Energy Economics and Policy
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Week – 01
Energy as an Economic Resource
Lecture – 02
Classification of Energy Resource

Welcome to the 2nd lecture, this is the 1st week and as we have said that we are going to cover the topic 'Energy as an Economic Resource'.

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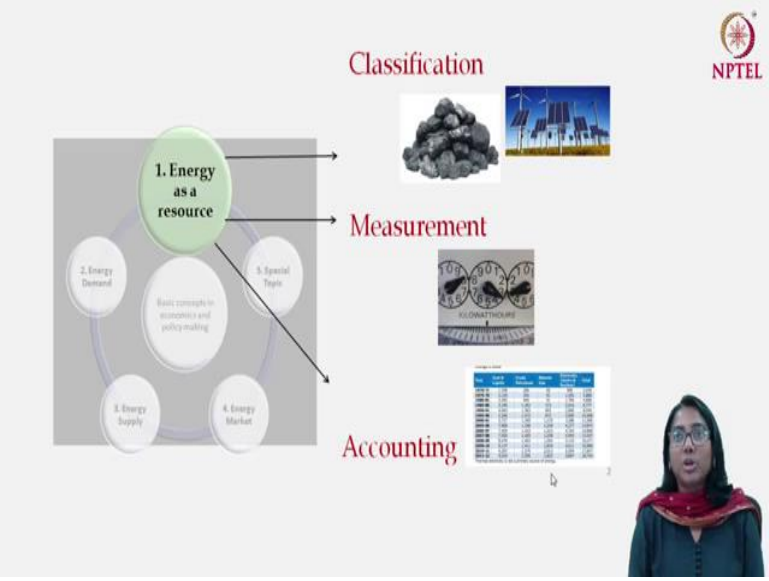

So, this is the 1st module, if you remember, out of the 5 modules that we are going to cover in this course and under this module we are going to talk about the

- Classification of energy resources
- Measurement of energy resources
- How we account energy resources

These are the three things we are going to discuss in this particular module during this week. So, let us begin with 'classification of energy resources'.

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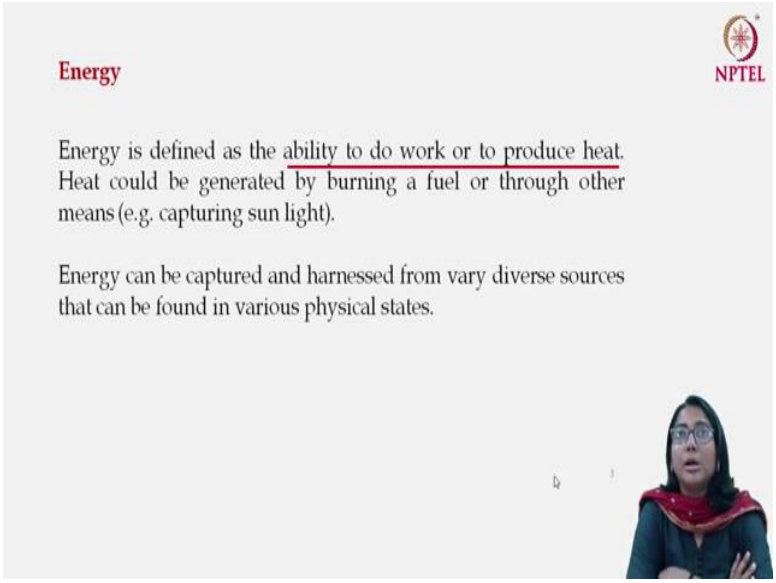

But before we go into classification, let me ask you, what do you understand by 'energy'? You may have different answers, but this is the classic definition of energy and it comes from the International Energy Agency and in many other places this is the scientific definition of energy. So, energy is basically defined as the "ability to work or to produce heat". So, either the ability to work or to produce heat. Now heat can be generated either by burning a fuel or it can also be generated through some other means. So, if you are actually getting the electricity from solar then you are not burning anything, but you are getting the energy. So, it can be, you know, there can be a fuel which can be burnt or there can be some other means.

Although we consider energy as an umbrella term, there can be variations of energy. So, what kind of energy are you using? What is the source of the energy? What kind of technology are you using to harness the energy? All these things are very important when you are talking about the classification of energy. And based on all these criteria we will try to see, how in various ways, we can actually classify energy.

See, this classification is actually very important when you are doing some empirical work, you are, you know, trying to refine your concepts, also when you are talking about policy making. So, there are various ways in which you can think about the classification.

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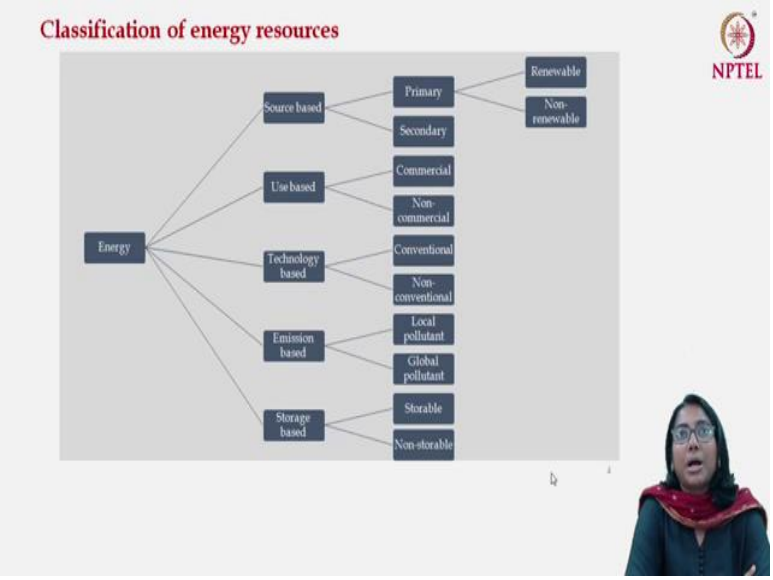

But here we are going to talk about five ways of classification of energy. There can be something other than this as well, but these are the main things that you consider while classifying the energy. So, it can be 1) source based, 2) use based, 3) based on the technology that you are using to harness the technology; 4) it can also be based on the kind of emission the burning of a particular type of energy or particular fuel is causing; 5) it can also be storage based. So, these are the 5 criterias that we are going to look at in this particular lecture and how we are going to classify energy based on these five criteria.

Let us begin with the source based classification of energy. If you think about the source, energy can be either ‘primary’ in nature or it can be ‘secondary’ in nature. Let us have a quick look at what is primary energy and what is secondary energy?

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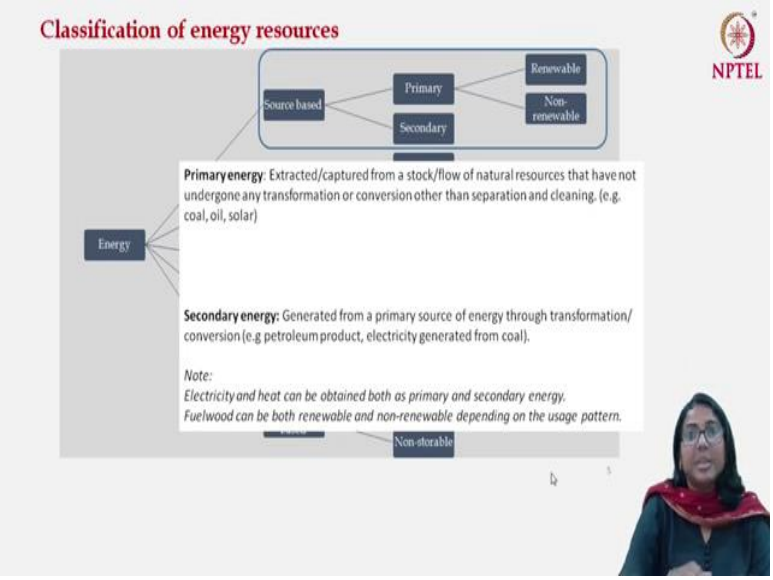

So, energy is called primary energy if it is extracted from a stock of natural resource or captured from a flow of natural resources that have not undergone any changes or transformation or conversion. So, the form of the energy in which you are using it, it's available in nature in that particular form only and it has not gone through any transformation.

So, think about coal. What do we do with coal? We take it out through mining, probably we wash it and the coal is burnt. So, the physical form of coal is not changing. So, this is a primary form of energy. What is a secondary form of energy? In case of a secondary form of energy basically you have to convert one primary energy to generate the secondary energy. So, this is generated from a primary source. You think about electricity which is being generated by the coal fired power plants. So, electricity in that particular form is not available on the earth. What are you using? You are actually using coal and you are converting that to electricity. Therefore, electricity, which is being generated from coal, is called a secondary source of energy. You must be very familiar with two terms, that is, ‘renewable energy’ and ‘non-renewable energy’. Now, whenever you discuss renewable energy and non-renewable energy, be very sure that you are actually talking about primary sources of energy and not a secondary source of energy.

So, the primary source of energy can be of two types: renewable and non-renewable. Now, what is a renewable source of energy? This is the form of primary energy, which is coming from an ‘infinite flow’. And what is non-renewable energy? In case of non-renewable energy, the primary energy is coming from a ‘finite stock’. Now, see when we are discussing renewable and non-renewable energy, for renewable energy, I am taking the word infinite flow and in case of non-renewable energy we are calling it a finite stock. So, there is an inherent difference

in terms of stock and flow. We are not going to discuss the concept here, but in some later lecture we will actually explore, what is the difference between flow and stock and what are the examples? So, if you want to take an example of renewable energy, solar energy is definitely a renewable energy, so the flow is infinite. If you think about non-renewable energy, this is coal. **B**ecause coal has a finite stock. I mean, after many years, may not be many years, after a few years the stock of coal is going to get over. So, it doesn't have an infinite stock.

Now, whenever you do a classification with respect to energy, be a bit careful about the boundary that you are actually considering because the boundaries are often not very clear cut. If you look at the note it's written that electricity and heat can be obtained both as primary as well as secondary energy. Now, why is it so? Think about electricity. What are the different ways in which you can get electricity? One, you can burn fuel in the coal fired power plants. You can burn, you know, natural gas in the gas power plants or you can use the solar power or wind turbines to generate electricity. So, there are several ways of generating electricity.

Now, when you are actually burning coal and producing electricity, at the backdrop of electricity there is a primary energy, which is present, that is coal. So, in this case electricity becomes a secondary form of energy. However, if you think of production of electricity through wind energy then essentially a mechanical energy is being converted to electricity. So, there is no energy i.e. fuel energy at the back of this particular electricity which is being produced.

So, when you are producing electricity by burning coal, it's a secondary form of energy, when you are producing electricity through wind turbines that is a primary form of energy. So, electricity can be both primary as well as secondary source of energy. The same is actually true in case of heat as well.

The classification that we have discussed in terms of renewable and non-renewable energy, can sometimes go very blur. You take this example of fuel wood. Suppose there is a household in a rural area in India and they are collecting fuel wood from the forest. Now do you think fuel wood is a renewable resource or is it a non-renewable resource of energy? It actually depends on the type of use; how much fuel wood are you extracting from the forest? So, if the rate of extraction of fuel wood is greater than the rate of growth of the forest then of course, after a point of time the entire forest will be degraded. So, in that case you can see that the fuel wood is a non-renewable resource. However, if you are using the fuel wood in such a manner that your rate of extraction is actually less than the rate of growth of the forest, then there will be a

flow of fuel wood for ever and ever. So, the availability of this resource is going to be in the form of an infinite flow. So, in this case, fuel wood is becoming a renewable resource. So, fuel wood per se, you can't really say whether it is renewable or non-renewable, it depends on the context. So, it depends on the rate of extraction viz a viz the rate of production.

See, in a sense coal is also like that, I mean, if your rate of extraction is very very low then even if it looks like a finite stock, to exhaust the entire finite stock it will take a very long period of time. So, the concept of renewable and non-renewable also depends on the concept of the rate of extraction and growth. So, this is something one has to be careful about.

Coming to the second characterization, second classification, we call it use-based classification and it actually refers to the fact whether a particular form of energy is being bought and sold in the market or not.

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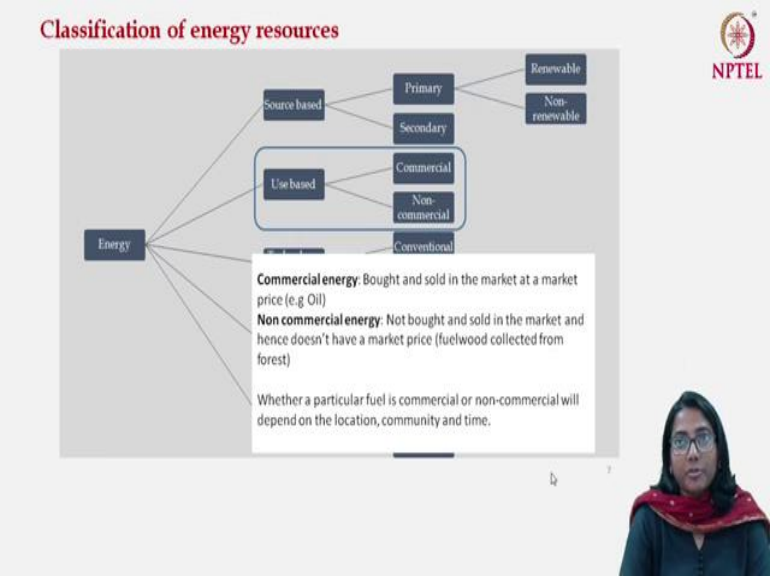

So, there are two types of energy with this respect; one is the commercial energy and the other is the non-commercial form of energy. This is pretty straight forward. If a particular form of energy is bought and sold in the market and therefore, commands a price then this is called a commercial energy. If there is an energy, which is not being bought and sold in the market and therefore, does not command any price then this will be called a non-commercial energy.

Now, again, you know the boundary between commercial and non-commercial energy can be very blurry. It depends on the context, it depends on the locality that you are talking about, it

depends on the type of use that you are talking about, it depends on the community that you are talking about.

So, in a particular area it might be the case that the household has to buy fuel wood from the market. In that case fuel wood is the commercial energy; however, in some cases they might be extracting the fuel wood from the forest and this is not bought and sold in the market. So, the same fuel wood again can either be a commercial energy or it can also be a non-commercial energy depending on the kind of use that you are talking about, or depending on the context.

So, this is the point that I was trying to make, that whenever you are trying to put a particular form of energy in a particular category, be very alert about the context that you are talking about. So, it's not exactly black and white in all the cases.

Now one interesting classification which is closely associated with commercial and non-commercial energy is the concept of modern fuel and traditional fuel. If you look at the non-commercial energy, we are saying that these are the forms of energy that are not bought and sold in the market. So, in many of the cases these are mostly biomass-based energy. For example, cow dung, fuel-wood and so on. So, they are not bought and sold in the market and these types of energy are often called the traditional energy. And if you think about, for example, LPG, electricity and so on, these are the things which are bought and sold in the market and these are called the modern fuel. And there is a huge volume of literature available in the context of energy economics and policy, which discusses and tries to understand the transition of the society from traditional fuel to modern fuel and this literature is called the literature on 'energy ladder'. So, this is one very common term in the context of energy literature if you want to go through it.

The third classification that we are going to talk about is technology-based. So, this is basically based on the kind of technology that you are using to extract or to convert the energy.

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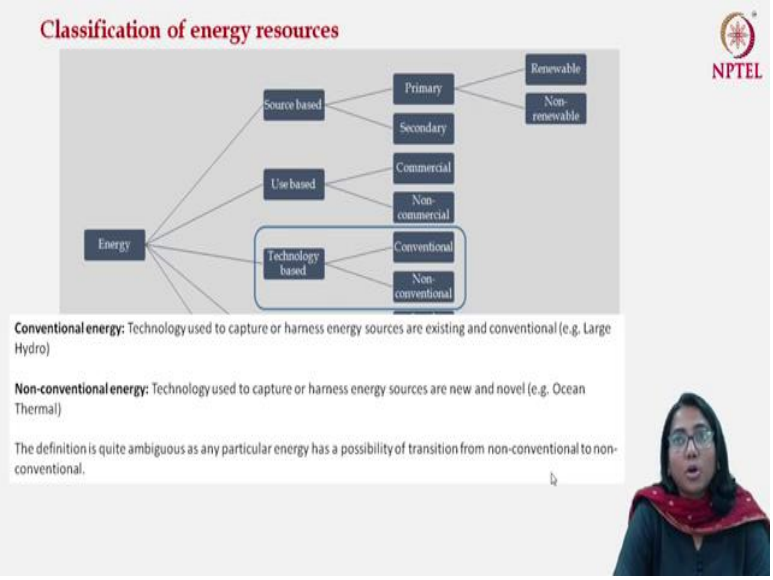

So, this can be either conventional or non-conventional. This is again a very simple straightforward definition that we have. In case of conventional energy, you actually use the technology, which is in place, which is existing, which is known, which is sort of conventional to capture or harness energy. For example, the large hydro-power project; for example, the coal-fired power plant. So, the technology is already known to us. The other kind of energy that we consider here is based on non-conventional technology.

Here the technology is not well known and it's kind of new and novel. So, to become conventional it will take some time. For example, ocean thermal. The technology is yet to be established. But once again, you know, the boundary is sometimes blurred between these two types because nothing is eternally non-convention or nothing is eternally conventional. For example, if you think about solar energy, 50 years back that was probably a non-conventional source of energy, non-conventional technology. So, it's contingent on the time period that you are talking about.

Over time a particular form of non-conventional energy has a potential to become a conventional form of energy. So, again when you are considering one particular form of energy to come up with the conclusion whether that is conventional or non-conventional, it's good to look at the timeline, or the time frame you are talking about.

The fourth classification is interesting. This is based on emission. Although we have written 'local pollutant' and 'global pollutant', this is not exactly the type of energy. What I want to

say here is that you can classify energy based on its emission of local pollutants and global pollutants. So, you can think about a scale of pollution and where on that scale you want to position a particular form of energy. Whether it's towards the end of low emission energy or whether it's towards the end of high emission energy. So, you have a scale and you are trying to position one particular form of energy on that particular on that scale with respect to the emission. Now here we had to use two terms local pollution and global pollution.

Now, these two are very important terms when we discuss energy economics or generally energy policy issues. Although they look like more environmental indicators, it's very closely related to energy and in later modules we'll actually try to understand what is the nexus between energy use and emission? So, coming to the local and global pollutant, let me give you a very brief understanding about these two terms.

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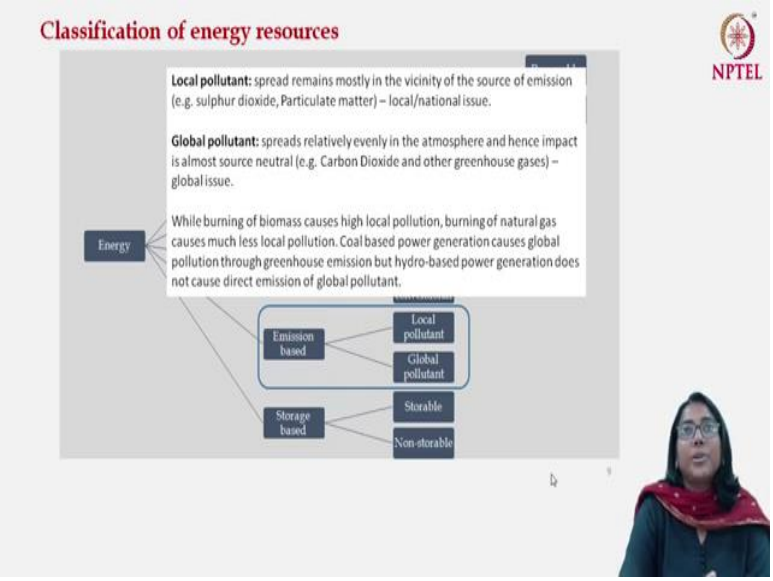

Local pollutants are basically those pollutants which stay in the vicinity of the source of pollution; for example, if you think about sulphur dioxide or if you think about, you know, particulate matter, then what happens, its stay close to the source of emissions. So, it will not be the case that these pollutants will be emitted in India and then travel to the US and the impact will be felt in the US. So, this is something which is not going to happen.

These are the pollutants which are not evenly mixed in the atmosphere and therefore, if you think about reduction of this kind of pollution then it remains more of a local or domestic issue of a country. On the other hand, if you think about global pollutants, these pollutants spread

evenly in the atmosphere and therefore, the impact of these pollutants are felt all over the globe, irrespective of their location of emission. So, this is the difference between the local pollutant and global pollutants.

Global pollutants are mostly the greenhouse gases, the carbon dioxide and methane and so on. So, it doesn't matter whether the greenhouse gas is emitted in India or in China, in Bangladesh or in, you know, any part of the USA, the impact will be more or less the same. So, when we talk about global warming and climate change, we not only really talk about the specific effects in different regions, but we also talk in terms of increase in the global mean temperature. So, the impact is felt all over.

Now, when you are thinking about one particular energy, it's interesting to understand where you are going to position that particular energy with respect to emission of both local pollutants as well as global pollutant. So, let us just deal with this example. Consider the cooking activity. So, cooking can be done using biomass. If you burn biomass in order to cook then it will create high indoor air pollution, which is local pollution. Suppose you replace biomass-based cooking with LPG. So, the local pollution will come down. Now if you replace LPG again by electricity there is actually no direct pollution if you use electricity in your cooking activities.

So, gradually the emission of local pollutants decreases if you move from biomass based cooking to LPG and from that to electricity. So, this is how you can categorize different types of energy. Second, you can take another example to understand the consequences with respect to global pollutants. Suppose you are producing electricity, now if you use coal to produce electricity then you emit a lot of carbon dioxide. So, your emission of global pollutants is high. If you replace coal with natural gas then what we see is that the carbon dioxide emission will come down. Further if you think about renewable energy the direct emission or the direct greenhouse gas emission from the production of electricity will be almost equal to zero.

This way you can position different energy with respect to emission of these two kinds of pollutants and this is gaining a lot of importance and this has been discussed when we talk about the energy environment and climate change nexus.

Coming to the final classification, this is based on the storage pattern: whether you are able to store a particular form of energy or not and this has also some implications towards policy making and development. So, what is storage-based classification? A form of energy either can be stored or it cannot be stored.

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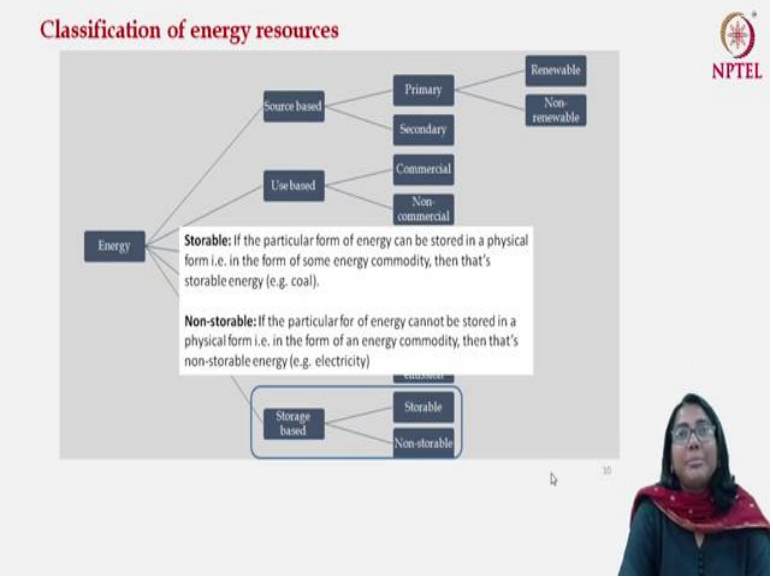

So, let me begin with an example, think of coal. You can hold a particular amount of coal, you can keep it at some place you can use it in future. So, this can clearly be stored in the same physical form. So, this kind of energy which can be stored in its physical form is called a storable energy.

However, if you think about electricity, essentially, you can't hold an amount of electricity and keep it somewhere and use it in future. Basically electricity cannot be stored, it's not a storable form of energy. However, if you want to store electricity the only way is to store it in a chemical form in a battery. But electricity per se is a non-storable form of energy. Now this is interesting, I mean it may seem to be a bit technical, but these things have different implications for pricing and for policy making. So, if you can store a particular form of energy there is no hard and fast rule that you have to use it up when you are producing it. So, whatever coal you mine today you can use it tomorrow, but mostly whatever electricity you are producing today, mostly you have to use it, I mean you can't have the entire production of electricity stored in batteries. So, there is an implication with respect to supply and demand. In case of non-storable energy, the supply and demand has to be simultaneous, whereas, in case of storable energy, the supply and demand may be lagged, they do not have to take place simultaneously.

So, this is basically, in a nutshell, the classification that we wanted to discuss about the energy. However, there can be other forms of classification that you may come across, but these are

the fundamental ways to look at it. This is the end of lecture 2 and we will discuss the measurement of energy in the 3rd lecture.

Thank you.