Energy Economics and Policy

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Week - 01
Energy as an Economic Resource
Lecture - 04
Energy Accounting

Welcome back. In the last two lectures, we have discussed the classification of energy resources and the measurement of energy resources. As I have mentioned in the first week, we are going to discuss (the concept of) 'energy as an economic resource' and now we come to the fourth lecture where we are going to talk about Energy Accounting.

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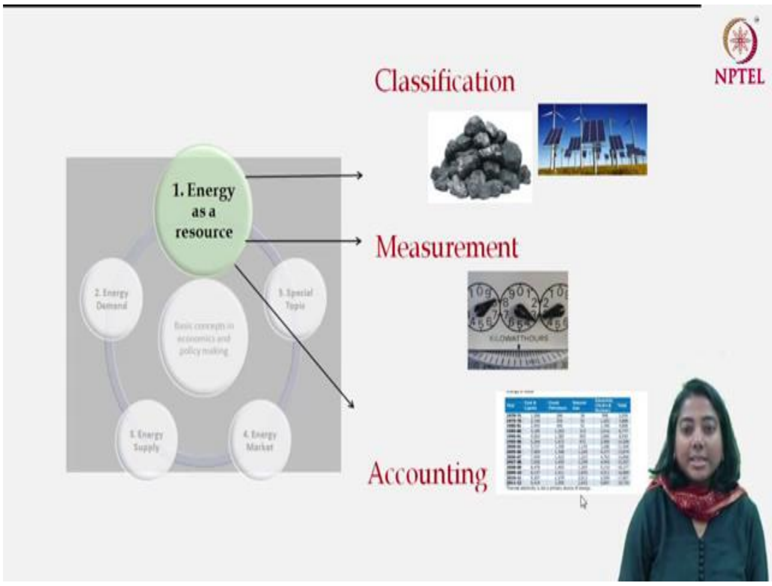

So, as we can see that we have already discussed classification and measurement, and today we are going to focus on accounting.

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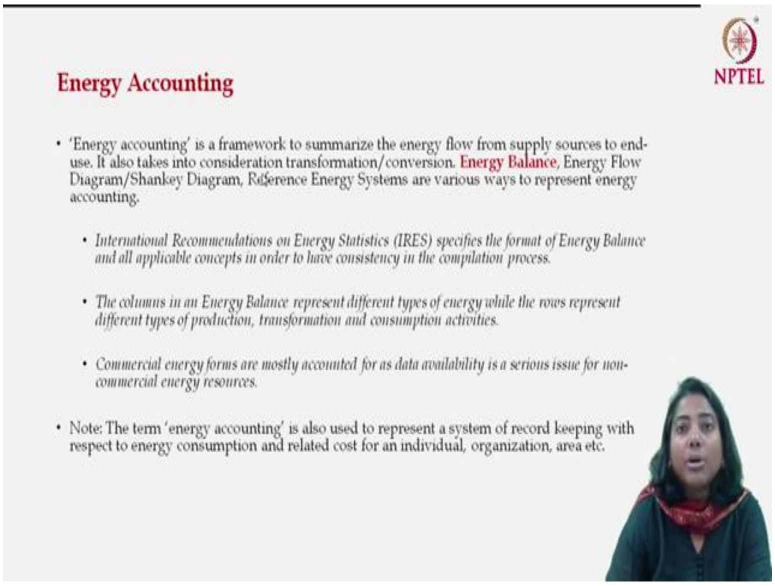

Let us first understand what do we mean by energy accounting? Energy accounting is basically a framework to summarize the energy flow from supply sources to the end uses. Note this point, ‘the flow from energy supply sources to the end uses’. It also takes into consideration the ‘transformation and conversion’. So, when we say transformation and conversion, one very important component of it is actually the conversion of primary resources to the secondary resources.

Actually there are various ways in which you can represent energy accounting. Some very common ways to do that are through ‘energy balance’, ‘energy flow diagram’, which is often called a ‘Shankey diagram’, or ‘reference energy system’. So, these are the various ways in which you can represent energy accounting. In today’s lecture we are going to focus on ‘energy balance’. If you are interested, you can actually refer to any text book, which will also give you an idea about the other ways of representation.

This energy accounting is actually carried out over time and for almost all the countries. Therefore, it’s very important that there is a consistency in the pattern of the compilation process. International Recommendations on Energy Statistics (IRES) specifies the format for energy balance and all applicable concepts that are used to develop the energy balance; so that there is a consistency in the compilation process. It’s actually represented in a tabular form and in the table the columns of this energy balance represent different types of energy (or different types of fuel, you can say), while the rows represent the different types of production, transformation and consumption activities. In a short while we are actually going to have a look at how exactly the energy balance looks like and discuss various components of it. One important thing to take into consideration when the energy accounting is carried out or for example, when the energy balance is developed, it's mostly based on the commercial use of energy.

Now that you have already gone through the classification of energy resources, you understand the difference between the commercial and non-commercial energy. So, non-commercial energy is something, which is not bought and sold in the market, and therefore, it's very difficult to get hold of data on non-commercial energy. So, in a sense, there is a kind of an incompleteness present in the energy balance, because we really can't take into consideration the non-commercial use of energy. So, this is something to keep in mind.

Finally, there is another point to observe that this term 'energy accounting' is also used to represent a system of record keeping with respect to energy consumption and the related cost of an individual, organisation or of a particular geographical area, etc.. Although this is also termed as energy accounting, this is more sort of a micro perspective of energy accounting. Whereas, what we are going to discuss here is more from a macro perspective. So, we are going to talk about how a country actually accounts for the energy production, consumption and transformation. So, what we are going to discuss is more a macro perspective and not the micro perspective.

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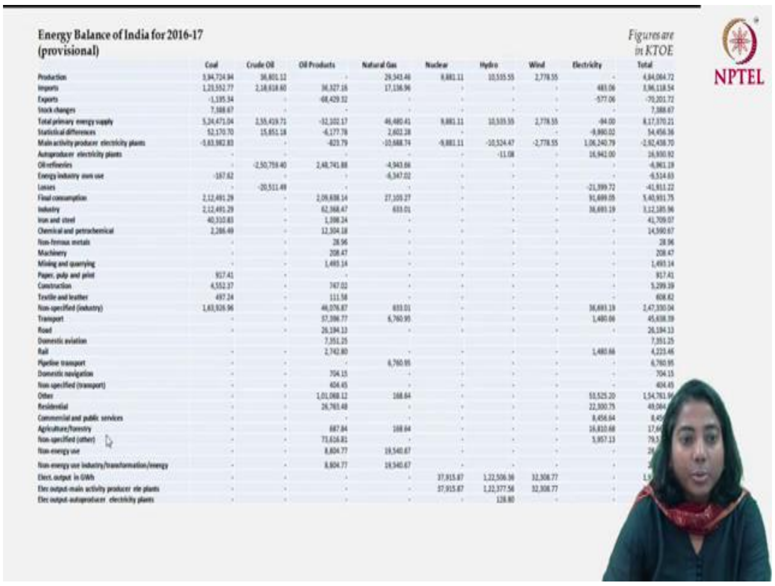

Before we go to different sections of energy balance, let us have a quick look at how it looks like. This is the Energy Balance for India for the year 2016-17, and these are the provisional figures which were published in the Energy Statistics of 2018. Here you can see, if you follow the arrow, you can see that the columns actually represent the different types of energy: coal, crude oil, oil products, natural gas, nuclear, hydro, wind and electricity. Interesting to observe, when we talk about nuclear, hydro or wind, these are the resources used to generate electricity.

However, coal, crude oil, oil products, these are actually used in its exact form. So, these are different, the columns do represent the different types of energy or different types of fuel. If you look at the rows, the rows have different entries. So, it starts with ‘production’, and then somewhere down the line you have ‘total primary energy supply’, then you have something called a ‘statistical difference’, then you have ‘activity producer electricity plants’. If you go further down, you will see for example, here you see that you have figures for final consumption, arising out of the industrial sector and several other sectors and so on. So, we are going to take a look at different parts of energy balance in order to understand it with more clarity.

Before we go into the detailed parts of energy balance, let us have an understanding about what is the difference between ‘energy balance’ and ‘energy commodity balance’. So, when you look at energy statistics or energy accounting, you will find these two terms. They are different in a sense, but they are more or less similar in other ways. So, many of the features are similar. Let us have a quick look at it.

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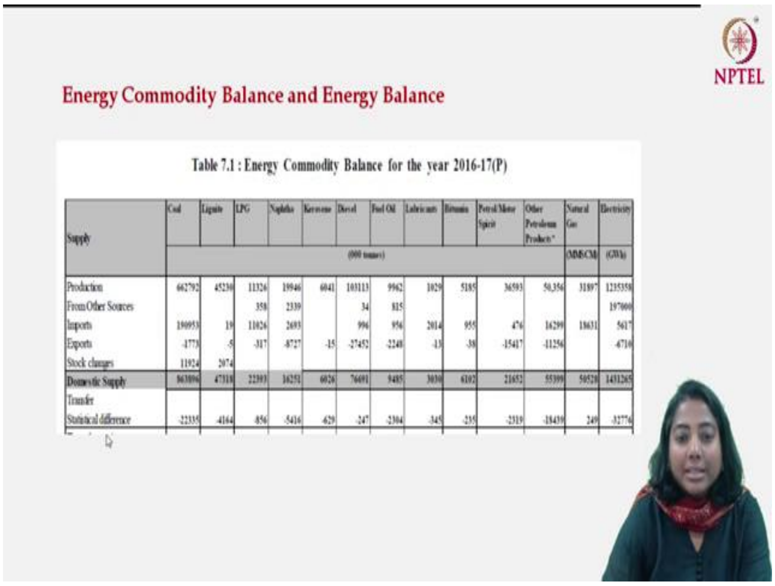

Table 7.1 : Energy Commodity Balance for the year 2016-17(P)

Supply	Coal	Lignite	LPG	Naphtha	Kerosene	Diesel	Fuel Oil	Lubricants	Bitumin	Petrol Motor Spirit	Other Petroleum Products*	Natural Gas	Electricity
	(000 tonnes)											(MMSCM)	(GWh)
Production	662792	45230	11326	19946	6041	103113	9962	1029	5185	36593	50,356	31897	1235358
From Other Sources			358	2339		34	815						197000
Imports	190953	19	11026	2693		996	956	2014	955	476	16299	18631	5617
Exports	-1773	-5	-317	-8727	-15	-27452	-2248	-13	-38	-15417	-11256		-4710
Stock changes	11924	2074											
Domestic Supply	863896	47318	22393	16251	6026	76691	9485	3030	6102	21652	55399	50528	1431265
Transfer													
Statistical difference	-22335	-4164	-856	-5416	-629	-247	-2304	-345	-235	-2319	-18439	249	-32776

So, this is how the energy commodity balance looks like. If you look here you see that this is only a part of the energy commodity balance table, this does not represent the full table. If you look at it, you will see that under supply we have different kinds of fuel: coal, lignite, LPG so on, petrol motor spirit, other petroleum products and so on. After that we have natural gas; after that we have electricity. However, all the different fuels are measured in suitable units of measurement. So, all of them are not measured in a uniform unit of measurement. For example, from coal, lignite, LPG, etcetera, up to 'other petroleum products', they are measured in terms of 1000 tons.

So, when you look at this figure, this particular figure, it says that the domestic production of coal in the year 2016-17 (provisionally) in India was 6,62,792 thousand tons of coal. When you look at petrol or motor spirit and you look at this figure, it actually means that in the same year the production i.e. the domestic production of petrol or motor spirit was actually 36,593 thousand tons. So, up to 'other petroleum products', all the figures are measured in thousand tons. If you go beyond that, if you look at natural gas, natural gas is no longer measured in terms of thousand tons. The unit of measurement for natural gas is in terms of cubic meter. If you go to electricity, this is measured in terms of GigaWatt hour.

As a result you see that different energy commodities are being represented or are being accounted for through different units of measurement. What is the result of that? The result is that you do not see any column, which says 'total' towards the end because it's impossible to add thousand tons of coal with you know x Giga Watt hour of electricity. This is not possible and therefore, you do not have any column, which gives you the total production of energy. However, it has its own usefulness because you have an understanding of what is the amount of energy commodity being produced, being consumed or being transformed.

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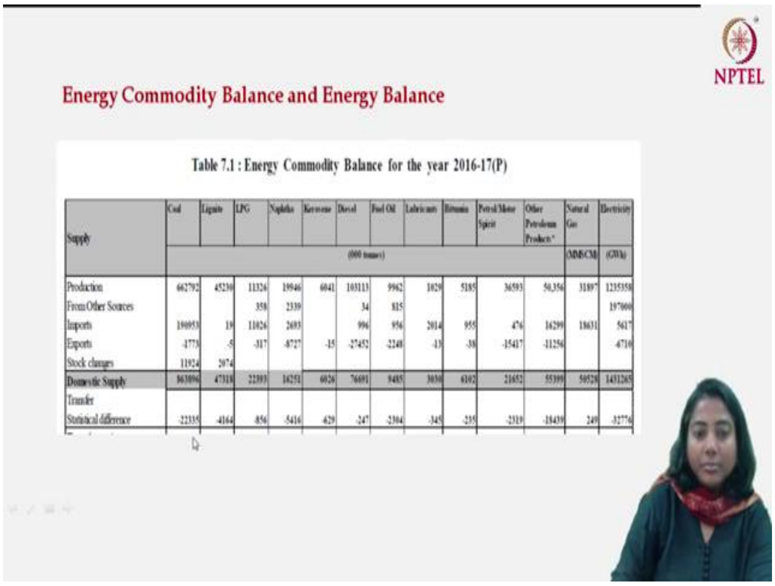

We already had a look at the energy balance table. So, this is a snapshot taken from the energy balance table of 2016-17 provisional years, for India. And this again only talks about the supply section. This is not the entire energy balance table; this is only a part of it. Here unlike energy commodity balance, what you can see is that all the energy is actually measured in terms of KTOE, which is a kiloton of oil equivalent.

So, if you look at this figure, it says that in the year 2016-17 (provisional figures), India produced 3,94,720 or almost 3,94,725 kiloton of oil equivalent of coal. Since everything is measured in terms of kiloton of oil equivalent, therefore here you have a column, which says ‘total’. So, you can add all the energy measured in kiloton of oil equivalent. This kind of table is actually very useful if you want to answer the questions like what is the proportion of coal in the total energy production in India.

Then you know that you have to express 394724.94 as a percentage of 484064, had it been the energy commodity balance you would not have been answered, able to answer this particular question. So, both energy balance and energy commodity balance are useful, but they have their own different uses.

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Let us now move on to the presentation of energy data using energy balance. Throughout the lecture we will talk about the energy balance, but if you consider tthe way in which data is actually entered in energy commodity balance, you’ll see that they are pretty much similar to the energy balance. So, our focus will remain on energy balance and not on energy commodity balance.

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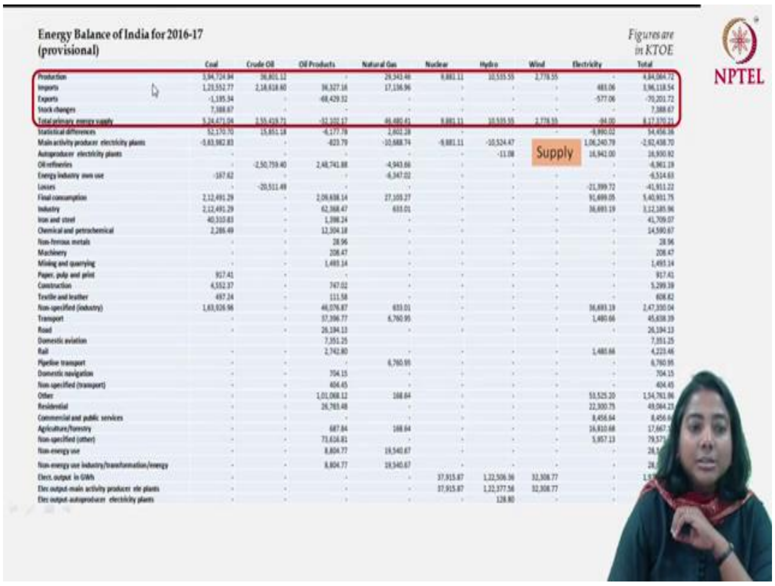

As I have mentioned that we have different sectors or different blocks that are present in the energy balance table. So, we come back to the same table for 2016-17. The first thing that you have to notice is this one: this represents the supply. If you look here, what does it say? It talks about the production, import, export, stock change and total primary energy supply. This is the first building block of energy balance.

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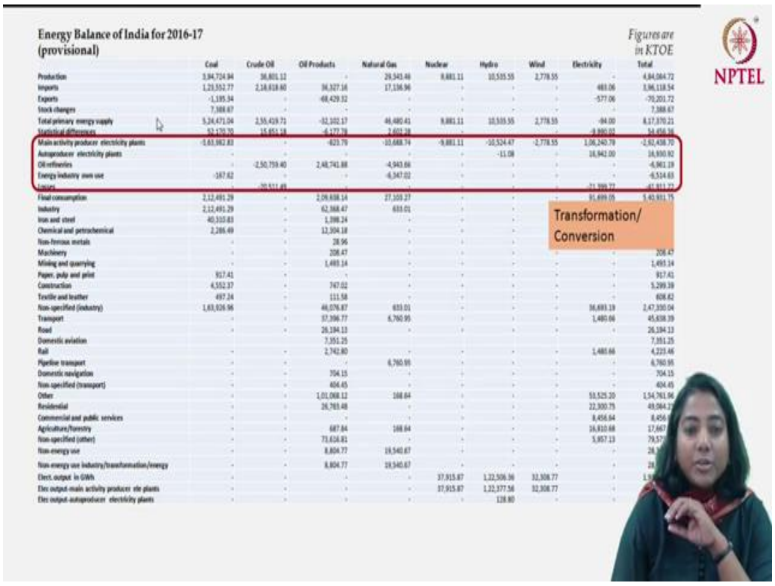

The second thing that is important to note is the transformation or conversion block. So, what is happening here is essentially some primary energy inputs are being converted into secondary energy inputs, so that is being captured in the transformation or conversion block.

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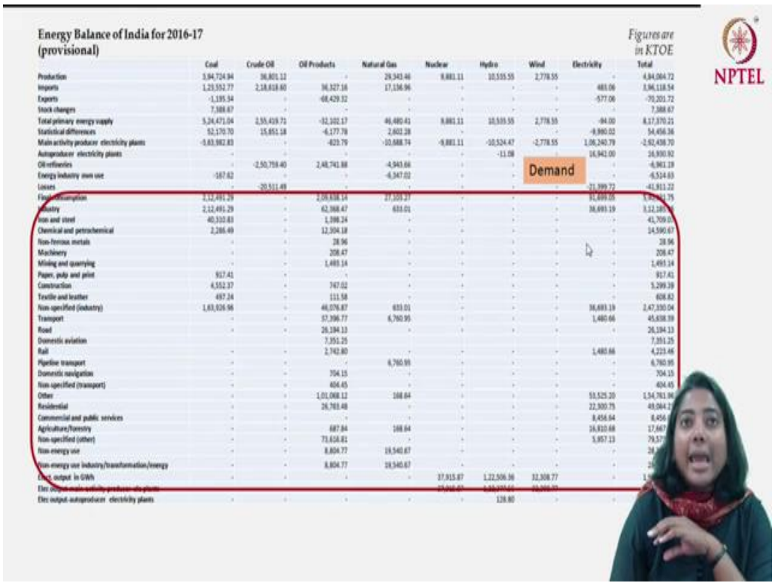

A large chunk actually represents the demand, and later you will see that it does not only represent the aggregate demand of several sectors. But it also gives the disaggregate demand pattern from several sectors which actually give you very important policy implications. So, now, we are going to discuss in detail these three building blocks: production, transformation or conversation and demand.

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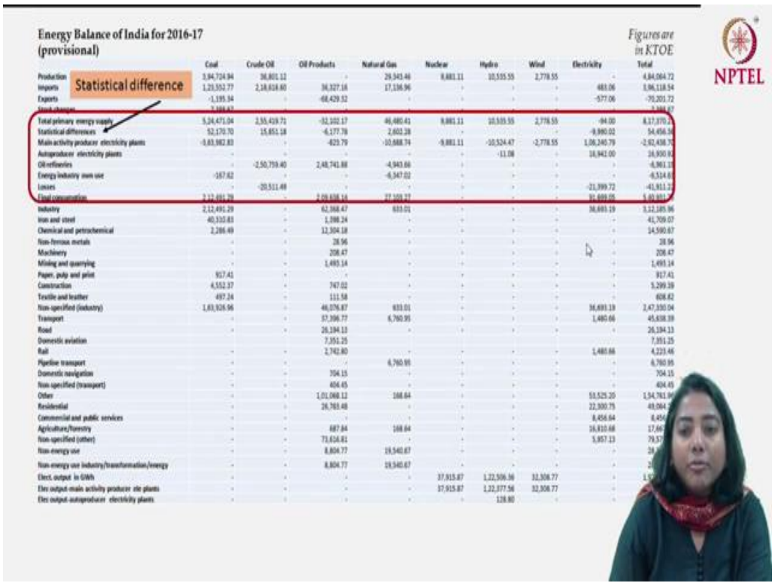

But before we do that, let us have a quick look at something which is called statistical differences. So, what is ‘statistical difference’? See, ideally whatever is being produced in an accounting framework should also be there in the consumption (including stock change). So, demand should match the supply. However, the process of data collection is different for these two different things (production and consumption).

So, when a country tries to gather the data on supply of energy, it interrogates different entities. When it tries to understand what are demands of energy from different sectors, it collects the data from different sectors. So, the sources of data are different. So, there is likely that there will be some discrepancy between the figure that you get for demand and the figure that you get for supply. It’s not always the case that supply matches the demand. And the difference between this demand and supply is considered to be the statistical difference, so this is because of the data collection and other related reasons.

So, let us have a quick look at what we exactly mean by the statistical difference and what do I mean by the matching of the demand and supply. So, if you look here, the total primary energy supply in India that comprises of the energy supply in different forms, if you look at this total primary energy supply, for example, with respect to coal, you see that the total primary energy supplied in this year is 5,24,471 kiloton of oil equivalent.

Now, what does an economy do with this coal? This coal will either be converted to electricity through the transformation sector or it will be directly used. So, either there will be a direct demand or there will be a conversion. So, the direct demand is actually captured by this figure: (~~two point, this figure is~~) 2,12,491 kiloton of oil equivalent. Other than that, 3,63,982 kiloton of oil equivalent is actually being transformed to electricity, and there is some energy industry's own use.

So, ideally if you add up these three figures: 3,63,982.83 with 162.67 with 2,12,491.29. The absolute value of these three figures should have added up to 5,24,471 kiloton of oil equivalent. But if you add them up, you will see that there is a discrepancy of the amount 52,170 kiloton of oil equivalent. So, this amount, this difference between the demand, i.e. this one, this one and this one, and the supply that is this one is called the statistical difference.

And when a country, you know, progresses, you will see that in case of developing countries, the statistical difference is always higher as compared to the developed countries. So, as your accounting framework develops, (~~your data collect~~) the process of your data collection becomes more and more sophisticated, you tend to reduce the statistical difference. And, if you actually look at the energy balance table that India publishes, one of the objectives that is stated in the document is to reduce the statistical difference over the years.

So, a low value of statistical difference is actually a representation of the precision of the data collection and the precision of the framework.

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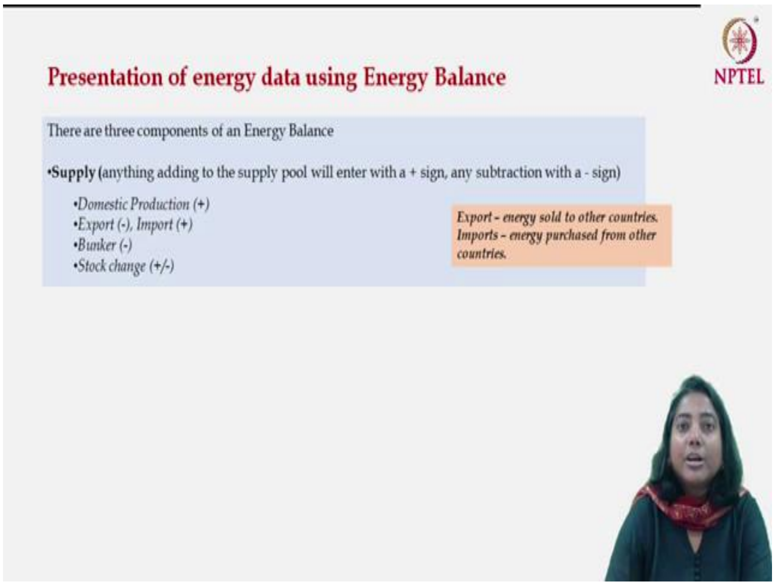

Now, let us move to different building blocks of energy balance. As we have said there are three building blocks; one is supply, the second is conversion and transformation and the third one is energy demand. Let us now begin with supply. What are the entities that go into the supply block? See, anything that increases the supply of energy will actually enter with a plus sign in the table, and anything that reduces the supply will enter with a minus sign in the table.

Now, let us have a look at what are the different components of supply. There are four major components. We have already discussed that the framework is more or less uniform across the countries. And in that common framework, you will see that there are four major components under supply. What are they? The first one is domestic production. What is domestic production? This is the domestically produced primary and marketable quantities of energy. I would like you to look at two very important phrases, one is 'primary' and the second is 'marketable'. So, we have already discussed in the lecture on classification, what is the difference between primary energy and secondary energy?

So, in case of supply, the domestic production only talks about primary energy. So, if electricity is being produced from coal, this electricity will not be a part of domestic production. However, coal that is being used to produce that amount of electricity will be accounted for domestic production. And the second important thing is that it has to be marketable, so that is again as we had discussed that it's very difficult to incorporate the non-commercial energy use. It's mostly the commercially available energy that is included in this supply framework.

Also, it's not only about commercial and non-commercial, if something is produced, in the process of production as the waste energy that is also not coming under the domestic production. For example, any waste-gas produced that is the production of energy, but that is not a part of the domestic production or that is not a part of the supply of energy as that cannot be used. The second component relates to foreign trade. So, this is actually a net effect of export and import. So, what is the export of energy? In case of export of energy, the country under consideration is actually selling some primary energy to other countries.

So, if a country is selling energy to other countries then it's actually taking out of the pool of the supply. So, any figure under export will actually come with a negative sign in the energy balance table, because as the export increases, the supply decreases. On the other hand, import comes with a positive sign, because when a country buys energy from other countries that adds to the supply pool of this country under consideration. So, export, any figure on export, comes with a negative sign; any figure on import comes with a positive sign.

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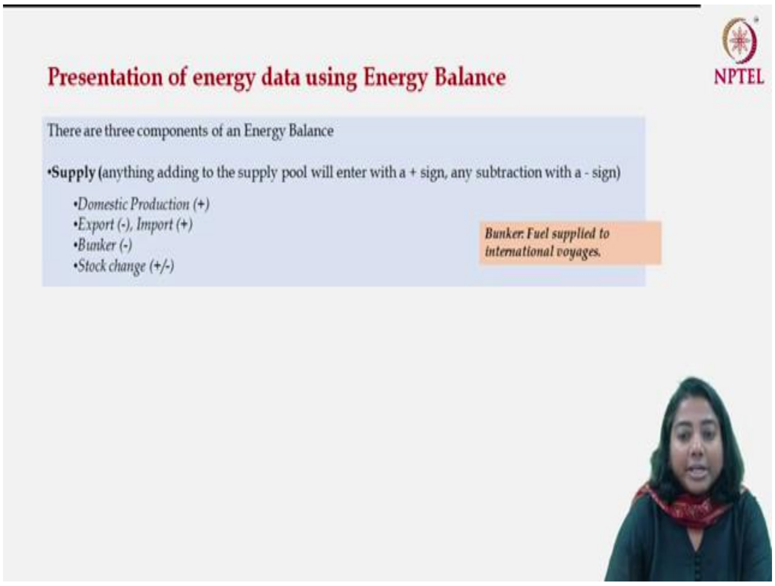

The third component is interesting: it's called 'bunker'. So, this is usually the fuel supplied to the international voyages. So, whatever fuel supplied by India for example, to international voyages will come under supply with a negative sign, because the amount that they are giving to these voyages are again something which you are taking out of your domestic supply pool.

Now, it doesn't matter what is the origin of this voyage or it doesn't matter where is which country is this voyage registered with. Irrespective of those things, whatever is given to these voyages, will come under 'bunker' and that actually comes with a negative sign under the supply block in energy balance.

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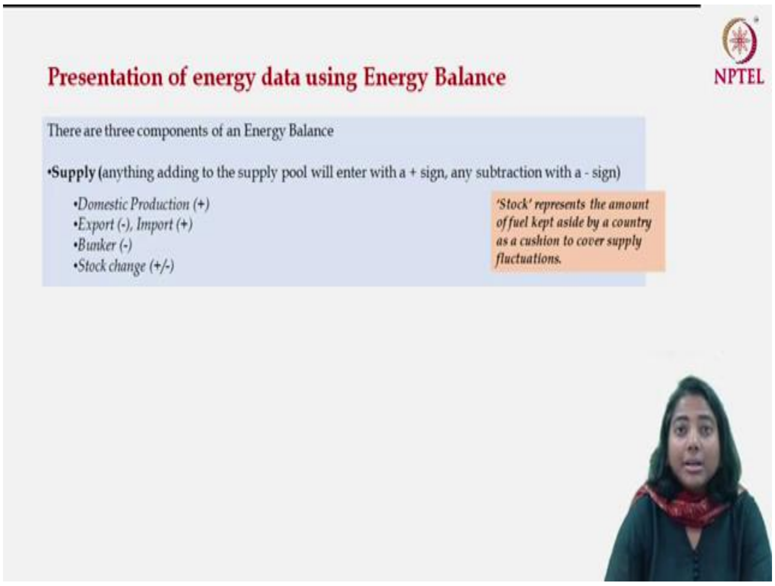

The final one, and this is a little bit tricky, this is called 'stock change'. So, what is the stock of energy? This is similar to strategic reserve. So, what is this, this is a particular amount of energy that every country will keep as a cushion to cover the supply fluctuation. So, if there are geopolitical turmoils or if there are some internal damages, which actually causes decline in the production, i.e. domestic production of energy, this is the amount of energy, which is kept with the nation in order to keep the economy running at least for a few days. So, this is called the 'stock'.

Now, when there is the stock increase, that means, some amount has been taken away from the supply and the figure actually enters the energy balance table with the minus sign. And when there is a decline in stock, it means that the amount of stock, that has declined, has already been added to the supply, domestic supply, and therefore, it comes with a plus sign. So, stock change may have a plus sign, it may also have a minus sign. It depends what, the change in the direction of the stock.

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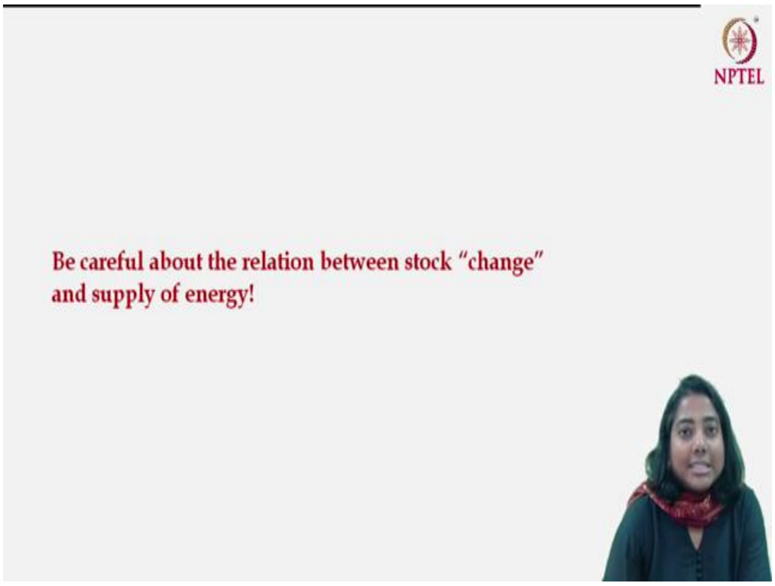

It's good to be a bit careful about the relation between stock change and supply of energy because a lot of confusion happens around this particular concept. So, let us spend some time to understand why and when the stock change entry and the supply will be positive and when it is going to be negative.

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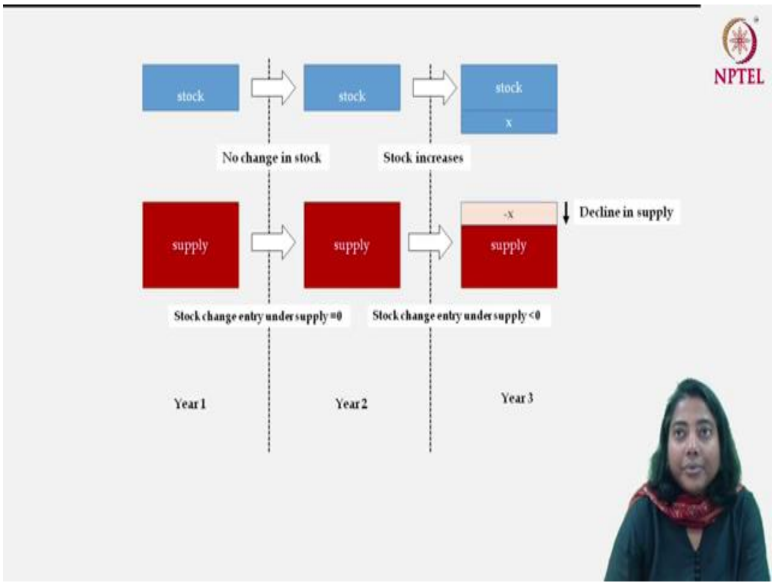

Think about the initial year. So, the blue rectangular area shows the stock that is maintained by a particular country; the red rectangular area shows the supply, the domestic supply of a particular country; this is the year 1. During the second year, suppose the country decides that it will keep the same stock, i.e. there is no plan to change the stock. If the rest of the things remain constant the supply will remain unchanged.

So, here there is no change in the supply because of change in stock. Supply, in actual case may change for some other reasons, but here we are taking a ceteris paribus kind of a condition where the rest of the things are unchanged. So, the supply will change only if the stock changes. Since there is no change in stock, there is no change in supply, and in the supply block you will see that the stock change entry will come with a sign 0.

During the third year, suppose the country decides that it’s going to increase its stock by the amount of x. Now, where will this x amount of stock come from, this additional amount of stock, where will it come from? It will essentially come by the way of reducing the supply. So, the x amount of energy is taken out of the domestic supply pool and added to stock. So, as a result there will be a decline in energy supply. So, when there is an increase in stock, I repeat, when there is an increase in stock, then the entry in the supply block will come with a negative sign, because the supply declines.

Once again when there is an increase in stock, the entry in the supply block will come with a negative sign, because there is a decline in supply.

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We look at the second scenario, what happens if there is a decline in the stock. So, the first two years are pretty much the same as the previous scenario, but during the third year the country actually decides to reduce the stock by the amount of y. Now, once it reduces the stock by the amount of y, if you think about the accounting where will this y amount of fuel go? It comes out of the stock and it will be added to supply.

So, supply increases. Therefore, when there is a decline in the stock the supply increases, and therefore, the entry that you see under stock in the supply block comes with a positive sign. So, once again when the stock declines, the supply increases, and therefore the entry in the supply block under stock change will come with a positive sign.

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	Coal	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Wind	Electricity	Total
Production	394,724.94	36,801.12	-	29,343.46	9,881.11	10,535.55	2,778.55	-	484,064.72
Imports	123,552.77	218,618.60	36,327.16	17,136.96	-	-	-	483.06	396,118.54
Exports	-1,195.34	-	-68,429.32	-	-	-	-	-577.06	-70,201.72
Stock changes	7,388.67	-	-	-	-	-	-	-	7,388.67
Total primary energy supply	524,471.04	255,419.71	-32,102.17	46,480.41	9,881.11	10,535.55	2,778.55	-94.00	817,37

If this part is clear, let us have a quick look at: what does the supply block look like? It looks like this; so this is from the same energy balance table, the provisional 2016-17 table that we have been discussing so far. Here you will see that the supply has production. So, it means that the domestic production of coal in India was 3,94,724.94 kiloton of oil equivalent. The domestic production of crude oil was this. The domestic production of natural gas was this.

Under nuclear hydro and wind, the figures that you see this is actually the electricity produced from nuclear hydro and wind domestically. Now, this again we discussed when we discussed the classification of energy when you are actually using these kinds of resources to produce electricity that is the primary form of electricity. You remember the discussion that we had that electricity can be both primary and secondary, because behind these production processes, there is no other energy involved; these are the primary forms of electricity produced.

However, in this table they are not added up to show as electricity, right? You can see the blank under ‘oil product’ as well. So, under production, there are two blanks one is for ‘oil product’ and the other is for ‘electricity’. Why? Because these are the two energy sources that are the secondary energy sources. And you remember we said that under supply, whatever we talk about is only the primary sources of energy and not the secondary sources.

If you look at the imports, all the entries do have a plus sign. So, there is an interesting observation, you can see that most of the oil that India uses, comes from import and a very low proportion is domestically produced. So, all the imports they do have positive signs. If you look at the export, the export has negative signs. We export a little bit of coal. And although we import a lot of crude oil, you see that we also export a lot of oil products. So, crude oil is exported, it goes to the oil refineries, certain oil products are produced, and then we export some amount of oil-product.

Here you can see that the stock change entry is positive. If the stock change entry is positive, this again implies that due to stock change there is an increase in the supply, therefore, the stock must have declined. So, a positive entry implies a decline in the stock. Then you add these figures up to get the total primary energy supply with respect to coal, crude oil, oil product, natural gas, nuclear, hydro and wind; these are essentially the electricity and then you get a total here. So, this tells you what is your total primary energy supply during the year 2016-17?

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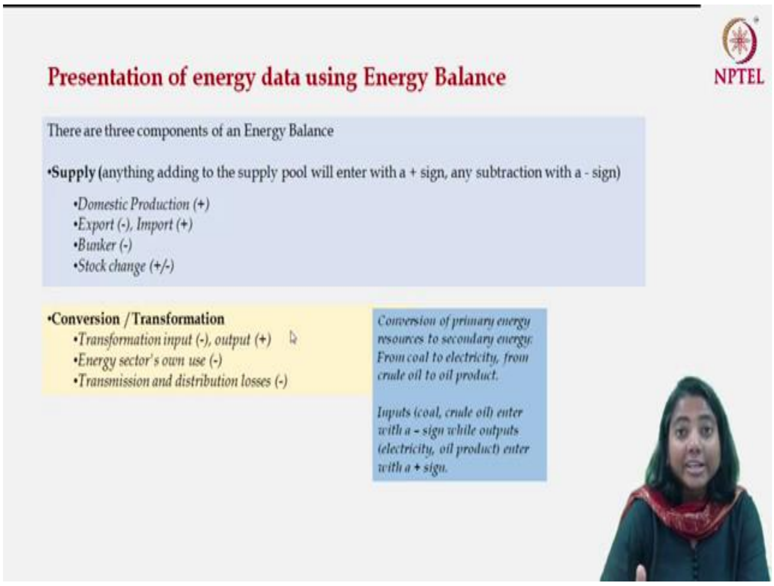

Let us next come to the second block, which is the conversion or transformation of energy. So, as we have discussed, this is actually going to document the transformation of primary energy to secondary energy along with some other components. Let us first begin with the transformation of input energy to output energy. So, conversion of primary energy, conversion of primary energy resources to secondary energy this activity is accounted for here.

For example, you take the coal fired power plants where coal is converted to electricity. So, coal is actually the input energy, and electricity is the output energy. When I am using coal, I am taking this coal out of my supply; therefore, the coal will enter with a negative sign. Whereas, the electricity produced that is available to be used, and therefore, electricity will enter as a positive sign.

So, you can see actually when we were talking about the supply block in the energy balance table, we were considering the primary energy; the supply of primary energy which can be demanded and used. When we are adding this conversion or transformation, we are actually adding the secondary energy to the supply pool in a sense. So, the "supply block" was talking about the supply of primary energy, and the conversion or transformation block is actually giving you an idea about the supply of the secondary energy as well.

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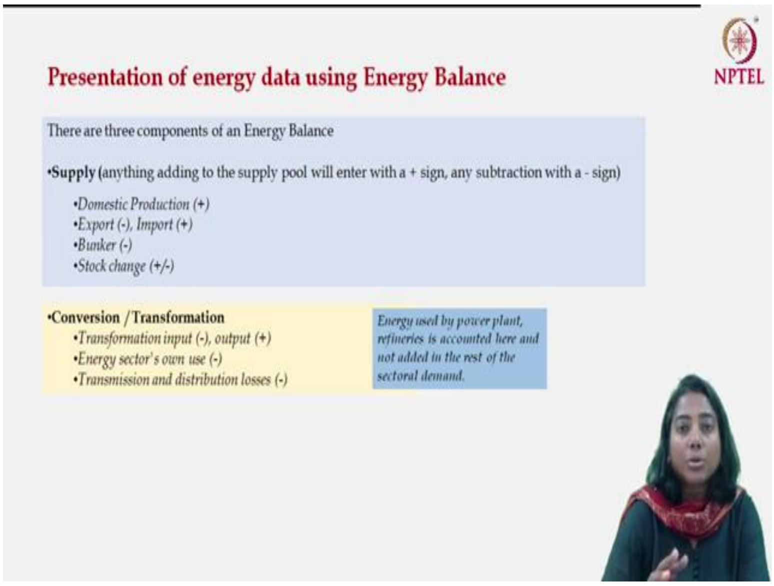

The next one is the energy sector's own use. So, if you think about an energy sector for example, the power plants, the oil refineries, they not only convert coal or crude oil respectively to some secondary energy output, but it also has its own use. For example, just to, you know, in order to run the power plant or just in order to run the oil refinery, you need electricity for many things, I mean even for lighting, I mean all those used by the energy sector come under the conversion or transformation.

So, you may think that it should ideally go under demand and should not come under conversion and transformation, but this is again you know, in order to have a uniformity of accounting across the countries. So, the protocol is that it should come under energy sector's own use, which falls under the conversion and transformation.

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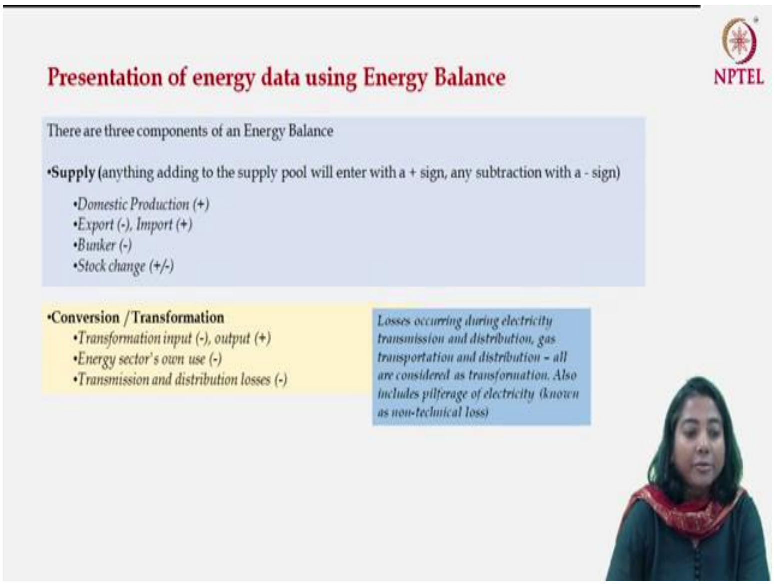

The final component, the final important component, I would say, is the transmission and distribution losses. So, this is the transmission and distribution loss that takes place during the conversion of a primary energy to secondary energy. These are more technical losses, these are occurring during electricity transmission and distribution or gas transportation or distribution etcetera. However, there can be non-technical losses as well. If you think about the pilferage of electricity that is quite well known in India and that is kind of a loss, but that is, sort of, you know, a non-technical loss.

However, this non-technical loss is also documented under conversion or transformation. So, not in every aspect you will see that under this block a primary energy is being converted to a secondary energy, but there are other components which are, which are actually the, actually parts of, this block of conversion and transformation.

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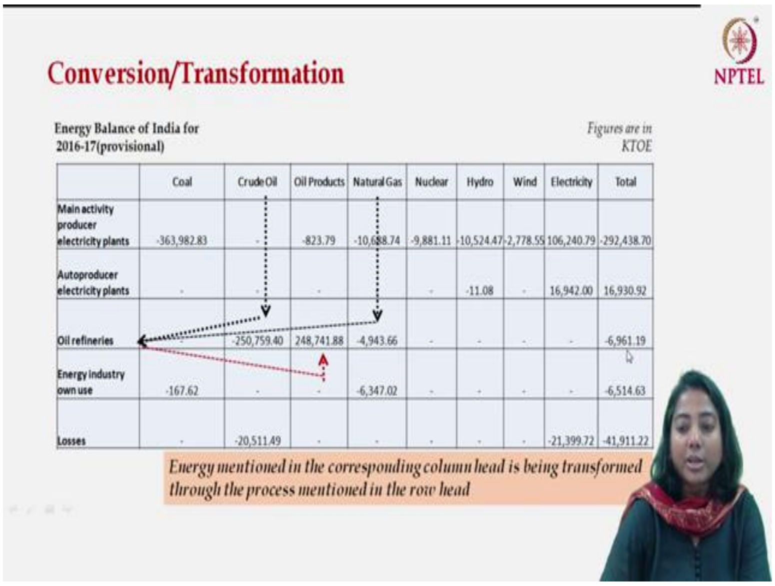

Let us have a quick look: how we read the table, the part of the energy table, when we talk about the conversion and transformation. Let us start from here. Think about the figure - 2,50,759 kiloton of oil equivalent. And we also have to consider the natural gas of the amount 4,946.6 kiloton of oil equivalent. So, this amount of crude oil and natural gas, they are going to the oil refineries and the oil refineries are producing 2,48,741.88 kiloton of oil products. So, basically what is happening is the energy mentioned in the corresponding column, that is here, the crude oil and natural gas, they are being transformed through a process, which is taking place in this particular row, in the corresponding row.

So, crude oil and natural gas, so if you think about this figure and this figure, it means crude oil and natural gas respectively, they are going to oil refineries and the oil refinery is producing this amount of oil product. So, this is how you read the conversion or transformation part of the energy balance table. Now, one important thing one has to notice is that there is a discrepancy in the figure, if you add up the figure for crude oil and natural gas that is not exactly equal to the figure that you are getting for the oil product.

So, there is some loss in the production which is 6,961.19 KTOE in case of the oil refineries. So, if x KTOE oil, i.e. x KTOE input goes into the oil refineries, it’s actually less than x KTOE oil product that will come out of the refineries, and that is the loss that you can see here.

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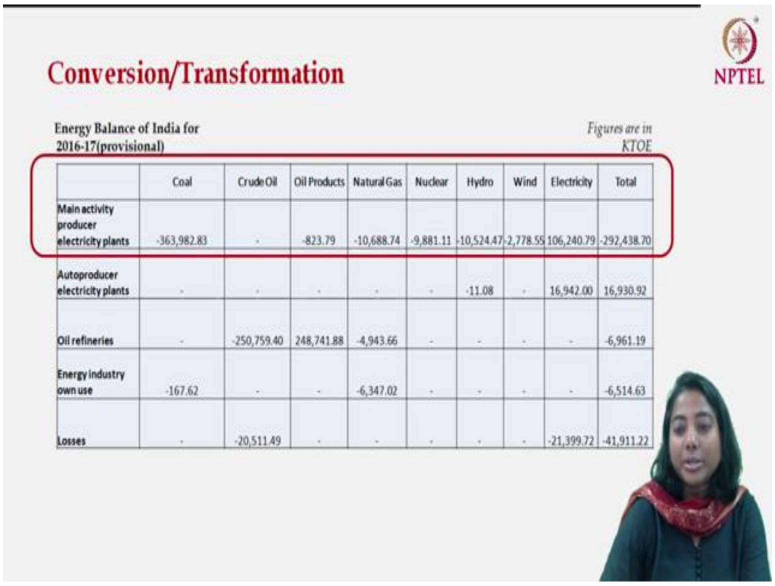

	Coal	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Wind	Electricity	Total
Main activity producer electricity plants	-363,982.83	-	-823.79	-10,688.74	-9,881.11	-10,524.47	-2,778.55	106,240.79	-292,438.70
Autoproducer electricity plants	-	-	-	-	-	-11.08	-	16,942.00	16,930.92
Oil refineries	-	-250,759.40	248,741.88	-4,943.66	-	-	-	-	-6,961.19
Energy industry own use	-167.62	-	-	-6,347.02	-	-	-	-	-6,514.63
Losses	-	-20,511.49	-	-	-	-	-	-21,399.72	-41,911.22

Let us now have a look at one more interesting thing, which is the production of electricity. See if you look at electricity, this is the total electricity which is being produced, which is equivalent to 1,06,042.79 kiloton of oil equivalent. Now, what are the sources of production of this electricity? some amount of coal is being converted. So, this amount of coal that is 3,60,982.83 KTOE coal, this is taken out from the domestic supply; not only domestic supply this is taken out from the total primary energy supply of the country that is why it enters with a minus sign. Because this will no longer be there and it is being converted to some amount of electricity; similarly, the same logic actually follows for oil products and natural gas.

What is interesting is to observe nuclear hydro and wind. If you go back to the previous tables, for supply you will see that this 9,881 or 10,524 or this 2,778 kiloton of oil equivalent actually were the entries under nuclear hydro and wind, but with a positive sign under the supply. So, here what we are saying is the primary form of electricity, we are taking it out from here and we are adding it to the pool of secondary form of electricity so that we can have a unique figure for electricity. So, now, when you see this 106042.79 KTOE of electricity produced in India, this is actually a combination of primary production of electricity as well as secondary production of electricity. So, this manipulation needs to be done in order to get a unique figure for electricity production.

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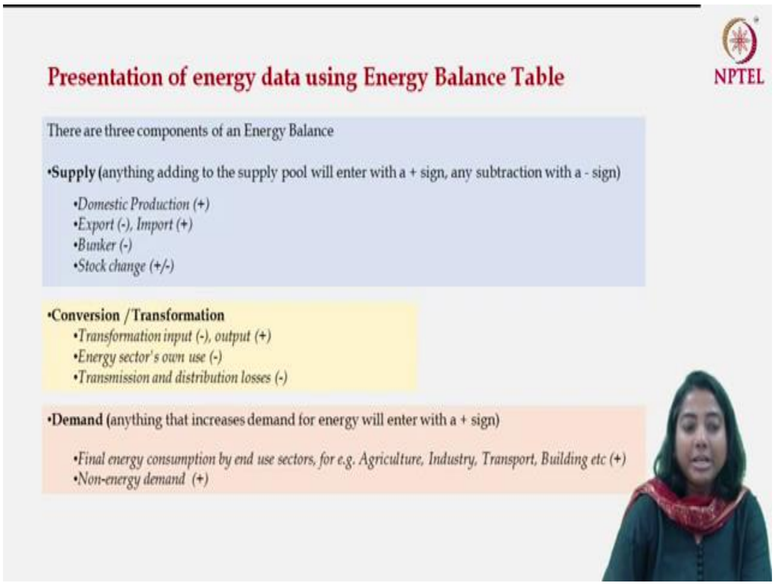

So, as we have said these are the three building blocks, now we come to the final one, which is demand. This is perhaps the easiest one to interpret; all the entries will come with a positive sign. Now, where does the demand come from? The demand will come from different sectors, for example, agriculture, industry, transport, building etcetera. And not only this, sectoral demands are provided in the table in the energy balance, you also get to see what are the disaggregate energy demands.

So, not only industry, but under industry, you will be able to see what is the demand coming from the iron and steel industry, what is the demand that has come from the chemical industry, what is the demand coming from the cement industry so on and this actually gives you a very rich data, because you try to understand what are the most energy consuming sectors in a country. And therefore, if you want to formulate a sort of energy policy and you want to target the most energy consuming sectors, this is one of the most important ways to figure that out. This is a rich source of data with this respect.

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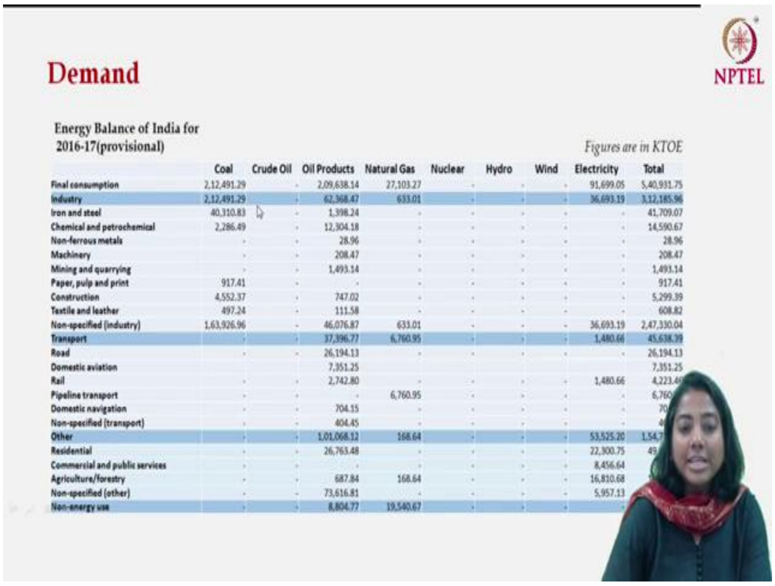

	Coal	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Wind	Electricity	Total
Final consumption	2,12,491.29	-	2,09,638.14	27,103.27	-	-	-	91,699.05	5,40,931.75
Industry	2,12,491.29	-	62,368.47	633.01	-	-	-	36,693.19	3,12,185.96
Iron and steel	40,310.83	-	1,398.24	-	-	-	-	-	41,709.07
Chemical and petrochemical	2,286.49	-	12,304.18	-	-	-	-	-	14,590.67
Non-ferrous metals	-	-	28.96	-	-	-	-	-	28.96
Machinery	-	-	208.47	-	-	-	-	-	208.47
Mining and quarrying	-	-	1,493.14	-	-	-	-	-	1,493.14
Paper, pulp and print	917.41	-	-	-	-	-	-	-	917.41
Construction	4,552.37	-	747.02	-	-	-	-	-	5,299.39
Textile and leather	497.24	-	111.58	-	-	-	-	-	608.82
Non-specified (industry)	1,63,926.96	-	46,076.87	633.01	-	-	-	36,693.19	2,47,330.04
Transport	-	-	37,396.77	6,760.95	-	-	-	1,480.66	45,638.39
Road	-	-	26,194.13	-	-	-	-	-	26,194.13
Domestic aviation			7,351.25						7,351.25
Rail	-	-	2,742.80	-	-	-	-	1,480.66	4,223.4
Pipeline transport	-	-	-	6,760.95	-	-	-	-	6,760
Domestic navigation	-	-	704.15	-	-	-	-	-	70
Non-specified (transport)	-	-	404.45	-	-	-	-	-	4
Other	-	-	1,01,068.12	168.64	-	-	-	53,525.20	1,54,7
Residential	-	-	26,763.48	-	-	-	-	22,300.75	49
Commercial and public services	-	-	-	-	-	-	-	8,456.64	[illegible]
Agriculture/forestry	-	-	687.84	168.64	-	-	-	16,810.68	[illegible]
Non-specified (other)	-	-	73,616.81	-	-	-	-	5,957.13	[illegible]
Non-energy use	-	-	8,804.77	19,540.67	-	-	-	-	[illegible]

Let us have a quick look at how the demand sector looks like in the energy balance table, in the energy balance. You will see, as I said, that it gives you both aggregate as well as disaggregate data. So, the rows, which have the darker shade of blue, this actually gives you the number for aggregate energy demand. So, the final consumption that is represented in the second row just after the heading this 2,12492 KTOE for coal and so on, this actually tells you what is the total final consumption demand coming from the economy.

Now, in order to reach at this number or at this number, you have to add up the corresponding elements that are appearing in the same column in the same column with the darker shades of blue. So, this 2,12,491 kiloton of oil equivalent of coal is the total demand for coal in the economy and that is coming from the industry sector only because the other entries are 0.

If you look at 2,09,638 kiloton of oil equivalent of oil products, the demand is actually coming from several sectors. So, the industry demand is little more than 62000; you see the transport sector will demand a little more than 37,000; the demand for other sectors will be a little more than 1 lakh, and there is something called a non-energy use, which we will just discuss in the, in the, in the future slides which is a little more than 8000. You add up these four figures and you what you get is this 2,09,638 kiloton of oil equivalent. Similar is the case for natural gas or in the case of electricity.

Now, if you look under each of these aggregate sectors, for example, let us take industry, what is the composition of the demand which adds up to 2,12,492 kiloton of oil equivalent? Out of this, over 40,000 kiloton of oil equivalent demand for coal is actually coming from the iron and steel industry, a little over 2,000 kiloton of oil equivalent demand for coal is coming from chemical and petroleum industry. More than 4,000 kiloton of oil equivalent demand is coming from the construction industry.

So, if you look at this figure, this particular figure, you can see what are the, you know, particular industries having the highest demand for coal. Similarly, if you look at the column represented by oil products, you can see which are the sectors with highest demand for oil, demand for natural gas or the demand for electricity. And if you look at the column, which gives you the total, it tells you what is the total demand of energy, total energy demand of energy of the industry sector. So, 3,12,185 kiloton of oil equivalent is the total energy demand for industry, which comprises coal demand, demand for oil products, demand for natural gas, and demand for electricity.

Similarly, if you look at this figure 45,638, this is an add up of all kinds of energy demand by the transport sector. There is 0 under coal because that kind of railway is gone now. You have the demand for oil products, you have the demand for natural gas and you have then, have the demand for electricity. So, this is how you read the demand part, demand segment of the energy balance table.

There are few interesting things to observe. If you look at demand for coal, you will see that the demand for coal is coming only from the industrial sector; none of the other sectors do have any demand for coal. But if you are aware of, then many of the rural households in India do actually use coal for cooking and other household activities. However, if you look at the residential sector here, the residential sector, you see there is no entry here, it's blank. Why is it so? Although we know that in the residential sector, there is some use of coal. The reason being, most of this kind of coal use or most of the use of the traditional fuel, they are non-commercial in nature. And therefore, they cannot be accounted for when you are, you know, developing the energy balance table. So, although there might be some uses, that cannot be accounted for in this particular framework. So, this is one important thing to notice.

The second one is that you will see that other than the industry sector, transport, other and non use energy, all of them, they actually have demand for electricity. When they have demand for electricity, indirectly they are consuming the primary energies, which are used to produce the electricity. So, when you see the demand for electricity, in most of the cases, this is considered as the secondary demand for secondary energy resources. And at the back of it, there is a primary demand.

So, for example, you can say that there is no direct demand for coal by the transport sector. However, the transport sector has an indirect demand for coal, because the electricity that they are using, a part of it, is actually coming from coal. So, this gives you an idea about the direct demand for energy and the indirect demand for energy.

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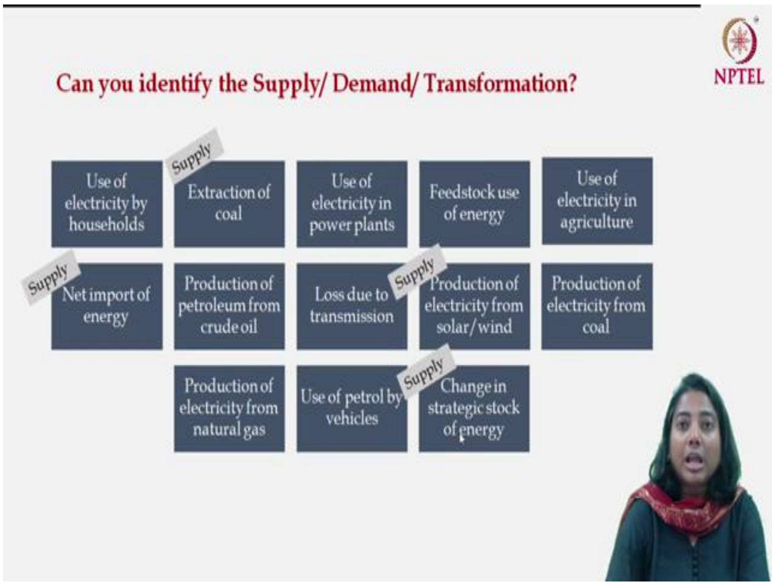

Let us now move on to a couple of activities and try to figure out whether we understand, whether they should go under the supply block, or they should go in the demand block or they should go under the transformation block. So, what are these 13 options? Use of electricity by households, extraction of coal, use of electricity in power plants, feedstock use of energy, use of electricity in agriculture, net import of energy, production of petroleum from crude oil, loss due to transmission, production of electricity from solar or wind, production of electricity from coal, production of electricity from natural gas, use of petrol by the vehicles, change in the strategic stock of energy for a particular country.

Let us first try to understand what are the components that will go under the supply? I would request you to pause the video for a while here, and do a brainstorm and identify which one will go under the supply head, which one will go under the demand head and which one will fall under transformation. If you are done with the exercise, let us have a quick look whether yours are actually matching with my matching. This is the supply component, extraction of coal. So, coal is a primary resource whatever you extract after washing, it's going to add to your domestic supply.

Second, net import of energy; by net import we imply import minus export. So, the net import of energy is going to be added to your supply pool. However, we really don't know what is going to be the sign of the net import component. Because, if the import is higher than the export then the net import will enter with the plus sign and will increase the supply; however, if the import is less than the export then we will see that the supply will decrease. So, the entry should have a negative sign. Although we have seen that there is not a single entry for net import, you have two different entries for import as well as export.

The third one is production of electricity from solar or wind. So, this is the primary form of electricity which is being produced. So, whatever as a primary form is a primary form of energy will come under the supply component, because it adds to the total primary energy supply TPES of a particular country. The fourth one is the change in strategic stock of energy, and we already had a discussion on what is, what should be, what are the different options of the signs for strategic for a change in the strategic stock of energy on energy supply. So, these are the four components that actually should fall under supply in an energy balance.

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Let us next look at the transformation. Under transformation, you will have use of electricity in the power plants. So, you may recall that this is the power plants' own use of electricity, and instead of putting it in the demand of energy that is raised by the other sectors, this falls under transformation. The second one is production of petroleum from crude oil. So, here the crude oil, primary form of energy is being transformed to a secondary form of energy that is petroleum oil product. So, this falls under transformation.

Loss due to transmission, this again we have discussed, this will fall under the transformation, all technical and non-technical losses. The fourth one, production of electricity from coal similar to the logic that we followed here that is the production from petroleum, from crude oil, this again falls under transformation. The final one, which again follows the same logic, the production of electricity from natural gas; so, these five components will enter the transformation block.

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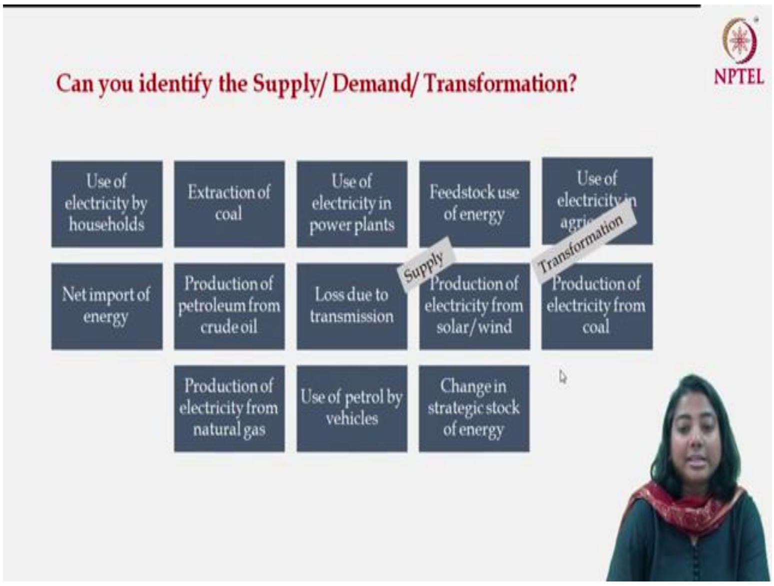

One very important thing to notice here is that although we are calling the production of electricity from coal as a part of transformation, we are calling the production of electricity from solar or wind as a part of supply. This is again because this is, you know, the production of electricity from solar and wind is a primary form of electricity, and the second one is a secondary form of electricity. So, this is something, this is going to come back over and over again, and you have to be very careful about this primary and secondary form of electricity when you are actually doing any kind of energy accounting.

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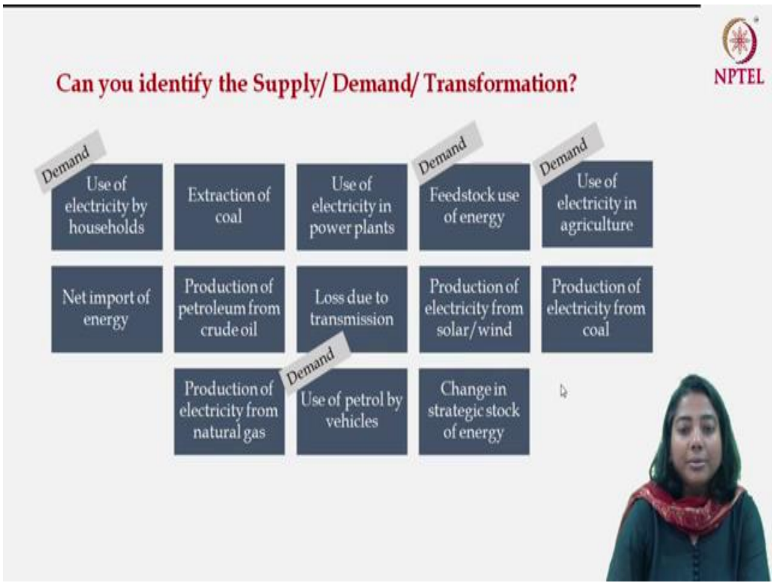

The third component, this is easy to identify probably the demand components, use of electricity by household, feedstock use of energy. Let us spend a minute to understand what is the feedstock energy use of energy? This is the non-energy use of energy. For example, if you look at the fertilizer industry, in order to produce fertilizer, natural gas is used. Now, natural gas is actually used here as a raw material and not as a fuel. So, in the production process, the natural gas will not be burnt to produce heat, but it's actually being used as a raw material. So, there is in a sense there is one implication that this kind of feedstock use or this kind of non-energy use does not relate to the energy related emission.

This is something we will discuss later. I mean also in case of classification, we discuss that you can actually, you know, put different types of fuel in the scale of high emitting to low emitting variety. But when we talk about the feedstock use of energy, we do not enter into a discussion of emission. So, here it is used as a raw material. But because this is a demand for energy this falls under the demand here.

The third one is the use of electricity in agriculture, which is pretty straight forward, and then we have use of petrol by vehicles. So, this is how we can identify what are the components that should go under the supply, what are the components that should go under demand, and what are the components that should go under transformation.

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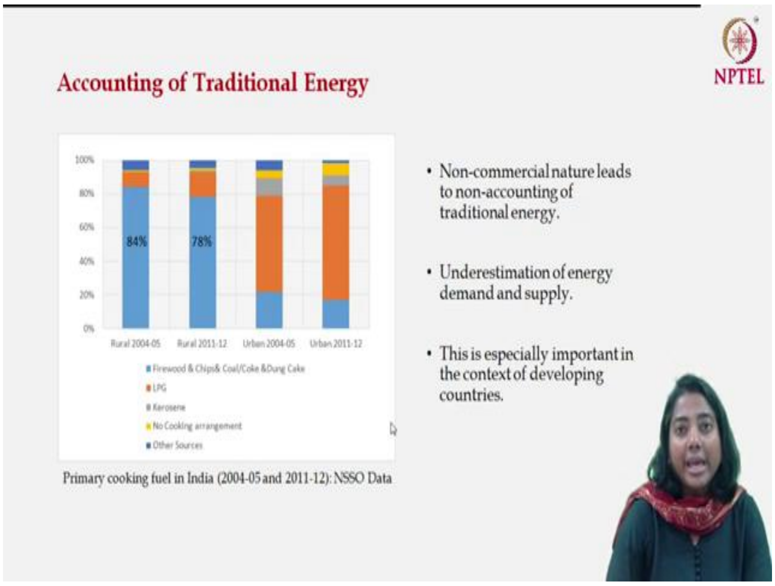

Before we end, let us have a quick discussion on very, few very important things. One is the accounting of traditional energy. As we have discussed and we have seen that when you look at the demand block of the energy balance table, you will see the entry for coal and other you know, sort of biomass based fuel, although that is not there in the demand sector that is 0 for the residential sector. But if you look at this data, this data is actually derived from the National Sample Survey data for India for the year 2004-5 and the year 2011-12.

And if you look at the left blocks, this blue part actually represents the percentage of rural households, the percentage of rural households that use fire wood chips, or coal or dung cake as their primary source of energy for cooking. Now, a large chunk of these 84 percent and 78 percent, I am sure, is non-commercial in nature. So, they are not being bought and sold in the market. The household actually derives this kind of fuel, extracts this kind of fuel may be from a forest or from other household uses or from animal residues and so on. Therefore, a large part of fuel or energy that is being used by households in the domestic sector will not be reflected in the energy balance table.

So, this is one of the major challenges that you face when you are trying to derive an energy balance table. And this is more prominent if you are thinking about the developing countries. So, this non-inclusion of traditional energy, because they are non-commercial in nature, is actually leading to a situation where you are not only understating the supply, but you are also under-stating the demand. So, the total supply or total demand of energy that is reflected in the energy balance table is actually less than probably less than what is actually being supplied and actually being demanded.

So, the higher the percentage of the, you know higher the amount of use of this kind of traditional energy this underestimation will be higher in case of energy balance. So, this is one thing one has to be very careful about. So, when you represent the energy balance, you better also state what is the use of traditional fuel in the particular economy. This is one point to be noted.

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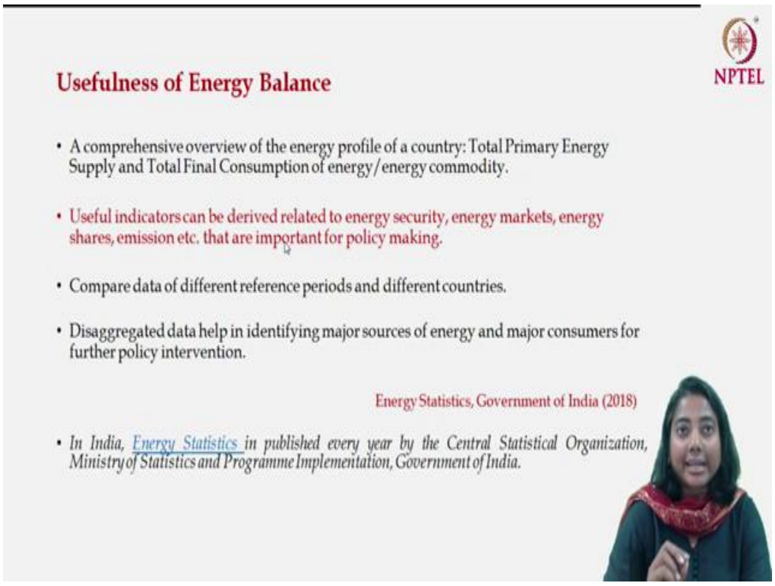

Next, we try to understand why we want to come up with such a, you know, kind of tedious job of coming up with the energy balance table, because that's quite complicated; you have to collect a lot of data from various sources. But energy balance tables are really, really useful, it gives you sort of a very comprehensive overview of the energy profile of a country. You can understand what are the sources of supply of both primary and secondary sources of energy; you also understand what is the profile for demand?

And you also get an idea about some very important energy indicators for example, total primary energy supply which is often stated with respect to a country very frequently whenever we are talking about energy supply, and total final energy consumption. It can be in terms of energy or it can also be in terms of energy commodities. Not only these indicators, there are several strategic indicators that can be derived from the energy balance table, which actually relates to energy security, energy market, energy share, emission etcetera. These are important for policy making. In the next slide, we will have a quick look at what exactly these indicators mean.

The third point is that we are often eager to compare the energy consumption pattern of one particular country, not only consumption but energy production and consumption pattern of a particular country, with the energy consumption and production pattern of a different country. You may have come across the comparison of energy consumption and energy production between the developing and developed countries. So, these things can be done based on energy balance.

Not only inter-country comparison is possible because nowadays all the countries, most of the countries are actually maintaining their energy balance for all the years, you can trace the change in the production and consumption of energy or the energy profile of a country over a period of time. So, inter-country comparison is possible, inter-temporal comparison is also possible, you have, if you have data on energy balance, if you have reliable data on energy balance. Because you remember if the statistical difference is too high in case of an energy balance, then it somehow losses the, its reliability.

The final one: since you have disaggregated data on energy consumption, it actually helps you to identify the major consumers of energy in a particular economy and develop policies accordingly. So, the energy policy of a country where most of the energy demand is coming from the industry sector will be different from the policies that need to be there for a country where the huge energy demand is coming from the residential sector. So, the policy will actually change depending on which one is your major energy consumer.

If you go to the.. in.. website of the Ministry of Statistics and Program Implementation, then you will see that every year, the Government of India through the Ministry of Statistics and Program Implementation actually publishes a report called Energy Statistics. This is published every year and one chapter in Energy Statistics is actually dedicated to the energy balance. And all the figures that I have been showing in the slides during 2016-17 provisional figures are taken from the latest Energy Statistics published in 2018. So, if you click on this link, it will take you to the latest Energy Statistics published in 2018.

And I would actually urge you to go through this report because this not only tells you about the, you know, the energy balance of India, but it gives you a very comprehensive understanding of the whole energy scenario of the country. How it’s changing over time regarding the price, regarding the quantity, foreign trade, energy security and so on. So, this is a very resourceful document and it's good to go through it.

As we have said there are several useful indicators that can be derived related to energy security, energy market, energy share and emission etcetera from the energy balance table. Let us have a quick look at different indicators that can actually, actually be derived from this.

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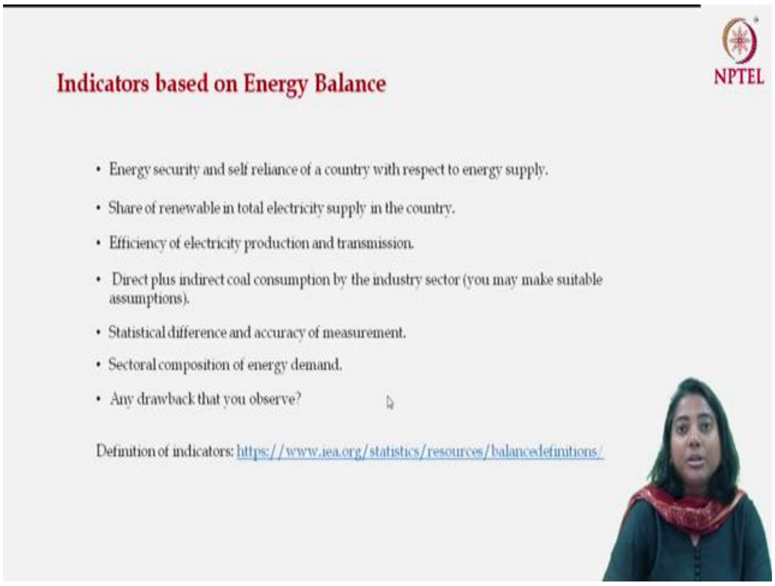

First one is related to energy security and self-reliance of a country with respect to energy supply. If you recall the supply component of energy balance, you will remember there is one row which represents the domestic production, the next row represents the import, the next one represents the export, then there was the stock change, and adding everything we were getting the total primary energy supply. So, if you express net import, if you express net imports as a percentage of total primary energy supply that will tell you how much you are dependent on other countries to procure energy.

So, the higher the import dependence, so the higher the ratio of net imports to total primary energy supply, lower will be your self-resilience and that will have implications towards your energy security. So, lower the import, lower the import proportion, higher will be your energy security and higher will be your self-resilience. Now, this kind of indicator you can derive for each of the energy. So, you can derive the self-reliance or import dependency with respect to oil, coal, natural gas and so on, you can also derive it for the aggregate industry overall what is the import, proportion of net import.

The second one the share of renewable energy in total electricity supply in the county. This is particularly relevant in the context of India; because in the context of, you know, climate change debate, India has been arguing that one of the main thrust areas will be to increase the renewable energy share in the electricity production. Now, again if you go back and think about the transformation block, not the supply block, but if you think about the transformation block you may recall that we were adding both primary and secondary forms of electricity produced to get one particular number. And from that number you can figure out what proportion is actually coming from renewable and what proportion is not coming from renewable that is coming from the non-renewable sources. So, this is one more interesting indicator.

The third one is efficiency of electricity production and transmission. This again takes you back to the transformation or conservation, sorry, or conversion block. You will, you remember that there was an entry with the negative sign for coal, x amount of coal which was producing y amount of electricity. So, if the less amount of coal is required to produce the same amount of electricity that shows that the efficiency of electricity production is going up. Similarly, if you, if you see, you know, a lower figure for the loss under transmission, the technical and non-technical loss, then you know your system of delivery has become more and more efficient.

The fourth one is direct plus indirect consumption of different fuel by a particular industry. So, this has implications for direct and indirect use of energy, and also direct and indirect use indirect emissions of different greenhouse gases. So, this is useful when you are actually trying to derive some indicator to do some analysis of climate change mitigation.

This is one important point to note the statistical difference and the accuracy of the measurement. As I have already said, we will see that the more robust and more efficient your system of data collection is, the statistical difference will go down eventually. That is why for the developing countries you see the statistical difference is a little higher than what you see in the context of the statistical difference in the developed countries.

The fifth, the sixth one this is again important the sectoral composition of energy demand, so which sector is most energy consuming, and therefore, what should be the guideline for developing a particular policy.

Although this, the entire framework of energy accounting and energy balance gives you very important indicators, one may also note that there are certain drawbacks; one drawback that we have already discussed in terms of non-inclusion of traditional fuel. There are certain other drawbacks as well if your statistical difference is high, that is another drawback. I would like you to go through the table, think about it, think about it a bit and come up with more drawbacks that you may observe that will give you a better understanding of the advantages and, you know, opportunities that are lying with along with the drawbacks of the energy balance.

As we have talked about the indicators, if you are interested about these energy related indicators, I would urge you to go through the website of IEA, this particular link is given here. The IEA stands for International Energy Agency and they provide a lot of information/ definition and international data on energy. So, this is a good sort of resource to explore. You can go through it and check for this. In fact, the International Energy Agency also produces, also actually makes available the energy balance table for different countries over a long period of year.

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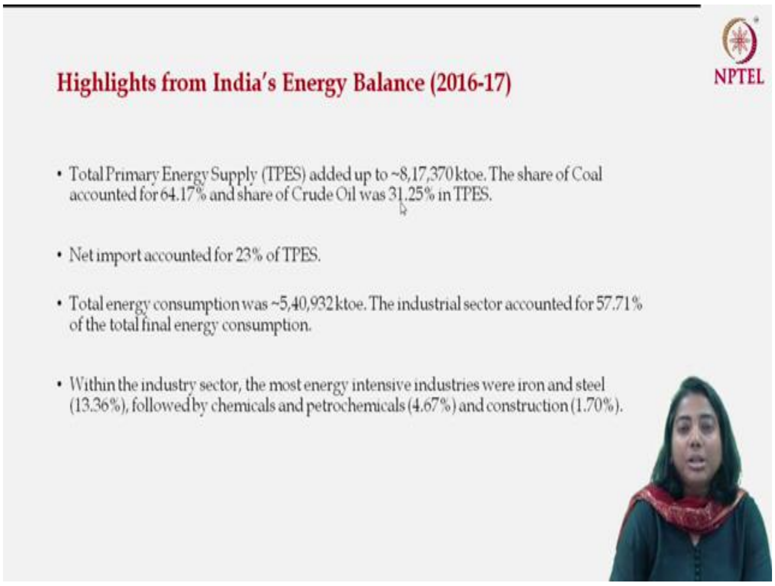

So, we are going to stop; before we look at a couple of indicators from India, some of the indicators that we have already discussed. So, these are the highlights from Indian energy balance table that we have been showing. And these are the kind of conclusions these are the kind of information that you can derive from this.

During the year 2016-17 as per the provisional figure, the total primary energy supply that is the TPES of India was added up to approximately a little more than 8 lakh kiloton of oil equivalent. Out of this 8 lakh kiloton of oil equivalent most of it came from coal. The share of coal in this total primary energy supply, was more than 64 percent, followed by the share of crude oil, which was a little more than 31 percent. So, you can see that the supply is mostly dependent on coal and crude oil dominated by coal.

The next one we have been talking about is self reliance and energy security. So, if you add up all the energy, you will see all together 23 percent of total primary energy supply in India is coming from abroad. So, the self-reliance is probably the 70 you can, you can say, that self reliance is 77 percent whereas, the dependence on, dependence on other countries in is 23 percent. So, that that not a very high import dependence. Although if you go to the disaggregate figure of different oils.. different energy, you will see that the dependencies very very high for oil.

The third observation is that the total energy consumption is little more than or you can say close to 5.5 lakh kiloton of oil equivalent. And who is the biggest consumer of energy? The industrial sector is the biggest consumer of energy and the demand for the industrial sector is more than 57 percent of total energy demand in India. Finally, if you look at the composition within industry which is the industry who is consuming most of the energy, you will see the most energy consuming industry is the iron and steel industry which is followed by the chemical petroleum and construction industry. So, these are very important observations that you can derive from the energy balance table. If you go through the indicators form the IEA, and if you try to figure out the indicator values based on those definitions from India's energy balance table, I am sure you will definitely find some very interesting observations.

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We are going to stop here. I will meet you during lecture 5.

Thank you.