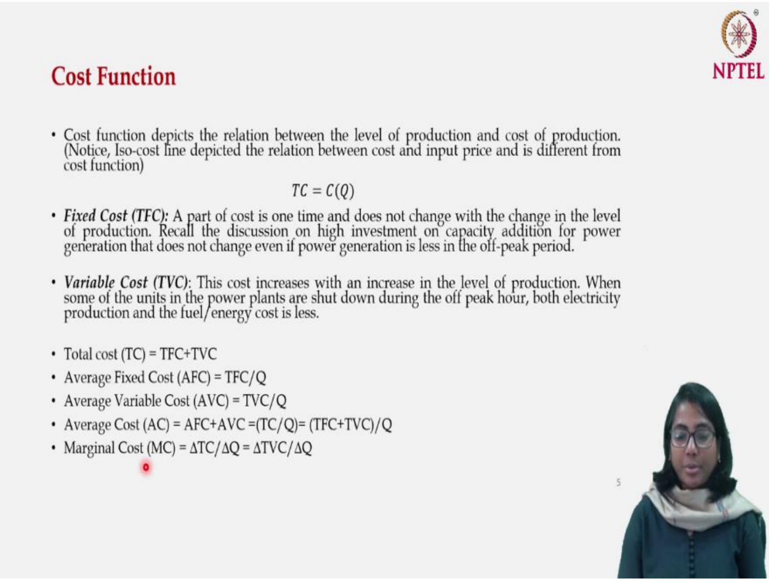

We started with the production function, we now move on to the concept of Cost function**.** What is the cost function? Cost function depicts the relationship between the level of production and the cost of production. One note regarding the difference between cost function and the iso-cost line. The cost function is depicting the relationship between the level of output, Q and the cost that you incur in order to produce that level of output, no input is taken into account here. Total cost is indirectly a function of the level of input because Q becomes a function of level of input, but directly total cost is a function of the quantity produced. In case iso-cost lines, we talk about the relationship between the inputs used and output produced. We are relating the concept of total cost with the level of output which is being produced in case of iso-cost line.

The way we discussed the fixed input and variable input, the analogy here is fixed cost and variable cost. We consider the example of the machinery that we have to put in place to set up the power plant. The capital investment was a fixed input. The money that you spend in order to set up that machinery is called the fixed cost. This is the part of cost which does not change with the level of change in output. It doesn't matter whether you are producing electricity during the peak period, that is high volume of electricity or you are producing electricity during the off-peak period, when the production is low, fixed cost is going to remain unchanged.

Analogous to the concept of variable input, comes the concept of variable cost. As discussed, during the off-peak period some of the units are shut down and therefore, you are not producing as much electricity that you have been producing during the peak period and therefore your cost on variable input for example, fuel comes down. You can also think about it in this way, lesser manpower; lesser material is required for production of lesser amount of output. The fixed cost does not vary with the level of output whereas the variable cost varies with the level of output. As the level of output increases the variable cost also increases.

We are going to discuss some fundamental ideas about the cost functions. The total cost (TC) that is represented as a function of Q can be divided into two parts, total fixed cost (TFC) and the total variable cost (TVC). The average fixed cost (AFC) similarly can be represented as $\frac{TFC}{Q}$. The average variable cost (AVC) is represented by $\frac{TVC}{Q}$. The average cost which takes into account both types of cost is the sum of average fixed cost and average variable cost. It can be written as : $\frac{TC}{Q} = \frac{TFC+TVC}{Q}$.

The next concept is called the marginal cost. Here, we are deviating from the concept of average as marginal is the change in cost due to change in output. The questions that we try to address here are: 'if I want to increase my output by 1 unit what will be the impact on my cost?'; 'How is my cost going to increase?' Marginal cost is not only equal to $\frac{\partial TC}{\partial Q}$, it's also equal to $\frac{\partial TVC}{\partial Q}$. The reason is that when we are talking about marginal cost, we consider only that part of the cost which changes with the change in the level of output, that is your total variable cost. Total fixed cost has no role to play in determination of marginal cost. In fact, it's not a part of the marginal cost at all.

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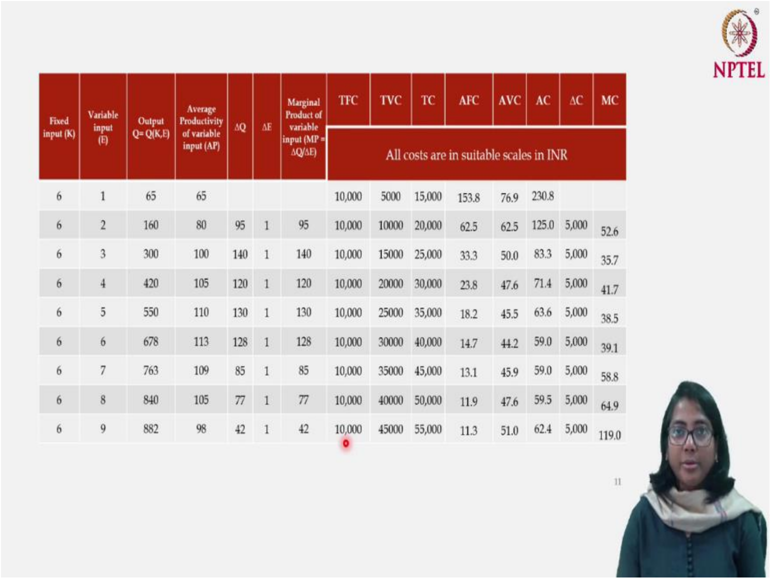

Fixed input (K)	Variable input (E)	Output Q= Q(K,E)	Average Productivity of variable input (AP)	ΔQ	ΔE	Marginal Product of variable input (MP = ΔQ/ΔE)	TFC	TVC	TC	AFC	AVC	AC	ΔC	MC
							All costs are in suitable scales in INR							
6	1	65	65				10,000	5000	15,000	153.8	76.9	230.8		
6	2	160	80	95	1	95	10,000	10000	20,000	62.5	62.5	125.0	5,000	52.6
6	3	300	100	140	1	140	10,000	15000	25,000	33.3	50.0	83.3	5,000	35.7
6	4	420	105	120	1	120	10,000	20000	30,000	23.8	47.6	71.4	5,000	41.7
6	5	550	110	130	1	130	10,000	25000	35,000	18.2	45.5	63.6	5,000	38.5
6	6	678	113	128	1	128	10,000	30000	40,000	14.7	44.2	59.0	5,000	39.1
6	7	763	109	85	1	85	10,000	35000	45,000	13.1	45.9	59.0	5,000	58.8
6	8	840	105	77	1	77	10,000	40000	50,000	11.9	47.6	59.5	5,000	64.9
6	9	882	98	42	1	42	10,000	45000	55,000	11.3	51.0	62.4	5,000	119.0

Let us have a quick numerical understanding of what all these concepts mean. These are some imaginary numbers which are measured in some suitable units. This is just to give an idea and not from any real example but only for the purpose of illustration.

In the first column we have the amount of fixed input. This is the capital that is going to stay during the lifetime or a particular duration of the lifetime of the project. This is a one-time investment and not going to change with the change in the level of output. There are 6 units of capital, you can think about it as 6 machines or 6 units of power production. We are assuming that the total fixed cost that has occurred due to 6 units of fixed input is 10000. You can take any unit in terms of rupees like thousand or lakh or crore for spending.

Now, there are multiple entries of 6 and 10000. When I put the value of output, the objective of doing this is to show that with the change of output there is no change in the fixed input.

Next, we are inserting the variable input. Along with 6 units of fixed input we are putting 1 unit of variable input. At every stage we just go on adding one extra variable input and we will see what is going to be the total variable cost. There is a simplified assumption, where we have assumed that each incremental unit of energy that is the variable input will cost 5000 rupees. When you are putting 1 unit of variable input,that is 1 unit of energy in your production process, the total variable cost is 5000. When you are putting 2 units of energy in your production process your expenditure, that is total variable cost is going to be 10000. Similarly, when you are putting 9000 that is 9 units of energy, your total variable cost is going to be 9 multiplied by 5000, which is 45000 rupees.

Now, let us see what is going to be the impact on output. While keeping the capital constant as we are increasing the fuel or increasing the energy input our output is increasing. For the first unit of variable input we are producing 65 units of output. It just increases as we go on adding more fuel in the production process and 9 units of variable input along with 6 units of fixed input is producing 882 units of output. Now, you can also relate to the fact that this varied level of output (increase in output) is associated with some total fixed cost and some increasing total variable cost.

If that is the case, let us first have a look at the average productivity of the variable input which is energy or fuel. The average productivity of variable input is calculated by dividing the total output by the units of variable input. This is $\frac{65}{1}$. When you have 110 as average productivity this is $\frac{550}{5}$, when you have 98, this is $\frac{882}{9}$.

Initially, the average productivity is increasing from 65 up to 113, after that the average productivity is declining. We will quickly come to the explanation of this kind of behaviour of average productivity when we pay more attention to the shape of the curve.

The next concept that we are going to look at is the marginal productivity of energy input or any variable input. You can also think about the average productivity and marginal productivity of labour. Let us first focus on the column of δE. Here in case of variable input that is for the second column, for E at every stage we are adding 1 unit of energy as the variable input. Therefore, δE at every stage is equal to 1. δQ is the change in output due to 1 unit addition of variable input. This 95 comes as a result of $(160 - 65)$. If you look at 128, this is a result of 550), if you look at 42 here this is $(882 - 840)$.

If you want to calculate the marginal productivity this is $\frac{\partial Q}{\partial E}$. This is a special case because $\delta E = 1$ everywhere here. You can see that δQ and the marginal productivity of labor are different. However, you can make some variation in order to have a better understanding. Instead of adding 1 unit of variable input, you can add multiple units of variable input, vary it from stage to stage and then see what is going to be the impact on marginal productivity of energy which is a variable input.

We started the discussion with the production function and all these relationships which are represented by Q, K, E, t, the behavior of the average productivity curve, the behavior of the marginal productivity curve, all of them together determine the shape of the production function.

The next discussion was on cost. Let us see what are the implications on cost with these kinds of numbers? We already have the information on total fixed cost (TFC) and total variable cost (TVC), we will add them up in order to come up with the figure for total cost (TC). Total cost is the addition of total fixed cost and total variable cost.

The next concept is the average fixed cost. We are getting the average fixed cost by dividing the total fixed cost by the units of production.153.8 is the value for average fixed cost which is $\frac{1000}{65}$. Again, 11.3 is nothing but $\frac{1000}{882}$. If you look at the shape of the average fixed cost curve, it can be observed that the value of average fixed cost is continuously falling as the production is increasing. This is quite obvious because 10,000 is being divided among more units of output that are being produced.

If you pay a little more attention you will see that if you multiply the average fixed cost (AFC) by Q, you get total fixed cost (TFC) which is constant. The shape of the average fixed cost in the cost-quantity plane takes the shape of a rectangular hyperbola.

We next move on to the concept of average variable cost. Similar to average fixed cost, here we are dividing the total variable cost by the quantity of output. If you look at this number 76.9, we are getting it by dividing $\frac{5000}{65}$. If you look at the last entry that is 51 as the average variable cost, here we are dividing $\frac{45000}{882}$. When we look at the average cost this is nothing but the summation of average fixed cost and average variable cost. The figure of 230 comes as a result $153.8 + 76.9$. Similarly, for the rest of the entries.

The next is the change in cost that is the marginal cost. Marginal cost is the change in cost due to 1-unit change in output, so $\frac{\partial C}{\partial Q}$. δQ has already been calculated and now we are going to calculate δC which is always 5000. $\delta C = average\ variable\ cost$ because that is the only component of cost which is changing the total cost as the level of output is changing.

δC is 5000 at every stage. To get 52.6 we have to divide $\frac{5000}{95}$. Similarly, if you come to the last entry 119 as the marginal cost this is $\frac{5000}{42}$. This is how you get a complete understanding of different concepts related to production function and cost function. Next, we are going to look at the shape of different relationships that are the shapes that can capture these relationships.

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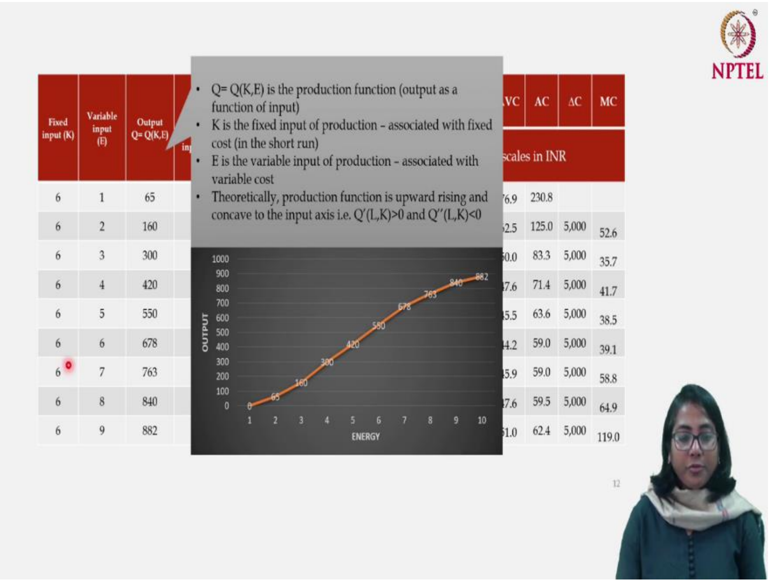

Let us start with the production function. We plot the numbers 65, 160 and up to 882 on the vertical axis and energy on the horizontal axis. The curve shows the relation between different levels of energy and different levels of output and has the shape as shown above.

One thing that you can observe is that K that is, capital is the fixed input and energy is the variable input that we are considering. As the variable input increases, the amount of production also increases. Up to a point it increases at an increasing rate and then it increases at a declining rate. Theoretically, production function is an upward rising function of the variable input, where the first order derivative is positive and second order derivative is negative.

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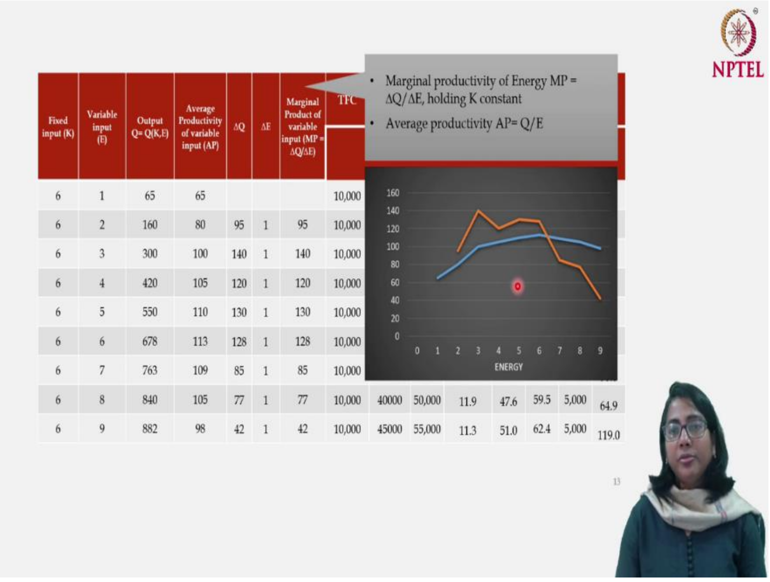

Next, we will look at the average productivity of the variable input holding the fixed input that is K constant. Average productivity is $\frac{Q}{E}$ and the shape that we get is shown above. If you look at this blue line, you have average productivity of energy and the orange line here is depicting the marginal productivity of energy.

Initially, the average productivity of energy was lower than the marginal productivity of energy, but marginal productivity of energy cuts the average productivity of energy from above and then it becomes less than the average productivity of energy. This is the relationship between the average productivity and the marginal productivity of a variable input. These concepts become very handy if you go into the rigorous discussion and calculation of the cost structure while setting up some kind of energy supply system.

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The next one which is very important is the shape of the cost curves. The blue line is the average fixed cost and as we have said this resembles a rectangular hyperbola because we are plotting the output and the cost.

The next is the average variable cost. The orange line in the diagram above gives the average variable cost. Although in this diagram it looks like a valley but theoretically it takes the form of a u shaped curve. Initially it declines, reaches a minimum, then starts increasing. Average cost is a combination of average fixed cost and the average variable cost so initially the average cost declines; however, after a point it starts rising.

Let us spend a little amount of time in order to understand the shape of these curves. Here if you look at the blue line, 10000 is being distributed to more units of output and therefore, this blue line representing the average fixed cost keeps on falling. However, if you think about the average variable cost (AVC) is $\frac{TVC}{Q}$. Initially as you have some fixed input which is capable of producing a certain amount of goods or services and you keep on adding more variable input then your fixed input is performing better and the average cost is declining.

In the diagram we see the average productivity of energy service is initially increasing and then it starts declining. Think of a power plant which is being set up to produce maybe 3000 megawatt of power and initially you are producing only 30 megawatts. As you keep on producing more power, productivity of energy input is increasing but beyond a certain point there will be over exploitation of capital and therefore the productivity of energy will decline.

If you look at the average cost curve or the average variable cost curve initially, they are declining because your variable input is becoming more and more efficient. After that there will be over exploitation of your fixed input and that makes your variable input less productive. As a result your average cost and average variable cost keeps on increasing so both average cost and average variable costs are u-shaped.

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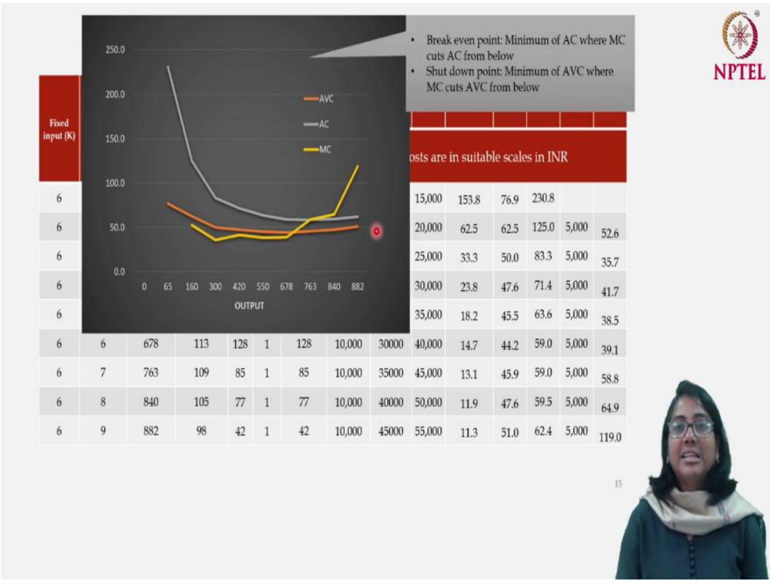

Now, we add the marginal cost curve in the picture. This sharp blue line is the marginal cost curve. Theoretically the marginal cost curve is also u-shaped. It starts from below the average fixed cost, average variable cost and average cost. However, cuts both the curve respectively from below and then eventually, it becomes higher than the average cost and average fixed cost.

At this point it’s worth discussing two very important concepts, one is the breakeven point and the other is the shutdown point. The breakeven point is the minimum point of the average cost curve. The average cost curve being u-shaped, the minimum point of this curve is the point where the marginal cost curve cuts the average cost curve from below.

What happens at the minimum point of the average cost curve? This is the point where you produce and this is the price that you are getting from the market, then the revenue that you earn will be exactly the same as the total cost of your production including the fixed cost as well as the variable cost.

If you produce here and the price that you get is also here, then your total revenue will be equal to total cost so you are breaking even. There is no emphasis either on cost or on revenue both are equivalents, this is called the breakeven point.

Now, one may be surprised that if the total revenue is equal to total cost then where does the profit come from. When the cost is calculated, the cost to the entrepreneur is also included in the total cost, that is the profit which is going to the entrepreneur is already included in the total cost and when that is there it's called a normal profit. We try to remember that at the minimum point of the average cost curve it's called a breakeven point and a company breaks even at this point because the total revenue is equal to total cost.

However, if in the short run your production is such that if the price falls a little below the average cost curve then it can survive because it can pay the variable inputs, it can make up for the fixed input for a certain period of time. However, if you come to the minimum point of the average variable cost this is called a shutdown point. Because at the minimum point of the average variable cost curve, the total revenue that you earn is equal to the total variable cost. If your revenue goes down below the total variable cost you cannot provide fuel to the power supply sector to produce electricity and you have to shut down your plant. You can delay the interest payment on capital but you cannot delay the payment for the fuel. This is called the shutdown point because if your point of operation is below the minimum point of average variable cost then that is not feasible and you have to shut it down.

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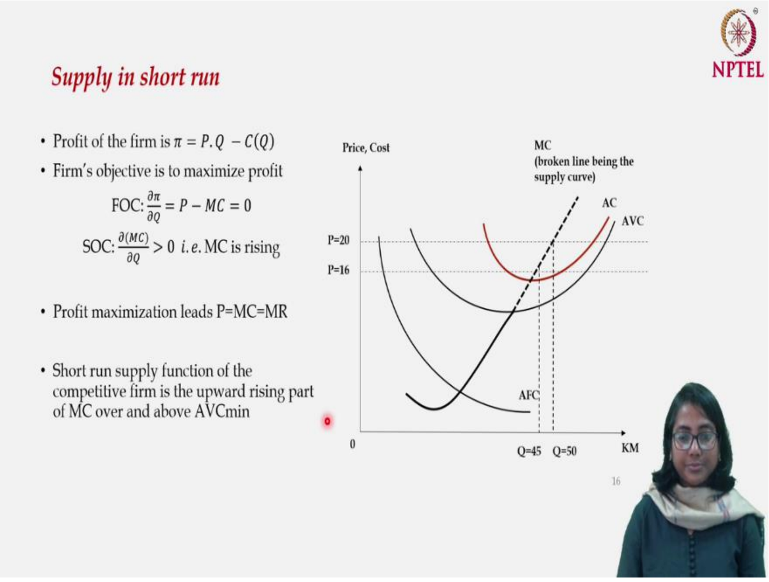

Next, we try to explore how the supply decision is made by a producer, especially in the short run? What is the difference between the short run and long run? In the short run the capital is considered to be constant whereas in the long run the capital will also be considered to be a variable input.

What happens in the short run? In the short run, the profit of the firm is given by π (pi). Total revenue of the firm is given by $P * Q$,where P is the price of the particular good or service that the firm is producing and Q is the quantity. For example, electricity, P is the wholesale price of electricity and Q is the amount or units of electricity produced by the power plant and C(Q) is the cost of producing the electricity. So, $\pi = P * Q - C(Q)$

What does the firm want? The firm's objective is to maximize the profit, π (pi) with respect to the decision variable Q? The firm is going to choose a particular quantity which maximizes the profit of the firm. The first order condition is given by $\frac{\partial \pi}{\partial Q} = 0$ which takes you to the same point where $P - MC = 0 \; or \; P = MC$ so the price has to be equal to marginal cost.

Now, when we talk about price one quick thing to note is that, the price is not something that a supplier can influence, that is the assumption here. This kind of situation happens when you are more in a competitive structure and the quantity that you are producing is only a small fraction of the total quantity of that particular item supplied in the market.

The price P is given from the outside and it is sort of exogenous for the producer. The first order condition gives you the result, $P = MC$. The second order condition says that $\frac{\delta^2\pi}{\delta Q^2}$ has to be negative because you are maximizing the profit. If that is negative then your marginal cost should be rising because if you take the second derivative $\frac{\delta MC}{\delta Q}$ comes with a negative sign. So, minus $\frac{\delta MC}{\delta Q}$ that has to be negative which means that $\frac{\delta MC}{\delta Q}$ has to be positive. The marginal cost has to be rising at the point of supply.

The profit maximization happens where $P = MC = MR$ where MR is the marginal revenue. Now, if $P * Q$ is your total revenue and you define your marginal revenue as $\frac{\delta TR}{\delta Q}$, then P becomes your marginal revenue. This is the profit maximizing condition for the producer. Now, let us have a quick look at the diagram. On the horizontal axis we are plotting the quantity produced and on the vertical axis we are plotting both price as well as cost.

What do the cost curves look like? The average fixed cost takes the shape of a rectangular hyperbola, the average variable cost is a u-shaped curve, then the average cost which is a combination of average fixed cost and average variable cost or more precisely this is the vertical sum of average fixed cost and average variable cost. And then we are plotting the marginal cost curve which is also u-shaped, but it starts from here and then goes up, cuts both average variable cost as well as average cost from below and then it goes up.

What is the profit maximizing condition for the firm? It says $P = MC$. We will come to this point in a while but let us have a quick look at the second order condition which says that it has to be the rising part of MC. That is, we cannot have any profit maximizing equilibrium at the downward falling part of MC. When we are talking about the supply curve it has to be the upward rising part of MC.

However, as we have come to know that the minimum point of average variable cost is a shutdown point, no production and supply can take place below this shutdown point and therefore, the supply curve is that portion of the rising marginal cost curve which is over and above the average variable cost. For all kinds of competitive equilibrium, the supply curve in the market is the upward rising part of the marginal cost curve over and above the average variable cost.

Now, let us pay a little bit of attention to what $P = MC$ says. If P is equal to 20 that is the market price is 20, this market price is exogenous to the producer and the producer cannot influence this price. The producer takes price P as given but the decision that the producer is going to take is: if $P = 20$,what is going to be the quantity that it should produce and supply in the market.

At $P = 20$, $P = MC$ is taking at the point, where the horizontal line stating $P = 20$ intersects with the marginal cost curve. If this is the equilibrium then what is the quantity produced by the producer? The producer is producing some quantity for example, $Q = 50$ and supplies in the market.

However, if the price falls from 20 to 16 that is there is a decline in the market price then you can see that the equilibrium of this producer is shifting from this point to a lower point of the marginal cost curve. And at this point, at $P = 16$ the quantity supplied by the producer in the market will be less than 50 and let us assume it is 45.

What is a supply curve? As the demand curve was depicting the relationship between the price and quantity demanded by a consumer, the supply curve is depicting the relationship between the price and quantity produced and supplied by the producer in the market. And this kind of a structure is prevalent in the context of a competitive framework.

If you go to a monopolistic framework the structure can change but here, we are dealing with only a competitive framework. Here we can see that as the price increases then the quantity produced and supplied by the supplier also increases. The supply curve that is why gives an upward rising curve when plotted in the plane with quantity supplied and the price.

However, one more point of caution, when I am saying that this is a shutdown point, that is the minimum value of average variable cost and the supply curve should lie over and above the average variable cost, my understanding is that we are talking about the short run. In the long run none of the variables remain fixed; everything becomes a variable input.

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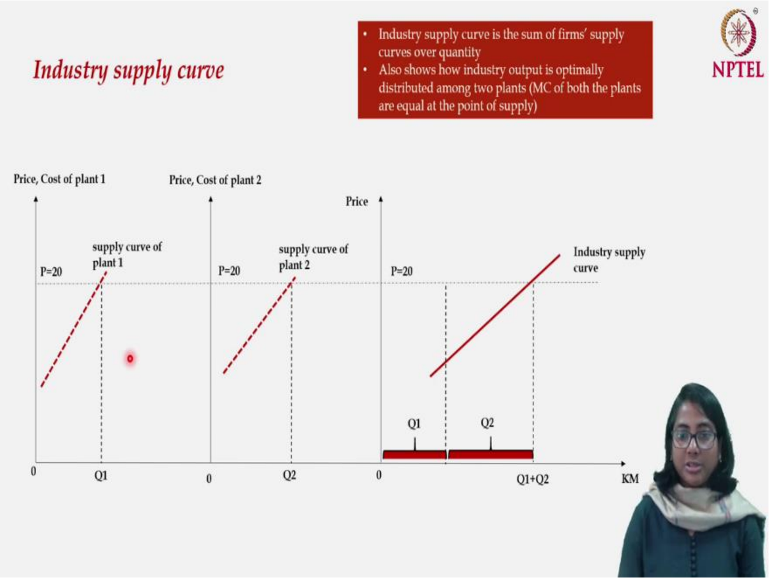

The last thing that we are going to look at is the shape of the industry supply curve. Again, if you go back to the example of power plant, there are various power plants who are producing the power and supplying to the grid, there is NTPC, Tata Power and there are a lot many of them. How the production or how the total supply is being distributed among different producers or how the production of different producers determines the total supply in the market?

Let us take 3 panels. In the first panel I am going to show the supply curve of the first plant producing electricity, in the second panel we are going to talk about the cost curve and supply curve of the second plant and in the third panel we are going to show what is happening in the market. The horizontal axis is representing the total output which is being produced.

Suppose, there is the supply function and the marginal cost of the first plant. The upward rising part of marginal cost for the first firm over and above the average variable cost. The next supply curve looks like this. Although they are producing the same thing the supply curves may vary. In case of plant 1 in order to increase 1 unit of production the increase in cost is much higher as compared to plant 2. The slope of the marginal cost for plant 1 is steeper as compared to plant 2.

Suppose the price is fixed at 20, this is the market determined price and both plant 1 and plant 2 are taking this market determined price as exogenous information. The first plant, given their profit maximizing behaviour will supply at point where P intersects the marginal cost curve, and the quantity supplied here is Q_1. For the second plant when P is equal to 20 given the profit maximization behaviour this plant is going to supply Q_2. When $P = 20$ the total supply in the market is going to be equal to $Q_1 + Q_2$.

The industry supply curve at price $P = 20$ that is the total output supplied will be equal to $Q_1 + Q_2$ and this is how the industry supply curve will look like. The absolute slope of the industry supply curve is less than the slope of individual plants.

If you keep on adding more and more plants in the system, after a point of time you will see that the industry supply curve will become horizontal. Any amount of quantity can be supplied at a particular price by the industry. To make a note, this is the structure which is prevalent in a competitive market. In monopoly, things are very different. In a competitive market the industry supply curve is a sum of firms supply curves over quantity, and not over price.

The second thing that I would like you to notice is that it also talks about the distribution. If the total quantity that you want to produce is $Q_1 + Q_2$, how do you distribute this entire quantity among the two plants, given a particular price? In this situation you ask the plant with lower cost to produce more and the plant with higher cost to produce less.

We have already discussed that for plant 1, the absolute slope is steeper as compared to plant 2 which has a lower slope. If the marginal cost curve is flatter that means to produce one additional unit of output you need less amount of extra cost. Plant 2 is the more efficient plant from the perspective of marginal cost and Q_2 is higher than Q_1. The plant with the lower marginal cost is contributing more to the market supply as compared to the plant with higher marginal cost. Likewise, in case of electricity supply the decision that the power supply sector has to take into consideration is which unit to keep shut for a particular point of day.

We are going to come back to all of the concepts as we cover different areas of energy supply. This week, for this lecture we are going to stop here, in the next lecture we are going to meet you with more topics related to energy supply.

Thank you.