Energy Economics and Policy
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Week - 08
Special Topics on Energy
Lecture - 03
Energy, Environment and Climate Change

Welcome back, this is the third and final lecture of week 8 and this happens to be the final lecture of this course on Energy Economics and Policy.

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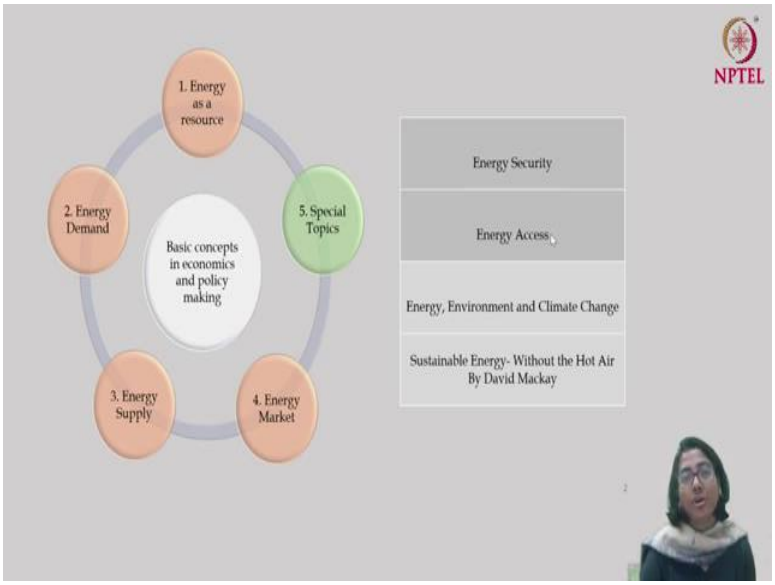

In this lecture what we are going to do? It's a very short video where I would like to motivate you to think about the nexus between energy use and climate change, a very contemporary issue. A lot of research is being done in this area, a lot of opportunity is left. So, if you are interested in energy policy it's worth visiting the area where you talk about the relationship between energy use, energy production, the impact on climate change, climate change mitigation and the related policies. This video is going to be based, majorly based on a book written by David Mackay in the year 2009 which is called "Sustainable Energy - Without the Hot Air". This book is freely available online, this is an open source book you can search it on Google and download all the chapters of the book. This is a really interesting reading that motivates you to think about and do work in this area.

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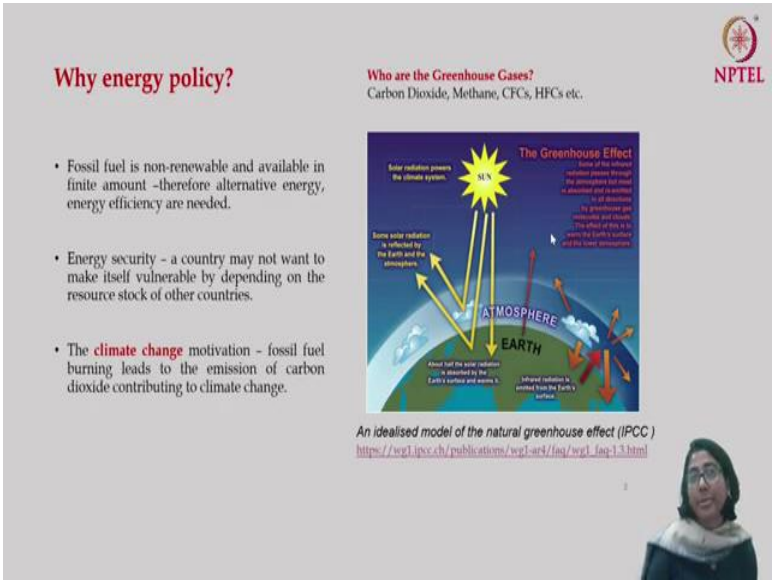

Let us begin with this question, why energy policy? If you recapitulate whatever we discussed in this course you will find that there are three underlying motivations that we have covered in order to understand why there should be energy policy, why energy policy needed at all? What are these motivations?

The first one is that, at the current stage, I mean till date most of our activities, the production as well as the consumption activities are based hugely on fossil fuel. The share of renewable energy has increased but till date what has been dominated is the use of fossil fuel. Now, what is the problem with using fossil fuel? The first problem arises from its inherent nature that the stock of the fossil fuel is finite. So, it's going to go over after a particular point of time.

If our production and consumption behavior are actually based primarily on fossil fuel, then what happens to that production and consumption behavior when the fossil fuels get over? So, this is the first fundamental question and in order to address this we talked about several policies starting from the energy efficiency policies, the demand side management policies, we also talked about the supply side policies which are there to promote renewable energy. All these policies try to address the fact that the stock of fossil fuel is finite and it's going to be over after a point of time.

The second motivation that comes into the picture is related to energy security. Now, it's not that everywhere fossil fuel will be over at the same point of time. So, if in my country for example, this is just an example, Suppose all the activities of my country are based on oil and

the stock of oil of this particular country gets over. So, I have to rely on other countries where geologically oil is still available.

I can still continue my production and consumption activities but for that I am making myself vulnerable by depending on a different country where everything can be affected by the geopolitical dynamics. This is the second issue. Now these issues are not much debated in a sense, everybody accepts these issues that you have to find an alternative to fossil fuel because it's going to be over. You also need to find an alternative to fossil fuel in order to increase the energy security of a country.

However, the recent motivation that comes into the picture is a little bit different from these two objectives. This is the climate change motivation. In the book David Mackay, in the motivation section he writes it as the climate change motivation which is very important. What is climate change motivation? Fossil fuel burning leads to the emission of carbon dioxide gas contributing to climate change. Let us see how.

There are few gases which are called the greenhouse gases for example, carbon dioxide, methane, chlorofluorocarbon and hydrofluorocarbon etc. which are present in the lower atmosphere of the earth. Now what do they do? The solar radiation powers the climate system. The solar radiation comes to the earth. What does earth do with the solar radiation? It absorbs almost half of the radiation which warms Earth's surface and half of it is being radiated back to the atmosphere.

Now, because of the presence of these greenhouse gases in the atmosphere some of this radiation which is reflected back stays within the lower atmosphere of the Earth, further increasing the temperature of the Earth surface. Thus, this lower atmosphere works like a jacket on the earth and if the concentration of the greenhouse gas increases then the jacket becomes heavier.

Now there is a certain temperature that is needed to prevail on the earth surface for life to flourish on Earth but if the mean temperature, if the average temperature on earth surface goes up beyond a particular point then that actually becomes unsustainable for the life to sustain.

So, it's important to have a particular concentration of greenhouse gas in the atmosphere but it is also important to check the concentration to some sustainable level. Now the problem is that when we burn too much fossil fuel, it leads to excess emission of carbon dioxide gases and

hence, excess concentration of carbon dioxide and other greenhouse gases in the atmosphere. This further leads to an increase of the average temperature of earth surface beyond the sustainable level, this is called the problem of global warming. If global warming takes place, this leads to other climatic events which are called climate change. So, there can be change in the pattern of rainfall, there can be increase in the extreme weather events and so on. Now-a-days you see a lot of debate and a lot of discussion is going around this climate change area and one of the major reasons now you understand is because of the burning of fossil fuel.

So, in order to curb or in order to mitigate climate change it's very important that you manage the use of fossil fuel, the burning of fossil fuel in a particular manner.

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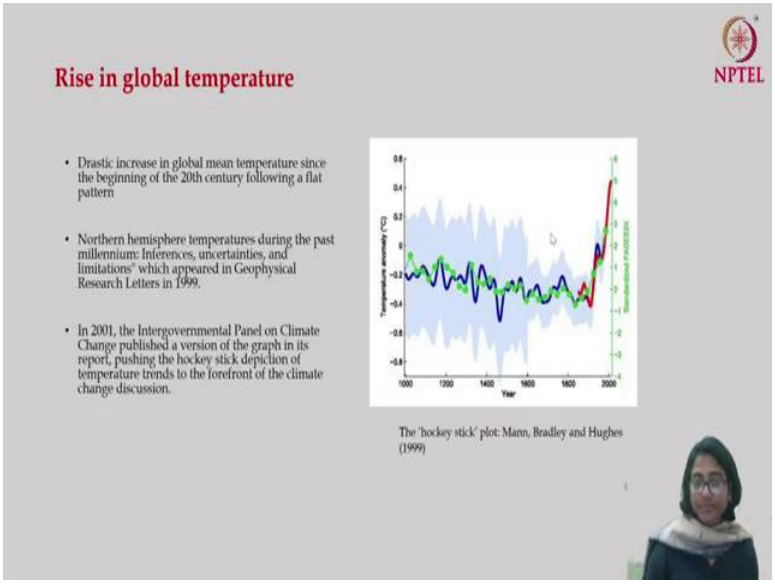

This is the graph which shows how the temperature of the earth surface increased over the past century. This is a very famous 'hockey stick' plot which was published in 1999 by Mann Bradley and Hughes where they are showing that there was a drastic increase. You see that there has been a drastic increase in the global mean temperature since the beginning of the 20th century, following up an almost horizontal pattern.

So, there was short time, short length increase and decrease in earth temperature; however, there was a sudden spike during the beginning of the 20th century which shows no tendency to come down. This is evidence that the temperature of the earth surface is going up beyond the sustainable limit.

If you go through the chapters published by the Intergovernmental Panel on Climate Change that is IPCC you will see that using this trend they have got a number of projections, a number of trajectories in which the earth's mean temperature can move and they also discuss the implications of the same.

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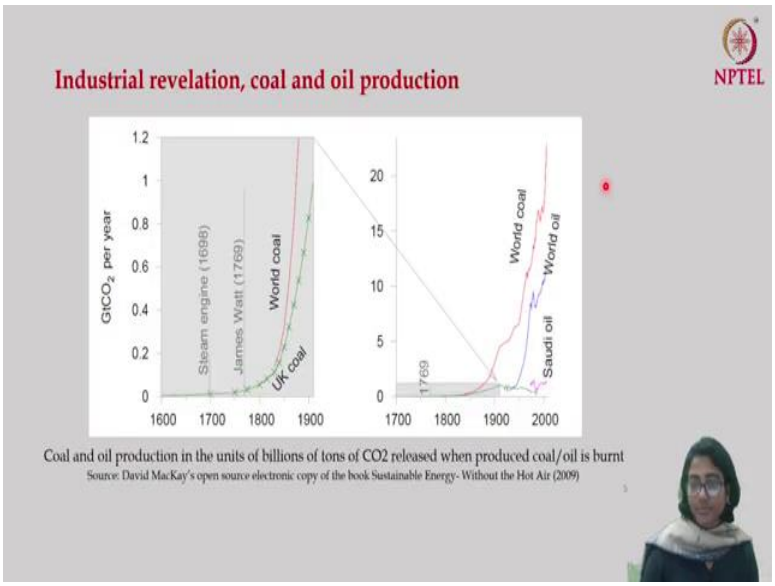

This shows that if you look at this diagram it says that in the beginning of 20th century there is a sudden increase, a spike in the increase in the earth temperature. Now we are trying to relate this increase in the global mean temperature with the increase in energy use.

So, if you look at this diagram, this has been taken from David Mackay's book again. So, as I have said this is a free resource book which is available, it's an excellent resource if you go through it. Here, he has plotted the energy use from the 17th century to the beginning of 20th century. You can observe that this is the point of rupture, this is 1769 where James Watt patented the steam engine. The modern steam engine which fueled the industrial revolution in the UK. Now once the industrial revolution came, a lot of energy was required for the production and consumption activities. Thus,you see suddenly there was an increase in the use of coal in the world.

So, this line is showing you the coal production in the world in a very interesting unit. If you look at the unit it doesn't say the tons of coal produced or tons of coal used. Here it's saying that gigaton of carbon dioxide per year. So, this red line shows the amount of carbon dioxide that was emitted by burning of the coal that was produced in a particular year.

This is the amount of coal that was produced, that is converted to the amount of carbon dioxide emission that it had potential to produce. We can see that the use of coal increased dramatically since the beginning of the 20th century and this actually with the spike in the global mean temperature.

Now, what we see in the next diagram. This panel is even more interesting. Look at the beginning of the 20th century, the potential emission that was caused by the coal used at that point of time was only 1.2 gigaton of CO_2 per year.

Now if you try to plot this much use of coal with respect to what is being used today, then it's very difficult to plot it in one single diagram. In the second panel what he has done is that, this 1.2 gigaton of carbon dioxide per year has been plotted here; it, has been scaled, the whole graph has been scaled down.

We see that it not only started in the beginning of the 20th century but after that the increase continued. So, the use of coal increased greatly after the 20th century and not only coal; it was added by the use of world oil which is represented by the blue line here. The importance of these two diagrams, this particular diagram and this diagram is that, it shows that after the industrial revolution there was a huge increase in the use of energy for the production and consumption behavior undertaken by human beings.

This not only has the implication towards the fact that we are using a lot of fossil fuel which has a finite stock which may have implications for energy security; but it also has the implication that this is contributing to the increase in global mean temperature beyond the sustainable level and leading to climate change.

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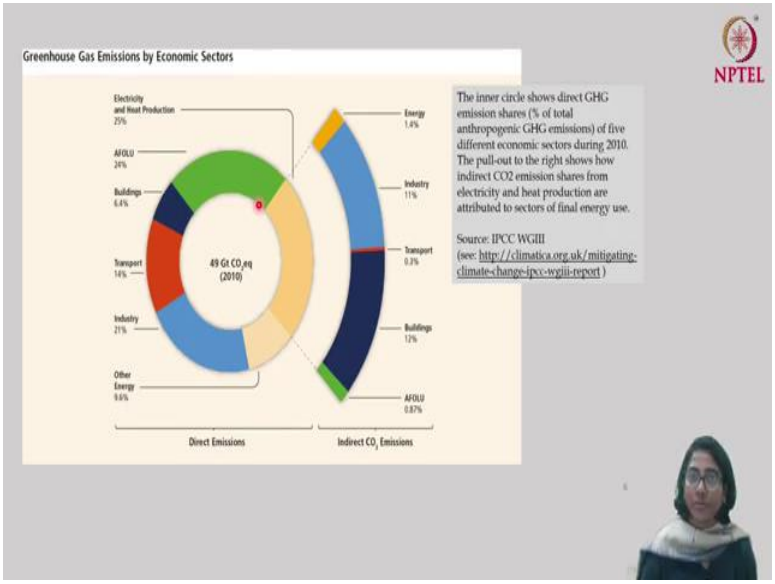

This diagram reemphasizes the fact. This is the diagram from the IPCC working group, working group 3, I have given you the link. This is also downloadable material, you can go to that and have a look at it. It shows that if you try to break up the total greenhouse gas emission by different sectors, 25% of greenhouse gas emission comes from electricity and heat production. Where does this electricity and heat go? It goes to several other sectors. So, electricity and heat production is contributing 25 percent of it.

Where do you get the other from? The others are coming from the industry sector, who is again using energy, it's coming from the transport sector, where again the source is majorly the energy. So, everywhere whatever sector is, it is coming from the source is the burning of fossil fuel, the burning of energy.

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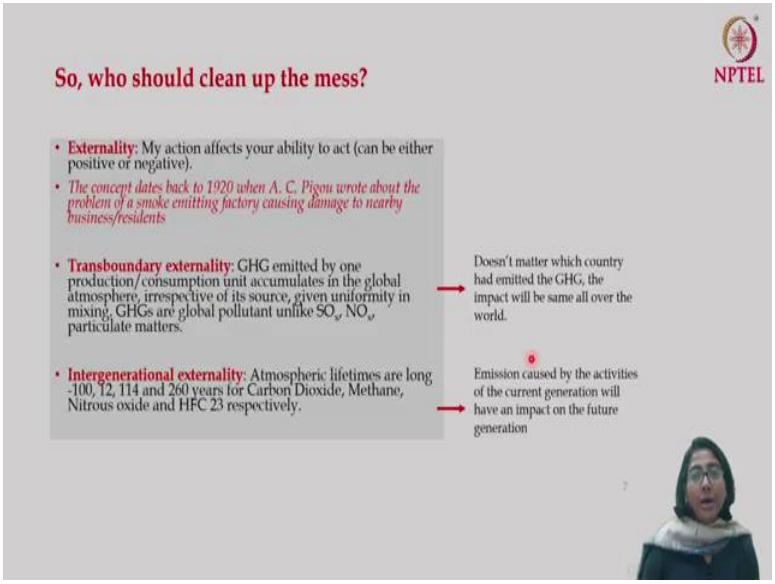

Now, the question is why is it such a complex issue? Why is it so problematic to have a policy which can, moderate or which can actually guide the energy use in order to curb climate change? It's because the moment the concept of climate change comes into the picture the things become very messy, you can't have only domestic policies in order to go for emission mitigation or have a sustainable solution for climate change, the question is why is it so?

Before we go into the discussion why it is so, we have to understand the concept of externality. Now what is externality? It is basically a concept when my action affects your ability to act, it can be positive, it can be negative. In economic literature the first mention of externality comes in 1920 where, A. C. Pigou, was writing about a smoke emitting factory which was emitting smoke and it was causing a negative externality health effect, the productivity effect for the nearby business and the residence. So, the activity by the industry was impacting in a negative manner to the business and the next residence nearby. This is externality. Now how can we solve this problem? You can always ask the industry to pay compensation to the business and the residence nearby, this is one process to go about, but why this compensation process doesn't really work when we talk about global warming.

The problem lies in the characteristic of these greenhouse gases. Now, what are the characteristics of these greenhouse gases? Two fundamental characteristics at that, first it spreads relatively evenly in the atmosphere. This is one thing and the second thing is that once emitted they are going to stay for a long period of time in the atmosphere.

What are the implications of that? So, when I say that they are actually going to be relatively evenly spread out, it means irrespective of the source of emission the impact will be on everybody.Irrespective of the source of emission generally this greenhouse gas will increase the concentration, their concentration in the lower atmosphere of the earth and therefore more heat energy will be trapped and the global mean temperature will increase.

This is one issue and therefore the externality that is built, there is obviously an externality. Suppose country A is the source of emission, then the impact will be felt everywhere all over the world. So, for the entire world this is an negative externality caused by the action of country A. Now the problem is that if the externality is trans-boundary in nature, it also means that if country A mitigates the emission of carbon dioxide the positive effect will also be felt all over the world.

There is a lot of debate who should mitigate because it doesn't matter who mitigates, the effect is going to be felt all over the world. This is one problem. Here I have given the example. So, the characteristic of the greenhouse gases with respect to the spreading is different from the local pollutants like SO_X, NO_X or particulate matter. When we talk about this local pollution for example, when we talk about vehicular pollution, then the national government or the local government can have the policies to tackle this problem because this is not a trans-boundary problem. Wherever it is being emitted it's going to stay in close proximity. But that is not the case of greenhouse gas emissions.

If you think about, reduction in greenhouse gas emission then probably all the countries need to have a talk together and therefore, you see a lot of global conversation going on around the topic of climate change mitigation.

The second problem is that as I said that once emitted this greenhouse gases are going to stay in the atmosphere for a very long period of time, what is the length of that? For example, carbon dioxide is going to stay for 100 years. As a result of my generation's activity, that is, my generation's production and consumption behavior is the cause behind the emission of carbon dioxide, the effect will be felt not only by my generation but also by the generations to come.

Now, this is again problematic because it also means if you mitigate today the benefit is going to be accrued in future generations. Your action towards mitigation depends on what is your time preference? How do you discount the future generation? How do you prefer the future generation? So, this trans-boundary nature of externality and intergenerational externality

caused by this greenhouse gases which are being emitted because of burning of fossil fuel is actually causing a lot of complexity in the policy formulation.

Here when I say that the greenhouse gases are emitted, CO_2 is emitted by the burning of fossil fuel, it doesn't mean that burning of fossil fuel is the only source of CO_2 emissions. There are natural processes as well and there are natural processes of assimilation as well.

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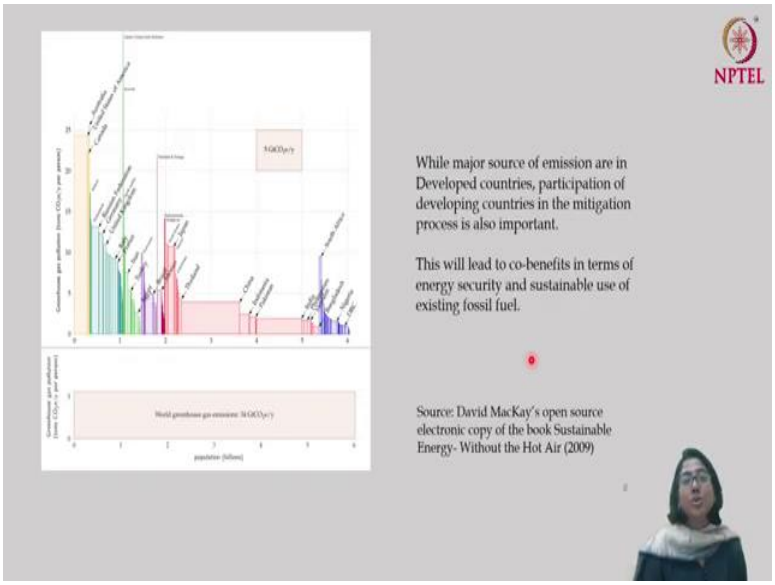

We can say that because this policy is difficult, so we come to the question of who should mitigate. If I mitigate everybody is going to be benefited from that, however, mitigation is expensive. So, some money has to go there. Secondly, if I mitigate today then impact is going to be felt tomorrow as well.

Thus, the question comes who should mitigate. Here again this example I have taken from David MacKay's book and I am giving you a little back-dated number but in order to be able to explain the figures I will stick to these numbers of 2000. Here is one thing if you look at the unit, it's called the gigaton of CO_2-e. CO_2-e means carbon dioxide equivalent. So, this is the total greenhouse gas emission expressed in terms of equivalents of carbon dioxide.

In the year 2000 if you look at the bottom diagram here, in the year 2000 the total greenhouse gas emission of the world was 34 gigaton of CO_2 equivalent and the total population was 6 billion. Now if I divide this 34 gigaton of the CO_2 equivalent by 6 billion then the, per head entitlement of greenhouse gas emission or per head greenhouse gas emission we found that this

is 5.5 ton. Now the question is that, is it the case that everybody is producing 5.5 ton of carbon dioxide equivalent, the answer is no.

There are some countries where per capita emission is much higher than 5.5 ton of CO_2 equivalent, there are many countries somewhere it's much lower and therefore, what he does is that he divides the 34 gigaton of CO_2 equivalent across countries depending on their per capita emission. So, if you look at the per capita emission figure this is the tallest bar, this is coming from united, this is not the tallest bar but this is the first bar actually this is coming from the USA. The second one is from Australia with the tallest bar and then you have Canada, Ireland and so on. Here you have South Africa also has a little higher emissions. So, you see this is 5, there are many countries for which the per capita emission is much higher than 5 ton per year. There are also many countries below 5 ton per capita, for example, China, India and many other countries are here like Nigeria, Bangladesh, even Thailand; here you see Egypt is much less than 5. There are countries whose emission is much less than the world average, there are countries whose emission is much greater than the world average. This is one thing that the contribution of per capita emission to the trans boundary pollution is different from different countries.

The second point is that if you look at the historical emission. So, these developed countries followed by industrial revolution they started using this energy and started emitting a lot of carbon dioxide since the beginning of 20^{th} century. However, the developing countries joined much later in the league.

So, if you look at the historical burden and this is one of the very popular terminologies in the context of climate change policies. If you look at the historical contribution to climate change, the developed countries are far ahead with respect to that. Therefore, one argument comes in the form that because it's largely the historical responsibility of the developed countries they should clean up the mess. So, they should take more actions towards mitigation which is partly of course true, but we also need to understand the fact that if countries like India whose contribution to climate change today is not that high, it will become much higher tomorrow. It's also good for them to take the climate change mitigation measures, why?

Because the impact of climate change is going to be felt all over the world and these developing countries with less infrastructure, less healthcare structure, they are going to face more trouble when climate change becomes real, right. So, it's their prerogative as well to mitigate CO_2

emission, to go for sustainable use of energy. This also gives them certain co-benefits like energy efficiency or energy security and so on.

Although the historical responsibility lies majorly with the developed nations, it's also important that the developing nations come and join hands in order to mitigate climate change and find out policies of sustainable energy use. So, I am going to stop here, this is the end of the course. I hope that the course was interesting to you and in the last part of it, in this video particularly if you are motivated to study more about the nexus between energy and climate change, there are many literature on that, this is buzzling field of research, you can always go through them. So, I am going to stop here. This is the end of the course, if you have any queries please feel free to write the question on the discussion forum, you are always welcome to contact me if you have any further questions.

So, Thank you very much for joining the course.