Energy Economics and Policy
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Week - 08
Special Topics on Energy
Lecture - 02
Energy Access

Welcome to the second lecture of week 8. In this lecture we are going to discuss the issues related to Energy Access.

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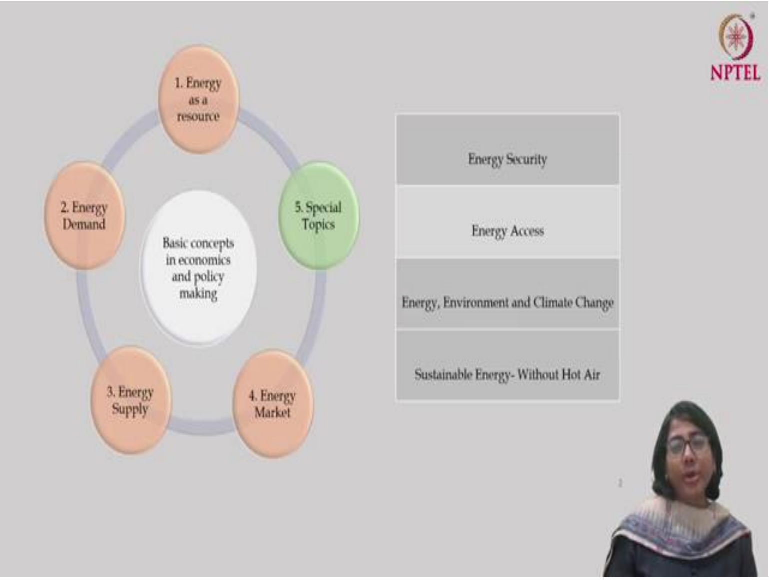

Although energy access again is a broad area of research, what we are going to focus on is basically the household energy access and we are going to restrict our discussion in India. We are going to take up the examples from India and see what are the policies that have been taken up by the Government of India in order to promote energy access.

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We start with the UNDP's 7th Sustainable Development Goal which is affordable and clean energy. Before I go into the description of this particular Sustainable Development Goal and try to understand its significance, let us spend a couple of minutes to understand what are these Sustainable Development Goals by UNDP. The United Nations Development Program in their national general assembly, 2015, set up 17 Sustainable Development Goals.

This encompasses various facets of development starting from reduction of poverty or I should say no poverty, zero hunger. It also encompasses areas like infrastructure development, environment, etc. One of these goals is related to energy access. All these goals have certain specific targets which can be measured. Not only the target or the final goal can be measured but also the progress of a country in order to achieve that goal can be measured. These targets of the goal have to be achieved by 2030.

Then we come back to the 7th Sustainable Development Goal which talks about affordable and clean energy. Now, why is it the case that affordable and clean energy is one of the building blocks of sustainable development. This again I quote from UNDP's website, they write that- "Energy is critical and people with no sustainable access to energy are deprived of the opportunity to become a part of national and global progress". I would strongly encourage you to visit the website that I have mentioned here to understand more about the 7th Sustainable Development Goal of, Sustainable Development Goal by UNDP.

What are the targets to be achieved under this goal? These are some specific targets. We are going to discuss two targets. Once we go through the discussion, you will see that our discussion is hovering around the first two targets but there are three others as well. What are the first two targets?

First target says that by 2030, we need to ensure universal access to affordable, reliable and modern energy services for the entire population of the world. There are three components – the affordable, reliable and modern energy services. Why is 'affordable' so important? Because it might be the case that the market clearing price for energy is not affordable to a particular economic section of the population and, therefore, the government needs to intervene and come up with some policies which can make this energy affordable to everybody.

The second component is 'reliable'. This is regarding the quality of power and energy that you are getting. For example, suppose you think about LPG. I am willing to take up LPG as my cooking fuel. However, there are not enough distributors who can supply LPG to me. So, the supply is not reliable. The same thing can happen with electricity, the quality of power that is being supplied may not be good, I may not get electricity for 24/7. All these things bring up the issue of quality of energy supply which needs to be tackled and these are the major issues in the context of developing countries.

The final component is the modern energy services. When we say modern energy services, I would like to take you back to the discussion of the first week. Recall that we discussed the different types of fuel, different types of energy. There we talked about the traditional fuel and the modern fuel or commercial fuel and non-commercial fuel because in most of the cases these traditional fuels are non-commercial in nature. So, one example of traditional fuel could be dung cake or the wood chip, charcoal etc. and the example of modern fuel can be LPG, electricity etc.

This is the main target and this is where our focus is going to lie, ensure universal access to affordable, reliable and modern energy services. In the rest of the lecture we are going to see what makes it so important, what are the evidences that it is so important to have access to energy. Second, we are going to see what are the indicators through which you can measure the energy access. Third, we can see what are the costs involved with respect to such a transition from traditional fuel to modern fuel and so on.

There are three other targets as well that are to be achieved under the 7th Sustainable Development Goal. However, the disclaimer is that in this lecture we are not going to focus on these but let us have a quick look at what they are. The third one is: increase substantially the share of renewable energy in the global energy mix. When you are talking about clean energy as a consumer if I am using electricity, electricity is a clean energy for me. It doesn't matter what is the source of that electricity, whether this is coming from solar or wind or nuclear or coal, it doesn't matter to me.

But, if you look at the electricity production sector, then it really matters what is the fuel mix that is producing this electricity. The entire India can start using electricity both as lighting as well as cooking fuel but the concern is then if you are burning too much coal that will not make electricity that much of a clean fuel throughout the entire chain. So, in order to make electricity or in order to make the greater access to fuel in a cleaner manner it's important to increase the renewable share in the global energy mix.

The next point is: double the global rate of improvement in energy efficiency. This also we have discussed. If the current rate of activity can be performed with less energy then you are left with residual energy which can be accessed by a lot of population who don't have access to electricity or energy at this point of time. The final one and it's a very crucial one. This talks about the increase in the cooperation between different countries in order to facilitate the research and development in clean energy and related technology.

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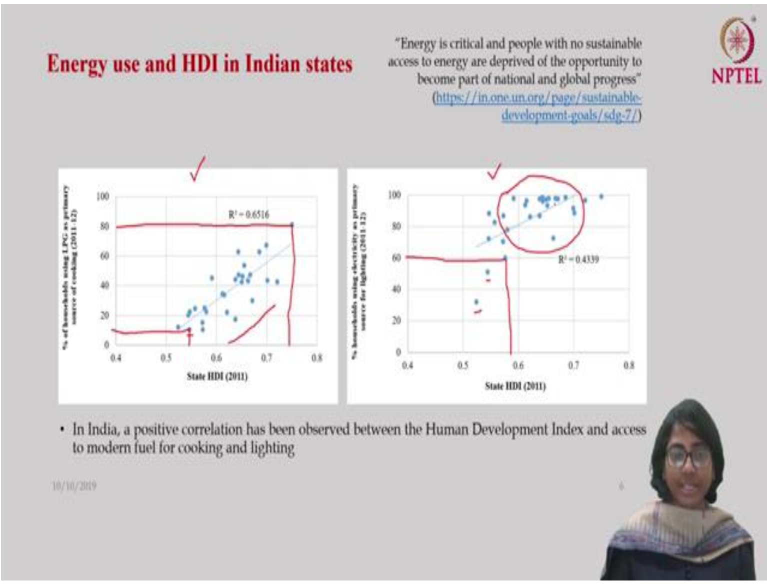

Let us now look at what kind of facts we can provide in order to support the argument that energy is critical and people with no sustainable access to energy are deprived of the opportunity to become a part of national and global progress. In order to understand this, we are going to see what is the relationship between energy use especially in terms of use of electricity and LPG with the Human Development Index of the states in India.

We have carried out this activity only for Indian states. You can try to do it for different countries as well if you take it up as a research. So, what is the Human Development Index? This is a relatively comprehensive measure of development of a nation or of a state.

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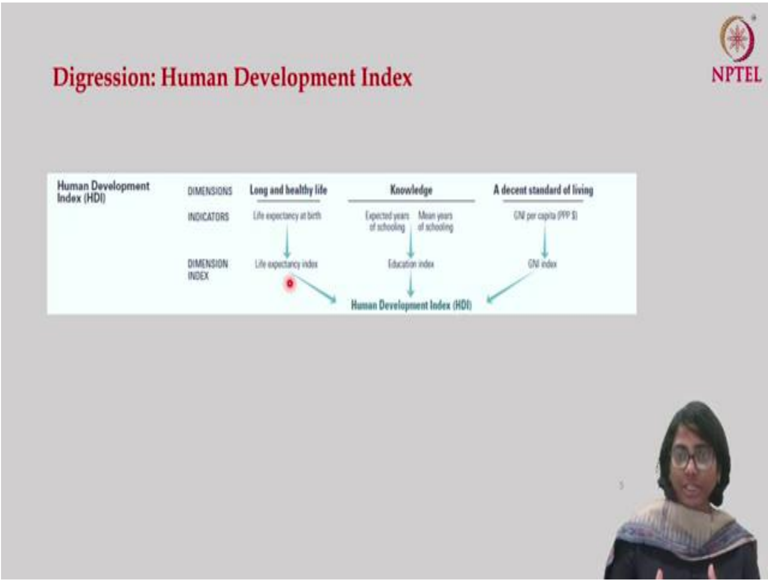

Why the comprehensive way to understand development? Let us have a quick look at the Human Development Index, what is it? So, earlier the development was mainly measured in terms of income, in terms of the gross domestic product or the national income etc. However, there are certain difficulties or there are certain loop holes if you use only income as a measure or as an indicator of development.

Having higher income doesn’t always mean that it is being translated into higher education or higher healthcare services and so on. So, we have this more comprehensive index which is called the Human Development Index and here apart from income, two other indicators are taken care of. What are these? If you look here there are three dimensions of the Human Development Index. One is long and healthy life: so, this is the health related dimension; next, you have knowledge, which is the education related dimension and finally, you have a decent standard of living which is of course, an income related dimension.

Now, what are the indicators that are considered to capture each of these dimensions? The first indicator in order to capture health dimension, is the life expectancy at birth. So, how many years a newborn child is expected to live? This is a demographic sort of indicator that can be derived for a country, for a state or for any particular population. So, the first indicator of the Human Development Index is the life expectancy at birth.

The second indicator is related to education. It has two indicators – one is expected years of schooling and the other is - mean years of schooling. So, expected years of schooling are applicable to the population of the age who are actually going to school. So, how many years of schooling they are expected to complete. The second one is the mean years of schooling, here we are taking the non-school going population. So, this is actually the population whose age is over and above 25 and what is the average number of years of school that they have attended in their life. This is expected years of schooling is more of a futuristic measure whereas, the mean years of schooling is more like the current measure. So, combining these two we get the education index. Basically, when you have the data on this you take the arithmetic mean of the expected years of schooling and the mean years of schooling in order to come up with the education index.

Finally, you have the income related indicator which represents a decent standard of living that is, for that the purchasing power parity adjusted Gross National Income is taken. Based on all these indicators we have three dimensions; one is related to health, life expectancy index; one is related to education which is represented by the education index and then we have the income related indicator which is called the GNI index. We take the geometric mean of these three indices to come up with the Human Development Index.

You can see that if the human development index of a particular population is higher that represents not only the population has a decent standard of living with a high level of income but it also implies that the population is leading a healthy life with high life expectancy at birth, they also have access to education. Thus, it’s the overall quality of life that we are talking about and the overall development of a particular population.

Now, if we come back to our discussion about the relationship between the energy used and Human Development Index in Indian states, what we can say is that if we observe a positive relationship, a positive correlation between energy use and Human Development Index, it supports the argument that energy is critical in order to have a healthy and productive life, the general development. So, energy use and the development; these two are positively related parameters that support this kind of argument. However, if we find that they are not positively related then we can say that this does not hold for Indian states.

When we plot the data we calculate the Human Development Index and we take some indicator to represent the **e**nergy use, we see that there is a significant positive correlation between energy use and the Human Development Index. To be more specific it's not actually energy use but the use of modern forms of energy.

If you observe the first graph, what does it depict? On the horizontal axis this is the Human Development Index of each state that has been captured. Now, HDI being an index it ranges between 0 and 1. We have started this from 0.4 because otherwise it was going too much towards the right. So, we started from 0.4 and it goes till 0.8.

On the other hand, on the vertical axis, we report here the percentage of households using LPG as the primary source of cooking fuel. These are the households for whom LPG is the primary source of cooking fuel. However, it does not negate the possibility of having other fuel as secondary fuel for cooking and this data has been obtained from the data provided by National Sample Survey Organization.

You can see that the data is a little old, it represents the energy using 2011 – 12 because that is the last year where the comprehensive report on NSSO is available. However, it gives you the picture I mean, you don't lose the generality even if you use the data of 2011-12. Here each point represents one state. If you look at this point here, if I go to this, for this state the Human Development Index is somewhat between 0.5 and 0.6 and the percentage of households using LPG as primary source of cooking fuel is somewhat around 10%. If you take this particular state then you see that the Human Development Index is relatively high, this is between 0.7 and 0.8 and the percentage of households using LPG as primary cooking fuel that too is high and this is little over 80%. If you look at all these points, you will observe that on an average the states, who have a higher percentage of households using LPG as the primary fuel of cooking, tend to have higher Human Development Index. Thus, with respect to Indian states, there is a positive correlation between the percentage of households using LPG and the Human Development Index.

Let us see what happens in case of electricity. In the case of electricity, we find a similar kind of feature. Here again we are plotting the Human Development Index on the horizontal axis and on the vertical axis, we are plotting the percentage of households using LPG as primary fuel for cooking. So in the previous graph we were talking about the use of LPG as cooking fuel, in this graph we are talking about the use of electricity as the lighting fuel.

Again if you take a particular point what does it depict? It depicts that for this particular state the Human Development Index is again somewhere close to 0.6 and 60 % of households in this particular state are using electricity as the primary fuel for lighting. However, in this graph you have a bigger cluster in this zone right. This shows that most of the households do have access to electricity.

Most of the households barring you know, few outliers maybe this one, this one and this one, most of the states, the percentage of households who are using electricity as their primary lighting fuel that's higher than 60% and in most of the cases you can see they are higher than 80%. Higher the access to electricity as lighting fuel, higher tends to be the Human Development Index. Here also we find a positive correlation between the percentage of households using electricity as primary lighting fuel and the Human Development Index.

This kind of supports the argument that use of energy is critical for the overall development. Why is it so? It's very simple to understand why it is so. If you don't have access to electricity, probably children going to school can't read and write properly, you can't perform many of the household chores if there is no electricity. Your productive hours during night is gone because there is no electricity and many of the works cannot be done for example, reading and writing.

Similarly, if you look at the cooking fuel, the use of traditional fuel causes the biomass burning. It causes a lot of indoor air pollution which also contributes to the outdoor air pollution and increases the health burden, the respiratory problem, the infectious diseases, etc. So, the transition from traditional fuel to modern fuel enhances the quality of life. It not only talks about the access to modern fuel but it also gives access to certain development, that is, it makes people able to achieve certain development goals. This is shown in case of Indian states as well, the overall development of Indian states were closely related to the percentage of households using the modern fuel for cooking and lighting.

Now, before I move on to the next slide, just one thing it's quite interesting to observe from here. As I said, if you look at the access to LPG, here in this graph the points are spread all over. So, in different states in India the access to LPG is very different. In some states it’s very low, in some states it’s not very high, actually you don’t find any of the states with access to LPG more than 80%. Generally the access to LPG is lower as compared to access to electricity. This is one quick observation and we will support this again with the help of some data.

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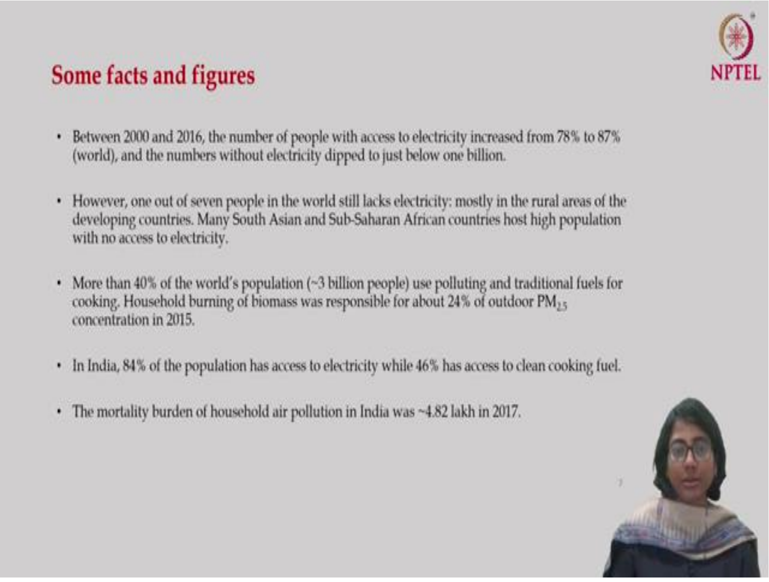

Here are again some facts and figures to support- why it is so important to have a transition towards modern fuel? Between 2000 and 2016, the World Bank report says that the number of people with access to electricity increased from 78% to 87% and the numbers without access to electricity had dipped to just below 1 billion.

Most of the people in the world do have access to electricity at this point. But given the fact that the world population is nearly 7 billion this also means, 1 out of 7 people in the whole world do not have access to electricity and this number is quite significant in that sense. 1 billion is not a small number, it’s a big number and where are we getting, where are these population pockets located? They are mostly located in the rural areas of developing countries specially in South Asian countries, Sub-Saharan Africa and so on. So, there are large pockets where there are people without access to electricity. India is one such country, Bangladesh is one such country, there are many African countries like that.

What is the scenario with respect to cooking fuel? More than 40% of the world's population which is close to 3 billion people, use polluting and traditional fuel for cooking. It causes a lot of indoor air pollution, leading to a lot of disease and health related burden. It is also a fact that this household burning of biomass which is causing indoor air pollution, goes outside as well and it contributes to approximately 24% outdoor PM 2.5 concentration, the outdoor particulate matter 2.5 concentration, this is the data for 2015.

So, this has a whole lot of significance with respect to the health and general development of the population. Let us have a quick look at what is the figure for India. In India, 84% of the population have access to electricity while 46% of the population have access to clean cooking fuel. The mortality burden of household air pollution in India was approximately 4.82 lakh which is a big number in the year 2017.

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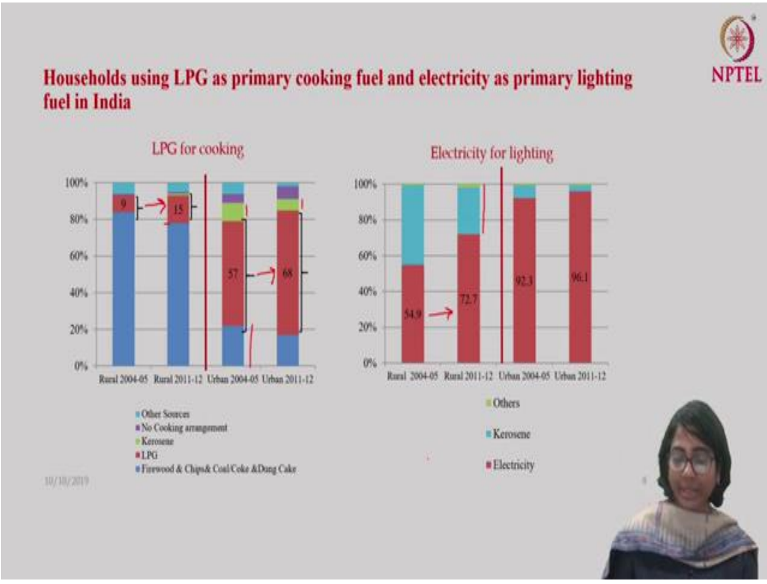

Let us now see how the transition from traditional to modern fuel had happened in India with respect to LPG as a primary cooking fuel and electricity for lighting. This is how it looks, if you look at each of the stacks this represents what percentage of the population or what percentage of households is using LPG for cooking.

The blue part of the bar represents the percentage of population using traditional fuel for cooking; the red part represents the percentage of population or of households using LPG for cooking. We are interested in how this red part is going to be bigger and bigger over time and how this blue part is going to shrink over time?

Now, we divide the data into two parts: one is the rural sector and the other is the urban sector because access is more sort of an issue in the case of the rural sector as compared to the urban areas. If you look at the scenario in India, you see that during 2004-05, only 9% of households in rural India had access to LPG as the primary cooking fuel. Over 80% of households relied on the traditional sources like firewood and chips, coal and cow dung etcetera.

Now if you come from 2004-05 to here in 2011-12, as we move the percentage only increases from 9% to 15% and you see that only little below 80% of households are still relying on the traditional fuel as their primary source of cooking fuel. What happened in the case of urban areas? In the urban area in 2004-05 you see that 57% of the urban population used LPG as their primary cooking fuel but that also implies that over 20% households even in the urban areas are relying on the traditional fuel. Things changed a little bit during 2011-12 but still you have around 17% to 18% urban households in 2011-12 who used traditional energy for their cooking purpose, as the primary fuel. One more observation, in the rural area you also see some use of kerosene as the primary fuel of cooking. Although the proportion is being reduced, the use is there. If you look at kerosene it’s not exactly a modern fuel, it's somewhat in between the modern fuel and the traditional fuel.

Let us see how the scenario looks with respect to electricity. This is a lot better but not again with respect to the rural areas. You see this red part again represents the percentage of households using electricity as their primary lighting fuel. In rural households it increased from approximately 55% to around 73% during the period 2004-05 to 2011-12. This blue part represents kerosene.

It says that in 2011-12 you have approximately more than 25%, more than one-fourth of the population, that did not have access to electricity. However, it has increased in the current years. It’s far better in case of the urban area, in India almost 100%, that is 96% of the population have access to electricity as the primary lighting fuel.

We can observe two things from this slide; one is that access to LPG as a cooking fuel is much less as compared to access to electricity as lighting fuel. In the later slides we will explore one of the reasons why it is so. So, this is the one observation. The second observation is that there are a number of households in India till date who do not have access to LPG as their primary cooking fuel and electricity as their primary lighting fuel, there are still such families. This number is not less, one-fourth of the rural population still do not have access to electricity as their primary lighting fuel and this number is quite big.

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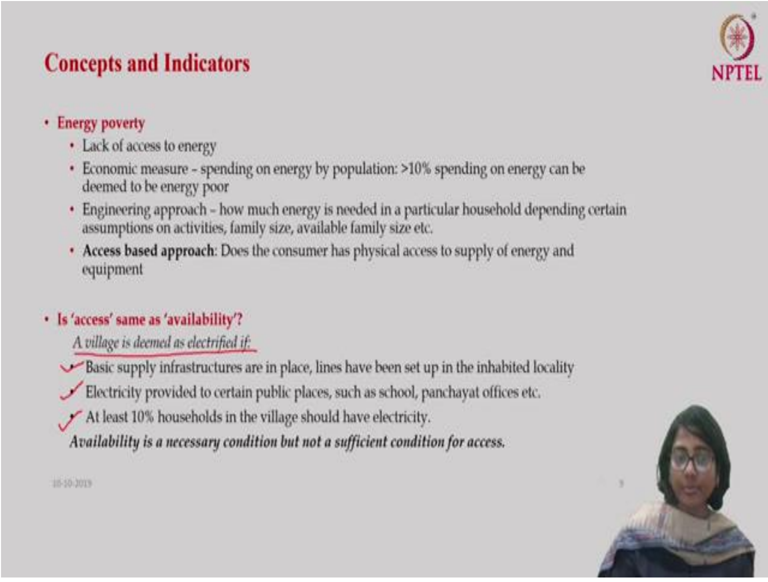

Said so, we come to the concepts and indicators that help us to understand what is the situation with respect to energy access and the concept is named as energy poverty. This says that a particular household or the particular section of population is energy poor if they do not have access to energy. What are the different measures that the indicators can be based on, to understand whether the particular household is energy poor or not.

There are three different types of indicators which are broadly used. These are economic measures, the engineering approach and finally the access based approach. So, what is the economic approach? To derive energy poverty in an economic sense the indicator is based on the expenditure that the household is incurring to buy the energy. The concept is very similar to the poverty line kind of a concept. This is to come up with an energy poverty line and it is said that this is one of the indicators. There is no hard and fast rule that you take it but some of the researchers go by this definition. They say that if the expenditure share on energy is more than 10% of total expenditure of a household then this household will be deemed to be an energy poor household. I repeat if the expenditure on energy, expenditure share on energy is more than 10% of total expenditure of a particular household then this household will be deemed to be energy poor.

Now, why is it so? Let me take you back to the concept of elasticity. You remember if the price increases what happens to the demand, what is the proportional change in demand and how does the expenditure change. We said that if we get some goods and services for which an increase in price does not have much impact on the consumption, then these are necessary commodities and energy is one such commodity. So, energy is a necessary commodity.

Now, it's more of a necessary commodity for the poor households because they don't have anything to substitute this energy for. If the household is already using dung cake as a fuel for cooking then you can't substitute dung cake by something else. However, if some household is using LPG and has a stock of kerosene and there is a sudden hike in the LPG price, then there is an option for this rich household to eliminate some part of use of LPG and start substituting kerosene.

The point is that for poor households it's very difficult to reduce the expenditure on energy and therefore, for the poorer households the expenditure share on energy is much higher as compared to the rich households. That is where the genesis of this concept is. It says that we come up with a threshold where we say that if a household spends more than 10% of its total expenditure on energy then this household will be considered as a poor household. But this measure is too broad as a measure. First of all this 10% cannot be justified by anything. This is one problem. The other thing is how much I am spending on energy that also depends on the energy equipment that I have.

Of course, if I use an incandescent bulb then I am using more energy and spending more on that. If I am using the LED light I am using less energy but it doesn't mean that one person does not have access to energy and the other person has access to energy. So, it depends a lot on the equipment, on the fuel mix that you are using, and many other demographic factors. Thus, this 10% cannot really be justified and there are many other factors that influence your energy expenditure. This income measure is not really that well recognized in the field of energy research.

The second approach is an engineering approach. This is kind of, in order to fix the parameters and then to come up with an understanding how much energy a family requires in order to sustain a healthy life. It takes care of different demographic things. How many family members are there, what kind of equipment are generally there in the household, what is the mix of the fuel that they are using and then what is the family size, what is the floor area etcetera and then come up with the, with an understanding of how much energy will this family require.

This is more of a bottom up engineering approach that can be used to understand the energy poverty or energy access for a relatively smaller area. But, in macro studies it's difficult to go by this sort of an engineering approach.

The third one which is more prominent in recent days is the access based approach. It just simply tries to understand whether the consumer does have physical access to the supply of energy and the energy equipment. It's not that you have the electricity connection available but you also need to have the equipment that can convert the electricity into lighting service. Both these things are very important and this kind of approach tries to understand whether the household has access to physical access to both the energy as well as the equipment.

Now, when I say whether the households do have access to energy, it brings us to a very interesting discussion. The question is access same as availability and the answer is no. In the literature if you want to do research in the area of energy access, if you go through the literature you will see that these two words are often used interchangeably- access and the availability. But, there is an inherent difference between these two; availability means physical availability. It's more of a supply side concept. Access means whether there is an actual uptake of that energy or not. Here in this we are thinking more from the perspective of the consumer.

Now, let us you know, take up an example in order to illustrate why access is different from availability. Take the example, take the definition of the rate of electrification in India. At the current state since 2018, India has achieved a hundred percent rate of electrification. So, all our villages are electrified. Now, the interesting part is that does it mean everybody has access to electricity? The answer is no. Why? The problem lies in the definition of the rate of electrification.

What do we understand by the rate of electrification? It says, now if you come here and look at this definition it says a village is deemed to be electrified if basic supply infrastructure is in place. So, lines are there, the transmission process is there and so on, in the inhabited locality. The second is that electricity is provided to certain public places such as schools, hospitals, panchayat offices etcetera. The third point is that at least 10% of households in the village should have been connected to electricity.

It keeps 90% of the villages out of the discussion. What is happening to the 90% of the households that are out of the discussion? So, it says that if you want to have access to electricity, it is available, you can have it; but it doesn't mean that I actually do have access to electricity. So, 100% rate of electrification of course, does not necessarily mean that 100 percent of the population in India do have access to electricity.

So, we may put it in this way that availability is, of course, a necessary condition but it's not a sufficient condition for access. So, whenever we have a discussion on energy access, it's very important to be clear that access is not the same as availability, I mean 100 percent availability does not mean 100 percent access. They are two different concepts.

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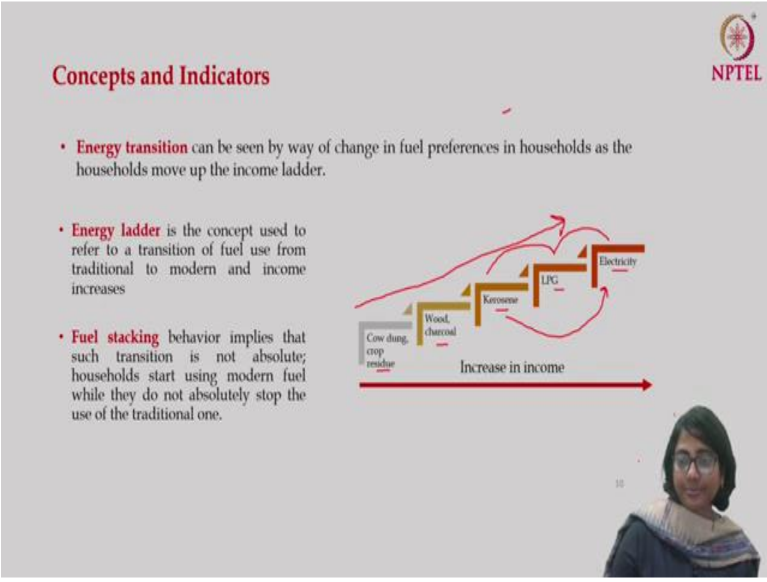

We also come to three other very important concepts and related indicators which are very important if you are doing research in developing countries and trying to understand energy poverty and energy access.

The first concept that we are going to talk about is Energy Transition. This is basically the way of change in fuel preference by a country. How the fuel preference changes as you move up on the income ladder. So, if I become richer, if my family or household becomes richer, then what kind of fuel I would like as compared to my preference for fuel when I was a poor household? This is called the energy transition.

If you remember this diagram; this actually captures the energy transition. If you plot these bars over the years you will see that here, this red part is increasing. Here also this red is increasing, here also the red part is increasing and this blue part is declining. It shows the energy transition where the preference towards LPG and electricity are increasing while the preference is for the traditional fuel and kerosene they have been decreasing overtime. So, this diagram captures a fuel transition for Indian households.

A more concrete measure and this is frequently available in the literature of energy access is called the Energy Ladder hypothesis. The energy ladder hypothesis says that as you move up on the income ladder that is as the income of households increases, then the households tend to move upward with respect to the income, with respect to the energy ladder. This is called an energy ladder where at the bottom of the ladder you have traditional fuel like cow dung, crop residue etcetera, then wood, charcoal, then something in the middle which is kerosene, then LPG and then electricity. As your income increases you gradually move from traditional fuel to modern fuel.

Now, It's not that you always pass through all the steps. If you are talking about lighting fuel of course, from kerosene you directly go to electricity; if you are talking about the cooking fuel, probably you go from kerosene to LPG and then you go from LPG to electricity. A lot of studies have been carried out in order to test this energy ladder hypothesis in various developing countries and the findings in many of the countries suggest that it's not so linear. I mean the transition is not so linear that you don't directly move from kerosene to electricity or you don't really directly move from kerosene to LPG. What happens is called a fuel stacking behavior. Now, what is fuel stacking? It says that when the income of a poor household increases it probably starts using LPG but it doesn't mean that it will stop using the wood or kerosene. It keeps all the options available, depending on the price they start using LPG. Gradually the proportion of use of LPG may increase, the proportion of use of traditional fuel may decrease but it's not the case, so it's not a binary case. It's not the case that you are using either kerosene or LPG, they keep everything available depending on the price most of the time and also depending on the cultural practices, convenience, they use LPG or kerosene or wood. These are the very important concepts and indicators that are used to understand energy transition or energy access.

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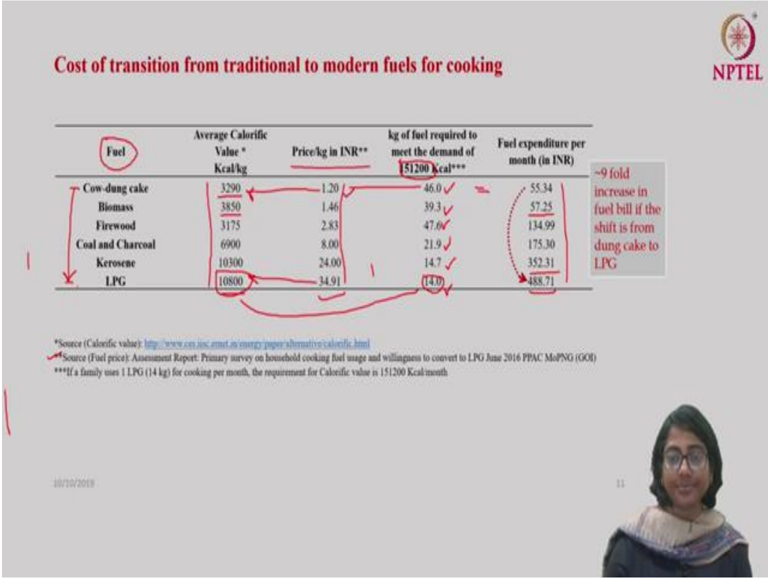

As we have a discussion on transition from traditional to modern fuel, we also need to understand that this is not a cost less procedure. That is why the concept of income ladder, the concept of energy transition everything has been linked to a change in income.

Now, I give you a small example and try to understand what is the cost of such a transition and this is the case, this is a simple calculation based on the data in India. Some of the data that we have used is a little older but even if all the data are old it doesn't change the main point.

Here these numbers are talking about the cost of transition from traditional to modern fuel for cooking. Let me explain this slide, what is happening here. If you look at the first column we are talking about the different types of fuel and as I move down from cow dung to biomass to firewood to coal and charcoal to kerosene to LPG, I am moving up on the energy ladder. This is the required transition that has to take place in the context of energy for cooking.

Now, see if I want to go from cow dung cake to LPG, what is the associated cost?; that is what we are going to calculate here. In order to do that the first thing that we need to do is to calculate the average calorific value that you are getting by burning each fuel by 1 kg. So, this figure 3290 represents the fact that if you burn 1 kg of cow dung cake, then 3290 kilocalorie of energy will be produced. If you burn 1 kg of biomass 3850 kilocalorie of energy will be produced. Similarly, if you burn 1 kg of LPG, then 10800 kilocalorie of energy will be produced.

You see that the calorific value of the fuel mostly increases as you move up on the energy ladder. The next thing that we have to understand is the price of these fuels. This is the data obtained from the sources that I have given below. This is the Government of India 2016 source and these are the prices.

1 kg of dung cake it costs you 1.2 INR, while 1 kg of LPG costs you 34.91 almost 35 INR but it seems to be very expensive but you also need to take into consideration the fact that by paying 35 INR you are obtaining 10800 kilocalorie of energy whereas by you know, spending 1.2 INR what you are obtaining is much less. Although in both the cases you have 1 kg of energy and this is another example of the conversion that we discussed in the first week that comes really handy.

Now, let us assume that there is a particular household who requires one cylinder per month for cooking. One cylinder actually means 14 kg. So, approximately it has 14 kg of LPG. Each kg of LPG produces 10800 kilocalories of energy. If I represent energy requirement for cooking of this family, in terms of calorific value I can say this household requires: $10800 \times 14 = 151200$ kilocalories of energy for cooking. In a nutshell this is a typical household who requires 151200 kilocalories of energy in order to meet their cooking requirement.

Now, let us see what are the cost implications, if these 151200 kilocalories come from different sources. If you want to meet the requirement of 151200 kilocalories by LPG then you need 14 kgs of LPG. If you want to meet this 151200 kilocalories of energy by kerosene you need 14.7 kgs of kerosene. Similarly, for the same you need almost 22 kg of coal and charcoal, almost 47 or 48 kg of firewood, 39 kg of biomass and 46 kg of dung cake. So, all these figures, 46 kg of dung cake, 39 kg of biomass, 14.7 kg of kerosene and 14 kg of LPG, all of them are able to produce 151200 kilocalories of energy. Now, what is the cost implication? Now given the fact that 1 kg of cow dung cake costs you 1.2 INR; if you multiply the price with the quantity this gives you this figure, $1.2 \times 46 = 15.34$, you need to spend 15.34 INR in order to get this desired 151200 kilocalories of energy by burning only the dung cake.

Similarly, if you want to get this amount of kilocalories through biomass you need to spend $39.3 \times 1.46 = 57$ INR. If you want to get this much of kilocalories by using kerosene you need 14.7 kg of kerosene and each kg of kerosene costing you 24 INR that is equivalent to $14.7 \times 24 = 352.31$ INR and if you want to use the LPG that will cost you $14 \times 34.91 = 488.71$ or almost 489 INR.

So, by spending these amounts you are getting the same amount of energy that is required for your cooking. If you use only cow dung cake in order to meet your energy demand for cooking you have to spend 55 INR. If you want to meet the similar demand for energy for cooking through LPG, the amount that you have to spend is close to 500 INR.

It means that if you want to have a movement on the energy ladder, that is if you want to move from the least efficient traditional fuel to the most modern fuel for cooking (we are keeping electricity out of the ambit but if you want to move from cow dung cake to LPG) it actually requires a 9 fold increase in your energy budget. Thus, the transition with respect to cooking fuel from traditional fuel to the modern fuel is really expensive and see what I am saying here is only the cost of fuel. It does not incorporate the cost of the equipment; I am not talking about the cost of the burner at all here or the cost of the oven, or the cost of the deposit. All that makes the process more expensive. The whole point is that although it’s very important to have the transition, this is not a costless process and since this is not a costless process the government has to intervene and come up with policies. In the later slides, we will have a small discussion on what kind of policies does India have in place.

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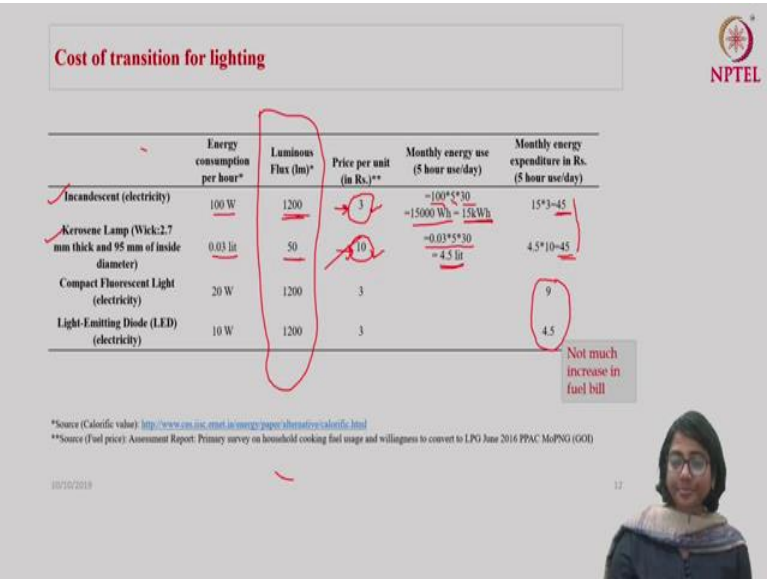

The interesting thing is that if you come to the case of lighting we will see that it is not so expensive. Again, I would just make a disclaimer, here we took the data from a relatively older document and therefore, you see both the price of electricity and kerosene that we have taken. The price of kerosene is taken as 10 INR per liter and this is the price of electricity that is taken

3 INR per unit. These are towards the little lower end but both of them prevailed at the same point of time. So, in that sense it doesn't lose the generality of comparison. Let us come back to this example.

We are considering the use of electricity through the incandescent and the use of kerosene through a particular lamp which has a wick of 2.7 millimeter(mm) and the 95 mm of inside diameter. What do they do? How much energy do they require? Both of them, they are producing lighting services, how much energy do they require? If you use the incandescent bulb for 1 hour it requires 100 watt of electricity; if you use this specific kerosene lamp it requires 0.03 liter of kerosene.

As said earlier, we have assumed that the price of electricity is 3 INR per unit and the price of kerosene is 10 INR per liter. So, remember in the previous slide when we are talking about kerosene that was kerosene in terms of kg, so it was measured in kg, everything was measured in kg; here we are measuring it in terms of liter. So, you need to pay 3 INR per unit for electricity, you need to pay 10 INR per liter of kerosene.

Now, assume that this lighting service is required for 5 hour a day for a particular household. If this lighting service is required for 5 hour a day, what is the requirement of electricity and kerosene for this household over a month? In one day if you use this incandescent for 1 hour you require 100 watt of electricity. You are now using it for 5 hour, you require $100\times5 = 500$ watt-hour of electricity and you are using it for 30 days therefore, in a month you need $500\times30 = 15000$ watt-hour that is 15 kilowatt-hour of electricity in order to fulfill your lighting demand which is 5 hour a day.

Similarly, if you think about the kerosene lamp, in order to produce lighting for 1 hour. This kerosene lamp requires 0.03 liter of kerosene. So, for 5 hour it will require 0.03 multiplied by 5 liter of petrol; for 30 days it will therefore require $0.03\times5\times30 = 4.5$ liters of kerosene. In order to have lighting service for 5 hour a day if you use electricity and if you use incandescent bulbs you need 15 kilowatt hour of electricity and if you use kerosene you need 4.5 liter of kerosene.

Now, given that the price of electricity is 3 INR per unit, it implies that this costs you $15\times3=$ 45 INR for a month. Given the fact that the price of kerosene is 10 INR a liter and you are buying 4.5 liter a month, this is also leading to $4.5\times10=$ 45 INR of expenditure per month. The interesting fact is that if you think about transition with respect to electricity it's not that expensive. For 5 hour of lighting service your expenditure will remain the same for the incandescent bulb and the kerosene lamp.

Even if the numbers vary a little bit it’s not something like a 9 fold increase, the one that we saw in case of LPG because the fact is that for lighting you have already moved up to the energy ladder. Kerosene is somewhere in the middle of the energy ladder so, when you are moving from kerosene to electricity the increment in your expenditure is not that high.

An interesting point here that I would like to emphasize is about the equipment. Although we are saying that for 5 hour of electricity you need the same amount of money to spend whether you go for an incandescent bulb through electricity or you go for a kerosene lamp through kerosene it’s the same.

The fact is that the quality of light that is produced by the incandescent is very different from the quality of light that is produced by the kerosene lamp. This quality of light can be measured by the lumen. Here I have added one more column. We are saying this is the luminous flux. So, what is the brightness of the light produced by this particular equipment?

The luminous flux of incandescent is 1200 whereas the luminous flux of kerosene lamp is only 50. An interesting thing here is that if you look at the luminous flux by spending 45 INR with an incandescent bulb you are getting a luminous flux of 1200 lumen for your lighting service. However, by spending 45 INR with a kerosene lamp you are only getting 50 lumen for 30 days, for 5 hours each day.

The quality of lighting service that you are getting through an incandescent bulb is much higher as compared to the quality of light that you are getting through a kerosene lamp. If you compare this with the more efficient equipment for example, CFL and LED you will see that if you do the calculations, how much energy is required. You will find that your electricity bill can actually go down if you make a transition from kerosene to these energy efficient equipment which uses electricity.

In a nutshell we can say that the transition from traditional to modern fuel with respect to lighting is less expensive as compared to the transition from traditional to modern fuel with respect to LPG. One has to be more careful when they are talking about the transition because there are a number of households who are still there and don’t have access to modern fuel for cooking.

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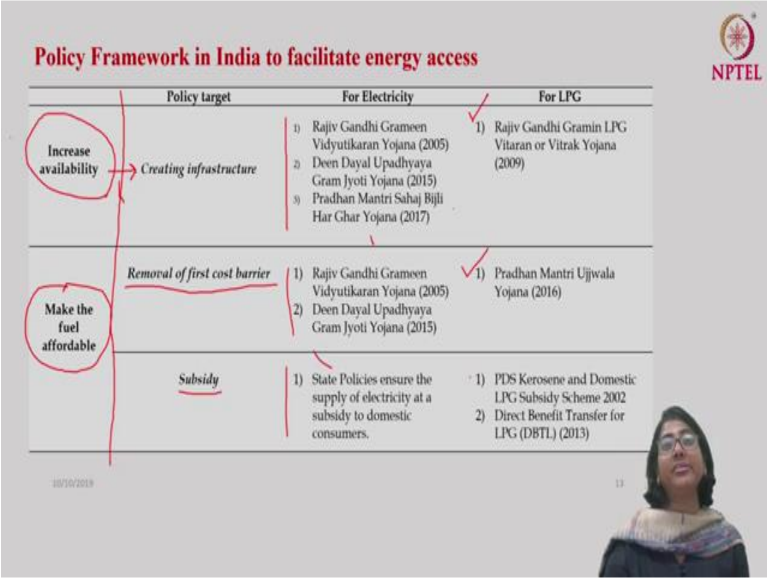

We are going to end this discussion with just briefing you about some of the policies that the Government of India has undertaken in order to facilitate energy access both in terms of cooking as well as in terms of lighting. I am not going to discuss this in detail but I have posted a write-up on the forum and also on the website. If you want to have a look at it and I will urge you to go through that, you can go a little bit of the details of these policies.

But, what I would like to focus here is that if you look at the policies that are being taken up in India you will see they have broadly two objectives to fulfill. The first objective is to increase the availability and the second objective is to make the fuel affordable. If you can recall this availability and affordability these were two of the many components of energy security as well.

Now, if you can recall the discussion on energy security, we kept on arguing that when we are talking about energy security, we have to understand whose energy security we are talking abou? If you are talking about household energy security, probably you are talking more about access. Therefore, these two dimensions become very important whether the energy is available and whether the energy is available at an affordable price or not. Broadly the policies are structurally divided into such a manner that they increase the availability as well as the affordability. When you also talk about increase in availability this is mainly through creation of infrastructure.

Here I have noted down several policies that the Government of India has adopted in order to create the infrastructure for example Rajiv Gandhi Grameen Vidyutikaran Yojana which was taken up in 2005, and then was subsumed by the Deendayal Upadhyay Gram Jyoti Yojana in 2015, then you have Pradhan Mantri Sahaj Bijli Har Ghar Yojana which was launched in 2017 and so on. All of them are talking about creation of infrastructure, increasing the rate of electrification and providing access to electricity to the households.

If you look at the policies that are there in order to make the fuel more affordable you will see that there are two types of policies. One type of policy, they are trying to remove the first cost barrier and another type of policy makes the fuel affordable over a period of time through subsidies.

Now, removal of the first cost barrier, why is it so important in case of energy? Because for energy it's not only the cost of energy, it's also the cost of equipment, I mean the installation of a meter if you want to use electricity costs money. The purchase of the oven, the first cylinder that also costs money. So, there are first cost barriers. Even if there are families who can afford the price of energy, the first cost acts as a challenge for them.

So, out of these policies that we were talking about if you look at this Rajiv Gandhi Grameen Vidyutikaran Yojana or if you look at the Deen Dayal Upadhyay Gram Jyoti Yojana; both have the component of providing the free electricity connection to the BPL households. They do not have to incur the first cost. If you look at the subsidy and subsidized rate for electricity is there in India for a long period of time; this subsidy is much higher for the domestic consumers. You also have the mechanism of block pricing where you can consume a smaller amount of electricity at a lower rate.

Coming to the context of LPG here, if you see for LPG we are talking about the policy, Rajiv Gandhi Grameen LPG Vitaran or Vitrak Yojana, this actually increased the number of distributors. So that way it is increasing the availability. You have to have a number of distributors who can supply the LPG to you. This is increasing availability.

If you go to Grameen, Pradhan Mantri Ujjwala Yojana this is removing the first cost barrier. This is an unique initiative where the connection is being given in the name of the female head of the household. Also they are giving a 1600 INR at a time in order to remove the first cost barrier and providing the options for installments.

The LPG also receives a lot of subsidies. Some of them are PDS Kerosene and Domestics LPG Subsidy Scheme which was there in 2002; but then it was abolished. Since 2013 we have Direct Benefit Transfer for LPG which is called DBTL scheme.

In a nutshell you can see that these policies are trying to create infrastructure, supply more, remove the first cost barrier and also provide the subsidy in order to make the fuel more affordable. Now, the discussion actually doesn't end here but we are going to stop here. For the research, what is more important in the context of energy economics is to understand how important these policies have been in order to promote access.

Hence, these policies give the opportunity. It makes some of the playing fields level but it doesn't mean that everybody gets the access. The evaluation of the policies become very important because giving subsidy involves a lot of budgetary stress from the fiscal side and so it's very important to understand what are the implications, and whether these policies are able to increase the access to energy in India or not.

We are going to stop here, if you want to go through the details of these policies that are already posted.

Thank you.