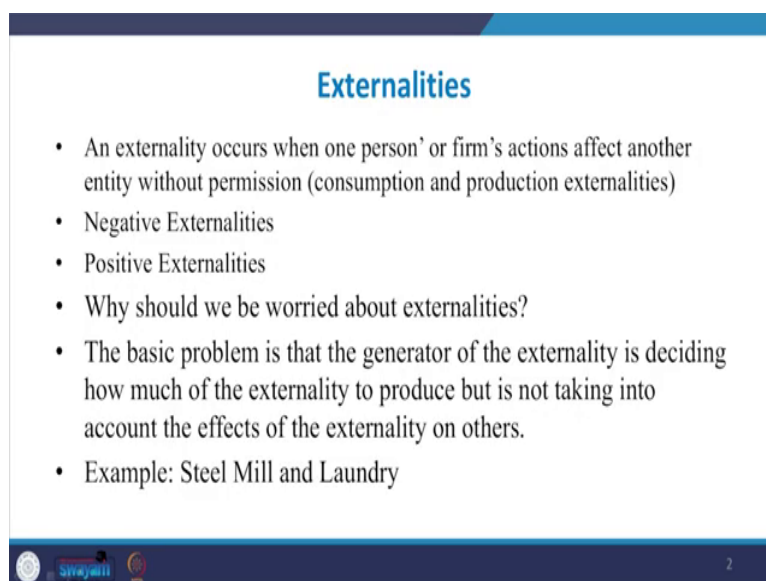**Introduction to Environmental Economics**
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Lecture - 45
Optimal Provision of Public Goods and Bads – III

Dear friends. In the preceding lecture, I explained Optimal Provision of Public Goods and Bads. And, you have studied that, in case of public goods market under provide these goods, because of nature of these products.

So, most of the public goods are non-rival non excludable. And, therefore, market generally fails to provide these goods and with the help of indifference curve. I also explained that the market provision of public good is at the lower level of quantity of public goods as compared to the efficient provision.

Externalities

- An externality occurs when one person' or firm's actions affect another entity without permission (consumption and production externalities)
- Negative Externalities
- Positive Externalities
- Why should we be worried about externalities?
- The basic problem is that the generator of the externality is deciding how much of the externality to produce but is not taking into account the effects of the externality on others.
- Example: Steel Mill and Laundry

Now, why it is happening? One of the important aspect is externality, because private players, private companies, when they produce certain kinds of goods and services they also generate waste, they also generate pollution and that create externality in the societies. So, due to lack of effective regulation private producers would not be willing to take into consideration the treatment of waste, which is released by them while producing the good product. And, that waste has some impact on the entire society.

So, unintentional harm received by a person not directly involved in the activity is called externality. For example, if someone is walking on the road, he or she may consume smoke released by the car running on the road. So, consumption of smoke will have adverse impact on the health of the person, who is consuming the smoke. So, this smoke is a kind of negative

externality because it is know the intention of the car owner to harm the person walking on the road. So, it is the unintentional harm, which is known as negative externality.

So, an externality occurs when one person or firms action, affect another person without permission. And, there may be externality in both, externality in consumption as well as externality in production. So, when we consume certain kind of product like if someone is smoking. So, he is enjoying the smoking, but the smoke released by him is inhaled by the person near to him and that generate negative externality.

Similarly, during the production take the example of a cement manufacturing company. So, cement is produced, but at the same time air pollution is also generated by the cement industry. So, this is called externality in production. So, we have both negative externality as well as positive externality. And, we have discussed it in the past the difference between negative externality and positive externality. Both externality actually destroyed the market, but we are more worried more concerned about negative externalities, because that harm the society.

So, why should we be worried about externalities? The basic problem is that the generator of externality is deciding how much of the externality to produce, but is now taken into account the effect of externality on the others. I can take an example of steel mill and laundry given by (Refer Time: 04:40) in his book on Environmental Economics.
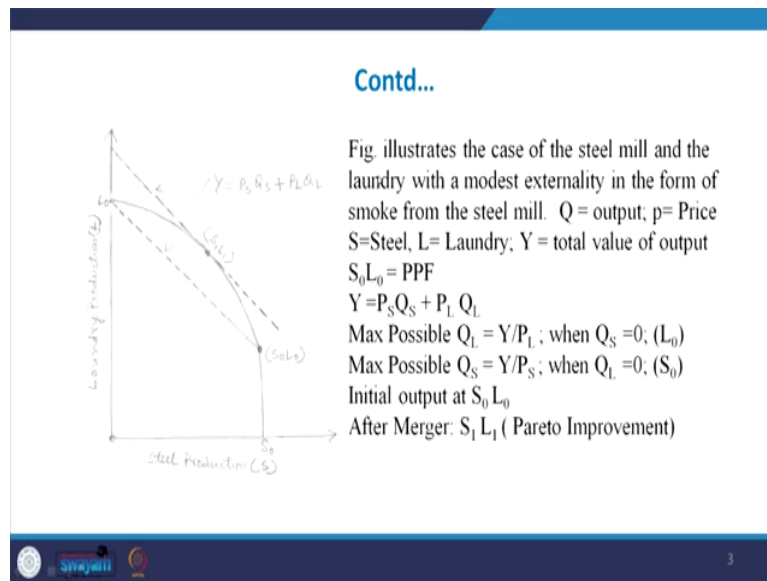
Let me take the production possibility curve with two products; 1 is laundry product and other is the steel product, I can explain it by a graph.
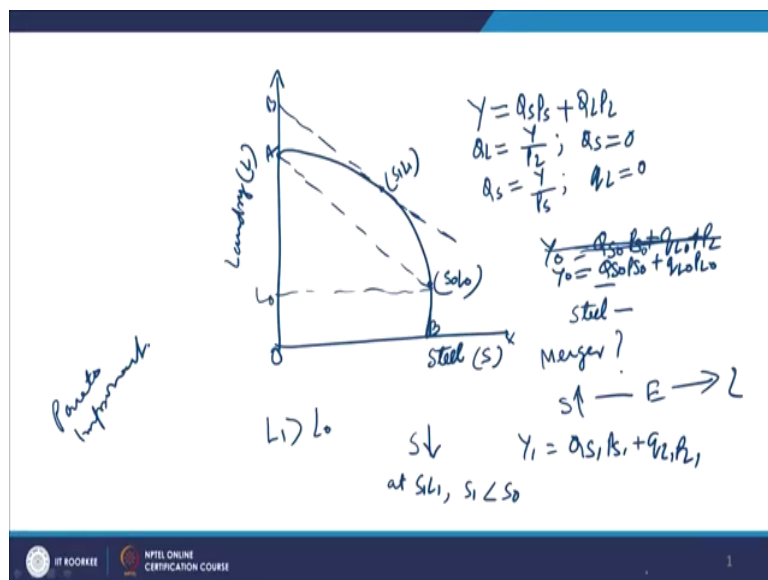
Suppose, we have two products is steel is steel is produced by the steel mill taken on x axis. And, also laundry, which is produced by the laundry like cleaning the cloth. We can draw the production possibility frontier, this AB is the production possibility frontier, which clearly shows that the resources are limited and there is a trade-off.

If all resources are spent on laundry the maximum possible output of laundry will be OA. And, if all resources available resources are spent on the production of steel then production of steel will be maximum production will be OB.

Now, since here laundry is affected by the externality. We can take a moderate kind of externality generated by the steel mill, when the steel is produced not only steel is produced,

but smoke is also air polluted air is also released by the steel mill, and that will affect the that will also affect the production of laundry.

So, if you take the total income generated, that will be Y equal to how much is the quantity of say steel Q S, how much will be the price of P S plus Q L P L. So, that is the total income received from the production of laundry and steel will be equal to Y is that total sales you can say or total income Q S is the quantity of steel produced, P S is the market price of the steel. So, when you multiply the market price of the steel with the quantity you will get the total revenue received after selling the steel in the market.

If, you multiply the quantity of laundry produced with the market price of laundry you will get this. Now, how much will be Q L quantity of L that will be Y divided by Q P L, if Q S is 0. So, this is the maximum possible at point A. So, with the available or at point A, so, o is the quantity multiplied by market price will be the total revenue received, after selling goods in the market.

Similarly, we can also get Q S is equal to Y upon P S when Q L is equal to 0. So, when quantity of Q is uh laundry is 0 we can get. So, now, these are the two extreme points. Actually, now this is the price ratio you can draw price ratio of steel and mill. If, you take in the presence of externality then this will be this will passes through the point A. And, that is the price ratio, when we have Y 0 equal to Q S 0 P S 0 plus Q L 0 plus P L 0, and we have say this is the 1 point where we have S 0 or S Q that is S 0 and L 0. So, this is 1 combination of where this line is intersecting is touching this.

But, what happens here externalities not internalize, because both parties are making individual decisions. Steel mill, steel mill is producing without considering the harm to the laundry, but what happens, if both the firms merge together, if firms merge together merger. If, merger is done, then what happens the ownership will be with the same person? So, if more steel is produced more will be the externality to the laundry.

So, so; obviously, the steel mill would not like to generate more externalities for the laundry and now in fact, that will not be called externality, because, now externalities, internalize,

because ownership is with the same company or same person. So, therefore, now the new equilibrium will be this line will be parallel and new line will be like this, which is parallel to the new Y 1.

So, now, Y this is the Y 0 now Y 1 will be equal to Q S 1 P S 1 plus Q S Q L 1 plus multiplied by P L 1. And, that point is here at S 1 L 1. So, these are new although steel there is some sort of externality, because entire externality cannot be eliminated.

But, in this case to some extent the external effect is neutralized. And, if you compare S 0 this point and S 1, S L, then you can see shifting from this point to that point indicate now, the quantity of steel is reduced. S is reduced quantity of S is reduced because S at S 1 L 1 point S 1 is lesser than S 0. And, laundry output is L 1 is greater than L 0 at S 1 point indicating that, now there is a shifting from the lower level of laundry output to the higher level of laundry output indicating that, now it is a kind of Pareto improvement ok. So, Y 0 equal to Q S 0, P S 0 plus q L 0 P L 0 so, you can take this ok.

So, now the new equilibrium point is at S 1 L 1 and this shows Pareto improvement, Pareto improvement. So, this is the case of Pareto improvement, because now after merger efficiency is improved. If, you take S 0 S 1 at this point externalities there.

And, therefore, due to externalities the output actually the output of laundries only this L 0, which is lower and here up to this extent this curve become vertical indicating that, up to this level the production becomes maximum production is achieved of steel mill at S 0 S S 0 L 0. Means the steel mill is maximizing the total output without considering how much output is generated by the laundry.

But, when the two firms merge together then the steel mill will also taken into consideration the interest of the laundry production. And, this new line will be Y 1 Q S 1, P S 1 plus Q L 1 P 1 and that will be parallel to the initial line that is A S 0. So, now, we shift to B point. So, this line is now tangent to so, of course, this point is not a tangent point. And, in economics we
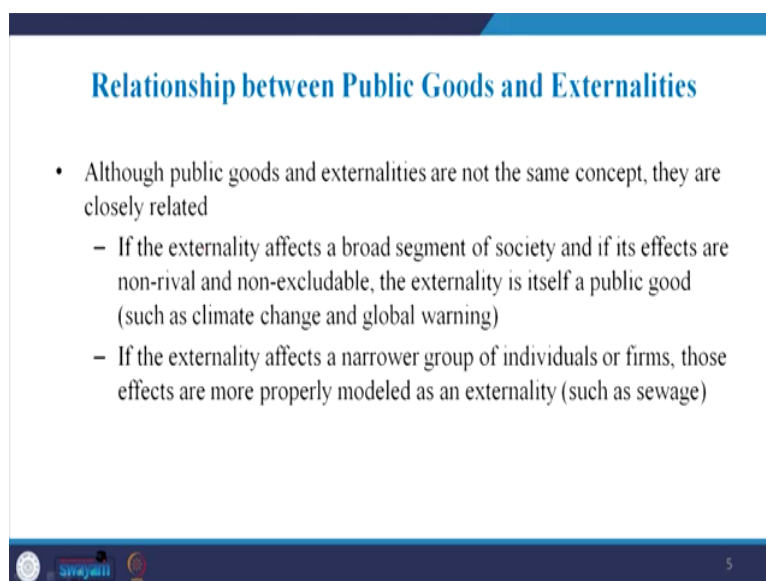
know and if slope of the production possibility curve it tangent to the slope of this price ratio of the laundry and steel.

So, optimization will occur. So, this is the optimum point and moment from this point to that point means Pareto improvement. And, in this way we can minimize the adverse impact of externality.

So, this is what I had discussed in this graph, you can again see from this graph, we have taken a steel production S on horizontal axis, laundry production L on vertical axis. We have a production possibility frontier L 0 S 0, which shows the maximum possible output, that can be produced with the available resources.

And, we have the income equation Y equal to P S Q S plus P L Q L. and Here you can see that after merger the equilibrium point shift from S 0 L 0 to S 1 L 1 that is Pareto improvement. So, initial output is at 0 L 1 this is the point here and then we shift to this point, which shows higher level of welfare to the society.

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Now, let me explain the relationship between public goods and externality. Actually both are closely related. Although public goods and externality are not same concept, they are closely related. If, externality affects a broad segment of the society and if it is effects are non-rival and non-excludable, then externality itself become public goods. As you know the definition of public good is that pure public goods are non-rival, non-excludable.

So, if effects of the externality becomes non rival, non-excludable, then externality can become public goods, I can give an example of climate change and global warming. So, if air pollution is leading to increase in global temperature and affect in the climate, then it becomes public good, public good or public bad. So, public bad and externality both becomes same, but externalities also different from public goods.

Some externality have effect of only narrow group of individuals or firms take an example of water pollution. So, water pollution in a particular pond or lake is not affecting the entire globe. So, it is externality similarly sewage is generated by the municipalities, if not treated may affect some section of the society some member. So, they can be termed as externalities. So, externality and public goods are closely related, but both are the different concept.

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So, now let me take an example to explain, what will be the optimum solution if externality is now taken into consideration. And, how much will be the optimum level of output if externality is internalized. So, we can take the example of sugar industry sugar is a polluted industry different kind of pollutants are released by the sugar mills when they produce the sugar which is a good product

We can assume that there is a perfect competition in the market supply curve is the marginal private cost and demand curve is the marginal private benefit. And, sugar production; generate pollution, which can be modelled as marginal external cost. So, MEC here is the marginal external cost this is very important MEC; Marginal External Cost. So, problem here is producers have no incentive to consider externalities. So, if there are no regulation. If, if regulation is not there then why should sh sugar mills will treat the waste before reaching the waste into the atmosphere, because if they start treating the waste, then it will increase the cost of production and that will affect their equilibrium points.
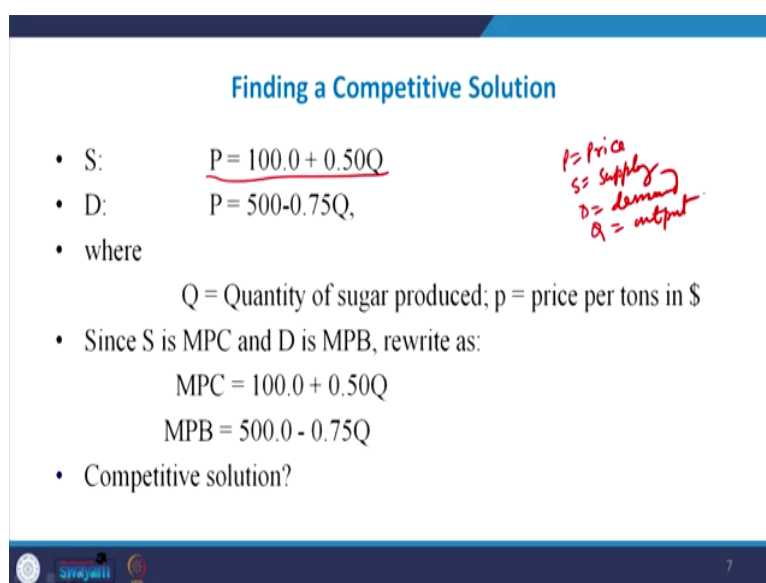
So, in the absence of the regulation a company would like to just equate the private benefit with private costs of Marginal Private Benefit will be equal to Marginal Private Cost to optimize the output and will not consider the pollution generated by the sugar industry. So; obviously, the result will be the competitive solution becomes in efficient. So, so the solution will not be optimum.

So, let me take the supply curve and demand curve. So, we have this supply curve P stands for price. So, P is price, S is supply, D is demand ok, Q is output ok. Now, P equal 200 plus 0.05 Q, that is the supply curve demand curve is P equal to 100 minus 0.75Q.

Now, for equilibrium level of output and price, what we have to do is we have to apply the optimization conditions. And, optimization is that marginal cost should be equal to marginal revenue. And, here marginal cost is marginal private cost and marginal benefit or marginal revenue is marginal private benefit.
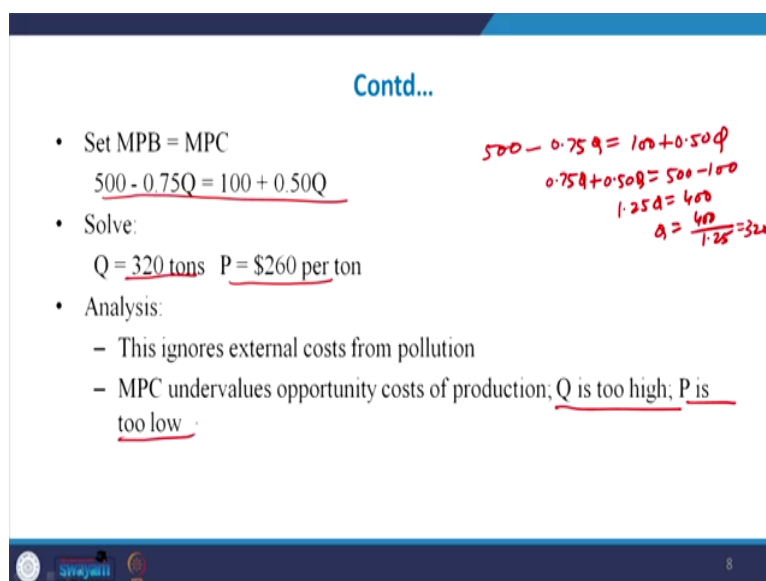
Since we are considering competitive market so, the price is also equal to the marginal benefits.

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So, now taking setting marginal private benefit equal to marginal private cost we can do it like 500 minus 7.5 Q equal to 100 plus 0.5 Q, when you solve it. Then, you will get quantity of output produced of the sugar is 320 tons you can easily see this like 500 minus 7.Q equal to 100 plus 0.5 Q.

So, now Q is 0.75 Q plus 0.5 Q equal to 500 minus 100 and that is 1.25 Q equal to 400 and Q equal to 400 divided by 1.25. And, that is how much 320? Now, putting the value of Q into any of the equation supply function or demand function you can easily estimate the price of 1 unit of output sugar and that is dollar 260 per ton.

Now, what is our analysis in this regard? This is the optimum output and equilibrium level of price, but it ignores the external cost of pollution generated by the sugar mill. If, this pollution is also made part of the cost, then the efficient solution will be different. So, here marginal

private costs undervalue the opportunity cost of the production and therefore, the result is output is too high and price is too low. So, due to this you can say there is a market distortion.

So, so, market cannot take care of the pollution generated in this regard, but if there is a regulation. And, if regulator says that whatever the pollution is generated it should be treated by the sugar mill before releasing it into the atmosphere, then the externality will be internalized.
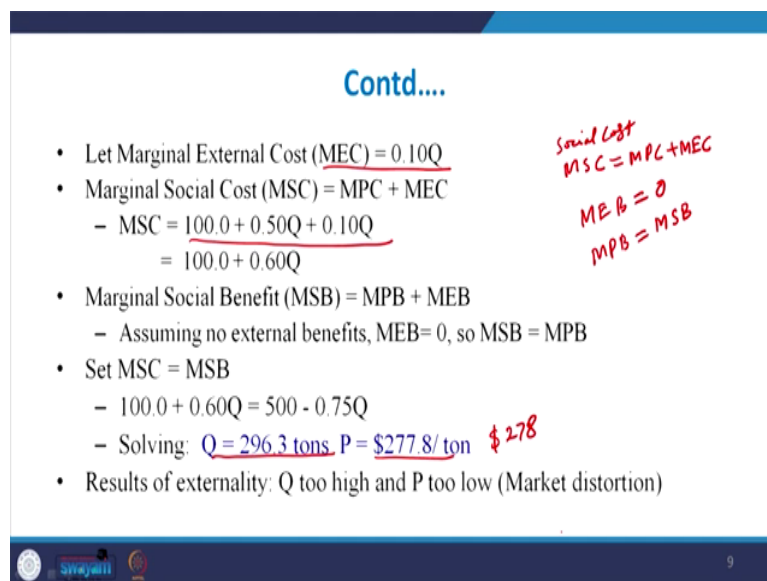
So, let me now take per ton of the output produce the externality or pollution generated by the sugar mill and this is 0.10 Q.

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So, this is the Marginal External Cost. So, if 1 unit of output is produce, then 0.10 will be the externality. So, now, externality we know. So, now, what we can do is we can now estimate social cost; social cost and that is marginal social cost.

Marginal Social Cost is equal to Marginal Private Cost plus MEC Marginal External Cost. And, MPC we already know the function supply function and now in supply function we can also include MEC and then get the Marginal Social Cost function.

So, Marginal Social Cost function is now 100 this plus 0.50 Q plus 0.10 Q that is 0.10 is here marginal external cost. So, total becomes now 100 plus 50 Q 0.5 Q plus 0.1 Q equal to 0.6 Q. So, this is now new figure Marginal Social Cost. Sometimes, some companies may also generate Marginal Social Benefit or Marginal External Benefit, but in this case we do not assume that sugar mill is generating any marginal external benefit. So, marginal external benefit is taken as 0.

And, therefore, marginal private benefit marginal private benefit is equal to Marginal Social Benefits. So, there are no difference between marginal social benefit and marginal private benefit.

Now, set equate the Marginal Social Cost to Marginal Social Benefit and solve the equation. And, now 100 plus 0.6 Q equal to 500 minus 0.05 Q and by solving it in the same manner as I did earlier, we get Q equal to 96.3 per ton and now market price, that is determined by the interaction is 277.8 or approximately, you can say 278 dollar. So, result of externality is that if there is a presence of the externality and not internalize the Q is too high and P is too low.

So, therefore, market is distorted, but in this case the new solution is at higher level of price and lower level of output and that benefit the society, because now since output of steel is reduced so; obviously, per unit marginal external cost will also come down

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The same things can also be done by another method in economics we know instead of taking supply equal to demand; you can also take marginal private marginal profit equal to 0. So, marginal profit, marginal profit means, net change in profit due to 1 unit change in output may be set equal to 0. And, that is where MC is equal to MR. So, at the point where marginal private cost is equal to marginal private benefit the marginal profit will be equal to 0. So, pi here we are taking pi as the profit, M stand for marginal. So, MR is marginal profit equal to 0.

So, now equating it then, what we get is the same solution actually, when you take marginal profit equal to 0, you will get 320 unit of output and 260, I think 200 this 260 dollar per ton the market price.

But, now since we wanted to internalize externalities and Marginal External Cost is MEC is equal to 0.110 Q. So, if we equate it here marginal benefit is equated with Marginal External

Cost, then same solution will come that is marginal benefit is equal to 100 minus 0.05 MEC is point 10.
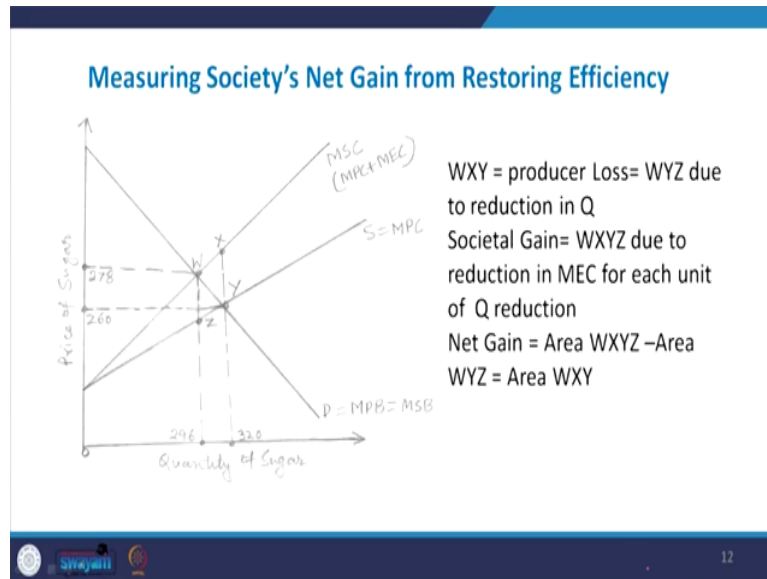
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And, now you can see the same solution comes. If, you there are two solution competitive solution, where you are equating marginal profit to 0 and efficient solution when you are equating marginal profit to MEC.

So, when you equate marginal profit to 0, you will get 320 the value of Q and the market price that is determined by the interaction of supply and demand is dollar 260. And, when you compare or when you equate marginal profit to Marginal External Cost, then you will get 296 tons of output produce and the market price is 277.8.
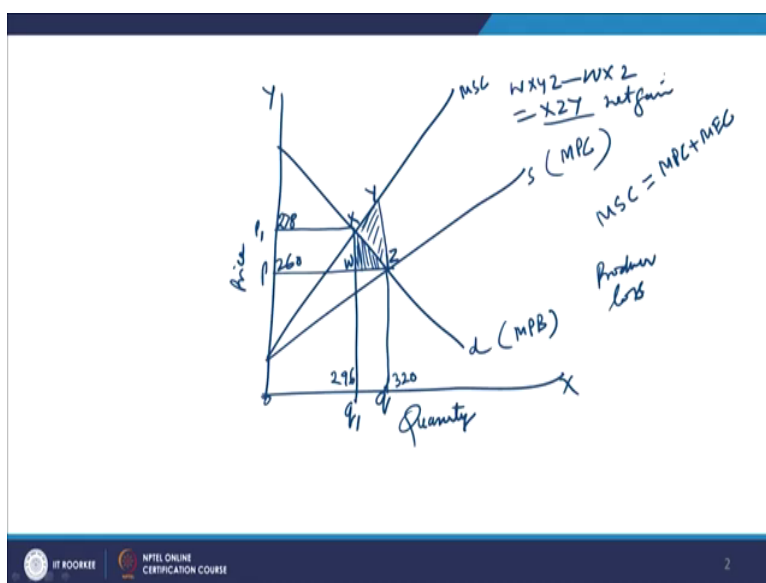
So, obviously, in conclusion you can say that when Marginal External Cost is taken into consideration then level of output will be lower and price will be higher and that will help to generate welfare in the society.

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And, this can be examined by the simple graph, I can also help you to draw it here.

Suppose, we have demand curve or marginal private benefit and supply curve. So, demand curve and supply curve, supply curve is also known as Marginal Private Cost. And, demand curve is marginal private benefit quantity is taken on Q is taken on X axis and price is taken on Y axis. Now, this is the equilibrium point. So, market price is o p and quantity o q.

Now, if you take Marginal Social Cost, which is equal to marginal private benefit plus MEC Marginal External Cost, then curve will be like this. So, this is M Marginal Social Cost. A new equilibrium is at lower level of output Q 1. So, in our example initial output was 320 and price was 260.

Now, when external cost is added when Marginal External Cost is added then new price P 1 is 200 I think 78. And, new output is 296, you can check from the numerical example and now we have X Y you can X Y Z W X Y Z.

So, here this is the portion actually that is the loss. Loss to the producer loss, because of additional cost and reduction in output, but this part is overall gain to the society is W X Y Z. So, W X Y Z is the overall gain to the society, but when you take W X Y Z minus W X Z, then you will get X Z Y, that is the net low net gain, net gain to the society.

So, when external cost is included in the production process, then the society will gain. So, welfare of the society will improve due to reduction in the pollution.
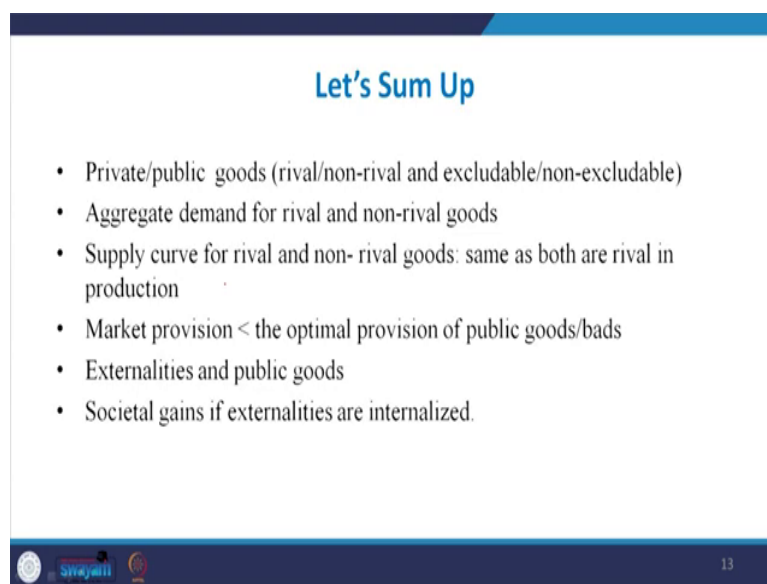
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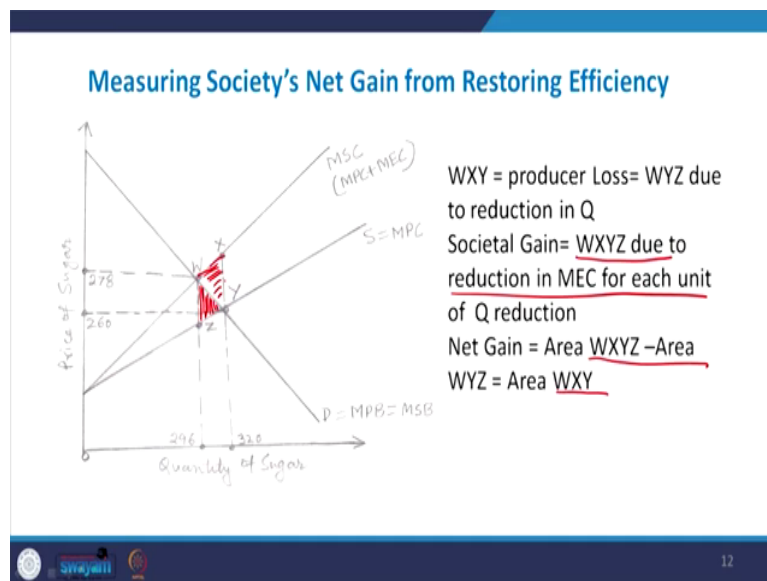
So, this is what is stated in this graph? You can see that W X Y, that is the producer loss you can see this part. So, this part is the producer loss and societal gain is W X Y Z. W X Y Z, the total gain due to reduction in MEC for each unit of Q, but since producer loss is there. So, if you deduct the producer loss, then you will get the net gain that is here area W X Y Z minus area W Y X. So, net gain is this.

So, this is the net gain the society is getting due to reduction in pollution or due to addition of marginal external cost in the private cost, or when the polluter actually is paying the cost of the pollution, then society will gain.

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So, let me now sum up the topic. In this topic I discuss the different types of goods like public goods, private goods, rival non rival excludable and non-excludable goods; I also explained

derivation of aggregate demand. So, aggregate demand is the horizontal summation of individual customer's demand, when the product is a rival product.

So, in case of rival product we can make horizontal summation of individual customer demand. We know the different customers react differently to the change in the price of the product. So, demand curve of individual customers may have different elasticities, but when we measure the demand of the market at the given market price we get the aggregate demand. So, aggregate demand can be done by horizontally summation in the making the summation of individual customers demand.

Similarly, in case of non-rival product we estimate the aggregate demand not by horizontal summation, but by vertical summation, because here quantity is not fixed in case of non-rival product. I also explained the market provision and efficient provision in case of public goods, and externalities and public goods have been discussed, and relationship between externality and public goods also discussed and also how the society gains if externalities are internalized.

Thank you very much.