Energy Economics and Policy
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Week 3
Energy Demand -Part II
Lecture – 04
Rebound Effect

Welcome everyone. This is the last lecture of the week which is on Rebound Effect. This deals with the issues regarding how a consumer behaves when a technology becomes more energy efficient? To give a little introduction to the concept, when we talk about energy efficiency that is when we introduce some energy efficient appliance or equipment we think about the technological potential.

The technological potential this equipment has to deliver in terms of energy efficiency. However, the human behaviour may actually vary from this technological potential and this is something we are going to explore in this video.

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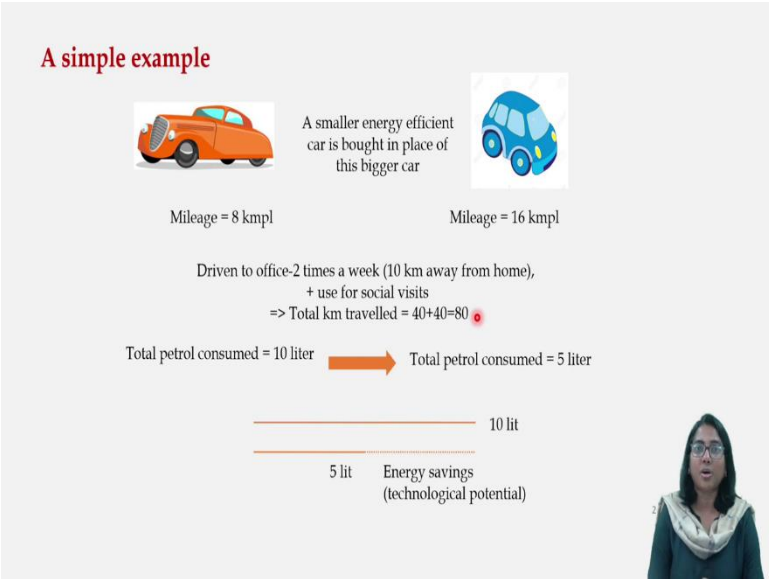

I will start with a simple example, that is a car I had, a big Ambassador car with very low mileage (kilometres that can be travelled with one litre of petrol). The mileage given by this old car was 8 kilometre per litre which was very low. I decided to change my car and purchased a smaller car which is much more energy efficient, that is it gives a higher mileage and I have replaced the big car. With the small car the mileage has gone up from 8 kilometre per litre to 16 kilometre per litre. This is the energy efficiency as you have replaced the non-energy efficient equipment with a more energy efficient equipment.

Now, what should ideally happen? What is the technological potential for energy saving? What was the consumption behaviour? Again, I would like to take you back to discussion of the first week's first lecture where we discussed that there are three things that you have to decide when you are talking about energy consumption. The equipment that you use, the type of fuel that you use and the level of use. That concept is used here again.

In the previous case I have made a choice of the equipment. Now, I am making some decisions regarding the level of my use. What is my use pattern with this car? I used to drive the car to my office twice a week because it was big and heavy and it consumed a lot of petrol and petrol is expensive. My office is 10 kilometres away from my home, so I am running my car for 40 kilometres, 20 kilometres per day. I am using the car for social visits for another 40 kilometres. So, my total use of the car was 80 kilometres initially.

Now, if my behaviour or the habit of using my own car remains unchanged then how much is the energy saving? The total petrol that I consumed with my old car was 10 litres because with one litre I could drive for 8 kilometre and with 10 litre I can drive for 80 kilometres. This was the initial scenario, so this is 10 litres of petrol.

Now, with the new car the mileage has doubled. So, with one litre of petrol I can drive two kilometres instead of one kilometre. I would need only five litres of petrol if I want to stick to my previous habit and still run it for 80 kilometres. My consumption comes down from 10 litres to 5 litres. The energy saving potential of this new technology is 5 litre per week. This is the technological potential of energy saving resulting in my energy consumption becoming half. This is how a technologist often looks at the problem but when you are thinking as a consumer your mind might work in a very different manner.

When you replace a big non-efficient car by a small energy efficient car the mileage goes up and you will have a tendency to use this car more. You may no longer drive it for 80 kilometres but you may end up driving it for 100 kilometres. Now, the question is what is the calculation that is going on, in the mind of the consumer, which is different from what is going on in the mind of the technologist and this interaction becomes very interesting.

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A consumer doesn't think about the way in which we have explained things. A consumer thinks, how much money am I paying for per kilometre travel that I am undertaking? What is my expenditure for one kilometre and there comes the role of price? When he had the big car, the mileage was 8 kilometres per litre, if you assume the petrol price is 60 rupees per litre, you have to spend 60 rupees to drive 8 kilometres. The price that you are paying for your mobility service, that is, price per kilometre is 7.5 rupees, this is the price from where the consumer gets the signal.

In the next case when you are changing your car the mileage becomes 16 kilometre per litre. As soon as the mileage becomes 16 kilometres per litre by spending the same 60 rupees, now you can drive more kilometres. That is by spending 60 rupees now you can drive 16 kilometres and the price per kilometre comes down to 3.75 rupees.

As a consumer if you think about the price of private mobility service, then you perceive the price as 7.5 rupees per kilometre and 3.75 rupees per kilometre. The price of mobility service has gone down. As soon as the price of mobility service goes down the law of demand holds and results in an increase in the mobility service and may end up running the car for more than 80 kilometres.

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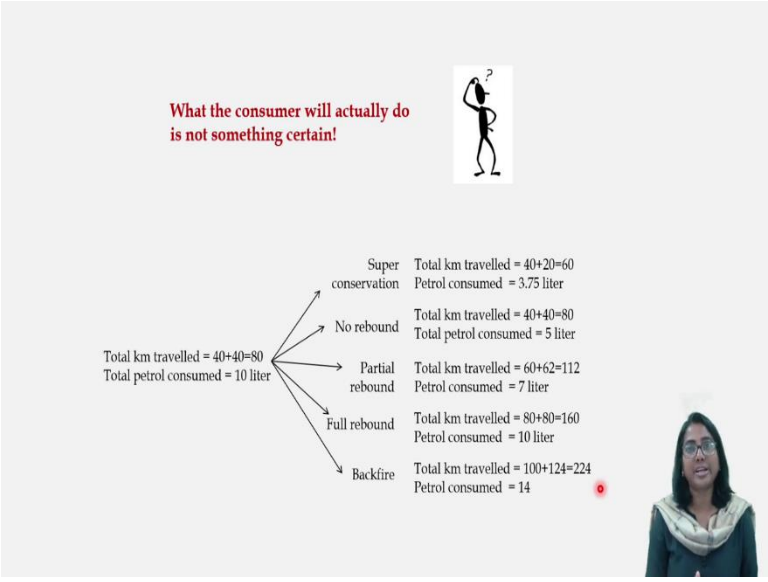

What the consumer will exactly do or how much energy will exactly be saved that cannot be understood before the use takes place. It can go into different directions. In the initial situation the total kilometre travelled was 80 kilometres and the petrol consumed was 10 kilometres.

The moment you change the car there can be multiple things, there is no one direction in which the consumer's mind can work, it can go into multiple directions. And in the context of policy making it is very important to understand the whole arena, all kinds of directions in which it can go. Let us have a quick look at what are the different possibilities that can take place. The first thing that we call a no rebound scenario, the level of consumption remains the same. The whole technological potential of energy saving is realised here. Although the price per kilometre travel has come down, the consumer has not changed the behaviour of travel. The kilometre that you travel is not responsive to the price.

If you go back to the concept of price elasticity of demand you can see in this scenario, that is in case of no rebound, the price elasticity of demand is zero. Although the price of some service is coming down, your demand has not changed, the change in demand due to change in price was the elasticity. The price is changing but there is no change in demand. This is called a situation of no rebound and if you have no rebound then only full technological potential of energy saving will be realised when some energy efficient equipment is introduced.

The second situation which is more plausible, is a situation where you have partial rebound. You thought that you would save 5 litres of petrol but instead you end up saving only 3 litres of petrol so rebound is 2 litres of petrol. As soon you see that the price of per kilometre travel has come down, you increase your total travel from 80 kilometres to 112 kilometres. Now to run 112 kilometres you need 7 litres of petrol, what you have saved is 10 minus 7, you are saving some energy but this is not what was claimed by the technological change. The realisation is much lower as compared to what the technology promised and this is happening because of the behavioural response.

Sometimes when we derive the models or do the projections, we say that if the technological progress takes a particular path, if this is the percentage of technological progress, then this is going to be the reduction in energy demand and hence this is going to be the reduction in CO_2 emission. But it's very important to take into account that the behavioural response may dilute a part of this gain that we are thinking about, as is the case of partial rebound.

The third can be a full rebound. The consumer feels that he wants to spend. His psychology could be to keep 500 rupees aside in order to buy petrol that is as many kilometres as he can drive with the petrol that can be purchased out of 500 rupees. This is a case of unit elasticity of demand; price elasticity of demand is 1. If there is one percent fall in the price per kilometre travelled, your kilometre travel will go up by 1 percent. As a result, the expenditure on petrol will remain unchanged and use of petrol will remain unchanged. Here, actually the kilometre travelled is going up from 80 to 160 with the same 10 litres of petrol. Although the technology promised a saving of 5 litre of petrol, you end up saving nothing because your mind as a consumer is behaving in a very different manner.

There can be some rosy scenarios as well but this is not the rosy one, this is the worst one where you can have some backfire. What is backfire? The consumer not only increases the consumption of petrol from 10 but the consumption may as well increase. Because, now you have kind of an energy efficient car, it's easy to drive, per unit expenditure is less and if price elasticity of demand is too flexible, then this 1 percent decline in price will actually lead to, maybe, 2-3 percent increase in use. As a result, total expenditure on petrol is going to go up and your demand for petrol is also going to go up. Rather than reducing anything you are increasing your consumption from 10 to 14 litres.

The rosy scenario that I was talking about could be a case of super conservation where the technology promises a saving of 5 litres of petrol but the consumer ends up saving more than that. This kind of situation is very rare and hardly has been documented in empirical studies, wherever it is documented it’s mostly because of the fact that energy efficient appliances were introduced along with some awareness programmes. If some energy efficient lighting equipment were distributed then along with that the consumers were also told about the expected energy saving and also, they were told that when you are going out of the room you better switch-off the lights. The behavioural changes are such that not only you realise the technological gain but your behaviour is changed in such a manner that you overshoot the technological gain but this is a very rare scenario. Which direction it finally goes is kind of uncertain? Unless the technology comes in place it’s a bit difficult to understand which direction it’s going to go but you can have some clue.

In the case of backfire, initially the car was driven for only 80 kilometres, now it is driven for 224 kilometres. When will that happen? This happens when you have a huge unsatiated demand. We have a lot of demand but it is constrained by resources, so you cannot meet your demand. In that case where the price declines you have a tendency to increase your demand manifold.

The backfire is often observed in the context of developing countries where you have a lot of unmet demand in place. The moment the technology comes, you actually tend to use it more. Think about a household where there was no electricity, initially when the electricity was introduced for a few hours you had some incandescent light, then it was said that the electricity was being supplied for 24 hours and then the CFLs were given. Two things are happening simultaneously, because this is a very fundamental demand the household will increase the use of electricity to get the lighting service to manifold uses.

Whenever you have unmet demand you can expect that technology/energy efficiency may not actually lead to reduction in energy use. It can lead to a sustainable increase in energy use, which is also very important for sustainable development. If you recall the concept of load building, we said that not only conservation but load building is also important for load management. This is a case of building the load through introduction of energy efficient technology.

There is a large debate in this context that if energy efficiency comes into place in the developing countries then because of rebound effect a lot of potential gain is not achieved. But this takes us into some political debate as well but one needs to understand that this kind of backfire happens, because a certain section of household or certain section of population is denied basic need for electricity or basic need for power.

This is a very important step towards sustainable development, we cannot look at it as if technology is being implemented and it’s not been able to deliver what it is supposed to deliver. If we can calculate the rebound effect, it gives an understanding about what is going to be future demand.

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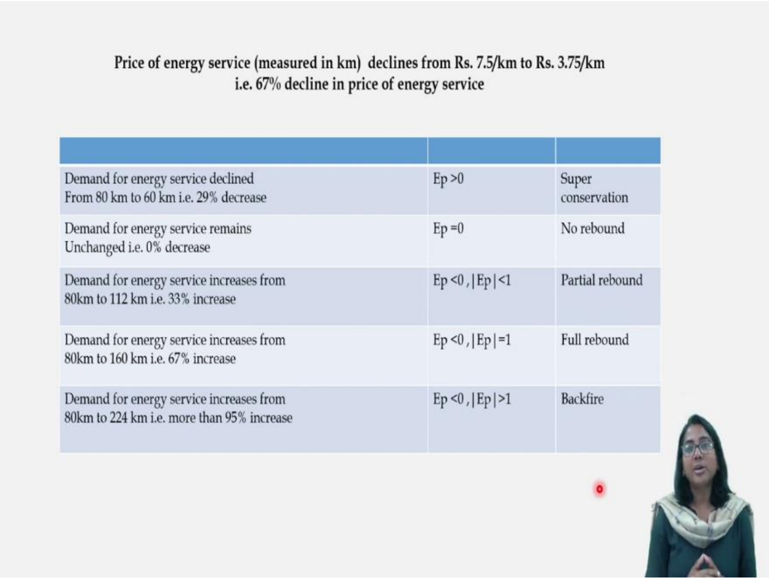

Finally, we are going to link the concept of rebound effect with the concept of own-price elasticity. This is only one way of looking at the problem. There are various ways you can calculate the rebound effect. If you have very basic information like I have given for the car. If you have this kind of information at the household level, you can calculate the rebound effect at a very disaggregate level, you can take the help of price elasticity in order to calculate the rebound effect, you can also take the help of a lot of modelling where certain parameters are used to understand the rebound effect. Another thing is that the rebound effect is not always equipment specific.

Rebound effect for the whole economy may also be calculated. While your industry is becoming more energy efficient probably you are saving a lot of energy and you are supplying that energy to the residential sector, where the residential load building is taking place. If you look at the economy wide, then shifting the energy consumption from one sector to another also reflects aggregate rebound effect.

But here we are going to discuss only the concept of own-price elasticity. Coming back to our example where price per kilometre travelled had declined from 7.5 per kilometre to 3.75 kilometre, this is actually a 67 percent decline in the price of energy service.

Notice, I am not saying this is the decline in the price of energy because the petrol price is not changing, what is changing is the price of energy service which is declining at 67 percent. In case of super conservation, the price elasticity is actually positive i.e.
$E_p > 0$. This is contrary to the expectation of the economic theory. A 67 percent decline is leading to a decline in the demand for energy.
The second case is the case of no rebound. Even if the price declines by 67 percent there is zero decline in the demand. This is leading to a price elasticity which is equal to 0 i.e.
$E_p = 0$ and therefore, you have no rebound.

In the third case when you have partial rebound is the most plausible kind of a situation. In most of the cases, own-price elasticity is negative. However, absolute value is less than 1 i.e. $E_p < 1$. A 67 percent decline in price has actually triggered 33 percent increase in your demand. Increase in demand is less than decrease in price.

In case of full rebound 500 rupees was decided to be spent on petrol to drive as many kilometres as possible. Here, there is a 67 percent decline in price which is being matched by a 67 percent increase in the demand. So, p declines at the rate of x, q increases at the rate of x as a result p multiplied by q remains constant i.e. $E_p = 1$

You can think about the shape of the demand curve if you have full rebound. This can be one exercise to think about.

The final one, in case of backfire a 67 percent decline in price has actually triggered a 95 percent increase in demand i.e. $E_p > 1$.

There is a whole lot of unmet demand that was present in this kind of a scenario which has resulted in backfire. In the current energy demand literature rebound effect is one of the important things to understand, especially in order to forecast the energy demand in the context of developing countries. But one should not think that this concept is very new and has been perceived only in recent times.

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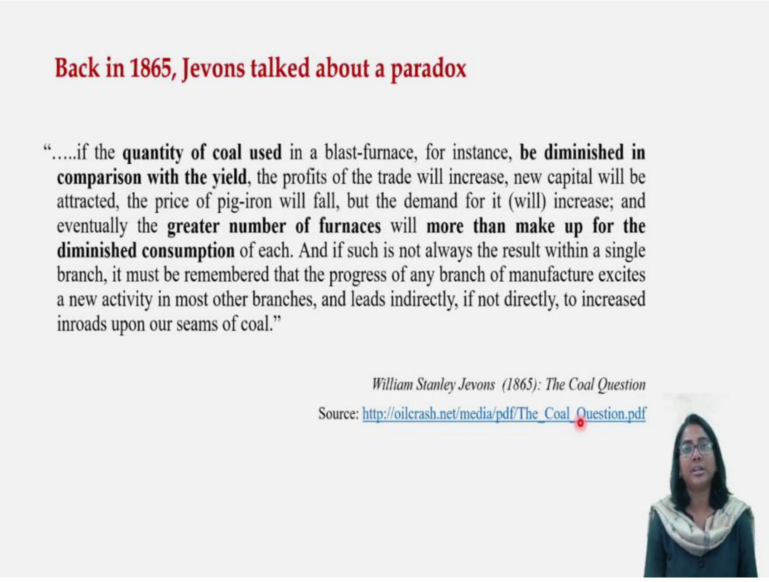

This concept has been discussed in economic literature for many years. For example, the writing by Jevons in 1865 from the paper called 'Coal Question'. You can access this paper free of cost if you go to this site, where he is saying, if the quantity of coal used in a blast furnace for instance be minimized in comparison with yield, the profit of the trade will increase, new capital will be attracted and price of pig iron will fall but the demand for it will increase.

Let us have a look at the phrase again, he is saying "if the quantity of coal used in the blast furnace" decreases there is energy efficiency. The amount of energy that you need to produce the same amount of pig iron, reduces and there you get energy use is diminished: "consumption in comparison to yield", you are saving on energy and energy bills.

As a result, the cost of production comes down, profit goes up. The moment profit goes up many people will be attracted towards this industry. There will be more units being added to this industry and eventually the greater number of furnaces will more than make up for the diminished consumption of each. Each unit is saving on their energy bill, therefore there will be an increase in profit, wherever there is energy efficiency. The moment there is an increase in profit more people will be attracted to produce pig iron so the production will increase. As the activity is going to increase, thus your total demand for coal is also going to increase. Initially you had 5 units who were producing; they become energy efficient however 5 more units are being added. Even if all the 10 units are energy efficient the total coal consumption has gone up.

This is the concept of rebound effect; this was probably the first writing where the concept of rebound effect was observed. After that it has taken different shapes and various methodologies have been devised how the rebound effect can be calculated. But this is a very important note where we are going to end our lecture on energy demand.

If you have any questions you can always post us. In the next week we are going to move on to the issues regarding energy supply.

Thank you.